Tscheke, Jan:

Operational Hedging of Exchange Rate Risks

Munich Discussion Paper No. 2016-18

Department of Economics
University of Munich

Volkswirtschaftliche Fakultät
Ludwig-Maximilians-Universität München

Online at https://doi.org/10.5282/ubm/epub.30227

Operational Hedging of Exchange Rate Risks

Jan Tscheke

LMU Munich

November 10, 2016

Exchange rate exposure of firms diminishes when imported intermediates and exports are denominated in currencies that move together. Appreciations of the domestic currency, raising foreign currency export prices, then also reduce marginal costs, allowing firms to counter the increase in foreign prices. Using firm-level data from seven European countries I estimate a structural model showing how exchange rate pass-through into sales depends on intermediate imports and the co-movement of export and import related exchange rates. I find that operational hedging requires firms to intentionally choose export and import regions with co-moving currencies. Analyzing the locational choice of firms confirms that the co-movement of currencies indeed appears to be taken into consideration.

JEL Classification: *D21, D22, F12, F14, F31, G15, L21, L23, L25, M16*
Keywords: Hedging, Offshoring, Intermediate Imports, Foreign Sourcing, Exporter, Effective Exchange Rates, Pass-Through, Disconnect Puzzle, Exchange Rate Co-Movement

Department of Economics, University of Munich, Ludwigstr. 28, 80539 Munich, Germany,
E-mail: jan.tscheke@econ.lmu.de

I am grateful to Penny Goldberg, Giordano Mion, Antonio Rodriguez-Lopez, André Romahn and Jeffrey Wooldridge for helpful comments on the paper. I thank Dalia Marin for her constant encouragement and support. I am also grateful to Philippe Fromenteau, Philipp Herkenhoff, Jan Schymik and Alexander Tarasov for shaping this project in countless discussions. Further I would like to thank Andreas Backhaus, Robert Grundke, Henrike Michaelis and Inga Heiland for valuable insights and suggestions. Franziska Hünnekes provided excellent research assistance. Financial support from the Deutsche Forschungsgemeinschaft through SFB TR15 is gratefully acknowledged. I have benefited from access to the EU-EFIGE/Bruegel-UniCredit database, managed by Bruegel and funded by the EU 7th Framework Programme ([FP7/2007-2013] under grant agreement no. 225551), as well as by UniCredit.

1 Introduction

Internationally active firms represent only a small fraction of all firms. Nevertheless, above average performance implies that their impact on aggregate economic activity is much larger than their number suggests. Using US data for the year 2000, Bernard et al. (2009) find that trading firms, a mere 4.1% of all firms, accounted for as much as 41.9% of employment outside government and education.[1] In the light of these findings, and spurred by the increasing availability of firm-level data, a major puzzle from macroeconomics has recently reemerged and come under the scrutiny of micro-data analysis: why have exchange rates so little effect on the real economy?[2]

A large body of literature, dealing with the exchange rate disconnect, has revealed that much of the puzzle can be traced back to incomplete pass-through of exchange rates into prices.[3] Thus, a devaluation of the dollar does not necessarily imply cheaper US imports for the rest of the world and accordingly no expenditure adjustments. The focus on firms' sourcing behavior can be seen as the latest addition to this literature. It is driven by the insight that internationally active firms are often exporting final goods and importing intermediate goods at the same time.[4] If both flows are denominated in the same currency, an appreciation, usually increasing the price tag on foreign sales, also implies higher purchasing power with respect to intermediate inputs. This reduction in costs helps firms to counter the increase in prices of goods sold in the foreign market, effectively preventing changes in foreign sales.

Adding to this branch of literature, this paper provides new firm-level evidence from European manufacturing firms, supporting the hypothesis that the missing link between exchange rates and the real economy is partly due to imports of intermediate goods. Yet, in difference to earlier results, I find the mechanism of offsetting exchange rate effects to hold for a subset of firms only. Specifically, I analyze to what extent export and intermediate import flows are denominated in the same currency and find

[1] Bernard et al. (2009), tables 14.1 and 14.3.

[2] See Obstfeld and Rogoff (2001) for an explicit formulation of that puzzle.

[3] See Goldberg and Knetter (1997) and Burstein and Gopinath (2014) for reviews of the literature. Classical explanations for this inelasticity of prices include price rigidities in the local currency (e.g. Gopinath and Rigobon (2008)), firms adjusting the profit margin (e.g. Atkeson and Burstein (2008)) and local-currency distribution costs (e.g. Goldberg and Campa (2010)).

[4] Bernard et al. (2009) find that of the 41.9% of US workers employed in trading firms, about 73% are employed in firms that are both exporters and importers (compare Bernard et al. (2009), table 14.1). As a study by the OECD for 2006 confirms, intermediate imports are thereby the dominant trade flows in OECD countries, representing 56% of the total trade in goods and 73% of the total trade in services. (compare Miroudot et al. (2009)).

that for many firms the alignment appears to be rather weak or even negative. This has important implications: if the exchange rate with respect to exporting regions moves independently from the exchange rate with respect to sourcing regions, the offsetting effect described above disappears. If exchange rates are negatively related, the effect of exchange rates on export sales is reinforced through intermediate imports. This is what I find for the average exporting firm in my sample.

From the macro perspective, this is an important finding because it implies that the link between intermediate imports and the exchange rate disconnect puzzle is specific to only a subset of importing firms, namely those with a positive alignment of export and intermediate import related exchange rates. Amiti et al. (2014) conceptually acknowledge this limitation, but, because they do not consider the full distribution of the measure of co-movement, their approach does not bring to light its empirical significance. To my knowledge, the present paper is the first to put the co-movement of exchange rates in the foreground.

The following analysis addresses two questions related to the effects of intermediate imports on the rate of exchange rate pass-through. The first part of the paper determines the offsetting effect of intermediate imports on the exchange rate pass-through into total sales, contingent on the co-movement of exchange rates. Technically, this part is closely related to the exchange rate disconnect literature. The second part of the paper asks whether exporters take into account the co-movement of exchange rates when deciding on sourcing regions. It connects to the hedging literature and, to my knowledge, is the first approach of addressing this question in a systematical manner.

In order to guide the empirical specification for the first part, I propose a stylized theoretical framework where demand is derived from standard CES preferences and firms set prices with a fixed markup over marginal cost. Marginal costs are determined by the composition of domestic and foreign inputs and firms can sell their output at home and abroad.[5] Partially differentiating the expression for sales with respect to the export weighted exchange rate leads to a simple structural estimation equation. For exporting firms, the structure predicts a positive association between sales and the foreign currency value. A potentially countervailing association is established when the firm is offshoring, i.e. purchasing inputs from abroad. A devaluation of the export related exchange rate then implies increasing input costs, *provided that*

[5]As my data does not provide information on the evolution of exports and imported inputs over time, I assume the optimal import and export decision to be sunk at the time of observation.

the co-movement between export and intermediate import related exchange rates is positive.

I estimate the equation for log-changes in sales over the years 2004 to 2013, using a large sample of manufacturing firms from seven European countries, including France, Germany, Italy, Spain and the UK.[6] The dependent variable is regressed on log-changes in the real effective exchange rate as well as interactions with the share of exports in total sales and the share of imported intermediates in total intermediates, i.e. offshoring. Following the literature, the effective exchange rate is constructed as a trade weighted geometric average of bilateral exchange rates, where weights are chosen according to export flows at the industry level. Because I expect the coefficient on the offshoring interaction to be contingent on the co-movement between the export and intermediate import weighted exchange rates, I add a triple interaction with a corresponding measure.[7]

I find the results to be in line with the theoretical predictions. Specifically, exporting firms on average face higher demand after a devaluation of the domestic currency. The effect is countered by imported intermediates if the co-movement between export and import weighted exchange rates is high enough. The coefficients of interest have the expected sign and are statistically significant. This implies that, for exporters, offshoring can in principle have a dampening effect on the exchange rate elasticity of sales. My data thus confirms earlier findings, showing that multiple foreign operations have the potential to provide an operational hedge against the exchange rate uncertainty facing exporters. Yet, different from earlier studies, I find the co-movement of exchange rates to be too low for the average firm in my sample. As pointed out earlier, importing intermediates then reinforces the exchange rate effects due to exporting.

In terms of economic significance, my findings suggest that doubling the average sample rate of exchange rate devaluation from 0.3% to 0.6% increases the growth rate of sales by about 8.8% for the average non-offshoring exporter. For the average offshoring exporter, the corresponding increase more than doubles to 18.5%. Thus,

[6] Different from earlier studies that relied on price-level or export data, the structure I propose is built upon firm-level variables that are easily available. This enhances the applicability to different data sources considerably.

[7] Note that the industry weights used in the construction of the intermediate import weighted exchange rate are chosen according to imports at the *input* industry level, using Input-Output (IO) coefficients to determine the importance of each input industry in the firm's output industry. For simplicity, I will use the terms import weighted exchange rate and intermediate import weighted exchange rates interchangeably.

instead of offsetting the effect of exchange rates on sales working through exports, offshoring appears to reinforce it on average. I find offshoring to work as a hedging device only for firms that, by purpose or luck, choose an offshoring region with high hedging potential, i.e. a high co-movement between export weighted and intermediate import weighted exchange rate. Thus, the best possible hedging region, with a co-movement indicator at the 99th percentile, completely offsets the export effect on sales with an import share of only 7%, while the same amount of offhoring can increase the export effects by more than 73% if the co-movement indicator is very low, i.e. at the 1st percentile.

In the hedging literature, it has long been recognized that the exchange rate exposure of firms is effectively reduced when the firm engages in multiple international activities. The underlying mechanism has often been referred to as natural hedging.[8] As the term *natural* suggests, the hedging effect is implicitly assumed to work through random diversification. For existing empirical studies, this assumption was usually sensible, given that most of them are dealing with data on large multinationals. But in the light of the results described above, the assumption needs to be qualified when small and medium-sized firms with limited international activity are concerned. For the average exporting firm in my sample intermediate imports tend to reinforce the effects of exchange rates, thereby increasing exchange rate exposure. This implies that most firms willing to engage in *operational hedging*[9] activities will have to carefully consider the exchange rate characteristics of export and sourcing regions.

This consequently provokes a question that has been barely addressed in the literature: do firms take into account the hedging potential when choosing an offshoring region?[10] Anecdotal evidence strongly suggests that they do.[11]

[8]See Clark (1973) for an early formulation of the natural hedging hypothesis.

[9]Because my findings suggest that hedging requires a non-random choice of sourcing regions for most firms, I will refer to *operational* hedging instead of *natural* hedging from now on.

[10]Amiti et al. (2014) indirectly approach the issue by determining whether the co-movement between export and import weighted exchange rates at the firm level is increasing in import intensity. Finding no significant relationship, they conclude that hedging is not systematic. Yet they do not address the choice of sourcing countries explicitly.

[11]In its annual report 2007, German car manufacturer BMW explicitly proclaims that "[f]rom a strategic point of view, i.e. in the medium and long term, the BMW Group endeavors to manage foreign exchange risks by 'natural hedging', in other words by increasing the volume of purchases denominated in foreign currency or increasing the volume of local production." (BMW Group Annual Report 2007, p. 63). Similar intentions are expressed in the annual reports of Toyota (2007, p.77) and Volkswagen (2009, p.188). While these very large multinationals are not representative of the manufacturing sector, a survey conducted by the Canadian export credit agency EDC among 260 exporters suggests that operational hedging might actually be relevant to a large number of exporters. The authors of the report note that "[a]lthough, natural hedging is an important tactic for

In order to address this question more formally, in the second part of this paper I regress regional offshoring choices on regional exports and their interaction with exchange rate characteristics. Regional exports are included as an indicator of exchange rate exposure and because, keeping constant regional characteristics, sunk cost of regional entry and network effects would predict that firms should be relatively more willing to import from a region that they already know. Nevertheless, if the region is highly volatile in terms of exchange rates and if firms dislike exchange rate volatility, then even regional exporters might not like to source from that region. Again, these results are contingent on the co-movement between import and export weighted exchange rates. If this co-movement is low for a given region, sourcing would reinforce the volatility effect of exports and, controlling for other area specific effects, firms would be wise to import from other regions. But once the co-movement exceeds a certain level, the high volatility of exchange rates can be effectively hedged through intermediate imports. Because higher volatility implies a higher risk level, I would then expect firms to be relatively eager to match exports with intermediate imports from a given region.

The analysis delivers results that are in line with these predictions. As expected, the data suggests that the probability of importing from a region is, on average, higher for regional exporters. Thus, ignoring any exchange rate risks, exporting increases the probability of importing by 15.9 percentage points. Factoring in the average level of exchange rate volatility significantly reduces this effect to 4.3 percentage points for an average level of co-movement between the export and the intermediate import weighted exchange rate. Thus, firms tend to avoid exchange rate risks. But additionally, the sourcing decision depends critically on the indicator of exchange rate co-movement. Accordingly, the positive effect of regional exports on regional imports increases to 7 percentage points in regions with high co-movement of exchange rates (90th percentile) but decreases to 2 percentage points for regions with low co-movement (10th percentile). The effects are more pronounced in high volatility regions (75th percentile of the volatility distribution), where an exporters facing high co-movement of exchange rates tends to be 4.2 percentage points more likely than a non-exporter to source from that region, whereas firms facing low co-movement tend

firms of all sizes, [...] small firms are particularly drawn to the use of natural hedging strategies." Overall, the report finds almost 60% of the respondents to engage in operational hedging activities (EDC (2009), p.6.). The report defines natural hedging as the attempt "to match revenues in a foreign currency with payments in that same foreign currency." Note also that Friberg and Huse (2014) derive counterfactual profit distributions for BMW and Porsche and find that operational hedging reduces exchange rate exposure.

to be on average 3.5 percentage points less likely. These findings represent a clear pattern in the choice of importing regions that is in line with the mechanisms explained above. I interpret them as evidence for *directed* operational hedging.

The rest of the paper is structured as follows: Section 2 summarizes the related literature. Section 3 presents the theoretical framework. Section 4 introduces data sources, key variables and discusses the empirical identification. Section 5 presents estimation results for the theoretical framework. Section 6 introduces the estimation equation for local sourcing and discusses the results. Section 7 concludes.

2 Related Literature

The paper connects two strands of the literature that have so far been developed apart from each other. On the one hand, there is a recent literature that focuses on imports and global value chains in order to explain the exchange rate disconnect puzzle. On the other hand, there is a branch of the finance literature that deals with the exchange rate exposure of multinationals and discusses reasons and means to deal with it.[12] Both strands have provided evidence suggesting that international sourcing is effectively hedging the exchange rate risk of exporters. Accordingly, the question arises whether firms might be actively directing their international activities towards hedging opportunities. This paper adds to both strands of the literature, providing new evidence for effective and directed operational hedging in the European manufacturing sector.

The first part of the paper relates to the pass-through literature with its recent focus on imported intermediates. This literature is looking at price adjustments in response to exchange rate variations and usually requires highly detailed data on prices or volumes. The analysis then follows from a structural decomposition of prices into markups and marginal costs. Proceeding this way, Athukorala and Menon (1994) use Japanese industry-level data and find evidence for an indirect effect of exchange rates on export prices that is operating through the cost of imported inputs. Goldberg and Hellerstein (2008) review empirical work and find that after accounting for the variation in markups, structural models of pass-through tend to produce substantial residual variation that could be due to movements in marginal costs. Fauceglia et al.

[12] Note that this paper also relates to a literature that examines the relation between exchange rate volatility and trade flows. It is surveyed in McKenzie (1999) and Clark et al. (2004) and I will briefly return to it in section 6.

(2012) use Swiss industry-level data and find high pass-through rates of exchange rates into import prices, concluding that importing intermediates potentially allows exporters to benefit from operational hedges.

But while these studies have confirmed the role of imported intermediates for pass-through at the sectoral level, evidence at the firm level remains relatively sparse. Using French firm-level data, Berman et al. (2012) estimate a pass-through regression at the firm level and find that importing firms increase their prices more than others in response to a devaluation. While they attribute this effect to a rise in input costs, the underlying mechanisms are not formally addressed and their analysis remains silent about the relationship between export and import weighted exchange rates. Amiti et al. (2014) develop and test a structural model of variable markups at the firm level that explicitly accounts for the role of imported intermediates and the co-movement between export and import weighted exchange rates. They find imported intermediates to significantly reduce pass-through rates in their sample of Belgian firms.

My work is closely related to the approach of Amiti et al. (2014), given that they analytically introduced the role of exchange rate co-movement for pass-through rates at the firm level in their theoretical model. Empirically though, these authors consider only very few points of the underlying distribution. In difference to their empirical approach, I add a further interaction that explicitly accounts for the co-movement between import and export weighted exchange rates, allowing the measure to vary continuously across firms. As shown in section 5, my results are analytically still in line with the earlier study, but for the average firm, the implications for hedging are now completely reversed. In a further difference from these authors, I measure pass-through into total sales instead of prices. This allows me to substantially extend the analysis to several countries but implies that price and volume adjustments remain closely entangled. Accordingly, I abstract from markup heterogeneity in the structural model.[13]

The paper is also closely related to Greenaway et al. (2010). Similar to the approach presented here, they focus on (export) sales rather than prices. Using data on UK manufacturing firms, they find an appreciation to reduce exports. Furthermore, they find an offsetting effect through imported intermediates. They also distinguish export and import weighted measures of the exchange rate but do not account for exchange rate co-movements. Furthermore, their measure of offshoring is not firm specific.[14]

[13]Note that this in theory implies a complete pass-through for firms that source domestically only. Empirically, I will add markup controls in order to allow for heterogeneous pricing-to-market.

[14]The role of imported inputs for pass-through is also confirmed in recent findings at the macro-level.

The second part of the paper shifts the focus towards the notion of exchange rate exposure. This concept originates from the business and finance literature and provides the basis for most of the hedging analysis. Authors like Heckerman (1972) and Shapiro (1975) define exposure as the sensitivity of the firm value to changes in the exchange rate. Among others, Jorion (1990) and Bodnar and Gentry (1993) have therefore used stock market values to assess the exchange rate exposure of multinational firms. Because these studies struggle to find significant effects, Bartov and Bodnar (1994) propose that the net exposure of multinationals depends on the relative size of foreign costs and revenues and that failure to measure exposure might be the result of offsetting cash flows. Using data on 409 US multinationals, Choi and Prasad (1995) provide evidence consistent with the idea.[15]

Accordingly, some authors have acknowledged the role of internationalization as a hedging device.[16] That firms actively determine their international activities according to operational hedging potential has, to my knowledge, only been addressed in theoretical contributions. Thus, Broll (1992) derives a model of risk averse multinationals and finds that, in the absence of forward markets, profit maximization leads to active operational hedging. Chowdhry and Howe (1999) show that operational hedging can be efficient even in a world with fixed quantity forward contracts, as the alignment of revenues and costs allows for flexible exchange rate hedges that are contingent upon sales in the foreign country. Empirically, most of the literature has focused on the relation between financial and operational hedges. Operational hedges are mostly treated as the result of predetermined geographic diversification rather

Thus, Ahmed et al. (2015) and Ollivaud et al. (2015) document a significant drop in the elasticity of aggregate manufacturing exports to the real effective exchange rate over the last two decades. They propose the expansion of global value chains as one of the major reasons for that change over time. Note that while the literature has proposed various determinants of low *levels* of pass-through, global value chains are especially suitable when it comes to explaining a *change* in recent years. Note also that Leigh et al. (2015) do not share the view of an increasing disconnect at the macro level but acknowledge the role of international production fragmentation in explaining a low pass-through of exchange rates into export prices.

[15] See Muller and Verschoor (2006) and Bartram et al. (2010) for more recent results on the determinants of exchange rate exposure.

[16] The question of whether and why firms hedge against exchange rate risks is not the focus of the present analysis but has been covered in several papers. Dumas (1978) introduces market imperfections such as capital market segmentation or bankruptcy costs in order to restore the relevancy of the financial hedging decision. Rodriguez (1981) presents results from interviews with financial officers of US multinationals and suggests that risk aversion might play an important role when it comes to exchange rate hedging. Mayers and Smith (1982) provide a more general discussion of corporate demand for insurance. A short overview of alternative theoretical assumptions that justify hedging activities is given Mian (1996).

than a specific match of import and export weighted exchange rates.[17] Thus, none of these papers provides evidence for firms actually choosing locations according to hedging potential. Additionally, because exposure is measured through changes in stock values, most of the literature has focused on large multinationals and fails to acknowledge the role of operational hedging for a broader set of firms.

3 Theoretical Framework

In order to guide the empirical specification, I propose a stylized Dixit-Stiglitz framework of internationally active firms. Using CES preferences keeps the structural equations tractable, but still flexible enough to provide useful predictions on the relation between exports, offshoring and exchange rate exposure.[18]

I define marginal costs to be a simple weighted average of domestic and foreign wages, with i representing the firm specific but exogenous physical imported input share and E_i representing the import weighted exchange rate in price notation ($E_{€/\$}$):[19]

[17] Examples include Houston and Mueller (1988) who note that more geographical diversification should tend to reduce the need for hedging but find no evidence for that effect in data on US multinationals. Makar et al. (1999) and Allayannis et al. (2001) also use measures of geographic diversification as a proxy for operational hedges and assess the effect of dispersion on the financial hedging decisions of firms. While the former find operational hedging to substitute for financial hedges, the latter find both types of hedges to be complementary. Pantzalis et al. (2001) show that operational hedging in terms of breadth and depth of the multinational network lowers exchange rate exposure after controlling for the presence of financial hedges. Ito et al. (2015) focus on the relationship between the choice of invoicing currencies and both, the need and effectiveness of financial and operational hedges. A summary of the hedging literature with a focus on Europe can be found in Döhring (2008), who points out that operational hedges, involving high sunk costs, are typically used to reduce longer-term exposure to economic risk, while transaction risk can be easily hedged using standard financial products. In general, the literature distinguishes transaction risk, economic risk and translation risk. While transaction risk refers to the impact of exchange rates on committed cash flows, economic risk refers to uncertain future cash flows. Translation risk refers to the impact of exchange rates on the valuation of assets and liabilities denominated in a foreign currency. Compare e.g. Döhring (2008). Recent survey evidence regarding hedging from a sample of 804 Swedish firms is presented in Amberg and Friberg (2015).

[18] Note that in this framework the costs of imported intermediates remain the sole determinant of the exchange rate pass-through into exporter prices, because a constant elasticity of demand effectively fixes the markup, muting any pricing-to-market effects. Compare e.g. Goldberg and Hellerstein (2008).

[19] All values are measured in local currency and multiplied with the corresponding exchange rate where necessary. Thus, foreign labor costs $w_{\$}$ are expressed in Dollars and need to be multiplied by the intermediate import-weighted exchange rate in order to enter the domestic marginal cost formula which is expressed in Euros.

$$MC \equiv (1-i)w_{€} + iw_{\$}E_i \tag{1}$$

Given marginal costs, we can write domestic and foreign prices in the usual markup formulation:

$$p_{€} = \mu \cdot MC \tag{2}$$

$$p_{\$} = \mu \cdot \tau \cdot MC \cdot \frac{1}{E_x} \tag{3}$$

where μ is the markup, τ represents iceberg trade costs and E_x is the export weighted exchange rate. Note that the markup is determined by the fixed elasticity of substitution σ.

The total sales equation can be written in the standard Dixit-Stiglitz notation:

$$r_{tot} = r_{€} + E_x \cdot r_{\$} = \Omega_{€} \left[\frac{p_{€}}{P_{€}}\right]^{1-\sigma} + E_x \cdot \Omega_{\$} \left[\frac{p_{\$}}{P_{\$}}\right]^{1-\sigma} \tag{4}$$

where r_j and Ω_j resemble firm revenues and GDP respectively in country j, and P_j is the country specific price aggregator, all measured in local currency.

Partially differentiating equation (4) with respect to the export weighted exchange rate (E_x) and multiplying with the total change in the exchange rate yields the following results:

$$\frac{\partial r_{tot}}{\partial E_x} \cdot \Delta E_x = \sigma \cdot E_x r_{\$} \cdot \frac{\Delta E_x}{E_x} - (\sigma - 1) \cdot r_{tot} \cdot IS \cdot \frac{dE_i}{dE_x} \frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x} + \epsilon_r \tag{5}$$

where the ϵ_r captures general equilibrium adjustments in domestic and foreign aggregate demand and IS is the share of imported intermediates in value terms.[20]

This equation has an intuitive interpretation and could, in principal, be directly estimated. Specifically, equation (5) shows that the change in total revenues due to

[20]Specifically, ϵ_r resembles a firm specific average of changes in the foreign and domestic demand shifter ($Q_{€}P_{€}^{\sigma}$ and $Q_{\$}P_{\$}^{\sigma}$). This is going to be the error term in the empirical specification and is explicitly formulated in section A.1.1 of the appendix. The share of imported intermediates in value terms is defined as: $IS \equiv \frac{iw_{\$}E_i}{(1-i)w_{€}+iw_{\$}E_i}$.

a devaluation of the domestic currency is composed of two effects.[21] The first term on the right hand side is the direct effect. It is positive and implies that total sales increase after a devaluation when the firm is exporting ($r_{\$} > 0$). This term captures both, the positive effect on foreign sales that is due to the lower conversion of domestic prices into foreign currency, and a second effect that is due to the higher conversion of foreign revenues into domestic currency. The second term captures the indirect effect of importing. It is indirect, because here we are looking at changes in the export weighted exchange rate. Thus, the indirect effect crucially depends on the elasticity of the import with respect to the export weighted exchange rate, as only the former has an effect on the cost of imported intermediates. Furthermore, it depends on the absolute importance of inputs denominated in foreign currency, measured by the import intensity times the total value of sales. The effect is negative whenever the co-movement of exchange rates is positive, given that the elasticity of substitution is larger than one and it captures the effect of higher material cost on foreign and domestic sales. Note further that the absolute size of both effects is increasing in σ, because a higher price elasticity of demand implies that the decrease in prices caused by the conversion effect and the increase in prices due to higher marginal cost both result in larger demand and therefore sales adjustments.[22]

Equation (5) requires data on *export* sales over time. Unfortunately, my dataset contains information on *total* sales only. In principle, I could easily construct the time varying equivalent for exports, assuming that the export share, that relates only to 2008 in the data, remains valid over the full period. Instead, I propose a small transformation that, while still depending on the same assumption, allows me to express the equation directly in terms of the export share. This provides for a better fit with my data and reduces the dimension of the interaction term on the import related effect by one:

$$\frac{\Delta r_{tot}}{r_{tot}} = \sigma \cdot XS \cdot \frac{\Delta E_x}{E_x} - (\sigma - 1) \cdot IS \cdot \frac{dE_i}{dE_x}\frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x} + \widehat{\epsilon}_r \tag{6}$$

[21]Note that a devaluation of the domestic currency corresponds to an increase in E_x. A more detailed decomposition of the effects is provided in section A.1.1 of the appendix.

[22]Defining equation (5), I implicitly assumed σ to be the same across countries for the sake of simplicity. It is straightforward to allow different sigmas at home ($\sigma_{€}$) and abroad ($\sigma_{\$}$). In this case, the sigma of the the first term on the right hand side of equation (5) would be the foreign price elasticity ($\sigma_{\$}$), while the σ of the second term would be a trade weighted average of the domestic and the foreign elasticity. The basic intuition would remain the same.

where XS is the export share.[23]

Finally, I am going to reformulate equation (6) in terms of *real* exchange rates, acknowledging that a change in the foreign price index relative to the domestic price index should have effects that work through the same channels as a change in the nominal exchange rate. While the derivation for the nominal exchange rate provides a helpful conceptional starting point, from the firm perspective it should not matter whether sales deteriorate due to a nominal appreciation or worsening terms of trade, induced for example by diverging rates of productivity growth across countries. Note that in difference to most financial hedging devices, operational hedging delivers a unique opportunity for firms to hedge against movements in real exchange rates. Thus, in order to determine the hedging potential of offshoring, it is worthwhile to consider the full range of macro-economic risks that the typical exporting firm is facing. Adjusting the equation for movements in real exchange rates is straightforward and leads to the following equation:[24]

$$\frac{\Delta r_{tot}}{r_{tot}} = \sigma \cdot XS \cdot \frac{\Delta R_x}{R_x} - (\sigma - 1) \cdot IS \cdot \frac{dR_i}{dR_x} \frac{R_x}{R_i} \cdot \frac{\Delta R_x}{R_x} + \bar{\epsilon}_r \tag{7}$$

The error term $\bar{\epsilon}$ now contains additional elements capturing the general equilibrium adjustments in the sectoral terms of trade. As with the demand shifters, these effects are firm specific because the exposure to the sectoral terms of trade effects with respect to exporting or importing countries depends on the export and the import intensity of the firm.[25]

Equation (7) can be directly estimated, assuming that the export and import decisions are fixed over time. This is a major simplification but necessary due to the restrictions of my data.

[23]The export share is defined as: $XS \equiv \frac{E_x r_\$}{r_{tot}}$.

[24]The equation follows from (6) by replacing E_i with $R_i * (P_€/P_\$)$, acknowledging that the relative price $\widehat{P} \equiv P_€/P_\$$ is itself a function of the real exchange rate and partially differentiating with respect to R_x.

[25]See equation (A.2) in the appendix for an explicit formulation.

4 Data Description, Key Variables and Identification

4.1 Data Sources and Construction of Key Variables

Firm-level data stems from two data sources: the *EU-EFIGE/Bruegel-UniCredit* (EFIGE) survey and Bureau van Dijk's *Amadeus* database. The EFIGE survey is at the core of the analysis as it defines the firm sample. Coordinated by the European think tank Bruegel and supported by the Directorate General Research of the European Commission, the full EFIGE sample encompasses almost 15.000 firms of the manufacturing sector in seven European countries: Germany, France, Italy, Spain, United Kingdom, Austria and Hungary.[26] The survey focus lies on the international activity of firms. Data was collected in 2010 and covers the years from 2007 to 2009. However, most information is cross-sectional and only available for the year 2008. From EFIGE I obtain the share of imported intermediates in total intermediates, the share of turnover exported as well as information on the regional structure of firms' international activities as of 2008. The EFIGE survey restricts regional information to the area level.[27] The destination area specific information will become important for the empirical exercise in section 6.

I match the firms from the EFIGE survey with Bureau van Dijk's Amadeus database. This allows me to add balance sheet data for the years 2005 to 2013 as well as detailed information on a firm's industry class. Especially, I obtain total sales in every year, as well as a range of other balance sheet variables that I use as controls or alternative dependent variables.[28] The sectoral details enable me to add industry specific exchange rates to the firm panel.

Industry, country and area specific real effective exchange rates for the years 2004 to 2013 are constructed from four additional data sources: Average monthly nominal exchange rates of the Euro against a range of other currencies are obtained from Eurostat. From these I derive bilateral exchange rates also with respect to the Forint and the Pound Sterling. I index all bilateral exchange rates with respect to the rate of

[26]The survey is representative in terms of the firm-size distribution at the country level for firms with more than 10 employees in the manufacturing industry. See Altomonte and Aquilante (2012) and Altomonte et al. (2012) for more details.

[27]EFIGE splits the world into eight areas: EU15, other EU, other Europe not EU, China & India, other Asia, USA & Canada, Central & South America and other areas. See Altomonte and Aquilante (2012) for a full list of countries and table A.1 in the appendix for a list of the countries used in the empirical analysis.

[28]A list of all variables used is provided in table A.2 in the appendix. The appendix also provides summary statistics for most variables in tables A.3 and A.4.

January 2004. I use seasonally adjusted nominal CPI data from World Bank's Global Economic Monitor, again indexed with respect to January 2004, in order to transform nominal into real exchange rates. The effective exchange rates are obtained by geometrically weighting the bilateral exchange rates according to the trade flow structure in a given industry with respect to a specific region of international activity.[29] The trade flow data is obtained from the WITS/Comtrade database and averaged over the years 2005 to 2007. I construct the export weighted and an intermediate import weighted real exchange rate at the two digit level (ISIC Rev.3). Intermediate import trade flows are linked to the firms' output industry using the two-digit Input-Output coefficients from the OECD Stan database as weights and arithmetically averaging over all input industries.[30]

Equations 8 and 9 formalize how the export weighted real effective exchange rate (R^x) and the intermediate import weighted real effective exchange rate (R^i) are constructed with respect to some region κ of international activity:[31]

$$R^x_{cs\kappa t} = \prod_{k\in\kappa}\left(E_{ckt}\cdot\frac{cpi_{kt}}{cpi_{ct}}\right)^{\frac{EX_{cks}}{\sum_{k\in\kappa} EX_{cks}}} \tag{8}$$

$$R^i_{cs\kappa t} = \prod_{k\in\kappa}\left(E_{ckt}\cdot\frac{cpi_{kt}}{cpi_{ct}}\right)^{\frac{\sum_{z\in IO(s)} \varsigma_{zs}\cdot IM_{ckz}}{\sum_{k\in\kappa}\sum_{z\in IO(s)} \varsigma_{zs}\cdot IM_{ckz}}} \tag{9}$$

where $k \in \kappa$ is the set of trading partners of country c in region κ, E_{ckt} is the price of country k's currency in terms of country c's currency at time t (i.e. the nominal exchange rate in price notation), cpi_{ct} is the consumer price index in country c, EX_{cks} are average industry s exports from country c to country k in industry s, IM_{ckz} are average sector z imports from country c to country k, where $z \in IO(s)$ is the set of input industries z related to industry s via IO-coefficients ς_{zs}.

[29] Geometric weighting is the usual approach for the construction of effective exchange rates. Different from arithmetic averages, percentage movements in a geometrically averaged index will not depend on whether the bilateral rates are expressed in price or quantity notation. They are also more robust to changes in the base period. Compare e.g. Ellis (2001). See table A.1 in the appendix for details on the final currency basket.

[30] I apply the German IO-coefficients for the year 2005 to all countries for simplicity.

[31] For the specification that results from the theoretical framework presented in section 3, I will define the relevant currency basket with respect to the world. In section 6 I will use effective exchange rates that are specific to a certain area of international activity, i.e. that contain only those currencies used in a specific EFIGE export destination or import sourcing area.

These real effective monthly exchange rates are then used to determine the covariance of exchange rates for a specific region κ and finally (arithmetically) averaged in order to obtain yearly exchange rates that can be matched to the firm-level data. I approximate the theoretical elasticity capturing the co-movement of exchange rates by the following projection coefficient:[32]

$$\frac{dR^{i}_{cs\kappa t}}{dR^{x}_{cs\kappa t}}\frac{R^{x}_{cs\kappa t}}{R^{i}_{cs\kappa t}} \approx \frac{cov(logR^{x}_{cs\kappa t}, logR^{i}_{cs\kappa t})}{var(logR^{x}_{cs\kappa t})} \equiv Proj^{didx}_{cs\kappa} \tag{10}$$

I use this country and sector specific elasticity as a proxy for the unobserved firm specific elasticity. Looking at the summary statistics for the implied correlation between export and import weighted exchange rates yields a mean coefficient of 0.90, with the minimum around 0.59. While this might be reasonable at the sector level, at the firm level one would expect the correlation to be much lower or even negative for some firms. I therefore demean the projection coefficient defined in equation (10) and use $\widehat{Proj}^{didx}_{cs\kappa}$ instead, which is centered around zero.[33] This has the additional advantage of substantially diminishing the amount of collinearity in the model. Thus, when regressing the triple interaction with offshoring and the projection coefficient on all other explanatory variables in the baseline specification, using the demeaned version of $Proj^{didx}_{cs\kappa t}$ reduces the variance inflation factor (VIF) from 60 to 1.9.

4.2 Discussion of the Empirical Strategy

The theoretical structure represented by equation (7) can be directly translated into the following empirical specification:

$$\frac{\Delta r_{csit}}{r_{csit}} = \left[\beta_1 \cdot XS_{csi} + \beta_2 \cdot (IS_{csi} \times \widehat{Proj}^{didx}_{cs})\right]\frac{\Delta R^{x}_{cst}}{R^{x}_{cst}} + \underbrace{\alpha_i + ... + \epsilon_{csit}}_{\bar{\epsilon}_r} \tag{11}$$

The main variation in regression equation (11) stems from log-changes in the country, sector and year specific real exchange rate. As Goldberg and Hellerstein (2008) point out, the advantage of using exchange rate data is that they provide a source

[32]In order to obtain the variance and covariance of the exchange rates, I use variation over 120 different points in time (12 month in each of the 10 years). Note that $Proj^{didx}_{cs\kappa}$ has no time dimension. Note also that an alternative time-varying approximation of $\frac{dR^{i}_{cs\kappa t}}{dR^{x}_{cs\kappa t}}\frac{R^{x}_{cs\kappa t}}{R^{i}_{cs\kappa t}} \approx \frac{cov(R^{x}_{cs\kappa t}, R^{i}_{cs\kappa t})}{var(R^{x}_{cs\kappa t})}\frac{R^{x}_{cs\kappa t}}{R^{i}_{cs\kappa t}}$ delivers almost identical results.

[33]Note that the proxy variable assumptions actually require a proxy variable to be mean zero in the population when it is used in an interaction term. Compare Wooldridge (2010), pp. 74-76.

of large and plausibly exogenous price variation. Additionally, note that the estimation in changes eliminates some of the endogeneity that usually arises in the context of firm-level survey data. On the downside, identification is restricted to variation in log-changes which arguably represents only a small fraction of the total variation. This makes it harder to establish statistically significant results and implies that the results can only account for a part of the economic significance. Yet, I would argue that the complexity of the effects involved would render it almost impossible to derive useful conclusions from a level regression that, though capturing more of the variation, would impede a structural interpretation.

Note that while the proposed theoretical structure is rather simple, the resulting empirical specification requires higher-dimensional interaction terms, on top of all the level effects, in order to identify the underlying mechanisms. As much of the identification depends on the proper translation of the theoretical into the empirical model, it is important to point out assumptions and simplifications that I impose when estimating equation (11). In this section, I will therefore discuss the potential problems arising from each. Most notably, note that I assume the export and import decisions to be firm specific but fixed parameters of the model and that I treat the markup that firms set over marginal costs to be the same for all firms and constant over time.

The assumption of fixed export and import decisions is due to data limitations. As pointed out before, variables of international activity are time invariant snapshots from the 2008 EFIGE survey and thus the assumption is necessary. At least the assumption of fixed import shares might not be too restrictive, as Amiti et al. (2014) find the import share to be empirically very persistent over time. Thus, they treat the offshoring decision as fixed in most specifications. Yet the assumption is a critical one and I will address potential endogeneity arising from it through the inclusion of sector- and country-specific year dummies. Inasmuch as the potential adjustments of export and import shares over time follow a sector specific trend, the fixed effects should account for a substantial part of the confounding effects.

The assumption of fixed markups is simplifying the theoretical framework considerably. Because I do not have price-level data, the structural equations are derived for aggregate variables, implying that the markup and marginal cost channels are blurred by mixing up price and quantity adjustments as well as domestic and foreign demand components.[34] Including variable markups into the structural model would

[34]Note that Amiti et al. (2014) use export price data, which allows them to conceptually split price

therefore substantially increase the complexity of the empirical model and render the distinction and identification of the hedging effects of offshoring less viable. As this is the channel least studied in the pass-through literature, I decided to keep the structure as focused on the import channel as possible. Still, because firm size, markups and international activity tend to be highly correlated, it is important to acknowledge the potential endogeneity arising from markup adjustments and to think about the impact it might have on my estimates.

A good starting point is the paper by Berman et al. (2012). The authors find that in models of heterogeneous pricing-to-market the high productivity firms usually adjust their markups more in response to exchange rate movements than low productivity firms, because the perceived demand elasticity is higher for the latter. Accordingly, when faced with a real devaluation, exporters will increase the markup and this effect will be stronger for more productive firms. For offshoring firms the opposite should hold. For them, a real devaluation implies higher marginal costs and therefore higher prices. Because this reduces demand, these firms will lower their markup in order to sustain sales. Again, the decrease in markups will be larger for more productive firms, perceiving demand to be less elastic.

In my framework, the positive effect on sales and the negative effect on sales are captured in separate interactions, including the export share and the import share respectively. As more productive firms on average tend to be internationally more active, I expect both the export and the import share to be larger for more productive firms and thus, to be positively correlated with the size of the unobserved markup adjustment. Because the export share interaction captures a positive effect on sales, it will induce firms to increase the markup, where the increase is going to be larger for firms with a larger market share. Not controlling for the markup variation should therefore bias the coefficient on the export interaction downward, as the increase in markups would tend to lower the positive effect on sales for large exporters. By the same token, an increase in material cost would force firms to lower the markup, effectively diminishing the increase in prices and the decrease in sales. Therefore, I further expect the coefficient on the offshoring interaction to be downward biased. Overall, omitting to control for markup adjustments should make it more difficult for me to find significant effects on the interactions of interest.

I add markup and size controls to control for other potential confounding effects

variation into markup and marginal cost variation and reliefs them from accounting for export intensity.

due to markup heterogeneity. Specifically, I use the log-change in total assets to control for changes in size and add alternative time-varying measures of the markup in levels. Additionally, I include firm fixed effects to control for the firm specific average of the sales reaction.

Because this paper is concerned with hedging potential, one obvious omitted factor in specification (11) is the hedging activity of firms. Effectively insured firms should be less affected by exchange rate changes and this would tend to diminish the absolute size of my estimates given that hedging would be relatively more frequent among exporting and offshoring firms. Again, this makes it more difficult to encounter significant results. Accordingly, the inclusion of firm fixed effects, controlling for the average hedging activity, should result in larger coefficients. Additionally, I provide a specification where I interact my measure of exchange rate movement with a dummy indicating whether a firm was using foreign exchange rate protection in 2008.

A related potential problem arises because the projection coefficient is derived at the sectoral level. Effectively, the proxy resembles the average hedging effectiveness in the firm's industry. Yet, the fact that it is sector specific implies that there remains a firm specific residual component of the projection coefficient in the error term. Following the directed hedging argument, one could argue that this unobserved component should be positively correlated with the import and the export share, as internationally more active firms face higher exposure and would thus tend to adjust sourcing regions in order to increase the co-movement of exchange rates above the sector average.[35] The sector specific projection coefficient would then underestimate the actual projection coefficient for firms with high import and export shares and the unobserved residual component in the error term would be positive. In the error term, this component would show up in various terms. Among others, in a simple interaction with offshoring. Note though, that this interaction should be accounted for when firm fixed effects are included. Furthermore, I would expect the unobserved residual to show up in an interaction with the exchange rate movement. While this term would probably be positively correlated with the interaction terms involving the exchange rate movement and exporting and importing respectively, it is not obvious how the unobserved interaction would affect the change in turnover

[35]Note that one argument against this potential endogeneity issue could be derived from the findings of Amiti et al. (2014). They explicitly test for a systematic relationship between the import intensity and the extent to which firms align import and export regions in their data and fail to find any supportive evidence. The error component would therefore be random with respect to the share of imported intermediates and not interfere with my results.

and therefore the potential bias is difficult to sign. Finally, there is potentially a triple interaction analogous to the one in the model, inflicting a negative impact on the dependent variable. Due to the positive correlation between the residual component and international activity, this might lead to a negative bias on both, the coefficients on the export and offshoring interaction with exchange rates respectively, as well as the triple interaction. Given the predicted signs of the model, this might cause only the offshoring interactions to falsely produce significant results. Fortunately, this is not really a problem, given that the effect in the error term and the resulting bias is actually part of the effect that I am trying to identify in the first place. Again, I try to mitigate these effects altogether by including firm fixed effects that should account for the firm specific projection coefficient, assuming that it is constant over time. Sector-country-year fixed effects will account for any mismeasurement of the projection coefficient over time, whenever it is specific to a certain sector. Finally, in some specifications I will replace the continuous measure of co-movement with a dummy variable, indicating whether the level of co-movement is above or below the average, which should reduce the dependence of my results on the finer details of the proxy.

This leaves the structural error term $\overline{\epsilon_r}$. Note again that this error term resembles changes in the dependent variables induced by changes in aggregate variables such as the domestic and foreign price index and the domestic and foreign demand shifter. It is firm specific because the weighting of domestic and foreign aggregate changes depends on firms' specific composition of domestic and foreign activity. Note that corresponding terms also form part of the error term in Amiti et al. (2014). Yet, these are residual effects that remain after controlling for the export and import related interactions that are present in equation (11). Amiti et al. (2014) therefore assume these factors to be idiosyncratic and mean zero.[36] I will follow their assumption but propose that controlling for firm and sector-country-year fixed effects should eliminate a large part of any remaining endogeneity.

[36]Compare Amiti et al. (2014), Assumption A3.

5 Estimation Results

5.1 Baseline Results

Table 1 shows the results from different empirical specifications implementing equation (7).[37] Column one ignores the additional interaction with the measure of co-movement and thus estimates the differential impact of offshoring for the sample-average co-movement. The negative sign indicates that, if anything, an increase in the rate of devaluation is slowing down sales growth if the firm is importing intermediates. This is in line with the theoretical predictions, though statistically the effect is indistinguishable from zero. The coefficient on the interaction with the export share on the other hand is positive and statistically highly significant. Thus, as the theory predicts, devaluation is positively associated with total sales if the firm is exporting, because domestic goods become cheaper for foreign consumers. Note further that, different from the theoretical model, there appears to be an effect from changes in the exchange rate on total sales growth that is working neither through exports nor offshoring. The effect is highly significant and probably captures alternative channels through which exchange rates have an impact on firms. Country-sector fixed effects are included as I don't want my results to hinge on certain countries or sectors in the sample. Thus, if a certain sector faces more volatile demand than another, these fixed effect would eliminate part of the difference by effectively equalizing average sales growth across sectors. Additionally, I add year fixed effects in order to control for shocks in time that equally affected firm sales in all countries and industries.

In specification (2) I add log-changes in total firm assets as a further control. Note that specification (1) only contains interactions of time-constant firm variables with the log change in the real effective exchange rate on the right hand side. Any time-varying firm characteristic that might have an impact on total sales growth is therefore captured in the error term. This becomes an issue if such a factor is correlated with exchange rates or the variables of international activity, because then the coefficients of interest might pick up variation that is not causally related to the import cost or the export sales channel described by the model. Most notably, total assets are directly related to what has been called the translation risk of exchange rates. Following Döhring (2008), this refers to the impact of exchange rate changes on the valuation of foreign assets. Foreign assets often result from foreign subsidiaries and

[37]If not indicated otherwise, the specifications are cluster robust at the firm level and contain the full set of sub-interaction terms and level effects.

Table 1: Baseline

	$Sales_{csit}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta logR^x_{cst}$	-0.464***	-0.154*	-0.114	-0.113	-0.161*	-0.161	
	(0.0870)	(0.0803)	(0.0933)	(0.0931)	(0.0962)	(0.291)	
$\Delta logR^x_{cst} \times XS_{csi}$	0.766***	0.747***	0.752***	0.744***	0.859***	0.859***	0.760***
	(0.176)	(0.157)	(0.157)	(0.156)	(0.165)	(0.233)	(0.217)
$\Delta logR^x_{cst} \times IS_{csi}$	-0.0521	-0.117	0.0677	0.0742	0.160	0.160	0.551**
	(0.189)	(0.168)	(0.180)	(0.180)	(0.189)	(0.237)	(0.211)
$\Delta logR^x_{cst} \times IS_{csi} \times \widehat{Proj}^{didx}_{cs}$			-2.518**	-2.543**	-2.939***	-2.939**	-2.432*
			(1.051)	(1.054)	(1.121)	(1.365)	(1.283)
$\Delta log(Assets_{csit})$	no	yes	yes	yes	yes	yes	yes
μ_{csit}	no	no	no	yes	yes	yes	yes
Fixed Effects	$\gamma_{cs} + \gamma_t$	$\gamma_{cs} + \gamma_t$	$\gamma_{cs} + \gamma_t$	$\gamma_{cs} + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_{cst}$
Cluster (Firm)	yes	yes	yes	yes	yes	no	no
Cluster (Sector#Country)	no	no	no	no	no	yes	yes
Nr. of Clusters	9063	9063	9063	9063	8641	177	153
Adj. R2	0.162	0.331	0.331	0.332	0.314	0.314	0.343
Observations	60,169	60,169	60,169	60,169	59,747	59,747	59,491

Notes: Observations relate to firm i in year t, where firms are based in country c and active in sector s. The dependent variable $Sales_{csit}$ represents total sales of firm i in year t. $\Delta logR^x_{cst}$ are annual log-changes of the country and sector specific export weighted real effective exchange rate. XS_{csi} and IS_{csi} denote the firm specific export and import share respectively. $\widehat{Proj}^{didx}_{cs}$ is the elasticity of the import weighted with respect to the export weighted real effective exchange rate. μ_{csit} is a markup control defined in the appendix. $\Delta log(Assets_{csit})$ is the log-change in total assets. γ_{cs} are country-sector fixed effects, γ_t are year fixed effects, γ_i are firm fixed effects and γ_{cst} are country-sector-year fixed effects. The sector level is defined at the 2-digit US SIC level. All specifications contain the full set of relevant sub-interaction terms and level effects. Standard errors are clustered either at the firm level or at the country-sector level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

are therefore, at least potentially, directly related to the exporting and offshoring decisions of firms. A devaluation of foreign assets also reduces the financial collateral of firms and might therefore reduce their capability to invest in an extension of the sales network. Potentially then, total assets might be confounding the effects observed in specification (1). Yet, adding log-changes in total assets does not alter the coefficients of interest substantially. The offshoring coefficient increases somewhat in size but remains insignificant. Note though that the level effect of log-changes in exchange rate is significantly reduced, both economically and statistically. This indicates that the asset control is picking up a substantial part of exchange rate effects other than those related to exports and imports.

Specification (3) introduces the triple interaction with the measure of co-movement between the export and the intermediate import weighted exchange rate. While the simple interaction remains insignificant, the coefficient on the triple interaction is negative as expected and statistically significant at the 5% level. Because the measure of co-movement is demeaned in the sample, this implies that offshoring has a negligible effect on the (export weighted) exchange rate pass-through into sales in sectors with an average level of exchange rate alignment, but counters the positive export effect when the co-movement between exchange rates in export and import regions is sufficiently high. Thus, the joint location of export and import regions matters for the hedging potential of imported intermediates.[38]

In specification (4) I add a time varying markup control defined as total sales over total cost.[39] Though the markup control is highly statistically significant (with a positive sign), the results do not change much, indicating that the markup control is either not picking up the relevant variation or markup effects are simply not too important. I therefore include firm fixed effects in specification (5) to see whether controlling

[38]While Amiti et al. (2014) also find the marginal cost channel to depend on the correlation of exchange rates, their offshoring coefficient is always significant and does not change signs even for a low correlation. Different from their result, my findings suggest that the offshoring effect might actually enhance the exchange rate effects caused by exporting. One potential reason for the discrepancy is that they define a low correlation to be everything below 0.7, which is still a relatively high correlation. I will discuss the heterogeneity of the offshoring effects in more detail below, together with a discussion of the marginal effects.

[39]The markup measure is winsorized at 1% due to some very low (zero) and some very high (above a billion) values. The winsorized measure varies from from 1 to 3.55. There is no significant change in the results when I completely drop observations where the original markup measure is below 1 or above 5. Alternative measures for the markup, such as total profits over turnover, the log of total assets or the constant export market share from 2008 (defined in Marin et al. (2014)) deliver similar results. I also tried adding the markup interacted with the log-change in exchange rates but the interaction is not significant and other results are practically the same.

for unobserved heterogeneity in time constant firm characteristics alters my results.[40] Controlling for heterogeneity increases both, the coefficient on the export interaction and the coefficient on the triple interaction, which is now significant at the 1%-level. As explained earlier, both unobserved market power (not captured by the markup control) and hedging activities could have biased the previous results towards zero. Including firm fixed effects eliminates the constant component of these confounding factors, which would explain the increase of the estimates.

Specification (6) accounts for a slightly more technical problem. Because the exchange rate measures are country and industry specific but not firm specific, error terms are potentially correlated for the firm within a certain country and industry cluster. I therefore explicitly allow for arbitrary clustering at the country-industry level in specification (6). Note that this allows error terms to be serially correlated across years and therefore subsumes the firm clusters used so far. The use of clustered standard errors results in slightly higher standard errors but the coefficients of interest remain statistically significant.

In specification (7) I retain firm fixed effects and the smaller number of clusters but replace year fixed effects by country-sector-year fixed effects. Among other things, these control for any sector specific changes in offshoring, exporting and market structure and eliminate the level effects of the real effective exchange rate and the measure of co-movement as well as their interaction. Thus, systematical errors through aggregation and approximation of exchange rates and their co-movement are better accounted for. Additionally, the set of fixed effects now controls for the sector and country specific general equilibrium effects feeding into the structural error term. Note that the results in specification (7) are now driven exclusively by deviations over time in the differential effect of exchange rates on sales growth resulting from offshoring and exporting within a certain country and industry cluster while accounting for the average characteristics of firms. Nevertheless, both the export and the offshoring interaction remain statistically different from zero, though the size of the coefficients and their significance is slightly reduced.

5.2 Marginal Effects

It is instructive to discuss the meaning of the coefficients in table 1 in terms of the marginal effects involved. I will refer to specifications (5) and (7) as my baseline and

[40] I loose some firms due to singleton observations but the change in the estimates is driven by the firm fixed effects rather than the change in the number of observations.

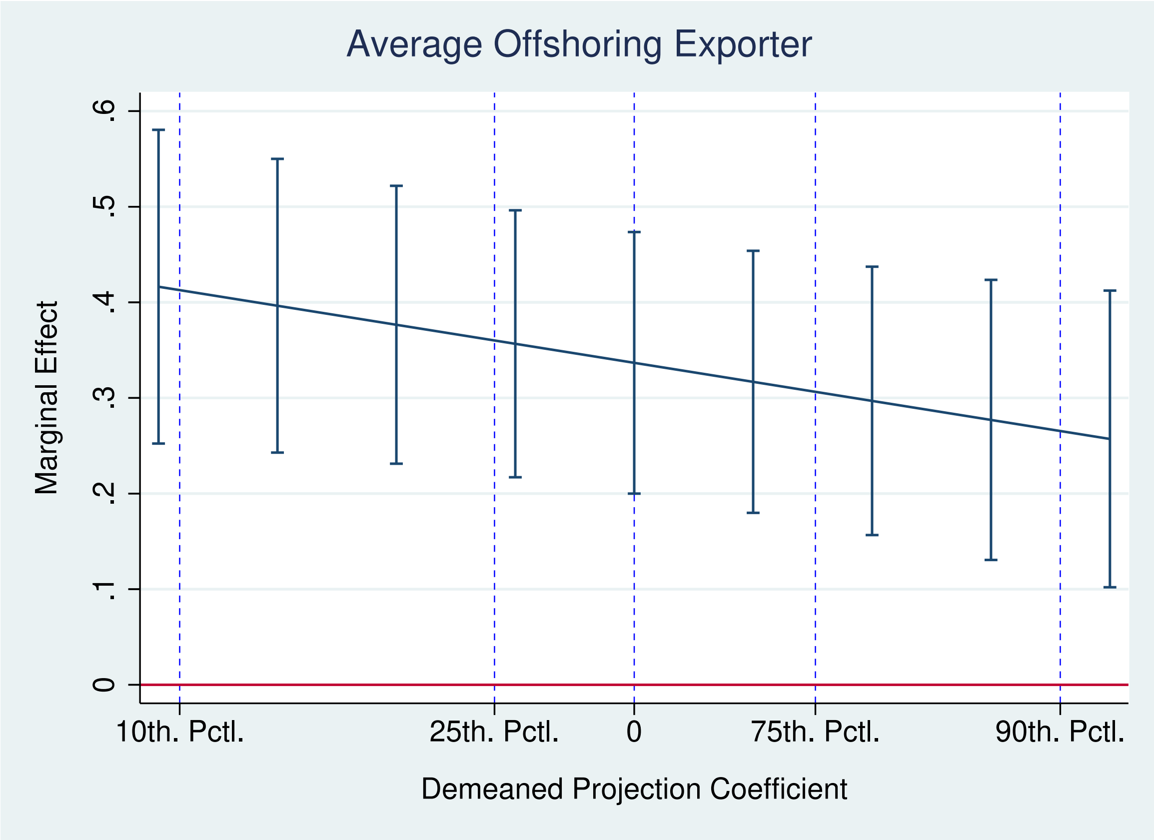
my fixed effects specification respectively and present marginal effects for these two specifications only. Specification (5) contains firm fixed effects, controlling effectively for unobserved firm level characteristics such as time-invariant productivity or financial hedging activity. Variation at the level of exchange rates is retained and can be used for identification. Specification (7) is much stricter in that it eliminates potential biases arising from the imperfect approximation of the exchange rate measures. On the downside, some precision of the estimates is lost. In analogy to the fixed effects, specification (5) adjusts standard errors for clustering at the firm level only, while specification (7) allows for arbitrary error co-variation within a certain country and sector. Again, there is a potential trade-off involved. While the larger size of clusters in specification (7) accounts much better for error correlation, the reduced number of clusters potentially leads to biased estimates of the variance-covariance matrix.[41] Taken together, these two regressions provide for a good compromise between precision and bias and I propose that the true effect is in the neighborhood of these estimates.

As noted earlier, the structural equations presented here describe log-changes in total sales as a function of log-changes in the exchange rate interacted with firm variables. Thus effectively, I can only explain changes in growth rates of sales.[42] For example, looking at the average exporting firm, and evaluating marginal effects for the average non-offshorer with an average projection coefficient, I find that doubling the sample average of the annual log-change of devaluation from 0.3% to 0.6% increases the rate of sales growth by 8.8% in the baseline and 18.5% in the fixed effects specification respectively. For the average offshoring firm, the increase in the rate of sales growth is 10.9% in the baseline and 25.3% in the fixed effects regression. Therefore, offshoring actually increases the rate of sales growth given an increase in the rate of devaluation at the average level of co-movement between export and import weighted exchange rates. This is not in line with the predictions of the model, because the mean projection coefficient in the sample is positive. But with a positive projection coefficient, the offshoring effect should counter the export effect and not reinforce it. Technically, this is due to the sign of the coefficient on the single interaction between the rate of devaluation and offshoring. The fact that the sign of this

[41] Some authors have proposed 50 or more as a rule of thumb for a sufficient number of clusters. According to this rule, 152 cluster groups appear to be more than enough. Nevertheless, the underlying analysis is based on state-year panel data and the required number of clusters might be much higher for unbalanced firm-level data. See Colin Cameron and Miller (2015) for a discussion.

[42] I would argue that the finding of evidence for hedging effects of offshoring at the level of growth rates is an important indicator of potentially much larger level effects.

Figure 1: Marginal Effects for Different Levels of the Projection Coefficient



Notes: The figure depicts marginal effects at different levels of $\widehat{Proj_{cs}^{didx}}$, i.e. the measure of co-movement between export and import weighted real effective exchange rates. Marginal effects are evaluated for the average exporting firm ($TS = 0.32$), with the average exporters' share of imported intermediates ($IS = 0.16$). All remaining variables are evaluated at the mean. The confidence level, depicted by vertical bars along the margins-line, is set to 95%. The marginal effects relate to specification (7) of table 1.

effect is positive potentially indicates that the sectoral proxy of the projection coefficient might overestimate the true, firm specific co-movement of exchange rates. If this unobserved true elasticity was negative for the average firm in the sample, then the coefficient on the interaction between the rate of devaluation and offshoring should have a positive sign indeed.

The possibility of the true elasticity being negative on average automatically brings the question of hedging effects to the foreground again. Apparently, the balancing effect of offshoring on exchange rate pass-through into sales might not be as obvious as previous findings suggest. The statistical significance of the triple interaction in table 1 provides evidence for that. It is then easy to see that hedging through offshoring requires a co-movement between import and export weighted exchange rate that is sufficiently high. Figure 1 shows how the marginal effect of a change in the rate of devaluation varies with the projection coefficient for the average offshoring exporter.[43] It is based on specification (7). At the mid-point of the x-axis, the demeaned projection coefficient is zero, indicating that this measure is at its sample mean. As noted above, the marginal effect at this point (0.34) therefore corresponds to an increase in the rate of sales growth of 25.3%, given a 100% increase in the growth rate of devaluation. The other points on the x-axis represent different percentiles from the distribution of the projection coefficient. Going from the midpoint to the right, the marginal effects depicted in the figure imply that the increase in the rate of sales growth for the average offshoring exporter is reduced to 23.02% at the 75th. percentile and to 19.9% at the 90th. percentile. Going to the left, i.e. diminishing the projection coefficient, the increase in the rate of sales growth becomes 27.1% at the 25th percentile and 31% at the 10th percentile.

Because in these examples offshoring always reinforces the exchange rate risks of exporting (up from 18.5%), it is instructive to examine whether it is principally possible for firms to use offshoring as a hedging instrument after all. In figure A.1 I therefore depict the marginal effects for various levels of offshoring. I thereby consider the best and the worst pairing of export and import regions in terms of exchange rate co-movement in my sample. Specifically, I examine the marginal effects at the 1st and the 99th percentile from the distribution of projection coefficients. This allows me to consider how large hedging effects can become if firms try to avoid the exchange rate risks attached to exporting by choosing the origin and share of imported intermediates according to hedging objectives. Furthermore, it shows how offshoring can dramatically increase exchange rate exposure if import regions are chosen badly in terms of hedging potential.

Panel A of figure A.1 presents the effects from the baseline specification for the average exporter. The intercept with the y-axis represents the marginal effect for a non-offshoring exporter. Using the same hypothetical doubling of the rate of devaluation, the marginal effect at this point implies that sales growth is increasing by 7% for a firm with a projection coefficient at the 99th percentile and 10.3% for a firm at the 1st percentile.[44] Increasing the share of imported intermediates shows how the

[43] I evaluate at the average export share (32.4%) and import share (16.4%) among all exporting firms in the sample.

[44] While the effects from the exchange rate interaction with the export share is identical for both firms, the difference here is explained by the sub-interactions, specifically the level effect of the exchange rate and the interaction of the exchange rate with the projection coefficient. This difference is absent from the fixed effects regression (panel B) because the sub-interactions are absorbed by the fixed

level of the projection coefficient determines whether offshoring is working as a hedging device: for the high-elasticity firm, the exchange rate effect through exporting is completely offset for an import share of only 7%. Instead, if the low elasticity firm offshores the same amount of intermediates, it increases the effect on sales growth by more than 73%, with the new effect now representing a 17.9% increase in total sales growth.

In Panel B, the intercept of both sub-graphs implies that doubling the rate of devaluation increases sales growth by 18.5%. The high elasticity firm can completely offset the devaluation effect through exports with an import share of 29%. But if the low elasticity firm would source the same share of intermediates from abroad, the increase in sales growth would substantially increase from 18.5% to 53.5%.

From this I conclude that if firms want to make use of operational hedges, they seriously need to consider how exporting and importing regions jointly behave in terms of exchange rate movements. As the analysis so far has shown, offshoring can significantly reinforce the exchange rate effects of exporting if firms just follow the average offshoring pattern in the industry. That average offshoring patterns typically reinforce the exchange rate risks of exporting is easily reconcilable with optimizing firm behavior if other criteria (such as lower prices) are relatively more important determinants for the choice of sourcing regions. But given the anecdotal evidence cited in the introduction, the potential for operational hedges might still play a role in the choice of import regions, once other characteristics such as wages and institutional factors have been accounted for. Section 6 addresses this question empirically.

5.3 Robustness

In table A.5 I address the robustness of the baseline and the fixed effects regression from table 1. Specifications (1) in table A.5 repeats the baseline regression for better comparability. In specification (2) I replace the projection coefficient with a dummy variable equal to one if the projection coefficient is positive and thus above the sample mean. This turns the measure of co-movement into an ordinal variable which is less dependent on the cardinal properties of the original proxy variable. The simple offshoring interaction now increases in size and becomes statistically significant, confirming that the positive export effect is reinforced through offshoring if the co-movement between export and import weighted exchange rates is below the average.

effects.

Plotting the marginal effects (not shown) confirms that offshoring serves as a hedging device if the dummy is equal to one. An offshoring share of about 20% then completely offsets the export related effects. In specification (3) I add an additional interaction between the log change in the real effective exchange rates and a dummy variable indicating whether a specific firm is using financial hedges. The result remain basically unchanged. Specification (4) uses the non-demeaned, raw projection coefficients. Now again, the positive coefficient on the simple interaction between exchange rates and offshoring becomes highly significant, indicating that for a projection coefficient of zero the effect of offshoring reinforces the effect of exporting on exchange rate pass-through into sales growth. Note though that this time a zero projection coefficient does not relate to the sample average but to zero co-movement between export and the import weighted exchange rates. For the sector-level proxy this never actually occurs in the sample. Taking the model seriously, the fact that the effect is still positive again implies that the unobserved firm-level co-movement is probably negative at this point. Specification (5) repeats the fixed effects specification from table 1. Specifications (6) to (8) apply the same robustness tests to the fixed effects specification that I applied to the baseline. Specifications (6) and (7) are further robust to sector-country-year fixed effects when using 4-digit instead of 2-digit industry codes. In specifications (9) and (10) I use nominal effective exchange rates instead of real effective exchange rates. These are constructed as in equation (8) and (9) but omit the CPI terms. Accordingly, specifications (9) and (10) correspond to a test of the theoretical equation (6). The coefficients are robust to the change but are slightly less significant in statistical terms. The results are also very similar in terms of marginal effects. Specifically, using the projection coefficient of nominal exchange rates at the 99th percentile and applying it to specification (9) implies that 9% offshoring is enough to balance out the effects of exporting. For real exchange rates, the corresponding share of offshored intermediates was 7%.

5.4 Extension

One further way to test the robustness of my results is to see whether the framework presented in section 3 is flexible enough to lend itself to other dependent variables. If the empirical results really capture the theoretical channels suggested above, then this should allow me to consider theoretically related effects and still find the empirical results to be in line with the predictions. Specifically, if sales are affected by exchange rates through the exporting and importing channel in the way that the theoretical structure suggests, than I should find analogous effects for material costs and profits. Clearly, total material costs should be related to the costs of intermediates and and the price of exports analogously to total sales. But if both sales and costs are affected then also profits should depend on exchange rates via exports and imports.

Adjusting the theoretical framework in order to obtain estimable equations analogous to equation (7) is straightforward, once I determine the theoretical counterparts of total costs and total profits. Abstracting from fixed costs, which should not depend to much on exchange rates, these are given as:[45]

$$c_{tot} = MC \cdot (q_{€} + q_{\$}) = MC \cdot Q_{€} \left[\frac{p_{€}}{P_{€}}\right]^{-\sigma} + MC \cdot Q_{\$} \left[\frac{p_{\$}}{P_{\$}}\right]^{-\sigma} \tag{12}$$

$$\pi_{tot} = r_{tot} - c_{tot} \tag{13}$$

where q_j and Q_j resemble firm and total quantities sold in the corresponding country. As before, I take the partial derivative with respect to the real effective exchange rate and obtain the following equations, that closely resemble the effects described in equation (7).

$$\frac{\Delta c_{tot}}{c_{tot}} = \sigma \cdot A \cdot XS \cdot \frac{\Delta R_x}{R_x} - (\sigma - 1) \cdot IS \cdot \frac{dR_i}{dR_x} \frac{R_x}{R_i} \cdot \frac{\Delta R_x}{R_x} + \bar{\epsilon}_c \tag{14}$$

$$\frac{\Delta \pi_{tot}}{\pi_{tot}} = \sigma \cdot B \cdot XS \cdot \frac{\Delta R_x}{R_x} - (\sigma - 1) \cdot IS \cdot \frac{dR_i}{dR_x} \frac{R_x}{R_i} \cdot \frac{\Delta R_x}{R_x} + \bar{\epsilon}_\pi \tag{15}$$

where $\quad A \in [0,1]$ and $B \in [1,\infty]$

The terms A and B are wedge factors indicating that, relative to total sales, the export related effects are smaller for total costs and larger for total profits. As shown in the appendix, the export related effects are the same for all three measures, and thus $A = B = 1$, if trade costs are zero ($\tau = 1$). Intuitively, positive trade costs create a wedge between foreign and domestic prices because exporters transfer the production cost for units lost during transportation onto foreign consumers. Given this wedge, a devaluation that increases foreign sales relative to domestic sales im-

[45] Details on the derivations and on the error terms are provided in section A.1.4 of the appendix.

plies that the average producer currency price charged by the affected firm is increasing. This increase in prices adds to the increase in revenues but not to the increase in quantities. Accordingly, the percentage increase in revenues is going to be higher than the percentage increase in total costs. With revenues increasing more than costs in percentage terms, the percentage increase in profits is going to be higher than the increase in revenues and costs.[46]

In analogy to equation (7), equation (14) shows that the change in total costs can be decomposed into a positive effect that results from the increase in quantities produced for the export market and a negative effect mainly working through the reduction in quantities produced due to higher costs and prices. Note that different from the revenue case, the export related effect now only resembles the lower conversion of domestic prices into foreign currency, as total material costs are already denominated in domestic currency. On the other hand, the import related effect now explicitly contains the higher conversion of imported input prices into domestic currency, given quantities produced. The effect on operating profits resembles the net of the effects on total revenues and total costs.

Table A.6 in the appendix shows the results from estimating equations (14) and (15). Specification (1) repeats the baseline regression for material costs. The effects are principally in line with the theoretical predictions though I fail to find a significant effect for offshoring. Note however, that the absolute size of the coefficient on the triple interaction is relatively close to the coefficients I obtained for total sales, which is exactly what theory would predict. Furthermore, the coefficient on the export interaction is smaller than in the sales regression, which is in line with the wedge factor $0 < A < 1$. In specification (2) I replace the continuous projection coefficient by a dummy variable indicating that the projection coefficient is above the sample mean. Thus, specification (2) in table A.6 correspond to specification (2) in the robustness table for total sales. Now the triple interaction becomes significant at the 5% level. Again, note how close the estimate on the interaction is to the one obtained in table A.5. Specification (3) and (4) repeat the exercise with the full set of fixed effects and the more aggregate cluster level. Qualitatively, the results do not change significantly.

Specification (5) to (8) do the same regressions for total profits. Here I do not find significant effects on the offshoring interactions. Yet, the export interaction is highly significant and shows the expected sign. More importantly, the coefficient is larger

[46]Note that B is also decreasing in μ, because the function that relates the percentage change in π_{tot} to the percentage changes in r_{tot} and c_{tot} puts higher weight on r_{tot} for higher markups.

than both the coefficients for total sales and total material cost, providing further evidence for the theoretical structure, as the predicted wedge factor B is larger than 1.[47]

Summing up, the regressions for total material costs in general confirm the findings for total sales. The theoretical prediction of wedge factors A and B is confirmed by the data, adding to the credibility of the theoretical framework. While I find highly significant effects on the export interaction for total profits, the import interactions are not significant. Note however that observed profits, to a much greater extent than sales and material costs, contain many elements that are not contained in the theoretical definition of profits. Most notably, the simple structure presented here does not account for fixed costs and the costs of employees. Additionally, firms usually shift profits strategically from one period to another in order to save on taxes. These omitted factors imply that the empirical profit term is measuring the simple theoretical equivalent with a lot of noise, probably much more than the other dependent variables. It is therefore not surprising that I find the estimates to be less precise in the profit specification.

6 Regional Choice of Importing Regions

The results from section 5 suggest that operational hedging requires firms to deliberately take exchange rate characteristics into account when deciding on sourcing regions. Specifically, in order to operate as a hedging device, offshoring needs to offset some of the exchange rate risk that is due to other international activities. As the previous analysis has shown, for exporters this requires the co-movement between export and intermediate import weighted exchange rates to be sufficiently high. Yet, to my knowledge, no empirical study to date has taken the co-movement of exchange rates into account in explaining exporters' choice of sourcing regions. In this section, I will therefore provide first empirical evidence relating firms' sourcing decisions to the co-movement of exchange rates.

I am going to capture sourcing decisions with a dummy variable indicating whether a firm was sourcing from a specific area in 2008. As noted earlier, EFIGE provides in-

[47]Note that taking the coefficients from the export interactions seriously actually allows me to determine the average trade costs and markups implied by the structural model. Using the estimates from the baseline regressions implies wedge factors $A = 0.85$ and $B = 1.55$. Evaluating the theoretical terms of factors A and B at the average export share in the sample (19%) implies trade costs of $\tau = 1.22$ and a markup of $\mu = 1.23$.

formation on the regional distribution of international firm activities as of 2008, where the world is split into eight distinct areas. For each of these areas, respondents where asked to indicate whether raw material or intermediate goods were purchased from or whether products were sold to that specific area. I use this information in order to expand my data along the geographic dimension. Again, I match the data with monthly real effective exchange rates. These are now constructed as a trade weighted average of all available exchange rates *within* a certain EFIGE area.[48]

I use the monthly data to construct time invariant measures of exchange rate volatility and the projection coefficient, using the full range of years in my data. Specifically, I determine the standard deviation of all measures of the effective exchange rate as well as the covariance between the intermediate import and the export weighted effective exchange rates, both in logs and in levels. Note that from these I can easily recover the regional projection coefficients defined in equation (10). I then drop the time dimension for the empirical analysis. Because EFIGE provides information on regional exports and imports for 2008 only, I am not able to make use of the time-dimension when analyzing the sourcing decision of firms. Thus, regression and identification in this section will be based on a firm-area panel, where one observation represents firm activity in a specific area of the world.

On this data, I run the following regression:

$$
\begin{aligned}
importer_{csi\kappa} = \gamma \quad &+ \quad \delta_1 \cdot exporter_{csi\kappa} \\
&+ \quad \delta_2 \cdot \left[exporter_{csi\kappa} \times sd(R^{xi}_{cs\kappa t})_{cs\kappa} \right] \qquad (16) \\
&+ \quad \delta_3 \cdot \left[exporter_{csi\kappa} \times sd(R^{xi}_{cs\kappa t})_{cs\kappa} \times \widehat{Proj}^{didx}_{cs\kappa} \right] \ldots
\end{aligned}
$$

where $importer_{csi\kappa}$ is a dummy variable indicating whether firm i, active in country c and sector s, was importing intermediates from area κ in 2008 and $exporter_{csi\kappa}$ is

[48] I use the same method as detailed in equations (8) and (9), only that this time region κ corresponds to a specific EFIGE area rather than the world as a whole. I will also construct a third real effective exchange rate that represents total trade, and thus both intermediate imports and exports. It is going to provide a measure of the overall regional volatility. I am using the overall trade weighted volatility rather than the export or intermediate import weighted volatility because those two measures are highly correlated and a separate identification of effects related to one or the other is therefore empirically not feasible. The trade weighted volatility is constructed as follows: $R^{xi}_{cs\kappa t} = \prod_{k\in\kappa} \left(E_{ckt} \cdot \frac{cpi_{kt}}{cpi_{ct}} \right)^{\frac{EX_{cks} + \sum_{z\in IO(s)} \varsigma_{zs} \cdot IM_{ckz}}{\sum_{k\in\kappa} \left[EX_{cks} + \sum_{z\in IO(s)} \varsigma_{zs} \cdot IM_{ckz} \right]}}$.

the corresponding dummy for exports. $sd(R^{xi}_{cs\kappa t})_{cs\kappa}$ is the standard deviation over all months in the sample period of the home country c specific trade weighted real effective exchange rate in region κ. $\widehat{Proj}^{didx}_{cs\kappa}$ is the area κ specific elasticity of the import weighted with respect to the export weighted real effective exchange rate. Additionally, I am going to add all relevant sub-interaction terms as well as a number of control variables and fixed effects to the model. Because standard errors are potentially clustered across areas for a given firm and because all firms in a given country-sector-area combination obtain the same measures of exchange rate volatility and co-movement, I allow for two-way clustering at the firm and the country-sector-area level.

My expectations with respect to the sign of the coefficients in equation (17) are explained in what follows. I expect the probability of firm i sourcing intermediates from region k to be higher if the firm is exporting to that very same region. The reason is that entering a new geographic region usually implies fixed costs, such as finding a translator, establishing business networks or getting to know the legal system. As a firm that already exports to a region will probably be able to save on some of these expenses, I expect δ_1 to be positive.[49] I expect δ_2 to be negative if the key assumption of this paper, that firms dislike exchange rate risk, holds in the data.[50] If firms are considering hedging activities because they want profits and sales to be less responsive to exchange rate shocks, then, *ceteris paribus*, they should be less inclined to source from highly volatile regions. This is true even if a firm is exporting to that region because, as has been shown in the previous sections, offshoring might actually add to the exchange rate risk of exporting for the average firm. Only if importing helps the firm to offset some of the exchange rate shocks to the export value, I would expect the probability of offshoring to be rising in exchange rate volatility for exporting firms. This is the case when the shock to the export weighted exchange rate translates into

[49] The reason for taking export status into the model in the first place, is that offshoring decisions are only related to operational hedging activities for firms that are actually exposed to exchange rate risks. The export status is clearly a good indicator for that.

[50] A large literature has shown that firms' international activities are related to the volatility of exchange rates. Thus, Cheung and Sengupta (2013) and Héricourt and Poncet (2015) show that firm-level exports to a specific destination are decreasing in the volatility of bilateral exchange rates. Earlier aggregate and sector-level evidence on the effects of exchange rate volatility on exports is surveyed in McKenzie (1999). Literature focusing on volatility and FDI flows is reviewed in Blonigen (2005). Note that in a recent paper Héricourt and Nedoncelle (2016) regress regional export performance on volatility measures and explicitly control for operational hedging by adding a regional import dummy interaction. They find imports to diminish the negative effect of exchange rate volatility on exports. While their approach is closely related to the one presented here, they focus on the intensive margin of exports rather than the extensive margin of intermediate imports. They also treat the importer status merely as a control variable and do not further discuss the implications of their results with respect to operational hedging.

a corresponding movement in the import weighted exchange rate. Theoretically, the degree to which the import weighted exchange rate responds to the export weighted exchange rate is given by the elasticity of the import weighted with respect to the export weighed exchange rate. Empirically, this elasticity is approximated by $Proj_{cs\kappa}^{didx}$ and accordingly I expect δ_3 to be positive.

Table 2 presents the results from estimating a linear probability model of equation (17). Note that all specifications include at least area and firm fixed effects, which control for the average level of sourcing in certain areas, industries or for specific firms. Other than that, specification (1) only contains the explanatory variables detailed in equation (17) and the relevant sub-interaction terms. As expected, the probability of firm i sourcing from area κ is on average higher for firms that exported to the given area in 2008. But note that the regional exporter status is becoming, *ceteris paribus*, a worse predictor of offshoring when the sourcing region is highly volatile in terms of the real effective exchange rate. As noted earlier, the reason for that is that the import weighted exchange rate is not trailing the export weighted exchange rate close enough for the average firm, even within specific areas. Abstracting from other reasons of offshoring, foreign sourcing then simply adds to the already higher exchange rate risks of exporters. Thus, while the model predicts the probability of regional offshoring to be 15.9 percentage points higher for regional exporters than for non-exporters when abstracting from exchange rate volatility, the exporter effect is reduced to 4.3 percentage points when factoring in the average level of exchange rate volatility. As the highly significant coefficient on the triple interaction indicates, the effect of volatility on the sourcing decision of exporters significantly changes with the elasticity of the import weighted with respect to the export weighted real effective exchange rate. Thus, evaluating at the 10th percentile of the elasticity distribution, exporting increases the probability of regional sourcing by merely 2 percentage points, whereas the effect is 7 percentage points for an elasticity at the 90th percentile.

The contrast becomes more pronounced when considering regions with above average volatility. Thus, setting the volatility to the 75th percentile of the distribution implies that the probability of regional sourcing actually *decreases* by 3.5 percentage points for a regional exporter that faces a low co-movement of exchange rates, while it *increases* by 4.2 percentage points for exporters facing a high co-movement.

The fact that the probability of importing responds not only to area characteristics, exporter status and the level of exchange rate volatility, but crucially depends on the co-movement between intermediate import and export weighted exchange rates

Table 2: Area Baseline

	$importer_{csi\kappa}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$exporter_{csi\kappa}$	0.159***	0.153***	0.147***	0.180***	0.0691***	0.0570***	0.0755***	0.0528***
	(0.0132)	(0.0139)	(0.0173)	(0.0157)	(0.0147)	(0.0182)	(0.0168)	(0.0172)
$exporter_{csi\kappa} \times sd(R^{xi}_{cs\kappa t})_{cs\kappa}$	-1.147***	-1.124***	-1.084***	-1.249***	-0.939***	-0.880***	-0.890***	-0.655***
	(0.119)	(0.123)	(0.133)	(0.128)	(0.114)	(0.121)	(0.110)	(0.143)
$exporter_{csi\kappa} \times sd(R^{xi}_{cs\kappa t})_{cs\kappa} \times \widehat{Proj}^{didx}_{cs\kappa}$	1.927***	2.376***	1.934***	1.786***	1.979***	2.046***	1.886***	3.014***
	(0.434)	(0.455)	(0.434)	(0.434)	(0.459)	(0.457)	(0.414)	(0.588)
$exporter_{csi\kappa} \times \widehat{Proj}^{didx}_{cs\kappa}$	-0.0629	-0.108*	-0.0700	-0.0300	-0.0349	-0.0458	-0.0630	-0.0710
	(0.0616)	(0.0641)	(0.0616)	(0.0633)	(0.0619)	(0.0632)	(0.0587)	(0.0687)
$sd(R^{xi}_{cs\kappa t})_{cs\kappa} \times \widehat{Proj}^{didx}_{cs\kappa}$	0.161	0.131	0.172	0.177	0.299	0.275		
	(0.242)	(0.249)	(0.242)	(0.243)	(0.271)	(0.244)		
$sd(R^{xi}_{cs\kappa t})_{cs\kappa}$	-0.0959	-0.135	-0.121	-0.0855	-0.146	-0.236*		
	(0.128)	(0.122)	(0.129)	(0.128)	(0.137)	(0.122)		
$\widehat{Proj}^{didx}_{cs\kappa}$	0.0453	0.0485	0.0455	0.0403	0.0237	0.0218		
	(0.0397)	(0.0441)	(0.0398)	(0.0399)	(0.0434)	(0.0427)		
$reg.\ io\text{-}import\ share_{cs\kappa}$		0.515***				0.501***		
		(0.0743)				(0.0732)		
$reg.\ final\text{-}export\ share_{cs\kappa}$		0.145***				0.145***	0.0747*	0.0634
		(0.0409)				(0.0408)	(0.0387)	(0.0402)
$exporter_{csi\kappa} \times rel.\ io\text{-}wage\ (p.C.)_{cs\kappa}$			0.00966			0.0410***	0.0455***	0.0718***
			(0.00898)			(0.0109)	(0.0113)	(0.0149)
$rel.\ io\text{-}wage\ (p.C.)_{cs\kappa}$			0.00211			0.00474		
			(0.00561)			(0.00618)		
$exporter_{csi\kappa} \times rel.\ io\text{-}lab.prod._{cs\kappa}$				-0.0111***		-0.0214***	-0.0233***	-0.0208***
				(0.00331)		(0.00597)	(0.00646)	(0.00594)
$rel.\ io\text{-}lab.prod._{cs\kappa}$				0.000529		0.00258		
				(0.00193)		(0.00257)		
$exporter_{csi\kappa} \times Grubel\text{-}Lloyd_{cs\kappa}$					0.129***	0.121***	0.0811***	0.0477***
					(0.0147)	(0.0150)	(0.0133)	(0.0137)
$Grubel\text{-}Lloyd_{cs\kappa}$					-0.0122**	-0.0180***	-0.0174***	-0.0203**
					(0.00613)	(0.00582)	(0.00632)	(0.00793)
Fixed Effects	$\gamma_\kappa + \gamma_i$	$\gamma_\kappa + \gamma_i$	$\gamma_\kappa + \gamma_i$	$\gamma_\kappa + \gamma_i$	$\gamma_\kappa + \gamma_i$	$\gamma_\kappa + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$
Area	κ	κ	κ	κ	κ	κ	κ	$\widehat{\kappa}$
Cluster (Firm)	12311	11229	12311	12311	11474	11228	11225	11080
Cluster (Sector#Country#Area)	1450	1026	1450	1450	1039	1026	1008	756
Adj. R2	0.303	0.313	0.304	0.304	0.307	0.315	0.335	0.363
Observations	95,490	86,988	95,490	95,490	88,567	86,952	86,934	65,003

Notes: Observations relate to firm i in area κ, where firms are based in country c and active in sector s. The dependent variable $importer_{csi\kappa}$ is an indicator equal to one if the firm is sourcing intermediates from region κ. $exporter_{csi\kappa}$ is an indicator equal to one if the firm is exporting to region κ. $sd(R^{xi}_{cs\kappa t})_{cs\kappa}$ is the standard deviation of the monthly export and import weighted, area κ specific real effective exchange rate, measured over the full sample period. $\widehat{Proj}^{didx}_{cs\kappa}$ is the demeaned elasticity of the import weighted with respect to the export weighted area κ specific real effective exchange rate. $reg.\ io\text{-}import\ share_{cs\kappa}$ is share of intermediate imports from area κ in all intermediate imports (2-digit). $reg.\ final\text{-}export\ share_{cs\kappa}$ is the share of final good exports to area κ in all final good exports (4-digit). $rel.\ io\text{-}wage\ (p.C.)_{cs\kappa}$ is the wage per employee in intermediate input industries in area κ relative to country c (2-digit). $rel.\ io\text{-}lab.prod._{cs\kappa}$ is the value added per employee in intermediate input industries in area κ relative to country c (2-digit). $Grubel\text{-}Lloyd_{cs\kappa}$ is the Grubel-Lloyed Index of industry s for trade with area κ (4-digit). γ_κ are area fixed effects, γ_i are firm fixed effects and $\gamma_{cs\kappa}$ are country-sector-area fixed effects. The sector level is defined at the 2-digit US SIC level. Specification (7) regroups small areas into larger areas. Specifically, Central & South America are grouped together with USA & Canada, and China & India are grouped together with Other Countries. Standard errors are clustered at the firm level and at the sector-country-area level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

is what I count as evidence for operational hedging. Note that the coefficient on the triple interaction can be read in two ways. On the one hand, it implies that for a given level of exchange rate volatility, the probability of regional sourcing for an exporter relative to a non-exporter is increasing in the co-movement of exchange rates. This is in line with operational hedging, because the co-movement of exchange rates implies that a shock to the export weighted exchange rate is offset partly by a change in marginal cost, keeping profits and sales of the exporter relatively stable. On the other hand, the triple interaction implies that exporters will attribute more importance to a given level of exchange-rate co-movement when the volatility of the potential sourcing region increases. Because then shocks to the value of exports due to exchange rate movements are relatively severe, exporting firms should have a higher interest in considering offsetting effects through adjustments in the marginal cost, i.e. operational hedging.

In specifications (2) to (6) I add various controls at the sectoral level that are potentially correlated with the sectoral exchange rate measures and are known to have an impact on the sourcing decision of firms. In specification (2) I add area κ's share in total intermediate imports of country c to the model, as well as the regional share in final good exports from country c. Both measures are country, industry and area specific and are indicative of the differential importance of area κ for sector-level trade. Not surprisingly, the estimates suggest that firms tend to source more frequently from areas that provide inputs to other firms in the sector. Furthermore, the probability of sourcing from a given region is increasing in the sectoral importance of that region as an export market. This is in line with an access cost story at the sectoral level. Controlling for the differential importance of region κ at the sectoral level does not alter the main results significantly, though the effect on the triple interaction increases in terms of absolute size.

While specification (2) controls for the overall importance of the different areas in terms of trade, specifications (3) to (6) consider specific industry characteristics of those regions. Specification (3) looks at the per-capita wage in region κ for all input industries of sector s and relates it to the corresponding wage in firm i's home country c. Note that I add the relative wage in levels and further allow it to interact with the exporter dummy. While the reason to enter the level control is quite obvious, the reason to add the interacted control is of a more technical nature: as the effects under examination happen at the interaction level, controls, supposed to disentangle the exchange rate effects from alternative channels, should also enter at the interaction level.[51] From table 2 it can be seen that the relative wage control is not affecting my estimates significantly. The coefficients on the controls are statistically close to zero, which is somewhat surprising, given that offshoring is often attributed to low foreign wages. Note however that the specification already controls for area fixed effects and that the relative wage control therefore measures wage effects only as long as they deviate at the sectoral level from the area average.

Specification (4) controls for the relative labor productivity in region κ's input industries. Again the level control is insignificant but now the effect is significant at the interaction level. Nevertheless, all interactions of interest remain significant at the 1% level. In specification (5) I add the Grubel-Lloyd index as a measure of intra-industry trade. This is supposed to control for the type of final good trade between area κ and home country c in firm i's output industry. A rise in the measure implies that comparative advantages are becoming less important in shaping trade patterns. The fact that the level effect on the control is negative is in line with offshoring being less relevant for regions that are similar to country c in terms of the trade structure. Not surprisingly, the control seems to be important for the correlation between export and import status and therefore reduces the exporter dummy effect substantially. In specification (6) I add all sector-level controls at the same time but the results remain stable.

In specification (7), I replace area dummies by country-sector-area fixed effects. Accordingly, all level effects relating to the exchange rate measures and some of the controls are dropped from the model.[52] Specification (7) is my preferred specification. Astonishingly, the marginal effects implied by specification (7) are very close to the effects discussed earlier. Thus, for a high volatility region (75th percentile of the distribution), specification (7) implies that exporting decreases the probability of regional sourcing by 3.4 percentage points if the projection coefficient is at the 10th percentile but increases the probability by 4.2 percentage points for a projection coefficient at the 90th percentile of the distribution. The earlier results were -3.5 and 4.2

[51] For the controls of specification (2), the inclusion of an interaction term yields insignificant results for the main effects under consideration. This is not surprising, given that the sectoral controls of specification (2) capture the full industry sourcing patterns and thus will also contain the average effects of operational hedging at the sectoral level. The remaining variation of the *sectoral* exchange rate measure is then simply not enough to identify additional firm specific effects. Different from the controls in specification (2), the controls in specifications (3) to (6) are focused exclusively on alternative channels, leaving the full variation related to exchange rates for identification.

[52] Note that controls determined at the final good industry level remain in the model because they are constructed at the 4-digit industry level, whereas sectoral dummies relate to the 2-digit level. See the variable description in the appendix for details.

respectively.

Specification (8) repeats specification (7), but is based on a different area grouping. Specifically, I group the smallest regions together, i.e. Central & South America together with USA & Canada and China & India together with Other Countries. As shown in table A.1 in the appendix, exchange rate data is available for a limited set of countries only. Matching the different data sets implies an additional loss of countries, such that in my data Central & South America consists of Brazil and Mexico only. Furthermore, the complete set of Other Areas is represented by South Africa alone. Naturally, if the number of countries in a given region becomes too small, the co-movement of exchange rates increases. Thus effectively, the correlation coefficient is equal to one for Other Areas and potentially gets close to one if the number of countries per area is small.[53] This effect was of no consequence in the first part of the paper, as all effective exchange rates were constructed over the same set of available countries. For the current specification, the number of countries that feed into the area-specific effective exchange rates is different across areas. Note though, that this is partly controlled for by area or country-sector-area fixed effects. Still, because I am identifying at the interaction level, some of the constructional bias in projection coefficients might still be present in my results. Regrouping countries into broader areas increases the minimum number of countries in a given area to four.[54] As shown in table 2, the results remain qualitatively the same for the new grouping. Quantitatively, the effects are slightly smaller, with the probability of regional imports from a high volatility region increasing in exporter status by 3.5 percentage points for a high projection coefficient but virtually independent of exporting for firms facing a low projection coefficient. Note though, that by reducing the number of areas from 8 to 6, a quarter of the observations yields no additional information and accordingly is lost for the empirical analysis. Because my focus lies on the qualitative results, I will stick to the full data set in what follows.

In table A.7 I present further robustness results, built upon specification (7) from the baseline table. Specification (1) to (5) consider real exchange rates and specification (6) to (10) nominal exchange rates. I will mention differences between the real and the nominal exchange rate specifications only if relevant. Specifications (1) and

[53]See table A.4 in the appendix.

[54]Except for EU15 (14) and Other Asian (8), the groups are now relatively homogenous in size, with four or five countries in each regional cluster. In the robustness section I will re-run the regression omitting the two larger areas and show that my results do not exclusively hinge on these two country clusters.

(6) repeat the baseline. Note that my baseline results are robust to using the nominal instead of the real exchange rate. The marginal effects are slightly larger, with the probability of regional sourcing 5 percentage points higher for a firm with projection coefficient at the 90th percentile and 4.3 percentage points lower for a firm at the 10th percentile (evaluated for regions with exchange rate volatility at the 75th percentile). In specifications (2) and (7), I use the non-demeaned projection coefficient which delivers identical results for the triple interaction. Specifications (3) and (8) use an indicator equal to one if the demeaned projection coefficient is larger than zero. The results remain qualitatively the same. The marginal effects implied are +3.6 and -1.6 percentage points for the real exchange rate (+4.3 and +1.6 for the nominal exchange rate) where these now refer to a firm with above and below average projection coefficient. Specification (4) and (9) use the demeaned correlation coefficient rather than the projection coefficient. This renders the coefficient on the triple interaction negative and insignificant. While this might be due to high collinearity of the triple interaction term,[55] I would argue that to some extent it also reflects the limited information content of the correlation coefficient. While the projection coefficient contains information regarding the actual size of the response in the intermediate import weighted exchange rate to a change in the export weighted exchange rate, the correlation just measures their linear association. Because hedging requires the response in the costs of intermediates to be *sizable*, the projection coefficient is the preferable measure.

Specification (5) and (10) finally omit EU15 and Other Asian Countries from the set of regions. As discussed earlier, these areas are especially large in terms of the number of distinct countries involved and thus the projection coefficient might be biased due to constructional reasons. Furthermore, EU15 is by far the most important area in terms of export and import activity (see table A.4), with about 48% of the firms exporting to and 35% of the firms sourcing from EU15. Additionally, note that 12 out of 15 countries in EU15 use the Euro as currency. For many of the firms in my data, the exchange rate risk for the EU15 activities is therefore relatively small and relates to changes in the relative price levels. Accordingly, it is important to check whether my results hinge on the EU15 alone. As shown in specification (5) and (10), the effect on the triple interaction turns insignificant after dropping EU15 and Other Asian Countries for real exchange rates but remains significant close to the 5%

[55] The variance inflation factor (VIF) of the triple interaction, for real exchange rates, is 16.9 for the correlation coefficient - up from 5.5 for the projection coefficient.

level for the nominal exchange rate (p-value = 0.051).[56] The marginal effects for the high and low projection coefficient implied by these estimates are +4.5 and -0.093% respectively.

7 Conclusion

This paper confirms earlier results, suggesting that imported intermediates are important determinants for the pass-through of exchange rates into prices and sales of an exporter. If marginal costs and export prices are denominated in currencies that are closely related, then shocks to the exchange rate will trigger offsetting effects on foreign demand. Specifically, a devaluation will lower foreign prices through a conversion effect and increase foreign prices due to higher marginal costs. The reverse effects hold for an appreciation. This is an important finding, given that the apparent disconnect between exchange rates and trade flows has been considered one of the major puzzles in macroeconomics. Yet, the shift of focus away from the macroeconomic country perspective towards decisions taken at the firm level has brought to light a second question: do internationally active firms synchronize international activities and *purposely* produce a disconnect between exchange rates and prices in order to reduce their exposure to exchange rates?

The findings presented in this paper shed new light on this question that has only been addressed for large multinationals in the previous literature. They suggest that a qualified yes might be the answer. Offshoring provides for a means to operational hedging if and only if sourcing regions are closely related to the firm's export market in terms of exchange rate co-movement. Note that the conditionality of the statement as well as the focus on small and medium-sized firms are two sides of a medal. Large multinationals are active in many countries and many dimensions, whereas the diversity of international activities decreases rapidly when considering smaller firms. Thus, while the diversification effect might provide a *natural* hedge for large multinationals, as earlier studies have confirmed, my findings suggest that smaller firms will have to actively match international activities in order to benefit from operational hedges.

Viewed from a different perspective, my results send a clear warning to small and medium-sized firms considering a mix of different international activities: because export and sourcing decisions are often taken for reasons other than exchange rate

[56] The p-value is 0.029 when only omitting the EU15 and keeping Other Asian Countries in the model.

considerations, such as cheap foreign inputs or promising foreign markets, firms are potentially underestimating the exchange rate risks involved. The tempting idea of natural hedges just doesn't appear to hold for the average firm.

References

Ahmed, Swarnali, Maximiliano Appendino, and Michele Ruta. Depreciations without exports? Global Value Chains and the Exchange Rae Elasticity of Exports. Policy Research Working Paper WPS 7390, World Bank, 2015.

Allayannis, George, Jane Ihrig, and James P. Weston. Exchange-Rate Hedging: Financial versus Operational Strategies. *American Economic Review*, 91(2):391–395, 2001.

Altomonte, Carlo and Tommaso Aquilante. The EU-EFIGE/Bruegel-Unicredit dataset. Working Papers 753, Bruegel, 2012.

Altomonte, Carlo, Tommaso Aquilante, and Gianmarco Ottaviano. The triggers of competitiveness: The EFIGE cross-country report. Working Papers 738, Bruegel, 2012.

Amberg, Niklas and Richard Friberg. Derivatives, Operational Hedging and Access to Liquidity as Tools for Risk Management: Results from a Questionnaire. mimeo, Stockholm School of Economics, 2015.

Amiti, Mary, Oleg Itskhoki, and Jozef Konings. Importers, Exporters, and Exchange Rate Disconnect. *American Economic Review*, 104(7):1942–78, 2014.

Athukorala, Prema-chandra and Jayant Menon. Pricing to Market Behaviour and Exchange Rate Pass-Through in Japanese Exports. *Economic Journal*, 104(423):271–81, 1994.

Atkeson, Andrew and Ariel Burstein. Pricing-to-Market, Trade Costs, and International Relative Prices. *American Economic Review*, 98(5):1998–2031, 2008.

Bartov, Eli and Gordon M. Bodnar. Firm Valuation, Earnings Expectations, and the Exchange-Rate Exposure Effect. *Journal of Finance*, 49(5):1755–1785, 1994.

Bartram, Söhnke M., Gregory W. Brown, and Bernadette A. Minton. Resolving the exposure puzzle: The many facets of exchange rate exposure. *Journal of Financial Economics*, 95(2):148 – 173, 2010.

Berman, Nicolas, Philippe Martin, and Thierry Mayer. How do Different Exporters React to Exchange Rate Changes? *Quarterly Journal of Economics*, 127(1):437–492, 2012.

Bernard, Andrew B., J. Bradford Jensen, and Peter K. Schott. Importers, Exporters and Multinationals: A Portrait of Firms in the U.S. that Trade Goods. In **Dunne, Timothy, J. Bradford Jensen, and Mark J. Roberts**, editors, *Producer Dynamics: New Evidence from Micro Data*, pages 513–552. University of Chicago Press, 2009.

Blonigen, Bruce A. A Review of the Empirical Literature on FDI Determinants. *Atlantic Economic Journal*, 33(4):383–403, 2005.

Bodnar, Gordon and William Gentry. Exchange rate exposure and industry characteristics: evidence from Canada, Japan, and the USA. *Journal of International Money and Finance*, 12(1):29–45, 1993.

Broll, Udo. The Effect of Forward Markets on Multinational Firms. *Bulletin of Economic Research*, 44(3):233–240, 1992.

Burstein, Ariel and Gita Gopinath. Chapter 7 - International Prices and Exchange Rates. In **Gita Gopinath, Elhanan Helpman and Kenneth Rogoff**, editors, *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, pages 391 – 451. Elsevier, 2014.

Cheung, Yin-Wong and Rajeswari Sengupta. Impact of exchange rate movements on exports: An analysis of Indian non-financial sector firms. *Journal of International Money and Finance*, 39(C):231–245, 2013.

Choi, Jongmoo Jay and Anita Mehra Prasad. Exchange Risk Sensitivity and Its Determinants: A Firm and Industry Analysis of U.S. Multinationals. *Financial Management*, 24(3), 1995.

Chowdhry, Bhagwan and Jonathan TB Howe. Corporate risk management for multinational corporations: Financial and operational hedging policies. *European Finance Review*, 2(2):229–246, 1999.

Clark, Peter B. Uncertainty, Exchange Risk, and the Level of International Trade. *Western Economic Journal*, 11(3):302, 1973.

Clark, Peter B., Natalia T. Tamirisa, Shang-Jin Wei, Azim M. Sadikov, and Li Zeng. A New Look at Exchange Rate Volatility and Trade Flows. IMF Occasional paper 235, IMF, 2004.

Colin Cameron, A. and Douglas L. Miller. A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, 50(2):317–372, 2015.

Döhring, Björn. Hedging and invoicing strategies to reduce exchange rate exposure: a euro-area perspective. Economic Papers 299, European Economy, 2008.

Dumas, B. The Theory of the Trading Firm Revisited. *Journal of Finance*, 33(3):1019–1030, 1978.

EDC. Currency Risk Management Practices of Canadian Firms. Research Report RR-CRMPCF-0709, Export Development Canada, 2009.

Ellis, Luci. Measuring the Real Exchange Rate: Pitfalls and Practicalities. RBA Research Discussion Papers rdp2001-04, Reserve Bank of Australia, 2001.

Fauceglia, Dario, Anirudh Shingal, and Martin Wermelinger. Natural hedging of exchange rate risk: the role of imported input prices. MPRA Paper 39438, 2012.

Friberg, Richard and Cristian Huse. Quantifying the effects of natural hedging - An examination of US production for BMW and Porsche. mimeo, Stockholm School of Economics, 2014.

Goldberg, Linda S. and José Manuel Campa. The sensitivity of the CPI to exchange rates: Distribution margins, imported inputs, and trade exposure. *Review of Economics and Statistics*, 92(2):392–407, 2010.

Goldberg, Pinelopi K. and Rebecca Hellerstein. A Structural Approach to Explaining Incomplete Exchange-Rate Pass-Through and Pricing-to-Market. *American Economic Review*, 98(2):423–29, 2008.

Goldberg, Pinelopi K. and Michael M. Knetter. Goods Prices and Exchange Rates: What Have We Learned? *Journal of Economic Literature*, 35(3):1243–1272, 1997.

Gopinath, Gita and Roberto Rigobon. Sticky Borders. *Quarterly Journal of Economics*, 123(2):531–575, 2008.

Greenaway, David, Richard Kneller, and Xufei Zhang. The Effect of Exchange Rates on Firm Exports: The Role of Imported Intermediate Inputs. *World Economy*, 33(8):961–986, 2010.

Heckerman, Donald G. The Exchange Risks of Foreign Operations. *Journal of Business*, 45(1):42–48, 1972.

Héricourt, Jérôme and Clément Nedoncelle. How Multi-Destination Firms Shape the Effect of Exchange Rate Volatility on Trade: Micro Evidence and Aggregate Implications. Working Papers 2016-05, CEPII research center, 2016.

Héricourt, Jérôme and Sandra Poncet. Exchange Rate Volatility, Financial Constraints, and Trade: Empirical Evidence from Chinese Firms. *World Bank Economic Review*, 29(3):550–578, 2015.

Houston, Carol O. and Gerhard G. Mueller. Foreign Exchange Rate Hedging and SFAS No. 52–Relatives or Strangers?. *Accounting Horizons*, 2(4):50 – 57, 1988.

Ito, Takatoshi, Satoshi Koibuchi, Kiyotaka Sato, and Junko Shimizu. Exchange Rate Exposure and Risk Management: The case of Japanese Exporting Firms. NBER Working Paper 21040, National Bureau of Economic Research, 2015.

Jorion, Philippe. The Exchange-Rate Exposure of U.S. Multinationals. *Journal of Business*, 63(3):331–45, 1990.

Leigh, Daniel, Weicheng Lian, Marcos Poplawski-Ribeiro, and Viktor Tsyrennikov. Chapter 3 - Exchange Rates and Trade Flows: Disconnected? In *World Economic Outlook - Adjusting to Lower Commodity Prices*, pages 105–152. International Monetary Fund, 2015.

Makar, Stephen D., Jay DeBruin, and Stephen P. Huffman. The management of foreign currency risk: derivatives use and the natural hedge of geographic diversification. *Accounting and Business Research*, 29(3):229–237, 1999.

Marin, Dalia, Jan Schymik, and Jan Tscheke. Organization as Competitive Advantage. mimeo, LMU Munich, 2014.

Mayers, David and Clifford W. Smith. On the Corporate Demand for Insurance. *Journal of Business*, 55(2):281–96, 1982.

McKenzie, Michael D. The Impact of Exchange Rate Volatility on International Trade Flows. *Journal of Economic Surveys*, 13(1):71–106, 1999.

Mian, Shehzad L. Evidence on Corporate Hedging Policy. *Journal of Financial and Quantitative Analysis*, 31(3):419–439, 1996.

Miroudot, Sebastien, Rainer Lanz, and Alexandros Ragoussis. Trade in Intermediate Goods and Services. OECD Trade Policy Papers 93, OECD, 2009.

Muller, Aline and Willem FC Verschoor. European foreign exchange risk exposure. *European Financial Management*, 12(2):195–220, 2006.

Obstfeld, Maurice and Kenneth Rogoff. The six major puzzles in international macroeconomics: is there a common cause? In *NBER Macroeconomics Annual 2000, Volume 15*, pages 339–412. MIT press, 2001.

Ollivaud, Patrice, Elena Rusticelli, and Cyrille Schwellnus. The Changing Role of the Exchange Rate for Macroeconomic Adjustment. OECD Economics Department Working Paper No. 1190, OECD, 2015.

Pantzalis, Christos, Betty J Simkins, and Paul A Laux. Operational hedges and the foreign exchange exposure of US multinational corporations. *Journal of International Business Studies*, pages 793–812, 2001.

Rodriguez, Rita M. Corporate Exchange Risk Management: Theme and Aberrations. *Journal of Finance*, 36(2):427–439, 1981.

Shapiro, Alan C. Exchange Rate Changes, Inflation, and the Value of the Multinational Corporation. *Journal of Finance*, 30(2):485–502, 1975.

Wooldridge, Jeffrey M. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, 2 edition, 2010.

A.1 Theoretical Appendix

A.1.1 Decomposition of Effects for Total Sales

$$\begin{aligned}
\frac{\partial r_{tot}}{\partial E_x} &= \frac{\partial r_€}{\partial E_x} + \frac{\partial E_x r_\$}{\partial E_x} = \frac{\partial p_€ q_€}{\partial E_x} + \frac{\partial E_x p_\$ q_\$}{\partial E_x} \\
&= \underbrace{\frac{\partial p_€}{\partial E_x} q_€}_{a} + \underbrace{\frac{\partial q_€}{\partial E_x} p_€}_{b+\epsilon_1} + \underbrace{\frac{\partial E_x}{\partial E_x} p_\$ q_\$}_{c} + \underbrace{\frac{\partial p_\$}{\partial E_x} E_x q_\$}_{d} + \underbrace{\frac{\partial q_\$}{\partial E_x} E_x p_\$}_{e+\epsilon_2}
\end{aligned}$$

Where in case of a devaluation total revenues change due to:

- the change in domestic revenues
  - a) higher prices due to higher import cost (given quantities)
  - b) lower demand due to higher prices
  - ϵ_1) sectoral effect that resembles general equilibrium adjustments in the domestic demand shifter
- and the change in foreign revenues
  - c) higher conversion of foreign revenues into domestic currency (given revenues in foreign currency)
  - d) change in foreign prices due to d_1) higher import cost and d_2) lower conversion of domestic prices into foreign currency (given quantities)
  - e) change in foreign demand due to the price changes induced by e_1) higher import cost and e_2) lower conversion of domestic prices into foreign currency (given quantities)
  - ϵ_2) sectoral effect that resembles general equilibrium adjustments in the foreign demand shifter

Using Dixit-Stiglitz definitions of prices, quantities and the price elasticity of demand, as well as my definitions of marginal cost and the share imported intermediates (IS), reordering, multiplying with the absolute change in E_x and keeping track of the effects we obtain equation (5):

$$\frac{\partial r_{tot}}{\partial E_x} \cdot \Delta E_x = \underbrace{\sigma \cdot E_x r_{\$} \cdot \frac{\Delta E_x}{E_x}}_{c+d_2+e_2} \underbrace{-(\sigma-1) \cdot r_{tot} \cdot IS \cdot \frac{dE_i}{dE_x} \frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x}}_{a+b+d_1+e_1}$$
$$+ \underbrace{r_{€} \cdot \frac{\Delta Q_{€} P_{€}^{\sigma}}{Q_{€} P_{€}^{\sigma}}}_{\epsilon_1} + \underbrace{E_x r_{\$} \cdot \frac{\Delta Q_{\$} P_{\$}^{\sigma}}{Q_{\$} P_{\$}^{\sigma}}}_{\epsilon_2}$$

The effects are now ordered in the following way:[57]

- A positive effect on foreign revenues due to a higher conversion of foreign revenues into domestic currency (c)
- A positive effect on foreign revenues due to a lower conversion of domestic prices into foreign currency $(d_2 + e_2)$
- A negative effect on domestic revenues due to higher material cost $(a + b)$,
- A negative effect on foreign revenues due to higher material cost $(d_1 + e_1)$
- Sectoral effects that resemble general equilibrium adjustments in the domestic and foreign demand shifter, weighted by firm activity at home and abroad $(\epsilon_1 + \epsilon_2)$

A.1.2 The Structural Error for Nominal Exchange Rates

$$\widehat{\epsilon}_r = (1 - XS) \cdot \frac{\Delta Q_{€} P_{€}^{\sigma}}{Q_{€} P_{€}^{\sigma}} + XS \cdot \frac{\Delta Q_{\$} P_{\$}^{\sigma}}{Q_{\$} P_{\$}^{\sigma}} \tag{A.1}$$

A.1.3 The Structural Error for Real Exchange Rates

$$\overline{\epsilon}_r = (1 - XS) \cdot \frac{\Delta Q_{€} P_{€}^{\sigma}}{Q_{€} P_{€}^{\sigma}} + XS \cdot \frac{\Delta Q_{\$} P_{\$}^{\sigma}}{Q_{\$} P_{\$}^{\sigma}} \tag{A.2}$$
$$+\sigma \cdot 1 \cdot XS \cdot \frac{\Delta \widehat{P}}{\widehat{P}} - (\sigma - 1) \cdot IS \cdot \frac{\Delta \widehat{P}}{\widehat{P}}$$

where $\widehat{P} \equiv P_{€} / P_{\$}$ resembles the relative price levels abroad and at home.

[57]Note that the quantity effect always dominates the price effect for $\sigma > 1$

A.1.4 Extension for Costs and Profits

Costs

$$\frac{\partial c_{tot}}{\partial E_x} = \underbrace{\frac{\partial q_{tot}}{\partial E_x} \cdot MC}_{\text{A: change in demand}} + \underbrace{q_{tot} \cdot \frac{\partial MC}{\partial E_x}}_{\text{B: change in marginal cost}}$$

Where the change in quantities produced (A) is determined by:

$$\begin{aligned}\frac{\partial(q_{€} + q_{\$})}{\partial E_x} &= Q_{€}P_{€}^{\sigma} \cdot \frac{\partial p_{€}^{-\sigma}}{\partial E_x} + Q_{\$}P_{\$}^{\sigma} \cdot \frac{\partial p_{\$}^{-\sigma}}{\partial E_x} + p_{€}^{-\sigma} \cdot \frac{\partial Q_{€}P_{€}^{\sigma}}{\partial E_x} + p_{\$}^{-\sigma} \cdot \frac{\partial Q_{\$}P_{\$}^{\sigma}}{\partial E_x} \\ &= \underbrace{-\sigma \cdot \frac{q_{€}}{p_{€}} \cdot \frac{\partial p_{€}}{\partial E_x}}_{a_1} + \underbrace{(-\sigma) \cdot \frac{q_{\$}}{p_{\$}} \cdot \frac{\partial p_{\$}}{\partial E_x}}_{a_2+a_3} + \underbrace{p_{€}^{-\sigma} \cdot \frac{\partial Q_{€}P_{€}^{\sigma}}{\partial E_x} + p_{\$}^{-\sigma} \cdot \frac{\partial Q_{\$}P_{\$}^{\sigma}}{\partial E_x}}_{\epsilon_c'}\end{aligned}$$

Thus, a devaluation:

a_1) decreases domestic demand due to higher domestic prices (higher input costs)

a_2) decreases foreign demand due to higher foreign prices (higher input costs)

a_3) increases foreign demand due to lower conversion of domestic prices into foreign prices

B) increases total cost due to higher conversion of imported input prices into domestic currency (given quantities)

ϵ_c') Sectoral effects that resemble general equilibrium adjustments in the domestic and foreign demand shifter, weighted by firm activity at home and abroad

Multiplying with the absolute change in exchange rates, using Dixit-Stiglitz definitions of prices, quantities and the price elasticity of demand, as well as my definitions of marginal cost and the share imported intermediates (IS), reordering and keeping track of the effects we obtain:

$$\frac{\partial c_{tot}}{\partial E_x} \cdot \Delta E_x = \underbrace{\sigma \cdot E_x c_\$ \cdot \frac{\Delta E_x}{E_x}}_{a_3} \underbrace{-(\sigma - 1) \cdot IS \cdot c_{tot} \cdot \frac{dE_i}{dE_x} \frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x}}_{a_1 + a_2 + B}$$

$$+ \underbrace{c_€ \cdot \frac{\Delta Q_€ P_€^\sigma}{Q_€ P_€^\sigma} + E_x c_\$ \cdot \frac{\Delta Q_\$ P_\$^\sigma}{Q_\$ P_\$^\sigma}}_{\epsilon_c}$$

Profits The equivalent of equation (15) in nominal terms results by using equations (6) and (A.3) and noting that:

$$\frac{\partial \pi}{\partial E_x} \cdot \Delta E_x = \frac{\partial r_{tot}}{\partial E_x} \cdot \Delta E_x - \frac{\partial c_{tot}}{\partial E_x} \cdot \Delta E_x$$

Wedge Factor for Costs

$$\frac{\Delta c_{tot}}{c_{tot}} = \sigma \cdot \frac{E_x c_\$}{c_{tot}} \cdot \frac{\Delta E_x}{E_x} - (\sigma - 1) \cdot IS \cdot \frac{dE_i}{dE_x} \frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x}$$

$$+ \underbrace{\frac{c_€}{c_{tot}} \cdot \frac{\Delta Q_€ P_€^\sigma}{Q_€ P_€^\sigma} + \frac{E_x c_\$}{c_{tot}} \cdot \frac{\Delta Q_\$ P_\$^\sigma}{Q_\$ P_\$^\sigma}}_{\widehat{\epsilon}_c}$$

Using:

$$E_x c_\$ = [(1-i)w_€ + i w_\$ E_i] \cdot q_\$ = E_x r_\$ \cdot \frac{1}{\mu\tau}$$

$$c_{tot} = [(1-i)w_€ + i w_\$ E_i] \cdot (q_€ + q_\$) = r_€ \cdot \frac{1}{\mu} + E_x r_\$ \cdot \frac{1}{\mu\tau}$$

$$\Rightarrow \frac{E_x c_\$}{c_{tot}} = \frac{E_x r_\$ \cdot \frac{1}{\tau}}{r_€ + E_x r_\$ \cdot \frac{1}{\tau}} = \frac{E_x r_\$}{r_{tot}} \cdot \frac{r_{tot}}{r_€ \tau + E_x r_\$}$$

$$= \frac{E_x r_\$}{r_{tot}} \cdot \underbrace{\left[\frac{r_€}{r_{tot}} \cdot \tau + \frac{E_x r_\$}{r_{tot}} \cdot 1\right]^{-1}}_{A \in [0,1]} = XS \cdot A$$

where: $\quad A \to 1$ if $\tau \to 1$ and $A \to 0$ if $\tau \to \infty$

Wedge Factor for Profits

$$\frac{\Delta \pi}{\pi} = \sigma \cdot \frac{E_x \pi_\$}{\pi_{tot}} \cdot \frac{\Delta E_x}{E_x} - (\sigma - 1) \cdot IS \cdot \frac{dE_i}{dE_x} \frac{E_x}{E_i} \cdot \frac{\Delta E_x}{E_x}$$

$$+ \underbrace{\frac{\pi_€}{\pi_{tot}} \cdot \frac{\Delta Q_€ P_€^\sigma}{Q_€ P_€^\sigma} + \frac{E_x \pi_\$}{\pi_{tot}} \cdot \frac{\Delta Q_\$ P_\$^\sigma}{Q_\$ P_\$^\sigma}}_{\widehat{\epsilon}_\pi}$$

Using:

$$E_x c_\$ = E_x r_\$ \cdot \frac{1}{\mu \tau}$$

$$c_{tot} = r_€ \cdot \frac{1}{\mu} + E_x r_\$ \cdot \frac{1}{\mu \tau}$$

$$\Rightarrow \frac{E_x \pi_\$}{\pi_{tot}} = \frac{E_x r_\$ - E_x c_\$}{r_{tot} - c_{tot}} = \frac{E_x r_\$ \left(1 - \frac{1}{\mu \tau}\right)}{r_{tot} - \left(E_x r_\$ \frac{1}{\mu \tau} + r_€ \frac{1}{\mu}\right)}$$

$$= \frac{E_x r_\$}{r_{tot}} \cdot \underbrace{\frac{\mu \tau - 1}{\mu \tau - \left(\frac{E_x r_\$}{r_{tot}} \cdot 1 + \frac{r_€}{r_{tot}} \cdot \tau\right)}}_{B \in [1,\infty]} = XS \cdot B$$

where: $\quad B \to 1$ if $\tau \to 1$ and $B \to \left[1 - \frac{r_€}{r_{tot}} \frac{1}{\mu}\right]^{-1} > 1$ if $\tau \to \infty$

The Structural Error for Real Exchange Rates - Costs

$$\bar{\epsilon}_c = (1 - XS \cdot A) \cdot \frac{\Delta Q_{€} P_{€}^{\sigma}}{Q_{€} P_{€}^{\sigma}} + XS \cdot A \cdot \frac{\Delta Q_{\$} P_{\$}^{\sigma}}{Q_{\$} P_{\$}^{\sigma}} \\ + \sigma \cdot A \cdot XS \cdot \frac{\Delta \widehat{P}}{\widehat{P}} - (\sigma - 1) \cdot IS \cdot \frac{\Delta \widehat{P}}{\widehat{P}} \tag{A.3}$$

The Structural Error for Real Exchange Rates - Profits

$$\bar{\epsilon}_\pi = (1 - XS \cdot B) \cdot \frac{\Delta Q_{€} P_{€}^{\sigma}}{Q_{€} P_{€}^{\sigma}} + XS \cdot B \cdot \frac{\Delta Q_{\$} P_{\$}^{\sigma}}{Q_{\$} P_{\$}^{\sigma}} \\ + \sigma \cdot B \cdot XS \cdot \frac{\Delta \widehat{P}}{\widehat{P}} - (\sigma - 1) \cdot IS \cdot \frac{\Delta \widehat{P}}{\widehat{P}} \tag{A.4}$$

A.2 Data Appendix

Table A.1: The Currency Basket

EFIGE Area	Partner Country	Currency
EU15	Austria	Euro
EU15	Belgium	Euro
EU15	Denmark	Danish krone
EU15	Finland	Euro
EU15	France	Euro
EU15	Germany	Euro
EU15	Greece	Euro
EU15	Ireland	Euro
EU15	Italy	Euro
EU15	Luxembourg	Euro
EU15	Netherlands	Euro
EU15	Portugal	Euro
EU15	Spain	Euro
EU15	Sweden	Swedish krona
EU15	United Kingdom	Pound sterling
OTHER EU COUNTRIES	Bulgaria	Bulgarian lev
OTHER EU COUNTRIES	Czech Republic	Czech koruna
OTHER EU COUNTRIES	Hungary	Hungarian forint
OTHER EU COUNTRIES	Poland	Polish zloty
OTHER EU COUNTRIES	Romania	Romanian leu
OTHER EUROPEAN COUNTRIES NOT EU	Croatia	Croatian kuna
OTHER EUROPEAN COUNTRIES NOT EU	Norway	Norwegian krone
OTHER EUROPEAN COUNTRIES NOT EU	Russian Federation	Russian rouble
OTHER EUROPEAN COUNTRIES NOT EU	Switzerland	Swiss franc
OTHER EUROPEAN COUNTRIES NOT EU	Turkey	Turkish lira
CHINA AND INDIA	China	Renminbi-yuan
CHINA AND INDIA	Hong Kong, China	Hong Kong dollar
CHINA AND INDIA	India	Indian rupee
OTHER ASIAN COUNTRIES	Indonesia	Indonesian rupiah
OTHER ASIAN COUNTRIES	Israel	Israeli shekel
OTHER ASIAN COUNTRIES	Japan	Japanese yen
OTHER ASIAN COUNTRIES	Korea, Rep.	South Korean won
OTHER ASIAN COUNTRIES	Malaysia	Malaysian ringgit
OTHER ASIAN COUNTRIES	Philippines	Philippine peso
OTHER ASIAN COUNTRIES	Singapore	Singapore dollar
OTHER ASIAN COUNTRIES	Thailand	Thai baht
USA AND CANADA	Canada	Canadian dollar
USA AND CANADA	United States	US dollar
CENTRAL AND SOUTH AMERICA	Brazil	Brazilian real
CENTRAL AND SOUTH AMERICA	Mexico	Mexican peso
OTHER AREAS	South Africa	South African rand
dropped due to missing price data	Australia	Australian dollar
dropped due to missing price data	New Zealand	New Zealand dollar
dropped due to missing price data	Serbia	Serbian dinar
dropped due to missing price data	Argentina	Argentine peso
dropped due to missing trade data	Iceland	Icelandic krona
dropped due to missing trade data	Macedonia	Denar (of the former Yugoslav Republic of Macedonia)
dropped due to missing trade data	Taiwan	New Taiwan dollar

Notes: I use bilateral nominal exchange rates with respect to the Euro from Eurostat [ert_bil_eur_m]. These are matched with seasonally adjusted CPI price data from World Bank's Global Economic Monitor [CPTOTSAXN] in order to construct real exchange rates with respect to the Euro, the Pound Sterling and the Hungarian Forint. Eurostat provides bilateral exchange rates with respect to the EURO for 36 currencies. I can match 32 of these currencies with the CPI data, loosing the Australian Dollar, the New Zealand Dollar, the Serbian Dinar and the Argentine Peso due to missing price data for the base month January 2004. Matching the combined exchange rate and price data with trade data leads to the loss of three additional currencies, the Icelandic Krona, the Macedonian Denar and the New Taiwan Dollar. The reason is that I want to keep the set of countries feeding into the weighting of exchange rates to be relatively constant across all industries and I want them to be the same for both export and import flows. As trade flows are a crucial determinant in the effective exchange rate construction, they also determine the co-movement of effective exchange rates. I therefore need to make sure that it is not missing data that is driving my results. Thus, I drop industries when too many countries are missing for those industries and I drop countries with two many missing industries. This results in a set of 29 currencies other than the Euro, plus 12 distinct real Euro exchange rates.

Table A.2: Description of Variables

variable	description
XS_{csi}	Percentage of annual turnover represented by exports (2008, *EFIGE*).
IS_{csi}	Percentage of intermediate goods purchased from abroad (2008, *EFIGE*).
$importer_{csi\kappa}$	Indicator equal to 1 if percentage of intermediate goods purchased from area κ larger than zero (2008, *EFIGE*).
$exporter_{csi\kappa}$	Indicator equal to 1 if percentage of exports sold to area κ larger than zero (2008, *EFIGE*).
FH_{csi}	Indicator equal to 1 if firm uses foreign exchange risk protection (2008, *EFIGE*).
$Sales_{csit}$	turnover in th. EUR (*Amadeus*), if missing: costs of goods sold - costs of employees in th. EUR (Amadeus).
$Materialcost_{csit}$	material cost in th. EUR (*Amadeus*)
$Profits_{csit}$	gross profit in th. EUR (*Amadeus*), if missing: turnover - costs of goods sold in th. EUR (Amadeus).
$Assets_{csit}$	total assets in th. EUR (*Amadeus*).
μ_{csit}	turnover / (cost of employees + material cost) in th. EUR (*Amadeus*). Alternative measures used: (turnover - cost of employees - material cost) /turnover in th. EUR (*Amadeus*) , $EMS^{2008}_{cs\kappa}$: $XS_{cs\kappa} * Sales^{2008}_{cs\kappa}$/ (total sectoral imports of the outside world (*WITS/Comtrade), see Marin et al. (2014) for detailed information*).
$R^{f}_{cs\kappa t}$ with $f \in x, i, xi$	Export weighted (x), intermediate input weighted (i) or export and import weighted (xi) real effective exchange rate specific to country c, sector s and area κ. If the κ is omitted, the weighting is done with respect to the whole world. See section 4 for detailed information.
$E^{f}_{cs\kappa t}$ with $f \in x, i, xi$	Export weighted (x), intermediate input weighted (i) or export and import weighted (xi) nominal effective exchange rate specific to country c, sector s and area κ. If the κ is omitted, the weighting is done with respect to the whole world. See section 4 for detailed information.
$Proj^{didx}_{cs\kappa}$	Elasticity of the monthly intermediate import weighted with respect to the export weighted exchange rate, measured over the full sample period. Real or nominal in accordance with the exchange rate measure used and specific to country c, sector s and area κ. If the κ is omitted, the weighting is done with respect to the whole world. $\widehat{Proj}^{didx}_{cs\kappa}$ is the corresponding measure demeaned for the sample. See section 4 for detailed information.
$\widehat{corr}_{cs\kappa}$	Simple correlation coefficient between the monthly intermediate import weighted and the export weighted exchange rate, demeaned for the regression sample and measured over the full sample period. Real or nominal in accordance with the exchange rate measure used and specific to country c, sector s and area κ.
$sd(R^{xi}_{cs\kappa t})_{cs\kappa}$	Standard deviation of the monthly intermediate import and export weighted real effective exchange rate specific to country c, sector s and area κ and measured over the full sample period.
$sd(E^{xi}_{cs\kappa t})_{cs\kappa}$	Standard deviation of the monthly intermediate import and export weighted nominal effective exchange rate specific to country c, sector s and area κ and measured over the full sample period.
$reg.\ io\text{-}import\ share_{cs\kappa}$	Share of region κ in all industry s intermediate imports into country c. Import data at the 2-digit level (ISIC Rev. 3) from *WITS/Comtrade*, linked to output industries via the IO-table from *OECD Stan*.
$reg.\ final\text{-}export\ share_{cs\kappa}$	Share of region κ in all industry s final good exports from country c. Export data at the 4-digit level (ISIC Rev. 3) from *WITS/Comtrade*.
$rel.\ io\text{-}wage\ (p.C.)_{cs\kappa}$	Wage per Employee (INDSTAT, ISIC Rev. 3, 2-digit) in region κ relative to Wage per Employee in country c. Relative wage is input-industry specific, where input industries have been linked to output industries via the IO-table from *OECD Stan*.
$rel.\ io\text{-}lab.prod._{cs\kappa}$	Value Added per Employee (INDSTAT, ISIC Rev. 3, 2-digit) in region κ relative to Value Added per Employee in country c. Relative labor productivity is input-industry specific, where input industries have been linked to output industries via the IO-table from *OECD Stan*.
$Grubel\text{-}Lloyd_{cs\kappa}$	$1 - \frac{\lvert EX_{cs\kappa} - IM_{cs\kappa}\rvert}{EX_{cs\kappa} + IM_{cs\kappa}}$, where $EX_{cs\kappa}$ are final good export flows from country c to area κ in industry s (*WITS/Comtrade*) at the 4-digit level (ISIC Rev. 3) and $IM_{cs\kappa}$ are corresponding final good import flows from region κ into country c.

Table A.3: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
	Summary Statistics for Section 5				
$\Delta log(Sales_{csit})$	60174	0.00	0.22	-0.75	0.66
$\Delta log(Materialcosts_{csit})$	60174	0.00	0.34	-1.15	1.04
$\Delta log(Profits_{csit})$	60174	-0.01	0.38	-1.51	1.20
			real		
$\Delta log R^{x}_{cst}$	60174	0.00	0.02	-0.10	0.14
$\widehat{Proj}^{didx}_{cs}$	60174	0.00	0.16	-0.51	0.67
$\widehat{Proj}^{didx}_{cs} > 0$	60174	0.43	0.50	0.00	1.00
$Proj^{didx}_{cs}$	60174	0.86	0.16	0.35	1.53
			nominal		
$\Delta log E^{x}_{cst}$	60174	0.00	0.02	-0.06	0.14
$\widehat{Proj}^{didx}_{cs}$	60174	0.00	0.14	-0.37	0.61
$\widehat{Proj}^{didx}_{cs} > 0$	60174	0.45	0.50	0.00	1.00
$Proj^{didx}_{cs}$	60174	0.65	0.14	0.28	1.25
IS_{csi}	60174	0.13	0.23	0.00	1.00
XS_{csi}	60174	0.19	0.27	0.00	1.00
μ_{csit}	60174	1.53	0.38	1.00	3.55
$\Delta log(Assets_{csit})$	60174	0.03	0.18	-0.51	0.61
FH_{csi}	60174	0.10	0.30	0.00	1.00
	Summary Statistics for Section 6				
$importer_{csi\kappa}$	86934	0.10	0.30	0.00	1.00
$exporter_{csi\kappa}$	86934	0.21	0.41	0.00	1.00
			real		
$sd(X^{xi}_{cs\kappa t})_{cs\kappa}$	86934	0.10	0.05	0.01	0.35
$\widehat{Proj}^{didx}_{cs\kappa}$	86934	0.00	0.16	-0.82	0.79
$Proj^{didx}_{cs\kappa}$	86934	0.98	0.16	0.16	1.77
$\widehat{Proj}^{didx}_{cs\kappa} > 0$	86934	0.46	0.50	0.00	1.00
$\widehat{corr}_{cs\kappa}$	86934	0.00	0.08	-0.86	0.05
			nominal		
$sd(X^{xi}_{cs\kappa t})_{cs\kappa}$	86934	0.09	0.05	0.00	0.25
$\widehat{Proj}^{didx}_{cs\kappa}$	86934	0.00	0.20	-1.18	0.87
$Proj^{didx}_{cs\kappa}$	86934	0.93	0.20	-0.25	1.81
$\widehat{Proj}^{didx}_{cs\kappa} > 0$	86934	0.41	0.49	0.00	1.00
$\widehat{corr}_{cs\kappa}$	86934	0.00	0.16	-1.08	0.11
$reg.\ io\text{-}import\ share_{cs\kappa}$	86934	0.12	0.20	0.00	0.75
$reg.\ final\text{-}export\ share_{cs\kappa}$	86934	0.13	0.19	0.00	0.94
$rel.\ io\text{-}wage\ (p.C.)_{cs\kappa}$	86934	0.59	0.56	0.04	5.86
$rel.\ io\text{-}lab.prod._{cs\kappa}$	86934	0.88	0.95	0.12	12.54
$Grubel\text{-}Lloyd_{cs\kappa}$	86934	0.52	0.29	0.00	1.00

Notes: Table provides selected summary statistics for the variables used in sections 5 and 6. For a definition of variables, see table A.2. $\Delta log(Sales_{csit})$, $\Delta log(Materialcosts_{csit})$, $\Delta log(Profits_{csit})$, $\Delta log(Assets_{csit})$ and μ_{csit} are winsorized at the 1%-level in order to normalize the error distribution. The results presented are robust to using the non-winsorized variables.

Table A.4: Summary Statistics - Key Variables (by Area)

Area	#c	Obs	Mean	Std. Dev.	Mean	Std. Dev.
				$importer_{csi\kappa}$		$exporter_{csi\kappa}$
EU15	14	11078	0.35	0.48	0.48	0.50
OTHER EU COUNTRIES	5	10799	0.09	0.29	0.23	0.42
OTHER EUROPEAN COUNTRIES NOT EU	5	10913	0.07	0.26	0.25	0.43
CHINA AND INDIA	3	10755	0.11	0.31	0.12	0.33
OTHER ASIAN COUNTRIES	8	10789	0.05	0.22	0.14	0.35
USA AND CANADA	2	10812	0.07	0.25	0.19	0.39
CENTRAL AND SOUTH AMERICA	2	10927	0.02	0.13	0.12	0.32
OTHER AREAS	1	10861	0.02	0.14	0.15	0.36
CHINA, INDIA + OTHER	4	10755	0.12	0.32	0.21	0.41
AMERICA	4	10812	0.08	0.27	0.22	0.42

Area	#c	Obs	Mean	Std. Dev.	Min	Max
					$sd(R^{xi}_{cs\kappa t})_{cs\kappa}$	
EU15	14	11078	0.02	0.02	0.01	0.09
OTHER EU COUNTRIES	5	10799	0.08	0.02	0.05	0.14
OTHER EUROPEAN COUNTRIES NOT EU	5	10913	0.08	0.02	0.05	0.14
CHINA AND INDIA	3	10755	0.13	0.02	0.11	0.18
OTHER ASIAN COUNTRIES	8	10789	0.09	0.02	0.07	0.15
USA AND CANADA	2	10812	0.06	0.01	0.05	0.10
CENTRAL AND SOUTH AMERICA	2	10927	0.13	0.03	0.06	0.23
OTHER AREAS	1	10861	0.12	0.00	0.12	0.13
CHINA, INDIA + OTHER	4	10755	0.12	0.02	0.09	0.17
AMERICA	4	10812	0.06	0.01	0.05	0.12

Area	#c	Obs	Mean	Std. Dev.	Min	Max	Corr
					$\widehat{Proj}^{didx}_{cs\kappa}$		
EU15	14	11078	-0.13	0.11	-0.49	0.12	0.96
OTHER EU COUNTRIES	5	10799	0.00	0.04	-0.23	0.08	0.98
OTHER EUROPEAN COUNTRIES NOT EU	5	10913	-0.14	0.06	-0.36	0.04	0.93
CHINA AND INDIA	3	10755	0.19	0.07	-0.06	0.45	0.96
OTHER ASIAN COUNTRIES	8	10789	-0.12	0.10	-0.34	0.12	0.86
USA AND CANADA	2	10812	0.01	0.02	-0.09	0.07	0.99
CENTRAL AND SOUTH AMERICA	2	10927	0.17	0.23	-0.82	0.79	0.86
OTHER AREAS	1	10861	0.01	0.00	0.01	0.01	1.00
CHINA, INDIA + OTHER	4	10755	0.23	0.09	-0.36	0.49	0.93
AMERICA	4	10812	-0.05	0.12	-0.43	0.42	0.87

Notes: Table provides selected summary statistics for the key variables used in section 6 by area. Areas are either the original EFIGE area groups or regrouped in order to increase the number of countries (#c) per area group. Specifically, China & India are grouped together with Other Areas, and USA & Canada are grouped together with Central & South America. *Corr* is the correlation coefficient that relates to each projection coefficient. For a definition of the variables, see table A.2. For the countries in each area, see table A.1.

Table A.5: Robustness

	$Sales_{csit}$								$\Delta logE^x_{cst}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta logR^x_{cst}$	-0.161*	0.0456	-0.150	-0.123					-0.167	
	(0.0962)	(0.126)	(0.160)	(0.368)					(0.149)	
$\Delta logR^x_{cst} \times XS_{csi}$	0.859***	0.872***	0.856***	0.859***	0.760***	0.758***	0.731***	0.760***	0.894***	0.737***
	(0.165)	(0.165)	(0.172)	(0.165)	(0.217)	(0.217)	(0.215)	(0.217)	(0.162)	(0.210)
$\Delta logR^x_{cst} \times IS_{csi}$	0.160	0.662**	0.158	2.683**	0.551**	1.083***	0.537**	2.639**	0.178	0.540**
	(0.189)	(0.290)	(0.189)	(1.045)	(0.211)	(0.318)	(0.210)	(1.218)	(0.192)	(0.218)
$\Delta logR^x_{cst} \times IS_{csi} \times f(Proj^{didx}_{cs})$	-2.939***	-1.028***	-2.934***	-2.939***	-2.432*	-1.077***	-2.400*	-2.432*	-1.424*	-1.435**
	(1.121)	(0.359)	(1.124)	(1.121)	(1.283)	(0.369)	(1.280)	(1.283)	(0.738)	(0.708)
$\Delta logR^x_{cst} \times FH_{csi}$			-0.0113				-0.117			
			(0.137)				(0.108)			
Measure of Co-movement	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$	$\widehat{Proj}^{didx}_{cs}$	$Proj^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$	$\widehat{Proj}^{didx}_{cs}$	$Proj^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs}$
μ_{csit}	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
$\Delta log(Assets_{csit})$	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Fixed Effects	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_{cst}$
Cluster (Firm)	yes	yes	yes	yes	no	no	no	no	yes	no
Cluster (Sector#Country)	no	no	no	no	yes	yes	yes	yes	no	yes
Nr. of Clusters	8641	8641	8641	8641	153	153	153	153	8641	153
Adj. R2	0.314	0.314	0.314	0.314	0.343	0.343	0.343	0.343	0.314	0.343
Observations	59,747	59,747	59,747	59,747	59,491	59,491	59,491	59,491	59,747	59,491

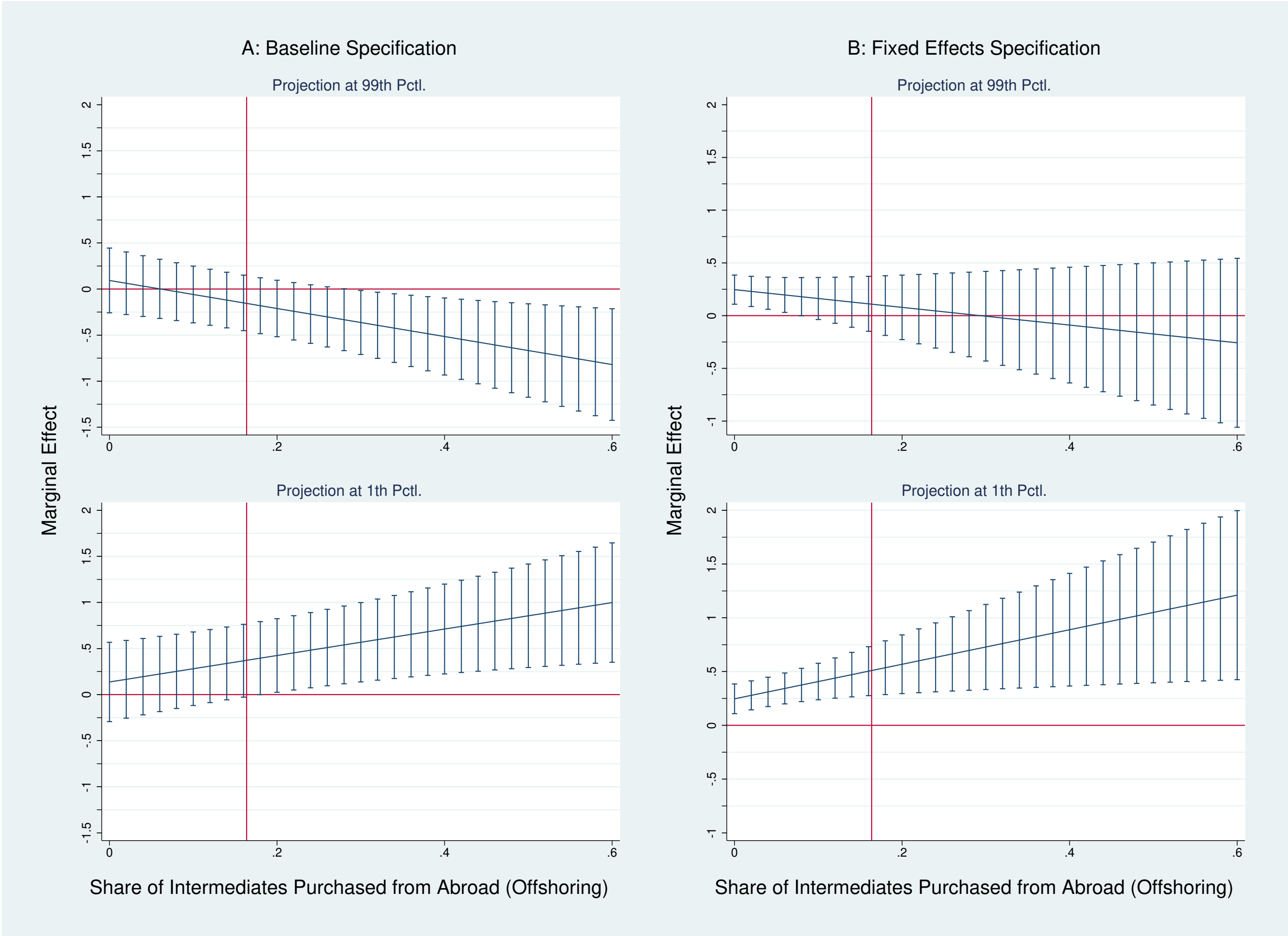
Notes: Observations relate to firm i in year t, where firms are based in country c and active in sector s. The dependent variable $Sales_{csit}$ represents total sales of firm i in year t. $\Delta logR^x_{cst}$ are annual log-changes of the country and sector specific export weighted real effective exchange rate. XS_{csi} and IS_{csi} denote the firm specific export and import share respectively. $\widehat{Proj}^{didx}_{cs}$ is a demeaned version of $Proj^{didx}_{cs}$, the elasticity of the import weighted with respect to the export weighted real effective exchange rate. In specifications (9) and (10), the real effective exchange rate is replaced by the nominal effective exchange rate E^x_{cst}, and the measure of co-movement is constructed accordingly. FH_{csi} is a dummy variable indicating whether firm i is using financial hedges. μ_{csit} is a markup control defined in the appendix. $\Delta log(Assets_{csit})$ is the log-change in total assets. γ_{cs} are country-sector fixed effects, γ_t are year fixed effects, γ_i are firm fixed effects and γ_{cst} are country-sector-year fixed effects. The sector level is defined at the 2-digit US SIC level. All specifications contain the full set of relevant sub-interaction terms and level effects. Standard errors are clustered either at the firm level or at the country-sector level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A.6: Extension

	$Materialcost_{csit}$				$Profits_{csit}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta log R^x_{cst}$	0.248*	0.625***			-0.0407	0.422**		
	(0.147)	(0.200)			(0.153)	(0.213)		
$\Delta log R^x_{cst} \times XS_{csi}$	0.729***	0.748***	0.593*	0.589*	1.327***	1.336***	1.368***	1.369***
	(0.242)	(0.242)	(0.317)	(0.318)	(0.287)	(0.286)	(0.363)	(0.363)
$\Delta log R^x_{cst} \times IS_{csi}$	-0.0275	0.576	0.685**	1.296***	-0.0717	-0.257	0.0892	-0.0699
	(0.305)	(0.464)	(0.304)	(0.413)	(0.327)	(0.496)	(0.337)	(0.584)
$\Delta log R^x_{cst} \times IS_{csi} \times f(Proj^{didx}_{cs})$	-2.605	-1.112*	-2.376	-1.195**	-0.359	0.311	-0.0534	0.243
	(1.679)	(0.580)	(1.861)	(0.540)	(1.825)	(0.617)	(1.702)	(0.666)
Measure of Co-movement	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$	$\widehat{Proj}^{didx}_{cs}$	$\widehat{Proj}^{didx}_{cs} > 0$
μ_{csit}	yes	yes	yes	yes	yes	yes	yes	yes
$\Delta log(Assets_{csit})$	yes	yes	yes	yes	yes	yes	yes	yes
Fixed Effects	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_t$	$\gamma_i + \gamma_{cst}$	$\gamma_i + \gamma_{cst}$
Cluster (Firm)	yes	yes	no	no	yes	yes	no	no
Cluster (Sector#Country)	no	no	yes	yes	no	no	yes	yes
Nr. of Clusters	8641	8641	153	153	8641	8641	153	153
Adj. R2	0.219	0.219	0.244	0.244	0.218	0.218	0.230	0.230
Observations	59,747	59,747	59,491	59,491	59,747	59,747	59,491	59,491

Notes: Observations relate to firm i in year t, where firms are based in country c and active in sector s. The dependent variables $Materialcost_{csit}$ and $Profits_{csit}$ represent total ma sales of firm i in year t. $\Delta log R^x_{cst}$ are annual log-changes of the country and sector specific real effective exchange rate. XS_{csi} and IS_{csi} denote the firm specific export and import share respectively. $\widehat{Proj}^{didx}_{cs}$ is the elasticity of the import weighted with respect to the export weighted real effective exchange rate. μ_{csit} is a markup control defined in the appendix. $\Delta log(Assets_{csit})$ is the log-change in total assets. γ_{cs} are country-sector fixed effects, γ_t are year fixed effects, γ_i are firm fixed effects and γ_{cst} are country-sector-year fixed effects. The sector level is defined at the 2-digit US SIC level. All specifications contain the full set of relevant sub-interaction terms and level effects. Standard errors are clustered either at the firm level or at the country-sector level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure A.1: Marginal Effects for Different Levels of Offshoring



Notes: The figure depicts marginal effects for different levels of offshoring (IS), evaluated for the average exporting firm ($TS = 0.32$) and, respectively, at the 1st and 99th percentile of the sample distribution of $\widehat{Proj}_{cs}^{didx}$, i.e. the measure of co-movement between export and import weighted real effective exchange rates. All remaining variables are evaluated at the mean. The vertical red line denotes the average share of imported intermediates among all exporting firms in the sample ($IS = 0.16$). The confidence level, depicted by vertical bars along the margins-line, is set to 95%. Panel A represents specification (5) and panel B specification (7) from table 1.

Table A.7: Area Robustness

	$importer_{csi\kappa}$									
	Real: $R^{x}_{cs\kappa t}$					Nominal: $E^{x}_{cs\kappa t}$				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$exporter_{csi\kappa}$	0.0755***	0.137**	0.0903***	0.0700***	0.0675***	0.0459***	0.171***	0.0596***	0.0638***	0.0575***
	(0.0168)	(0.0536)	(0.0163)	(0.0153)	(0.0173)	(0.0127)	(0.0315)	(0.0130)	(0.0140)	(0.0128)
$exporter_{csi\kappa} \times sd(X^{xi}_{cs\kappa t})_{cs\kappa}$	-0.890***	-2.741***	-1.148***	-0.664***	-0.428***	-0.838***	-3.545***	-0.990***	-0.850***	-0.533***
	(0.110)	(0.412)	(0.128)	(0.0871)	(0.120)	(0.0890)	(0.439)	(0.0902)	(0.101)	(0.0974)
$exporter_{csi\kappa} \times sd(X^{xi}_{cs\kappa t})_{cs\kappa} \times f(Proj_{cs\kappa})$	1.886***	1.886***	1.024***	-2.428	0.0609	2.893***	2.893***	1.055***	0.798	1.191*
	(0.414)	(0.414)	(0.172)	(1.560)	(0.546)	(0.447)	(0.447)	(0.185)	(0.753)	(0.608)
$exporter_{csi\kappa} \times f(Proj_{cs\kappa})$	-0.0630	-0.0630	-0.0893***	0.430***	0.0817	-0.134***	-0.134***	-0.0855***	0.0362	-0.0175
	(0.0587)	(0.0587)	(0.0190)	(0.166)	(0.0768)	(0.0324)	(0.0324)	(0.0172)	(0.0504)	(0.0473)
Measure of Co-movement	$\widehat{Proj}^{didx}_{cs\kappa}$	$Proj^{didx}_{cs\kappa}$	$\widehat{Proj}^{didx}_{cs\kappa} > 0$	$\widehat{corr}_{cs\kappa}$	$\widehat{Proj}^{didx}_{cs\kappa}$	$\widehat{Proj}^{didx}_{cs\kappa}$	$Proj^{didx}_{cs\kappa}$	$\widehat{Proj}^{didx}_{cs\kappa} > 0$	$\widehat{corr}_{cs\kappa}$	$\widehat{Proj}^{didx}_{cs\kappa}$
$exporter_{csi\kappa} \times controls_{cs\kappa}$	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Fixed Effects	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$	$\gamma_{cs\kappa} + \gamma_i$
Cluster (Firm)	11225	11225	11225	11225	10989	11225	11225	11225	11225	10989
Cluster (Sector#Country#Area)	1008	1008	1008	1008	756	1008	1008	1008	1008	756
Adj. R2	0.335	0.335	0.336	0.335	0.244	0.336	0.336	0.336	0.335	0.245
Observations	86,934	86,934	86,934	86,934	64,841	86,934	86,934	86,934	86,934	64,841

Notes: Observations relate to firm i in area κ, where firms are based in country c and active in sector s. The dependent variable $importer_{csi\kappa}$ is an indicator equal to one if the firm is sourcing intermediates from region κ. $exporter_{csi\kappa}$ is an indicator equal to one if the firm is exporting to region κ. $X^{xi}_{cs\kappa t} \in R, E$ is either the real or the nominal real effective exchange rate in area κ at time t. $sd(X^{xi}_{cs\kappa t})_{cs\kappa}$ is the standard deviation of the monthly export and import weighted, area κ specific real or nominal effective exchange rate, measured over the full sample period. $\widehat{Proj}^{didx}_{cs\kappa}$ is the demeaned elasticity of the import weighted with respect to the export weighted area κ specific real or nominal effective exchange rate $Proj^{didx}_{cs\kappa}$. $\widehat{corr}_{cs\kappa}$ is the demeaned correlation coefficient between the import weighted and the export weighted real or nominal effective exchange rate. $controls_{cs\kappa}$ include: 1. *reg. final-export share*$_{cs\kappa}$ is the share of final good exports to area κ in all final good exports (4-digit). 2. *rel. io-wage* $(p.C.)_{cs\kappa}$ is the wage per employee in intermediate input industries in area κ relative to country c (2-digit). 3. *rel. io-lab.prod.*$_{cs\kappa}$ is the value added per employee in intermediate input industries in area κ relative to country c (2-digit). 4. *Grubel-Lloyd*$_{cs\kappa}$ is the Grubel-Lloyed Index of industry s for trade with area κ (4-digit). γ_κ are area fixed effects, γ_i are firm fixed effects and $\gamma_{cs\kappa}$ are country-sector-area fixed effects. The sector level is defined at the 2-digit US SIC level. Specification (5) and (10) exclude the EU15 area and Other Asia Countries. Standard errors are clustered at the firm level and at the sector-country-area level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$