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Corporate investment and the exchange rate: The financial channel[1]

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Abstract

Currency depreciation dampens corporate investment through a financial channel. Using firm-level data for 16 major economies, we find that depreciation reduces investment by interacting with firm leverage. The finding is consistent with predictions from a stylized model of credit risk in which the exchange rate affects credit supply and investment when firms borrow in foreign currency, or in local currency from foreign lenders. Empirically, the channel is significantly more pronounced in emerging market economies (EMEs), reflecting greater dependence on foreign funding and less developed financial systems. Our findings suggest that the depreciation of EME currencies since 2011 probably contributed in a significant way to the investment slowdown in these economies.

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Key words: corporate investment, emerging markets, exchange rates, financial channel, financial constraints.

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1. Introduction

There is a growing body of literature examining the financial channel of the exchange rate in emerging market economies (EMEs), which operates through currency mismatches on borrower or lender balance sheets (e.g. Bruno and Shin, 2015; Avdjiev et al., 2019; Hofmann et al., 2020).[3] Due to these mismatches, currency depreciation can tighten financial conditions and dampen economic activity, particularly investment. This effect can overshadow the classical trade channel where depreciation boosts international competitiveness and thus investment.[4] The financial channel of the exchange rate may hence give rise to difficult trade-offs for monetary policy, as exchange-rate movements can push inflation and output in opposite directions (BIS, 2019). Moreover, the relevance of the channel for corporate investment is of particular importance because investment is a key determinant of long-run economic growth.

In this paper, we fill a gap in the literature by assessing empirically the financial channel of the exchange rate based on firm-level data from both advanced economy (AE) and EME firms. Specifically, we analyze the effect of the exchange rate on business investment in six major AEs (Canada, France, Germany, Italy, Japan and the United Kingdom) as well as in ten major EMEs (Brazil, Chile, India, Indonesia, Korea, Malaysia, Mexico, Russia, South Africa and Thailand). The analysis draws on annual firm-level data from Worldscope for the period 2000–19, with nearly 240,000 firm-year observations.

In our analysis of the financial channel of the exchange rate, the interaction between the exchange rate and firm leverage plays a key role.[5] We hypothesize that

[3] Many EMEs rely heavily on borrowing foreign currency or on borrowing their local currency from foreign lenders, reflecting in part a less developed domestic institutional investor base (Carstens and Shin, 2019; Committee on the Global Financial System, 2019; BIS, 2019). In addition, markets to hedge exchange rate risk are thinner so that hedging is more difficult and more costly (Upper and Valli, 2016). While little is known about the extent of foreign exchange (FX) hedging in practice, there are indications that hedging of FX positions in EMEs is limited and often completely absent (Chui et al., 2014). As a result, adverse financial effects of exchange rate fluctuations may result from valuation effects on borrower or lender balance sheets which influence credit supply (BIS, 2019).

[4] In the classical Mundell-Fleming model (Mundell, 1963; Fleming, 1962), a depreciation of the exchange rate boosts export competitiveness and hence production, which could also lead to an increase in firms' investment. A more direct and immediate effect stems from export revenues. Exchange rate depreciation would immediately raise export revenues and hence firm cash flow, which would expand the investment capacity of firms (e.g. Dao et al., 2017). In our analysis, we focus on the latter effect, but we also consider the former in a robustness check in Appendix 2.

[5] As such, our paper is in line with the growing recent literature which considers the presence of nonlinearities in firm-level financial data in explaining credit risk (see Ben Cheikh et al., 2021).

when the financial channel is at work, exchange rate changes affect the investment spending of firms through their leverage. Specifically, when the local currency weakens, firms that are more highly indebted, and hence financially more vulnerable, are more affected and reduce investment more than less indebted firms. This hypothesis is consistent with the predictions of a stylized credit risk model in which the exchange rate affects credit supply because firms borrow in foreign currency or in local currency from foreign lenders.

The empirical analysis yields the following results. First, currency depreciation dampens corporate investment through firms' leverage, supporting the presence of a financial channel of the exchange rate. Second, the effect is significantly stronger for EME corporates than for corporates in AEs. This finding is in line with the notion that EMEs are more exposed to the financial channel as a consequence of greater dependence on borrowing from abroad and less developed financial markets. Finally, our estimates imply that, through the financial channel of the exchange rate, the large depreciation of EME currencies against major funding currencies has probably contributed in a significant way to the investment slowdown in EMEs over the past decade or so.

The remainder of the paper is structured as follows. The next section provides a short review of the relevant literature. Section 3 develops a simple credit risk model with a financial channel of the exchange rate. Section 4 describes the data. In Section 5, we present the empirical methodology and the estimation results. Section 6 concludes.

2. Literature review

The analysis of this paper contributes to various strands of the literature. First, we contribute to the emerging literature on financial effects of the exchange rate on corporate investment. Kalemli-Ozcan et al. (2016) find that domestic firms with large unhedged foreign currency liabilities cut investment by more when a currency crisis was accompanied by a banking crisis. Avdjiev et al. (2019) show that a broad-based appreciation of the US dollar has a dampening impact on both cross-border bank flows and on real investment activity in EMEs. Kearns and Patel (2016) document that an appreciation of the domestic currency against funding currencies boosts economic activity, particularly investment. Dao et al. (2017) present evidence suggesting that a depreciation of the real exchange rate boosts investment of tradable-sector firms by improving their internal financing opportunities through higher export revenues. Brito et al. (2018) find that the effect of real exchange-rate appreciation on investment depends on the degree of economic complexity. Structurally less complex, and therefore capital importing countries register a positive effect of exchange-rate appreciation as this lowers the cost of imported capital.

In addition to the impact on corporate investment, some studies have examined other aspects of the financial channel of the exchange rate. Bruno and Shin (2015) show that cross-border banking flows are positively associated with an appreciation of the domestic currency, consistent with a risk-taking channel. Hofmann et al. (2020) find that an appreciation of EME currencies against the US dollar leads to an easing of domestic financial conditions by lowering the credit risk-spread component of local currency sovereign bonds. Kalemli-Ozcan et al. (2018) find that exchange-rate appreciation is associated with higher risk taking by more indebted firms. Bruno and Shin (2019) document that US dollar appreciation leads Mexican banks to reduce credit supply to exporting firms.

Finally, our analysis ties in with studies that have analyzed the determinants of investment in EMEs more generally. Magud and Sosa (2015) find that investment of EME firms is positively related to firm-level expected future profitability, cash flows and debt flows, and is negatively associated with firm-level leverage. Kose et al. (2017) analyze the investment slowdown in EMEs after the Great Financial Crisis (GFC) using aggregate data. They find that the slowdown has been related, among other factors, to negative terms-of-trade shocks, declining foreign direct investment inflows, and adverse spillovers from major advanced economies.

3. Model

In this section, we develop a simple theoretical model which links corporate investment to the exchange rate and generates key predictions for the subsequent empirical analysis. Appendix 1 provides a more detailed exposition of the model with detailed derivations of the model equations, while the remainder of this section sketches the main elements and results.

The model builds on Bruno and Shin (2015), which is in turn based on the credit risk models of Merton (1974) and Vasicek (2002). The model of Bruno and Shin (2015) features credit risk and corporate borrowing in foreign currency, which introduces a role for the exchange rate in the determination of credit supply. We extend this model along two dimensions. First, we include a trade channel of the exchange rate. Second, we consider different scenarios for the currency-denomination of corporate borrowing from abroad: (i) corporates borrow in foreign currency, as in Bruno and Shin (2015); (ii) corporates borrow in local currency from foreign lenders; and (iii) corporates do not directly borrow from abroad but global bond investors' portfolio adjustments affect domestic benchmark interest rates.

In the model, there is a continuum of potential corporate borrowers which are risk-neutral entrepreneurs with access to a project that needs one unit of fixed investment and one unit of labour input. The model covers two periods, with investment and credit in the first period (period 0) and project realisation and repayment in the second (period 1). Firms borrow from banks at the loan rate *r* and banks' funding rate on liabilities is *f*. Trade effects are introduced into the model by assuming that the firm sells a share *b* of its production abroad and invoices in the foreign currency without currency risk hedging. As a result, exchange rate movements affect export revenues in local currency. The exchange rate θ measures the value of the local currency with respect to the foreign currency, so that an increase denotes an appreciation of the domestic currency.

Loan demand can be shown to be decreasing in *r* (see Bruno and Shin, 2015) and the loan interest rate *r* is determined by market clearing that equates loan demand with loan supply. For any fixed demand curve for credit by entrepreneurs, increased credit supply results in more projects being financed. Aggregate investment by the corporate sector is therefore increasing in credit supply, so that any effect of the exchange rate on credit supply translates into an effect on investment in the same direction.

Foreign currency borrowing

Under foreign currency borrowing, the entrepreneurs bear currency risk as they borrow on an unhedged basis. As shown in Appendix 1, under this set up, the model yields a supply of foreign currency credit to domestic corporates given by:

$$C_S = \frac{E}{1-\frac{1+r}{1+f}\varphi} \tag{1}$$

where *E* denotes the book equity of the foreign bank. Credit supply is hence a positive function of bank equity and of the loan rate *r*, and a negative function of the bank funding rate *f*. It also increases in φ, which is a function deriving from the bank's Value-at-Risk (VaR) constraint. φ is decreasing in the probability of default *p* as lower credit risk relaxes the VaR constraint. *p* is in turn decreasing in the term θ_0^{1-b} which implies that an appreciation of the exchange rate in period 0 reduces the probability of default and increases credit supply. Foreign currency-credit supply to corporates and hence corporate investment is therefore increasing when the domestic currency appreciates. The effect becomes smaller the higher *b*, the share of the firm's production sold abroad, as a stronger exchange rate reduces export revenue in local currency terms (trade channel).

Local currency borrowing

When corporates can borrow from abroad in their local currency, currency risk shifts from borrowers to lenders. As shown in Appendix 1, the supply of local currency credit by foreign banks to domestic corporate borrowers is then given by:

$$C_S = \frac{E}{1-\frac{1+r}{1+f}\varphi\theta_0} \tag{2}$$

The credit supply equation (2) differs from equation (1) in two important ways. First, the exchange rate θ_0 now appears in the denominator in a way such that a currency appreciation increases credit supply. This is because the loan repaid by domestic currency borrowers must be converted into the funding bank's currency. A higher level of the domestic exchange rate therefore implies a larger amount repaid to the foreign bank in the foreign currency. Second, the probability of default p is now decreasing in the term θ_0^{-b} so that an appreciation of the exchange rate in period 0 increases the probability of default, which in turn increases φ in equation (2), and thereby reduces credit supply. This is because under local currency borrowing, the exchange rate affects borrower credit risk only through the export-revenue channel, so that a currency appreciation lowers export revenues and thereby increases the default probability. The overall impact of a domestic currency appreciation is therefore ambiguous. An exchange-rate appreciation increases credit supply if the trade channel operating through export revenues is weak enough so that the exchange-rate elasticity of φ is less than one.

Exchange-rate fluctuations can also affect credit supply by domestic banks in domestic currency. This occurs if the domestic interest rate fluctuates with the exchange rate as a consequence of global bond investors' portfolio adjustments. Hofmann et al. (2020) develop a simple model of international bond portfolio choice and present empirical evidence suggesting that the spread of EME sovereign bond yields over the (risk-free) U.S. Treasury yield moves inversely with the value of the domestic currency. This effect trickles down to domestic lending rates more widely to the extent that the latter are priced relative to domestic sovereign benchmark bond yields. In our set-up, this effect can be captured by a relationship of the form:

$$r = \frac{m}{\theta_0} + \bar{r} \tag{3}$$

where the mark-up of the domestic lending rate over a risk-free global benchmark rate $\bar{r}$, e.g. the U.S. Treasury yield, decreases when the exchange rate appreciates. As shown in Appendix 1, there are again two countervailing effects, namely the export-revenue channel and the financial channel operating through interest-rate spreads. As a consequence, the impact of exchange rate appreciation on the probability of default p, and thus ultimately on credit supply, depends again on the relative strength of the two channels and is *a priori* ambiguous.

4. Data

We use annual firm-level data from the Worldscope database which covers listed firms. We use data for the period 2000–19 for six major AEs (Canada, France, Germany, Italy, Japan and the United Kingdom) and ten major EMEs (Brazil, Chile, India, Indonesia, Korea, Malaysia, Mexico, Russia, South Africa and Thailand).[6]

The Worldscope database provides data for most variables required to test the predictions of the model, in particular capital expenditure (CAPEX) as a measure of capital investment, firm debt, and cash holdings. We further retrieve data for key firm-level control variables such as total assets, Tobin's q, cash flow, sales, and the sector of the firm which enables us to classify the firms as part of either the tradable or the non-tradable sector. We classify all firms with SIC2 code above 39 as part of the non-tradable sector (see Alfaro et al., 2017).

Worldscope does not provide information on the currency denomination of firm debt. In order to assess the role of foreign currency borrowing in the exchange rate-investment nexus, we follow Kalemli-Ozcan et al. (2018) and use a proxy measure of firm foreign currency (FX) leverage. Specifically, we use country-level data on the ratio of FX debt to total debt, measured as the sum of FX liabilities of financial and non-financial corporates divided by total debt. In the numerator, FX liabilities include both cross-border bank credit and international debt securities outstanding, while in the denominator, total debt is the entire stock of credit to the private non-financial sector. Then, we multiply this ratio – which varies both across time and across economies – by leverage at the level of an individual firm. We follow Goldstein and Turner (2004) and measure total FX liabilities as the sum of non-financial and financial sector FX liabilities. This approach effectively treats the EME corporate sector (banks and non-banks) as one unit. This has the advantage of better capturing total FX exposures of corporates, given that a large chunk of corporate FX debt is intermediated through the domestic banking sector (Avdjiev et al., 2020).[7]

We measure the financial sensitivity of a firm to exchange rate changes through its net leverage and its net FX leverage. Net leverage is calculated as total debt minus cash holdings as a ratio to total assets. Net FX leverage is calculated in the same way, but using total FX debt instead of total debt. We rely on net measures of leverage as they capture the role of cash holdings as financial buffers for firms

[6] We exclude the United States as U.S. firms have very little FX debt and exchange rate effects appear to work in the opposite direction compared to those highlighted in the theoretical model. Specifically, Niepmann and Schmidt-Eisenlohr (2018) show that an appreciation of the U.S. dollar is associated with tightening financial conditions, reflecting the association between dollar strength and tightness of global financial conditions. We also exclude China because Chinese firms have very little FX debt and, more importantly, because the renminbi is not a floating currency.

[7] In Appendix 2, we show that measuring FX debt only through the FX liabilities of the non-financial sector does not qualitatively change the results.

against financial shocks.[8] Net leverage captures more broadly the balance sheet effects of the exchange rate working through firms' debt, as well as the wider effects of induced changes in financial conditions. Net FX leverage captures more narrowly balance sheet vulnerabilities related to foreign currency debt.[9]

Number of observations, by country — Table 1

Country	Number of firm-year observations	Firm-year observations, tradable sectors	% tradable sector observations of total
AEs			
Canada	16,458	10,966	66.6%
Germany	9,165	5,204	56.8%
France	10,838	5,481	50.6%
United Kingdom	22,040	9,921	45.0%
Italy	4,231	2,571	60.8%
Japan	67,106	37,136	55.3%
EMEs			
Brazil	4,475	2,964	66.2%
Chile	2,523	1,458	57.8%
Indonesia	6,905	4,559	66.0%
India	31,002	24,492	79.0%
Korea	27,458	21,445	78.1%
Mexico	2,128	1,261	59.3%
Malaysia	15,441	10,851	70.3%
Russia	5,887	4,785	81.3%
Thailand	9,248	6,016	65.1%
South Africa	4,587	2,379	51.9%

Source: Worldscope and authors' calculations.

Note: The number of observations is based on the availability of the CAPEX/Total assets variable.

8 We also consider gross leverage, i.e. debt over total assets, as a measure of financial vulnerability. The results, which are available upon request, are qualitatively similar.

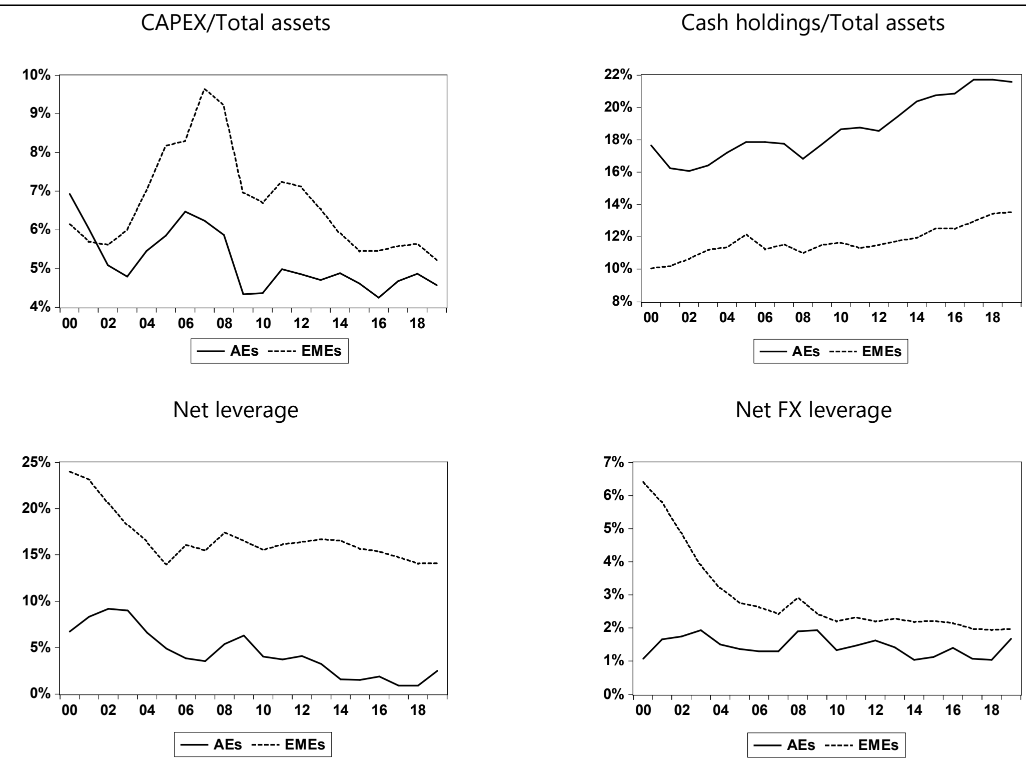
9 Kaplan and Zingales (1997) propose an alternative measure containing, besides net leverage, firm cash flow, and Tobin's Q. The latter two variables could affect investment demand through mechanisms other than the balance sheet channels described earlier, and both are included as independent regressors in our analysis. Financial market-based measures of the financial strength of a firm, such as bond or commercial paper ratings, would also be useful but are not available for many EME firms we have in our sample.

We clean the firm-level data in the following standard way. We drop firms with negative sales, negative total assets, or negative total liabilities. We further exclude financial firms, as well as firms from the utilities sector. Moreover, we exclude firms that do not report cash and equivalents, as well as those that do not report common equity or total liabilities. In order to eliminate outliers, we winsorize all firm-level variables except for total assets at the 1% level. The resulting unbalanced panel contains a total of 239,492 firm-year observations, of which 129,838 are for AEs and 109,654 for EMEs (see Table 1).

Figure 1 gives a visual impression of the dynamics of some key variables since 2000, while Table 2 presents some descriptive statistics. Firm-level data confirm the slowdown in business investment after the GFC in both AEs and EMEs documented before based on aggregate data (Banerjee et al., 2015; Kose et al., 2017). The average AE firm has seen a decline in CAPEX as a share of total assets from around 7% before the crisis to around 5% post-GFC (Figure 1, top left panel). In EMEs, the decline was more significant. Average business investment fell from above 9% of total assets before the GFC to below 6% in 2019.

Selected firm-level variables, averages for each year

Figure 1



Sources: Worldscope; authors' calculations.

Mirroring the decline in investment, the data show a significant rise in corporate cash holdings since the GFC (Figure 1, top right panel), reinforcing the previous increase documented e.g. by Bates et al. (2009). AE firms' cash holdings have risen on average from 18% of their assets in 2000 to close to 22% in the late 2010s. In EMEs, average cash holdings rose from 10% to around 13% by 2019.

Firm net leverage has declined over time in both AEs and EMEs (Figure 1, bottom left panel). These dynamics result from the joint behavior of book leverage and rising cash holdings. Average net leverage of AE firms has declined from a peak of 9% in 2002 to about 3% in 2019. In the case of EME companies, it has declined from around 24% to 14% over the sample period. These trends in net leverage are also reflected in the evolution of our proxy measure of net FX leverage (Figure 1, bottom right panel). In particular, in EMEs, net FX leverage has trended down since the early 2000s, from above 6% to below 3% recently. This development is consistent with the notion of increased resilience of EMEs after the 1990s crises (e.g. BIS, 2019).

Descriptive statistics, selected firm-level variables — Table 2

AEs				
	CAPEX/ total assets, %	Cash ratio, %	Net leverage, %	Net FX leverage, %
Mean	5.194	18.647	4.434	1.451
Median	2.747	13.129	4.617	0.432
St dev	8.055	17.846	36.153	11.863
3. quartile	5.846	25.245	24.006	2.900
Observations	129,838	138,609	138,609	138,609
EMEs				
Mean	6.650	11.878	16.249	2.613
Median	3.510	6.722	15.772	2.135
St dev	9.193	13.977	35.333	6.594
3. quartile	8.240	16.213	34.404	4.775
Observations	109,654	120,424	120,424	120,424

Source: Worldscope and authors' calculations.

The exchange rate data are taken from the BIS database. As we test the financial channel of the exchange rate, we rely on a financial exchange rate concept, i.e. the debt-weighted exchange rate (*DWER*) constructed by the BIS. The *DWER* is calculated based on the total foreign currency-denominated debt of an economy. More specifically, for each economy, the *DWER* is the geometric average of the economy's bilateral exchange rate against each of the five major global funding currencies (US dollar, euro, Japanese yen, pound sterling and Swiss franc), weighted by the shares of these currencies in the country's total foreign currency debt. The weights are re-computed for each quarter (see Berger, 2016, for more details).

The *DWER* is also likely to be a better gauge than the nominal or real effective exchange rate (*NEER* or *REER*) of the cash flow effects of exchange-rate changes operating through export revenues. Gopinath et al. (2019) show that the bulk of exports and imports is invoiced in the major currencies, suggesting that the export revenues of an economy are affected by fluctuations in the exchange rates against these major currencies rather than in the *NEER/REER*. As the *DWER* is composed of the bilateral exchange rates against major currencies, it captures better the exchange-rate movements that are relevant for export revenues. Moreover, there is often a close regional correspondence between the use of foreign funding currencies and export invoicing currencies.[10]

5. Empirical analysis

Our theoretical model in Section 3 suggests that exchange-rate depreciation dampens corporate investment through a financial channel. The effects operate through borrower and lender balance sheets, and through credit risk premia embedded in lending rates. On the other hand, depreciation boosts investment through an export-revenue channel. We would therefore expect to see that the effect of exchange-rate depreciation on investment is negatively linked to a firm's balance sheet vulnerability to exchange-rate changes and to financial conditions more generally. At the same time, we would expect it to be positively related to the tradability of a firm's output, as this would raise the relevance of the export-revenue channel.

With these considerations in mind, we estimate the following investment panel equation:

$$CAPEX_{i,c,t} = \beta_1 LEV_{i,c,t-1} \cdot DWER_{c,t} + \beta_2 TRD_{i,c,t-1} \cdot DWER_{c,t} + \beta_3 X_{i,c,t-1} + \alpha_{c,t} + \gamma_i + \varepsilon_{i,c,t} \quad (4)$$

The dependent variable is firm-level capital investment ($CAPEX$), measured as a ratio to total assets, in firm *i* in country *c* in year *t*. We assess the presence of financial effects of exchange-rate changes by interacting the lagged leverage-asset ratio (LEV) with the log level of the debt-weighted exchange rate of the respective

10 As shown in BIS (2019), Graph II.5, there is regional variation in invoicing practices. US dollar invoicing dominates in emerging Asia and in Latin America, while euro invoicing dominates in Central and Eastern Europe. In advanced economies, trade is invoiced in both US dollar and euro as well as in domestic currency. This regional variation is consistent with the variation in the weights of major currencies in the *DWER* in the respective region (Berger, 2016). In Appendix 2, we show that using the *REER*, which would capture price competitiveness effects playing out in the longer run, indeed yields weaker and statistically insignificant evidence on the strength of the trade channel.

country $DWER_{c,t}$. Since an increase in the exchange rate is an appreciation of the domestic currency, the sign of the coefficient of this variable is expected to be positive (the more positive the effects of $DWER$ appreciation are, the more leveraged the company). We estimate Equation (4) separately for the two measures of net leverage described before, net leverage and the proxy for net FX leverage.

We further aim to capture the relevance of the export-revenue channel by interacting a dummy variable capturing whether the firm operates in the tradable sector (*TRD*) with the exchange rate. The expected sign of this interaction variable is negative. For firms in the tradable sector, the negative effects of an exchange-rate appreciation on cash flow are expected to be stronger.

The set of firm control variables $X_{i,c,t-1}$ includes the respective measure of firm leverage (either net leverage or net FX leverage) and the tradable sector dummy variable. It further includes the firm's Tobin's Q, measured as market capitalization plus total debt minus current assets divided by total assets. Cash flow is similarly normalized by total assets, sales growth is expressed as the year-on-year growth rate, and total assets are included to control for possible size effects in firm's propensity to invest.[11] The panel equation also includes country-time fixed effects, $\alpha_{c,t}$, and firm fixed effects, γ_i. By including country-time fixed effects, we control for country-specific macroeconomic and financial factors, while the firm fixed effects control for unobserved time invariant firm-specific factors.[12]

The timing assumption in Equation (4) is that the "shock" (exchange-rate change) occurs in period *t* and affects investment in period *t* given the initial balance-sheet conditions in that period. The initial balance-sheet conditions are given by the year-end realization of the variables in *t-1*. This timing assumption, as well as the set-up of the equation and the estimation approach more generally, are in line with recent papers analyzing investment dynamics (e.g. Ottonello and Winberry, 2020; Bahaj et al., 2020).

For the sake of brevity, we report in Table 3 only the most relevant coefficient estimates.[13] The results support the notion of a financial channel of the exchange rate affecting firm investment. Both net leverage and net FX leverage interact in a highly

[11] In order to check for multicollinearity problems, we re-estimated the models, adding the controls one-by-one. The results, which are reported in Appendix 2, suggest that the key coefficients are hardly affected by the combination of controls included.

[12] The Hausman test rejects the random effects model as an alternative to the fixed effects model at the 1% level.

[13] The full estimation results for all control variables are available upon request.

significant way with the exchange rate. As the domestic currency appreciates against the major funding currencies, there is a positive effect on investment operating through leverage. Put differently, more leveraged firms are forced to cut their investment back by more when the domestic currency depreciates against funding currencies. The difference in the size of the interaction coefficients between net leverage and net FX leverage reflects in part the difference in the mean levels of the two variables (see Table 2). We will elaborate on the economic significance of the interaction between the exchange rate and the two net leverage measures further below.

Baseline model, all economies

Table 3

	Dependent variable : (CAPEX/Total Assets)$_t$	
	(1)	(2)
	Net leverage	Net FX leverage
DWER*leverage	0.0193**	0.159***
	(0.00878)	(0.0287)
Leverage	-0.121***	-0.814***
	(0.0400)	(0.134)
DWER*tradable	-1.423***	-1.445***
	(0.425)	(0.428)
Controls	Yes	Yes
Firm and country-year fixed effects	Yes	Yes
Observations	192,301	192,301
R^2	0.482	0.479

Note: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Standard errors clustered by firm and country-year.

Table 3 also shows that higher leverage is associated with lower investment, all else equal. The negative relationship suggests that higher net leverage reflects higher financial vulnerability and more difficult access to credit, dampening investment activity, consistent with the classical analyses of Myers (1977) and Stiglitz and Weiss (1981). It is also in line with recent evidence on firm-level investment dynamics in advanced economies (Gebauer et al., 2018) and in EMEs (Magud and Sosa, 2015). The coefficient estimates suggest that an increase in the net leverage ratio by one percentage point is associated with a decline of around 0.12 percentage points in the ratio of capital expenditures to total assets. Another way of interpreting our findings is that the negative effect of leverage on investment is muted when the exchange rate strengthens and financial conditions ease.

The results further confirm the relevance of the trade channel, operating through export revenues, for investment dynamics. An exchange-rate appreciation has a more negative effect on investment of firms operating in the tradable sector than of those in the non-tradable sector. Specifically, an appreciation of the exchange rate by one standard deviation lowers the investment ratio in the tradable sector by about 0.2 percentage points relative to the non-tradable sector.

As the next step, we assess whether there is a difference in the strength of the financial channel of the exchange rate between EME and AE firms. Net leverage and net FX leverage are higher in EMEs than in AEs (Table 2). Moreover, as mentioned in the introduction, financial systems in EMEs differ from those in AEs in important ways (BIS, 2019). Hedging markets are less developed and the domestic institutional investor bases are considerably weaker. Exchange-rate risk is therefore harder to hedge and swings in global investor sentiment, possibly driven by, or interacting with, exchange-rate swings, would have larger effects on domestic financial conditions. As a result, the financial channel of the exchange rate would be expected to be stronger in EMEs than in AEs.

In our set-up, we can test this hypothesis by re-running Equation (4) in an augmented way, including additional interaction terms distinguishing EME firms from their AE peers. Specifically, we run the following augmented panel regression:

$$\begin{aligned} CAPEX_{i,c,t} = {} & \beta_1 LEV_{i,c,t-1} \cdot DWER_{c,t} + \beta_2 TRD_{i,c,t-1} \cdot DWER_{c,t} + \beta_3 X_{i,c,t-1} + \\ & \beta_4 LEV_{i,c,t-1} \cdot DWER_{c,t} \cdot D^{EME}_{i,c,t} + \beta_5 TRD_{i,c,t-1} \cdot DWER_{c,t} \cdot D^{EME}_{i,c,t} + \\ & \beta_6 X_{i,c,t-1} \cdot D^{EME}_{i,c,t} + \alpha_{c,t} + \gamma_i + \varepsilon_{i,c,t} \end{aligned} \tag{5}$$

where we add all explanatory variables interacted with a dummy variable indicating whether a firm is from an EME or not. Specifically, the dummy variable D^{EME}_i takes the value of one if a firm is from an EME and the value of zero if it is from an AE.

The estimation results, reported in Table 4, support the notion that the financial channel of the exchange rate is much more prominent in EMEs than in AEs. The interaction coefficient of net leverage and the exchange rate is economically and statistically significant only for EME corporates. For net FX leverage, the interaction coefficient is statistically significant in both country groups, but it is almost twice as large in EMEs as it is in AEs.

Also, the export-revenue channel turns out to be more powerful in EMEs than in AEs. On firms in the tradable sector in EMEs, exchange-rate appreciation has a significantly more negative effect than on those in the non-tradable sector. Specifically, a one standard deviation appreciation reduces investment of EME firms in the tradable sector by around 0.5 percentage points more than in the non-tradable sector. For AEs, the relative effect between the two sectors is not statistically significant.

For EMEs, the financial effects of the exchange rate working through firm leverage are also economically significant. For an EME firm with average net leverage (16.2%), the coefficient estimate in Column (1) of Table 4 suggests that a depreciation of the exchange rate by one standard deviation (19.7%) reduces the CAPEX/total assets ratio by 0.15 percentage points. In turn, for a firm with leverage at the 3rd quartile of the net leverage distribution (34.4%), an exchange-rate depreciation of the same size reduces capital expenditures by 0.31 percentage points. These effects correspond to a reduction of 2.2% and 4.7% respectively relative to the average level of firms' CAPEX over assets of 6.6%. For net FX leverage (Column (2) of Table 4), the effects are somewhat smaller. An exchange-rate depreciation by one standard deviation reduces capital expenditures by 0.1 and 0.17 percentage points for a firm with net FX leverage at mean and at the 3rd quartile level, respectively. These economically smaller effects through FX leverage could, however, also reflect the imperfect measurement of firm FX leverage as described in the data section.

Exchange rates and leverage, models with EME interactions — Table 4

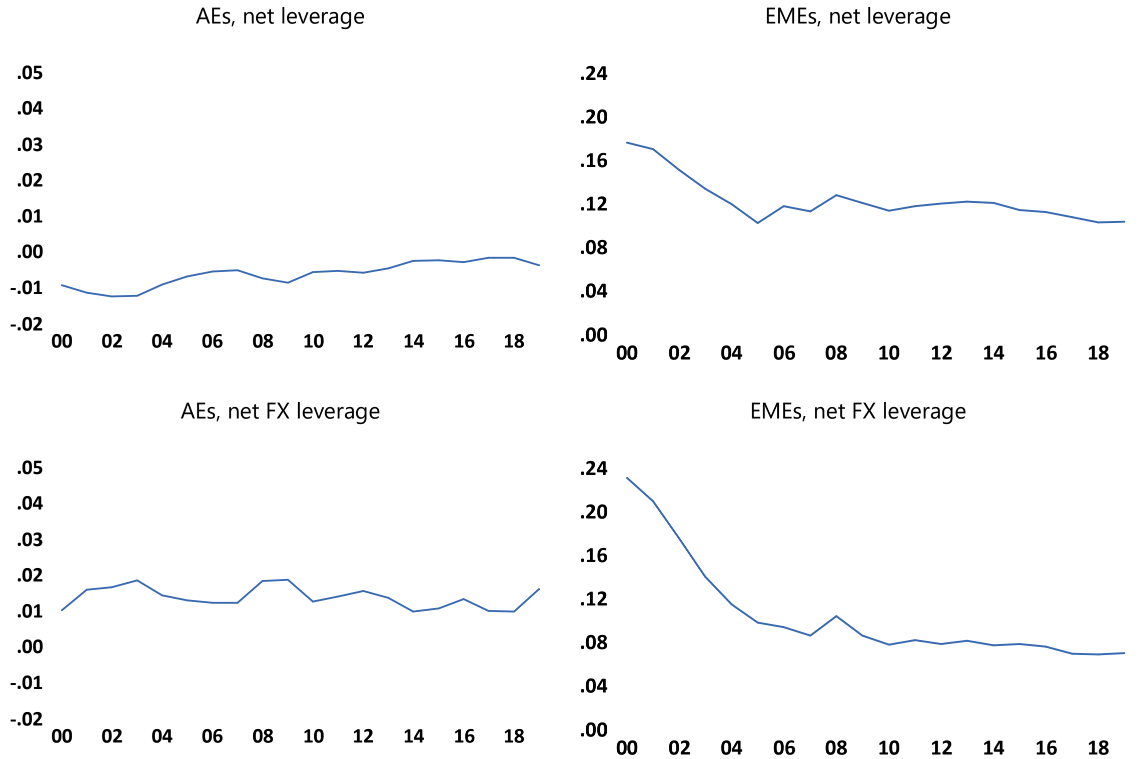
Dependent variable : (CAPEX/Total Assets)$_t$		
	(1)	(2)
	Net leverage	Net FX leverage
DWER*leverage	-0.00901	0.0685**
	(0.00946)	(0.0308)
DWER*leverage*EME	0.0467***	0.116*
	(0.0154)	(0.0635)
Leverage	0.0165	-0.374***
	(0.0426)	(0.143)
Leverage*EME	-0.230***	-0.636**
	(0.0696)	(0.289)
DWER*tradable	0.154	0.226
	(0.525)	(0.532)
DWER*tradable*EME	-2.722***	-2.862***
	(0.805)	(0.807)
Controls	Yes	Yes
Firm and country-year fixed effects	Yes	Yes
Observations	192,301	192,301
R2	0.484	0.482

Note: * p<0.1; ** p<0.05; *** p<0.01. Standard errors clustered by firm and country-year.

The coefficient estimates in Table 4 also allow a simple back-of-the-envelope calculation to assess the role of the exchange rate in the recent investment slowdown in EMEs. Capital expenditures as a share of total assets for the average EME firm declined from 7.2% in 2011 to 5.2% 2019 (Figure 1). Over the same period, the average depreciation in EME debt-weighted exchange rates was about 28%. Using the coefficient estimate in Column (1) and the mean net leverage ratio of EME firms, we get an effect of the exchange-rate depreciation on the CAPEX/total asset ratio of the average EME firm of –0.21 percentage points. This accounts for around 10% of the overall drop in capital expenditures over the period. This effect is sizable, taking into account that, for the sake of clean identification, this is the effect that is restricted to run through leverage, abstracting from potential wider effects which are harder to identify.

Impact of a one standard deviation DWER appreciation on CAPEX at mean firm leverage

Figure 2



Source: Authors' calculations based on coefficient estimates in Table 4. A one standard deviation exchange rate appreciation corresponds to a 14.4% and 19.7% appreciation respectively for advanced and emerging economies.

We can also use our estimates to assess the evolution of the strength of the financial channel of the exchange rate over time. We do this with a simple back-of-the-envelope calculation, multiplying the estimated coefficient of the exchange rate-leverage interaction term with the mean net leverage ratio. This yields a time series of the sensitivity of firm investment for the mean leveraged firm (Figure 2). The results of this calculation again highlight that the financial channel of the exchange rate is considerably stronger for EMEs than for AEs. At the same time, the calculations suggest that, as a consequence of lower net leverage and lower net FX leverage, the strength of the financial channel in EMEs has declined since the early 2000s. While the effect of a one standard deviation appreciation of the *DWER* on investment was over 0.2 percentage points in 2000, it was below 0.1 percentage points in 2019 (based on net FX leverage). These calculations should of course be taken with a pinch of salt, as the empirical model cannot capture possible changes of the dynamics and the underlying relationship that may have happened over time. That said, testing for a possible change in the relationship after the GFC does not indicate significant shifts in the estimated relationships (see Appendix 2).

6. Conclusions

In this paper, we analyze the implications of the financial channel of the exchange rate for corporate investment. First, we propose a simple theoretical model that shows that exchange-rate depreciation has a negative effect on investment through its effect on credit risk, while a countervailing effect arises through export revenues. This implies that the financial channel is likely to be stronger for firms that are financially more vulnerable, while the trade channel is likely to be stronger for companies in the tradable sector.

Using firm-level data for 16 major economies, we find evidence confirming that the exchange rate affects corporate investment through a financial channel. We document that a negative effect of exchange-rate depreciation on investment operates through firm net leverage and net FX leverage. This effect is more pronounced for EME corporates, consistent with the notion of a stronger financial channel of the exchange rate in EMEs due to greater dependence on foreign funding and less developed financial systems. At the same time, we document a positive effect of exchange-rate depreciation on investment of firms in the tradable sector relative to the non-tradable sector, reflecting the trade channel of the exchange rate.

Overall, our findings suggest that the large depreciation of EME currencies against major funding currencies probably contributed significantly to the post-GFC investment slowdown in these economies. At the same time, our results suggest that the deleveraging of EME corporates since 2000 may, on average, have reduced the strength of the financial channel of the exchange rate over the past two decades.

Our findings also have implications for the design of macro-financial stability frameworks. While a detailed discussion of such implications is beyond the scope of this paper, we note that from the perspective of our analysis, policy measures mitigating the excessive build-up of leverage, in particular in foreign currency, would reduce the sensitivity of firms' investment to exchange-rate swings. Candidate tools for this purpose are macroprudential and capital-flow management measures as well as FX intervention. In line with such considerations, these tools do indeed play a prominent role in the macro-financial stability policy frameworks of many EMEs (BIS, 2019). From a longer-term perspective, developing a stronger domestic investor base in order to reduce dependence on foreign funding, as well as deepening FX derivatives markets to facilitate the hedging of FX risk, will be key to addressing the financial channel of the exchange rate (Committee on the Global Financial System, 2019).

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Appendix 1: A simple model of credit risk with exchange rate effects

Denote by V_t the local currency value of the project at date *t* and by θ_t the value of the local currency with respect to the foreign currency, so that an increase in θ_t denotes an appreciation of the local currency. Assume further for simplicity of notation that exchange rate expectations follow a random walk so that $E_{t-1}\theta_t = \theta_{t-1}$.

Foreign currency borrowing

The period 0 expected domestic and foreign currency values of the borrowers' project at date 1 follow the Merton (1974) model of credit risk, and are respectively given by the random variable:

$$E_0\left(\frac{V_1}{\theta_1^b}\right) = \frac{1}{\theta_0^b} exp\left\{\mu - \frac{s^2}{2} + sW_j\right\} \tag{1}$$

$$E_0(\theta_1^{1-b}V_1) = \theta_0^{1-b} exp\left\{\mu - \frac{s^2}{2} + sW_j\right\} \tag{2}$$

W_j is a standard normal, and μ and s are positive constants. The local currency value in (1) decreases when the exchange rate appreciates as the local currency revenues on the share of production b that is exported and invoiced in foreign currency fall. The foreign currency value in (2) is equal to the domestic currency value multiplied by the exchange rate as credit is denominated in foreign currency. The foreign currency value of the project therefore increases when the exchange rate appreciates.

The lender is a bank that can diversify across many borrowers and can therefore diversify away idiosyncratic risk. Credit risk follows the Vasicek (2002) model, a many borrower generalisation of Merton (1974). The standard normal W_j in (1) is given by the linear combination:

$$W_j = \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{3}$$

where Y and X_j are mutually independent standard normals. Y is the common risk factor while each X_j is the idiosyncratic risk facing the borrower j. The parameter $\rho \in (0,1)$ determines the weight given to the common factor Y.

The borrower defaults when the project realisation is less than the repayment amount of the loan, $1+r$, and the recovery value is zero when default occurs. Default hence occurs when $\theta_1^{1-b}V_1 < 1+r$. The probability of default is then given by

$$p_j = \Pr(\theta_1^{1-b}V_1 < 1+r) = \Pr(W_j < -d_j) = \Phi(-d_j) \tag{4}$$

where d_j is the distance to default:

$$d_j = \frac{\ln\left(\frac{\theta_0^{1-b}}{1+r}\right) + \mu - \frac{s^2}{2}}{s} \tag{5}$$

Equations (4) and (5) show that a borrower's probability of default decreases in θ_0, so it falls when the exchange rate of the domestic currency appreciates against foreign currency.

Conditional on Y, defaults are independent. In the limit where the number of borrowers becomes large, the realised value of one unit of foreign currency face value of loans can be written as a deterministic function of Y, by the law of large numbers. The realised value per unit of foreign currency face value of loans is the random variable $w(Y)$ defined as:

$$w(Y) = Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}(p(Y)\right) = \Phi\left(\frac{Y\sqrt{\rho}-\Phi^{-1}(p)}{\sqrt{1-\rho}}\right) \tag{6}$$

where $p(Y)$ is the probability of default conditional on Y. The c.d.f. of w is then given by

$$\Pr(w(Y) \leq z) = Pr(Y > w^{-1}(z)) = \Phi\left(-w^{-1}(z)\right) = \Phi\left(\frac{\Phi^{-1}(p)+\sqrt{1-\rho}\,\Phi^{-1}(z)}{\sqrt{\rho}}\right) \tag{7}$$

From (7), the c.d.f. of w is increasing in p, so that higher values of p imply a first-degree stochastic dominance shift left for the asset realisation density. Since p decreases with local currency appreciation (that is, an increase in θ_0), exchange rates have a direct impact on the credit environment in the model.

Credit supply to corporates is subject to a Value-at-Risk (VaR) constraint. Denote by C_S the credit supplied by global banks at date 0 (in foreign currency). Since the interest rate is r, the payoff of the bank at date 1 is given by the random variable:

$$(1+r)C_S \cdot w \tag{8}$$

Denote by E the book equity of the bank and by L the funding raised by the foreign bank (in foreign currency from the perspective of the borrower) and denote by f the funding cost, which we assume is constant for simplicity. The bank is risk-neutral, and maximises expected profit subject only to its VaR constraint that stipulates that the probability of default is no higher than some fixed constant $\alpha>0$. The bank remains solvent as long as the realised value of $w(Y)$ is above its notional liabilities at date 1. Since the funding rate on liabilities is f, the notional liability of the bank at date 1 is $(1+f)L$. Since the bank is risk-neutral, its VaR constraint binds so that we have

$$\Pr\left(w \leq \frac{(1+f)L}{(1+r)C_S}\right) = \Phi\left(\frac{\Phi^{-1}(p)+\sqrt{1-\rho}\,\Phi^{-1}\left(\frac{(1+f)L}{(1+r)C_S}\right)}{\sqrt{\rho}}\right) = \alpha \tag{9}$$

Re-arranging (9), we can write the ratio of notional liabilities to notional assets as follows:

$$\frac{(1+f)L}{(1+r)C_S} = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(p)}{\sqrt{1-\rho}}\right) \quad (10)$$

We will use the shorthand

$$\varphi(\alpha,p,\rho) = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha)-\Phi^{-1}(p)}{\sqrt{1-\rho}}\right) \quad (11)$$

Clearly, $\varphi \in (0,1)$. From (10), the balance sheet identity $E+L=C_S$, and assuming that $1-\frac{1+r}{1+f}\varphi > 0$,[14] we can solve for the bank's supply of foreign currency credit

$$C_S = \frac{E}{1-\frac{1+r}{1+f}\varphi} \quad (12)$$

Local currency borrowing

If borrowers can borrow in domestic currency, the probability of default becomes a negative function of the exchange rate, as now only the export revenue effects are present:

$$d_j = \frac{\ln\left(\frac{\theta_0^{-b}}{1+r}\right)+\mu-\frac{s^2}{2}}{s} \quad (13)$$

As a consequence, p is now increasing in θ_0 and w becomes a decreasing function of the exchange rate.

However, a balance sheet channel of the exchange rate is still present as the expected payoff of the foreign bank who lends in domestic currency becomes:

$$\theta_0(1+r)C_S \cdot w \quad (14)$$

The loan repaid by domestic currency borrowers must be converted into the funding bank's currency. A higher level of the domestic exchange rate implies a larger amount repaid to the foreign bank in the foreign currency.

The VaR constraint then becomes:

$$\Pr\left(w \leq \frac{(1+f)L}{\theta_0(1+r)C_S}\right) = \Phi\left(\frac{\Phi^{-1}(p)+\sqrt{1-\rho}\,\Phi^{-1}\left(\frac{(1+f)L}{\theta_0(1+r)C_S}\right)}{\sqrt{\rho}}\right) = \alpha \quad (15)$$

With the same steps as before, we can solve for the foreign bank's credit supply in domestic currency C_S:

[14] We make this assumption in order to ensure a positive credit supply.

$$C_S = \frac{E}{1-\frac{1+r}{1+f}\varphi\theta_0} \tag{16}$$

Exchange rate fluctuations can also affect credit supply by domestic banks in domestic currency because of their effect on domestic benchmark interest rates. Assume that benchmark interest rates are given by:

$$r = \frac{m}{\theta_0} + \bar{r} \tag{17}$$

where the mark-up of the domestic lending rate over a risk-free global benchmark rate $\bar{r}$, e.g. the U.S. Treasury yield, decreases when the exchange rate appreciates. The distance to default is then given by:

$$d_j = \frac{\ln\left(\frac{\theta_0^{-b}}{1+\bar{r}} + \frac{\theta_0^{1-b}}{m}\right) + \mu - \frac{s^2}{2}}{s} \quad . \tag{18}$$

Appendix 2: Robustness checks

Alternative specifications of the estimations

	Dependent variable : (Capex/Total Assets)	
	(1)	(2)
	Net leverage	Net FX leverage
Non-financial FX liabilities		
DWER*leverage	0.0193**	0.312***
	(0.00878)	(0.0900)
Leverage	-0.121***	-1.753***
	(0.0400)	(0.414)
DWER*tradable	-1.423***	-1.401***
	(0.425)	(0.430)
Observations	192,301	192,301
R2	0.482	0.480
Trade channel associated with REER		
DWER*leverage	0.0185**	0.158***
	(0.00864)	(0.0285)
Leverage	-0.118***	-0.809***
	(0.0394)	(0.133)
REER*tradable	-0.412	-0.484
	(0.415)	(0.419)
Observations	192,301	192,301
R2	0.482	0.479
Changes post-GFC (post-GFC dummy =1 from 2010)		
DWER*leverage	0.0272***	0.136***
	(0.00957)	(0.0299)
DWER*leverage*post GFC	-0.0209*	0.0190
	(0.0125)	(0.0616)
Leverage	-0.149***	-0.701***
	(0.0432)	(0.140)
Leverage*post GFC	0.0795	-0.0991
	(0.0566)	(0.283)
DWER*tradable	-1.997***	-1.774***
	(0.524)	(0.531)
DWER*tradable*EME	0.865	0.550
	(0.688)	(0.702)
Observations	192,301	192,301
R2	0.483	0.480

Note: * p<0.1; **p<0.05; ***p<0.01. Standard errors clustered by firm and country-year.

Including control variables separately

	Dependent variable: (Capex/Total Assets)					
	(1)	(2)	(3)	(4)	(5)	(6)
Tobin's Q	0.572***					0.558***
	(0.0403)					(0.0448)
Cash flow		0.0718***				0.0547***
		(0.00452)				(0.00403)
Sales growth			0.0464***			0.0211***
			(0.00374)			(0.00345)
Assets					-2.05e-05***	-1.84e-05***
					(5.60e-06)	(4.94e-06)
Tradable*DWER				-1.516***		-1.431***
				(0.515)		(0.426)
Net leverage *DWER	0.0197**	0.0271***	0.0272***	0.0360***	0.0350***	0.0192**
	(0.00909)	(0.00845)	(0.00836)	(0.00920)	(0.00907)	(0.00876)
Net leverage	-0.131***	-0.148***	-0.154***	-0.194***	-0.189***	-0.121***
	(0.0419)	(0.0383)	(0.0379)	(0.0418)	(0.0412)	(0.0399)
Observations	201,960	208,786	213,921	227,291	227,291	192,301
R-squared	0.477	0.471	0.465	0.463	0.463	0.482

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	Dependent variable: (Capex/Total Assets)					
	(1)	(2)	(3)	(4)	(5)	(6)
Tobin's Q	0.561***					0.544***
	(0.0393)					(0.0433)
Cash flow		0.0766***				0.0611***
		(0.00494)				(0.00444)
Sales growth			0.0484***			0.0213***
			(0.00385)			(0.00347)
Assets					-2.00e-05***	-1.78e-05***
					(5.60e-06)	(4.91e-06)
Tradable*DWER				-1.495***		-1.445***
				(0.518)		(0.428)
Net FX leverage*DWER	0.193***	0.162***	0.186***	0.210***	0.207***	0.159***
	(0.0323)	(0.0262)	(0.0274)	(0.0291)	(0.0289)	(0.0287)
Net FX leverage	-0.995***	-0.807***	-0.930***	-1.039***	-1.027***	-0.814***
	(0.152)	(0.122)	(0.128)	(0.137)	(0.136)	(0.134)
Observations	201,960	208,786	213,921	227,291	227,291	192,301
R-squared	0.473	0.470	0.463	0.460	0.460	0.479

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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