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

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**Abstract**

Using firm-level data for 18 major global economies, we find that the exchange rate affects corporate investment through a financial channel: exchange rate depreciation dampens corporate investment through firm leverage and FX debt. These findings are consistent with the predictions of a stylised model of credit risk in which exchange rates can affect investment through FX debt or borrowing in local currency from foreign lenders. Empirically, the channel is more pronounced in emerging market economies (EMEs), reflecting their greater dependence on foreign funding and their less developed financial systems. Moreover, we find that exchange rate depreciation induces highly leveraged firms to increase their cash holdings, supporting from a different angle the notion of a financial channel of the exchange rate. Overall, these findings suggest that the large depreciation of EME currencies since 2011 was probably a significant amplifying factor in the recent investment slowdown in these economies.

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## 1. Introduction

Corporate investment is a key determinant of long-run economic growth, enhancing output and productivity growth and also fostering technological progress. At the same time, investment is the most cyclical component of GDP, making its dynamics a key driver of business cycle fluctuations. A large literature has explored the determinants of firm-level investment dynamics. The focus of this literature has included the role of stock market valuations (e.g. Erickson and Whited (2012)), corporate cash flow (Fazzari et al (1988), Gilchrist and Himmelberg (1995)), corporate bond premia and prices (Gilchrist and Zakrajcek (2007), Philippon (2009)), secular trends in asset tangibility (Almeida and Campello (2007), Alexander and Eberly (2018)), and the effects of monetary policy (Cloyne et al (2019), Ottonello and Winberry (2019)).

The bulk of the extant literature focuses on investment dynamics in major advanced economies, in large part on the United States. Probably for this reason, the role of the exchange rate for firms' capital formation has been a somewhat underexplored factor. From the perspective of the traditional trade channel, exchange rate depreciation would be expected to have an expansionary effect on investment activity. The classical Mundell-Fleming model (Mundell (1963), Fleming (1962)) suggests that a depreciation of the exchange rate would boost export competitiveness and hence production, which could also lead to an increase in firms' investment. A more direct and immediate effect works through 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)).

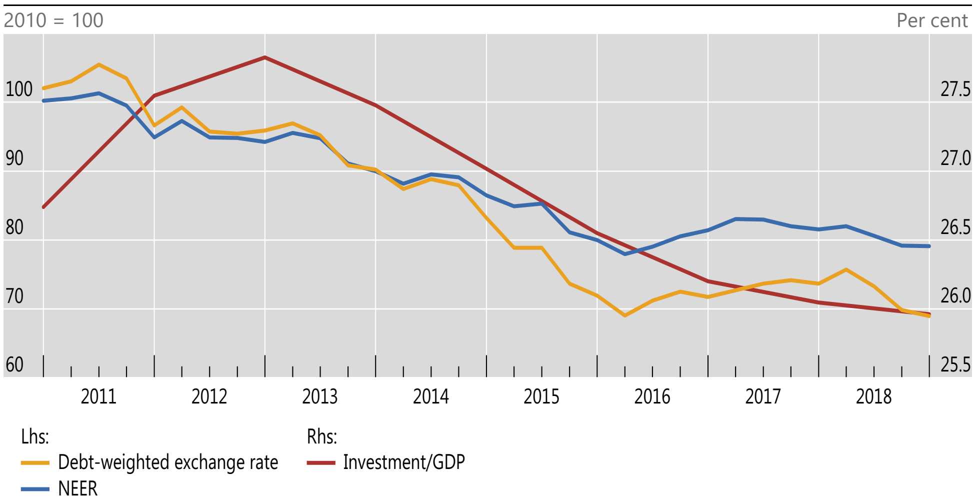
Recently a growing literature has examined the financial channel of the exchange rate. This channel implies that an exchange depreciation could lead to a tightening of financial conditions, thus exerting a dampening effect on investment activity. One mechanism works through borrower currency mismatches. In the presence of such mismatches, a weaker exchange rate erodes the balance sheet of dollar borrowers as liabilities rise relative to assets (Krugman (1999), Céspedes et al (2004), Bruno and Shin (2015a, b)).[3] Similarly, if corporates borrow from foreign lenders in domestic currency, financial effects of exchange rate fluctuations may arise through the balance sheets of the foreign lenders. This occurs, as exchange rate fluctuations give rise to valuation effects on the lenders' assets, influencing their

[3] The occurrence of such mismatches has been related to an inherent inability of countries, in particular emerging market economies (EMEs), to borrow abroad in their domestic currency, a situation that has been referred to as "original sin" (Eichengreen and Hausmann (1999), Eichengreen et al (2002)). More recently, it has been related to a carry-trade associated with the differential between domestic interest rates and the interest rate levels prevailing in major foreign funding currency markets, in particular the United States (Bruno and Shin (2017), Huang et al (2018)).

credit supply (Carstens and Shin (2019)). Also the credit supply of domestic lenders can be affected as the risk premium of benchmark local-currency sovereign yields rises when the exchange rate depreciates, reflecting portfolio adjustments of global bond investors (Hofmann et al (2019b)).

The financial channel of the exchange rate would be expected to be more prominent in EMEs than in advanced economies as a consequence of less developed financial systems (BIS (2019)). Many EMEs rely heavily on borrowing in foreign currency or on borrowing in their local currency from foreign lenders and investors, 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 FX hedging in practice, there are indications that hedging of FX positions in EMEs is limited and often completely absent (Chui et al (2014)).[4]

Corporate investment and the exchange rate in EMEs — Graph 1




Sources: IMF, *World Economic Outlook database*; BIS.

Indeed, a cursory glance at aggregate data suggests that a financial channel of the exchange rate is at work. The investment slowdown in EMEs after 2013 coincided with a strong currency depreciation (Figure 1). EME exchange rates depreciated sharply in the wake of the so called "taper tantrum" when expectations

[4] There is country-level evidence that EME exporters are largely unhedged against currency risks. See Liriano (2016) for the case of Chile and Chuaprapaisilp et al (2018) for the case of Thailand.

of an imminent tapering of asset purchases by the United States Federal Reserve mounted. This was followed by a marked slowdown in investment activity. The correlation is stronger for the debt-weighted exchange rate – based on the currency composition of a country's foreign currency debt – than for the trade-weighted exchange rate, which is based on trade linkages.[5]

This paper aims to explore more rigorously the presence of any financial effects of the exchange rate on corporate investment. We first propose a simple theoretical model that builds on Bruno and Shin (2015) but includes both the trade and more general forms of the financial channel of the exchange rate. In the model, we analyse different mechanisms through which the exchange rate can impact credit supply and hence investment. First, when corporates borrow in foreign currency. Second, when corporates borrow in local currency from foreign lenders. Finally, following Hofmann et al (2019b), we model the case where there are no currency mismatches. In each case, exchange rate fluctuations lead to changes in credit supply due to their impact on borrower and lender balance sheets and on domestic risk premia through adjustments in global bond investors' portfolios.

The model shows that a negative effect of exchange rate depreciation through the financial channel operates through foreign currency debt, or more generally through corporate leverage, due to the impact of the depreciation on credit supply of foreign lenders. Second, a positive effect of exchange rate depreciation on investment activity works through export revenues.

We then proceed to assess empirically the financial channel of the exchange rate using firm-level data for a group of advanced and emerging market economies. Specifically, we analyse the effect of exchange rates on business investment in the G7 countries as well as a group of nine major EMEs: Brazil, Chile, China, India, Indonesia, Korea, Mexico, Russia and South Africa. The analysis draws on annual firm-level data from Worldscope for the period 2000–15, yielding over 210,000 firm-year observations.

The presence of both advanced economy and emerging market corporates in our dataset enables us to test if these mechanisms are present more generally and whether they are stronger in EMEs. Moreover, our analysis provides evidence for the more conventional determinants of business investment, such as Tobin's q and cash flows, and how their effects differ between advanced economies and EMEs.

[5] The debt-weighted exchange rate (*DWER*) uses the shares of foreign currency debt to weight a country's bilateral exchange rates, as described in Box A in Kearns and Patel (2016). More details are provided in the data section later.

In order to identify the financial channel of the exchange rate on investment, we use cross-sectional variation in firm leverage. The rationale behind this approach is that, through the financial channel, exchange rate depreciation would tighten credit supply. This would have a stronger negative effect on financially more vulnerable corporations, with leverage as a proxy for the degree of financial vulnerability. We also use a proxy measure for firm-level FX leverage in order to assess the specific role of foreign currency debt in the transmission of exchange rate changes to investment. As an additional test of the financial channel, we further assess the role of the exchange rate for the cash flow sensitivity of firms' cash holdings. Almeida et al (2004) have shown that the cash flow sensitivity of cash holdings is larger for firms that are more financially fragile as they have to build financial buffers. We test whether this effect also depends on exchange rate dynamics, and specifically whether it is stronger when the exchange rate depreciates, tightening financial conditions through the financial channel.

The empirical analysis yields the following results. First, exchange rate depreciation dampens corporate investment through firms' leverage, supporting the notion of the presence of a financial channel of the exchange rate. Second, the effect is stronger for EME corporates than for corporates in advanced economies. This finding is in line with the notion that EMEs are more exposed to the financial channel of the exchange rate as a consequence of higher foreign currency debt, higher borrowing from foreign investors, relatively underdeveloped hedging markets and often an underdeveloped domestic institutional investor base. Third, we document that exchange rate depreciation also has a positive effect on corporate savings out of cash flow through the level of corporate leverage, supporting from a different angle the notion of a financial channel of the exchange rate. Overall, our findings suggest that the large depreciation of EME currencies against major funding currencies has contributed in a significant way to the investment slowdown in these economies in recent years through the financial channel of the exchange rate.

*Related literature*

The analysis of the paper contributes to various strands of the literature. First, we contribute to the emerging literature on the effects of the financial channel of the exchange rate on corporate investment. Bleakly and Cowan (2008) use firm-level data for five Latin American countries in the 1990s and show that, following a depreciation, firms holding more dollar debt do not invest less than their peso indebted counterparts. Such evidence speaks against the relevance of balance sheet effects of exchange rate changes operating through borrower balance sheets. More recently, Kalemli-Ozcan et al (2016) study four episodes of currency crises in EMEs and assess how firm investment responded to devaluation shocks. Matching data for firms and banks, they find that domestic firms with large unhedged foreign currency liabilities cut investment when the currency crisis was accompanied by a banking crisis. Avdjiev et al (2018) show, using both aggregate and firm-level data, that a broad based appreciation of the US dollar has a dampening impact on both cross-border bank flows and on real investment activity. Kearns and Patel (2016), using aggregate country-level data for advanced and emerging economies, document that an appreciation of the domestic currency against funding currencies boosts economic activity and in particular investment. This partly offsets the negative effect through the trade channel, in particular in EMEs, while the offsetting effect is weaker in advanced economies. 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.

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 for a panel of 46 countries that cross-border banking flows are positively associated with an appreciation of the domestic currency, consistent with a risk taking channel. Using high-frequency data for local currency bond spreads in 11 EMEs, Hofmann et al (2019b) find that an appreciation of EME currencies against the US dollar, the dominant funding currency of EME foreign currency borrowing, 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) explore the effect of exchange rate appreciation on corporate risk taking, proxied by firm leverage, using firm-level data for ten Asian EMEs. They show that exchange rate appreciation is associated with higher risk taking by the more indebted firms. Bruno and Shin (2019) document, based on bank and firm-level data for Mexico, that banks relying more on US dollar wholesale funding contract credit supply by more in the wake of a US dollar appreciation, and that this translates into a large contraction in the exports of firms who rely on funding from these banks.

Second, our analysis ties in with studies that have analysed 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 negatively associated with firm-level leverage. At the same time, investment is positively related to (country-specific) commodity export prices and capital inflows. Kose et al (2017) analyse the investment slowdown in EMEs after the Great Financial Crisis (GFC), using aggregate data. They find that the slowdown is related, among other factors, to negative terms-of-trade shocks, declining foreign direct investment inflows, and adverse spillovers from major advanced economies.

Third, we also contribute to the literature on the drivers of corporate cash holdings. As already mentioned, Almeida et al (2004) have shown that firms retain a higher share of their cash flow as cash holdings when they are financially constrained. The topic has subsequently received growing attention in the wake of the significant increase in corporate cash holdings since the 2000s in both advanced and emerging market economies (Bates et al (2009), Pinkowitz et al (2012), Sanchez and Yurdagul (2013)). Bates et al (2009) suggest that precautionary motives are driving this phenomenon, specifically uncertainty about future cash flow in the presence of financial constraints.

The remainder of the paper is structured as follows. Section 2 develops a simple credit risk model, demonstrating how a financial channel of the exchange rate can arise and how it affects firm investment. Section 3 describes the data. In Section 4, we present the methodology and the baseline estimations for the link between firm investment and the exchange rate. Section 5 presents the results of robustness checks and Section 6 the findings of an alternative test of the financial channel based on firms' propensity to retain cash flow as cash holdings. Section 7 concludes.

## 2. Model

In this section, we develop a simple theoretical framework for the analysis of the link between corporate investment and the exchange rate that generates the key predictions for the empirical analysis. The framework builds on Bruno and Shin (2015) but extends it in two dimensions. First, we include a trade channel of the exchange rate operating through trade invoicing that can counteract the financial channel. Second, we consider different real world mechanisms through which financial effects of the exchange rate on investment can arise. Specifically, we consider three cases: (i) corporates borrow in foreign currency as in Bruno and Shin (2015); (ii) corporates borrow in local currency from foreign lenders; and (iii) the case where there are no currency mismatches but global bond investors' portfolio adjustments affect domestic risk premia.

*Foreign currency borrowing*

We start with the baseline model of corporates that borrow from foreign lenders in foreign currency, i.e. the classic original sin case, following Bruno and Shin (2015).

There is a continuum of potential corporate borrowers which are risk-neutral entrepreneurs with access to a project that needs one unit of foreign currency of fixed investment and one unit of labour input. Denote by *r* the interest rate on the loan, so that the borrowers must repay *1+r*. Credit is granted at date 0 and the project realisation and repayment are due at date 1. The entrepreneurs bear currency risk as they borrow in foreign currency on an unhedged basis. The foreign currency value of the project depends on the exchange rate. Denote by $V_t$ the local currency value of the project at date *t* and by $\theta_t$ the value of the local currency with respect to the foreign currency, so that an increase in $\theta_t$ denotes an appreciation of the local currency. Assume further for simplicity of notation that exchange rate expectations follow a random walk so that $E_{t-1}\theta_t = \theta_{t-1}$. Finally, trade effects are introduced into the model by assuming that the firm sells part of its production abroad and invoices in the foreign currency, with the share of goods that is exported denoted by $b$.[6]

The period 0 expected domestic currency value of the borrowers' project at date 1 follows the Merton (1974) model of credit risk, and is given by the random variable:

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

The period 0 expected foreign currency value of the project in period 1 is then given by

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

where $W_j$ is a standard normal, and $\mu$ and $s$ are positive constants.

The lender is a bank who 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:

$$W_j = \sqrt{\rho}Y + \sqrt{1-\rho}X_j \quad (3)$$

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 $\theta_1 V_1 < 1+r$. The probability of default is then given by

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

where $d_j$ is the distance to default:

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

Equations (4) and (5) show that a borrower's probability of default decreases in $\theta_0$, so it falls when the exchange rate of the domestic currency appreciates against foreign currency.

6 We thank Steve Wu for suggesting to us this approach for integrating trade effects into the model.

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:

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

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

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

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 $\theta_0$), 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:

$$(1+r)C_S \cdot w \quad (8)$$

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

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

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, $\phi \in (0,1)$. From (10), the balance sheet identity $E+L=C_S$, and assuming that $1 - \frac{1+r}{1+f}\varphi > 0$,[7] we can solve for the bank's supply of foreign currency credit

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

The loan interest rate $r$ is determined by market clearing that equates loan demand with loan supply. Loan demand can be shown to be decreasing in $r$ (see Bruno and Shin (2015)). Foreign currency credit supply in (12) is increasing in $\theta_0$, as $\varphi$ is decreasing in $p$, which in turn is decreasing in the exchange rate $\theta_0$. In other words, foreign currency credit supply to corporates is increasing as the domestic currency appreciates against the foreign currency. For any fixed demand curve for foreign currency credit by entrepreneurs, increased foreign currency credit supply results in more projects being financed. Aggregate investment by the corporate sector is therefore increasing in the value of the domestic currency.

*Borrowing in local currency*

Even in the absence of foreign currency debt, exchange rate movements can impact credit supply to domestic borrowers through financial channels working through the balance sheet of foreign lenders.

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 $\theta_0$ 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.

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

The VaR constraint then becomes:

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

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

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

The impact of a domestic currency appreciation is now ambiguous. $\varphi$ is decreasing in $p$, which in turn is now increasing in the exchange rate. At the same time, $\theta_0$ exerts a direct negative effect on $C_S$ so that the overall effect of exchange rate appreciation depends on the parameters of the model.

Finally, even in the absence of foreign lenders, exchange rate fluctuations can 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 (2019b) develop a simple model of international bond portfolio choice and present empirical evidence that the spread of EME sovereign yields over the risk free rate moves inversely with the domestic currency. This effect trickles down to domestic lending rates more widely to the extent that the latter are priced-off domestic sovereign benchmark bond yields. In our set-up, this effect can be captured by a relationship of the form

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

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 then becomes

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

There are again two countervailing effects, the export revenue channel on the one hand and the financial channel operating through interest rate spreads on the other. As a consequence, the impact of exchange rate appreciation on the distance to default and on the probability of default $p$ and hence ultimately on credit supply depend on the relative strength of the two channels and is *a priori* ambiguous.

*Main predictions for the empirical analysis*

The main predictions of the theoretical model for the empirical analysis are as follows. First, the effect of the exchange rate on corporate investment is ambiguous. A positive effect of exchange rate appreciation is more likely when foreign currency borrowing is high, or more generally when corporates are more highly leveraged, making their investment activity more sensitive to shifts in credit supply arising from lender balance sheet effects and risk premium effects of exchange rate fluctuations. Second, a negative effect of exchange rate appreciation on investment activity is smaller when a firm's export share is high, given that exports are largely invoiced in major currencies (Gopinath et al (2018)). In the following sections, we will test these predictions using international firm-level data.

## 3. Data

We use annual firm-level data from the Worldscope database which covers listed firms. We use data for the period 2000–15 for the G7 economies (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) and nine major EMEs (Brazil, Chile, China, India, Indonesia, Korea, Mexico, Russia and South Africa).

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 calculate gross firm leverage as the ratio of total debt to total assets and net firm leverage as the ratio of debt minus cash holdings to total assets. We further retrieved data for key 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 the tradable or 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 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, the FX liabilities include both cross-border bank credit and international debt securities issuance, 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. In contrast to Kalemli-Ozcan et al (2018), we follow Goldstein and Turner (2004) and measure total FX liabilities as the sum of credit to both the non-financial and financial sectors. This effectively treats the EME corporate sector (banks and non-banks) as one unit. This has the advantage of better capturing total FX exposures in an economy, but the drawback of potentially double counting if domestic banks extend foreign currency credit to domestic corporates.

We measure the financial sensitivity of a firm to exchange rate changes through its net leverage, i.e. debt minus cash holdings as a ratio to total assets. This measure captures the balance sheet effects of the exchange rate working through firms' debt, as well as the wider effects working through implied changes in financial conditions. It further captures the role of cash holdings as financial buffers for firms against financial shocks.[8] In addition, it enables us to zoom in on the effect working through foreign debt, using the proxy for FX leverage proposed by Kalemli-Ozcan et al (2018). 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 the 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.

Prior to the empirical analysis, we clean the firm-level data in the following standard way. We drop firms with negative sales; those with negative total assets or total liabilities; we exclude financial firms and firms from the utilities sector; we do not include firms that do not report cash and equivalents; and those that do not report common equity or total liabilities. In order to eliminate outliers, we further winsorise all firm-level variables except total assets at the 1% level.

The resulting unbalanced panel contains a total of 268,106 firm-year observations, of which 174,570 are for the G7 economies and 93,536 for EMEs (see Table 1). The number of observations ranges from 1,635 in Mexico to 67,758 in the United States. The share of firm-year observations in the tradable sector is 55.5% in the G7 and 76.2% in EMEs.

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.

Number of observations, by country Table 1

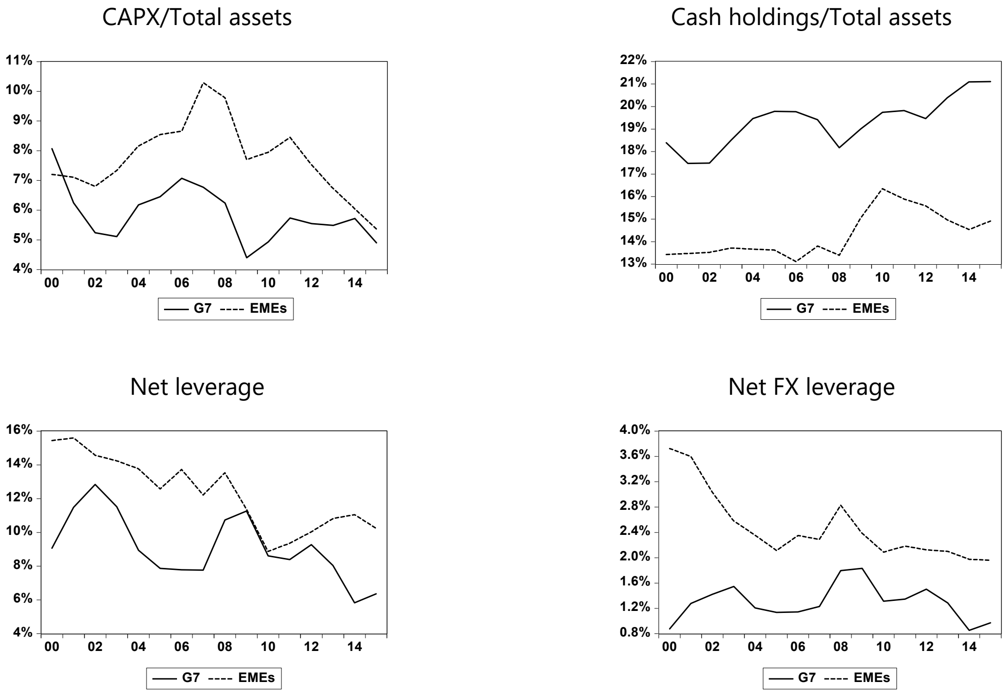
| Country | Number of firm-year observations | Firm-year observations, tradable sectors | %, tradable sector observations, of total |
|---|---|---|---|
| G7 | | | |
| Canada | 14,172 | 9,620 | 67.9% |
| France | 9,097 | 4,559 | 50.1% |
| Germany | 9,081 | 5,124 | 56.4% |
| Italy | 3,100 | 1,931 | 62.3% |
| Japan | 52,683 | 29,888 | 56.7% |
| United Kingdom | 18,679 | 8,339 | 44.6% |
| United States | 67,758 | 37,413 | 55.2% |
| EMEs | | | |
| Brazil | 3,461 | 2,407 | 69.5% |
| Chile | 2,045 | 1,180 | 57.7% |
| China | 33,376 | 25,820 | 77.4% |
| India | 19,975 | 16,150 | 80.9% |
| Indonesia | 4,845 | 3,271 | 67.5% |
| Korea | 20,149 | 15,987 | 79.3% |
| Mexico | 1,635 | 1,010 | 61.8% |
| Russia | 4,326 | 3,463 | 80.1% |
| South Africa | 3,724 | 1,942 | 52.1% |

Source: Worldscope and authors' calculations.

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

Graph 2 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 advanced and emerging economies that has been documented before based on aggregate data (Banerjee et al (2015), Kose et al (2017)). The average advanced economy firm has seen a decline in CAPEX as a share of total assets from around 7% before the crisis to below 5% in 2010 (Graph 2, top left panel). It subsequently recovered but fell again to 5% in 2015. In EMEs, the decline was more significant. Average business investment fell from above 10% of total assets before the GFC to below 6% in 2015.

Selected firm-level variables, averages for each year  Graph 2




Sources: Worldscope; authors' calculations.

The firm-level data also confirm the rise in corporate cash holdings since the GFC (Graph 2, top right panel), adding to the less pronounced upward trend since the turn of the millennium documented by Bates et al (2009), Pinkowitz et al (2012) and Sanchez and Yurdagul (2013). Advanced economy firms' cash holdings have risen on average from 18% of their assets in 2000 to 21% in 2015. In EMEs, average cash holdings rose from below 14% to above 16% in the wake of the GFC, but subsequently receded somewhat.

Meanwhile, firm net leverage has declined throughout the 2000s in both advanced and emerging economies, with a brief interruption of the trend during the GFC (Graph 2, bottom left panel). These dynamics result from the joint behaviour of book leverage and cash holdings. Average net leverage of G7 firms has declined from a peak of close to 13% in 2002 to about 6% in 2015. In the case of EME companies, it has declined from around 15% to 10% over the same period. These trends in net leverage are also reflected in the evolution of our proxy measure of net FX leverage (Graph 2, bottom right panel).

Descriptive statistics, selected firm-level variables Table 2

| G7 | Capital expenditure/ total assets, % | Cash ratio, % | Net leverage, % | Net FX leverage, % |
|---|---|---|---|---|
| Mean | 5.914 | 19.263 | 9.176 | 1.298 |
| Median | 2.884 | 12.154 | 6.295 | 0.441 |
| St dev | 9.718 | 20.389 | 50.318 | 9.920 |
| 3. quartile | 6.302 | 26.396 | 27.946 | 2.203 |
| Observations | 174,570 | 186,238 | 186,238 | 186,238 |
| **EMEs** | | | | |
| Mean | 7.692 | 14.548 | 11.720 | 2.345 |
| Median | 4.397 | 9.744 | 12.895 | 0.850 |
| St dev | 9.748 | 14.933 | 30.461 | 5.406 |
| 3. quartile | 9.874 | 20.386 | 31.196 | 4.609 |
| Observations | 93,536 | 102,930 | 102,930 | 102,930 |

Source: Worldscope and authors' calculations.

The exchange rate data are from the BIS database. As we test the financial channel of the exchange rate, we rely on a financial exchange rate concept, ie the debt-weighted exchange rates (DWERs) constructed by the BIS. These are calculated based on the total foreign currency-denominated debt for each economy. More specifically, for each country, 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 debt-weighted exchange rate is also likely to be a better gauge than the NEER of the cash flow effects of exchange rate changes operating through export revenues which we will also test in the analysis. Gopinath et al (2019) show that the bulk of exports and imports is invoiced in major currencies, suggesting that export revenues are affected by fluctuation in these major currencies rather than in the NEER. As the debt-weighted exchange rate 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 regional correspondence between the use of foreign funding currencies and export invoicing currencies.[9]

## 4. Testing for the financial channel in firm investment dynamics

The conceptual analysis in Section 2 showed that, from the perspective of a credit risk model, exchange rate depreciation would, all else equal, boost corporate investment through financial channels. These operate through borrower and lender balance sheets, and through credit risk premia embedded in lending rates. On the other hand, depreciation would boost investment through an export revenue channel. In other words, we would expect to see that the effect of exchange rate depreciation on investment is negatively linked to a firm's vulnerability to changes in the exchange rate and to the implied changes in financial conditions more generally. At the same time, it would 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 adopt an identification scheme based on a difference-in-difference estimation approach in the spirit of Rajan and Zingales (1998). Specifically, we estimate the following investment panel equation:

$$CAPX_{i,c,t} = \beta_1 LEV_{i,c,t-1} \cdot e_{c,t-1} + \beta_2 TRD_{i,c,t-1} \cdot e_{c,t-1} + \beta_3 X_{i,c,t-1} + \alpha_{c,t} + \gamma_i + \varepsilon_{i,c,t} \quad (19)$$

The dependent variable is firm-level capital investment ($CAPX$), measured as a ratio to total assets in firm $i$ in country $c$ in year $t$. We assess the presence of balance sheet channels of exchange rate changes by interacting the lagged leverage-asset ratio ($LEV$) with the lagged log level of the debt-weighted exchange rate of the respective country $e_{c,t-1}$. Since an increase in the exchange rate is an appreciation of the domestic currency, the sign of the coefficient on this variable is expected to be positive (with more positive effects of the exchange rate appreciation the more highly leveraged the company). We estimate Equation (19) separately for the two measures of net leverage described before, net leverage and the proxy for net foreign currency 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

9 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 debt-weighted exchange rate in the respective region (Berger (2016)).

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 $X_{i,c,t}$ includes firm leverage and the tradable sector dummy on its own, as well as the firm's Tobin's Q, measured as market capitalisation plus total debt less current assets divided by total assets. Cash flow is similarly normalised by total assets. Sales growth is expressed as the year-on-year growth rate. Total assets are also included as a separate explanatory variable to control for the possibility that the propensity to invest depends on the size of the firm. Finally, the panel equation includes country-time fixed effects, $\alpha_{c,t}$, and firm fixed effects, $\gamma_i$.

The results, reported in Table 3, support the notion of a financial channel of the exchange rate affecting firm investment. Leverage interacts in a highly significant way with the exchange rate. As the domestic currency appreciates against the funding currencies and financial conditions become easier, there is a positive effect on investment operating through leverage. As a corollary, highly leveraged firms are forced to cut their investment back by more when the domestic currency depreciates against funding currencies. For a firm with average net leverage (10.1%), the coefficient estimate in Column (1) suggests that a 10% depreciation of the exchange rate reduces the CAPEX/total assets ratio by 0.05 percentage points. In turn, for a firm with leverage at the 3rd quartile (29.3%), an exchange rate depreciation of the same size reduces capital expenditures by 0.15 percentage points. When net FX leverage is used instead (Column (2) of Table 3), a 10% exchange rate depreciation reduces capital expenditures by 0.10 percentage points for a firm with FX debt at the 3rd quantile.

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 a 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 0.3 percentage points in the ratio of capital expenditures to total assets. Another way of interpreting our findings is therefore that the negative effect of leverage on investment is muted when the exchange rate strengthens and financial conditions ease.

The results also confirm the relevance of the trade channel for investment dynamics. An exchange rate appreciation has a more negative effect on investment for firms operating in the tradable sector than those in the non-tradable sector. Specifically, a 10% appreciation of the exchange rate lowers the investment ratio in the tradable sector by 0.2 percentage points relative to the non-tradable sector.

For the control variables, the estimations also yield plausible results consistent with the existing literature. Tobin's Q exerts a highly significant positive effect on investment. A one percentage point increase in Tobin's Q raises CAPEX/assets by 0.6 percentage point, so there is a less than unit relationship consistent with previous studies (eg Gulen and Ion (2016)). Also cash flow and sales growth have a highly significant positive effect, while the relationship between the size of the firm (measured by total assets) and capital formation is negative. Also these results are in line with previous evidence (eg Fresard and Valta (2016); Gebauer et al (2018); Gulen and Ion (2016)). Finally, the fit of the estimated models is good, with R-squares above 50%, suggesting that the models explain a rather large share of firm investment dynamics.

Baseline model, all economies

Table 3

| Dependent variable : (Capex/Total Assets) | | |
|---|---|---|
| | (1) | (2) |
| | Net leverage | Net FX leverage |
| DWER*leverage | 0.0521*** | 0.341*** |
| | (0.0146) | (0.0594) |
| Leverage | -0.260*** | -1.672*** |
| | (0.0668) | (0.280) |
| DWER*tradable | -2.079*** | -2.080*** |
| | (0.647) | (0.643) |
| Tobin's q | 0.634*** | 0.626*** |
| | (0.0327) | (0.0307) |
| Cash flow/total assets | 0.0383*** | 0.0404*** |
| | (0.00421) | (0.00458) |
| Sales growth | 0.0134*** | 0.0140*** |
| | (0.00451) | (0.00481) |
| Total assets | -1.75e-05*** | -1.76e-05*** |
| | (4.52e-06) | (4.50e-06) |
| Firm and country-year fixed effects | Yes | Yes |
| Observations | 217,855 | 217,855 |
| $R^2$ | 0.514 | 0.514 |

Note: * $p$<0.1; ** $p$<0.05; *** $p$<0.01. All explanatory variables lagged by one period. Constant term not shown. Standard errors clustered by firm and country-year.

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 advanced economy firms. As mentioned in the introduction, financial systems in EMEs differ from those in G7 countries in important ways that may raise the prominence of exchange rate effects on investment (BIS (2019)). In particular, hedging markets are less developed and the domestic institutional investor bases 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 more prominent in EMEs than in advanced economies.

In our set-up, we can test this hypothesis by re-running Equation (19) in an augmented way, including additional interaction terms distinguishing EME firms from their advanced economy peers. Specifically, we run the following augmented panel regression:

$$CAPX_{i,c,t} = \beta_1 LEV_{i,c,t-1} \cdot e_{c,t-1} + \beta_2 TRD_{i,c,t-1} \cdot e_{c,t-1} + \beta_3 X_{i,c,t-1} + \beta_4 LEV_{i,c,t-1} \cdot e_{c,t-1} \cdot D_{i,c,t}^{EME} + \beta_5 TRADE_{i,c,t-1} \cdot e_{c,t-1} \cdot D_{i,c,t}^{EME} + \beta_6 X_{i,c,t-1} \cdot D_{i,c,t}^{EME} + \alpha_{c,t} + \gamma_i + \varepsilon_{i,c,t} \qquad (20)$$

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 $D_i^{EME}$ takes the value one if a firm is from an EME and the value zero if it is from the G7.

The estimation results, reported in Table 4, support the notion that the financial channel of the exchange rate is more prominent in EMEs. The interaction coefficient of net leverage and the exchange rate is more than twice as large for EME corporates than for those from the G7 and the difference is statistically significant at the 1% level. Specifically, for firms at average net leverage ratios, a 10% appreciation boosts investment by 0.03 percentage points in the G7 countries and by 0.1 percentage points in EMEs. For net FX leverage, the effect is 0.02 percentage points for the G7 countries and 0.11 percentage points for EMEs.

Also the export revenue channel turns out to be more powerful in EMEs than in the G7 countries. For firms in the tradable sector, exchange rate appreciation has a significantly more negative effect than on those in the non-tradable sector. Specifically, a 10% appreciation reduces investment of EME firms in the tradable sector by around 0.35 percentage points more than in the non-tradable sector. This compares with a difference of 0.1 percentage points in the G7 countries.

Interestingly, also the investment impact of the financial control variables, Tobin's Q and cash flow, is significantly larger in EMEs than in the G7 economies (Table 5). Specifically, the effect of Tobin's Q is twice as large in EMEs and not significantly different from one. The effect of cash flow is even five times larger in EMEs than in the G7 peers. This suggests that the lower financial development of EMEs that strengthens the relevance of the financial channel of the exchange rate is also reflected in greater sensitivity of EME firms' investment to financial factors more generally.

## 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 | 0.0308** | 0.189*** |
| | (0.0120) | (0.0488) |
| DWER*leverage*EME | 0.0552** | 0.302** |
| | (0.0266) | (0.121) |
| Leverage | -0.153*** | -0.935*** |
| | (0.0548) | (0.228) |
| Leverage*EME | -0.298** | -1.596*** |
| | (0.123) | (0.563) |
| DWER*tradable | -0.986 | -0.956 |
| | (0.686) | (0.683) |
| DWER*tradable*EME | -2.508** | -2.681** |
| | (1.094) | (1.099) |
| Firm and country-year fixed effects | Yes | Yes |
| Observations | 217,855 | 217,855 |
| R2 | 0.519 | 0.518 |

Note: * $p$<0.1; **$p$<0.05; ***$p$<0.01. All explanatory variables lagged by one period. Standard errors clustered by firm and country-year.

## Tobin's q and cash flow, models with EME interactions

Table 5

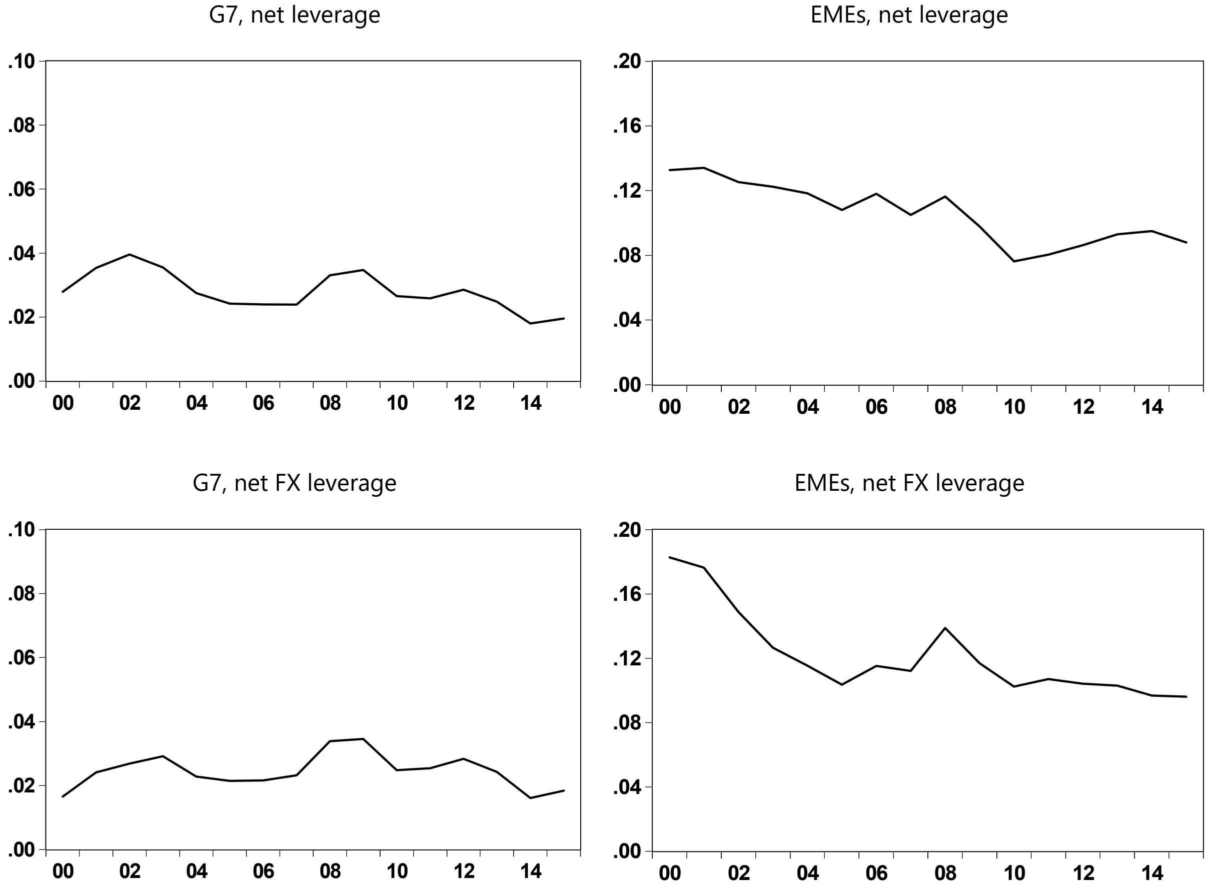
| Dependent variable : (Capex/Total Assets)$_t$ | | |
|---|---|---|
| | (1) | (2) |
| | Net leverage | Net FX leverage |
| Tobin's q | 0.572*** | 0.570*** |
| | (0.0296) | (0.0288) |
| Tobin's q*EME | 0.435*** | 0.484*** |
| | (0.114) | (0.125) |
| Cash flow/total assets | 0.0232*** | 0.0239*** |
| | (0.00315) | (0.00319) |
| Cash flow/total assets*EME | 0.0800*** | 0.0921*** |
| | (0.0120) | (0.0145) |
| Firm and country-year fixed effects | Yes | Yes |
| Observations | 217,855 | 217,855 |
| R2 | 0.519 | 0.518 |

Note: * $p$<0.1; **$p$<0.05; ***$p$<0.01. All explanatory variables lagged by one period. Standard errors clustered by firm and country-year.

These coefficient estimates 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 firm declined from 8.5% in 2011 to 5.5% 2015. Over the same period, the depreciation in EME debt-weighted exchange rates was about 40%. Using the coefficient estimates in Column

(2) and the mean net FX leverage ratio of EME firms, this yields a contribution to the CAPEX/total asset ratio from exchange rate depreciation for the average EME firm of –0.4 percentage points, accounting for almost 15% 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 hard to identify.

Impact of 10% appreciation of DWER on capex, firm at mean leverage Graph 3




Source: Authors' calculations based on coefficient estimates in Table 4. The graph shows the effect on capital investment in the following year.

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 leverage ratio. This yields a time series of the sensitivity of firm investment for the mean leveraged firm (Graph 3). The results of this calculation again highlight that the effect of the financial channel of the exchange rate on investment is considerably larger for EMEs than for the G7 economies, by an order of magnitude between 4 and 11. At the same time, the calculations suggest that, as a consequence of lower net leverage and net FX leverage, the strength of the financial channel in EMEs has declined since the early 2000s. While the effect was 0.18 in 2000, it was 0.10 in 2015 (based on net FX leverage).

Robustness tests, models for investment, with EME interactions

Table 6

| | Dependent variable : (Capex/Total Assets)$_t$ | |
|---|---|---|
| | (1) | (2) |
| | Net leverage | Net FX leverage |
| | Excluding large FX changes | |
| DWER*leverage | 0.0284** | 0.164*** |
| | (0.0123) | (0.0503) |
| DWER*leverage*EME | 0.0587* | 0.449*** |
| | (0.0318) | (0.147) |
| DWER*tradable | -1.020 | -0.997 |
| | (0.747) | (0.746) |
| DWER*tradable*EME | -2.240* | -2.409* |
| | (1.216) | (1.227) |
| Observations | 192,189 | 192,189 |
| R2 | 0.531 | 0.531 |
| | Excluding GFC | |
| DWER*leverage | 0.0305** | 0.194*** |
| | (0.0123) | (0.0519) |
| DWER*leverage*EME | 0.0633** | 0.310** |
| | (0.0277) | (0.123) |
| DWER*tradable | -0.876 | -0.851 |
| | (0.690) | (0.688) |
| DWER*tradable*EME | -2.560** | -2.711** |
| | (1.135) | (1.144) |
| Observations | 186,887 | 186,887 |
| R2 | 0.538 | 0.537 |
| | Excluding the United States and China | |
| DWER*leverage | 4.38e-05 | 0.195*** |
| | (0.0121) | (0.0525) |
| DWER*leverage*EME | 0.126*** | 0.304** |
| | (0.0236) | (0.123) |
| DWER*tradable | -0.707 | -0.633 |
| | (0.661) | (0.656) |
| DWER*tradable*EME | -2.694** | -2.671** |
| | (1.181) | (1.191) |
| Observations | 139,663 | 139,663 |
| R2 | 0.525 | 0.524 |

Note: * $p$<0.1; **$p$<0.05; ***$p$<0.01. All explanatory variables lagged by one period. Standard errors clustered by firm and country-year.

## 5. Robustness checks

We consider three different robustness tests. First, we distinguish between small and large exchange rate changes. The identified effects of the exchange rate on investment could be driven by large swings in the exchange rate and may not hold more generally. Financial conditions may tighten especially when the depreciation against the funding currency is particularly large, as such shifts may have more adverse implications for balance sheets and global investor sentiment. In the first block of Table 6, we report results excluding large exchange rate changes, defined as a change in the exchange rate that is outside the interquartile range. For brevity, we only report the coefficient estimates for the key interaction terms. The results suggest that the effect of the exchange rate on investment is not limited to periods of large exchange rate changes. The coefficient on the interaction between leverage and the exchange rate remains positive and statistically significant. These estimates also fall within two standard errors of the full sample estimates reported in Table 4.

Second, we evaluate whether the results are robust to the exclusion of the Great Financial Crisis, i.e. a period associated with major financial stress in many countries as well as large shifts in exchange rate constellations. The results, reported in the second block of the table, show that the main coefficients are little changed by the exclusion of the years 2008-09 from the sample. Thus, our findings about the relevance of the financial channel of the exchange rate are not driven by the extreme events during the GFC.

Third, we assess the robustness of the results to excluding the two largest economies from the sample, the United States and China. The United States accounts for 39% of the firm-year observation in the G7 economies, while China accounts for 36% of the firm-year observations in EMEs. The third block of Table 6 suggests that the results are also robust to this modification.

## 6. The cash flow sensitivity of cash and the exchange rate

As an additional test of the financial channel of the exchange rate, we assess the role of the exchange rate for the cash flow sensitivity of firms' cash holdings. Almeida et al (2004) have shown that the cash flow sensitivity of cash holdings is larger for firms that are more financially constrained and have to build up financial buffers. We extend the analysis of Almeida et al (2004) and test whether this sensitivity is also affected by exchange rate movements, which would be indicative of the presence of a financial channel. Put differently, if exchange rate depreciation is associated with tighter financial conditions, it would be expected to lead to an increase in firms' propensity to retain cash flow as cash in order to build up liquidity buffers, in part a mirror image of lower CAPEX. This effect would also be expected to be larger for firms which are more financially vulnerable, i.e. firms that are more highly leveraged, especially in foreign currency.

In order to test this hypothesis, we run the following panel regression:

$$\Delta CASH_{i,c,t} = \beta_1 CF_{i,c,t-1} \cdot LEV_{i,c,t-1} \quad + \beta_2 CF_{i,c,t-1} \cdot LEV_{i,c,t-1} \cdot e_{c,t-1} + \beta_3 LEV_{i,c,t-1} \cdot e_{c,t-1} + \beta_4 X_{i,c,t-1} + \alpha_{c,t} + \gamma_i + \varepsilon_{i,c,t} \qquad (21)$$

The dependent variable is the change in firm-level cash holdings ($\Delta CASH$), measured as a ratio to total assets. The first term on the right-hand side of the equation is firm cash flow (to total assets) interacted with the leverage-asset ratio ($LEV$). The expected sign of the coefficient on this interaction term is positive, i.e. higher leverage would lead to a higher share of cash flow added to cash holdings, as suggested by the findings of Almeida et al (2004). The financial channel of the exchange rate is tested based on the second term on the right-hand side, which is a triple interaction term interacting cash flow, leverage and the log level of the debt-weighted exchange rate of the respective country $e_{c,t-1}$. Since an increase in the exchange rate is an appreciation of the domestic currency, the sign of the coefficient of this triple interaction term is expected to be negative. When the exchange rate appreciates and financial conditions loosen, the propensity of more highly leveraged forms to retain cash flow as cash would be reduced (more positive effects of exchange rate appreciation the more highly leveraged the company). We further include the interaction between firm leverage and the exchange rate in order to make sure that the triple interaction term which we use to test our hypothesis does not just proxy for the interaction between leverage and the exchange rate, which may also have a negative relationship with cash holdings. In addition, we include a similar set of firm control variables as in the investment regressions, together with country-time and firm fixed effects.

The results reported in Table 7 support the notion of a financial channel of the exchange rate operating also through firm cash holdings. We find, in line with Almeida et al (2004), that the propensity to retain cash flow as cash increases in firm net leverage. This effect is significantly reduced when the exchange rate appreciates, reflected in the negative coefficient of the triple interaction term between cash flow, leverage and the exchange rate. Both effects are statistically significant at the 5% level in the case of net FX leverage – not surprisingly, the financial channel of the exchange rate appears to be working mainly through foreign currency debt.

The results reported in Table 7 also suggest some other interesting dynamics. In the case of foreign currency debt, the interaction between leverage and the exchange rate has a statistically significant negative effect on cash holdings. Thus, for a given exchange rate appreciation that loosens financial conditions, the reduction in liquidity buffers would be larger, the more highly leveraged the company. Moreover, higher net FX leverage on its own is associated with a build-up of cash buffers.

Finally, and as suggested by Almeida et al (2004), an increase in capital expenditures reduces cash holdings as firms draw down their cash reserves.

Cash holdings

Table 7

| Dependent variable: d(Cash)$_t$/Total Assets$_t$ | | |
|---|---|---|
| | (1) | (2) |
| | Net leverage | Net FX leverage |
| (Cash flow/TA)*Leverage | 0.0033 | 0.0234** |
| | (0.0026) | (0.0103) |
| (Cash flow/TA)*DWER*Leverage | -0.0006 | -0.00497** |
| | (0.0006) | (0.00218) |
| (Cash flow/TA)*DWER | -0.0002 | -0.00287*** |
| | (0.0008) | (0.000904) |
| DWER*leverage | 0.0145 | -0.235** |
| | (0.0208) | (0.115) |
| Leverage | 0.0623 | 1.488*** |
| | (0.0945) | (0.541) |
| Capex/total assets | -0.119*** | -0.136*** |
| | (0.00651) | (0.00740) |
| Tobin's q | 0.00959 | 0.0768*** |
| | (0.0315) | (0.0290) |
| Cash flow/total assets | 0.0533*** | 0.0554*** |
| | (0.00491) | (0.00488) |
| Total assets | -3.88e-06 | -2.55e-07 |
| | (3.19e-06) | (2.96e-06) |
| Firm and country-year fixed effects | Yes | Yes |
| Observations | 211,201 | 211,201 |
| R2 | 0.192 | 0.154 |

Note: * $p$<0.1; **$p$<0.05; ***$p$<0.01. All explanatory variables except Capex/total assets and Cash flow/total assets lagged by one period. Constant term not shown. Standard errors clustered by firm and country-year.

## 7. Conclusions

In this paper, we have analysed the effects of the financial channel of the exchange rate on corporate investment. First, we proposed a simple theoretical model that considers the exchange rate effect under different mechanisms: when corporates borrow in foreign currency; when they borrow in local currency but from foreign lenders; and the case where there are no currency mismatches but global bond investors' portfolio adjustments affect domestic risk premia. The model shows that exchange rate depreciation has a negative effect on investment through its effect on credit risk, while a countervailing effect arises through trade revenues. This implies that the financial channel is likely to be stronger for firms are financially vulnerable while the trade channel is likely to be stronger for exporting companies.

Then, using firm-level data for sixteen major economies, we confirm that the exchange rate affects corporate investment through a financial channel. We document that a negative effect of exchange rate depreciation on investment arises through and increases in firm leverage and FX debt. This effect is more pronounced for EME corporates, consistent with the notion of a more prominent financial channel of the exchange rate due to greater dependence on foreign funding and less developed financial systems. Moreover, we find that when the exchange rate weakens, highly leveraged firms increase the share of cash they save out of cash flow, supporting, from a different angle, the notion of a financial channel of the exchange rate. 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 working of the trade channel.

Overall, our findings suggest that the large depreciation of EME currencies against major funding currencies probably contributed significantly to the recent investment slowdown in these economies. At the same time, our results suggest that the deleveraging of EME corporates since 2000 may have, on average, 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 currencies would tend to contain 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.[10] In line with such considerations, these tools do indeed play a prominent role in the macro-financial stability policy frameworks of many EMEs (Agénor and Pereira da Silva (2019), BIS (2019)).

[10] For a study on the microeconomic effects of macroprudential policies, including on firm-level credit growth, see Ayyagari et al (2018). For a cross-country analysis of the effectiveness of macroprudential FX regulations, see Ahnert et al (2018). For a recent analysis of the effects of FX intervention on domestic corporate borrowing for the case of Colombia, see Hofmann et al (2019a).

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