BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers

No 695

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Monetary and Economic Department

January 2018

JEL classification: F31, F32, F34, F41

Keywords: financial channel, exchange rates, cross-border bank lending, real investment

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This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

The dollar exchange rate as a global risk factor: evidence from investment[1]

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Paper prepared for the IMF 18th Jacques Polak Annual Research Conference

Abstract

Exchange rate fluctuations influence economic activity not only via the standard trade channel, but also through a *financial channel*, which operates through the impact of exchange rate fluctuations on borrowers' balance sheets and lenders' risk-taking capacity. This paper explores the "triangular" relationship between (i) the strength of the US dollar, (ii) cross-border bank flows and (iii) real investment. We conduct two sets of empirical exercises - a macro (country-level) study and a micro (firm-level) study. We find that a stronger dollar is associated with lower growth in dollar-denominated cross-border bank flows and lower real investment in emerging market economies. An important policy implication of our findings is that a stronger dollar has real macroeconomic effects that go in the opposite direction to the standard trade channel.

[1] We thank Signe Krogstrup, Amal Mattoo, Linda Tesar, two anonymous referees, participants at the IMF 18th Jacques Polak Annual Research Conference and seminar participants at the Federal Reserve Board for valuable comments and suggestions. Bat-el Berger and Zuzana Filková provided excellent research assistance. We also thank Stijn Claessens, Hui Tong, and Shang-Jin Wei for sharing their data series on financial dependence. The views expressed are those of the authors and not necessarily those of the Bank for International Settlements.

1. Introduction

Exchange rate fluctuations influence economic activity through both real and financial channels. The conventional trade channel with effects on the real economy operates through net exports. This channel is well-known and standard in open-economy macro models. By contrast, the financial channel operates through exchange rate fluctuations which trigger valuation changes, balance-sheet adjustments and shifts in risk-taking, both in financial and real assets, with impact on the real economy. Although the financial channel of exchange rates has historically been less prominent than the net exports channel, it has become more important with the greater integration of the global financial system in recent years.

Crucially, the financial channel of exchange rate fluctuations often operates in the opposite direction relative to the net exports channel. Specifically, under the net exports channel, it is when the domestic currency *depreciates* that real economic activity picks up. By contrast, the financial channel operates through the liabilities side of the balance sheet of domestic borrowers, so that it is when the domestic currency *appreciates* that balance sheets strengthen and economic activity picks up.

The key empirical regularity at the heart of the financial channel of exchange rates is the empirical association between the depreciation of an international funding currency and the greater borrowing in that currency by non-residents. In the specific case of the US dollar, the empirical regularity is that when the dollar depreciates against the currency of a given country, the residents of that country tend to borrow more in US dollars.

This empirical regularity has several drivers, both on the *demand* for dollar credit on the part of borrowers and on the *supply* of dollar credit by lenders. In terms of the *demand* for dollar credit, a borrower who had borrowed in dollars to finance domestic real estate assets would see a strengthening of their balance sheet due to the depreciation of the dollar. More commonly, an exporting firm with dollar receivables or an asset manager with dollar-denominated assets – but with domestic currency obligations – would hedge currency risk more aggressively when the dollar is expected to depreciate more. Incurring dollar liabilities, or an equivalent transaction off balance sheet, would be the way to hedge currency risk in such instances.

The link between dollar depreciation and greater borrowing in dollars by non-residents may also operate through the *supply* of dollar credit, and has been dubbed the "*risk-taking channel*" by Bruno and Shin (2015b). When there is the potential for valuation mismatches on borrowers' balance sheets arising from exchange rate fluctuations, a weaker dollar flatters the balance sheet of dollar borrowers, whose liabilities fall relative to assets. From the standpoint of creditors, the stronger credit position of the borrowers reduces tail risk in the credit portfolio and creates spare capacity for additional credit extension even with a fixed exposure limit as given by a value-at-risk (VaR) constraint or an economic capital (EC) constraint.

The financial channel of exchange rate fluctuations has both a price and a quantity dimension. The price dimension has been addressed by Hofmann et al (2016) and Avdjiev et al (2017). Hofmann et al (2016) use data on sovereign bond spreads to show that a currency appreciation is associated with greater risk-taking by both borrowers and lenders. There is also rapidly mounting empirical evidence for the existence of the quantity dimension of the financial channel of exchange rate fluctuations. Avdjiev et al (2017) have demonstrated that an appreciation in the US dollar is associated with contractions in cross-border bank lending denominated in US dollars. In addition, Kearns and Patel (2016) have found evidence that the financial channel partly offsets the trade channel for emerging market economies (EMEs) and that investment is found to be particularly sensitive to the financial channel.

In this paper, we build on the literature above by exploring the "triangular" relationship between (i) the strength of the US dollar, (ii) cross-border bank flows and (iii) real investment. More specifically, we examine the triangular relationship through two sets of empirical exercises – a macro (country-level) study, and a micro (firm-level) study. In the first one, we examine evidence from structural panel vector autoregressions (SPVARs) using country-level data on real investment, cross-border bank credit, the strength of the US dollar, US monetary policy and global uncertainty. In the second study, we estimate the relationship between corporate capital expenditure (CAPEX) and the strength of the US dollar (while controlling for a number of additional factors) in a firm-level panel setup.

In principle, there are three concepts of exchange rates that could potentially be relevant. First, in the classic Mundell-Fleming paradigm, the trade-weighted exchange rate of a given country affects economic activity in that country through its impact on net exports. Second, the bilateral exchange rate of a country's currency vis-à-vis the US dollar operates through both net exports via its impact on import prices and quantities (as highlighted by the "dominant currency paradigm" literature) and credit demand from local borrowers via its impact on the net worth of borrowers with currency mismatches on their balance sheets (as emphasised by the EME crisis literature). Third, the broad US dollar index affects the credit risk in a diversified portfolio of US dollar-denominated loans of borrowers with currency mismatches and determines the tail risk in a diversified global portfolio of dollar-denominated loans of global banks. As a consequence, it has an impact on the supply of credit by global banks through the value-at-risk (VaR) constraint (Bruno and Shin, 2015a and 2015b; Avdjiev et al, 2016). Which of the above three exchange rates is most relevant for real investment is the subject of our empirical investigation.

We find that a stronger US dollar is associated with lower dollar-denominated cross-border bank flows and lower real investment in EMEs. Our empirical investigation establishes four findings. First, in line with the predictions of Bruno and Shin (2015b), we find a negative relationship between the strength of the US dollar and cross-border bank lending denominated in US dollars, both for the bilateral dollar exchange rate and the broad dollar index. Second, increases in US dollar-denominated cross-border bank credit to a given EME are associated with greater real investment in that EME. Third, the combination of the first two relationships results in the most important link that we discover – an appreciation of the US dollar leads to a decline in real investment. Finally, we find that the broad dollar index is the most relevant exchange rate for real investment, in line with previous studies that have found that dollar lending by global banks fluctuates with the broad dollar index and highlight the prevalence of the credit supply mechanism (Avdjiev et al, 2016; Avdjiev et al, 2017).

Our results add to previous evidence that a stronger dollar has real macroeconomic effects that go in the opposite direction to the standard trade channel. Whereas a stronger dollar would normally benefit those countries that export to the United States, the dampening effect of the dollar on investment may offset any benefits that accrue from the trade channel. In additional tests that we run, we find evidence that, when it comes to their net impact on overall economic activity in a given country, the financial channel actually dominates the traditional trade channel.

In addition to the papers discussed above, our work is also related to several additional strands of literature.

First, our paper is most closely linked to the literature that examines the financial channels through which exchange rate movements affect macroeconomic and financial outcomes across countries. On the theoretical side, several models with financial frictions predict that exchange rate fluctuations have a balance-sheet effect and generate results according to which depreciation is contractionary if firms have foreign currency-denominated liabilities on their balance sheets (for example, Krugman, 1999; Céspedes et al, 2004).

On the empirical side, there is rapidly mounting evidence of the existence of the above exchange rate channels. Bebczuk et al (2010) and Kohn et al (2015) have demonstrated that local currency devaluations can be contractionary. Bruno and Shin (2015a) and Avdjiev et al (2016) have found that a US dollar appreciation can cause a reduction in cross-border bank lending through its impact on the balance sheets of global banks. Kim et al (2015) have demonstrated that, in the case of Korea, the balance-sheet effect is important for small, non-exporting firms that entered the global financial crisis with short-term foreign currency-denominated debt. Eichengreen and Tong (2015) examine the impact of a renminbi revaluation on non-Chinese firms' stock returns through the trade channel. Du and Schreger (2016) have found that a higher reliance on external foreign currency corporate financing is associated with a higher default risk on sovereign debt. Using loan-level data from US banks' regulatory filings, Niepmann and Schmidt-Eisenlohr (2017) have demonstrated that exchange rate changes can affect the ability of currency-mismatched firms to repay their debt. Further, Claessens et al (2015) find that the euro crisis had a larger impact on firms with greater ex ante financial dependence and, in particular, on firms residing in creditor countries that are more financially exposed to peripheral euro countries through bank claims. In addition, Druck et al (2017) document a negative relation between the strength of the US dollar and emerging markets' growth: when the dollar is strong, emerging markets' real GDP growth decreases, and vice versa.

Second, our paper is related to the literature on the link between the strength of the US dollar and international trade. Goldberg and Tille (2008) and Gopinath (2015) have found evidence that the overwhelming majority of trade is invoiced in a small number of "dominant currencies", with the US dollar playing an outsize role. In turn, Casas et al (2016) have developed a "dominant currency paradigm" in which dollar-denominated trade prices are sticky and have shown that the bilateral exchange rate of a country's currency against the dollar is a primary driver of that country's import prices and quantities, regardless of where the good originates from. Furthermore, Boz et al (2017) have demonstrated that the US dollar exchange rate quantitatively dominates the bilateral exchange rate in price pass-through and trade elasticity regressions, and that the strength of the US dollar is a key predictor of the "rest-of-world's" aggregate trade volume and consumer/producer price inflation.

Third, our work is connected to the literature on the global financial cycle. Several papers have demonstrated that monetary policy shocks in financial centres can be transmitted further afield and have a significant impact on global financial conditions. Miranda-Agrippino and Rey (2012) and Rey (2015) make the case for the existence of a global financial cycle that synchronises capital flows, asset prices and credit growth. The global financial cycle is, in turn, associated with the stance of monetary policy in the United States. Furthermore, the main types of capital flows are also highly correlated with each other and negatively correlated with the VIX (Forbes and Warnock, 2012).

Last but not least, our paper is also related to the literature on international shock transmission by banks. This literature dates back to two seminal papers by Peek and Rosengren (1997, 2000). Our work is most closely linked to the strand within this literature that focuses on emerging market borrowers (eg McGuire and Tarashev, 2008; Takáts, 2010; Cetorelli and Goldberg, 2011; Schnabl, 2012, Avdjiev et al, 2012; Beck, 2014; Cerutti et al, 2016; Goldberg and Krogstrup, 2017).

The rest of this paper is organised as follows. We describe our empirical framework in Section 2. In Section 3, we introduce the data used to conduct our empirical exercises. Section 4 describes our benchmark results. In Section 5, we present robustness analyses and additional tests. We conclude in Section 6.

2. Empirical framework

We split our empirical investigation into two parts – a macro (country-level) study and a micro (firm-level) study. In the first one, we examine evidence from SPVARs using macro data. In the second one, we estimate firm-level panel regressions on the relationship between corporate CAPEX and the exchange rate value of the US dollar.

2.1 Macro (country-level) study

The SPVARs exploit the dynamic relationships among cross-border bank flows, bilateral exchange rates, financial and interest rate conditions, and corporate investments. The main principle of the SPVAR is the same as that of any panel methodology. That is, by allowing for fixed effects in the model, we capture the unobservable time-invariant factors at the individual country level, while treating all variables as jointly determined (Abrigo and Love, 2015).

More concretely, we consider the following SPVAR:

$$By_{i,t} = f_i + A(L)y_{i,t-1} + u_{i,t} \tag{1}$$

where $y_{i,t}$is an m-dimensional vector of our stacked endogenous variables, f_i is a diagonal matrix of country-specific intercepts, $A(L) = \left(\sum_{j=0}^{p} A_j L^j\right)$ is a polynomial of lagged coefficient A_j, L^j is the lag operator, B is a matrix of contemporaneous coefficients, and $u_{i,t}$ is a vector of stacked structural innovations with a diagonal covariance matrix described by $u_t \sim N(0, \mathrm{I}_m)$ and $E[\boldsymbol{u}_t \boldsymbol{u}'_s] = \boldsymbol{0_m}$ for all $s \neq t$.

In our baseline specification, we examine a five-dimensional vector, $y_{i,t}$, which consists of the following variables: (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) the strength of the US dollar and (5) the VIX.[2] The ordering of the variables is consistent with the mechanism in Bruno and Shin (2015a, 2015b), where a decrease in the cost of borrowing or other risk measures is reflected in firms' balance-sheet management and cross-border flows.

Since f_i is correlated with regressors due to the lags of the dependent variables in dynamic panels, OLS-based estimation would lead to biased coefficient estimates (Nickell, 1981). To avoid this concern, we rewrite the SPVAR in (1) as an m-dimensional system of equations in first differences with $\boldsymbol{e}_t$ as an m x 1 vector of reduced-form residuals based on $e_t \sim N(0, \Sigma_e)$ and $E[e_t e'_s] = 0_m$ for all $s \neq t$.

$$\begin{aligned} \Delta y_{1,i,t} &= \textstyle\sum_{j=1}^{p} \gamma_{11}^{j} \, \Delta y_{1,i,t-j} + \cdots + \sum_{j=1}^{p} \gamma_{1m}^{j} \, \Delta y_{m,i,t-j} + e_{1,i,t} \\ &\vdots \\ \Delta y_{m,i,t} &= \textstyle\sum_{j=1}^{p} \gamma_{m1}^{j} \, \Delta y_{1,i,t-j} + \cdots + \sum_{j=1}^{p} \gamma_{mm}^{j} \, \Delta y_{m,i,t-j} + e_{m,i,t} \end{aligned} \tag{2}$$

We utilise Arellano-Bond's GMM/IV technique to estimate the system in (2) using four lags of our endogenous variables as instruments (Arellano and Bond, 1991). This procedure gives us an estimate of the variance-covariance matrix $\sum_e \ = E\left[e_{i,t} e'_{i,t}\right]$.

The equivalent moving average representation of the SPVAR model (1) can be re-stated as follows:

$$\boldsymbol{B} y_{i,t} = \Phi(L) u_{i,t} \tag{3}$$

with $\Phi(L) = \sum_{j=0}^{\infty} \Phi_j L^j = \sum_{j=1}^{\infty} A_1^j L^j$ describing the structural-form responses of horizon j to unit-variance structural innovations with $\Phi_0 = A_1^0 \equiv \mathrm{I}_m$.

As $B^{-1} u_{i,t} = e_{i,t}$, we can rewrite $\sum_e \ = E\left[\boldsymbol{B}^{-1} u_{i,t} u'_{i,t} \boldsymbol{B}^{-1\prime}\right]$ with $u_{i,t}$ denoting the structural innovations which are assumed to be uncorrelated $\left(u_{i,t} u'_{i,t} = \mathrm{I}_m\right)$ leading to $\sum_e \ = E\left[B^{-1} \quad B^{-1\prime}\right]$. We can hence retrieve the $\boldsymbol{B}$ matrix by decomposing the estimate of our variance-covariance matrix $\sum_e$ into two lower triangular matrices. To identify the model, we orthogonalise the contemporaneous responses. Specifically, we impose the ordering restriction on our baseline specification in that foreign exchange (FX) shocks do not have a contemporaneous effect on changes in lending, whereas shocks to lending are allowed to contemporaneously affect the FX rate.

[2] All endogenous variables enter in first differences or growth rates, except for the VIX, which enters in log-levels.

We follow Lütkepohl (2007) to obtain impulse responses at horizon h from the vector moving average representation of the SPVAR. The marginal responses Φ_h are recovered recursively:

$$\Phi_h = \sum_{k=1}^{h} \Phi_{h-k} A_h \tag{4}$$

Then we multiply all Φ_h by our estimate of B^{-1} and use an m-dimensional impulse response vector $s \equiv [1, \ldots, 0]'$ to construct the matrix P of structural responses at horizon *h*:

$$P = \begin{bmatrix} B^{-1}\Phi_0 s \\ \vdots \\ B^{-1}\Phi_h s \end{bmatrix}_{hxm} \tag{5}$$

After recovering the point estimates of all the impulse response functions, we calculate standard errors non-parametrically through a simulation algorithm with 1000 Monte Carlo-type replications at a horizon of 10 quarters.

2.2 Micro (firm-level) study

We use firm-level data on capital expenditure to estimate our panel regressions. We employ the following benchmark specification:

$$\frac{CAPEX}{TA}_{ijt} = \alpha \Delta BER_{jt} + \beta \Delta BER_{jt} * FINDEP_i + Controls_{it} + FE + \varepsilon_{ijt} \tag{6}$$

The dependent variable, $\frac{CAPEX}{TA}_{ijt}$, is the CAPEX of firm *i* from country *j* at time *t* as a share of its total assets. The main explanatory variable of interest is ΔBER_{jt}, the annual percentage change in the value of the US dollar vis-à-vis country *j*'s domestic currency (a positive value of ΔBER_{jt} implies that the US dollar has appreciated against the domestic currency of country *j* during period *t*). A positive coefficient estimate α suggests that a depreciation of the domestic currency of a given country against the US dollar spurs firm-level investment in that country. In addition, we include the interaction of the bilateral exchange rate (ΔBER_{jt}) with an industry-level indicator of external financial dependence $FINDEP_i$ (see Rajan and Zingales, 1998, for more details on the methodology). This allows us to test our hypothesis that firms with higher external financing needs are hit more severely by an appreciation of the US dollar. To control for other factors at the firm level, we include $Controls_{it}$ capturing a host of typical firm characteristics like size, short-term investments, profitability and the share of property, plants and equipment in total assets. We challenge our specification with different combinations of fixed effects at the industry, time and country level.

We also examine a specification in which we replace the bilateral exchange rate with the component of the annual percentage change in the US dollar nominal effective exchange rate (NEER) index that is unrelated (ie *orthogonal*) to the change in the bilateral exchange rate ($\Delta NEER_{jt}^{orth}$):

$$\frac{CAPEX}{TA}_{ijt} = \alpha_2 \Delta NEER_{jt}^{orth} + \beta_2 \Delta NEER_{jt}^{orth} * FINDEP_i + \gamma \Delta NEER_{jt}^{orth} + Controls_{it} + FE + \varepsilon_{ijt} \quad (7)$$

Finally, we examine a specification in which we let both exchange rate concepts (the bilateral rate and the broad dollar index) enter simultaneously.

$$\frac{CAPEX}{TA}_{ijt} = \alpha_1 \Delta BER_{jt} + \alpha_2 \Delta NEER_{jt}^{orth} + \left(\beta_1 \Delta BER_{jt} + \beta_2 \Delta NEER_{jt}^{orth}\right) * FINDEP_i + \gamma \Delta NEER_{jt}^{orth}$$
$$+ Controls_{it} + FE + \varepsilon_{ijt} \quad (8)$$

After estimating our baseline specifications for the full sample, we re-run it for different subsamples in order to isolate firms operating in the non-tradable sector and those located in countries with a floating exchange rate regime.

In an earlier work, Bruno and Shin (2014) find that global liquidity influences corporate risk-taking across regions and across industry sectors. In particular, more accommodative credit conditions associated with global liquidity at the centre lead to lower risk-adjusted lending rates that induce firms to apply lower discount rates (and hence higher net present values) in their investment decisions. Other things being equal, firms take on more investment projects for any given profile of expected fundamental cash flows. In this way, global factors can induce co-movements in risk-taking and they induce greater synchronisation of risk-taking across regions and sectors.

3. Data

Table 1 provides the descriptive statistics of all variables used to conduct our benchmark macro (country-level) and micro (firm-level) analysis.

Panel A contains a summary for the variables used in the macro analysis, which is based on quarterly data from Q2 2001 to Q4 2016 for a sample of 34 EMEs[3].

For our benchmark exchange rate variable, we draw on quarterly averages of daily values of the *bilateral* exchange rate between the domestic currency of the borrowing country and the US dollar. An increase in the exchange rate variable indicates an appreciation of the US dollar relative to the local

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[3] Appendix A provides a list of all country groups used in our macro- and micro-level empirical analyses.

currency. We then compare the results obtained using the bilateral exchange rate versus the US dollar against the results generated using an alternative measure of US dollar strength – the BIS broad US dollar NEER index.

We obtain the series on US dollar-denominated cross-border bank flows from the BIS locational banking statistics (LBS). They capture outstanding claims and liabilities of banks located in BIS reporting countries, including intragroup positions between offices of the same banking group (BIS, 2015). The BIS LBS are compiled following principles that are consistent with the balance of payments framework. To take exchange-rate fluctuations and breaks-in-series into account, adjusted changes in amounts outstanding are calculated as an approximation for flows. Most importantly for our empirical investigation, the BIS LBS provide information about the currency composition of cross-border claims, which allows us to isolate the US dollar-denominated component of cross-border bank lending. Furthermore, we exploit the BIS LBS breakdowns by borrower country and sector and link them to the changes in gross fixed capital formation as reported for the private sector in a given counterparty country.

Since the main monetary policy rates in advanced economies were stuck at the zero lower bound for large parts of our benchmark period, we use shadow rates as a measure of the US Federal Reserve's monetary policy stance. More concretely, we use quarterly changes in those shadow policy rates as described in Krippner (2015). Krippner's shadow rate estimates are based on a two-factor model which is shown to be more stable over time than the alternative, three-factor model. There are some concerns that the estimated level of the shadow rate may not be a perfect measure of monetary policy stance as it is sensitive to the assumption underlying the specification. However, changes in shadow rates – the focus of this project – are shown to be a consistent and effective proxy for monetary policy changes.

For our aggregate investment variable, we use the country-level series on gross fixed (private) capital formation from the IMF *International Financial Statistics* and *World Economic Outlook*.

We use the VIX as proxy for global financial market conditions. We obtain those data series from the CBOE website. In order to match the frequency of the other variables in our benchmark empirical specification, we convert the daily VIX data into quarterly averages.

Descriptive statistics Table 1

	Obs.	Mean	Std Dev	1st percentile	99th percentile
PANEL A: Variables used in the macro analysis					
Δirate (percentage points)	1,893	-0.058	0.675	-1.699	1.898
ΔBER_ave (%)	1,893	0.637	4.656	-7.836	19.516
ΔBER_end (%)	1,893	0.625	5.341	-10.155	19.658
ΔNEER	1,893	-0.009	2.848	-7.180	8.280
ΔXB_Claims (%)	1,893	2.269	14.736	-34.959	66.533
Δln_GFCF (%)	1,893	1.861	10.529	-30.240	25.214
ln_vix	1,893	2.931	0.356	2.433	3.787
ΔFRB_EME_USD_index (%)	1,893	0.039	2.674	-6.499	8.162
ΔMacro_EME_USD (%)	1,893	1.757	5.273	-5.865	29.037
PANEL B: Variables used in the micro analysis					
CAPEX/TA	121,632	0.620	0.071	0.001	0.419
Size	121,632	4.684	2.157	-5.286	13.353
Cash/TA	121,632	0.124	0.141	0.003	0.760
PPE/TA	121,632	0.351	0.227	0.010	0.922
ROA	121,632	4.139	6.866	-25.935	27.816

Panel A shows descriptive statistics for the quarterly variables used in the macro-level analysis. *Δirate* denotes quarterly changes in the US federal funds rate up until Q4 2007 and quarterly changes in Krippner's (2015) shadow short rate after Q1 2008. *ΔBER_ave* denotes percentage changes in the average bilateral exchange (*ΔBER_end* refers to end-quarter data), *ΔNEER* refers to quarterly changes in the BIS broad USD nominal effective exchange rate (NEER) index, *ΔXB_Claims* indicates quarterly percentage changes in cross-border, US-dollar denominated claims on country *i*, *Δln_GFCF* denotes quarterly growth rates in gross-fixed capital formation and *ln_vix* stands for log levels of the CBOE option-implied S&P 500 volatility index from the CBOE. Changes in the bilateral exchange rates and in cross-border lending are winsorised at the 1% level in each tail of the distribution. *ΔFRB_EME_USD_index* is a trade-weighted average of the foreign exchange value of the US dollar against the following set of EMEs: Mexico, China, Taiwan, Korea, Singapore, Hong Kong, Malaysia, Brazil, Thailand, Philippines, Indonesia, India, Israel, Saudi Arabia, Russia, Argentina, Venezuela, Chile and Colombia. *ΔMacro_EME_USD* is trade-weighted average of the foreign exchange value of the US dollar against the set of EMEs included in the macro study (listed in Appendix A). Period covered: Q2 2001–Q3 2016. Panel B provides descriptive statistics for the annual variables used in the micro-level analysis. *CAPEX/TA* is defined as a firm's capital expenditure (CAPEX) as a share of its total assets. *Size* is the logarithm of total assets (in USD), *Cash/TA* is Cash and other short-term investments scaled by total assets, *PPE/TA* is property, plant and equipment scaled by total assets and *ROA* is a measure of profitability (return on assets). Scaled capital expenditure is winsorised at the 1% and 99% level in each tail. Period covered: 2000–2015.

Sources: Krippner (2015); Board of Governors of the Federal Reserve System; Federal Reserve Bank of St Louis FRED; IMF *International Financial Statistics* and *World Economic Outlook*; Chicago Board Options Exchange; national data; BIS locational banking statistics; Bloomberg; Capital IQ; authors' calculations.

Panel B of Table 1 contains a summary for the variables used in the micro-level analysis, which exploits annual data from Capital IQ based on firm-level reports from 32 EMEs for the period between 2000 and 2015. Besides firm-level CAPEX, which is used as our key dependent variable, we use basic firm characteristics such as size as measured by total assets (TA), cash holdings, profitability measures (return on assets (ROA)) and other fixed assets (property, plant and equipment). Our sample consists exclusively of non-financial firms. To examine whether financial dependence amplifies the exchange rate effect, we utilise an updated version of the industry-level index of external financial dependence, originally developed by Rajan and Zingales (1998). All other independent variables, like the bilateral exchange rate, the VIX and the measure of US monetary policy correspond to those used in the macro-level analysis.

4. Benchmark results

The results from both of our main empirical exercises (the macro (country-level) study and the micro (firm-level) study) strongly suggest that an appreciation of the US dollar is associated with slowing investment on a global scale. In the rest of this section, we discuss the key results from our two benchmark empirical exercises. We start with the main results from the macro (country-level) SPVARs. We then discuss the key findings from the micro (firm-level) panel regressions.

4.1 Results from the macro (country-level) study

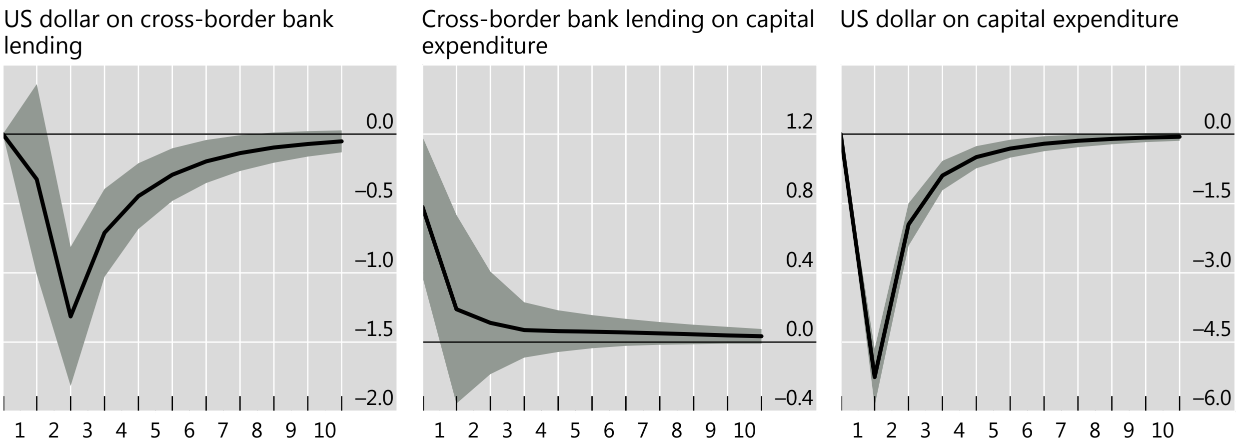
We conduct our macro exercise using the SPVAR methodology described in Section 2.1. In our benchmark estimation, we follow Bruno and Shin (2015a) when ordering the five endogenous variables in our SPVAR system. It is important to note that we order cross-border bank lending ahead of the strength of the US dollar exchange rate. This rules out any contemporaneous effects of the US dollar on cross-border bank lending, thus tilting the odds against us finding evidence in support of the predictions of the theoretical model of Bruno and Shin (2015b).

Figure 1 presents the key impulse responses from our benchmark SPVAR estimation. The left-hand panel shows that a strengthening in the dollar is associated with a fall in dollar-denominated cross-border bank lending. This finding is in line with the conclusions of Bruno and Shin (2015a, 2015b). In turn, the centre panel of Figure 1 reveals that an increase in cross-border US dollar bank lending to a given country boosts real investment activity in that country. This effect goes beyond simply financing real investment with dollars – the financial channel of exchange rates generates broader incentives to take or shy away from risks associated with currency fluctuations. This channel is especially powerful when currency movements cause the value of borrowers' assets or debts to grow or shrink. At the same time, the exchange-rate fluctuations of the local currency vis-à-vis the US dollar impact the risk premium of local currency sovereign bonds (Hofmann et al, 2016), and hence shape domestic financial conditions more generally.

The right-hand panel presents our key finding – a US dollar appreciation affects investment, but in the opposite direction to the trade channel. When the domestic currency weakens against the dollar, there is a sharp *drop* in investment. Thus, a stronger dollar dampens economic activity, rather than stimulating it. More concretely, a one standard deviation appreciation in the value of the US dollar vis-à-vis the local currency leads to a five percentage point decline in the growth rate of gross capital formation in the subsequent quarter. The effect emerges during the first quarter after a US dollar appreciation and remains statistically significant for more than two years.

Impulse response functions: US dollar, cross-border bank lending, investment

Benchmark SPVAR, full sample Figure 1



Black lines show the estimated impulse response functions to a one-standard-deviation shock to the exchange rate equation using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral average US dollar exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

In sum, the impulse response functions generated by the benchmark SPVAR analysis provide strong evidence that the financial channel of exchange rates points in the opposite direction relative to the trade channel. Intuitively, a stronger US dollar deteriorates the creditworthiness of currency-mismatched EME borrowers, as their liabilities increase relative to their assets. For instance, suppose that an EME borrower has local currency assets and dollar-denominated liabilities. Even if assets generate dollar-denominated cash flows, a stronger dollar weakens the borrower's cash flows due to the rising debt service costs, as in the case of oil firms. From the standpoint of creditors, the weaker credit position of the borrower increases tail risk in the credit portfolio and decreases the capacity for additional credit extension, even with a fixed exposure limit through a VaR constraint or economic capital constraint. This leads to a decline in cross-border bank lending. Bruno and Shin (2015a, 2015b) have labelled this the "risk-taking channel of currency appreciation". As our benchmark results illustrate, the decline in cross-border lending triggered by a depreciation in the currency of a given country against the US dollar ultimately results in a contraction in real investment in that country.

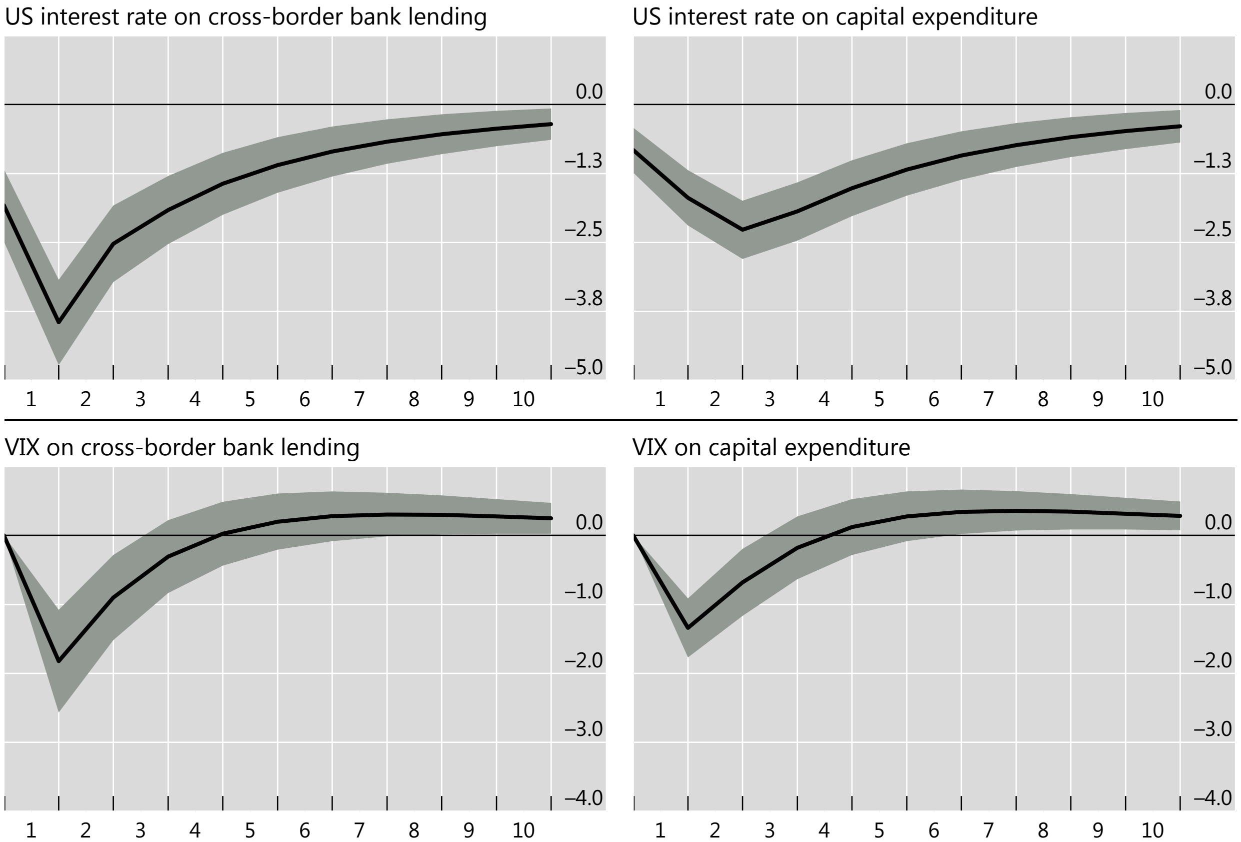
Next, we delve deeper into the estimated dynamic relationships implied by our benchmark SPVAR estimates. Figure 2 displays the impulse responses of cross-border lending (left-hand panels) and real investment (right-hand panels) to shocks in US monetary policy (top panels) and global uncertainty, measured by the VIX (bottom panels). The results displayed in the top panels suggest that a tightening in US monetary policy is associated with sharp and prolonged declines in both cross-border bank credit and real investment. The impulse responses displayed in the lower panels reveal that a rise in global uncertainty also leads to significant falls in both cross-border bank lending and real investment. Nevertheless, in both cases, the duration of the contractions triggered by spikes in global uncertainty is somewhat smaller than the respective duration of the declines caused by a tightening of US monetary policy. Since US monetary policy tends to have a greater and longer-lasting impact on the value of the US dollar, the results presented in Figure 2 could be interpreted as further evidence of the existence of the financial channel of exchange rates.

In the next step of our macro exercise, we examine the degree to which switching from the bilateral exchange rate to the broad US dollar index impacts our benchmark results. More concretely, we replace the benchmark bilateral exchange rate vis-à-vis the US dollar (which is a country-specific variable in the context of our SPVAR specification) with the broad US dollar index (which now enters the SPVAR as a global variable). The ordering of our five endogenous variables remains unchanged.

As discussed in the Introduction, the bilateral USD rate and the broad USD index could affect cross-border lending into a given country and capital expenditure in that country through two distinct channels. An appreciation of the bilateral US dollar rate versus the currency of a given country could lead to a fall in the demand for cross-border credit by causing a decline in the net worth of local borrowers with currency-mismatched balance sheets. Meanwhile, a broad appreciation in the value of the US dollar (as captured by a rise in the US dollar NEER index) could result in a tightening of the VaR constraints of internationally-active banks and ultimately lead to a reduction in the supply of cross-border credit (Bruno and Shin, 2015b; Avdjiev et al, 2016).

Impulse response functions: US rates, VIX, cross-border bank lending, investment

Benchmark SPVAR, full sample Figure 2



Black lines show the estimated impulse response functions to a one-standard-deviation shock using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral average US dollar exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

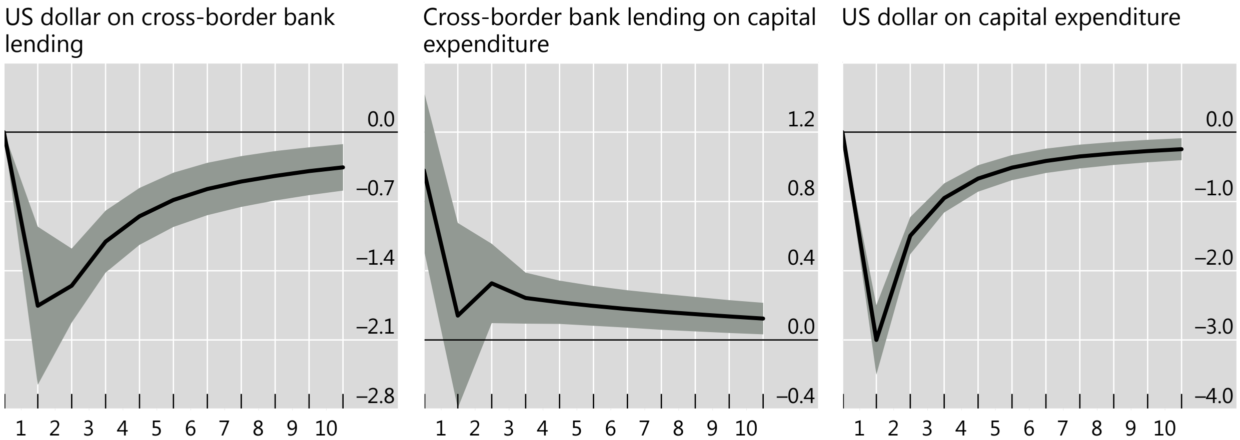
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

The impulse response functions presented in Figure 3 suggest that the effects of a rise in the broad US dollar index are broadly similar to those of an appreciation in the bilateral US dollar exchange rate. Namely, the US dollar index has a negative, statistically significant and persistent impact on real investment in EMEs.

Nevertheless, there is also an important difference between the two sets of results. When the bilateral exchange rate is used, the impact of cross-border bank lending on capital expenditure is statistically significant only contemporaneously (Figure 1, centre panel). The statistical significance disappears in subsequent periods. By contrast, when the broad US dollar index is used, the (statistically significant) effect is much longer-lasting (Figure 3, centre panel). This set of results implies that the cross-border credit supply channel highlighted in Avdjiev et al (2016) tends to be stronger and more persistent than the standard credit demand channel emphasised by the EME crisis literature.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (using broad US dollar index instead of bilateral rate), full sample Figure 3



Black lines show the estimated impulse response functions to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) BIS USD NEER broad index and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

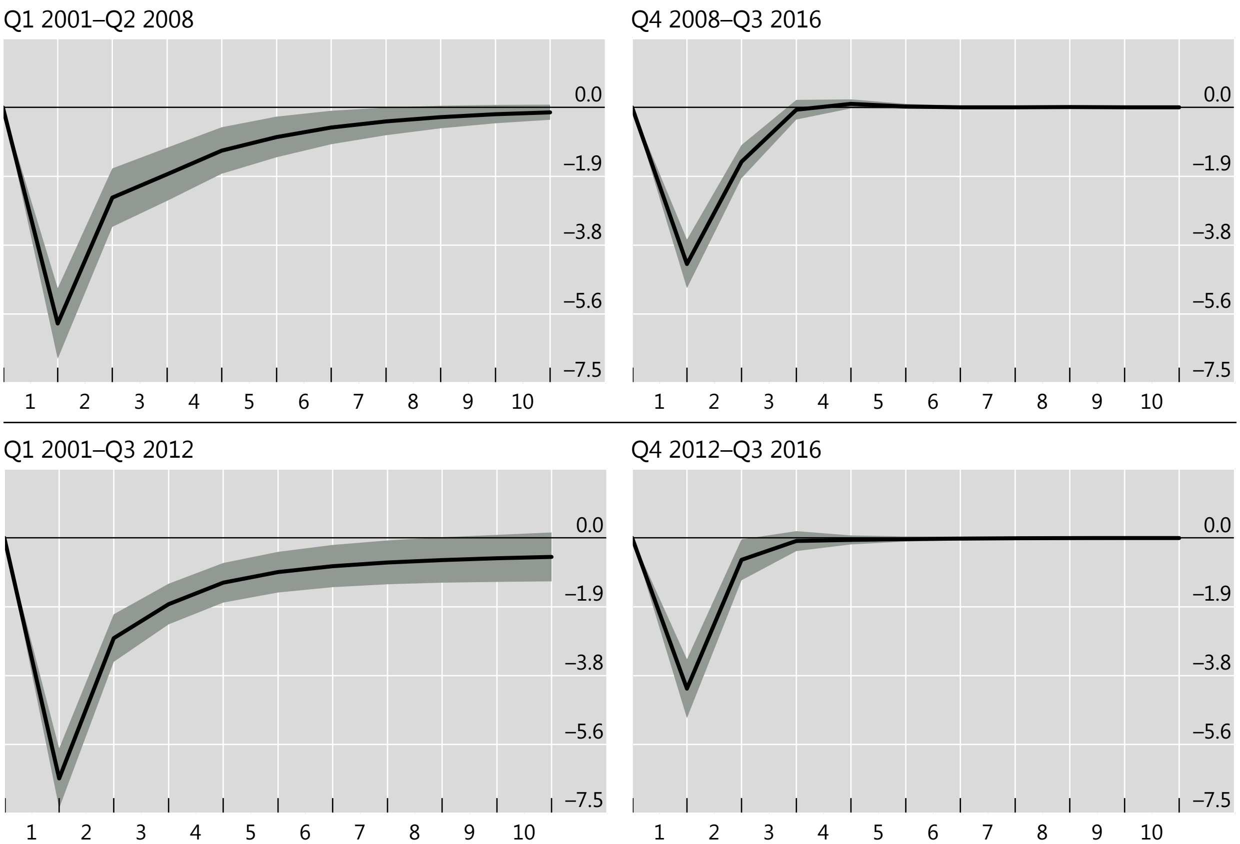
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Furthermore, we examine the degree to which our benchmark results are driven by specific time periods within our benchmark sample window. More concretely, we examine four subsample time windows defined by two critical points in the recent history of the global financial system – the peak of the Global Financial Crisis (Q3 2008) and the point in time after which the high correlation between the US dollar and the VIX started to weaken (Q3 2012).

The key impulse response functions for the above four time windows are presented in Figure 4. They reveal that the strong negative relationship between the value of the US dollar and real investment is present in all individual sub-periods within our sample. The estimated impact was a bit larger and longer-lasting before the crisis than during the post-crisis period. The pre-crisis impact peaked at about -6% and lasted for roughly two years (top left-hand panel), while the post-crisis impact peaked at about -4.5% and lasted for about a year (top right-hand panel). The estimated effect between 2001 and 2012 is even larger, reaching its highest level at almost -7% (bottom left-hand panel). Finally, although the impact during the post-2012 subsample is not as large as its pre-2012 counterpart, it is still very sizeable (peaking at roughly -4%) and strongly statistically significant for several quarters after the initial shock (bottom right-hand panel).

Impulse response functions: US dollar on capital expenditure

Benchmark SPVAR, alternative time windows Figure 4



Black lines show the estimated impulse response functions to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral average US dollar exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

4.2 Results from the micro (firm-level) study

We conduct our micro (firm-level) empirical examination of the impact of the US dollar exchange rate on real investment using the panel regression setup described in Section 2.2.

Table 2 reports the benchmark panel regressions for firm-level CAPEX variable for a sample of 32 countries over the period between 2000 and 2015. Column 1 shows that the coefficient estimate of the bilateral exchange rate (*ΔBER*) is positive and statistically significant. Hence, a depreciation of the local currency spurs competitiveness and firms' investments. This finding reflects the standard textbook competitiveness channel.

Benchmark regression results of CAPEX/TA

Firms in the full sample — Table 2

	(1)	(2)	(3)
ΔBER	0.0168***		0.0123***
	(0.0032)		(0.0032)
$\Delta NEER^{orth}$		-0.1598***	-0.1220***
		(0.0243)	(0.0239)
Size	-0.0004**	-0.0004**	-0.0004**
	(0.0002)	(0.0002)	(0.0002)
Cash/TA	0.0184***	0.0183***	0.0183***
	(0.0019)	(0.0019)	(0.0019)
PPE/TA	0.1353***	0.1354***	0.1353***
	(0.0020)	(0.0021)	(0.0021)
ROA	0.0014***	0.0014***	0.0014***
	(0.0001)	(0.0000)	(0.0000)
Constant	-0.0032	0.0006	-0.0012
	(0.0065)	(0.0086)	(0.0086)
Year FE	Y	Y	Y
Country FE	Y	Y	Y
Industry FE	Y	Y	Y
Observations	121,632	121,632	121,632
R-squared	0.208	0.208	0.208

This table reports OLS results with industry, year, country and country-year dummies where the dependent variable is firm-level capital expenditure scaled by total assets. Exchange rate (*ΔBER*) is the annual percentage change in the value of the dollar vis-à-vis the local currency. *Size* is the logarithm of total assets (in USD), *Cash/TA* is Cash and other short-term investments scaled by total assets, *PPE/TA* is property, plant and equipment scaled by total assets and *ROA* is return on assets. Non-tradable sectors refers to the all the industries except the following two-digit SIC codes (tradable sectors): 1 to 14 (agriculture, oil and mining), 20 to 39 (manufacturing). $\Delta NEER^{orth}$ is the component of the annual percentage change in the US dollar NEER index that is unrelated (ie orthogonal) to the change in the bilateral exchange rate. All regressions include country, industry and year fixed effects. Standard errors are either adjusted at the firm level or, if the number of firm-level clusters is too small, at the country level. We report standard errors in parentheses.

Sources: BIS; Capital IQ;

Next, we compare the estimated impact of the bilateral exchange rate to that of the broad US dollar index. To address collinearity concerns, we use the component of the broad US dollar index that is unrelated (ie *orthogonal*) to the change in the bilateral exchange rate ($\Delta NEER^{orth}$), defined as the residuals obtained from regressing the broad US dollar index on the bilateral exchange rate.

When we use the orthogonal component of the broad US dollar index instead of the bilateral rate (ΔBER), its estimated coefficient is negative and statistically significant (column 2).[4]

In column 3, we report the results from a specification in which we simultaneously include both the bilateral exchange rate and the orthogonal component of the broad US dollar index. The coefficient of the bilateral exchange rate (ΔBER) remains positive and statistically significant, while the coefficient of the broad US dollar residuals ($\Delta NEER^{orth}$) remains negative and statistically significant.

Taken together, the above results suggest that, for the full sample, a strengthening of the broad US dollar index has the opposite effect on firms' investments than an appreciation of the US dollar's bilateral exchange rate vis-à-vis the local currency. The estimated impact of the former is negative, while that of the latter is positive. We delve deeper into this dichotomy using the next set of regressions.

In Table 3, we restrict the analysis to the subsample of non-tradable sectors in countries with floating exchange rate regimes. Non-tradable sectors refers to all the industries except the following two-digit SIC codes: 1 to 14 (agriculture, oil and mining), 20 to 39 (manufacturing). The classification of the countries exchange rate arrangements is from the IMF Annual Report on Exchange Arrangements and Exchange Restrictions.

The results reported in column 1 reveal that the coefficient of the bilateral exchange rate is no longer statistically significant for this subset of firms.

In column 2, we interact the bilateral exchange rate with an industry-level indicator of external financial dependence (*FINDEP*). The interaction coefficient of the bilateral exchange rate with *FINDEP* is negative and statistically significant. This implies that the reduction in investment triggered by a US dollar appreciation is greater for firms that are more dependent on external financing. The magnitude of the effect is large: a one percentage point increase in the bilateral value of the US dollar reduces the capital

[4] When we use the broad US dollar index (instead of its orthogonal component), its coefficient estimate is also negative and statistically significant. The results from that additional specification are available upon request.

expenditure ratio by 0.003 (5.5% of the sample mean) more in industries at the 66th percentile than in industries at the 33rd percentile of the *FINDEP* index.[5]

Benchmark regression results of CAPEX/TA

Firms in non-tradable sectors and floating exchange rate regime countries — Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
ΔBER	0.0005	0.0074	-0.0084	0.0011		
	(0.0078)	(0.0088)	(0.0075)	(0.0136)		
$\Delta NEER^{orth}$			-0.3043***	-0.4268**		
			(0.0799)	(0.1903)		
*ΔBER * FINDEP*		-0.0208**		-0.0241***	-0.0243**	-0.0203***
		(0.0105)		(0.0072)	(0.0088)	(0.0060)
$\Delta NEER^{orth}$ * *FINDEP*				0.3597	0.3612	
				(0.2368)	(0.2449)	
Size	-0.0009**	-0.0009**	-0.0009**	-0.0009	-0.0008	-0.0008
	(0.0004)	(0.0004)	(0.0004)	(0.0012)	(0.0013)	(0.0013)
Cash/TA	0.0089**	0.0086**	0.0089**	0.0085	0.0076	0.0078
	(0.0041)	(0.0041)	(0.0041)	(0.0066)	(0.0066)	(0.0065)
PPE/TA	0.1364***	0.1366***	0.1364***	0.1368***	0.1364***	0.1363***
	(0.0043)	(0.0043)	(0.0043)	(0.0120)	(0.0118)	(0.0117)
ROA	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0005)	(0.0005)	(0.0005)
Constant	-0.0210**	-0.0421	-0.0207**	-0.0380*	-0.0108	-0.0137
	(0.0102)	(0.0302)	(0.0102)	(0.0213)	(0.0176)	(0.0187)
Year FE	Y	Y	Y	Y	N	N
Country FE	Y	Y	Y	Y	N	N
Industry FE	Y	Y	Y	Y	Y	Y
Country-year FE	N	N	N	N	Y	Y
Observations	20,877	20,818	20,877	20,818	20,818	20,818
R-squared	0.215	0.215	0.215	0.215	0.221	0.220

This table reports results from the same type of regressions as Table 2, but restricted to the sample of firms in non-tradable sectors and countries with floating regimes. *FINDEP* is an industry-level indicator of external financial dependence (as defined in Rajan and Zingales, 1998). All other variables are defined as in Table 2. Standard errors are adjusted at the firm level and are reported in parentheses.

Sources: BIS; Capital IQ; Compustat.

[5] In results that are available upon request, we find that the above evidence does not apply to firms in tradable sectors. A dollar appreciation leads to higher real investment by firms in tradable sectors, which is consistent with the trade channel.

Next, we add the orthogonal component of the broad US dollar index (*ΔNEER*^{orth}) to the main specification (column 3). The coefficient on the broad US dollar index is negative and statistically significant, while the coefficient of the bilateral exchange rate remains statistically insignificant.

We then interact both exchange rates with *FINDEP* and include country and year dummies (column 4) or country-year (column 5) fixed effects. The coefficient of the interaction term *ΔBER***FINDEP* is negative and statistically significant, whereas the coefficient of the interaction term *ΔNEER*^{orth}**FINDEP* is statistically insignificant. Column 6 confirms that the negative and statistically significant coefficient on the interaction term *ΔBER***FINDEP* is robust to using country-year and industry fixed effects. Taken together, the above results suggest that on average there is a global dollar *credit supply* effect that dominates the local credit demand effect (*ΔBER* is statistically insignificant, whereas *ΔNEER*^{orth} is negative and statistically significant).[6] However, when we consider individual firms' external financing needs, the interaction term *ΔBER* **FINDEP* is negative and statistically significant, which implies that the reduction in investment triggered by a US dollar appreciation is greater for firms that are more dependent on external financing, ie those firms that *demand more* external funds.

Table 4 presents the results from supplementary specifications that examine several additional (country group and time period) splits of the subsample of firms in non-tradable sectors and in floating exchange rate regime countries. We start with a specification that includes country-year fixed effects and split the sample into a pre- and a post-2011 period. Column 1 of Table 4 shows that the negative coefficient of the interaction term between exchange rate and external financial dependence is driven by the post-2011 period, when the dollar borrowing by non-financial corporates in emerging markets rose significantly. Accordingly, column 2 confirms that the evidence is weaker before 2011.

When we further split the sample between firms in emerging Asia and emerging Europe, we see that the negative coefficient is large in magnitude and statistically significant for emerging Asia (column 3), but not for emerging Europe (column 4). Finally, column 5 shows that our results are robust to additional country-level control variables.

[6] In order to compare the economic impacts of the two types of exchange rates, the bilateral exchange rate vis-à-vis the US dollar and the broad nominal US dollar index, we run the baseline specifications including each of them (one at a time), without year fixed effects. The coefficient estimate of the bilateral exchange rate is -0.021, while that on the broad US dollar index is -0.09. Those estimates imply that the impact of the broad dollar index on capital expenditures is roughly four times larger than the respective impact of the bilateral exchange rate.

Regression results of CAPEX/TA, alternative subsamples

Firms in non-tradable sectors and in floating exchange rate regime countries — Table 4

	(1) Post-2011	(2) Pre-2011	(3) Emerging Asia	(4) Emerging Europe	(5) Full sample
ΔBER					0.0099
					(0.0099)
*ΔBER * FINDEP*	-0.0219***	-0.0240	-0.0591**	0.0250	-0.0247**
	(0.0059)	(0.0192)	(0.0166)	(0.0362)	(0.0109)
Size	-0.0011	-0.0003	0.0004	-0.0069***	-0.0005
	(0.0010)	(0.0019)	(0.0003)	(0.0019)	(0.0004)
Cash/TA	0.0090	0.0020	-0.0094	0.0000	0.0065
	(0.0073)	(0.0051)	(0.0051)	(0.0068)	(0.0043)
PPE/TA	0.1272***	0.1630***	0.1429***	0.1100***	0.1418***
	(0.0054)	(0.0282)	(0.0068)	(0.0083)	(0.0046)
ROA	-0.0001	0.0008***	0.0011***	0.0008***	0.0003***
	(0.0005)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
MarketCap/GDP					0.0142**
					(0.0059)
Stock price					0.0766***
					(0.0231)
GDP per capita					-0.0346*
					(0.0196)
Constant	-0.0894***	-0.0121	-0.0909***	0.0892***	0.2463
	(0.0171)	(0.0235)	(0.0052)	(0.0230)	(0.1783)
Year FE	N	N	N	N	Y
Country FE	N	N	N	N	Y
Industry FE	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	N
Observations	14,798	6,020	5,810	1,715	17,688
R-squared	0.200	0.297	0.257	0.215	0.228

This table reports results from the same type of regressions as Table 2, but restricted to the sample of firms in non-tradable sectors and countries with floating regimes. It also uses the following additional firm-level control variables: Stock market capitalisation to GDP in % (*MarketCap/GDP*), Stock price volatility, GDP per capita; all other variables are defined as in Table 2. Standard errors are either adjusted at the firm level or, if the number of firm-level clusters is too small, at the country level, and are reported in brackets.
Sources: BIS; World Bank Global Development Database; Capital IQ; Compustat.

5. Robustness analysis

We examine the robustness of our key results by estimating a number of alternative specifications for both our macro SPVARs and our micro panel regressions.

5.1 Robustness tests for the macro study

In theory, there could be an alternative explanation for our benchmark results. Namely, during periods in which the risk-adjusted returns associated with investing in EMEs are high, global investors (including internationally-active banks) would be more likely to engage in carry trade activities, shorting US dollar assets and going long in EME assets. This would increase the supply of US dollars in global FX markets and ultimately lead to a depreciation of the US dollar.

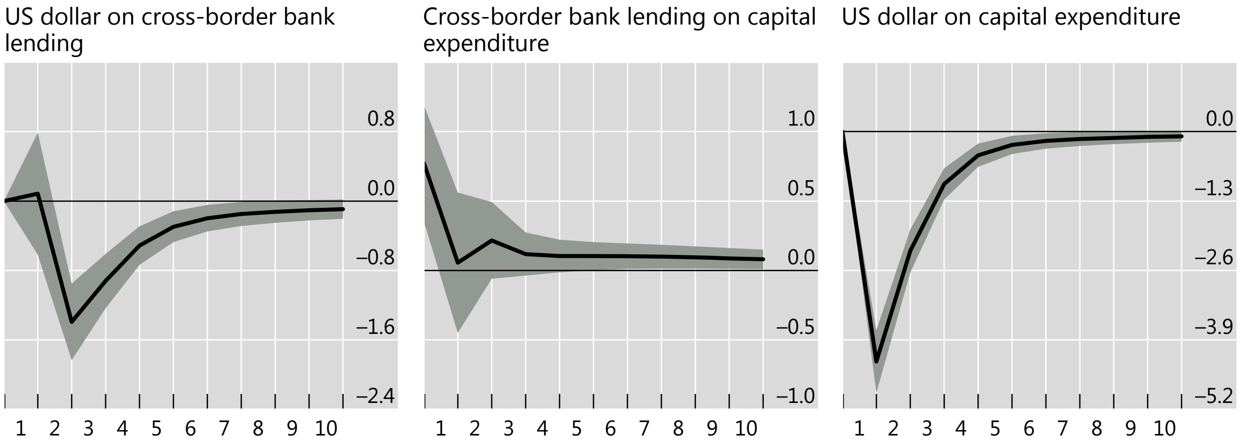
In order to test the above hypothesis, we add a variable that captures carry trade incentives to our SPVAR. More specifically, we use the Bloomberg carry trade index, which is defined as the cumulative total return of a buy-and-hold carry trade position that is funded with short positions in the US dollar and that is long in eight emerging market currencies.[7] We place the EME carry trade index in the second position in the SPVAR ordering, ahead of cross-border bank flows and gross capital formation, thus allowing it to impact both of the latter variables contemporaneously. This SPVAR ordering stacks the odds in favour of the "carry trade activity" hypothesis and against our main hypothesis.

The key impulse responses generated by the above six-variable SPVAR system are presented in Figure 5. They provide further evidence in support of our main hypothesis. Just as in our benchmark results (displayed in Figure 1), a US dollar appreciation has a negative and statistically significant impact on cross-border bank lending (left-hand panel), which in turn has a positive and statistically significant impact on capital expenditure (centre panel). The combination of the above two dynamic patterns once again generates our main result – an appreciation in the value of the US dollar leads to a statistically significant contraction in capital formation.

[7] The following currencies enter the Bloomberg carry trade index: Brazilian real, Mexican peso, Indian rupee, Indonesian rupiah, South African rand, Turkish lira, Hungarian forint and Polish zloty. We compute percentage changes of quarterly averages constructed using monthly data.

Impulse response functions: US dollar, cross-border bank lending, investment

Six-variable SPVAR (adding the carry trade index), full sample Figure 5



Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's six endogenous variables follow the order (1) US interest rate, (2) carry trade index, (3) US dollar-denominated cross-border bank flows, (4) gross capital formation, (5) bilateral average US dollar exchange rate and (6) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

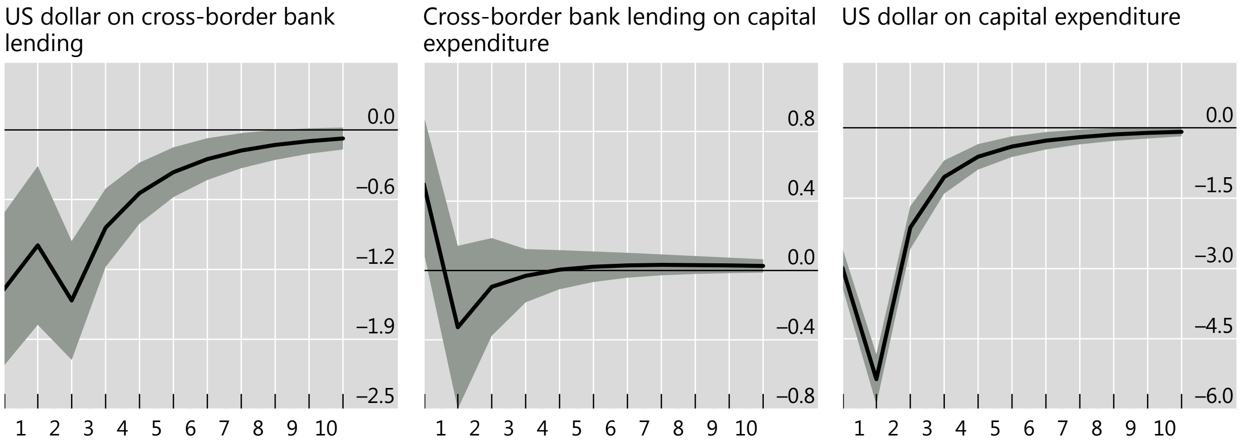
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Next, we test the robustness of our results to the ordering in the SPVAR system. More concretely, we move the US dollar exchange rate variable to the second position, ahead of cross-border bank flows and gross capital formation. This ordering allows the US dollar exchange rate to have a contemporaneous impact on the latter two variables, thus also addressing the possibility of any persistent carry trade dynamics. We perform the above robustness check for both the SPVAR system which includes the bilateral US dollar rate and the system that includes the broad US dollar NEER index, instead.

Figures 6 and 7 display the key impulse responses generated by the above alternatively-ordered SPVARs. They reveal that our benchmark results are robust. Namely, a US dollar appreciation leads to a decline in cross-border lending (left-hand panels). Furthermore, in both cases (for the bilateral US dollar exchange rate and the for the broad US dollar NEER index), the estimated contractions are even deeper and more persistent than their counterparts in the benchmark specifications (in Figures 1 and 3, respectively). Similarly, in both alternative estimations, a US dollar appreciation shock causes a sharp fall in capital expenditure (right-hand panels of Figures 6 and 7).

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (ordering the bilateral exchange rate in second position), full sample Figure 6

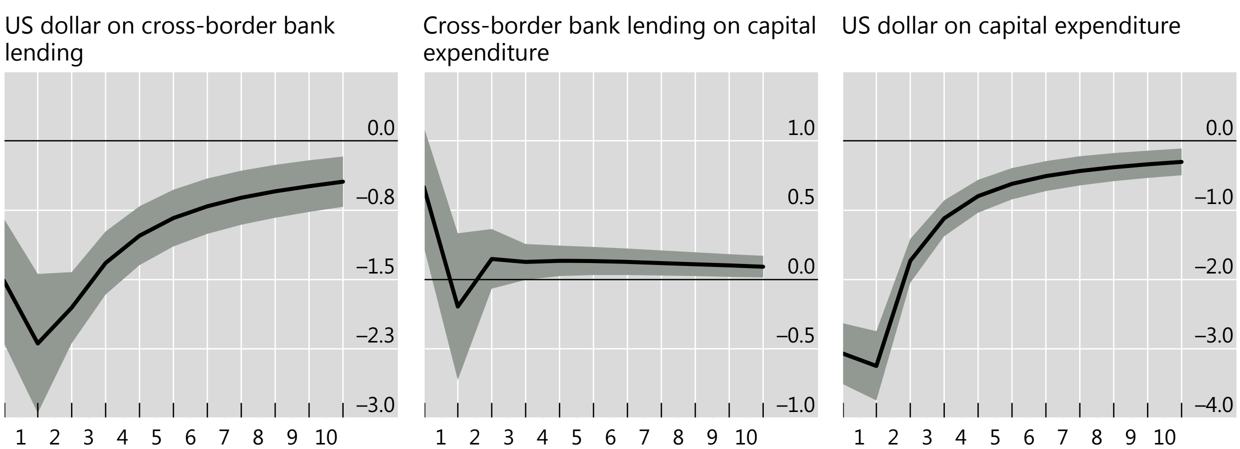


Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables now follow the order (1) US interest rate, (2) bilateral average US dollar exchange rate, (3) US dollar-denominated cross-border bank flows, (4) gross capital formation and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (ordering the USD NEER in second position), full sample Figure 7



Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables now follow the order (1) US interest rate, (2) BIS USD NEER broad index (3) US dollar-denominated cross-border bank flows, (4) gross capital formation and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Our benchmark results for the impact of the "broad" US dollar index draw on the US dollar NEER. Since this is a trade-weighted index, it naturally places greater weights on the bilateral exchange rates of the most important trading partners of the United States – Canada, Mexico, China and the euro area. Nevertheless, for the main question we examine, what matters most are the fluctuations in the value of the US dollar against a wider range of EME currencies.

That is why we examine the robustness of our benchmark results by replacing the US dollar NEER with two alternative US dollar indices. The first one is the Federal Reserve Board's EME broad US dollar (trade-weighted) index,[8] which captures fluctuations of the US dollar exclusively against EME currencies. For the second alternative US dollar index, we construct our own (GDP-weighted) average of the value of the US dollar against the currencies of the set of EMEs used in our benchmark macro study.

Both of the above alternative indices exhibit a highly positive and significant correlation with the US dollar NEER index used in our benchmark macro study. The correlation coefficient between the FRB's EME broad dollar index and the US dollar NEER is 0.87 and is statistically significant at the 1% level. The second alternative US dollar EME exchange rate index is also highly correlated with the US dollar NEER – although the correlation between those two indices (0.44) is not as high as in the case of the FRB's EME index, it is still highly statistically significant (at the 1% level).

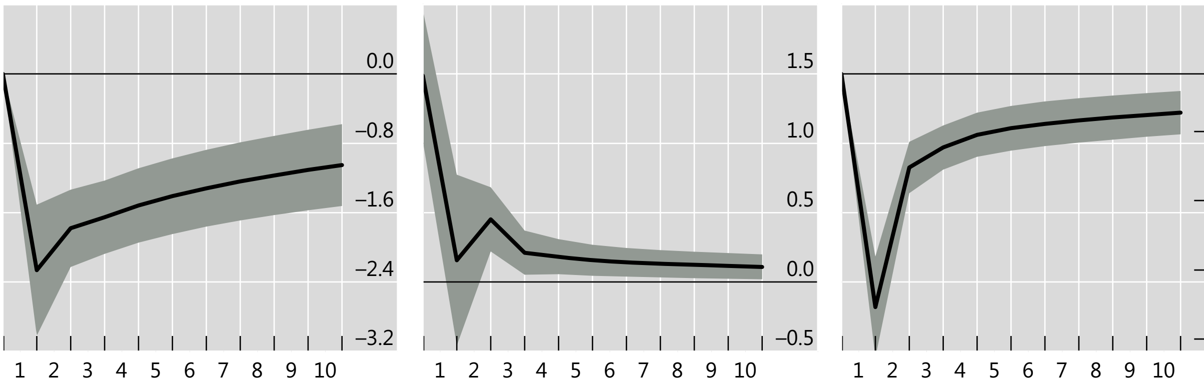
Figures 8 and 9 display the most important impulse responses from the SPVARs using the above two alternative US dollar EME exchange rate indices. In both cases, the results are very similar to the ones obtained from the benchmark specification. Namely, a US dollar appreciation has a negative impact on cross-border bank lending (left-hand panels), which, in turn, has a positive impact on capital expenditure (centre panels). The combination of the above two estimated impacts naturally results in the third key estimated response – that of capital expenditure to a US dollar appreciation – which is sharply negative.

[8] Formal name: Trade Weighted U.S. Dollar Index: Other Important Trading Partners.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (replacing the USD NEER with the FRB EME USD index), full sample Figure 8

US dollar on cross-border bank lending | Cross-border bank lending on capital expenditure | US dollar on capital expenditure



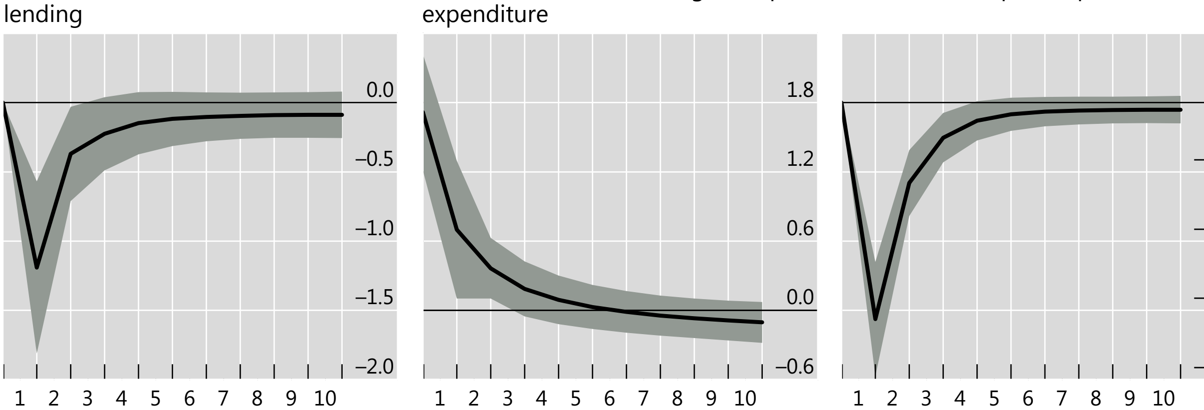
Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) FRB EME USD broad index and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; Board of Governors of the Federal Reserve System; authors' calculations.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (replacing the USD NEER with the GDP-weighted EME USD index), full sample Figure 9

US dollar on cross-border bank lending | Cross-border bank lending on capital expenditure | US dollar on capital expenditure



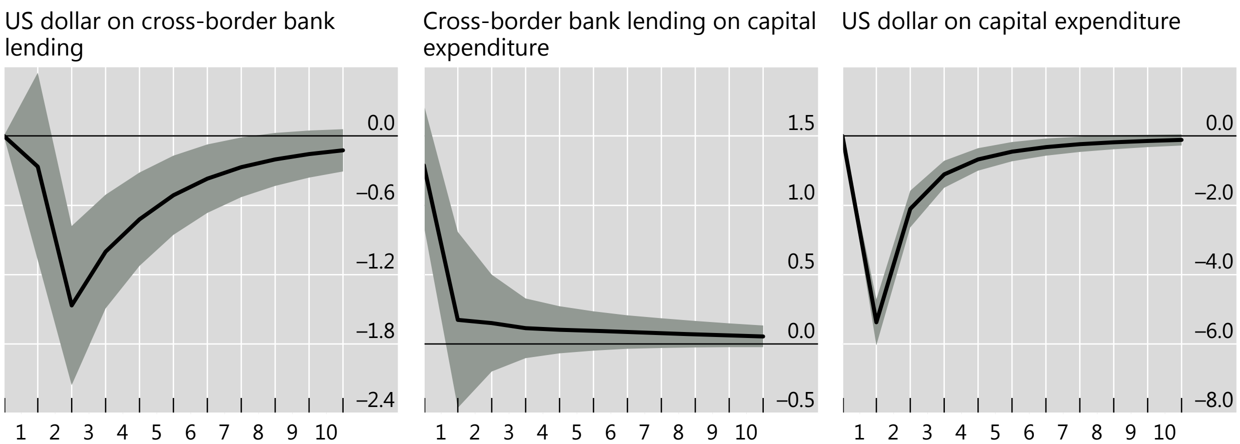
Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) GDP-weighted EME USD exchange rate index, and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Next, we restrict the EME sample of the benchmark five-variable SPVAR system to the set of EME countries that enters our micro (firm-level) study presented in Table 2. Our specification and the order of included endogenous variables remain unchanged. The impulse responses generated by that alternative sample are presented in Figure 10 and reveal that our results are robust to alternative sets of borrowing countries. Namely, the impact of the bilateral US dollar exchange rate on cross-border bank lending and on real investment is still negative and statistically significant for at least two years after the initial appreciation shock.

Impulse response functions: US dollar, cross-border bank lending, investment

Benchmark SPVAR, sample of countries in the micro study Figure 10



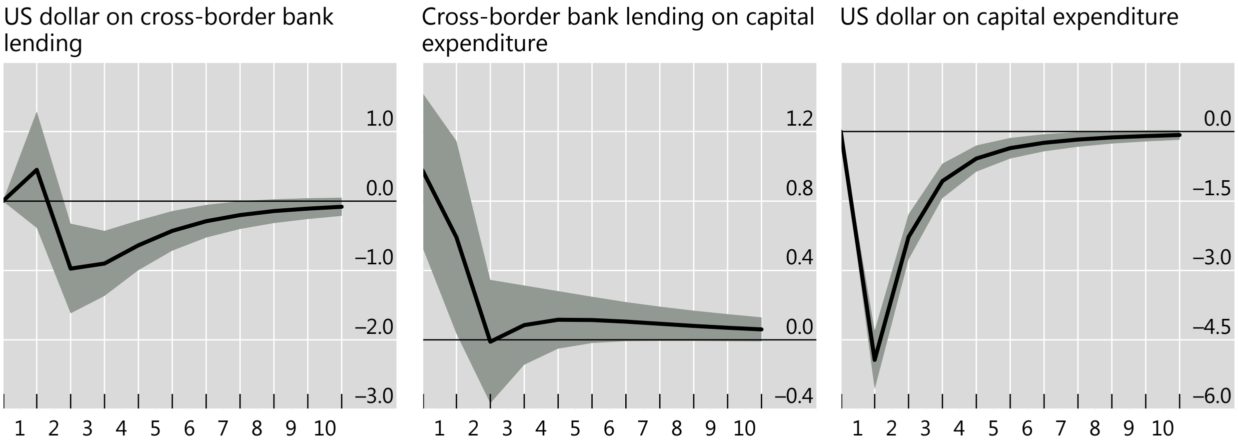
Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral average US dollar exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 28 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Figure 11 links our macro SPVAR with the micro panel analysis by further reducing the set of borrowing countries to those with floating exchange rate regimes (as shown in Table 3 and Table 4). Once again, the exhibited patterns align well with the results based on the full sample.

Impulse response functions: US dollar, cross-border bank lending, investment

Benchmark SPVAR, sample of countries with floating exchange rate regimes Figure 11



Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral average US dollar exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 23 EMEs. For more information on the SPVAR, see Section 2.1.

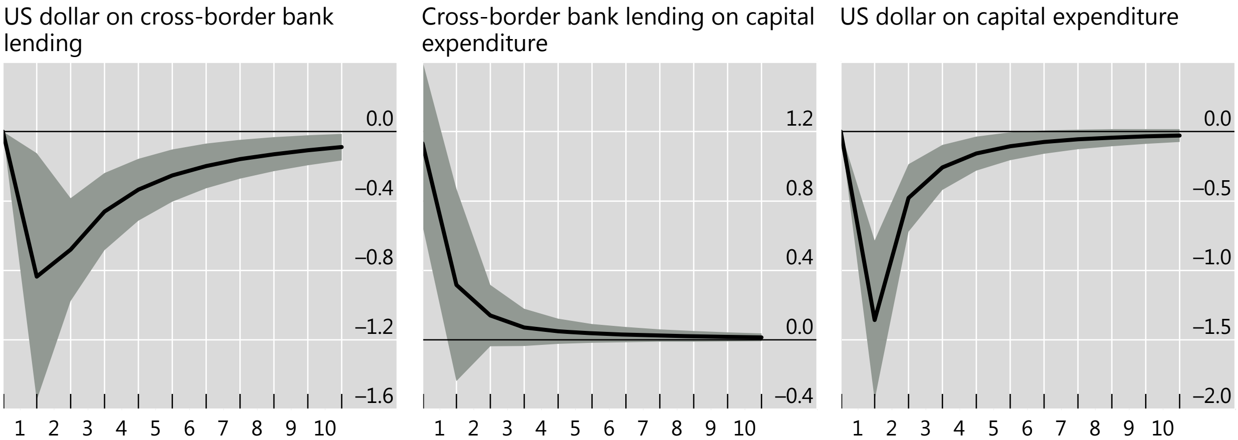
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Next, we return to our Section 4.1 benchmark set of borrowing EMEs, while replacing the average quarterly bilateral exchange rate with the end-of-period quarterly bilateral exchange rate. Figure 12 shows that the estimated impulse response functions are virtually the same as their counterparts implied by the benchmark SPVAR estimation.

We also test the extent to which the VIX as a global endogenous variable drives our benchmark SPVAR findings. In order to do that, we replace the VIX with global GDP growth, another global variable shown to act as an important global push factor of international capital flows by the existing empirical literature. Figure 13 illustrates that, although the magnitude of the impact of US dollar on cross-border bank credit and real investment declines a bit, its statistical significance and its persistence are both preserved in that specification as well.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (replacing average BER rate with end-of-period BER rate), full sample Figure 12

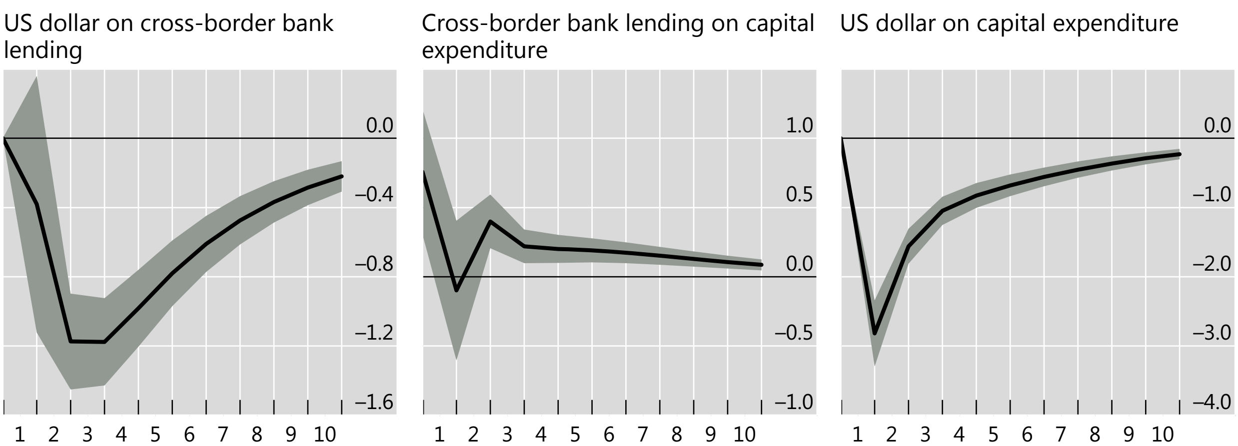


Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral end-of-quarter US exchange rate and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Impulse response functions: US dollar, cross-border bank lending, investment

Alternative SPVAR (replacing VIX with global GDP growth), full sample Figure 13



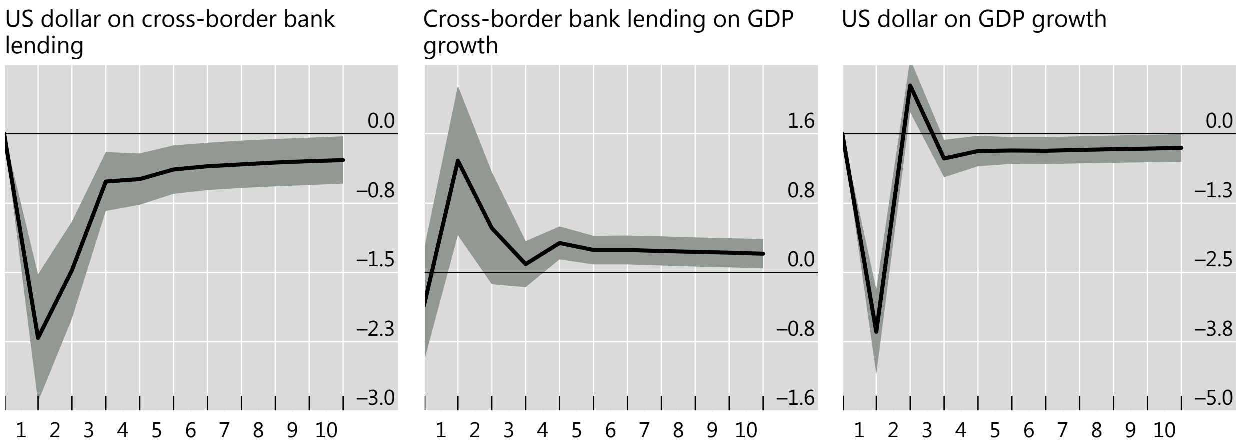
Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) BIS USD NEER broad index and (5) real global GDP growth. All variables are expressed in percentage changes. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

Finally, we examine the impact of a US dollar appreciation on overall economic activity in the borrowing country. We do that by replacing the country-specific investment growth variable in our benchmark SPVAR system with its country-specific GDP growth counterpart. The impulse responses, displayed in Figure 14, reveal that an appreciation of the US dollar against the domestic currency of a given country leads to a sharp contraction in GDP growth in that country. Even though this is followed by a brief (one-quarter) reversal, the impact beyond the third quarter after the initial FX shock remains negative and statistically significant for at least another year.

Impulse response functions: US dollar, cross-border bank lending, GDP growth

Alternative SPVAR (replacing investment growth with GDP growth), full sample Figure 14



Black lines show the impulse responses to a one-standard-deviation shock to the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) real national GDP growth, (4) BIS USD NEER broad index and (5) the VIX. All variables are expressed in percentage changes except for the VIX, which enters the SPVAR in log-levels. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated SPVAR. Period covered: Q2 2001–Q3 2016, based on 29 EMEs. For more information on the SPVAR, see Section 2.1.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; Capital IQ; Bloomberg; authors' calculations.

5.2 Robustness tests for the micro (firm-level) study

Next, we conduct robustness tests for the micro specifications. More concretely, we estimate alternative specifications with different control variables for the subsample of firms in the non-tradable sectors located in countries with floating exchange rate regimes.

The first set of robustness results is presented in Table 5. It confirms that these subsample results are consistent with the benchmark finding that a dollar appreciation has a contractionary effect on capital flows and capital expenditures.

Columns 1 and 2 represent a horse race between the *financial channel* and the conventional *savings channel*, which may be also affected by exchange rate movements. Column 1 shows that, as expected, higher gross savings (as a percentage of GDP) are associated with higher capital expenditures. Nevertheless, the effect is smaller for firms with higher external financial dependence – the interaction term has a negative and statistically significant coefficient estimate. In other words, the savings channel works in the opposite direction to the financial channel. Adding the exchange rate and its interaction with *FINDEP* in column 2 confirms our previous evidence on the financial channel by providing support to the risk-taking channel of exchange rates.

Column 3 reveals that countries with a larger proportion of external loans and deposits of reporting banks vis-à-vis all sectors (in percent of domestic bank deposits) are associated with higher capital expenditures for those firms that are more dependent on external financing. The negative coefficient estimate of the interaction between the exchange rate change and *FINDEP* retains its statistical significance.

In the next couple of specifications (columns 4 and 5), we also sequentially include the US interest rate and the VIX, interacted with *FINDEP*. In both cases, the coefficient on the interaction term between the exchange rate change and financial dependence remains negative and significant.

Finally, column 6 presents the estimates for the specification in which we control for the share of bank debt (as a stand-alone variable and interacted with financial dependence). Once again, we obtain a negative and significant coefficient on the interaction term between the exchange rate change and *FINDEP*.

Regression results of CAPEX/TA, alternative specifications

Firms in non-tradable sectors and in floating exchange rate regime countries — Table 5

	(1)	(2)	(3)	(4)	(5)	(6)
ΔBER		0.0158*	0.0022	0.0073	0.0075	0.0429
		(0.0091)	(0.0101)	(0.0088)	(0.0088)	(0.0803)
*ΔBER * FINDEP*		-0.0354***	-0.0193*	-0.0204*	-0.0213**	-0.0171*
		(0.0113)	(0.0104)	(0.0105)	(0.0104)	(0.0088)
ExLoans			-0.0000			
			(0.0003)			
*ExLoans * FINDEP*			0.0006***			
			(0.0002)			
Savings	0.0008***	0.0009***				
	(0.0003)	(0.0003)				
*Savings * FINDEP*	-0.0004***	-0.0005***				
	(0.0001)	(0.0001)				
*ΔUS rate * FINDEP*				0.0007		
				(0.0006)		
*ΔVIX * FINDEP*					0.0020	
					(0.0031)	
Bank debt						0.0159*
						(0.0087)
*Bank debt * FINDEP*						-0.0151
						(0.0808)
Size	-0.0009**	-0.0009**	-0.0006	-0.0009**	-0.0009**	0.0008
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0005)
Cash/TA	0.0090**	0.0091**	0.0068	0.0086**	0.0086**	0.0069
	(0.0041)	(0.0041)	(0.0044)	(0.0041)	(0.0041)	(0.0071)
PPE/TA	0.1372***	0.1371***	0.1419***	0.1366***	0.1366***	0.1298***
	(0.0043)	(0.0043)	(0.0046)	(0.0043)	(0.0043)	(0.0055)
ROA	0.0001	0.0001	0.0003***	0.0001	0.0001	0.0011***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	-0.0613**	-0.0749**	-0.0176	-0.0368	-0.0417	-0.0535
	(0.0306)	(0.0309)	(0.0454)	(0.0302)	(0.0302)	(0.0367)
Observations	20,753	20,753	17,730	20,818	20,818	11,243
R-squared	0.216	0.216	0.227	0.215	0.215	0.258

This table reports results from the same type of regressions as Table 2, but restricted to the sample of firms in non-tradable sectors and countries with floating regimes. It also uses the following additional country-level control variables: external loans as % of domestic bank deposits (*ExLoans*), gross savings as a percentage of GDP (*Savings*), VIX in log differences (*ΔVIX*), US interest rates in first differences (*ΔUS rate*) and total bank debt as a percentage of total debt (*Bank debt*). As in Table 2, all regression specifications include country, industry and time fixed effects. Standard errors are either adjusted at the firm level or, if the number of firm-level clusters is too small, at the country level, and are reported in brackets.

Sources: World Bank; Capital IQ; Chicago Board Options Exchange; Compustat; Bank for International Settlements.

Table 6 presents the results from an additional set of robustness tests that we conduct. In the first specification, we use a more granular measure for dependence on external finance. More specifically, we use the three-digit industry measure from Claessens et al (2012). Column 1 reveals that our key results are robust to the inclusion of this more granular measure of dependence on external finance – the coefficient on the interaction term between the exchange rate change and *FINDEP* remains negative and significant.

Next, we include country-year and industry-year fixed effects (while returning to our benchmark two-digit SIC code *FINDEP*). We estimate this specification for the full sample (column 2) and for the sample that drops the period of the global financial crisis (column 3). In both cases, our main results not only remain intact, but also become even more statistically significant.

Finally, we re-estimate the specification reported in column 2, while controlling for firm-level profitability with Tobin's Q (column 4). The inclusion of this additional variable reduces the size of the sample considerably. Nevertheless, the coefficient on the interaction term between the exchange rate change and financial dependence remains negative and strongly statistically significant.

Regression results of CAPEX/TA, alternative specifications and subsamples

Firms in non-tradable sectors and in floating exchange rate regime countries — Table 6

	(1) Full sample	(2) Full sample	(3) Excl 2008–2011	(4) Full sample
ΔBER	0.0086			
	(0.0098)			
*ΔBER * FINDEP*	-0.0106*	-0.0528***	-0.0546***	-0.0551***
	(0.0057)	(0.0124)	(0.0153)	(0.0155)
Size	-0.0011**	-0.0008*	-0.0011**	-0.0004
	(0.0004)	(0.0004)	(0.0004)	(0.0005)
Cash/TA	0.0059	0.0078*	0.0095**	0.0021
	(0.0043)	(0.0041)	(0.0047)	(0.0067)
PPE/TA	0.1381***	0.1358***	0.1268***	0.1417***
	(0.0049)	(0.0043)	(0.0047)	(0.0063)
ROA	0.0002*	0.0001	-0.0001	0.0008***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Tobin's Q				0.0009***
				(0.0004)
Constant	-0.0316**	0.0615	0.3959***	-0.0143
	(0.0159)	(234.6837)	(0.0295)	(0.0157)
Year FE	Y	N	N	N
Country FE	Y	N	N	N
Industry FE	Y	N	N	N
Country-year FE	N	Y	Y	Y
Industry-year FE	N	Y	Y	Y
Observations	17,825	20,818	14,798	11,452
R-squared	0.219	0.230	0.208	0.279

This table reports results from the same type of regressions as Table 2, but restricted to the sample of firms in non-tradable sectors and countries with floating regimes. Column 1 uses the Claessens et al (2012) industry-level index of external financial dependence, Columns 2 to 4 use the Rajan and Zingales (1998) industry-level index of external financial dependence, updated for the period 1990-2000. Column 3 excludes years 2008-2010 from the sample. Column 4 uses Tobin's Q, defined as the sum of the market value of equity plus the book value of liabilities over the book value of total assets. Standard errors are either adjusted at the firm level or, if the number of firm-level clusters is too small, at the country level, and are reported in brackets.

Sources: BIS; Capital IQ; Compustat.

6. Conclusion

In this paper, we examine the “triangular” relationship between the strength of the US dollar, cross-border bank flows and real investment. We do this in two sets of empirical settings. First, we conduct a macro (country-level) SPVAR study. Second, we estimate a set of micro (firm-level) panel regressions.

We find evidence of three key relationships. First, there is a strong negative relationship between the US dollar and cross-border bank lending denominated in US dollars. Second, an increase in US dollar-denominated cross-border lending to a given EME is associated with greater real investment in that EME. Finally, a decline in the value of a country’s currency against the US dollar triggers a decline in real investment in that country. These results are robust to a number of alternative specifications.

Our analysis provides evidence that a stronger dollar has real macroeconomic effects that go in the opposite direction to the standard trade channel. Whereas a stronger dollar tends to boost net exports, the dampening effect of the dollar on investment may temper any benefits that arise from the trade channel.

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Annex A: Country groups

Set of EMEs used in the macro (country-level) study

Argentina, Azerbaijan, Brazil, Bulgaria, Chile, Chinese Taipei, Colombia, Costa Rica, Croatia, Czech Republic, Ecuador, Georgia, Hungary, India, Indonesia, Iran, Israel, Korea, Kazakhstan, Malaysia, Mexico, Nigeria, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, Sri Lanka, South Africa, Thailand, Turkey, and Ukraine.

Set of EMEs used in the micro (firm-level) study

Argentina, Azerbaijan, Bulgaria, Brazil, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Georgia, Hungary, India, Indonesia, Israel, Korea, Kazakhstan, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, Serbia, South Africa, Thailand, Turkey, Ukraine, Uruguay, Venezuela, and Vietnam.

Set of EMEs used in the micro (firm-level) study with floating exchange rate regimes

Argentina, Brazil, Chile, Colombia, Czech Republic, Georgia, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, Serbia, South Africa, Thailand, Turkey, Ukraine, and Uruguay.

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