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

Stefan Avdjiev (BIS)

Valentina Bruno (American University)

Catherine Koch (BIS)

Hyun Song Shin (BIS)

27 October 2017

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 slower 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 two anonymous referees for valuable comments and suggestions, as well as Bat-el Berger and Zuzana Filkova for 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 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. The financial channel of exchange rates is less standard compared to the net exports channel, but 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 may have several drivers, both on the *demand* for dollar credit on the part of borrowers as well as 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 the 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 changes, 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 through a value-at-risk (VaR) constraint or 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 (2016). Hofmann et al (2016) use data on sovereign bond spreads to show that 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 (2016) 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 above literature 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 evidence on the existence of the above 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 VARs (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 regression setting.

Conceptually, there are three exchange rates that could potentially be relevant for the above transmission mechanism. 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 affects the net worth of borrowers with currency mismatches on their balance sheets (e.g. USD dollar liabilities and local currency assets). It thus has an impact on demand for credit from local borrowers, 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 and determines the Value-at-Risk (VaR) of global banks' loan portfolios. As a consequence, it has an impact on the supply of credit by global banks (Bruno and Shin, 2015a and 2015b; Avdjiev et al 2016).

Which of the above three exchange rates is most relevant for the mechanisms that we investigate in this paper? Since the trade-weighted exchange rate is more related to the standard macro (net exports) channel, it is safe to assume that the other two exchange rates should be more relevant for our investigation. Which of those two rates is more relevant is an empirical question. In line with the prevailing convention in the existing literature, we conduct our benchmark empirical exercises using the bilateral exchange rate. Nevertheless, we also re-estimate our main (country-level and firm-level) specifications using the broad US dollar index, which allows us to compare the relative importance of the two exchange rate types.

We find that a stronger US dollar is associated with slower dollar-denominated cross-border bank flows and lower real investment in EMEs. Our inspection of the underlying mechanisms uncovers three key relationships. 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 in US dollars. Second, increases in US dollar-denominated cross-border bank credit to a given EME are associated with greater real investment in that EME. Finally, the combination of the first two relationships results in the third key link that we discover – a decline in the value of a country's currency against the US dollar leads to a decline in real investment in that country.

The above results have significant policy implications. Most importantly, they provide further 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 temper 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 linked 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 U.S. 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 versus 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 dollar exchange rate quantitatively dominates the bilateral exchange rate in price pass-through and trade elasticity regressions and that the strength of the U.S. dollar is a key predictor of rest-of-world aggregate trade volume and consumer/producer price inflation.

Second, our work is related 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 (2013) make the case for the existence of a global financial cycle that synchronises capital flows, asset prices and credit growth, and which is associated with the stance of monetary policy in the Unites 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 and 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 and Cerutti et al 2014).

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 structural panel VARs (SPVARs) using macro data. In the second one, we estimate firm-level panel regressions on the relationship between corporate capital expenditure (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 structural panel VAR 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 structural panel VAR:

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

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 (see Nickell, 1981). To avoid this concern, we rewrite the structural panel VAR 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 $s \neq t$.

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

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

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

The equivalent moving average representation of the structural panel VAR 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 $\sum_e \ = E[\boldsymbol{B}^{-1}u_{i,t}u'_{i,t}\boldsymbol{B}^{-1\prime}]$ 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 $\sum_e \ = E[B^{-1} \ \ B^{-1\prime}]$. 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 orthogonalize 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.

We follow Lütkepohl (2007) to obtain impulse responses at horizon h from the vector moving average representation of the structural panel VAR. 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 $s \equiv [1, \dots ,0]'$ 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. The exact benchmark specification that we focus on is given by:

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

The dependent variable, $\frac{CAPEX}{TA}_{ijt}$, is the capital expenditure (CAPEX) of firm *i* from country *j* at time *t* as a share of its total assets. The main explanatory variable of interest is ΔFX_{jt}, the annual percentage change in the value of the US dollar vis-à-vis country j's domestic currency (a positive value of ΔFX_{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 interact ΔFX_{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 the firms with higher external financing needs are hit more severely by an appreciation of the US dollar. We also include firm-level control variables $Controls_{it}$ and challenge our specification with different combinations of fixed effects at the industry, time and country level.

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 synchronization of risk-taking across regions and sectors.

After estimating our baseline specification (6) 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.

3. Data

Our empirical analysis at the macro level draws on quarterly data from Q2 2001 to Q4 2016 for a sample of 34 EMEs[3]. Table 1 provides the descriptive statistics of all variables used to conduct our macro (country-level) analysis described in Section 2.1.

Descriptive statistics on the macro-level analysis — Table 1

	Obs.	Mean	Std. Dev.	1st percentile	99th percentile
Δirate (percentage points)	1893	-0.058	0.675	-1.699	1.898
ΔFX_ave (%)	1893	0.637	4.656	-7.836	19.516
ΔFX_end (%)	1893	0.625	5.341	-10.155	19.658
ΔUSD index (Δ index units)	1893	-0.009	2.848	-7.180	8.280
ΔXB_Claims (%)	1893	2.269	14.736	-34.959	66.533
Δln_GFCF (%)	1893	1.861	10.529	-30.240	25.214
ln_vix (log index units)	1893	2.931	0.356	2.433	3.787
vix (index units)	1893	20.081	8.204	11.390	44.140

This table shows the descriptive statistics of our macro-level analysis. *Δirate* denotes changes in the US federal funds rate and switches to Krippner's (2015) shadow short rate in in 2008q1. *ΔFX_ave* gives percentage changes in the average bilateral exchange (*ΔFX_end* refers to end-quarter data), *ΔUSD index* refers to the BIS nominal effective exchange rate (NEER) index using the broader set of countries in first differences, *ΔXB_Claims* indicates percentage growth rates of cross-border, US-dollar denominated claims vis-à-vis country *i*, *Δln_GFCF* denote quarterly growth rates in gross-fixed capital formation and *ln_vix* gives log levels of the CBOE option-implied S&P500 volatility index from the CBOE. Changes in the bilateral exchange rates and in cross-border lending are winsorized at the 1% level in each tail of the distribution. Period covered: Q2 2001–Q3 2016, based on 34 EMEs as detailed in Appendix A.
Sources: Krippner (2015); FRED St. Louis Fed; IMF *International Financial Statistics* and *World Economic Outlook*; Chicago Board Options Exchange; national data; BIS locational banking statistics; authors' calculations.

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 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 US dollar Nominal Effective Exchange Rate (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

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

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 (BoP) 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 series.

Our micro-level analysis exploits annual data from Capital IQ based on firm-level reports from 32 emerging market economies for the period between 2000 and 2015. Besides firm-level capital expenditure (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, Plants 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). We also add data for gross savings from the World Bank and external loans from the World Bank *Global Financial Development Database*. 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 a shock to the value of the dollar vis-à-vis the local currency 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 empirical exercise using the SPVAR methodology described in Section 2.1. In our benchmark estimation, we focus on a five-variable system. We follow Bruno and Shin (2015a) when selecting the order of the variables for our benchmark estimation. More concretely, the five endogenous variables in our benchmark SPVAR system have the following order: (1) US policy 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.

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 the results predicted by the theoretical model of Bruno and Shin (2015b).

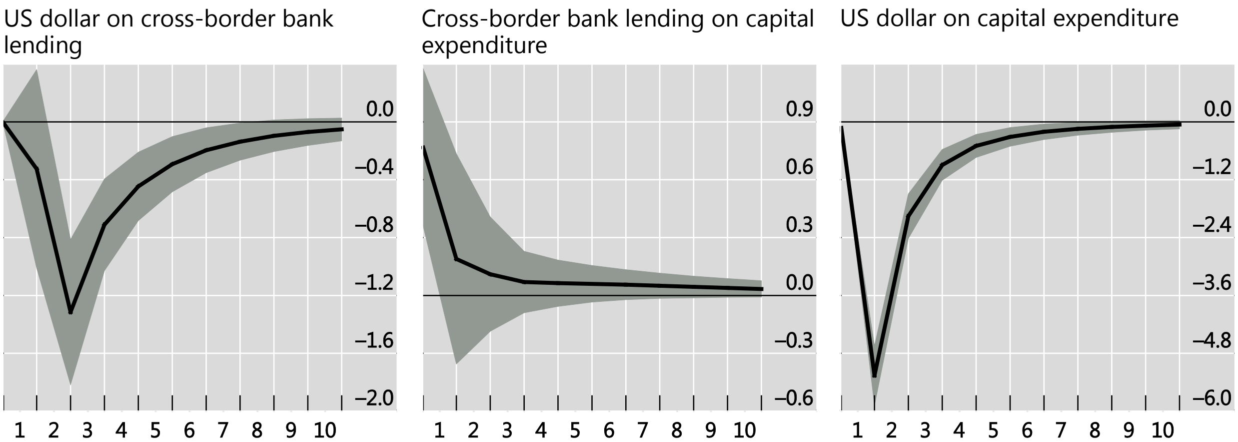
Figure 1 presents the key impulse responses from our benchmark SPVAR estimation.[4] The left-hand panel shows that a strengthening in the dollar is associated with a fall in dollar-denominated cross-border bank lending. This finding is in line with the conclusions of Bruno and Shin (2015a and 2015b). 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 has to do with more than 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

[4] See the footnote of Figure 1 for further details on sample and method.

currency sovereign bonds (Hofmann et al, 2016), and hence shape domestic financial conditions more generally.

Impact of a dollar appreciation shock on emerging market economies (EMEs)

Full sample Figure 1



Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on 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 exchange rate and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

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

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 percentage point 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.

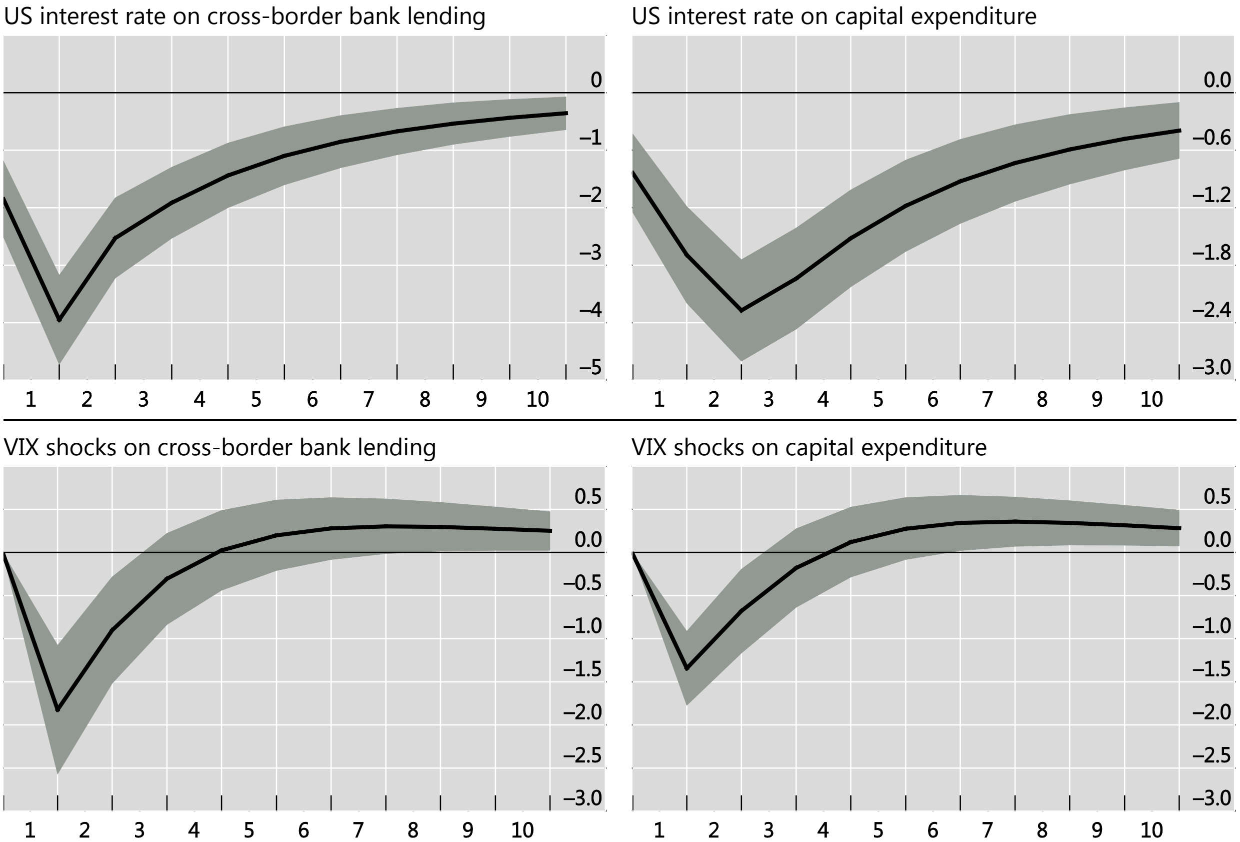
In sum, the impulse response functions generated by the benchmark SPVAR analysis provide strong evidence that the financial channel of exchange rates points in the opposite direction to the trade channel. Intuitively, a stronger US dollar deteriorates the creditworthiness of currency-mismatched EME borrowers as their liabilities increase relative to their assets. More concretely, 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 borrowers increases tail risk in the credit portfolio and decreases the capacity for additional credit extension, even with a fixed exposure limit through a value-at-risk constraint or economic capital constraint. This leads to a decline in cross-border bank lending. Bruno and Shin (2015a and 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 (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 (approximated by the VIX) also leads to significant falls in cross-border bank lending and real investment. Nevertheless, in the case of both response variables (cross-border lending and real investment), the duration of the contractions triggered by spikes in global uncertainty is somewhat smaller than the respective duration of the declines caused by the 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 (country-level) empirical 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 order of endogenous variables remains unchanged.

Impacts of US interest rate and VIX shocks on EMEs

Full sample Figure 2



Black lines show the estimated impulse response functions to a one percentage point exchange rate 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 exchange rate and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

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

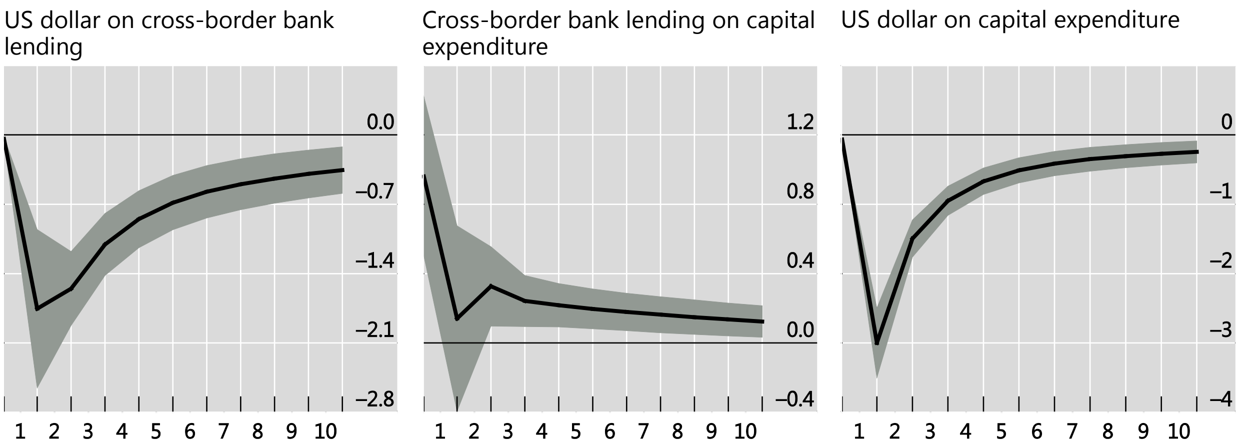
The key impulse response functions, presented in Figure 3, suggest that the effects of a rise in the broad US dollar index are broadly similar to those of an appreciation in the bilateral US dollar exchange rate. Namely, the US dollar index has a negative, statistically significant and persistent impact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

Furthermore, we examine the degree to which our key results are driven by various time periods within our benchmark sample window. More concretely, we examine four subsample time windows defined by two critical points in time in 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).

Impact of a dollar appreciation shock on EMEs

Replacing the average quarterly *bilateral* FX rate with the broad US dollar *index* Figure 3



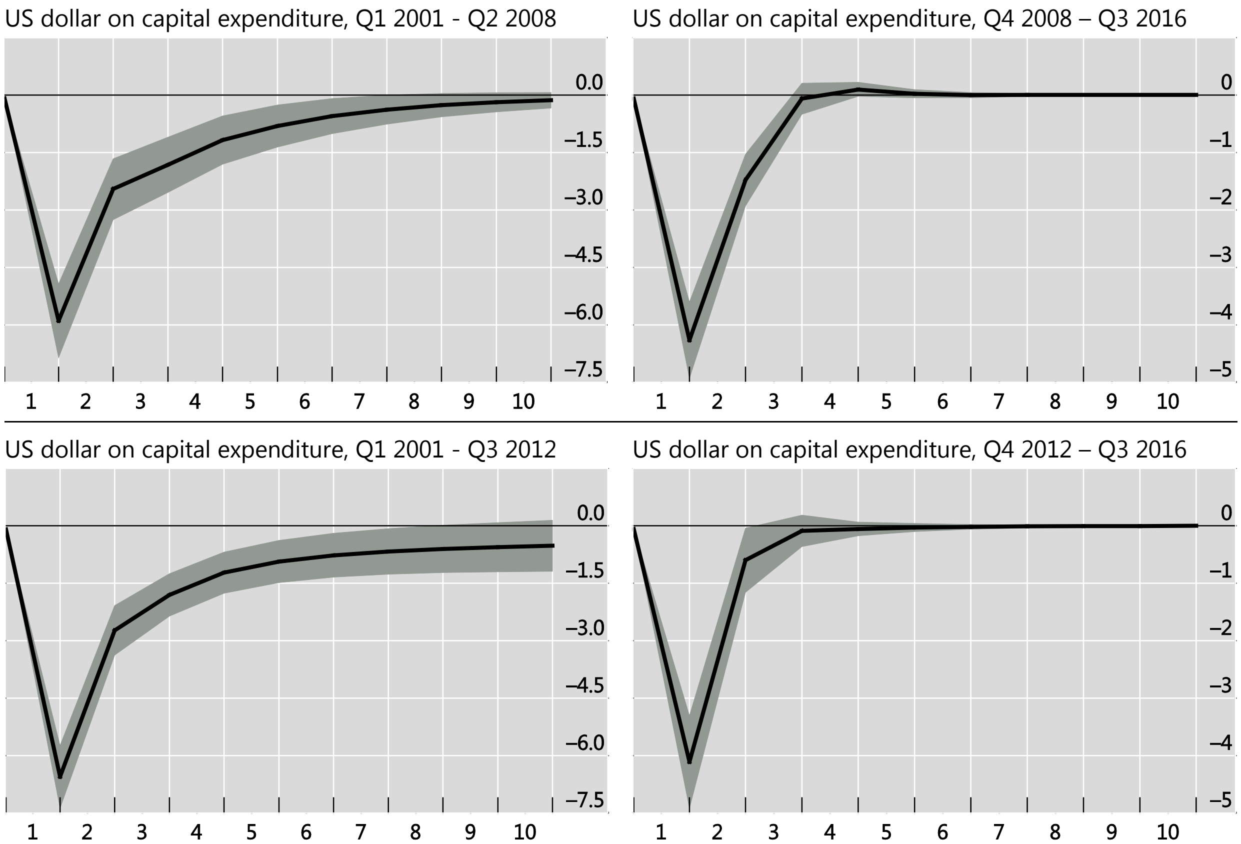
Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) BIS USD NEER index and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

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

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 major 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 around -6% and lasted for roughly two years (top left-hand panel), while the post-crisis impact peaked at around -4.5% and lasted for about a year (top left-right panel). The estimated impact for the period between 2001 and 2012 is even larger, peaking at almost -7% (bottom left-hand panel). Finally, although the impact during the post-2012 sub-sample 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-right panel).

Impact of a dollar appreciation shock on EMEs

Alternative time windows Figure 4



Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on 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 exchange rate and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Total period covered: Q2 2001–Q3 2016, based on 34 EMEs.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; 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 set-up introduced in Section 2.2.

Table 2 reports the results from the benchmark panel regressions for firm-level Capex variable for a sample of 32 countries over the period between 2000 and 2015. Our dependent variable is capital expenditure scaled by total assets. We winsorise the ratio at the 1% and 99%-level in each tail, respectively. The exchange rate (% change) is the annual percentage change in the value of the dollar vis-à-vis the local currency, with a positive value meaning that the local currency depreciates against the US dollar. 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, Plants and Equipment scaled by total assets and ROA is a measure of profitability (return of assets). Financial firms are excluded. 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 brackets.

Benchmark regression results of Capex/TA

Table 2

	(1) Full sample	(2) Non-tradable sectors & floating regimes	(3) Non-tradable sectors & floating regimes	(4) Tradable sectors
ΔFX	0.0168***	0.0005	0.0074	0.0198***
	(0.0032)	(0.0078)	(0.0088)	(0.0038)
*ΔFX * FINDEP*			-0.0208**	0.0071**
			(0.0105)	(0.0033)
Size	-0.0004**	-0.0009**	-0.0009**	-0.0002
	(0.0002)	(0.0004)	(0.0004)	(0.0002)
Cash/TA	0.0184***	0.0089**	0.0086**	0.0235***
	(0.0019)	(0.0041)	(0.0041)	(0.0024)
PPE/TA	0.1353***	0.1364***	0.1366***	0.1428***
	(0.0020)	(0.0043)	(0.0043)	(0.0025)
ROA	0.0014***	0.0002	0.0001	0.0019***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	-0.0032	-0.0210**	-0.0421	-0.0127
	(0.0065)	(0.0102)	(0.0302)	(0.0114)
Year FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Number of observations	121,632	20,877	20,818	77,904
R-squared	0.208	0.215	0.215	0.211

This table reports OLS results with industry, year, and country dummies where the dependent variable is firm-level capital expenditure scaled by total assets. Exchange rate (*ΔFX*) is the annual percentage change in the value of the dollar vis-a-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, Plants 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). FINDEP is the Rajan and Zingales (1998) industry-level index of external financial dependence, updated for the period 1990-2000 and at the two-digit SIC sector-level. Countries with floating regimes follow the International Monetary Fund AREAER classification. Standard errors are adjusted at the firm-level, and are reported in brackets.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; Capital IQ; Bloomberg; Compustat.

Column 1 shows the results for the entire sample of countries, irrespective of the exchange rate regime. The coefficient estimate of the exchange rate is positive and statistically significant, meaning that a depreciation of the local currency spurs competitiveness and firms' investments. This reflects the standard textbook competitiveness channel.

However, when we restrict the analysis to the subsample of non-tradable sectors in countries with floating exchange rate regimes, we see that the coefficient is no longer statistically significant (column 2).[5]

In column 3, we interact the bilateral exchange rate with an industry-level indicator of external financial dependence (FINDEP). We update the original Rajan and Zingales (1998) index for the period 1990-2000 and the two-digit SIC sector-level. The index is based on US firms under the assumption that external dependence reflects technological characteristics of the industry that are relatively stable (see Rajan and Zingales (1998) for more details on the methodology).

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 percent increase in the exchange rate value of the US dollar reduces the capital 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.

Column 4 shows 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 conduct an exercise that is similar in spirit to the one reported in the macro (country-level) specifications, in which we compare the relative impacts of the two potentially relevant exchange rates. More concretely, we re-estimate our benchmark regression specification that uses only the set of firms operating in non-tradable sectors and located in countries with floating exchange rate regimes, while replacing the bilateral exchange rate with the board US dollar index.

The results from those regressions, presented in Table 3, echo those from the respective macro estimations and provide further evince that the broad US dollar index has an even greater impact on cross-

[5] 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).

border bank lending and real investment than the bilateral exchange rate. The coefficient on the interaction term between the broad US dollar and the financial dependence variable is negative and statistically significant (Column 1). Moreover, when the interactions of both exchange rates with the financial dependence variable enter the regression, only the interaction including the broad US dollar index remains statistically significant, while the one with the bilateral exchange rate becomes insignificant (Column 2).

In order to compare the economic impacts of the two types of exchange rates, we run the baseline specification including each of them (one at a time), without year fixed effects. The coefficient estimate of the bilateral exchange rate is -0.021 (Column 3), while that on the broad US dollar index is -0.089 (Column 4). 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.

In summary, the micro (firm-level) results on the relative strength of the two types of exchange rates are consistent with the respective macro (country-level) results. Both sets of results suggest that the broad US dollar index has an even greater impact on cross-border bank lending and real investment than the bilateral exchange rate. In turn, this implies that the international credit supply channel, highlighted in Avdjiev et al (2016) is more potent than the international credit demand channel, emphasized by the EME crisis literature.

Next, we estimate a set of regression on various subsamples of the set of firms that are in non-tradable sectors and in countries with floating exchange rate regimes. The results from those regressions are presented in Table 4.

Column 1 confirms that the above results are robust to using country-year and industry fixed effects. We continue with country-year fixed effects and split the sample between before and after 2011.

Column 2 of Table 4 shows that the negative coefficient of the interaction term between exchange rate and external financial dependence is driven by the years after 2011, when the dollar borrowing by non-financial corporates in emerging markets as most prevalent. In contrast, column 3 shows that the evidence is weaker for the period pre-2011.

Regression results of Capex/TA, comparing alternative exchange rates

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

	(1)	(2)	(3)	(4)
ΔFX			-0.0214***	
			(0.0054)	
*ΔFX * FINDEP*		-0.0099		
		(0.0093)		
ΔUSD index				-0.0886***
				(0.0099)
*ΔUSD index * FINDEP*	-0.0582***	-0.0455***		
	(0.0146)	(0.0153)		
Size	-0.0007*	-0.0007*	-0.0009**	-0.0009**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Cash/TA	0.0090**	0.0090**	0.0091**	0.0090**
	(0.0041)	(0.0041)	(0.0041)	(0.0041)
PPE/TA	0.1366***	0.1366***	0.1366***	0.1367***
	(0.0043)	(0.0043)	(0.0042)	(0.0042)
ROA	0.0002*	0.0002*	0.0002*	0.0002*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	-0.0355	-0.0366	0.0792***	0.0788***
	(0.0305)	(0.0305)	(0.0103)	(0.0103)
Year FE	N	N	N	N
Country FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Number of observations	20,818	20,818	20,877	20,877
R-squared	0.209	0.209	0.210	0.212

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. US dollar index (*ΔUSD index*) is the change in Federal Reserve Board's US trade-weighted broad dollar index; all other variables are defined as in Table 2. Standard errors are adjusted at the firm-level and are reported in brackets.
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; Capital IQ; Bloomberg; Compustat.

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 the sample of firms located in emerging Asia (column 4), but not for those in emerging Europe (column 5). Finally, column 6 shows that our results are robust to additional country-level control variables.

Regression results of Capex/TA, alternative subsamples

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

	(1) Full sample	(2) Post 2011	(3) Pre 2011	(4) Emerging Asia	(5) Emerging Europe	(6) Full sample
ΔFX						0.0099
						(0.0099)
*ΔFX * FINDEP*	-0.0203***	-0.0219***	-0.0240	-0.0591**	0.0250	-0.0247**
	(0.0060)	(0.0059)	(0.0192)	(0.0166)	(0.0362)	(0.0109)
Size	-0.0008	-0.0011	-0.0003	0.0004	-0.0069***	-0.0005
	(0.0013)	(0.0010)	(0.0019)	(0.0003)	(0.0019)	(0.0004)
Cash/TA	0.0078	0.0090	0.0020	-0.0094	0.0000	0.0065
	(0.0065)	(0.0073)	(0.0051)	(0.0051)	(0.0068)	(0.0043)
PPE/TA	0.1363***	0.1272***	0.1630***	0.1429***	0.1100***	0.1418***
	(0.0117)	(0.0054)	(0.0282)	(0.0068)	(0.0083)	(0.0046)
ROA	0.0001	-0.0001	0.0008***	0.0011***	0.0008***	0.0003***
	(0.0005)	(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	-0.0137	-0.0894***	-0.0121	-0.0909***	0.0892***	0.2463
	(0.0187)	(0.0171)	(0.0235)	(0.0052)	(0.0230)	(0.1783)
Year FE	-	-	-	-	-	Y
Country FE	-	-	-	-	-	Y
Industry FE	Y	Y	Y	Y	Y	Y
Country-year FE	Y	Y	Y	Y	Y	-
Observations	20,818	14,798	6,020	5,810	1,715	17,688
R-squared	0.220	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. Stock market capitalization to GDP in % (*MarketCap/GDP*), Stock price volatility, GDP per capita; all other variables are defined as in Table 2. Standard errors are adjusted at the firm-level or at the country-level, and are reported in brackets.
Sources: FRED, St. Louis Fed; IMF *International Financial Statistics* and *World Economic Outlook*; World Bank; Capital IQ; Bloomberg; Compustat.

In sum, the above results show that for the sample of non-tradable sectors in countries with floating exchange rate regimes, the financial channel dominates the trade channel.

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.

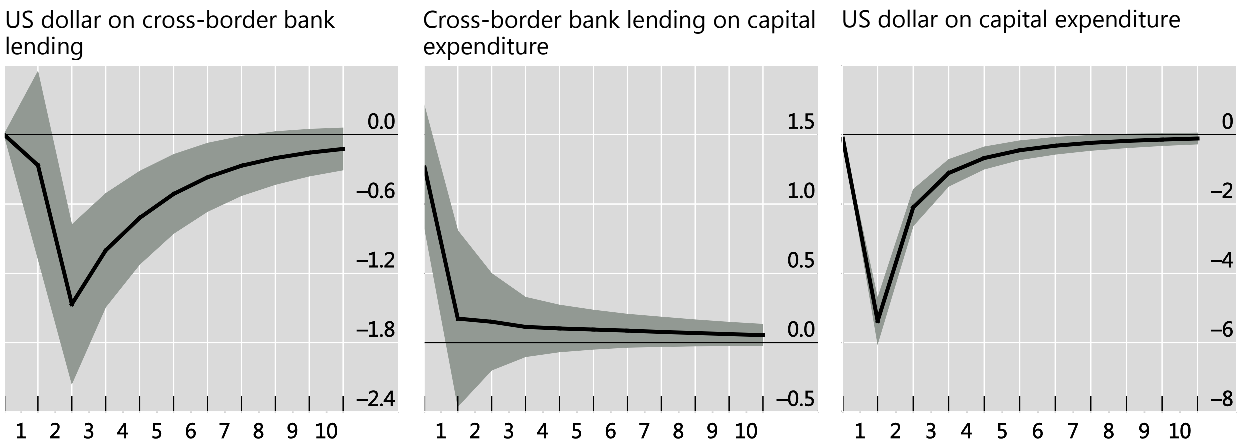
5.1 Robustness tests for the macro study

We start by tailoring the EME sample of the benchmark five-variable SPVAR system to the reduced set of 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 5 and they 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.

Figure 6 links our macro SPVAR with the micro panel analysis by further reducing the set of borrowing countries to those with floating FX regimes (as shown in Table 3 and Table 4). Once again, the exhibited patterns align well with the results based on the full sample.

Impact of a dollar appreciation shock on EMEs

Results for the set of countries in the micro (firm-level) study — Figure 5



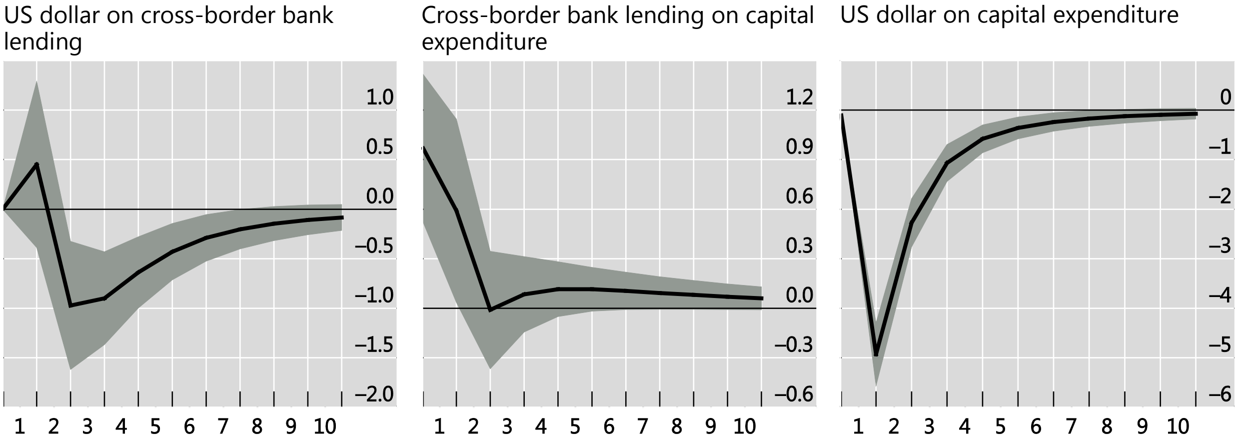
Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral end of quarter US exchange rate and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

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

Impact of a dollar appreciation shock on EMEs

Results for the subset of countries with floating FX regimes

Figure 6



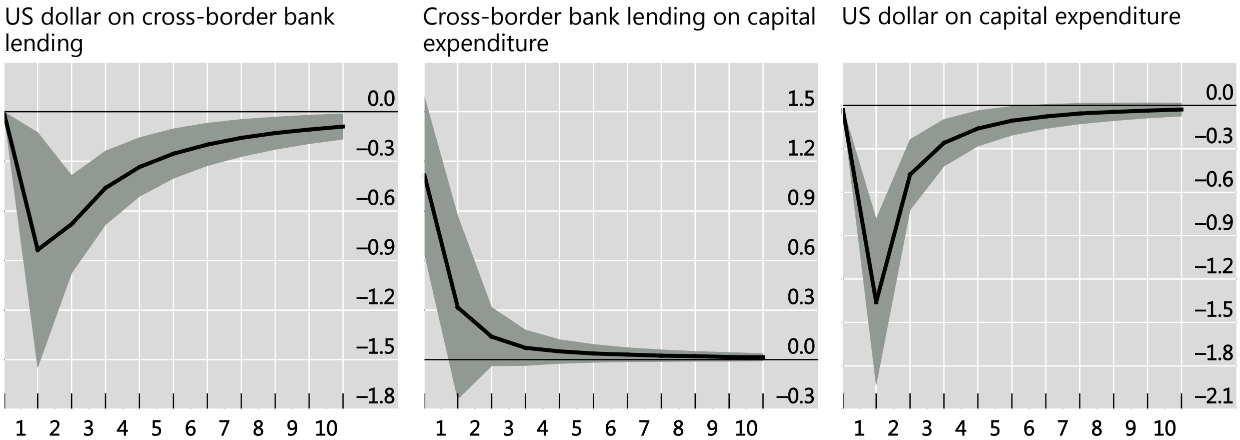
Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) bilateral end of quarter US exchange rate and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; 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 7 shows that the estimated impulse response functions are virtually the same as their counterparts implied by the benchmark SPVAR estimation.

Impact of a dollar appreciation shock on EMEs

Replacing the *average* quarterly bilateral FX rate with the *end-of-period* quarterly bilateral FX rate Figure 7



Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on 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. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

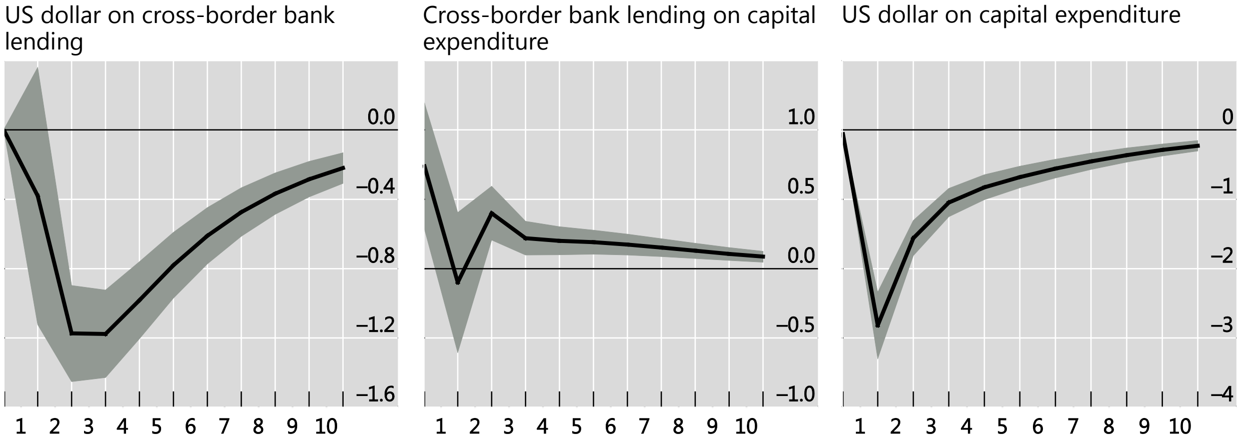
Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; authors' calculations.

We also test to which extent 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 8 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.

Impact of a dollar appreciation shock on EMEs

Replacing VIX with global GDP

Figure 8



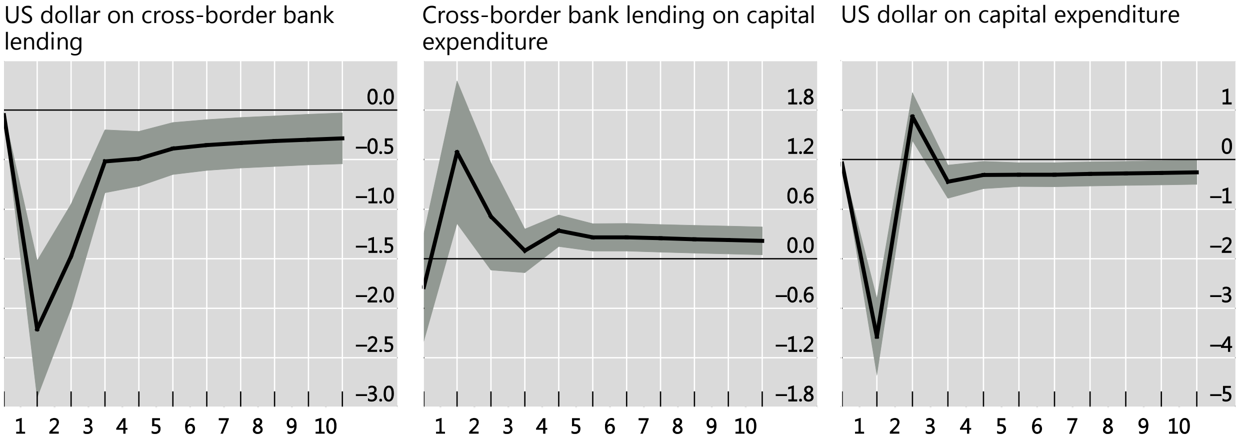
Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on the exchange rate using a Cholesky decomposition. The SPVAR's five endogenous variables follow the order (1) US interest rate, (2) US dollar-denominated cross-border bank flows, (3) gross capital formation, (4) BIS USD NEER index and (5) real global GDP growth. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 34 EMEs.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; 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 9, 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.

Impact of a dollar appreciation shock on EMEs

Replacing country-specific investment growth with country-specific GDP growth — Figure 9



Black lines show the estimated impulse response functions to a one percentage point exchange rate shock on 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 index and (5) the VIX. Confidence bands reflect 95% confidence intervals using a Gaussian approximation based on 1,000 Monte Carlo draws from the estimated structural panel VAR. Period covered: Q2 2001–Q3 2016, based on 29 EMEs.

Sources: IMF *International Financial Statistics* and *World Economic Outlook*; national data; BIS locational banking statistics; 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 aforementioned finding that a dollar currency appreciation has 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 (in % 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 estimates 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 the financial dependence variable (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 financial dependence (FINDEP).

Regression results of Capex/TA, alternative specifications

Firms in non-tradable sectors and in floating regime countries

Table 5

	(1)	(2)	(3)	(4)	(5)	(6)
ΔFX		0.0158*	0.0022	0.0073	0.0075	0.0429
		(0.0091)	(0.0101)	(0.0088)	(0.0088)	(0.0803)
*ΔFX * 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 % of GDP (*Savings*), VIX in log differences (*ΔVIX*), US interest rates in first differences (*ΔUS rate*) and total bank debt as % of total debt (*Bank debt*). As in Table 2, all regression specifications include country, industry and time fixed effects.
Sources: FRED, St. Louis Fed; IMF *International Financial Statistics* and *World Economic Outlook*; World Bank; Bloomberg; 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 3-digit industry measure from Claessens, Tong, and Wei (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 Financial Dependence remains negative and significant.

Next, we include country-year and industry-year fixed effects (while returning to our benchmark 2-digit SIC code FINDEP). We estimate that specification for the full sample (column 2) and for the sample that drops the period of the global financial crisis (column 3). In both of those 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 regime countries — Table 6

	(1)	(2)	(3)	(4)
	Full sample	Full sample	Excl. 2008–2011	Full sample
ΔFX	0.0086			
	(0.0098)			
*ΔFX * 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	–	–	–
Country FE	Y	–	–	–
Industry FE	Y	–	–	–
Country-year FE	–	Y	Y	Y
Industry-year FE	–	Y	Y	Y
Number of 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 and Tong (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 adjusted at the firm-level and are reported in brackets.
Sources: IMF International Financial Statistics and World Economic Outlook; Bloomberg; 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, increases in US dollar-denominated cross-border bank credit to a given EME are 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 main results provide 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 accrue from the trade channel.

References

Abrigo M and I Love (2015). “Estimation of Panel Vector Autoregression in Stata: a Package of Programs.” University of Hawaii working paper.

Arellano, M, and S Bond (1991). “Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations”. *Review of Economic Studies,* 58(2).

Avdjiev, S, Du, W, Koch, C and H S Shin (2016). “The dollar, bank leverage and the deviation from covered interest parity”, *BIS Working Paper* No 592.

Avdjiev, S, Koch, C, von Peter, G and P McGuire (2017). “Transmission of monetary policy through global banks: whose policy matters ?” BIS Mimeo.

Avdjiev, S, R McCauley and H S Shin (2016). “Breaking free of the triple coincidence in international finance”, *Economic Policy*, 31(87), pp 409–451.

Bank for International Settlements (2015). "Introduction to BIS statistics", *BIS Quarterly Review*, September, pp 35-51.

Basso, H, O Calvo-Gonzalez, O and M Jurgilas, M (2011). “Financial dollarization: The role of foreign-owned banks and interest rates”, *Journal of Banking & Finance*, 35(4), pp 794-806.

Beck, T, Demirguc-Kunt, A and M S M Peria (2007). “Reaching out: Access to and use of banking services across countries”, *Journal of Financial Economics*, 85(1), pp 234-266.

Bluedorn, JC and J Bowdler (2010). “The empirics of international monetary transmission: identification and the impossible trinity*”, Journal of Money, Credit and Banking*, 42(4), pp 679-713.

Boz, E, Gopinath, G and M Plagborg-Møller (2017). “Global Trade and the Dollar”, *Working Paper*.

Bruno, V and H S Shin (2014). “Globalization of Corporate Risk Taking”, *Journal of International Business Studies*, 45, pp 800-820.

——— (2015a). “Capital flows and the risk-taking channel of monetary policy”, *Journal of Monetary Economics*, Vol 71, pp 119–32.

——— (2015b). “Cross-border banking and global liquidity”, *Review of Economic Studies*, 82(2), pp 535–64.

Caruana, J (2016). “Credit, commodities and currencies”, lecture at the London School of Economics and Political Science, London, 5 February, www.bis.org/speeches/sp160205.htm

Casas, C, Diez, F, Gopinath, G and P-O Gourinchas (2016). “Dominant currency paradigm”, *Working Paper*.

Cerutti, E, Claessens, S and L Ratnovski (2016). “Global liquidity and drivers of cross-border bank flows”, *IMF Working Papers* 14/69.

Cetorelli N and L Goldberg (2011). "Global Banks and International Shock Transmission: Evidence from the Crisis", *IMF Economic Review*, 59(1), pp 41-76.

Claessens, S, Tong, H and S-J Wei (2012). “From the financial crisis to the real economy: Using firm-level data to identify transmission channels”. *Journal of International Economics*, 88, pp 375-387.

De Nicoló, G, Honohan, P and A Ize (2005). “Dollarization of the Banking System: Causes and Consequences”, *Journal of Banking and Finance*, 29, pp 1697-1727.

Fender, I and P McGuire (2010). “European banks’ US dollar funding pressures”, *BIS Quarterly Review*, June, pp 57–64.

Fisman, R. and I. Love (2003). “Trade Credit, Financial Intermediary Development, and Industry Growth”, *The Journal of Finance*, 58, pp. 353-374.

Forbes, KJ and F Warnock (2012). “Capital flow waves: Surges, stops, flight, and retrenchment”, Journal of International Economics, 88, pp 235-251.

Goldberg, L and C Tille (2008). “Vehicle currency use in international trade”, *Journal of International Economics*, 76(2), pp 177–192.

Gopinath, G. (2015). “The International Price System”. In Jackson Hole Symposium, Volume 27. Kansas City Federal Reserve.

Hofmann, B, I Shim and H S Shin (2016). "Sovereign yields and the risk-taking channel of currency appreciation”. *BIS Working Papers* No 538.

Krippner, L (2015). “Zero lower bound term structure modeling: A practitioner’s guide”. Springer.

Lütkepohl, H (2007). “New Introduction to Multiple Time Series Analysis”. Berlin. Springer.

McGuire, P and N Tarashev (2008). “Bank health and lending to emerging markets*”, BIS Quarterly Review,* December, pp 67–80.

Nickel, S (1981). “Biases in Dynamic Models with Fixed Effects”, *Econometrica*, 49 (6), pp. 1417-26.

Miranda-Agrippino, S and H Rey (2012). “World Asset Markets and the Global Financial Cycle”, *NBER Working Paper*, 21722.

Peek, J and E Rosengren (1997). “The international transmission of financial shocks: The case of Japan”, *The American Economic Review*, 87(4), pp 495-505.

Peek, J and E Rosengren (2000). “Collateral damage: Effects of the Japanese bank crisis on real activity in the United States”, *The American Economic Review*, pp 30-45.

Rajan, R and L Zingales, (1998). ”Financial dependence and growth”, *The* American Economic Review, 88, pp 559-586.

Rey, H (2015). “Dilemma not trilemma: The global financial cycle and monetary policy independence”, *NBER Working Paper*, 21162.

Schnabl, P (2012). “The International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market”, *Journal of Finance*, 67(3), pp 897-932.

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 flexible 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.