International Bank Lending Channel of Monetary Policy[*]

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Abstract

How does domestic monetary policy in center countries spillover to the rest of the world? This paper examines the bank lending channel of monetary policy in the international context. We use exogenous surprises in monetary policy stance in systemically important economies, including the U.S., and the local projection method to estimate the dynamic effect of monetary policy shocks on bilateral cross-border bank lending. We find robust evidence that the bank lending channel of monetary policy is still potent in the international context: an exogenous monetary tightening leads to a statistically and economically significant decline in cross-border bank lending. This effect tends to be larger during periods of lower global risks or uncertainty (proxied by the VIX) and when lending toward emerging market borrowers. While no clear-cut evidence emerges on the ability of a floating exchange rate regime in reducing the cross-border spillover of monetary policy, our finding is still consistent with the theoretical prediction of the trilemma when the exchange rate regime and capital account openness are jointly considered.

Keywords: Monetary policy spillovers; International bank lending channel; Cross-border banking flows; Global financial cycles; Trilemma

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I. INTRODUCTION

What is the transmission channel of domestic monetary policy actions in the cross-border context? What are the factors affecting this transmission channel? Does the Mundellian trilemma help understand the degree of spillover effect? Despite their paramount importance in international finance, there has been a lack of empirical consensus on these questions. We contribute to the literature by suggesting a dynamic and flexible empirical framework in testing the channel of cross-border spillovers of domestic monetary policy in systemically important countries, as well as offering a new set of empirical findings, which reconciles the contrasting evidence in the recent literature. We find that a bank lending channel of monetary policy is still potent in the international context and argue that identifying exogenous monetary policy surprises from an overall monetary policy stance is key to understanding the lack of empirical consensus.

Rising financial integration has stimulated research on the cross-border effects of domestic monetary policy actions in systemically-important economies. In particular, the sharp increase in cross-border banking flows since the 1990s has led recent research to focus on the role of global banks in explaining the international transmission of monetary policy (Bruno and Shin, 2015b; Correa et al., 2017; Avdjiev et al., 2018; Bräuning and Ivashina, 2018; Temesvary et al., 2018; Avdjiev and Hale, forthcoming). We contribute to this emerging literature by investigating the dynamic spillover effect of exogenous monetary policy actions in systemically-important economies, including the U.S. through cross-border bank lending originated from these economies.

The reason for focusing on cross-border banking flows is threefold. First, while most previous studies focused on net capital flows, the rapid expansion of gross international asset and liability positions calls for a deeper understanding of the spillovers through gross flows that better reflect the impact on national balance sheets (Milesi-Ferretti and Tille, 2011; Forbes and Warnock, 2012; Broner et al., 2013). Second, to the extent that cross-border banking flows have meaningful implications for economic and financial conditions in recipient countries, as suggested by the recent empirical studies (Peek and Rosengren, 2000; Khwaja and Mian, 2008; Schnabl, 2012; Bruno and Shin, 2015a; Bräuning and Ivashina, 2018), examining the effect of monetary policy shocks on these flows helps identify the transmission channel of monetary policy spillovers. Third, the bilateral nature of cross-border banking flow data permits a cleaner identification of the international transmission channel of monetary policy since it allows controlling for credit demand factors in a recipient country (Cetorelli and Goldberg, 2011; Correa et al., 2017; Avdjiev et al., 2018).

While the monetary policy in systemically-important economies, such as the U.S., has proven to be a robust factor of international capital flows and risky asset prices across the globe (Rey, 2013), there is no consensus on the sign of the effect of monetary policy actions on cross-border banking flows. In principle, the credit channel of the monetary policy suggested by Bernanke and Gertler (1995) amplifies the effect of monetary policy shocks through frictions in either the financial intermediary-side (a bank lending channel) or the firm-side (a borrower balance sheet channel) or both. In either case, monetary policy tightening would result in a decline in bank lending.

However, monetary policy actions do not necessarily have the same effect on bank lending found in the domestic context, when extending to the international context. For example, while a conventional bank lending channel predicts monetary policy tightening would reduce bank lending by increasing banks' funding costs (e.g., Kashyap et al., 1993; Bernanke and Gertler, 1995), the presence of global banks may nullify this channel if they are able to substitute lost domestic deposits with foreign deposits. Moreover, the balance sheet channel of monetary policy may coexist with a portfolio rebalancing channel (e.g., Den Haan, 2007) when adopted to the cross-border setup. This is because tighter monetary policy actions, by eroding the net worth and collateral value of domestic borrowers, can lead to a reallocation of lending toward relatively safer borrowers abroad, thereby increasing cross-border bank lending (Correa et al., 2017).

The existing empirical evidence on the effect of monetary policy on cross-border bank lending is mixed. Using data from the Bank for International Settlements (BIS)' Locational Banking Statistics (LBS) for the period 1995–2007, Bruno and Shin (2015a) find that higher U.S. interest rates have a negative impact on cross-border bank lending, which is consistent with an international bank lending channel of monetary policy. Bräuning and Ivashina (2018) and Temesvary et al. (2018) corroborate this finding using banks-firms matched loan-level data. In contrast, Cerutti at al. (2017), also using the data from the BIS LBS, find that higher U.S. short-term interest rates are associated with an increase in cross-border bank lending. Correa et al. (2017) and Avdjiev et al. (2018) extend this finding to a large sample of lender countries, providing supporting evidence for the portfolio rebalancing channel. Avdjiev and Hale (forthcoming) find mixed evidence regarding the effect of monetary policy on international lending depending on the prevailing international capital flow regimes (high vs. low bank lending growth) and on the drivers of the monetary policy rate (macroeconomic fundamentals vs. monetary policy stance).[5]

We argue, and show, that this lack of empirical consensus is mostly due to the use of short-term policy rates in testing the two contrasting theoretical channels and our general empirical framework can reconcile the mixed evidence in the literature. Because monetary policy is typically guided by a rule, the largest part of the variation in monetary policy actions is due to the systematic component of monetary policy—that is, the response of the central bank to the current and expected future state of the economy. As discussed by Ramey (2016), identifying the causal effect of monetary policy requires looking at the exogenous deviations from the monetary rule. Most earlier studies also identified exogenous shocks to monetary policy when investigating the credit channel of monetary policy (Bernanke and Gertler, 1995). Surprisingly, however, most of the existing studies on cross-border bank lending have not effectively addressed this issue. Rather, they have typically examined the effect of an increase in the policy rate, which is confounded by the endogenous response of monetary policy to underlying economic conditions.

To address the endogeneity concern, we employ exogenous monetary policy shocks in the U.S.—the shocks identified by a narrative approach of Romer and Romer (2004) and Coibion (2012) and those identified by external instruments using high-frequency data of

[5] Avdjiev and Hale (forthcoming) decompose changes in the Federal funds rate into what is predicted by the Taylor rule (the "macro fundamentals component") and the difference between the Federal funds rate and the one implied by the Taylor rule (the "monetary policy stance component"). However, they find that an increase in both components has positive effects on cross-border bank lending from U.S. banks, especially when lending to advanced economies, which is in sharp contrast to our findings.

Gertler and Karadi (2015)—and in other eight advanced economies—the exogenous shocks series constructed by Furceri et al. (2018)[6] and apply the local projection method (Jordà, 2005) in estimating the dynamic effect of monetary policy on cross-border bank lending. We pay particular attention to the effect of U.S. monetary policy shocks given the dominance of U.S. monetary policy in shaping international capital flows, including banking flows, and the special role of U.S. dollar in the international financial system (Gerko and Rey, 2017). Thus, our analysis complements the voluminous literature on the real, monetary, and financial spillover effects of U.S. monetary policy (Kim, 2001; Canova, 2005; Di Giovanni and Shambaugh, 2007; Miranda-Agrippino and Rey, 2015; Dedola et al., 2017; Iacoviello and Navarro, forthcoming).

Given the ample empirical evidence on the nonlinear effect of monetary policy shocks on economic and financial activity (Cover, 1992; Weise, 1999; Tenreyro and Thwaites, 2016; Castelnuovo and Pellegrino, 2018), we further investigate whether the effect of monetary policy shocks on cross-border banking flows depends on the underlying state of business cycles (expansions vs. recessions) in the source economy, global financial risks or uncertainty (low-uncertainty vs. high-uncertainty), and the sign of the shocks (tightening vs. easing). In addition, we analyze whether certain types of a recipient country' characteristics (such as the exchange rate regime, monetary independence, and capital account openness guided by the Mundellian trilemma) amplify or dampen the international bank lending channel of monetary policy, which bears significant policy implications.

The key results of the paper are the following:

- Exogenous monetary policy tightening in systemically important source economies leads to an economically and statistically significant decline in cross-border bank lending. This holds for the U.S. as well as the other advanced economies analyzed. These results sharply contrast with the evidence presented in previous studies using

[6] The eight advanced economies are Canada, Germany, Italy, Japan, the Netherlands, Spain, Sweden, and the United Kingdom.

similar data but relying on the level of policy rates as a measure of monetary policy actions (Correa et al., 2017; Avdjiev et al., 2018).

- U.S. monetary policy shocks have a statistically and economically significant effect on cross-border bank lending even when controlling for global financial risks or uncertainty (proxied by the VIX) or liquidity risks (proxied by the Libor-OIS spread), implying that U.S. monetary policy is an independent source of the so-called "global financial cycle."[7]

- The effect tends to be larger during periods of lower measured global risks or uncertainty (proxied by the VIX index of implied volatility on the U.S. equity options), consistent with the monetary policy ineffectiveness during the period of high uncertainty (Aastveit et al., 2017; Castelnuovo and Pellegrino, 2018) and when lending toward emerging market economies, consistent with the international risk-taking channel of monetary policy (Temesvary et al., 2017; Bräuning and Ivashina, 2018; Lee et al., 2018).

- Consistent with Rey (2013), we do not find significantly stronger spillovers of U.S. monetary policy shocks toward a recipient country with a fixed exchange rate regime or open capital accounts, and a country with the floating exchange rate regime is not fully insulated from cross-border spillovers. However, when the exchange rate regime and capital account openness are jointly considered, our finding corroborates the theoretical prediction of the trilemma, highlighting the importance of the joint consideration of the three dimensions along the trilemma (Aizenmann et al., 2013).

The remainder of the paper is organized as follows. Section II describes the data on cross-border banking and exogenous measures of monetary policy shocks. Section III illustrates the empirical methodology and provides a thorough analysis of the international

[7] See Rey (2015) and Cerutti et al. (forthcoming) for contrasting evidence on the existence of the global financial cycle.

bank lending channel of monetary policy, including various robustness tests and additional exercises. Section IV concludes.

II. DATA

A. Cross-border Banking Flows

We use data on cross-border claims from the BIS' LBS to test the international bank lending channel of monetary policy in systemically important countries. This dataset provides a geographical breakdown of reporting banks' counterparties and the information about the currency composition of their balance sheets. The LBS dataset captures outstanding claims and liabilities of internationally active banks located in reporting countries against their counterparties residing in more than 200 countries. The data is compiled following the residency principle that is consistent with the BoP (Balance of Payments) statistics.

As the conventional bank lending channel relates to conditions in the location where banks make funding and lending activities, the residency principle has a conceptual appeal over the nationality principle used in Consolidated Banking Statistics (CBS). Moreover, to the extent to which foreign affiliates are subject to host-country regulation or have access to local bank liquidity facilities (Avdjiev et al., 2018), the residency principle is more appropriate than the nationality principle in identifying the international bank lending channel of monetary policy.

The major advantage of the BIS LBS data, compared to the banking flows collected from the BoP statistics, is the detailed breakdown of the reported series by recipient countries.[8] Banks record their positions on an unconsolidated basis, including intragroup positions between offices of the same banking group. Currently, banking offices located in 46 countries, including many offshore financial centers, report the LBS. The LBS dataset captures around 95 percent of all cross-border interbank business (Bank for International Settlement, 2017). The bulk of cross-border bank claims and liabilities takes a form of loans and securities of the

[8] Wang (2018) shows that banking inflows constructed using the BIS data move in tandem with the aggregate capital inflows from the BoP statistics. Moreover, flows to banking sectors as reported in the BoP closely track the banking flows reported by BIS.

domestic banking sector vis-à-vis all counterparty sectors (including banks and non-banks, and the private and public sector).

Another advantage of the BIS LBS dataset is that the currency composition of cross-border claims and liabilities is available so that cross-border banking flows expressed in U.S. dollars are adjusted for movements in exchange rates. The adjustment for exchange rate movements turns out to be crucial in our setup since fluctuations in the exchange rate, which are influenced by monetary policy shocks, also affect cross-border bank lending. The availability of a currency breakdown enables the BIS to calculate break- and exchange rate-adjusted changes in amounts outstanding. Such adjusted changes approximate underlying flows during each quarter.[9]

The adjusted change is calculated by first converting U.S. dollar-equivalent amounts outstanding into their original currency using the end-of-period exchange rates, then calculating the difference in amounts outstanding in the original currency, and finally converting the difference into a U.S. dollar-equivalent change using the average period exchange rates.[10] As the BIS LBS only report the exchange rate-adjusted flows, we construct the exchange rate-adjusted stock of the cross-border claims from a country *i* to a country *j* as the cumulated sum of the exchange rate-adjusted flows, where the initial value of the exchange rate-adjusted stock is set equal to the exchange rate-unadjusted claims—directly available from the BIS LBS.[11]

[9] Adjusted changes in amounts outstanding are calculated, as an approximation for flows. In addition to exchange rate fluctuations, the quarterly flows in the locational datasets are corrected for breaks in the reporting population. In Table A.1, we summarize the data availability in the BIS International Banking Statistics by reproducing Table 1 in Avdjiev and Takáts (2014). This summary highlights the available information of each statistics, together with their limitations.

[10] Nevertheless, the adjustment practice by the BIS cannot eliminate the possibility of under- or overestimation of actual flows. Adjusted changes could still be affected by changes in valuations, writedowns, the underreporting of breaks, and differences between the exchange rate on the transaction date and the quarterly average exchange rate used for conversion. See Avdjiev and Hale (forthcoming) for further details.

[11] Figure A.1 in the appendix shows the exchange rate-unadjusted and adjusted U.S. cross-border claims. While the two series co-move very closely (the correlation is 0.75) over the entire sample, accounting for the valuation effect results in a more pronounced decline in cross-border bank lending from the U.S. during the global financial crisis (GFC), suggesting that the appreciation of U.S. dollars during this period partially offsets a larger decline

The time-series coverage of LBS database varies significantly across countries. Some advanced economies like the U.S. have reported these statistics since 1977, while some emerging market economies started reporting statistics only after the 2000s. Owing to the extensive availability of cross-border banking flow data and well-identified exogenous monetary policy shocks, together with its dominance in shaping international capital flows and the special role of U.S. dollars in the international financial system, we first analyze the international bank lending channel of U.S. monetary policy using data from 1990Q1 to 2012Q4.[12] In the subsequent analysis of the international bank lending channel of monetary policy from other advanced economies, the sample is restricted to the 2001Q1-2012Q4 period due to the limited availability of exogenous monetary shock series.

Throughout the analysis, we drop offshore financial centers using the IMF classification from our sample because their behaviors might differ substantially from the rest of the sample. Following Correa et al. (2017) and Choi and Furceri (2019), we further drop observations with the size of cross-border positions less than $5 million, or with negative total outstanding claims. Observations of the dependent variable in the upper and lower one percentile of the distribution are excluded from the sample to reduce the influence of outliers.[13]

Table 1 lists the final sample of countries used in the analysis, together with their income status, an indicator whether they belong to the euro area, and their average status regarding the exchange rate regime, monetary policy independence, and capital account openness during the sample period using use the trilemma index constructed by Aizenman et al. (2013).[14] The details on this index will be discussed in the following section. We use these

in "real" cross-border bank lending originally denominated in U.S. dollars. The correlation between the exchange rate-adjusted and unadjusted series in the other eight advanced economies is about 0.6.

[12] Data before 1990 are sparse and with gaps.

[13] The qualitative results are robust to the inclusion of the observations less than $5 million. They are also robust to (i) dropping the dependent variables at the top/bottom 2.5 percentile, (ii) winsorizing the dependent variables at the 1 or 2.5 percentile of the distribution, and (iii) including all the observations.

[14] For each country, we take the time-series average of each measure to summarize the overall characteristics during the period between 1990 and 2012. The exchange rate regime and monetary policy independence is defined vis-à-vis the U.S. A country with * denotes that it is also a source country where monetary policy shocks are originated in the second part of the analysis.

country-specific characteristics to investigate factors affecting the cross-border bank lending channel of monetary policy.

To provide a first look at the pattern of cross-border bank lending, we present the size of total cross-border claims and liabilities as a share of the GDP in 2010Q4 for the 9 reporting countries in Table 2. Table 2 demonstrates the dominance of advanced economies in shaping the cross-border banking system. When normalized to the size of domestic GDP, the predominant role of European countries in the cross-border banking system is apparent. Cross-border claims of global banks operating in advanced economies are, on average, larger than liabilities, suggesting that they are net lenders in this market.

We further illustrate the bilateral structure of the data by presenting examples of bilateral cross-border claims between the U.S. and six countries in Figure A.2 in the appendix. Given the confidentiality of the data, we do not reveal the identity of the individual counterparties, but the first four recipient countries are advanced economies and the last two recipient countries are emerging market economies. Some observations stand out from the figure. First, the different scales of the y-axis in these graphs re-emphasizes the dominance of advanced economies in accounting for these flows. Second, the pattern of cross-border lending is quite heterogeneous across countries, suggesting that a recipient country's characteristics could play an important role in shaping the international bank lending channel of monetary policy.

B. Identification of Monetary Policy Shocks

As discussed earlier, the proper identification of the causal effect of monetary policy actions on cross-border bank lending requires using monetary policy actions that are orthogonal to current and expected future macroeconomic conditions (Ramey, 2016). This is the main novelty of the paper compared to many existing studies on the spillover effects through cross-border bank flows.

Measures of exogenous U.S. monetary policy shocks

In the baseline analysis, we use the exogenous monetary policy shock series constructed by Coibion (2012) who extends the monetary policy shocks identified by Romer and Romer

(2004) using a narrative approach. Romer and Romer (2004) extract measures of the change in the Fed's target interest rate at each meeting of the Federal Open Market Committee (FOMC) and regress these policy changes on the Fed's real-time forecasts of relevant macroeconomic variables in the Greenbooks prior to each FOMC meeting. Then, they identify exogenous monetary policy shocks as the residuals from this regression. Specifically, they estimate the following equation:

$$\Delta ff_m = \alpha + \beta ffb_m + \sum_{i=-1}^{2} \gamma_i F_m \Delta y_{m,i} + \sum_{i=-1}^{2} \lambda_i \left(F_m \Delta y_{m,i} - F_{m-1} \Delta y_{m,i}\right) + \sum_{i=-1}^{2} \varphi_i F_m \pi_{m,i} + \sum_{i=-1}^{2} \theta_i (F_m \pi_{m,i} - F_{m-1} \pi_{m,i}) + \mu_i F_m un_0 + \varepsilon_m, \quad (1)$$

where m denotes the FOMC meeting, ffb_m is the target federal funds rate going into the FOMC meeting, $F_m \Delta y_{m,i}$ is the Greenbook forecast from meeting *m* of real output growth in quarters around meeting m, $F_m \pi_{m,i}$ is the Greenbook forecast of GDP deflator inflation, and $F_m un_0$ is the Greenbook forecast of the current quarter's average unemployment rate.

The estimated residuals $\hat{\varepsilon}_m$ are then defined as exogenous monetary policy shocks, purged of anticipatory effects related to economic conditions. Our quarterly measure of monetary policy shocks comes from summing the orthogonalized innovations to the Federal funds rate from each meeting within a quarter. As a robustness check, we also use the identification strategy of Gertler and Karadi (2015) based on high-frequency data used as external instruments (see next section).

Measures of exogenous monetary policy shocks in other advanced economies

We follow the methodology of Furceri et al. (2018) to construct quarterly measures of exogenous monetary policy shocks for other eight advanced economies. They identify monetary policy shocks in two steps, which closely follow the work by Auerbach and Gorodnichenko (2013) in identifying fiscal shocks in advanced economies. First, they compute the unexpected changes in policy rates (proxied by short-term rates) using the forecast errors of the policy rates provided by *Consensus Economics*.[15] Second, they regress for each country

[15] The Consensus Economics publications report forecasts for short-term (3-months) rates at the end of the next three months.

the forecast errors of the policy rates on similarly-computed forecast errors of inflation and output growth and identify the shocks as the residuals of this regression. We follow this approach, but we further purify these surprises of any predictable components by projecting it on current and lagged GDP growth and inflation, in order to eliminate any remaining endogeneity issue. Specifically, we estimate

$$FE_{i,t}^{r} = \alpha_i + \beta FE_{i,t}^{\Delta y} + \gamma FE_{i,t}^{\pi} + \sum_{j=0}^{4} \delta_j \Delta y_{i,t-j} + \sum_{j=0}^{4} \theta_j \pi_{i,t-j} + \varepsilon_{i,t}, \qquad (2)$$

where $FE_{i,t}^{X}$ $(X = r, \Delta y, \pi)$ is the unexpected changes in policy rates (proxied by short-term rates), real GDP growth, and the inflation rate, respectively—defined as the difference between the actual value at the end of the quarter and the value expected by analysts as of the beginning of the last quarter for each country i. $y_{i,t}$ and $\pi_{i,t}$ are corresponding actual real GDP growth and the inflation rate. The estimated residuals $\hat{\varepsilon}_{i,t}$ are then defined as exogenous monetary policy shocks for advanced economies other than the U.S.

As discussed by Furceri et al. (2018), this methodology has two main advantages. First, it overcomes the issue of "policy foresight" (e.g., Leeper et al., 2013) where economic agents receive news about possible changes in monetary policy and alter their behavior before the actual changes in policy happen. Changes in actual policy rate cannot capture this policy foresight of economic agents, leading to inconsistent estimates of the effect of monetary policy shocks on cross-border bank lending. Our approach, on the contrary, is free from this issue since it uses forecast errors which already reflect policy foresight by its construction. Second, this methodology reduces endogeneity issues as the shocks are orthogonal to unexpected changes in economic activity as well as to current and lagged endogenous variables.

Figure A.3 plots the distribution of the exogenous monetary policy shocks we constructed at a quarterly frequency, which is available for the nine advanced economies, including the U.S. for comparison. Table 3 shows the standard deviation of the country-specific exogenous monetary policy shock series, together with its correlation with the U.S. monetary policy shocks constructed by Furceri et al. (2018) and Coibion (2012), respectively. The correlation between the U.S. monetary policy shock series from Furceri et al. (2018) and that from Coibion (2012) is 0.62 for the overlapped sample. The correlation between the country-specific monetary policy shock series with the U.S. is typically small except for Canada, ensuring that the identification of international bank lending channel of monetary policy from other advanced economies is not confounded by the effect of U.S. monetary policy on the short-term rates in these economies.[16]

III. Empirical Analysis

A. Local Projection Method

We use Jordà (2005)'s local projection method to estimate the dynamic effect of monetary policy shocks on cross-border bank lending. The local projection method has been advocated by Auerbach and Gorodnichencko (2012) and Ramey and Zubairy (2018), among others, as a flexible alternative to VAR specifications without imposing the pattern generated by structural VARs. Thus, local projections are more resilient to model specifications than VARs. In the bilateral panel data setting, we adopt the local projection method over commonly used VAR models for the following specific reasons.[17]

First, the exogenous shocks we use are already orthogonalized to contemporaneous and expected future macroeconomic conditions. For this reason, we do not need to further identify monetary policy shocks using restrictions in VAR models—a common approach in many empirical analyses in both domestic and international setups.

Second, our estimation entails a large international panel dataset with the constellation of the fixed effects, which makes a direct application of standard VAR models more difficult. In addition, the local projection method obviates the need to estimate the equations for dependent variables other than the variable of interest, thereby significantly economizing on the number of estimated parameters.

[16] The high correlation between the monetary policy shocks in the U.S. and Canada reflects the close economic ties between the two countries and is consistent with Gilchrist et al. (2018) who find that Canada is the only country among a group of advanced economies experiencing a near complete passthrough of conventional U.S. monetary policy for short-term interest rate.

[17] See Choi et al. (2018) and Miyamoto et al. (2019) for the recent application of local projections to the estimation of a nonlinear and interaction effect of exogenous shocks using a large international panel dataset.

Third, the local projection method is particularly suited to estimating nonlinearities (for example, how the international bank lending channel of monetary policy shocks differs during expansions and recessions in the source economy), as its application is much more straightforward compared to non-linear structural VAR models, such as Markov-switching or threshold-VAR models. Moreover, it allows for incorporating various time-varying features of source (recipient) economies directly and allow for their endogenous response to monetary policy shocks.

Lastly, the error term in the following panel estimations is likely to be correlated across countries. This correlation would be difficult to address in the context of VAR models, but it is easy to handle in the local projection method by either clustering standard errors by time period or using the Driscoll-Kraay standard errors allowing for arbitrary correlations of the errors across countries and time (Driscoll and Kraay, 1998).

Despite the advantages mentioned above, the local projection method has some drawbacks compared to structural VARs. First, since the iterated VAR method produces more efficient parameter estimates than the local projection method, the impulse response function estimated by local projections is often associated with large confidence intervals. This problem of imprecise estimates exacerbates as a forecast horizon increases due to the decreasing sample size in each estimation. Thus, we report both 68% and 90% confidence intervals in the following analyses.

Second, compared to a single equation framework in the local projection method, structural VARs allow tracing the dynamic endogenous response of various macroeconomic variables, such as output or the exchange rate, to monetary policy shocks, which in turn can also affect the dynamics of cross-border bank lending. We overcome this limitation and enhance the credibility of the identified shocks by analyzing separately the effect of monetary policy shocks on domestic economic variables (such as real GDP, inflation, and the exchange rate vis-à-vis the U.S.).[18]

[18] See Figure A.4 in the appendix and Coibion (2012).

B. International Bank Lending Channel of U.S. Monetary Policy Shocks

The local projection method simply requires the estimation of a series of regressions for each horizon h for each variable. Following Auerbach and Gorodnichencko (2012) and Ramey and Zubairy (2018), we run a series of regressions for different horizons, $h =, 1, 2, \dots H$ as follows, which can be seen as a dynamic extension of Correa et al. (2017) and Avdjiev and Hale (forthcoming):

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \beta^h M\,Pshock_{\,t} + \sum_{p=1}^{n} \gamma^h X_{j,t-p} + \varepsilon_{j,t+h}, \tag{3}$$

where $y_{j,t}$ is the log of exchange rate-adjusted cross-border claims from the U.S. located global banks to borrowers in countries j in time t; α_j^h is a recipient country-fixed effect, which controls unobserved time-invariant characteristics specific to a country j; $M\,Pshock_{\,t}$ is the measure of exogenous U.S. monetary policy shocks; $X_{j,t}$ is a set of control variables including lags of the dependent variable and the monetary policy shocks, and various control variables in the recipient country j (for example, real GDP growth, the short-term interest rate, inflation, and the nominal exchange rate growth vis-à-vis the U.S.) and their lags.

While the impulse responses generated by the local projections are not an estimate of the total effects of U.S. monetary policy, the exogeneity of the monetary policy shock allows us to investigate the international spillover channel. In the baseline analysis, we use four lags of control variables in $X_{j,t}$ (i.e., $n = 4$), however, the selection of the lag length does not affect our findings.[19]

We estimate equation (3) using OLS, which would result in the inconsistency of the least squares parameter estimates due to the combination of lagged dependent variables and fixed effects (Nickell, 1981). However, because the time series dimension of the panel dataset is quite large, the inconsistency is unlikely a major concern. Following Auerbach and Gorodnichencko (2012), standard errors are clustered by time to account for the fact that the shock is identical to all recipient countries in any given period. Equation (3) is estimated for

[19] When policy rates are not available, we use interbank rates. When interbank rates are not available, we use money market rates. We also include a linear time trend, but it hardly changes the estimation results.

h=0, 1, 2,…, 7 so that we trace the dynamic effect of monetary policy shocks over two years. After dropping outliers and missing observations following the criterion explained above, our baseline estimation of the U.S. monetary policy shocks covers cross-border lending to 45 recipient countries.

Baseline results

Figure 1 presents the dynamic response of cross-border bank lending to exogenous U.S. monetary policy shocks. The results provide evidence of a significant cross-border bank lending channel of monetary policy. In particular, a 100 basis-point (bp) exogenous tightening is found to lead to more than a 10 percent decline in cross-border bank lending after two quarters, which is not only statistically but also economically significant.[20]

Table 4 summarizes the full estimation results using exogenous U.S. monetary policy shocks above.[21] The coefficients on the lagged dependent variable are negative and highly statistically significant, suggesting that the growth rate of the cross-border bank lending is mean-reverting. The coefficients on a recipient country's real GDP growth are positive, although they are not statistically significant in most cases.[22]

The coefficients on the recipient country's short-term interest rate are not statistically significant. While this finding is in contrast to Bruno and Shin (2015a), who find that a higher interest rate in a recipient country increases cross-border bank lending toward this country, it is mostly driven by the emerging market recipient economies in the sample where the interest rate is typical countercyclical (Vegh and Vuletin, 2012). Indeed, when we restrict the set of recipient countries to advanced economies, we find a positive and statistical coefficient on the

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[20] A 100 bp increase corresponds to an approximately two standard deviations of the exogenous monetary policy shock series.

[21] While we control for the four lags of the variables, we only report the estimation results up to one lag to save space here. The results are available upon request.

[22] Once we drop the exchange rate growth in the estimation, the coefficients on a recipient country's real GDP growth become statistically significant without any material change in the coefficients of the monetary policy shock. This finding is consistent with the stylized fact that local economic growth is a pull factor of international capital flows. The results are available upon request.

recipient country's short-term interest rate, consistent with the finding that interest rate differentials are a strong pull factor of cross-border banking flows.

The results on the exchange rate suggest that a depreciation of the local currency is associated with a decline in cross-border bank lending toward the recipient country, which is consistent with the findings from the existing studies (Cerutti et al., 2017; Correa et al., 2017; Choi and Furceri, 2019). Bruno and Shin (2015b) also show that U.S. dollar appreciation induces a contraction of cross-border bank lending due to an increase in the risk of global banks' balance sheets, suggesting a balance sheet channel of U.S. monetary policy spillovers. Overall, the sign of coefficients of recipient country variables is consistent with the literature on push vs. pull factors of cross-border banking flows.

Comparison with the literature

Previous studies have typically examined the response of cross-border bank lending to changes in the monetary policy instrument, using a static framework. To compare our results with those, we perform two exercises. First, we regress the quarterly growth of cross-border bank lending on the lagged level of the Federal funds rate, which follows closely the specification in Correa et al. (2017).[23] Column (I) in Table 5 summarizes the estimation results. Consistent with many existing studies, an increase in the U.S. monetary policy rate is associated with an increase in cross-border bank lending. Column (II) provides the estimation results using the changes in the Federal funds rate instead of its lagged level, which deliver similar results although the estimated coefficient of interest is not statistically significant. Interestingly, the sign of the estimated coefficient of interest switches its sign when employing the exogenous U.S. monetary policy shocks (column III).[24]

Second, we examine the dynamic effect by re-estimating equation (3) using changes in the Federal funds rate as a measure of monetary policy shocks. Also, in this case, we do not find any evidence of the international bank lending channel of monetary policy: the effect is

[23] For the ZLB period (since 2008Q4), we replace the federal funds rate with the Wu-Xia shadow federal funds rate (Wu and Xia, 2016).

[24] Column (IV) to (VI) summarize the estimation results when dropping the recipient country-fixed effect.

not statistically significant over the all estimation horizons with a smaller magnitude and mixed signs (Figure 2).[25] Thus, misidentification of monetary policy shocks from an endogenous policy response to current and expected economic conditions in the previous literature has resulted in the misleading conclusion that global banks are insulated from the bank lending channel of monetary policy.

Overall, these results suggest that simply controlling for domestic variables that might affect cross-border bank lending (such as real GDP growth, inflation, stock returns, and the exchange rate) is not sufficient to identify the causal effect of monetary policy and test the international bank lending vs. portfolio rebalancing channel of monetary policy. In addition, the responses of bank lending to monetary policy shocks are better captured by a dynamic framework than a static one mixing short- and medium-term effects.

High-frequency identification with external instruments

We verify the validity of our baseline results using the identification of monetary policy shocks based on a narrative approach by further exploiting an alternative identification strategy based on high-frequency data used as external instruments (Gertler and Karadi, 2015; Gerko and Rey, 2017; Cloyne et al., 2018). This hybrid approach, proposed by Gertler and Karadi (2015), combines the high-frequency identification widely used in the finance literature (Kuttner, 2001; Cochrane and Piazzesi, 2002; Gurkaynak et al., 2005) with external instrument methods (Stock and Watson, 2012; Mertens and Ravn, 2013). The main idea behind this approach is that changes in the Federal funds futures in a narrow window (e.g., 30 minutes) around the FOMC monetary policy announcements capture the unexpected Fed policy actions. The key assumption is that these financial market surprises are uncorrelated with shocks other than the monetary policy ones. Since these changes are a noisy measure of the monetary policy structural shock, Gertler and Karadi (2015) used them as instruments in a proxy-SVAR framework.[26]

[25] Our findings are not driven by the inclusion of the GFC or ZLB periods. See Figure A.5 in the appendix.

[26] For a detail discussion on the proxy-SVAR and the use of external instrument, see Mertens and Ravn (2013), Gertler and Karadi (2015), and Ramey (2016).

One drawback of this approach is that it is not immune to policy foresight issues coming from the mismatch of the information set of the private agents and the policymakers. In other words, the FOMC may have additional information about the future path of the economy. Without accounting for these different information sets in the VAR, the shock may incorporate the endogenous response of the policy instrument to the expected future path of macroeconomic variables (Ramey, 2016). Furthermore, these shocks can be correlated with the Fed's real-time forecasts of relevant macroeconomic variables, and therefore not exogenous.[27] In contrast, the narrative approach used in the baseline analysis does not suffer from these problems, as the shocks are orthogonal to the Fed's real-time forecasts of relevant macroeconomic variables.

We estimate Gertler and Karadi (2015)'s monthly reduced-form VAR over the period 1990M1-2012M12. The VAR includes U.S. industrial production and the consumer price index (both in logarithm), the government bond yields at different maturities (the policy indicator), and the excess bond premium constructed by Gilchrist and Zakrajšek (2012), which is an indicator for refinancing conditions on the secondary corporate bond markets. We then apply Ramey (2016)'s three-step approach to extract the structural monetary policy shocks. In the next step, following Cloyne et al. (2018), we aggregate these surprises at a quarterly frequency and use them as instruments for the Treasury bond yield i_t. Specifically, we estimate the following equation during the period 1990Q1-2012Q4 using an instrumental variable approach:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \beta^h i_t + \sum_{p=1}^{n} \gamma^h X_{j,t-p} + \varepsilon_{j,t+h}. \quad (4)$$

As any other instrumental variable framework, additionally to the exogeneity condition (i.e., the external instrument must be uncorrelated with the other structural shocks), the instrument must satisfy the relevance condition, and namely, it should be contemporaneously and highly correlated with the instrumented variable. Following Gertler and Karadi (2015), we test different combinations of policy indicators (three and six-month government bond yields

[27] Using FOMC-frequency data and regressing these financial surprises on all Greenbook variables that Romer and Romer used to create their shocks, Ramey (2016) found that these surprises are predicted by Greenbook projections.

as well as one/two/three/five/seven/ten-year government bond yields) and instruments (six/nine-month and one-year ahead on three-month Eurodollar deposits, current/one/two-month Fed funds futures). Based on the F-test of the joint model (the F-statistic on the first stage) and the Stock and Yogo (2005) critical values, we chose the combinations that pass the weak instrument test.[28]

Figure 3 shows the evolution of the structural shocks from the proxy-SVAR over the sample period and compare it with the shock identified through the narrative approach and the changes in the Federal funds rate. Figure 4 presents the results obtained using the two-year government bond yield as a policy indicator and surprises in the three-month ahead futures as an instrument.[29] The results confirm that exogenous U.S. monetary policy tightening leads to a statistically and economically significant decline in cross-border bank lending. The pattern of the impulse response is very similar to the one found using the exogenous shocks from a narrative approach.

Robustness checks

In this section, we further test the robustness of our baseline findings to various sensitivity tests: (i) including domestic control variables, (ii) using different lag length selections, (iii) using an alternative way of computing standard errors, and (iv) controlling for time-varying country-pair variables such as bilateral trade flows. To save space, the results from robustness checks are reported in the appendix.

First, since our measures of monetary policy shocks are exogenous, we do not control for any other macroeconomic variables in the U.S. economy in the baseline analysis. Indeed as shown in Panel A in Figure A.6 in the appendix, the inclusion of additional control variables (U.S. real GDP growth, inflation rate, and stock returns) does not result in any material changes in the estimated impulse response functions.

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[28] Note that Stock and Yogo (2005) recommend a threshold higher than 10 for the F-statistic from the first-stage regression.

[29] The results are robust to a lager set of non-weak instruments and treasuries yield combinations as well as restricting the sample to 2008Q4.

Second, we have used four lags of the dependent variable and the control variables in the baseline analysis. We demonstrate that our findings do not depend critically on the selection of lags. Panel B in Figure A.6 shows that our results hardly change with the selection of eight lags and similar results (available upon request to save space) are obtained for other lags.

Third, while we have clustered standard errors at the time level in the baseline specification, we test the robustness of our findings by clustering standard errors at the recipient country level or at the recipient country-time level. We also compute Driscoll-Kraay standard errors that allow arbitrary correlations of the errors across countries and time. We only report the results from using Driscoll-Kraay standard errors in Panel C in Figure A.6 to save space, but the results obtained using standard errors clustered at the recipient country level and at the recipient country-time level are similar to those clustered at the time-level. In sum, the statistical significance of our findings does not hinge on the way we account for the correlations in the error term.

The use of the recipient country-fixed effects and a recipient country's macroeconomic variables cannot fully control for potential time-varying factors affecting cross-border banking flows at the bilateral level. One obvious candidate for such factors is bilateral trade flows between the U.S. and its counterpart countries. This variable is particularly relevant for the study of international capital flows, as the current account and the financial account are tightly related by the accounting identity. While banking flows correspond to only a subset of total capital flows, therefore mitigating this criticism, we test the robustness of our findings when controlling for bilateral trade flows.[30] We take bilateral trade flow data from the IMF Directions of Trade Statistics. We add the growth of U.S. imports and exports (and their lags) from a country j and re-estimate equation (3). Panel D in Figure A.6 shows that our results are nearly identical when controlling for bilateral trade flows.

Controlling for global financial and liquidity risks

[30] The category "other investment" is the residual in the balance of payment statistics and includes loans, currency and deposits, and trade credits.

We further test whether our findings are robust to controlling for two additional global factors: global financial and liquidity risks. First, given the importance of global financial conditions—often measured by the VIX—in driving the price of risky assets and international capital flows worldwide (Rey, 2013), a natural question is whether our findings are biased due to the omission of this global factor. In this context, Bekaert et al. (2013) find that U.S. monetary policy and the VIX are systematically related. Moreover, the VIX has been recently found to be an important driver of cross-border bank lending regardless of its interpretation as uncertainty, risk aversion, or financial distress (Bruno and Shin, 2015a; Cerutti et al., 2017; Correa et al., 2017; Wang, 2018; Choi and Furceri, 2019). Second, the recent empirical literature has also documented an important role of liquidity shocks in driving cross-border banking flows (Cetorelli and Goldberg, 2011; Cetorelli and Goldberg, 2012; Schnabl, 2012; Correa et al., 2015). Following Correa et al. (2015), we use the Libor-OIS spread—the rate at which banks use lending to one another—to measure liquidity conditions in interbank markets.[31]

To address these issues and compare the importance of U.S. monetary policy shocks in driving cross-border banking flows with that of global financial and liquidity risks, we augment equation (3) with the log level of the VIX (and their four lags) and the level of the Libor-OIS spread (and their four lags), respectively. Figure A.7 in the appendix confirms that the effect of U.S. monetary policy shocks on cross-border bank lending is independent of global financial and liquidity risks.[32]

State-dependency in the international bank lending channel of U.S. monetary policy

There exists vast empirical evidence that the effect of monetary policy shocks on real and financial variables is state-dependent (Weise, 1999; Tenreyro and Thwaites, 2016). Thus, the average response of cross-border bank lending presented in the previous section may mask substantial heterogeneity depending on the underlying economic regime at the time of the

[31] The Libor-OLS spread is calculated as the average, within a quarter, difference between the three-month U.S. dollar Libor and the OIS rate for the Federal funds.

[32] The response of cross-border bank lending to U.S. monetary policy shocks hardly changes when we replace the VIX with U.S. economic policy uncertainty constructed by Baker et al. (2016).

monetary policy shock (expansions vs. recessions). To examine this issue, we estimate the following equation in which the dynamic response is allowed to vary with the state of the economy:

$$y_{j,t+h} - y_{j,t-1} = F(z_t)\left(\alpha_{R,j}^h + \sum_{p=1}^n \gamma_R^h X_{j,t-p} + \beta_R^h MPshock_t\right) +$$

$$(1 - F(z_t))\left(\alpha_{E,j}^h + \sum_{p=1}^n \gamma_E^h X_{j,t-p} + \beta_E^h MPshock_t\right) + \varepsilon_{j,t+h} \quad (5)$$

with $F(z_t) = \frac{exp\,(-\theta z_t)}{1+exp\,(-\theta z_t)}$ and $\theta > 0$,

where z_t is an indicator of the state of the economy normalized to have zero mean and unit variance. The estimated parameters depend on the average behavior of the economy in the historical sample between *t* and *t+h*, given the shock, the initial state, and the control variables.

The parameter estimates on the control variables incorporate the average tendency of the economy evolving between the states. Thus, the estimates incorporate both natural transitions and endogenous transitions from one state to the other that occur in the data. The indicator of the state of the economy is the five-quarter moving average of real GDP growth and $F(z_t)$ is a smooth transition function used to estimate the effect of monetary policy shocks in expansions vs. recessions.[33] We choose $\theta = 1.5$ following Auerbach and Gorodnichencko (2012) so that the economy spends about 20 percent of the time in a recessionary regime.[34] As shown in Figure A.8 in the appendix, the probability of a recession regime we estimate using a smooth transition function captures well the official NBER recession dates.

This approach is equivalent to the smooth transition autoregressive model developed by Granger and Teräsvirta (1993) and has the following advantages. First, compared with a model in which each dependent variable would interact with a measure of the business cycle position, it permits a direct test of whether the effect of monetary policy shocks on cross-border banking flows varies across different regimes. Second, compared with estimating structural VARs for each regime, it allows the effect of monetary policy shocks to change smoothly

[33] The results, available upon request, are similar when considering a measure of output gap.

[34] Our results hardly change when using alternative values of the parameter θ, between 1 and 6.

between recessions and expansions by considering a continuum of states to compute the impulse response functions, thus making the response more stable and precise. Third, we can use the full sample for estimation, which makes our estimates more precise.

The coefficients β_E^h and β_R^h trace the dynamic response to monetary policy shocks when the economy is in expansions and recessions, respectively. Figure 5 presents the dymaic responses during recessions and expansions using both measures of monetary policy shocks. We do not find a meaningful state-dependent effect of monetary policy shocks on cross-border bank lending when using an exogenous monetary policy shock by Coibion (2012), although the response is weaker and less precisely estimated during recessions due to a smaller sample size (top panel). In contrast, the sign of the response of cross-border bank lending to changes in the Federal funds rate differs between expansions and recessions (bottom panel). While an increase in the Federal funds rate is associated with an increase in cross-border banking flows in recessions, the effect is negative in expansions. This difference further suggests an identification issue when using the policy rate itself to measure monetary policy shocks.

The effect of U.S. monetary policy on cross-border banking flows may also depend on the phase of global financial cycles. Global financial cycles fluctuate between the high-uncertainty (or a decrease in global risk aversion—proxied by the VIX) and the low-uncertainty (an increase in global risk aversion) periods. To test this hypothesis, we repeat a similar exercise to the one for the state of the business cycles but identifying global financial risk regimes based on the VIX.[35] Figure 6 shows that the international bank lending channel of U.S. monetary policy tends to be weaker during the high-uncertainty period, suggesting that heightened uncertainty reduces the effectiveness of monetary policy (Aastveit et al., 2017; Castelnuovo and Pellegrino, 2018).

Monetary policy tightening vs. easing

The effect of monetary policy on economic activity is found to be larger for monetary policy tightening than easing (Cover, 1992; Tenreyro and Thwaites, 2016). To test for a similar

[35] Consistent with the previous exercise, we calibrate the parameters so that the U.S. economy spends about 20 percent of the time in a high-uncertainty period.

asymmetry on its effects on cross-border banking flows, we estimate the following specification:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \beta_+^h D_t MPshock_t + \beta_-^h (1 - D_t) MPshock_t + \sum_{p=1}^{n} \gamma^h X_{j,t-p} + \varepsilon_{j,t+h}, \quad (6)$$

where D_t is a dummy variable that takes a value of one for monetary policy tightening and zero otherwise, and β_+^h and β_-^h capture the effect of a monetary tightening and easing, respectively. The results presented in the top panel of Figure A.9 in the appendix do not point to a significant evidence of asymmetric effects of monetary policy shocks on cross-border bank lending in this case.

While the previous exercise implicitly assumes that the occurrence of monetary policy tightening and easing does not depend on the underlying state of the business cycles, it is likely that easing (tightening) is more common during recessions (expansions). Thus, we consider the underlying state of the business cycles and the type of shocks jointly. The bottom panel in Figure A.9 in the appendix compares the effect of monetary tightening during expansions with that of monetary easing during recessions. If anything, monetary policy tightening during expansions seems to have a more persistent effect than monetary easing during recessions.

International transmission of monetary policy through the lens of Mundellian Trilemma

The increasing spillover effect of U.S. monetary policy and the importance of global financial cycles put the mighty Mundellian trilemma—which establishes the impossibility of the coexistence of a fixed exchange rate, free capital movements, and independent monetary policy—into a question and invoke heated debates regarding its relevance. On the one hand, Rey (2013) and Miranda-Agrippino and Rey (2015) claim that the floating exchange rate regime does not insulate a country from cross-border spillovers anymore. On the other hand, Aizenman et al. (2016) argue that trilemma policy arrangements, including exchange rate flexibility, continue to affect the sensitivity of recipient countries to policy changes and shocks in the center economies.[36] To further shed light on this debate, we expand equation (3) as follows:

$$y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \beta_1^h D_{j,t} M\ Pshock\ _t + \beta_2^h (1 - D_{j,t}) M\ Pshock\ _t + \sum_{p=1}^{n} \gamma^h X_{j,t-p} + \varepsilon_{j,t+h}, \quad (7)$$

where $D_{j,t}$ is an indicator variable regarding the trilemma status of each recipient country j in time t and $X_{j,t}$ includes the four lags of $D_{j,t}$ in addition to the previous control variables.

As emphasized by Dedola et al. (2017), to the extent that the exchange rate regime or capital account openness varies over time, using the time-invariant characteristics—a common practice in VAR studies—could bias the results toward finding less stark difference driven by monetary policy shocks across country groups. In this case, the results in Rey (2013) and Miranda-Agrippino and Rey (2015) might be driven by a lack of statistical power to reject the dilemma hypothesis, rather than the ineffectiveness of a floating exchange rate regime in mitigating cross-border spillovers. Our local projections provide a fresh look on this debate in the literature since they allow the individual country' trilemma characteristics change over time, thereby reducing potential measurement errors plagued in the previous studies using VARs, such as Canova (2005), Miranda-Agrippino and Rey (2015), Dedola et al. (2017).

We use the trilemma index constructed by Aizenman et al. (2013) to test how the Mundellian trilemma characterizes the degree of spillovers of U.S. monetary policy through the international bank lending channel. Their index quantifies the degree of achievement along the three dimensions of the trilemma hypothesis: exchange rate stability, monetary policy independence, and financial openness, thereby providing a comprehensive and consistent overview of an individual recipient country's trilemma status. Here, we describe each of the three indices only briefly. See Aizenman et al. (2013) for further details about the construction of the index and some caveats in its interpretation.

In principle, annual standard deviations of the monthly exchange rate between the home country and the base country are calculated to measure exchange rate stability and the index is

[36] In a related study, Han and Wei (2018) provide some reconciling evidence that the role of a recipient country's exchange rate regime, thereby the relevance of trilemma, depends on the sign of monetary policy shocks in the center countries.

normalized between zero and one.[37] The extent of monetary independence is measured as the reciprocal of the annual correlation of the monthly money market rates between the home country and the base country and normalized between zero and one. We use the updated version of the Chinn-Ito index (KAOPEN) to measure capital account openness (Chinn and Ito, 2008). Since KAOPEN is based upon reported restrictions, it is necessarily a de jure index of capital account openness.[38] Since a recipient country fixed effect will absorb any time-invariant recipient country characteristic in our specification, it is important to note that what we identify is the within variation in the time-varying trilemma index.

Figure 7 reports the results from the first exercise and show that the effect of U.S. monetary policy shocks on cross-border bank lending does not significantly vary with the exchange rate regime and the degree of capital account openness. Consistent with Rey (2013) and Miranda-Agrippino and Rey (2015), the floating exchange rate regime does not insulate a country from cross-border spillovers of U.S. monetary policy shocks (as shown in panel A).[39] Although capital controls seem to moderate the spillovers, the difference between the two regimes is not statistically different (panel B). The only meaningful difference between the regime emerges when monetary policy independence is considered. Panel C shows that the

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[37] The base country is defined as the country that a home country's monetary policy is most closely linked with as in Shambaugh (2004). Since we are interested in the cross-border spillovers of U.S. monetary policy shocks, we use its base country's value with respect to the U.S. when the base country of a sample country is not the U.S. For example, since Belgium's base country is Germany, the Belgian exchange rate regime is floating vis-à-vis the U.S., although it is pegged to Germany.

[38] This index is a widely-used *de facto* measure of the country's capital controls and available back to 1970 for a large group of countries. We focus on the KAOPEN measure of capital controls in Chinn and Ito (2008), updated in July 2017. KAOPEN is based on the four binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions: (i) capital account openness; (ii) current account openness; (iii) the stringency of requirements for the repatriation and/or surrender of export proceeds; and (iv) the existence of multiple exchange rates for capital account transactions. KAOPEN index's main merit is that it attempts to measure the intensity of capital controls insofar as the intensity is correlated with the existence of other restrictions on international transactions.

[39] We also use the updated version of binary regime classification by Shambaugh (2004) to sort out *de facto* pegged and floating exchange rate regimes for robustness checks. We use the most basic measure of the exchange rate regime employed in Shambaugh (2004). In Shambaugh's classification, a country is classified as pegged if its official nominal exchange rate stays within ±2 percentage bands over the course of the year against the base country. Non-pegs are also assigned a base determined by the country they peg to when they are pegging at other times in the sample. The floating regime does not necessarily include pure floats only but includes all sorts of non-pegged regimes. Probably due to the binary nature, we find even less stark difference in this case.

spillover tends to be stronger when the recipient country maintains monetary policy independence (i.e., not increasing the interest rate in response to U.S. monetary policy tightening).

The insignificant difference across the exchange rate regime and the degree of capital controls might be driven by the high correlation between the two. Financial market development may lead a country to become more prepared to adopt greater exchange rate flexibility (i.e., abandoning peg) and open its capital markets to international investors. Indeed, the correlation between the average exchange rate stability index and the capital openness index is -0.54 (p-value of 0.005). Such a strong negative relationship is evidence of the so-called "binding" trilemma (Aizenman et al., 2013) and suggests that ignoring the mutual dependence would bias the estimation results.

Thanks to the flexibility provided by local projections, we can consider the effect of the exchange rate regime and capital account openness jointly. To sharpen the identification of the trilemma, we construct a two-by-two regime based on the interaction between the exchange rate stability index and capital account openness index. Figure 8 shows that monetary policy spillovers tend to be the strongest in countries with a fixed exchange rate regime *and* open capital accounts than others. If anything, the spillover is close to zero over all horizons for a recipient country with a floating exchange rate regime *and* closed capital account. Despite the large standard errors due to a decrease in the effective sample size in each regime, this finding corroborates the theoretical prediction of the trilemma. Thus, our findings somewhat reconcile the contrasting evidence regarding the dilemma vs. trilemma debate in the recent literature.

International risk-taking channel of U.S. monetary policy: advanced vs. emerging market economies

In this section, we further investigate the international risk-taking channel of U.S. monetary policy by utilizing the heterogeneity in a pool of foreign borrowers. Consistent with the domestic risk-taking channel of monetary policy (Borio and Zhu, 2012; Dell'Ariccia et al., 2017), there has been empirical evidence supporting this channel in the cross-border spillover context. For example, Temesvary et al. (2017) find that cross-border lending of U.S. global banks toward low-income countries is more sensitive to U.S. monetary tightening using U.S.

bank-level data. Using detailed loan-level data, Bräuning and Ivashina (2018) find that borrowers from emerging market economies experience a greater increase (decrease) in the volume of loans issued by foreign banks than do borrowers from advanced economies over a U.S. monetary easing (tightening) cycle. Using syndicated loan-level data, Lee et al. (2018) also find that loans extended toward borrowers in emerging market economies are riskier than those in advanced economies and lenders in the global syndicated loan market tend to extend riskier loans in response to U.S. monetary easing.

To test such an international risk-taking channel of U.S. monetary policy, we estimate the effect of U.S. monetary policy shocks on cross-border bank lending toward borrowers in advanced and emerging market economies, separately. However, advanced and emerging market economies are different in many other dimensions in addition to the riskiness in their portfolios. For example, as discussed in the previous section, there is a strong correlation between income status and the exchange rate regime and capital account openness, which also affect the cross-border spillover effect of monetary policy. Moreover, changes in the exchange rate regime and capital account openness are endogenous to domestic/external economic conditions. For this reason, we condition our analysis of the group of recipient countries that are never pegged to the U.S. during the sample period. Figure 9 summarizes the results. Consistent with the risk-taking channel of monetary policy, cross-border bank lending toward risky borrowers (emerging market economies) is more sensitive to U.S. monetary policy shocks compared to lending toward safer borrowers (advanced economies).[40]

C. International Bank Lending Channel of Monetary Policy in other Advanced Economies

So far, we have focused on the international bank lending channel of U.S. monetary policy given the dominance of the U.S. economy and dollars in shaping the international financial system. However, a natural question is whether we can generalize the U.S. results to

[40] We also test whether there is an asymmetry in cross-border lending toward borrowers in euro vs. non-euro area in response to U.S. monetary policy shocks. Figure A.10 in the appendix shows that the spillover tends to be stronger toward euro-area borrowers.

other systematically important advanced economies. Despite its paramount importance in policy making, the existing studies have not reached a consensus on this issue.

For example, Correa et al. (2017) find that monetary policy tightening—identified by an increase in the policy rate—in a panel of 29 (mostly advanced) economies induces an increase in cross-border bank lending toward recipient countries during the similar sample period to our study and propose the portfolio rebalancing channel as an alternative explanation. Other studies document an asymmetric effect on cross-border lending of monetary policy between the U.S. and other countries. For example, Avdjiev et al. (2018) find that while U.S. monetary easing fuels cross-border lending in U.S. dollars, a monetary tightening in other lender countries increases international dollar lending, as global banks turn to U.S. dollars for cheaper funding and toward borrowers abroad.

To shed light on this issue, we extend equation (3) to incorporate the bilateral panel structure of the data as follows:

$$y_{i,j,t+h} - y_{i,j,t-1} = \alpha_{i,j}^{h} + \alpha_{j,t}^{h} + \beta^{h} MPshock_{i,t} + \sum_{p=1}^{n} \gamma^{h} X_{i,j,t-p} + \varepsilon_{i,j,t+h}, \qquad (8)$$

where i and j indi1cate the reporting ('source') and counterparty ('recipient') countries, respectively; $y_{i,j,t}$ is the log of cross-border lending from global banks located in a country i to borrowers in countries j in time t; $\alpha_{i,j}^{h}$ is a source-recipient fixed effect; $\alpha_{j,t}^{h}$ is a recipient-time fixed effect; $MPshock_{i,t}$ is the measure of exogenous monetary policy shocks in a country i described earlier; $X_{i,j,t}$ is a set of control variables, including four lags of the dependent variable and of the monetary policy shocks.

Equation (8) is estimated using the bilateral cross-border banking data between the eight source countries with the available data on exogenous monetary policy shocks (Canada, Germany, Italy, Japan, Netherlands, Spain, Sweden, and the U.K.) and their (maximum of) 45 recipient countries from 2001Q1 to 2012Q4. A shorter time span of the other advanced economy data compared to the analysis of the U.S. monetary policy is compensated by a larger cross-sectional dimension of the data. The identification strategy in equation (8) relies on the existence of bank lending from multiple source countries to one given recipient country at a given point in time, which resembles the identification strategy in Cetorelli and Goldberg

(2011) that extends the firm-level empirical setup in Khwaja and Mian (2008) to the country level. The advantages of having a bilateral panel dataset in our context are threefold.

First, it mitigates concerns about reverse causality. While it is difficult to identify causal effects of country-specific shocks using aggregate capital flows, it is much more likely that domestic monetary policy shocks in a country i affect cross-border bank lending toward a particular country j than the other way around.

Second, the inclusion of the country-pair fixed effects $\alpha_{i,j}^{h}$ allows us to control for any unobserved time-invariant characteristic between two countries, such as a set of gravity factors widely used in the trade literature.[41] More importantly, the inclusion of recipient country-time fixed effects allows us to control for any macroeconomic shocks affecting recipient countries, including external and idiosyncratic recipient-specific shocks as well as the indirect impact of monetary tightening through other recipient countries. Thus, we no longer need to control for domestic macroeconomic variables in the recipient country and global factors, such as the VIX or Libor-OIS spread. Together with the exogenous nature of monetary policy shocks in each lender country, the inclusion of these two-way fixed effects gives a clean identification of the international bank lending channel of monetary policy, largely immune to endogeneity issues.

Third, the inclusion of recipient country-time fixed effects allows us to maximize the sample coverage of our analysis because some recipient countries might not have sufficient time-series data on some of the control variables.

Baseline results

Figure 10 shows the response of cross-border lending to the exogenous monetary policy shocks in the eight advanced economies for which the exogenous monetary policy shocks are available. To demonstrate the importance of using exogenous monetary policy shocks in identifying the international bank lending channel of monetary policy, we also present the results using changes in the policy rate as a measure of monetary policy shocks. Consistent

[41] The inclusion of $\alpha_{i,j}^{h}$ is more flexible than controlling for any set of common time-invariant regressors, as those commonly used in the Gravity model of international finance and controls simultaneously for any time-invariant characteristics specific to a country i and a country j, respectively.

with the U.S. evidence, we do not find any effect of monetary policy actions when using changes in the policy rate, whereas we find negative and significant effects of an exogenous monetary tightening on cross-border bank lending.

A one percent point exogenous tightening in monetary policy leads to an about 5 percent decline in cross-border bank lending after one year and the decline reaches 10 percent after two years, suggesting that the cross-border bank lending channel of monetary policy is not only statistically but also economically significant for other systemically important economies. While these findings are in sharp contrast to those in Correa at al. (2017) and Avdjiev et al. (2018), they further demonstrate that the identification of the causal effect of monetary policy on cross-border banking flows hinges on separating the exogenous component in policy rates from the endogenous response to changes in the economic environment.

Robustness checks and additional exercises

As for the U.S. analysis, we conduct various robustness checks and additional exercises to confirm the validity of our findings. First, while we use monetary policy shocks identified using forecast data in the eight small open economies, countries in the euro area are subject to the same policy rate. To address this issue, we repeat our exercise after dropping the euro area countries other than Germany from the sample. Second, the inclusion of the two-way fixed effects in equation (8) does not control for economic conditions in lender countries that might affect cross-border bank lending simultaneously. To confirm the exogeneity of the identified monetary policy shocks and disentangle their effect from other confounding factors, we control for domestic macroeconomic variables (real GDP growth, inflation, stock returns, and the growth rate of the exchange rate vis-à-vis the U.S.) in the eight lender countries. Figure A.11 in the appendix confirms that the results are robust to these alternative specifications.

We further conduct the following sensitivity tests: (i) alternative standard error clustering; (ii) including more lags; and (iii) controlling for bilateral trade flows. Our findings are largely unaffected by these alternative specifications, and the results are available upon request. We test whether the spillover effect of monetary policy is asymmetric between the low-uncertainty and the high-uncertainty periods. Consistent with the evidence from the spillover effect of U.S. monetary policy shocks in the previous section, the results tend to be stronger during the former, further suggesting a monetary policy ineffective in the presence of heightened uncertainty (Figure A.12 in the appendix).

Lastly, given the central role of European banks in shaping global banking flows (Cetorelli and Goldberg, 2011; Ivashina et al., 2015), an interesting question is whether the international bank lending channel of monetary policy in the euro area operates differently toward borrowers in the euro and non-euro area. A common monetary policy framework and currency in the euro area might weaken the cross-border effect of monetary policy shocks. To answer this question, we conduct a subsample analysis for cross-border bank lending from euro area countries to (i) euro area countries and (ii) non-euro area countries. If anything, the results suggest a stronger spillover toward the non-euro area economies, which is somewhat different from the case of U.S. monetary policy shocks (Figure A.13 in the appendix). Taken together, they suggest that the spillover of monetary policy shock through cross-border bank lending is somewhat mitigated in the common currency area.

IV. CONCLUSION

We examine the international bank lending channel of monetary policy by employing exogenous changes in the policy rate in systemically important advanced economies, including the U.S. We estimate the dynamic effect of monetary policy shocks on cross-border bank lending using the local projection method. The results suggest that exogenous monetary policy tightening in systemically-important advanced economies leads to an economically and statistically significant decline in cross-border bank lending, suggesting that the bank lending channel is still potent in the international setup, suggesting that global banks cannot fully substitute drained domestic reserves and deposits with an alternative source of foreign funding after monetary tightening. These results sharply contrast with the evidence presented in the previous studies using similar data but relying on imperfect measures of exogenous monetary policy actions, thereby echoing Ramey (2016), which emphasizes the importance of distinguishing exogenous surprises from the endogenous response in monetary policy stance when evaluating the effect of monetary policy.

When jointly estimated with measures of global financial risks or liquidity risks, U.S. monetary policy shocks still have a significant effect on cross-border bank lending, implying that U.S. monetary policy is an independent source of the so-called "global financial cycles." This finding is important since demand factors for cross-border bank lending are already controlled in our empirical framework so that our findings provide a conservative estimate on the size of the spillover effect of U.S. monetary policy shocks. We also find that the international bank lending channel of monetary policy tends to be stronger during the low-uncertainty than the high-uncertainty periods. Moreover, cross-border bank lending in response to monetary policy actions is more sensitive when lending toward riskier borrowers in emerging market economies compared to advanced economies, consistent with the risk-taking channel of monetary policy.

In contrast, no clear-cut evidence emerges on the ability of capital controls and floating exchange rate regimes in reducing the cross-border spillover effect of monetary policy when they are considered separately. However, Aizenman et al. (2013) emphasize the binding trilemma hypothesis in which each of the three dimensions along the trilemma is negatively related. When the exchange rate regime and capital account openness are jointly considered, we find significant spillovers toward countries with a fixed exchange rate regime *and* open capital accounts. Thus, our findings somewhat reconcile the contrasting evidence regarding the dilemma vs. trilemma debate in the recent literature.[42]

Stretching somewhat further, we also make some methodological innovation, which is useful for future applied works. The dynamic estimation framework of local projections applied to the bilateral dataset allows for estimating impulse response functions, which are familiar for most applied researchers, but difficult to be estimated when using a large bilateral dataset. The impulse response functions we estimate are also consistent with the spirit of earlier works on the domestic bank lending channel of monetary policy using VARs. Our findings suggest that a static estimation framework adopted in the existing studies on the panel dataset may not be adequate to identify the international bank lending channel of monetary policy. To our best knowledge, this paper is one of the first kind to apply such a dynamic estimation

[42] Since the adoption of exchange rate regimes and measures of capital controls are an endogenous decision and certainly correlated with other structural characteristics of the economy, the evidence found in this paper is only suggestive and it calls for more careful analysis for future research.

framework to a large international bilateral dataset, thereby advancing an econometric framework for empirical researchers.

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Tables and figures

Table 1. List of countries in the final sample

Recipient countries	=1 if advanced economy	=1 if euro area	=1 if fully pegged	=1 if capital account is fully open	=1 if monetary policy is fully independent
Argentina	0	0	0.66	0.44	0.41
Australia	1	0	0.27	0.81	0.35
Austria	1	1	0.27	0.96	0.38
Belgium	1	1	0.27	0.96	0.38
Brazil	0	0	0.29	0.25	0.58
Bulgaria	0	0	0.26	0.50	0.33
Canada*	1	0	0.37	1.00	0.34
Chile	0	0	0.33	0.49	0.46
China	0	0	0.87	0.14	0.45
Colombia	0	0	0.38	0.25	0.55
Czech Republic	1	0	0.27	0.81	0.30
Denmark	1	0	0.27	0.99	0.38
Finland	1	1	0.27	0.96	0.38
France	1	1	0.27	0.94	0.38
Germany*	1	1	0.27	1.00	0.38
Greece	1	1	0.27	0.73	0.38
Hungary	0	0	0.27	0.61	0.36
India	0	0	0.49	0.17	0.42
Indonesia	0	0	0.43	0.77	0.40
Israel	1	0	0.35	0.65	0.50
Italy*	1	1	0.27	0.94	0.38
Japan	1	0	0.27	0.99	0.38
Korea	1	0	0.38	0.41	0.44
Lithuania	0	0	0.29	0.94	0.28
Malaysia	0	0	0.56	0.54	0.45
Mexico	0	0	0.36	0.63	0.47
Netherlands*	1	1	0.27	1.00	0.38
New Zealand	1	0	0.27	1.00	0.35
Norway	1	0	0.27	0.87	0.38
Pakistan	0	0	0.59	0.16	0.48
Peru	0	0	0.43	0.87	0.43
Philippines	0	0	0.38	0.40	0.48
Poland	0	0	0.26	0.29	0.36
Portugal	1	1	0.27	0.90	0.38
Romania	0	0	0.25	0.47	0.48
Russia	0	0	0.40	0.38	0.61
Slovak Republic	1	1	0.29	0.44	0.18
South Africa	0	0	0.26	0.17	0.56
Spain*	1	1	0.27	0.88	0.38
Sweden*	1	0	0.27	0.93	0.38
Thailand	0	0	0.45	0.36	0.39
Turkey	0	0	0.27	0.29	0.50
U.K.*	1	0	0.27	1.00	0.38
U.S.*	1	0	0.00	1.00	0.00
Venezuela	0	0	0.58	0.39	0.51

Note: We compute the time-series average of the status regarding the exchange rate regime, capital account openness, and monetary policy independence. A country with “*” denotes that it is also a source country where monetary policy shocks are originated in the second part of the analysis.

Table 2. Total cross-border claims and liabilities as a share of GDP

	Total cross-border claims as a share of GDP	Total cross-border liabilities as a share of GDP
Canada	88.99	66.26
Germany	289.92	130.79
Italy	101.95	127.21
Japan	162.92	72.29
Netherlands	524.19	469.70
Spain	135.20	171.35
Sweden	278.91	169.49
U.K.	643.95	379.29
U.S.	63.55	49.65

Note: Total cross-border claims and liabilities as a share of the domestic GDP in 2010Q4 under locational banking statistics with the residency principle.

Table 3. Summary of exogenous monetary policy shocks in 9 OECD countries: 2001Q1-2012Q4

Source country	Standard deviation	Correlation with U.S. monetary policy shocks (Furceri et al., 2018)	Correlation with U.S. monetary policy shocks (Coibion, 2012)
Canada	0.215	0.592	0.441
Germany	0.169	0.120	0.098
Italy	0.238	0.076	-0.004
Japan	0.065	0.211	-0.101
Netherlands	0.192	0.181	0.069
Spain	0.198	0.011	-0.071
Sweden	0.184	0.107	-0.026
U.K.	0.231	0.160	-0.041
U.S.	0.341	1.000	0.619

Note: The quarterly exogenous monetary policy shock series are constructed following Furceri et al. (2018).

Table 4. Baseline estimation results from a dynamic framework

	h=0	h=1	h=2	h=3	h=4	h=5	h=6	h=7
Log cross-border claims (-1)	-19.219***	-21.519***	-30.160***	-26.235***	-29.294***	-36.463***	-34.726***	-28.889***
	(2.773)	(2.570)	(3.422)	(2.923)	(3.301)	(3.579)	(2.973)	(3.562)
Monetary policy shock	-3.090	-11.131***	-10.799**	-8.668*	-3.762	-1.076	-3.501	0.405
	(3.583)	(4.177)	(4.351)	(4.366)	(5.978)	(5.690)	(7.481)	(5.855)
Monetary policy shock (-1)	-5.499	1.027	4.895	10.244*	6.827	4.681	11.595	13.019**
	(3.308)	(4.031)	(4.827)	(5.599)	(6.769)	(6.932)	(7.456)	(6.082)
Recipient GDP growth	0.712*	0.354	0.672	1.085	0.768	1.420	1.558	0.423
	(0.411)	(0.618)	(0.684)	(0.835)	(0.832)	(0.954)	(1.026)	(1.067)
Recipient GDP growth (-1)	-0.154	0.324	0.267	-0.104	0.680	0.650	-0.173	0.474
	(0.435)	(0.515)	(0.689)	(0.691)	(0.847)	(0.978)	(1.006)	(0.963)
Recipient interest rate	0.053	-0.002	-0.189	0.139	-0.128	-0.125	-0.226	-0.350
	(0.108)	(0.131)	(0.216)	(0.168)	(0.187)	(0.209)	(0.233)	(0.258)
Recipient interest rate (-1)	-0.110	-0.248	0.202	-0.314*	0.120	0.003	0.064	-0.114
	(0.137)	(0.156)	(0.183)	(0.179)	(0.214)	(0.240)	(0.285)	(0.298)
Recipient exchange rate	-0.217**	-0.369**	-0.456***	-0.695***	-0.435**	-0.366	-0.497**	-0.651***
	(0.096)	(0.147)	(0.146)	(0.169)	(0.206)	(0.223)	(0.220)	(0.246)
Recipient exchange rate (-1)	-0.192*	-0.131	-0.233*	0.013	-0.019	-0.264	-0.286	-0.221
	(0.101)	(0.129)	(0.135)	(0.175)	(0.201)	(0.204)	(0.225)	(0.238)
Recipient inflation rate	0.473	0.317	0.850	1.252**	0.219	0.554	0.192	0.597
	(0.447)	(0.514)	(0.741)	(0.619)	(0.653)	(0.809)	(0.655)	(0.717)
Recipient inflation rate (-1)	0.350	0.884	0.098	-1.008	-0.232	-0.310	0.649	1.084
	(0.484)	(0.697)	(0.761)	(0.696)	(0.768)	(0.915)	(0.726)	(0.834)
Obs	3,085	3,041	3,001	2,956	2,918	2,880	2,835	2,797
R-squared	0.08	0.10	0.13	0.14	0.15	0.18	0.22	0.22
Recipient country-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

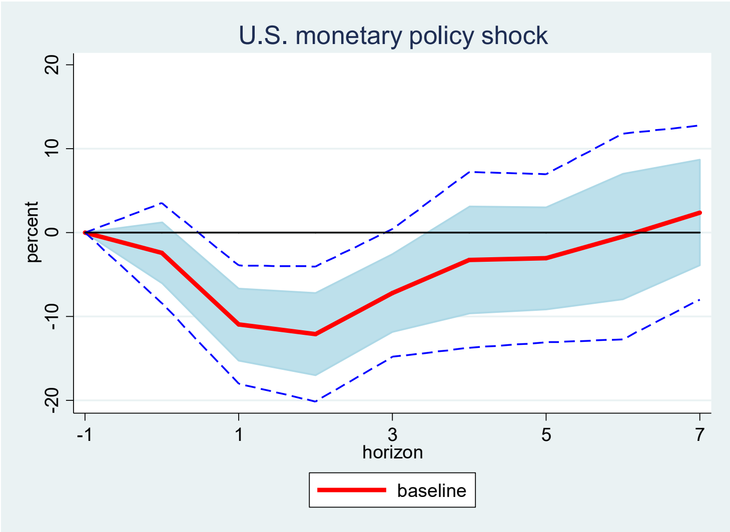
Note: Estimates are based on equation (1). Autocorrelation and heteroskedasticity-consistent standard errors are clustered at the time levels. *** denotes 1% significant level, ** denotes 5% significance level, and * denotes 10% significance level. While we control for the four lags of the variables, we only report the estimation results up to one lag to save space here.

Table 5. Results using a static framework

Independent variables	(I)	(II)	(III)	(IV)	(V)	(VI)
The lagged Federal funds rate	0.707**			0.609**		
	(0.298)			(0.282)		
Changes in the Federal funds rate		0.786			0.826	
		(1.573)			(1.550)	
Monetary policy shock			-0.338			-0.309
			(3.201)			(3.174)
Lagged GDP growth (U.S.)	0.657	0.810	0.997	0.534	0.688	0.882
	(1.429)	(1.556)	(1.521)	(1.423)	(1.545)	(1.511)
Lagged stock returns (U.S.)	0.190	0.169	0.180	0.195	0.175	0.186
	(0.133)	(0.132)	(0.134)	(0.132)	(0.130)	(0.133)
Lagged inflation rate (U.S.)	-3.260	-2.208	-2.420	-3.322	-2.262	-2.485
	(1.961)	(1.818)	(1.854)	(1.911)	(1.760)	(1.794)
Lagged GDP growth (recipient)	-0.570	-0.472	-0.435	-0.346	-0.335	-0.299
	(0.627)	(0.624)	(0.631)	(0.604)	(0.595)	(0.604)
Lagged short-term interest rate (recipient)	0.004	0.072	0.070	0.036	0.078	0.076
	(0.094)	(0.091)	(0.090)	(0.080)	(0.080)	(0.079)
Lagged inflation (recipient)	0.260	0.227	0.219	0.257	0.174	0.166
	(0.449)	(0.455)	(0.456)	(0.404)	(0.408)	(0.408)
Lagged exchange rate growth (recipient)	-0.370***	-0.344**	-0.336**	-0.371***	-0.345**	-0.337**
	(0.128)	(0.131)	(0.131)	(0.129)	(0.132)	(0.131)
Obs	3,293	3,293	3,293	3,293	3,293	3,293
R-squared	0.02	0.02	0.02	0.01	0.01	0.01
Recipient country-fixed effect	Yes	Yes	Yes	No	No	No

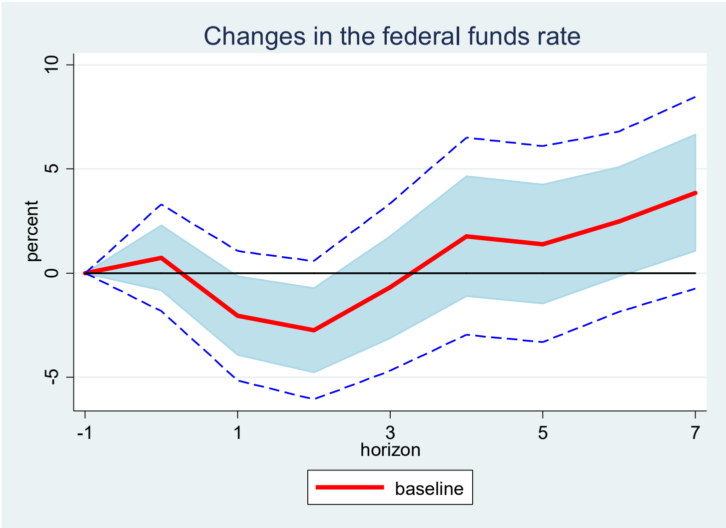
Note: The dependent variables are the growth rate of exchange rate-adjusted U.S. bilateral cross-border claims. The measure of monetary policy shocks is the lagged Federal funds rate in column (I) and (IV), the changes in the Federal funds rate in column (II) and (V), and the exogenous monetary policy shocks from Coibion (2012) in column (III) and (VI). Heteroskedasticity-robust standard errors are clustered at the time levels. *** denotes 1% significant level, ** denotes 5% significance level, and * denotes 10% significance level.

Figure 1. Effect of a U.S. monetary policy shock on cross-border bank lending



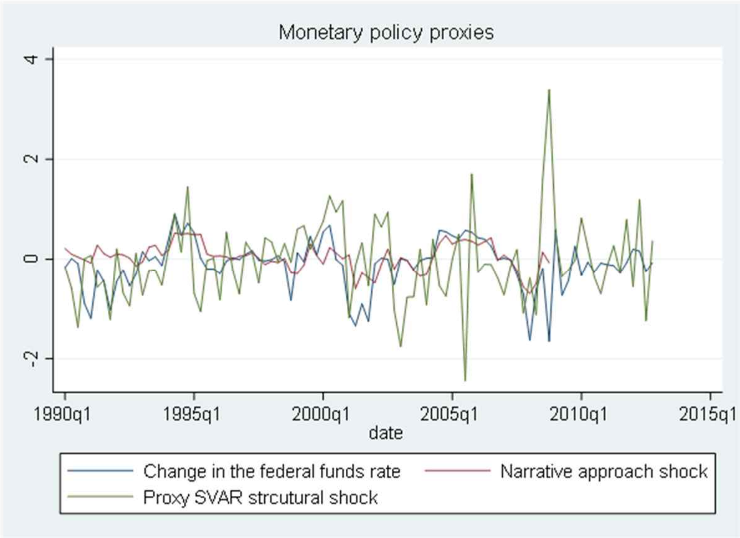
Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 2. Effect of a change in the Federal funds rate on cross-border bank lending



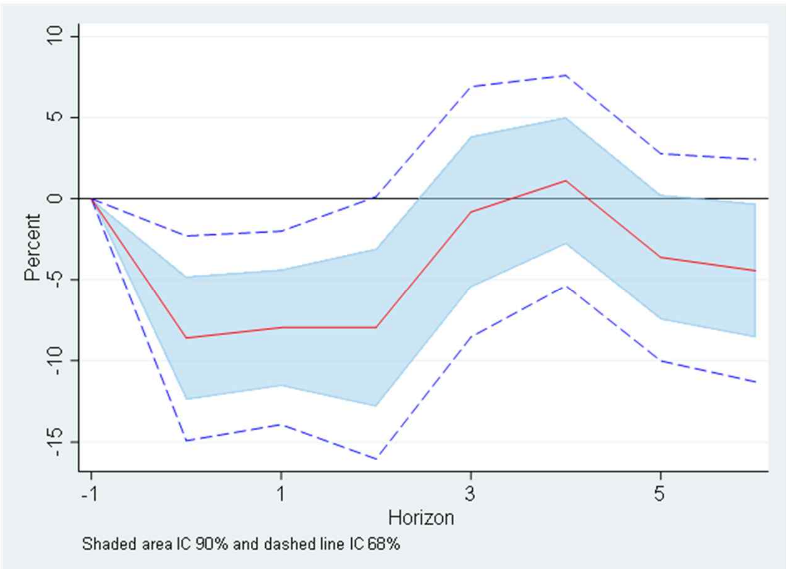
Note: The graph shows the response of cross-border bank lending to a 100 bp increase in the Federal funds rate and their 68% and 90% confidence bands. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 3. U.S. monetary policy shock (narrative approach), U.S. monetary policy shock (proxy-SVAR structural shock), change in the Federal funds rate



Note: Measures of monetary policy changes: changes in the Federal funds rate, narrative shocks identified by Romer and Romer (2004) and Coibion (2012), proxy-SVAR identified shock using two-year treasury yield, instrumented with three-month ahead Fed funds futures.

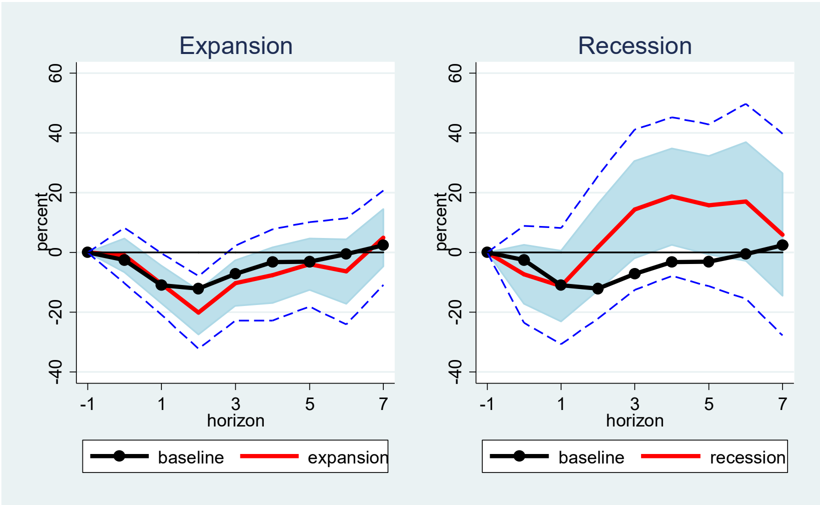
Figure 4. Effect of a U.S. monetary policy shock (proxy-SVAR structural shock) on cross-border bank lending



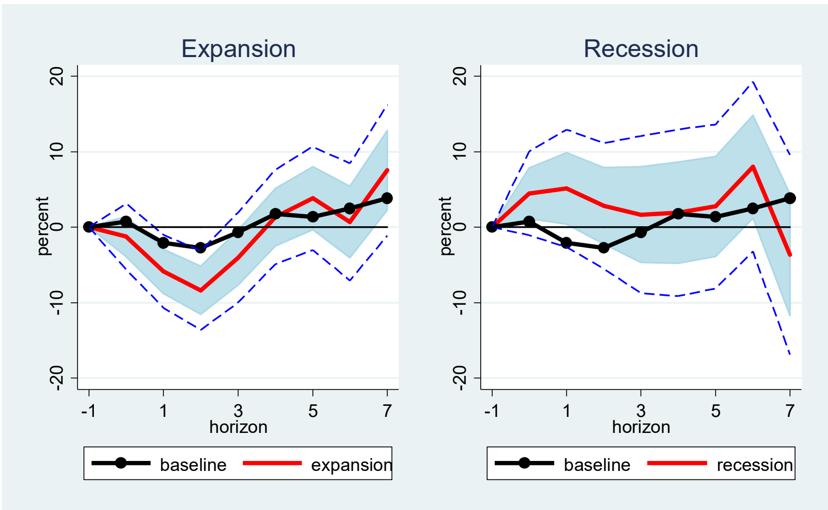
Note: Response of cross-border bank lending to a 100 bp U.S. monetary policy structural shock identified via proxy-SVAR and their 68% and 90% confidence bands. Horizon h=0 captures the impact of the shock, and the units are in percentage.

Figure 5. Effect of a U.S. monetary policy shock on cross-border bank lending: expansions vs. recessions

A) Exogenous monetary policy shocks

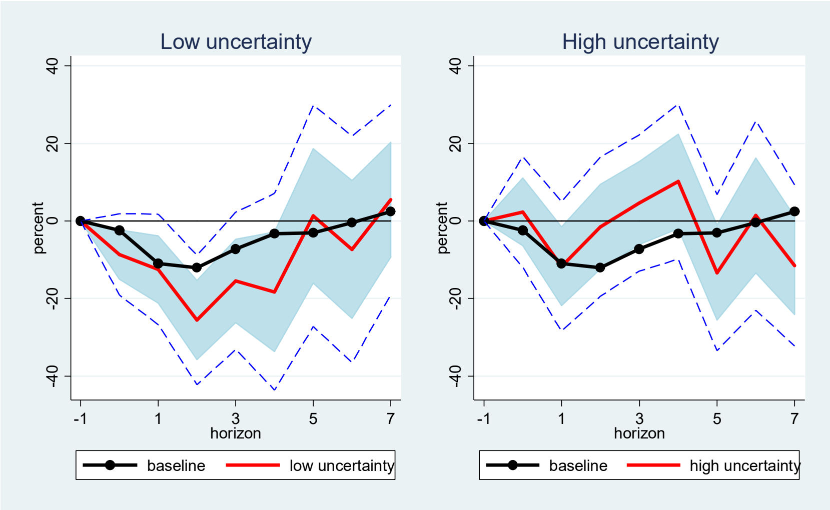


B) Changes in the Federal funds rate



Note: The top panel shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands during expansions (left) and recessions (right). The bottom panel shows the response of cross-border bank lending to a 100 bp increase in the Federal funds rate and their 68% and 90% confidence bands during expansions (left) and recessions (right). Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

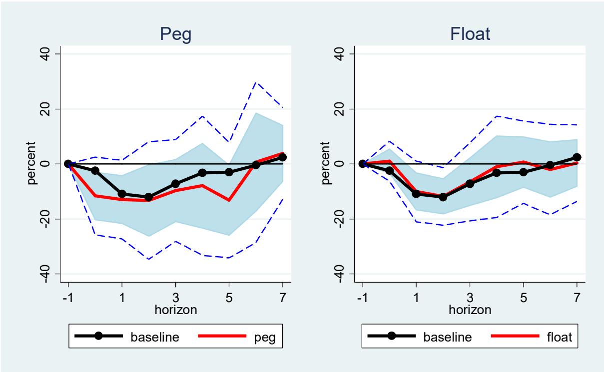
Figure 6. Effect of a U.S. monetary policy shock on cross-border bank lending: low uncertainty vs. high-uncertainty periods



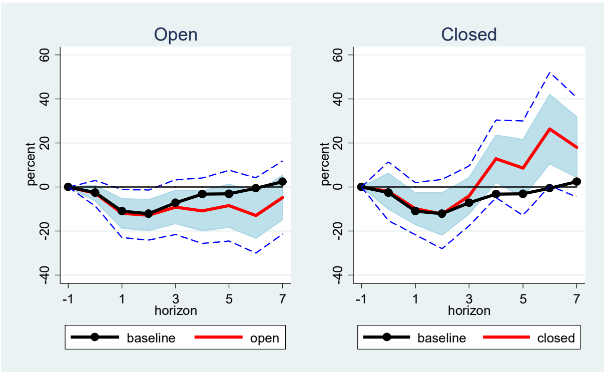
Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands during low-uncertainty (left panel) and high-uncertainty (right panel) periods using the exogenous monetary policy shocks. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 7. Effect of a U.S. monetary policy shock on cross-border bank lending through the lens of Mundellian trilemma

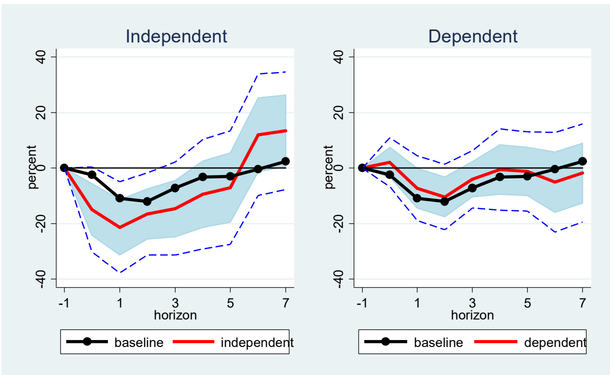
A) Exchange rate regime



B) Capital account openness

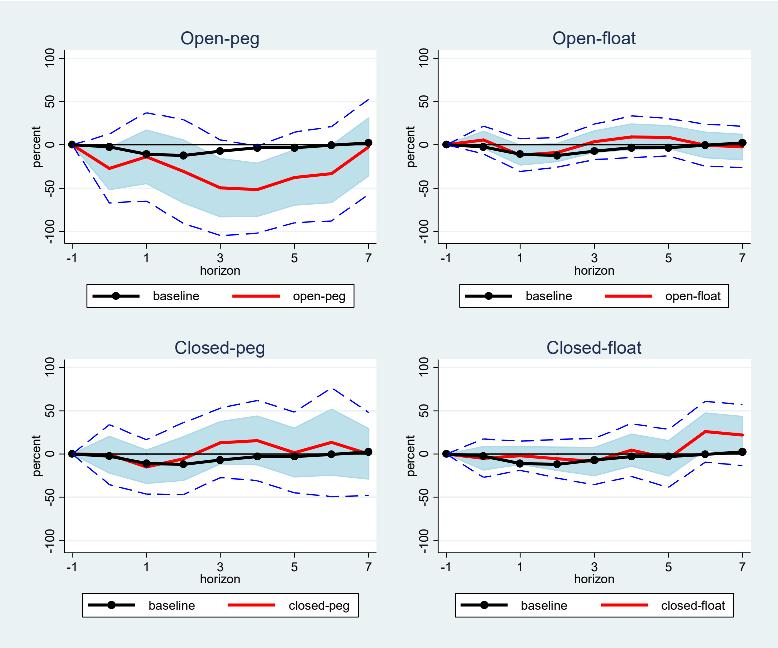


B) Monetary policy independence



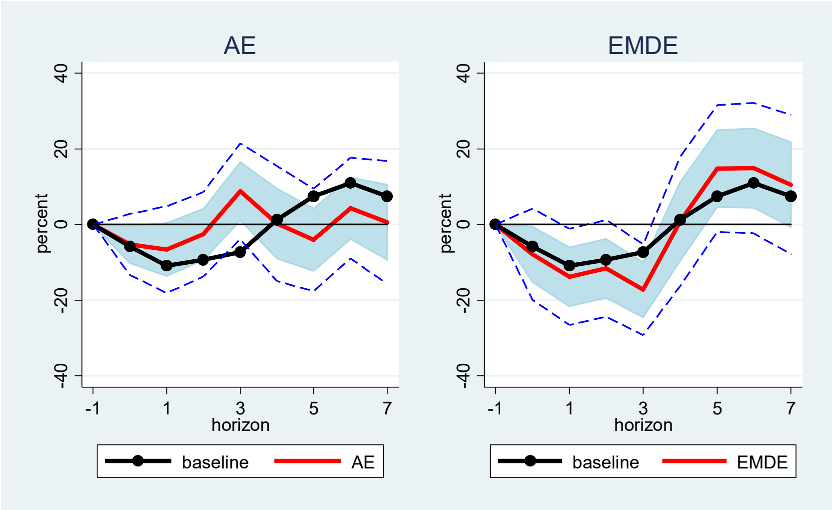
Note: The graph shows the response of cross-border bank lending to 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 8. Effect of a U.S. monetary policy shock on cross-border bank lending using the two-by-two regimes



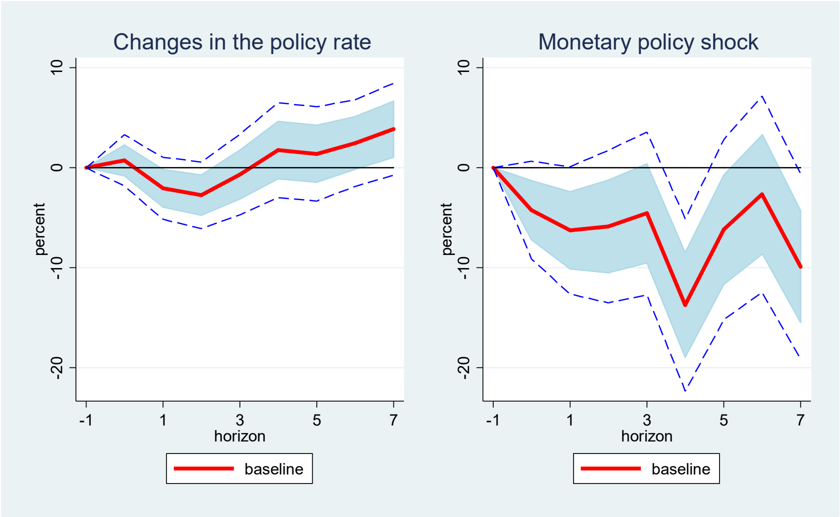
Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 9. Effect of a U.S. monetary policy shock on cross-border bank lending: borrowers in advanced vs. emerging market economies



Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. The left (right) panel shows the response of cross-border bank lending to borrowers in advanced (emerging market) economies. The recipient countries used in this analysis are never pegged to the U.S. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure 10. Effect of a monetary policy shock on cross-border bank lending from eight OECD countries



Note: The graph shows the response of cross-border bank lending to a 100 bp change in the policy rate and their 68% and 90% confidence bands (left) and monetary policy shock (right) in the eight OECD countries. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

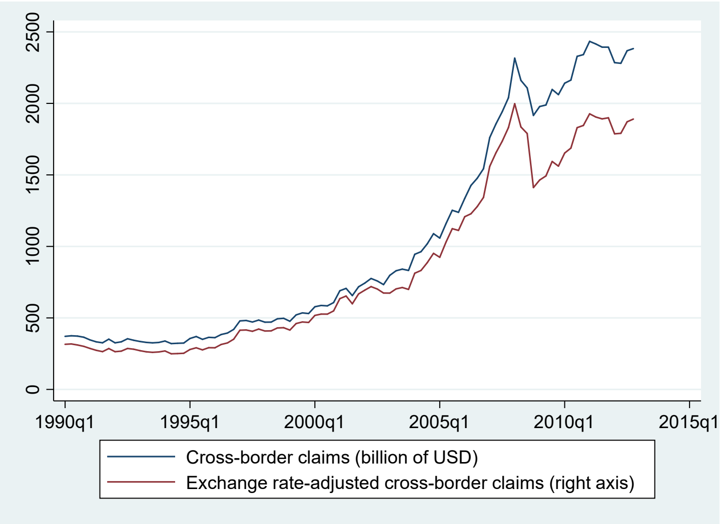
Appendix A. Additional Figures and Tables

Table A.1. Data availability on cross-border flows in the BIS International Banking Statistics

	Nationality of lending bank	Residence of borrowers	Currency composition
Consolidated banking statistics	Yes	Yes	No
Locational banking statistics			
by residence	No	Yes	Yes
by nationality	Yes	No	Yes
stage 1 data	Yes	Yes	Yes

Note: This table is reproduced from Table 1 in Avdjiev and Takáts (2014). In addition to exchange rate fluctuations, the quarterly flows in the locational datasets are corrected for breaks in the reporting population. The BIS consolidated banking statistics group claims according to the nationality of banks (i.e., according to the location of banks' headquarters), netting out inter-office positions. The BIS locational banking statistics define creditors and debtors according to their residence, consistently with national accounts and balance of payments principles. The Stage 1 enhanced data are the first consistent data set to provide all three dimensions at the same time, but the construction of comprehensive time series data is still in progress.

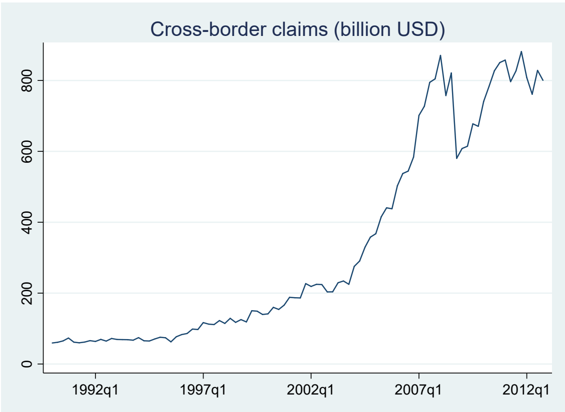
Figure A.1. Total U.S. cross-border bank claims: raw stock vs. exchange rate-adjusted stock



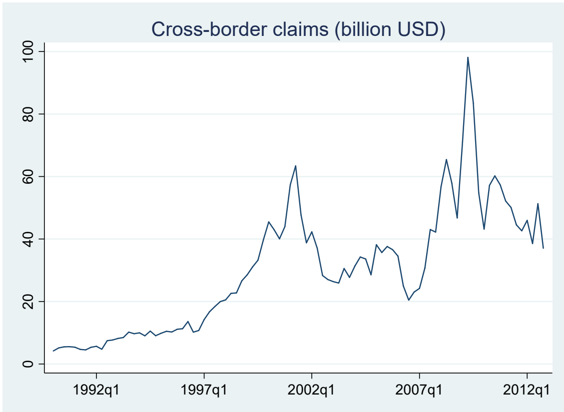
Note: The graph shows total U.S. cross-border bank claims (both exchange rate-unadjusted and adjusted) from 1990Q1 to 2012Q4.

Figure A.2. Exchange-rate adjusted U.S. cross-border bank claims to individual countries

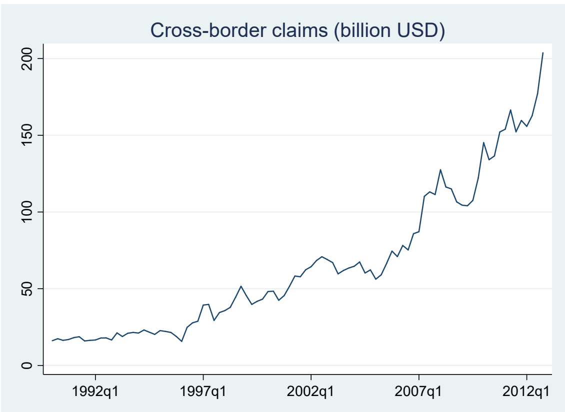
a) country A



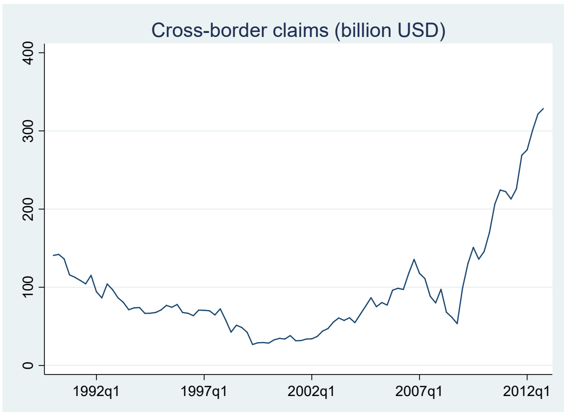
b) country B



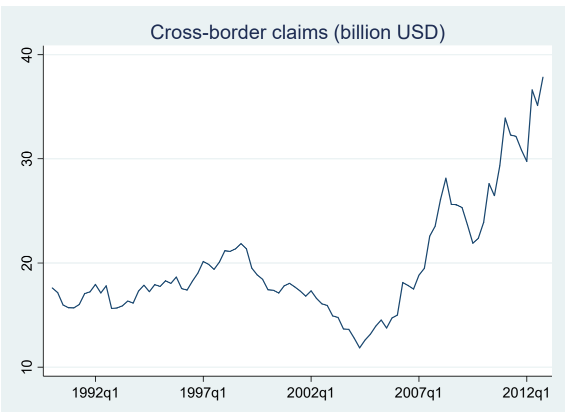
c) country C



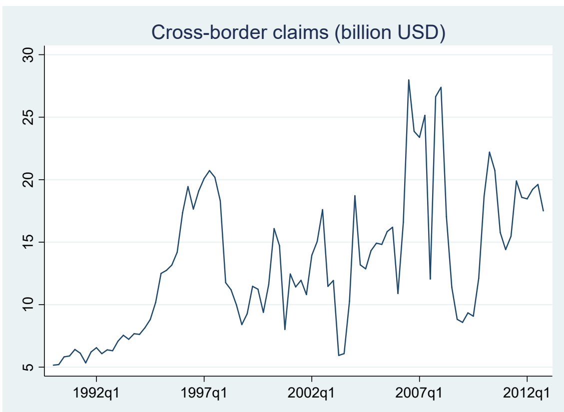
d) country D



e) country E

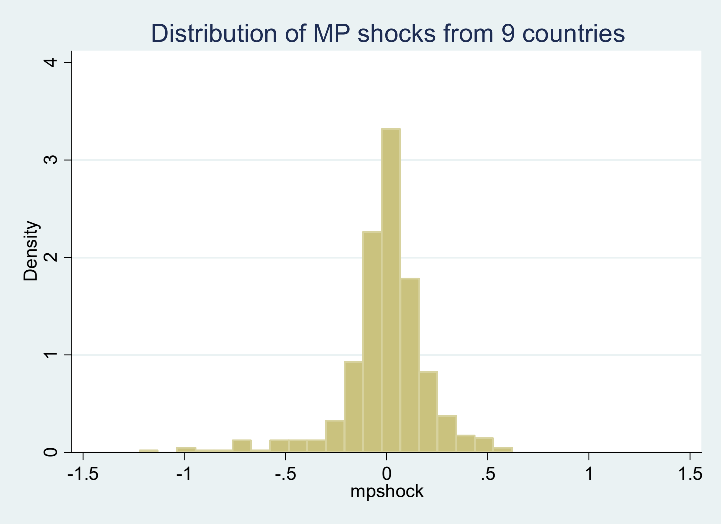


f) country F



Note: Each graph shows bilateral exchange rate-adjusted cross-border claims between the U.S. and the corresponding recipient country from 1990Q1 to 2012Q4.

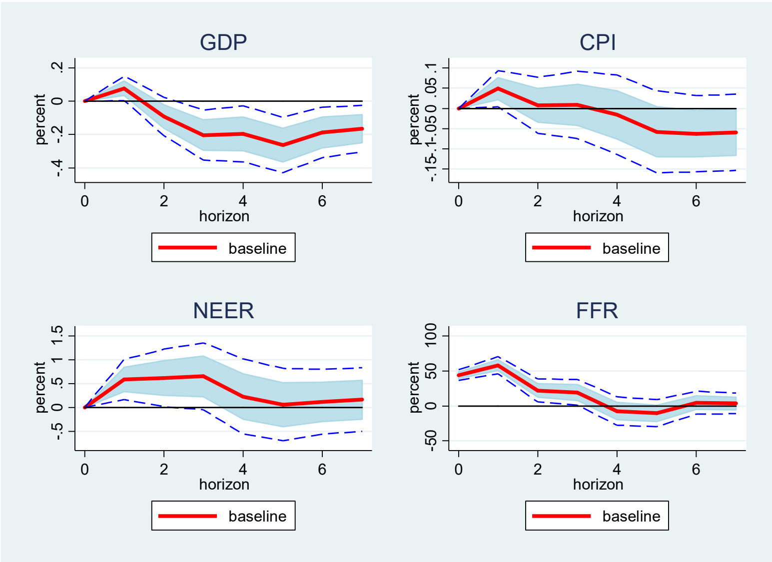
Figure A.3. Distribution of monetary policy shocks in 9 OECD countries (2001Q1-2012Q4)



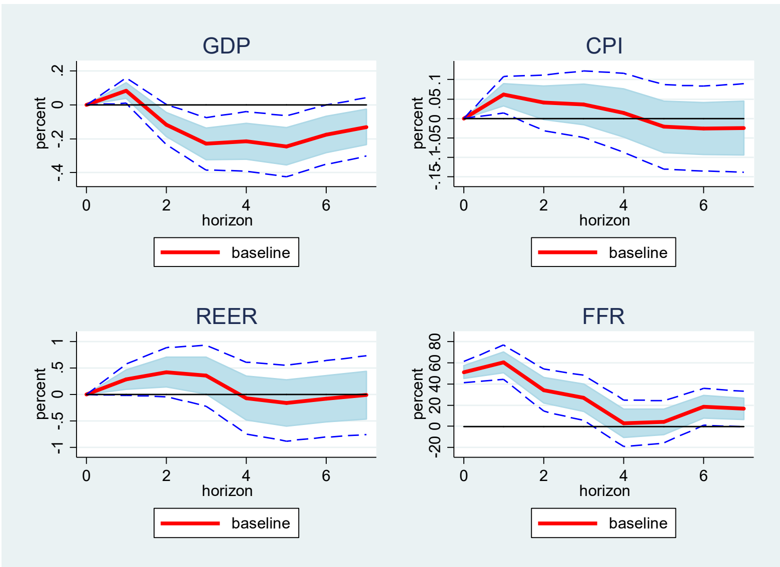
Note: The graph shows the distribution of exogenous monetary policy shocks in the nine OECD countries: Canada, Germany, Italy, Japan, the Netherlands, Spain, Sweden, the U.K, and the U.S. from 2001Q1 to 2012Q4.

Figure A.4. Effect of U.S. monetary policy shocks on domestic variables

A) Using nominal effective exchange rates and the nominal interest rate

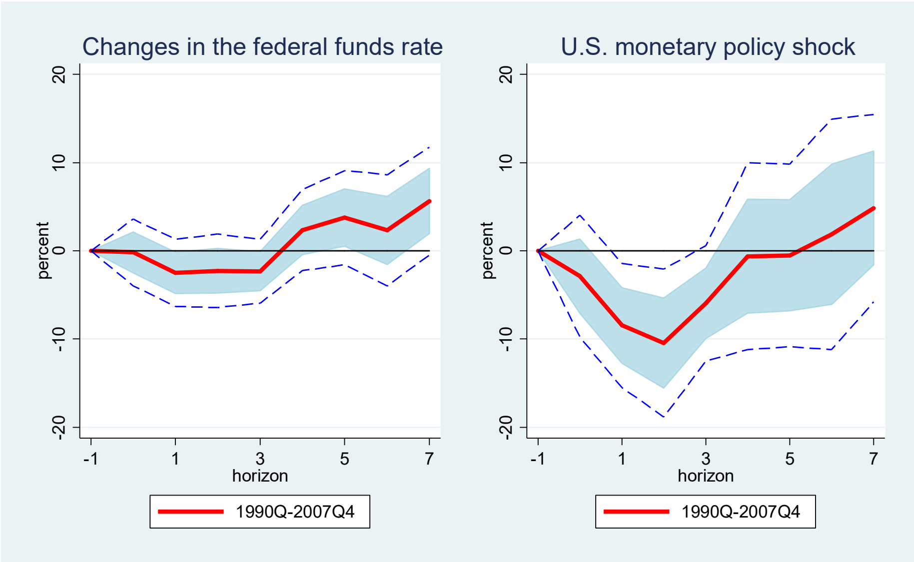


B) Using real effective exchange rates and the real interest rate



Note: The graph shows the response of U.S. domestic variables to the 100 bp exogenous monetary policy shock. Horizon *h*=0 captures the impact of the shock, and the units are in percentage except for the Federal funds rate (in basis points).

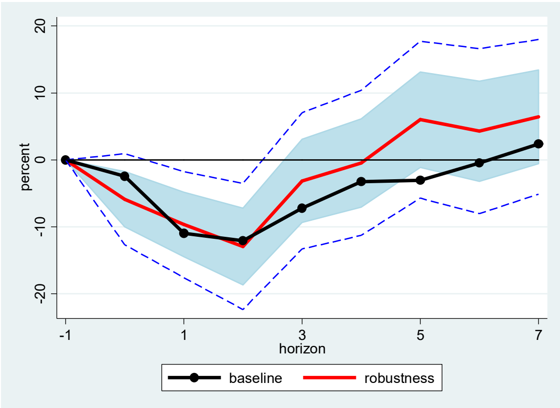
Figure A.5. Effect of a U.S. monetary policy shock on cross-border bank lending (1990Q-2007Q4)



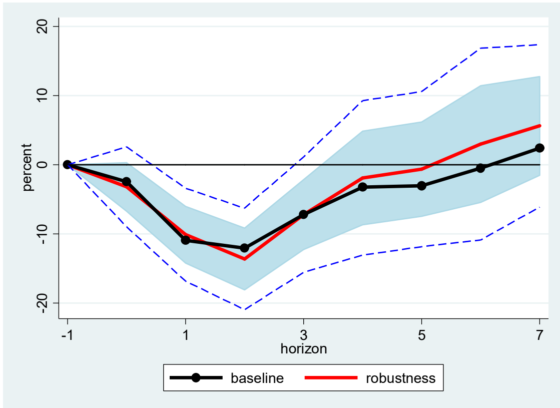
Note: The graph shows the response of cross-border bank lending to a 100 bp increase in the Federal funds rate (left panel) and the U.S. monetary policy shock (right panel) and their 68% and 90% confidence bands when the sample is restricted to 2007Q4. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure A.6. Effect of a U.S. monetary policy shock on cross-border bank lending: robustness checks

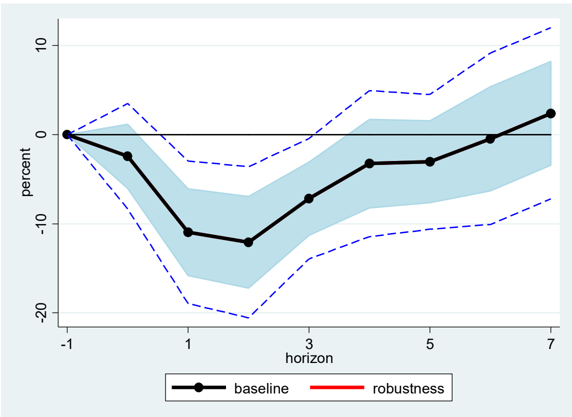
A) Controlling for domestic variables



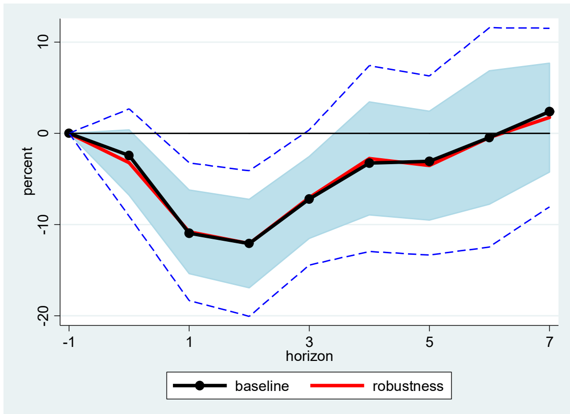
B) Using eight lags



C) Driscoll-Kraay standard errors

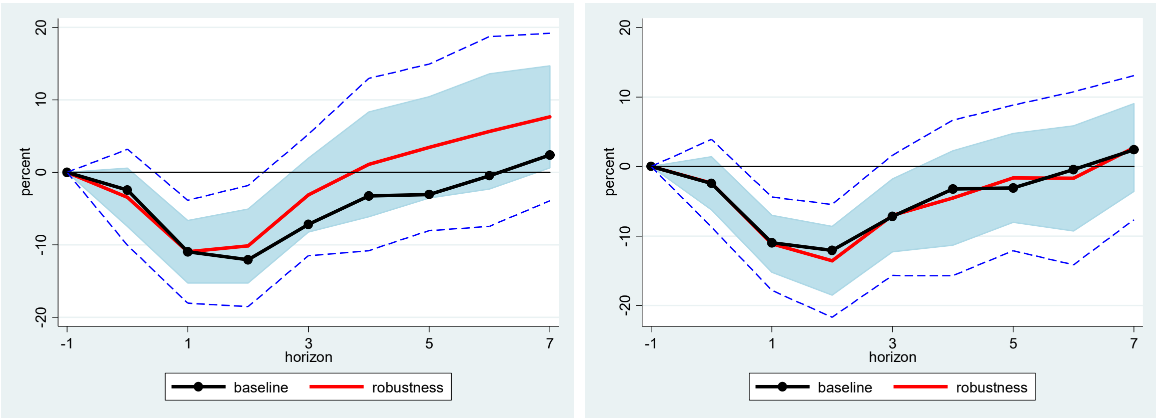


D) Controlling for bilateral trade flows



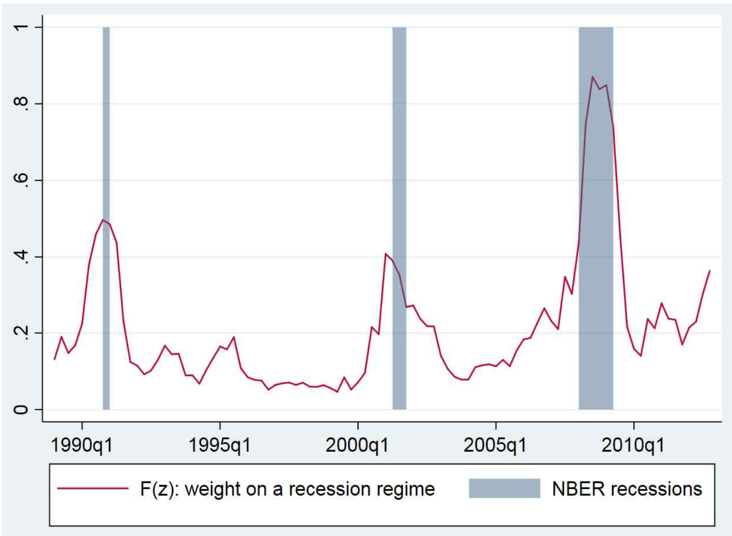
Note: Each panel shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. Horizon h=0 captures the impact of the shock, and the units are in percentage.

Figure A.7. Effect of a U.S. monetary policy shock on cross-border bank lending: controlling for global financial risks (left) and liquidity risks (right)



Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands after controlling for global financial risks (left panel) and liquidity risks (right panel). Horizon h=0 captures the impact of the shock, and the units are in percentage.

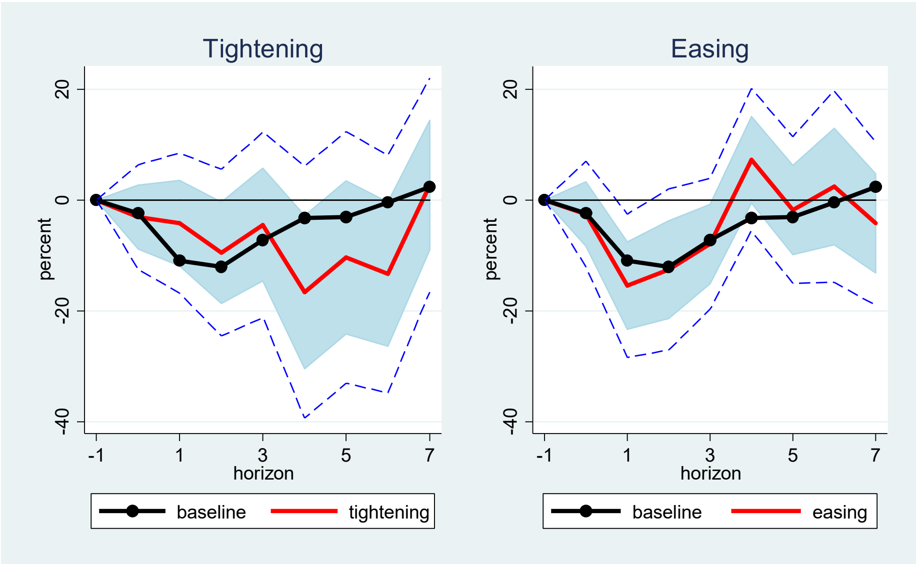
Figure A.8. NBER recession dates and the weight on a recession regime



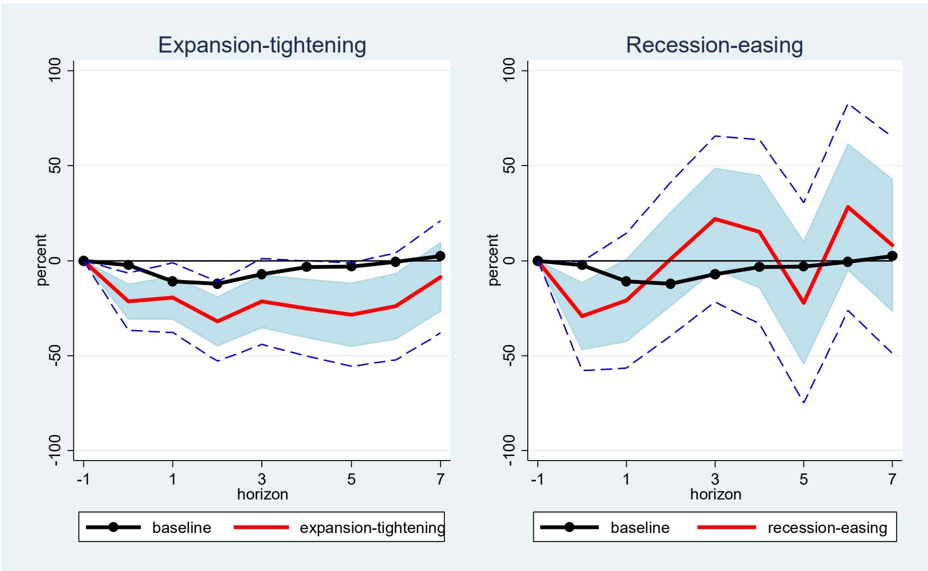
Note: The shaded areas indicate NBER recessions, while the red solid line denotes the weight on a recession regime.

Figure A.9. Non-linear effect of a U.S. monetary policy shock on cross-border bank lending

A) Tightening vs. easing

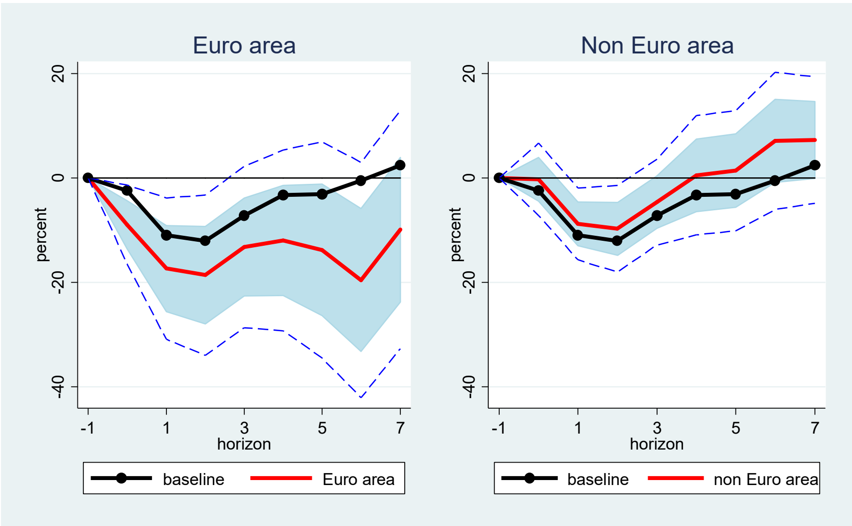


B) Tightening during expansions vs. easing during recessions



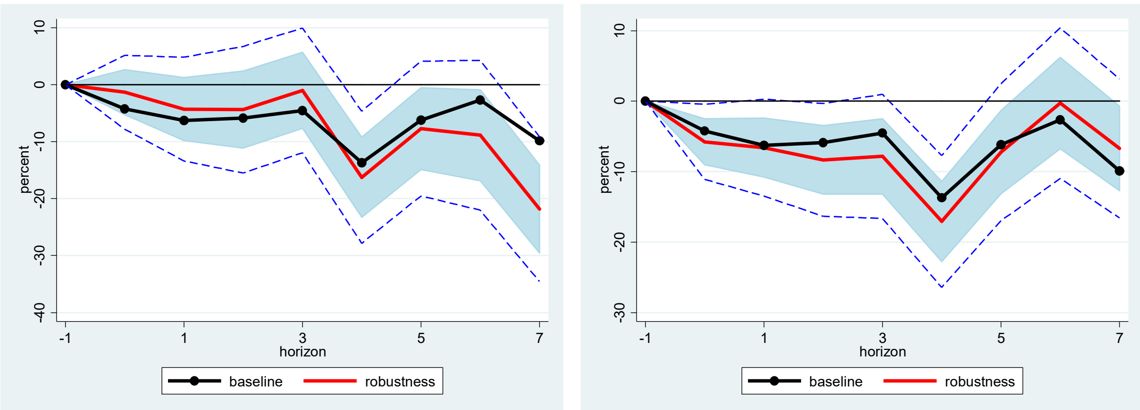
Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock of tightening (left) and easing (right) and their 68% and 90% confidence bands in the top panel and of tightening during expansions (left) and easing during recessions (right) in the bottom panel. Horizon h=0 captures the impact of the shock, and the units are in percentage.

Figure A.10. Effect of a U.S. monetary policy shock on cross-border bank lending: borrowers in euro vs. non-euro area countries



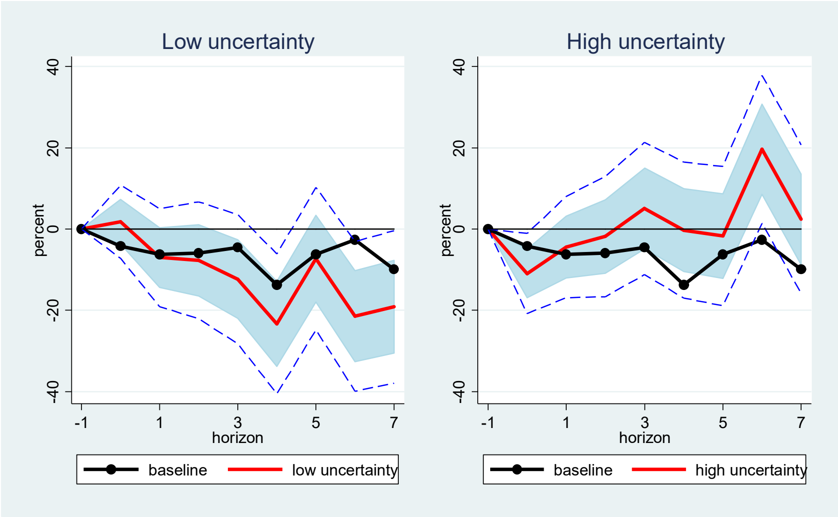
Note: The graph shows the response of cross-border bank lending to a 100 bp U.S. monetary policy shock and their 68% and 90% confidence bands. The left (right) panel shows the response of cross-border bank lending to borrowers in euro (non-euro) area countries. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure A.11. Effect of a monetary policy shock on cross-border bank lending from eight OECD countries: excluding other euro area countries (left) and controlling for domestic controls (right)



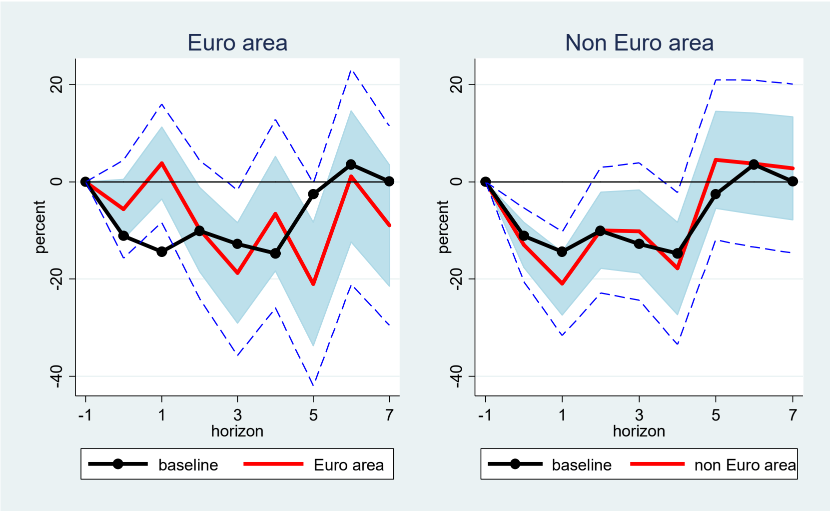
Note: The graph shows the response of cross-border bank lending to a 100 bp monetary policy shock and their 68% and 90% confidence bands in the eight OECD countries. The left panel corresponds to the case where the euro area countries other than Germany (Italy, the Netherlands, and Spain) are dropped, while the right panel corresponds to the case where additional domestic control variables are included. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure A.12. Effect of a monetary policy shock on cross-border bank lending from eight OECD countries: low-uncertainty vs. high-uncertainty periods



Note: The graph shows the response of cross-border bank lending to a 100 bp monetary policy shock and their 68% and 90% confidence bands in the eight OECD countries during the low-uncertainty (left panel) and high-uncertainty (right panel) periods using the exogenous monetary policy shocks. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.

Figure A.13. Effect of a monetary policy shock on cross-border bank lending from the four euro-area countries: borrowers in euro vs. non-euro area countries



Note: The graph shows the response of cross-border bank lending to a 100 bp monetary policy shock and their 68% and 90% confidence bands in the four euro-area countries. The left (right) panel shows the response of cross-border bank lending to borrowers in euro (non-euro) area countries. Horizon *h*=0 captures the impact of the shock, and the units are in percentage.