



International spillovers from US monetary policy: Evidence from Asian bank-level data[☆]

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ABSTRACT

We investigate spillovers from US monetary policy to bank lending in Asia. When Asian banks use funding denominated in US dollars and other currencies, a tightening of US monetary policy will contract bank loan supply via funding volumes/costs. Panel regressions demonstrate such effects on bank lending volumes and prices in Asia, holding constant local economic conditions. Supplementary results are consistent with transmission channels via funding conditions. Our results extend work on the impact of US monetary policy on international inter-bank funding flows and are consistent with several implications from findings in that literature.

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1. Introduction

International spillovers from US monetary policy have attracted a lot of research interest given their impact on business cycles and financial conditions in countries linked to the US economy. Traditional textbook channels of international monetary policy transmission include those via trade linkages and pass-through from US interest rates to local interest rates. Recent studies have focused on the role of globalization in the banking sector in generating additional channels for international spillovers from US monetary policy. One strand of research explores the impact of US monetary policy on international flows of inter-bank funding. Bruno and Shin (2015) demonstrate that US monetary policy tightening constrains the flow of funding to the global banking system, while Lee and Bowdler (2020) document a similar finding using a monetary policy shock identification based on the work of Romer and Romer (2004). Using international panel data, Avdjiev and Hale (2019) explore the impact of US monetary policy on foreign funding available to national banking sectors, and show that it varies over time, across Emerging Market and Advanced economies, and according to whether US policy changes are linked to US output and inflation movements. Using US bank-level data, Temesvary et al. (2018) show that the cross-border claims of US financial institutions, which are a source of dollar funding for the rest of the world, vary systematically with US monetary policy. A second and related strand of research focuses on the role of global banks in propagating the monetary policy of the United States and other countries through the lending practices of their foreign subsidiaries, see Cetorelli and Goldberg (2012), Morais et al. (2019) and Correa et al. (2018).

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This paper examines spillovers from US monetary policy to bank lending in 328 banks operating across twelve Asian countries, using annual bank-level micro panel data for the period 2005–2018. For the Asian countries in our analysis (Australia, Hong Kong SAR, Indonesia, India, South Korea, Malaysia, Philippines, Singapore, Chinese Taipei, Cambodia, New Zealand and Thailand), foreign debt accounts for a significant portion of total bank liabilities. According to BIS statistics available for 9 of the 12 countries, at the end of 2018 the share of foreign debt in total bank balance sheet liabilities ranged from 8.4 percent to 69.5 percent (see [Table 1](#)). Furthermore, for those countries for which we have data, the share of US dollar denominated debt in total foreign debt is 50 percent or more in all but one of the cases. Motivated by these observations, our hypothesis is that a tightening of US monetary policy will raise the average funding costs of Asian banks directly and bring about a contraction of their lending volumes and an increase in lending interest rates that operate independently of any knock-on effects of US monetary policy on local monetary policy, e.g. as might arise in the case of a currency peg.

We employ an empirical framework that is standard in the literature on bank lending and monetary policy. In these bank panel regressions lending growth or loan interest rates are explained in terms of monetary policy measures, macro controls such as GDP growth and interactions between monetary policy measures and bank characteristics.¹ In this paper, we estimate models that explain bank lending in Asian countries in terms of both domestic and US monetary policy. Whilst the former control is standard in bank lending regressions, the latter allows for a spillover from US monetary policy to local bank lending that may occur when Asian banks draw part of their funding in US dollars and other global currencies, and are therefore directly dependent on financing costs set in the United States.

In the empirical analysis, our first main result is that transmission of US monetary policy to bank lending in Asian countries is quantitatively important and statistically significant. We find that banks cut loan growth rates by 0.769 percentage points in response to a 1 percentage point increase in the federal funds rate (loan quantity regressions). The figure is approximately one half the impact of domestic monetary policy on bank lending growth. The interest rates charged on commercial bank loans increase by 0.052 percentage points in response to a 1 percentage point increase in the federal funds rate and this is equivalent to about one eighth of the effect estimated from the same change to domestic monetary policy (loan price regressions). In terms of the bank characteristics that influence the strength of monetary transmission, we find some evidence that less liquid banks reduce lending by more in response to US monetary policy. We also find weak evidence that bigger banks adjust their lending by more in response to US monetary policy, possibly because such banks are more likely to access international capital markets and are therefore more sensitive to global inter-bank funding costs.

In order to probe the mechanism behind our main results we construct a measure of the change to funding costs at each bank, which is a variable through which the impact of US monetary policy on bank lending will be mediated under the dollar funding hypothesis. In supplementary regressions we show that after a rise in the US federal funds rate, funding costs increase. Furthermore, when our core loan price regression is augmented with the funding costs measure in order to ‘turn off’ the transmission channel that we emphasise, we find that the impact of US monetary policy on Asian bank lending is reduced. Taken together, these findings are consistent with an explanation of our core results in which rises in US monetary policy interest rates tighten dollar funding conditions in global capital markets, constraining overall funding supply to Asian banks, and hence reduce lending quantities and increase lending interest rates. At the same time, we recognise that our evidence is not conclusive, e.g. there may exist some separate channels through which tight US monetary policy reduces Asian bank lending. In Section 4 we discuss this issue and consider the alternative transmission channels that may account for our results.

In the final part of Section 4 we investigate three important forms of heterogeneity in the impact of US monetary policy on international bank funding flows as suggested in [Avdjiev and Hale \(2019\)](#). Firstly, it is time-varying, with the contractionary effect of higher US interest rates on dollar flows abroad observed in stagnation phases of global capital market cycles, but not in boom phases. However, we do not find evidence consistent with this study. In fact, we find that the impact of US monetary policy on Asian bank lending is stronger, particularly for lending interest rates, in the first half of our sample in which boom phases are more relevant. Secondly, international bank funding flows are more sensitive to movements in US monetary policy that are unrelated to Taylor rule arguments such as US output and inflation. We address this issue through adding US growth and inflation as controls in our core regressions, but do not find statistically significant changes to the impact of US monetary policy on Asian bank lending. Thirdly, the contractionary effects of tighter US monetary on bank funding supply could be larger for Emerging Market economies than for Advanced economies. When we focus on a sub-sample of banks from Emerging Markets in Asia, we find a stronger impact of US monetary policy on loan quantities, but not on loan prices.

Our findings extend the existing literature in two ways. Firstly, we show that the impact of US monetary policy on international flows of bank funding, studied in previous research, extends to bank loan supply in Asia, which is partly financed in US dollars and other major currencies. Secondly, we extend the existing literature on bank lending in Asia, see for instance

¹ It has been found that bank characteristics, such as size, liquidity, equity capital holdings, affiliation with bank holding companies, and affiliation with a global banking network may affect the responsiveness of bank lending to monetary policy rates. For example, see [Kashyap and Stein \(1995\)](#) for bank size and capital structure; see [Kashyap and Stein \(2000\)](#), [Kashyap et al. \(2002\)](#), [Stein \(1998\)](#) for liquidity; see [Peek and Rosengren \(1995\)](#), [Kishan and Opiela \(2000\)](#), [Van den \(2002\)](#) for capitalization; see [Houston and James \(1998\)](#), [Campello \(2002\)](#) for affiliation with a bank holding company; see [Romer and Romer \(1990\)](#) and [Disyatat \(2011\)](#) for noncore liabilities; see [Gambacorta and Marques-Ibanez \(2011\)](#) for riskiness; see [Borio et al. \(2017\)](#) for profitability; See [Cetorelli and Goldberg \(2012\)](#), [Lee and Bowdler \(2019\)](#) for affiliation with a global bank network.

Table 1

Foreign debt in banks' liabilities in selected Asian countries.

Country	Foreign debt ¹⁾	Share in total debt ²⁾	Share of USD debt ³⁾
Australia	701	25.0	50.0
Hong Kong SAR	1,267	41.6	63.5
Indonesia	50	9.6	..
India	183	8.4	21.5
South Korea	248	12.1	68.3
Malaysia	118	16.7	..
Philippines	23	8.5	79.0
Singapore	751	69.5	..
Chinese Taipei	222	12.0	77.7

Notes: 1) The amount of liabilities that the banking sector in each country borrows from international interbank markets. Units: Billions of US dollars. 2) The share of foreign debt in total bank liabilities. Units: Percentage points. 3) The share of US dollar-denominated debt in total foreign debt. Units: Percentage points. Figures relate to the end of 2018. Entry .. indicates data unavailable at the time of writing. Source: BIS Locational banking statistics.

Lee and Bowdler (2019), through providing evidence that US monetary policy is an important driver of loan quantities and loan prices.

The remainder of this paper proceeds as follows. We provide details of the dataset in Section 2. We then present our estimation strategy and core empirical results in Section 3. Section 4 investigates the possible mechanisms behind our main findings, and Section 5 presents a series of robustness tests. Section 6 concludes.

2. Data description

In this section we describe the bank-level dataset that is used in our empirical analysis in Section 3. We use Standard and Poor's Market Intelligence database to construct the annual unbalanced panel data for bank lending and bank characteristics. The Market Intelligence database provides information from individual bank balance sheets and financial statements in a standard format. We only include commercial banks to exclude possible biases arising from different behaviors by entities such as government banks. In our dataset we consider 328 commercial banks from twelve Asian countries observed over the period 2005–18 (the countries are Australia, Cambodia, Hong Kong SAR, India, Indonesia, Korea, Malaysia, New Zealand, the Philippines, Singapore, Chinese Taipei and Thailand). We select the list of countries in the analysis in light of data availability, levels of financial development and openness to capital flows.² Data are at the annual frequency rather than the quarterly frequency due to availability constraints. At the time the data were collected, using quarterly data would have reduced the number of banks in the sample by approximately one half. The key advantage of quarterly data is that we would be able to study the dynamic effects of monetary policy, whereas using annual data we can only estimate the average effect over twelve months. Since in this study we are mainly concerned with the overall extent of any US monetary policy effect on Asian bank lending and the channels through which it may occur, we decided to maximize the number of banks included in the analysis at the expense of being able to observe their lending responses only at the lower, annual frequency.

We now turn to definitions of the bank-level variables used in our analysis. We consider two dependent variables. The first is the real annual growth rate of bank lending. This is measured by deflating nominal loans outstanding at year end in local currency by the consumer price level (CPI), and taking the percentage change of that loan stock. The second dependent variable is a proxy for the change in the real interest rate charged by banks. This is defined as the annual change in the ratio of interest income to total interest earning assets.

Our dataset includes measures of a range of bank characteristics: liquidity, the equity capital ratio, total assets, the riskiness of the bank, the profitability of the bank, and the size of non-core liabilities. These variables are defined as follows. Liquidity is the ratio of liquid assets to total assets. Capitalization is the ratio of equity capital to total assets. Bank size is the log of total assets measured in US dollars. Riskiness is the ratio of the annual loan loss provision to total loans held. Profitability is the ratio of net income to total assets (Return on Average Assets, ROAA). Non-core, or non-deposit, liabilities is the ratio of non-deposit liabilities (defined as total liabilities (excluding equity) minus total deposits) to total liabilities (Brei et al., 2013). These variables have often been considered in empirical investigations of the bank lending channel of monetary policy transmission. For example, small banks with relatively simple funding structures, and banks with less liquid assets and poor capital ratios, cannot effectively find alternative non-deposit funding sources when deposits are drained from the market by central bank actions (Kashyap and Stein, 1995; Kashyap and Stein, 2000; Kashyap et al., 2002; Stein, 1998; Peek and Rosengren, 1995; Kishan and Opiela, 2000 among others). There exist opposing views on the relationship between banks' non-core liabilities and the strength of monetary policy transmission. Structural developments that increase banks' access

² We exclude banks from a number of developing countries in Asia because there exist quite small numbers of observations for such banks. We exclude Japanese banks on the grounds that its monetary policy rate has been at the zero lower bound throughout the sample period, and it has been implementing unconventional monetary policy, which means the best measure of monetary policy is unclear. We also exclude Chinese banks on the grounds that the monetary policy toolkit includes a range of measures such as changes to reserve requirements, so that the measurement of monetary policy is not straightforward (Fungáčová et al., 2016).

to non-deposit sources of funds are seen as mitigating the importance of the bank lending channel (Romer and Romer, 1990). In contrast, greater reliance on market-based funding could enhance the importance of this channel by increasing the sensitivity of banks' funding costs to monetary policy (Disyatat, 2011).

To eliminate the impact of outliers in the regression analysis we order observations according to the growth in real lending volumes and the change to the real interest rate proxy and exclude the top and bottom 1 percent of readings in each case (exclusions based on lending volume changes remove cases of very rapid asset growth due to mergers and similar events). We also exclude the highest and the lowest 1 percent of bank-year observations in the distributions for the six bank characteristics (for the bank size and non-core funding characteristics we considered the distributions of the growth rates of those variables rather than the levels). After these exclusions, we have an unbalanced dataset, consisting of 2,175 bank-year observations for 328 banks, with 315 bank-year observations having been removed. The average time series length across the 328 banks (rounded to the nearest whole year) is 7 years, a figure that varies from a minimum of 4 years for New Zealand banks to a maximum of 9 years for Taiwanese banks. In order to demonstrate that our main results are not dependent on the outlier exclusion procedure, in our robustness section we include regressions estimated using the maximum feasible sample, including all of the outliers excluded from our core results.

Table 2 provides descriptive statistics for the bank lending variables and bank characteristics, for different categories of bank. For the full sample after outlier exclusions, the growth rate of real bank lending averages 6.78 percent per annum, and the real loan interest rate averages 6.28 percent. Liquid assets account for 25.35 percent of total assets. Equity capital is 10.71 percent of total assets. Average total assets is 47.58 billion US dollars. The measure of bank riskiness (loss provisions relative to assets) averages 0.43 percent. Net annual income relative to assets, the profitability measure, averages 0.85 percent. The non-core liabilities ratio averages 17.83 percent. In the lower part of Table 2 we report summary statistics of the dataset for various sample splits based on each of the bank characteristics. Although there are some small differences in loan growth rates and loan interest rates across categories of banks, these are not statistically significant.³

3. Identification strategies and estimation results

This section consists of two sub-sections. In Section 3.1 we measure the responsiveness of bank lending in Asian countries to domestic monetary policy and US monetary policy indicators. In Section 3.2 we investigate how responses to monetary policy depend on bank characteristics.

3.1. Impact of US monetary policy on local bank lending

3.1.1. Identification model

We use Eq. (1) to study the determinants of bank lending in selected Asian countries, either the loan growth rate or the loan interest rate proxy. Our model is similar to the models used by Kashyap and Stein (1995), Kishan and Opiela (2000), Gambacorta (2005), Gambacorta (2008), Lee and Bowdler (2019):

$$\begin{aligned} \Delta l_{ijt} = & \eta + \eta_c I_{crisis} + \sum_{m=1}^2 \gamma_m (\Delta i_t^m \times I_{crisis}) + \sum_{k=1}^K \theta_{ck} (\tilde{X}_{k,ijt-1} \times I_{crisis}) \\ & + \sum_{m=1}^2 \beta_m \Delta i_t^m + \sum_{m=1}^2 \sum_{k=1}^K \beta_{mk} (\Delta i_t^m \times \tilde{X}_{k,ijt-1}) + \sum_{m=1}^2 \sum_{k=1}^K \beta_{cmk} (\Delta i_t^m \times \tilde{X}_{k,ijt-1} \times I_{crisis}) \\ & + \sum_{n=1}^N \kappa_n M_{n,jt} + \sum_{k=1}^K \theta_k \tilde{X}_{k,ijt-1} + f_i + e_{ijt} \end{aligned} \quad (1)$$

where subscript i denotes an individual bank, j denotes one of the twelve countries in which the banks operate, and t denotes a year. Δl_{ijt} denotes a bank lending decision, either the annual growth rate of real bank lending (the lending quantity choice) or the annual change in the proxy for the average real loan interest rate (the lending price choice). Δi_t^m captures domestic monetary policy (MP_{jt}) and US monetary policy indicators (FFR_t). MP_{jt} denotes the change to the monetary policy interest rate (an overnight inter-bank money market rate) in country j , and FFR_t denotes the US monetary policy measure which is the change in the effective federal funds rate (all interest rate concepts are the average rate observed during a particular year). $\tilde{X}_{k,ijt}$ indicates a set of bank characteristics that are demeaned relative to the average value of the characteristic in each country in each year (we will discuss this in detail below). $M_{n,jt}$ is a set of N macroeconomic controls from country j , including GDP growth in that country. I_{crisis} is a dummy variable set to 1 for 2008 and 2009, the years of the global financial crisis, and controls for abnormal movements in lending and other bank level variables during that period. f_i denotes bank fixed-effects.

³ See appendix for correlation coefficients across bank level variables used in the analysis.

Table 2
Descriptive statistics.

	obs.	Loan quantity				Loan rates				Liq.	Cap.	Siz.	Ris.	Prof.	Nonc.
		mean	min	max	s.d.	mean	min	max	s.d.						
(a) Total banks															
All observations	2,175	6.78	−47.6	101.8	12.5	6.28	0.29	23.48	3.93	25.35	10.71	47.58	0.43	0.85	17.83
(b) Banks by six characteristics															
Less liquid	1,227	6.68	−28.8	86.0	10.5	6.12	0.29	23.48	3.96	18.36	10.22	38.66	0.43	0.83	16.94
More liquid	948	6.92	−47.6	101.8	14.7	6.49	0.39	22.15	3.88	34.40	11.34	59.13	0.42	0.88	18.99
Less capitalized	1,380	6.73	−32.3	94.3	10.4	5.96	0.29	23.48	3.87	23.98	8.49	63.66	0.41	0.80	17.43
More capitalized	795	6.87	−47.6	101.8	15.5	6.84	0.57	22.43	3.96	27.73	14.56	19.68	0.45	0.93	18.53
Smaller banks	1,062	6.77	−47.6	101.8	15.1	6.65	0.29	23.48	4.04	26.15	12.11	6.24	0.38	0.69	14.87
Bigger banks	1,113	6.79	−24.0	75.0	9.4	5.93	1.21	22.93	3.79	24.58	9.37	87.04	0.48	1.00	20.66
Less risky	1,379	7.58	−47.6	101.8	13.0	6.24	0.29	21.70	3.79	24.80	10.73	30.99	0.15	0.85	15.79
More risky	796	5.40	−32.7	88.5	11.5	6.36	0.57	23.48	4.16	26.30	10.66	76.33	0.90	0.85	21.37
Less profitable	1,090	6.49	−47.6	101.8	14.3	6.03	0.29	23.48	3.56	24.96	10.23	26.71	0.45	0.45	15.98
More profitable	1,085	7.07	−47.6	74.9	10.4	6.53	0.56	22.93	4.25	25.74	11.18	68.56	0.40	1.26	19.69
Less noncore	1,422	6.27	−37.9	86.1	11.0	6.46	0.61	23.48	3.84	24.62	10.62	29.98	0.40	0.81	9.76
More noncore	753	7.75	−47.6	101.8	14.9	5.93	0.29	22.93	4.07	26.73	10.87	80.84	0.48	0.93	33.07

Notes: Figures are from 2,175 bank-year observations used in the regression analysis. Loan quantity indicates a growth rate of real bank lending volume, and loan rates indicates real loan interest rates, which is the ratio of interest income to total earning assets. Bank level variables are constructed as defined in Section 2, except size of banks, which is expressed in billions US dollars.

Given that our main focus is the transmission of monetary policy to bank lending we highlight two important points pertaining to the measurement of monetary policy and the interpretation of the monetary policy controls. Firstly, the overnight inter-bank loan rate is taken to be the main measure of monetary policy targeted by central banks. In some episodes monetary policy may have targeted overnight lending quantities, as in the early years of the Volcker chairmanship of the US Federal Reserve, but since our sample commences in 2005 these episodes are unlikely to appear in our sample. Secondly, for the period in which the US monetary policy measure, the federal funds rate, is at the zero lower bound, we replace the effective rate with the shadow federal funds rate devised by [Wu and Xia \(2016\)](#). The shadow rate reflects the Fed's additional easing at the lower bound through unconventional policies, and thus can be negative even when the federal funds rate is at zero.⁴

Our regression specification holds constant both local monetary policy conditions and local GDP growth. Such controls capture traditional channels through which US monetary policy may spillover to the Asia region and banking sector activity there. For instance, a common spillover channel arises when Asian countries mimic US interest rate changes in an attempt to minimize the impact of US monetary policy on local currency values and cross-border funding movements, so that US monetary policy impacts the Asia region through forcing a change to local monetary policy conditions. Another textbook spillover channel is that a US policy tightening slows global GDP growth, including that in the Asia region, so that bank lending amongst Asian banks declines with slowing economic activity. Since both local monetary policy interest rates and local GDP growth are held constant in our regressions, any spillover from US monetary policy to Asian bank lending must operate through a separate channel, and we contend that this channel arises from global financial linkages, with Asian banks partly funded in US dollars and other currencies, and therefore subject to a direct increase in financing costs when US short-term interest rates increase. In Section 4 we provide further evidence relevant to the dollar funding cost channel.

$X_{k,ijt}$ consists of bank-level characteristics that may condition the response of lending to monetary policy. As noted in Section 2, these are the degree of liquidity and capitalization, size, riskiness, profitability and the extent of non-core liability funding. The literature suggests that banks that are more liquid, better capitalized and larger in size are better able to access alternative options to finance their loans, and thus would be less responsive to monetary policy shocks. The riskiness of bank loan borrowers and bank profitability are also amongst the controls as these factors may influence the supply of bank loans.

All of the bank characteristics are demeaned with respect to the average value of a bank characteristic measured across all banks in a particular country in a particular year. To be specific, each bank characteristic, $X_{k,ijt}$, as defined in Section 2, is expressed as follows:

$$\tilde{X}_{k,ijt} = X_{k,ijt} - \frac{1}{n_{jt}} \sum_{i=1} X_{k,ijt} \quad (2)$$

where, n_{jt} denotes the number of banks operating in country j in year t . After this normalization, each characteristic $\tilde{X}_{k,ijt}$ now represents a deviation of the corresponding feature of bank i from an average level of banks operating in the same territory j in the specific year t . This adjustment brings about several benefits. First, we can interpret the coefficient on monetary policy indicators as responses of average banks to the monetary policy indicators ([Ehrmann et al., 2001](#); [Gambacorta, 2008](#)), since average banks have characteristic values equal to zero. Second, some of our characteristics such as bank size show trends at the bank level, since the nominal value of a bank's assets can be expected to rise over time due to underlying inflation and growth in real activity. Such characteristics could generate spurious effects through proxying drift or breaks in the magnitude of the monetary policy effect on bank lending. Normalization removes trends through expressing, for instance, the size of a bank as its size relative to other banks operating in the same national market in the same year.

It should also be noted that in order to avoid reverse causation, bank characteristics are lagged by one year relative to the dependent variable. This is standard in the literature. Reverse causation in the effects of the bank characteristics is ruled out under the assumption that bank characteristics do not respond to expected future values of bank lending growth and bank real loan interest rates.

$M_{n,ijt}$ includes macroeconomic controls such as real GDP growth and the unemployment rate. These variables are intended to control for loan demand shifts and to ensure that the estimated effect of monetary policy captures adjustments of bank loan supply.⁵ The motivation for the inclusion of local/domestic macroeconomic variables also draws on our consideration of the possible endogeneity of the domestic monetary policy measure. In our basic regression the monetary policy measure is unlikely to be directly endogenous to the dependent variable, namely bank level lending growth or loan interest rates, because monetary policy is determined in light of aggregate economic conditions rather than the behavior of any single bank. However, it is still possible that aggregate conditions in each country play a part in shaping both individual bank lending and the setting of monetary policy, such that an unconditional relationship between the two arises spuriously. Controlling for aggregate macroeconomic conditions ensures that we consider the conditional relationship between monetary policy and bank lending, which cannot be subject to the same critique. The maintained assumption is that the GDP growth rate and the unemployment rate are the drivers of endogenous monetary policy actions that may correlate with bank lending movements.

We assume that the US monetary policy measure is exogenous, because US monetary policy is not affected by bank lending decisions in individual Asian countries. This is a standard maintained assumption in empirical studies of US monetary

⁴ For example, when the Fed was pursuing quantitative easing, the shadow rate dropped to minus 3 percent through mid-2014.

⁵ In robustness tests we consider other country-level variables that could affect bank lending. These include price inflation, the exchange rate and two indicators that represent banking sector conditions (HHI index, financial depth). See Section 5 for details.

policy spillovers. It is still possible that US monetary policy is endogenous to US macroeconomic conditions, which then also correlate with Asian macroeconomic conditions and hence bank lending in Asia, but this possible simultaneity is short-circuited through our inclusion of domestic macroeconomic controls for Asian countries.

3.1.2. Estimation method

Estimation is implemented by Ordinary Least Squares. We cluster the standard errors at the bank-level, so that the standard errors are asymptotically robust to both heteroscedasticity and serial correlation. As noted above we use bank-fixed effects to control for bank-level heterogeneity in lending patterns not captured in other explanatory variables.

3.1.3. Estimation results (1): Loan quantity equation

Our first empirical results are reported in Table 3. Column (1) is the baseline estimate of Eq. (1) and the remaining columns report some variations on this specification. In column (2), we remove interaction terms between monetary policy indicators and bank characteristics. In column (3) we control for the domestic policy indicator only, whilst in column (4) only the US policy indicator is included (these specifications address possible multi-collinearity between US and domestic monetary policy measures). In column (5) we adopt a random effects estimator instead of a fixed effects estimator. As is well-known, the fixed effects estimator loses efficiency if all systematic bank-level variation in the dependent variable is captured by the controls in the model.⁶ To save space, we present the coefficient estimates for only the key domestic and US monetary policy variables.

Our main result in Table 3 is that the transmission of US monetary policy to bank lending growth in Asia is of the expected sign and statistically significant. We find that banks cut annual loan growth by 0.769 percentage points in response to a 1 percentage point increase in the federal funds rate, and the figure is significant at the 5 percent level. Furthermore, the effect appears quantitatively important, being approximately one half the magnitude of the lending growth reduction following a 1 percentage point rise in the domestic monetary policy rate. We interpret this evidence as supportive of a direct spillover from US monetary policy to bank lending in Asia. Furthermore, as noted previously, since we are controlling for domestic monetary policy and domestic output, this spillover cannot arise through standard transmission channels such as interest-rate pass through under currency pegs, or trade linkages driving economic activity in Asia. Instead, we associate the effect with financial linkages that arise when Asian banks choose to partly finance their activities in US dollars and other currencies through accessing integrated global capital markets in which funding conditions depend on US monetary policy. Finally, from column (1) we note that the transmission of domestic monetary policy to bank lending growth, at -1.464 percentage points for a 1 percentage point rise in the monetary policy interest rate, is also significant at the 1 percent level.⁷

The results from the baseline regression are robust across alternative model specifications. The sign, magnitude and significance of the US monetary policy measure are robust through column (4). In column (5) the magnitude of the effect declines slightly but is significant at the 5 percent level. Similar results are recorded for the domestic monetary policy measure, though it should be noted that the random effects estimator in column (5) is rejected in favour of the fixed-effects specification in column (1). Finally, coefficients on the interaction terms between monetary policy measures and the financial crisis indicator are of opposite sign to the coefficients on monetary policy during the rest of the sample. This suggests that monetary transmission was attenuated during the crisis period, though it should be noted that the effects are not statistically significant.

3.1.4. Estimation results (2): Loan price equation

Table 4 reports estimates of Eq. (1) in which the annual change in the proxy for the real loan interest rate is the dependent variable. Specifications across columns are as explained for Table 3. In the baseline model, column (1), the coefficient on domestic monetary policy rates is 0.431 and highly significant. The coefficient on the US monetary policy rate is 0.052 and significant at the 5 percent level. This means that banks increase the real loan interest rate by 0.052 percentage points when the US monetary policy rate rises by 1 percentage point. This estimate is about one eighth the size of the effect from domestic monetary policy changes on bank loan rates. Although the effect of US monetary policy on loan interest rates is less powerful than that estimated for loan quantities, there is clear evidence that US monetary policy spills over to local bank lending rates, even after holding constant domestic monetary policy and domestic income growth. The baseline results are generally robust across the remaining columns of Table 4.

3.2. Bank characteristics and monetary policy transmission

In this sub-section we focus on how bank lending responses to domestic and US monetary policy vary with bank characteristics. In order to do this we create dummy variables for each of the six characteristics, the dummy being set to one for observations for which the value of the characteristic exceeds the median value of that characteristic in the relevant country and year, and zero otherwise. Then, in Eq. (1), we replace each bank characteristic, $\tilde{X}_{k,ijt}$ with the corresponding

⁶ The fixed effects model is preferred according to a Hausman test for both loan quantity and loan price equations.

⁷ Lee and Bowdler (2019) examine monetary policy transmission in Asia in bank-level panel regressions for the period 2000 to 2014, and report that banks reduce real loan growth by 1.128 percentage points in response to a 1 percentage point increase in the domestic monetary policy interest rate, and increase loan interest rates by 0.426 percentage points.

Table 3

Responses of bank lending to monetary policy (Loan quantity equation).

	Dependent: Loan quantity				
	(1)	(2)	(3)	(4)	(5)
MP	−1.464*** (0.404)	−1.418*** (0.380)	−1.364*** (0.409)		−0.867** (0.361)
MP × I _{crisis}	0.997 (1.407)	0.887 (1.404)	0.741 (1.082)		0.499 (1.326)
FFR	−0.769** (0.299)	−0.804*** (0.283)		−0.709** (0.296)	−0.607** (0.277)
FFR × I _{crisis}	1.237 (2.421)	1.340 (2.357)		0.786 (0.626)	1.247 (2.266)
Adjusted R ²	0.347	0.347	0.345	0.346	
Observations	2,175	2,175	2,175	2,175	2,175
Banks	328	328	328	328	328

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level. Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. Column (1) represents the baseline regression, Column (2) excludes interaction terms between monetary policy measures and bank characteristic variables, Column (3) excludes US monetary policy indicator (FFR), Column (4) excludes domestic monetary policy indicator (MP), Column (5) adopts a random effects estimator instead of a fixed effects estimator.

Table 4

Responses of bank lending to monetary policy (Loan price equation).

	Dependent: Loan rates				
	(1)	(2)	(3)	(4)	(5)
MP	0.431*** (0.050)	0.421*** (0.050)	0.423*** (0.050)		0.439*** (0.040)
MP × I _{crisis}	−0.401*** (0.097)	−0.385*** (0.115)	−0.322*** (0.083)		−0.409*** (0.081)
FFR	0.052** (0.021)	0.048** (0.020)		0.035 (0.022)	0.048*** (0.018)
FFR × I _{crisis}	−0.353* (0.207)	−0.328 (0.225)		0.136** (0.058)	−0.317* (0.177)
Adjusted R ²	0.151	0.134	0.149	0.051	
Observations	2,175	2,175	2,175	2,175	2,175
Banks	328	328	328	328	328

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level. Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. Column (1) represents the baseline regression, Column (2) excludes interaction terms between monetary policy measures and bank characteristic variables, Column (3) excludes US monetary policy indicator (FFR), Column (4) excludes domestic monetary policy indicator (MP), Column (5) adopts a random effects estimator instead of a fixed effects estimator.

dummy variable, $I_{\tilde{x}_k}$. Furthermore, in order to limit the number of estimated parameters from the fixed sample size, we run six sets of regressions in which one characteristic and its interactions with the monetary policy measures is included at a time.

Table 5 presents the estimation results for both lending growth and loan interest rates. We report the marginal effects of domestic and US monetary policy when the binary version of a characteristic measure is zero, the marginal effects when the binary variable is one, and the difference between these two effects. Looking first at the results for lending growth, banks that hold more liquid assets contract their lending by less following US monetary policy tightening, though the effect is not statistically significant (the p-value for the hypothesis that the coefficient for the interaction of the dummy and the policy measure is zero is 18 percent). Transmission of US monetary policy is more pronounced amongst larger banks, which may reflect greater use of foreign currency funding by large banks, and so greater exposure to rising funding costs when US monetary policy tightens. However, our evidence is only weak evidence (the p-value for the hypothesis of no difference by bank size is 21 percent for loan quantities and 28 percent for loan prices). The results for the other bank characteristics that we consider are far from statistically significant. This includes the interaction based on the use of non-deposit funding. In theory, banks whose non-equity capital funding derives more heavily from debt than deposits should be more exposed to rising dollar funding costs when US monetary policy tightens, making the absence of a significant effect surprising. However, it is important to note that our measure focuses only on the importance of overall debt rather than foreign currency denominated debt specifically. The costs of domestic currency denominated debt are unlikely to respond to US monetary policy after holding constant domestic monetary policy, and this may account for the absence of a significant effect.

Table 5
Responses of bank lending across heterogeneous banks.

	(I) Liquidity	(II) Capital	(III) Size	(IV) Riskiness	(V) Profitability	(VI) Nonc liab.
Panel A. Loan quantity equation						
MP	−1.091** (0.540)	−1.071* (0.560)	−1.532** (0.669)	−1.361** (0.671)	−1.786*** (0.601)	−0.978** (0.484)
MP + I_{X_k}	−1.621** (0.646)	−1.806*** (0.628)	−1.081** (0.493)	−1.450*** (0.544)	−1.057** (0.484)	−1.794*** (0.579)
Difference : I_{X_k}	−0.530 (0.875)	−0.735 (0.913)	0.450 (0.872)	−0.089 (0.934)	0.729 (0.766)	−0.816 (0.759)
FFR	−1.182*** (0.357)	−0.921** (0.364)	−0.459 (0.484)	−0.961** (0.419)	−0.714 (0.459)	−0.803* (0.422)
FFR + I_{X_k}	−0.470 (0.426)	−0.691 (0.450)	−1.173*** (0.323)	−0.694** (0.350)	−0.886*** (0.336)	−0.79** (0.370)
Difference : I_{X_k}	0.713 (0.533)	0.230 (0.598)	−0.714 (0.568)	0.268 (0.510)	−0.172 (0.565)	0.012 (0.551)
Panel B. Loan price equation						
MP	0.331*** (0.073)	0.428*** (0.071)	0.417*** (0.079)	0.352*** (0.062)	0.449*** (0.082)	0.340*** (0.081)
MP + I_{X_k}	0.499*** (0.068)	0.414*** (0.078)	0.412*** (0.061)	0.486*** (0.064)	0.394*** (0.062)	0.486*** (0.059)
Difference : I_{X_k}	0.167* (0.096)	−0.014 (0.108)	−0.006 (0.099)	0.134* (0.074)	−0.056 (0.104)	0.146 (0.099)
FFR	0.050* (0.027)	0.057** (0.027)	0.031 (0.029)	0.029 (0.024)	0.036 (0.032)	0.063** (0.025)
FFR + I_{X_k}	0.050 (0.031)	0.041 (0.028)	0.068*** (0.023)	0.065** (0.028)	0.059** (0.026)	0.029 (0.028)
Difference : I_{X_k}	−0.001 (0.042)	−0.017 (0.037)	0.037 (0.034)	0.037 (0.035)	0.023 (0.043)	−0.034 (0.035)

Notes: Standard errors are in parentheses. ***, significant at 1 percent level, **, significant at 5 percent level, *, significant at 10 percent level. Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. The figures in this table present estimation results of Eq. (1) with bank characteristic variable X_k replaced by the corresponding binary indicator variable I_{X_k} . In each regression, we include only one characteristic variable we are interested in and exclude all other bank characteristic variables to minimize possible multicollinearity across bank characteristic variables.

4. Exploring the transmission mechanisms

This section consists of two sub-sections. In Section 4.1 we examine whether bank funding cost movements are consistent with the foreign debt funding channel that we emphasise in accounting for the impact of US monetary policy on Asian bank lending. We also discuss alternative transmission channels. In Section 4.2 we investigate heterogeneity in the impact of US monetary policy on Asian bank lending in light of previous research findings concerning international inter-bank funding flows.

4.1. Funding costs and bank lending

In this section we consider what might be the explanation for the finding that US monetary policy impacts the lending volumes and loan interest rates of Asian banks. Given the importance of foreign currency funding to our sample of banks (see Table 1), our main hypothesis is that US monetary policy tightening reduces the quantity and raises the price of funding sourced by Asian banks in US dollars and other major currencies, which in turn contracts the supply of bank loans in Asian markets. If this interpretation of our results is correct, one would expect (1) evidence that US monetary policy rate directly impacts the funding volumes and funding costs of Asian banks; (2) evidence that on controlling for funding volumes or funding costs in our core regressions, the impact of US monetary policy on Asian loan quantities and loan prices is reduced (since such specifications ‘shut down’ the foreign funding transmission channel). We evaluate these predictions for funding costs, but not for funding volumes, as a regression of loan quantity on funding volume may capture reverse causation effects. To be specific, the changes to loan demand stemming from changes to monetary policy may force banks to adjust their funding volumes.

We add a variable to our bank level panel dataset, which is a funding cost measure for each bank, defined as the annual change in the ratio of interest expenses incurred to total financial liabilities. This is a proxy for the overall cost of funds obtained by a bank and will increase with the cost of funding in US dollars and other currencies in global capital markets. There is a theoretically preferred definition of funding costs, namely the cost of foreign currency denominated funding, but we do not observe that aspect of overall funding costs in our dataset. Nevertheless, our measure of funding costs is expected to vary systematically with US monetary policy under the foreign funding interpretation of the relationship between US monetary policy and bank lending in Asia, and as such provides a basis for testing the mechanism that we emphasise.

In column (1) of [Table 6](#) we present results from regressions of the funding cost measure on local monetary policy, US monetary policy and their interactions with the crisis episode dummy, plus all of the other controls included in the baseline model specification in Section 3.1.1. Column (2) presents the same model estimated by random effects rather than fixed effects. To save space we present only the estimated coefficients from the monetary policy terms. The results show that funding costs increase with a tightening of US monetary policy and that the effect is significant at the 5 percent level (fixed effects estimate) and the 1 percent level (random effects estimate).

In order to investigate whether this increase in funding costs accounts for the impact of US monetary policy on bank loan rates, we consider the effects of extending our baseline regression estimates to hold constant the price dimension of funding supply. In [Table 6](#), column (3) shows the baseline lending price regression from column (1) in [Table 4](#). In column (4) we augment that specification with the change to the funding cost proxy. The results show that the amount by which rises in US monetary policy interest rates raise interest rates on Asian bank loans falls by roughly one half, and the new estimate is not significant at standard levels.

Taken together, the results in [Table 6](#) indicate that US monetary policy impacts the terms on which Asian banks obtain funding, and that once these changes to funding arrangements are held constant, the effect of US monetary policy on bank lending in Asia is reduced along the price dimension. These findings are consistent with the claim that our main results arise from the impact of US monetary policy on foreign funding opportunities for Asian financial institutions. Furthermore, since our estimates in [Table 6](#) hold constant local monetary policy, we can rule out the possibility that US monetary policy impacts funding conditions and bank lending through its effects on local monetary policy conditions. Instead, there appears to be a direct impact of US monetary policy on the funding available to Asian banks.

One possibility that we cannot rule out is that the impact of US monetary policy on bank funding conditions and lending decisions arises only from those Asian banks that are subsidiaries of American banks, and therefore directly integrated into capital market structures affected by US monetary policy. If this were the case then the mechanism that we emphasise would be limited to a subset of US-owned Asian banks and would not operate more broadly. Whilst this possibility exists, it seems unlikely that it accounts for the magnitude of the results that we have documented. Recall that the impact of a 1 percentage point increase in US monetary policy rate on Asian lending quantities equates to roughly half the size of the effect from a 1 percentage point increase in local monetary policy rate. For such results to arise purely from the actions of Asian subsidiaries of US banks would require a significant share of the Asian banking system to be US-owned. [Lee and Bowdler \(2019\)](#) discuss the ownership structure of banks in 8 of the 12 Asian nations in this study (Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand). In 2010 US-owned entities accounted for just 2.5 percent of the total assets in those 8 banking systems (a further 29.4 percent of assets were held by foreign-owned banks whose global headquarters were outside the US). At such levels of market share, US banks are unlikely the sole source of transmission of US monetary policy to Asian bank lending. Any part of the effect of US monetary policy on Asian bank lending not accounted for by subsidiaries of US banks suggests a possible role for the mechanism that we have proposed, namely that banks operating in Asia access global capital markets and fund part of their operations in US dollars and other currencies, with the result that their funding (and hence their lending) is directly dependent on US monetary policy.

The final point that we note in relation to the [Table 6](#) results is that after holding constant funding conditions there remains some impact of US monetary policy on Asian bank lending; the effect is close to significant at the 10 percent level. This suggests that whilst a dollar funding channel may be relevant, it is unlikely to be the sole mechanism driving the impact of US monetary policy on Asian bank lending. Instead, it appears that following contractionary US monetary policy Asian banks tighten their lending standards over and above any impact predicted by changes to their funding conditions. One explanation may be that rises in the federal funds rate reduce the risk appetite of Asian banks ([Borio and Zhu, 2012](#)) so that their loan supply declines even when holding constant funding conditions. Exploring such channels and their roles in accounting for the transmission of US monetary policy to Asian bank lending is an interesting topic for future research.

4.2. Heterogeneity in the impact of US monetary policy

In this sub-section we investigate heterogeneity in the impact of US monetary policy on bank lending in Asia, building on the findings of [Avdjiev and Hale \(2019\)](#), who use a quarterly dataset spanning 114 countries and the years 1978 to 2015 to study the impact of US monetary policy on international inter-bank funding flows. Their results show three important forms of heterogeneity in the relationship. Firstly, the magnitude of funding flows is time-varying. There are boom periods, in which the growth rate and volatility of funding flows are high, and stagnation periods in which they are low. The results reported by Avdjiev and Hale show that for Emerging Market economies, a tightening of US monetary policy reduces the supply of dollar funding in the stagnation regime, but not in the boom regime. Reproducing the regime classifications, which are derived from Markov-Switching regressions, using our dataset is not feasible given that our data are annual rather than quarterly, and cover a shorter time frame. Instead we split our sample period into two sub-periods based on the regime reported in Avdjiev and Hale and then examine the possible heterogeneous impact of US monetary policy on Asian bank lending. An inspection of Fig. 3 in their paper shows that after 2005 (the period covered by our dataset), both the stagnation and boom regimes applied, but the stagnation regime is observed more frequently in the years at the very end of our sample than in the years immediately following 2005. We therefore create a dummy variable for the years 2012–18 and interact it with both the domestic and US monetary policy measures in our baseline quantity and price regressions (column (1) in [Tables 3](#) and [4](#), respectively). Based on the findings from Avdjiev and Hale, we expect the impact of US monetary policy

Table 6

Responses of bank funding costs and bank lending costs to monetary policy.

	Dependent: Funding costs		Loan rates	
	(1)	(2)	(3)	(4)
MP	0.407*** (0.034)	0.428*** (0.026)	0.431*** (0.050)	0.032 (0.046)
FFR	0.024** (0.012)	0.030*** (0.010)	0.052** (0.021)	0.028 (0.017)
Funding costs				0.980*** (0.060)
Adjusted R ²	0.266		0.151	0.460
Observations	2,174	2,174	2,175	2,174
Banks	327	327	328	327

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level. Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. In Columns (1) and (2) the dependent variable is the change in the real funding costs. Column (1) present the results from a fixed effects estimator, and Column (2) present the results from a random effects estimator. In Columns (3) and (4) the dependent variable is the change in the real loan rates. Column (3) present the baseline regressions as shown in Column (1) of Table 4. Column (4) present the regression results with the funding costs held constant.

on bank lending in Asia to be stronger in the second half (2012 to 2018) than in the first half of the sample (2005 to 2011) because the second half of the sample is more commonly associated with the stagnation regime in which a rise in US interest rates leads to a decline in inter-bank funding. In Table 7, column (1) presents the extended lending quantity regression and column (4) presents the extended lending price regression. We find that the estimates of the dummy variables for the years 2012–18 (stagnant regime) show a sign opposite to that of corresponding monetary policy indicators, which means that the impact of US monetary policy on bank lending is weaker (not stronger) in stagnant regimes, though the estimate is not significant for the loan quantity equation.

A second form of heterogeneity in the propagation of US monetary policy to international inter-bank funding flows documented by Avdjiev and Hale relates to the origins of federal funds rate changes. The authors perform a decomposition of US monetary policy into components that are endogenous to standard Taylor rule controls, and those that are exogenous and occur independently of those controls. The impact of a policy tightening on dollar funding flows is stronger after exogenous tightenings, possibly because effects from endogenous tightenings are confounded by separate effects of US GDP growth and US inflation on dollar funding flows (see Lee and Bowdler, 2020). In order to isolate exogenous movements in US monetary policy in our regressions we extend the baseline estimates from Tables 3 and 4 to include US GDP growth and US inflation, thus holding constant federal funds rate movements linked to those variables. The results are presented in columns (2) and (5) of Table 7. The negative impact of the federal funds rate on bank lending quantities increases slightly in magnitude relative to Table 3, column (1), from 0.769 to 0.808, but the change is unlikely to be statistically significant. The point estimate for the impact of the federal funds rate on bank lending interest rates is unchanged relative to our baseline results. As such, we do not find evidence that our main results depend on separating endogenous and exogenous movements in US monetary policy, though clearly there are more sophisticated methods for performing this decomposition that could be examined in future research.

The third form of heterogeneity identified by Avdjiev and Hale is that the negative effect of tighter US monetary policy on global inter-bank funding flows is larger for Emerging Market economies than for Advanced economies (a similar finding is reported in Lee and Bowdler, 2020). In fact, there is some evidence that Advanced economies benefit from greater access to funding through a flight-to-quality effect in global capital markets. Motivated by this finding, in column (3) of Table 7 we report the baseline specification for the growth in the lending quantity from Table 3 for a sample that excludes banks from Australia, Hong Kong, New Zealand and Singapore, the Advanced economies in our sample. In column (6) of Table 7 we use the same trimmed sample for the baseline loan price regression from Table 4. The results for bank lending quantities show a much larger effect from US monetary policy amongst the sub-sample of Emerging Market banks. The point estimate on the federal funds rate is roughly double that observed in the full sample and slightly exceeds the effect of domestic monetary policy changes on lending growth. This is consistent with the stronger impact of US monetary policy on international bank funding flows to Emerging Markets documented in previous research. The results for loan interest rates do not follow a similar pattern, however. The point estimate on the US monetary policy measure falls by roughly one third and is insignificant at standard levels. As such, our results only provide support for a stronger propagation of US monetary policy to Emerging Market Asian banks in the case of lending quantities and not in the case of loan prices.

Table 7

Heterogeneous responses of bank lending to monetary policy.

	Dependent: Loan quantity			Loan rates		
	(1)	(2)	(3)	(4)	(5)	(6)
MP	−1.558 (0.988)	−1.114*** (0.402)	−1.366*** (0.422)	0.435*** (0.107)	0.404*** (0.055)	0.438*** (0.055)
FFR	−0.967 (0.803)	−0.808** (0.319)	−1.527*** (0.409)	0.286*** (0.062)	0.052** (0.024)	0.036 (0.032)
MP × I _{2012–18}	0.175 (1.154)			−0.026 (0.120)		
FFR × I _{2012–18}	0.191 (0.851)			−0.264*** (0.067)		
Adjusted R ²	0.346	0.348	0.350	0.157	0.153	0.116
Observations	2,175	2,175	1,355	2,175	2,175	1,355
Banks	328	328	190	328	328	190

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level. Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. In Columns (1) and (4), an indicator $I_{2012-18}$, that is 1 for the years 2012–2018 and 0 otherwise, and its interactions with monetary policy measures are included. Columns (2) and (5) present regression results controlling for both US growth and US CPI inflation. Columns (3) and (6) exclude bank-year observations in 4 advanced economies (Australia, Hong Kong, New Zealand, Singapore).

5. Robustness tests

In this section we present robustness tests for our main results linking lending quantities and lending interest rates amongst Asian banks to US monetary policy. Table 8 provides results for lending quantities and Table 9 results for loan interest rates. Column (1) in each table replicates the baseline results from column (1) in Table 3 and column (1) in Table 4. In column (2), we exclude observations for banks operating in Hong Kong SAR and Singapore, for two reasons. First, those two countries maintain a fixed exchange rate versus the US dollar, which may mean that there is little independent variation in US monetary policy in a regression that also holds constant local monetary policy. Second, the percentage of foreign debt in total banking sector debt is much higher for those countries than for others in our sample, see Table 1 (this may reflect the roles of Hong Kong and Singapore as financial hubs). Whilst there are small changes to the magnitude of the impact of US monetary policy on both lending quantities and lending prices, both effects remain significant at the 5 percent level.

In column (3), we include country-level variables that describe the national banking sector, such as the Herfindahl–Hirschman index (HHI) and a measure of financial depth. HHI measures the degree of concentration or competition in the banking industry.⁸ Financial depth denotes the overall size of the financial resources provided to the private sector and is proxied by private credit as a percentage of gross domestic product (GDP). The loan quantity results are robust to this extension of the model, but the loan price effect is roughly halved and loses significance at standard levels.

Column (4) in each table adds the home country inflation rate as a control (recall the domestic GDP growth is one of the baseline controls). A key rationale for these controls is that they account for possible endogenous responses of domestic monetary policy to economic conditions that may also correlate with domestic bank lending and so induce bias in bank lending responses to monetary policy. By extending the set of macroeconomic controls to include the domestic inflation rate we address any biases that may arise should inflation movements induce changes to both monetary policy and domestic bank lending. Our main findings are robust to this model extension and it should be noted that the loan price effect doubles in both magnitude and statistical significance.

Column (5) is the baseline specification from column (1) but estimated using the maximum feasible sample that does not exclude outliers. This implies an increase in the sample size from 2,175 observations in column (1) to 2,540 observations in column (5). As expected, the standard errors associated with our estimates increase with the inclusion of outliers. In the case of the loan quantity results the magnitude of the estimated effect increases proportionately so that the statistical significance of the result is maintained. In the case of the loan price effect the coefficient does not increase and is significant only at the 15 percent level rather than the 5 percent level.

In column (6) in each table we add to the baseline model the change in the ECB monetary policy interest rate. The objective of this exercise is to determine whether the estimated effects of US monetary policy are an artefact of some correlation between Asian bank lending and a global interest rate cycle that is proxied by the US monetary policy measure. One way to evaluate this possibility is to control for ECB monetary policy, which is a driver of the global interest rate cycle alongside US monetary policy. The ECB policy measure is significant at the 10 percent level in the loan quantity results, but is not significant in the case of the loan price results. In contrast, the US monetary policy effect is robust in both magnitude and significance. The stronger effect on Asian bank lending from US monetary policy than from ECB monetary policy may arise due to

⁸ More specifically, Herfindahl–Hirschman index is defined as $\sum_{i=1}^N s_{ijt}^2$, where $s_{ijt} = \frac{Asset_{ijt}}{\sum_{i=1}^N Asset_{ijt}}$, and subscript i denotes an individual bank, j denotes the country in which the bank operates, and t denotes year.

Table 8
Robustness tests of loan quantity equation.

	Dependent: Loan quantity						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MP	−1.464*** (0.404)	−1.333*** (0.393)	−1.480*** (0.434)	−1.326*** (0.437)	−1.380* (0.741)	−1.207*** (0.410)	−1.144*** (0.433)
FFR	−0.769** (0.299)	−0.644** (0.315)	−0.850*** (0.306)	−0.864*** (0.315)	−1.413** (0.651)	−0.773*** (0.298)	−0.592** (0.299)
HHI			−0.080 (0.076)				
Financial depth			0.047 (0.042)				
Inflation				−0.246 (0.283)			
EUMP						−0.327* (0.171)	
VIX							−0.023** (0.011)
Adjusted R^2	0.347	0.347	0.348	0.347	0.259	0.348	0.348
Observations	2,175	1,950	2,134	2,175	2,540	2,175	2,175
Banks	328	296	318	328	343	328	328

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level, Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. Column (1) represents the baseline regression as shown in Column (1) of Table 3, Column (2) excludes samples of banks located in Hong Kong SAR or Singapore, Column (3) includes HHI index and a measure of financial depth of each country as controls, Column (4) adds the inflation rate of each country as a control, Column (5) is estimated using the full sample without the exclusion of any outliers, Column (6) controls for annual changes to ECB monetary policy, Column (7) includes the change in the VIX index as an explanatory variable.

Table 9
Robustness tests of loan price equation.

	Dependent: Loan rates						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MP	0.431*** (0.050)	0.422*** (0.050)	0.402*** (0.051)	0.349*** (0.048)	0.532*** (0.125)	0.444*** (0.054)	0.412*** (0.056)
FFR	0.051** (0.021)	0.058** (0.023)	0.021 (0.024)	0.108*** (0.022)	0.049 (0.034)	0.051** (0.021)	0.041* (0.022)
HHI			0.019*** (0.005)				
Financial depth			0.007*** (0.002)				
Inflation				0.146*** (0.022)			
EUMP						−0.017 (0.014)	
VIX							0.001* (0.001)
Adjusted R^2	0.151	0.126	0.159	0.176	0.259	0.152	0.152
Observations	2,175	1,950	2,134	2,175	2,540	2,175	2,175
Banks	328	296	318	328	343	328	328

Notes: Standard errors are in parentheses. ***: significant at 1 percent level, **: significant at 5 percent level, *: significant at 10 percent level, Standard errors are corrected for heteroscedasticity and clustered at bank level to control for the effects of residual autocorrelation. Column (1) represents the baseline regression as shown in Column (1) of Table 4, Column (2) excludes samples of banks located in Hong Kong SAR or Singapore, Column (3) includes HHI index and a measure of financial depth of each country as controls, Column (4) adds the inflation rate of each country as a control, Column (5) is estimated using the full sample without the exclusion of any outliers, Column (6) controls for annual changes to ECB monetary policy, Column (7) includes the change in the VIX index as an explanatory variable.

the fact that, as indicated in Table 1, US dollar denominated debt is the dominant form of foreign funding utilised by Asian banks.

In column (7) in each table we include the change to the VIX index of market volatility, to control for another factor in the global financial cycle that may impact Asian bank lending. The VIX index exerts a negative effect on lending quantities that is significant at the 5 percent level and a positive effect on loan interest rates that is significant at the 10 percent level. These results are consistent with the notion that market volatility curtails bank loan supply. The US monetary policy indicator effect declines slightly in both magnitude and significance in both tables, but is significant at the 5 percent level in the loan quantity case and the 10 percent level in the loan price case. As such, there remains evidence of a direct transmission of US monetary policy to Asian bank lending when holding constant a measure of market volatility.

6. Conclusion

In this study we measured the influence of US monetary policy on bank lending in Asia using data for 328 banks from 12 Asian countries. We found significant spillovers from US monetary policy changes to both lending growth rates and loan interest rates. Furthermore, these spillovers exist after controlling for domestic monetary policy changes and domestic income growth, and therefore appear to be driven by channels of international policy transmission other than those linked to interest-rate pass-through and income sensitive trade flows. Our interpretation of the results is that the monetary policy spillovers that we estimate arise from Asian banks' use of foreign currency denominated funding whose availability and price is sensitive to US monetary policy decisions. In order to provide evidence in support of our interpretation, we showed that for our sample of Asian banks funding costs increase following a tightening of US monetary policy, and that when the funding cost is held constant, the impact of US monetary policy on Asian bank interest rates in our core regression is reduced. These findings are consistent with the interpretation that US monetary policy impacts Asian bank lending activity through the funding conditions faced by those banks. In order to relate our findings to the existing literature we provided some evidence that the impact of US monetary policy is stronger after holding constant changes to US monetary policy endogenous to economic conditions, and in a sample that isolates Emerging Market banks.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

A.1. Data sources

Bank-level data: Bank-level variables are collected from Standard and Poor's Market Intelligence. The database classifies banks into five categories, based on their specialization and field of business: commercial banks, saving banks (including thrift/mutual banks), FHLB/development banks, central banks, and other banks. Among these, we investigate commercial banks and saving banks. Country-level variables: Real gross domestic product (GDP), consumer price index (CPI), unemployment rate, money market interest rates, exchange rates are collected from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Financial depth is from the World Bank database (<https://www.worldbank.org/en/publication/gfdr/gfdr-2016/background/financial-depth>). US real domestic product and inflation rate are collected from FRED database. HHI index of each country are calculated by using bank-level data collected from Standard and Poor's Market Intelligence.

A.2. Descriptive statistics

Table A1

Descriptive statistics and pairwise cross-correlation.

	Descriptive statistics		Pairwise cross-correlation coefficients								
	Mean	s.d.	$\Delta \ln \text{Asset}$	$\Delta \ln \text{Loan}$	ΔLoanR	Liq.	Cap.	Siz.	Risk.	Profit.	Nonc.
$\Delta \ln \text{Asset}$	5.95	10.13	1								
$\Delta \ln \text{Loan}$	6.78	12.51	0.686*	1							
$\Delta \text{LoanRate}$	−0.24	0.85	−0.132*	−0.160*	1						
Liquidity	25.35	13.40	0.024	0.057*	0.059*	1					
Capital	10.71	5.27	0.012	0.040	−0.006	0.220*	1				
Size	15.49	2.43	−0.010	0.004	0.089*	0.095*	−0.366*	1			
Riskiness	0.43	0.71	−0.059*	−0.053*	0.053*	0.031	0.156*	0.069*	1		
Profitability	0.85	0.72	0.138*	0.149*	0.051*	0.138*	0.263*	0.171*	0.007	1	
Noncore liab.	17.83	16.76	0.005	0.071*	0.050*	0.140*	0.063*	0.386*	0.069*	0.045*	1

Notes: Figures are from 2,175 bank-year observations used in the regression analysis. Bank level variables are constructed as defined in Section 2. * indicates statistical significance at the 5 percent level.

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