Quantitative Easing and Cross-Border Bank Credit Supply

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Abstract

This paper studies the effects of Quantitative Easing (QE) on cross-border bank credit supply, using confidential balance sheet data of UK-resident banks. There are two main findings. First, QE has loan supply effects. Banks that receive more QE liquidity extend more loans to foreign residents. A one-percent increase in QE liquidity leads to an increase in cross-border bank lending of about 0.29%. Second, cross-border banking plays an important role in the international spillovers of QE. Banks that are more exposed to QE increase more holdings of foreign assets. Banks' total foreign claims increase by about 0.32% resulting from a one-percent increase in QE exposure.

1 Introduction

This paper attempts to answer two questions on quantitative easing (QE) that are largely unanswered by the literature: Does QE have supply effects on bank loans? And does cross-border banking contribute to the international spillovers of QE? This paper answers the

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questions using a dataset of cross-border claims of UK-resident banks to about 200 countries during the QE period.

Two features of the dataset help to identify a casual effect of QE on cross-border credit supply. First, the Bank of England intentionally avoided banks and purchased assets only from non-bank financial institutions during QE. This special feature implies that reverse causality is not a major problem for identifying credit supply effects of QE. Second, in the dataset multiple UK banks lend to a foreign country. This fact enables us to introduce a borrower-specific fixed effect to control for credit demand effects.

The literature has not reached a consensus on the first question: Does QE have supply effects on bank loans? In the UK, policy makers anticipated QE to work through the portfolio balance channel, but expected little bank lending impact for the reason that banks were under pressure to deleverage.[1] However, empirical studies have different conclusions. Joyce and Spaltro (2014) find a small, yet significant bank lending effect of QE in the UK. On the contrary, Butt et al. (2014) find no evidence in the UK that QE worked through the bank lending channel.[2]

This paper contributes to this debate by studying banks' cross-border lending in responses to QE. It differs from the existing literature, which usually studies domestic bank lending data. One advantage of this paper is that studying cross-border lending makes it easier to isolate loan supply effects from loan demand effects. The fact that multiple UK banks lend to a foreign country enables us to introduce a borrower-specific fixed effect to control for credit demand effects, as in Khwaja and Mian (2008) and Aiya et al. (2014). In other words, we use within borrower comparison to identify credit supply effects.

The literature does not have a good answer for the second question either: Does cross-border banking play an important role in the international transmission of QE? Related research on international capital flows resulting from QE usually focuses on asset reallocations of managed funds. For example, Fratzscher, Lo Duca and Straub (2013) show that

[1] See minutes of the Monetary Policy Committee of the Bank of England meeting on March 4 and 5, 2009. Similarly, Bernanke (2010) also expected asset purchases to work through the portfolio balance channel.

[2] In the case of Japan, Bowman, Cai, Davies and Kamin (2011) find significant lending impact of QE.

QE in the US triggered cross-border flows of both equity funds and bond funds.[3] Different from the literature, this paper studies how banks adjust their holdings of foreign assets in responses to large scale asset purchases.[4] It sheds light on the role played by global banking in the global spillovers of QE.

This paper finds positive answers to both questions. First, QE has loan supply effects. Banks that receive more QE liquidity extend more loans to foreign residents. A one-percent increase in QE liquidity leads to an increase in cross-border bank lending of about 0.29%. Second, cross-border banking plays an important role in the international transmission of QE. Banks that are more exposed to QE hold more foreign assets. Banks' total foreign claims increase by about 0.32% resulting from a one-percent increase in QE exposure.

The paper is organized as follows. The next section describes the monetary policy framework and quantitative easing in the UK. Section 3 outlines the model and data used in this paper. Section 4 presents main results. Robustness of the main results are discussed in Section 5. Section 6 uses country-level data to study credit supply effects of QE. Section 7 concludes.

2 Quantitative Easing in the UK

This section provides some background information on the UK monetary policy framework, and describes briefly the implementation of QE in the UK and its impact on bank balance sheets.

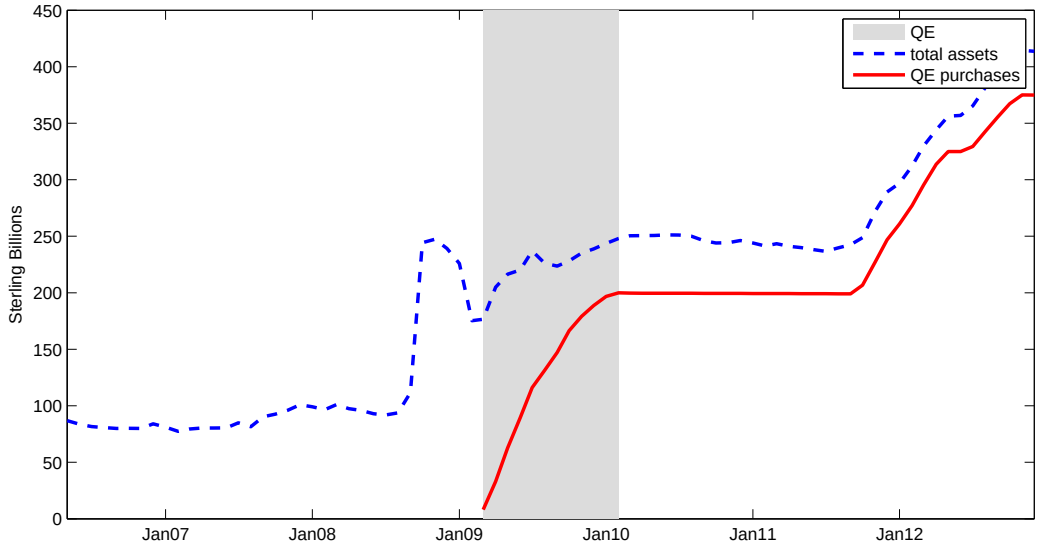
We focus on the first round of QE during 2009 and 2010. The Bank of England started its asset purchase program financed by the creation of central bank reserves on March 11, 2009. The initial target of the purchase was 75 billion pounds, which was extended to 125 billion pounds on May 7, and then to 200 billion pounds on November 5, 2009. Though the Bank

[3]There also exists research on the announcement impact of QE on financial markets in foreign countries. See, e.g., Rogers, Scotti and Wright (2014) and Bowman, Londono and Sapriza (2014).

[4]Total foreign claims consist of loans and advances, claims under sale and repurchase agreements, bills, certificates of deposit and commercial papers, and portfolio investments.

bought some private assets, the overwhelming majority of its purchases were UK government bonds with maturities from 3 to 25 years. On February 4, 2010, the MPC announced that asset purchases would be maintained at 200 billion pounds. As shown in Figure 1, the size of the balance sheet of the Bank of England and the size of assets purchased increased gradually during the QE period.

Figure 1: The Size of the Balance Sheet of the Bank of England and Assets Purchased during QE



Note: The size of the balance sheet of the Bank of England (the dashed line, in Sterling billions) and the size of total asset purchases (the solid line). The shaded area indicates the period when the first round of QE was implemented.

In designing the implementation of QE, the Bank of England intentionally avoided banks, and purchased assets only from non-bank financial institutions, such as pension funds, insurance companies and asset managers. The MPC believes that buying assets directly from the non-bank financial sector is more effective:

> The Committee noted that these asset purchases were likely to be most effective if they were purchased from the domestic non-bank financial sector rather than from

banks. Domestic non-bank institutions were likely to use some of the proceeds from asset sales to buy other assets.[5]

In other words, the MPC expects QE to work through a portfolio balance channel. As long as deposits are not close substitutes to securities, the sellers would wish to rebalance their portfolios towards riskier assets. This portfolio rebalancing increases demand on riskier assets and pushes up their prices.[6] Higher asset prices mean lower yields, which may stimulate spending as borrowing cost of firms and households are lower. In addition, portfolio rebalancing may also stimulate spending by increasing asset prices, and therefore, wealth of asset holders.

2.1 The Impact of QE on Bank Balance Sheets

Before the introduction of QE, the Bank of England implemented a reserves averaging scheme. About 30 banks and building societies that are members of the reserve scheme are invited to set their target reserves (the average amount of reserves they will hold) at the beginning of each maintenance period (the MPC's decision date until the next, roughly one month).[7] Banks maintain reserves toward their targets by trading in the interbank market, or with the Bank of England at inferior rates. The reserves are remunerated at the policy rate provided that they are maintained within a small range around the target over the maintenance period. And banks are charged for holding an average level of reserves outside the target range. In this regime, reserves at the Bank of England reflects liquidity demands of banks.

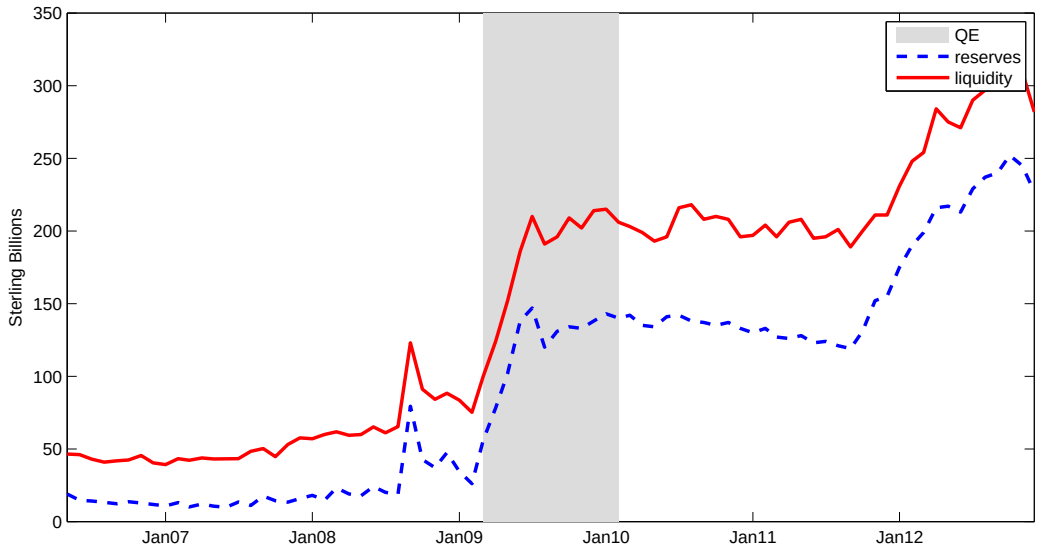
[5]See minutes of the Monetary Policy Committee meeting on March 4 and 5, 2009.

[6]Research has shown that the portfolio balance channel was functioning during QE. For example, Joyce, Miles, Scott and Vayanos (2012) and Krishnamurthy and Vissing-Jørgensen (2011) find that QE significantly decreased yields on government and corporate securities.

[7]Participation in the reserve scheme is voluntary except for settlement banks in the main wholesale payment and securities settlement systems. See Acharya and Merrouche (2012) and the document "The Bank of England's Sterling Monetary Framework (the 'Red Book')", available at http://www.bankofengland.co.uk/markets/documents/money/publications/redbook.pdf.

QE has immediate impacts on the reserves averaging scheme, even though the Bank of England purchased assets exclusively from non-bank financial institutions. When the Bank of England buys assets from a pension fund, for example, the bank of the fund receives deposits from the fund and reserves of a corresponding size at the Bank of England.[8] Figure 2 shows total reserves and liquid assets of all banks that have reserve accounts at the Bank of England during the period. Reserves and liquidity of these banks had a sharp increase during the QE period.

Figure 2: The Impact of QE on Bank Balance Sheets



Note: Total reserves and liquidity (in Sterling billions) of 37 banks that have continuously maintained reserve accounts at the Bank of England during 2009Q2-2010Q4. The shaded area indicates the period when the first round of QE was implemented.

The large scale asset purchases injected excess reserves relative to banks' demands. The imbalance in the demand and supply of reserves could have resulted in loss of control over market interest rates had banks been required to continue to set and meet targets. To

[8]Butt et al. (2014) also demonstrate that banks that participated in QE operations on behalf of their clients had a significant increase in deposits from non-bank financial institutions and reserves at the central bank.

deal with the problem, the Bank of England suspended reserves averaging in March 2009, along with the introduction of QE. Changes in reserves in the QE period, therefore, reflect primarily the supply of liquidity as a result of the large scale asset purchases, rather than changes in the demand of reserves.

If QE works through the portfolio balance channel as the MPC expected, balance sheets of banks are further changed in the process of portfolio rebalancing. If a pension fund participating in QE uses its QE money to buy corporate bonds from a company, its bank deposits move to the company that issue the bond. And the bank of the company experiences a corresponding increase in reserves. Therefore, the impact of QE on liquidity positions of banks is not limited to banks that directly participate in QE transactions. However, as mentioned earlier, not all banks have reserve accounts at the central bank. For banks without reserve accounts measuring QE exposure is more difficult. This paper, therefore, focuses on banks that have continuously maintained reserve accounts at the Bank of England during the QE period.

2.2 Bank Credit Supply Effects

In addition to the portfolio balance channel, QE may work through bank credit supply effects. There are several channels through which QE may affect bank credit supply. The first one is the bank balance sheet channel. One consequence of QE on banks' balance sheets is that banks piled up a large amount of excess reserves. By the end of 2009, reserves at the Bank of England reached 144.03 billion pounds from 48.63 billion pounds at the end of 2008. As shown earlier, these reserves reflect liquidity supply of large scale asset purchases, not banks' liquidity demand. Moreover, banks did not seem to substitute reserves for other liquid assets.[9] As a result, liquidity of the banking system increased greatly. Bank liquidity matters for lending. It is well documented in the literature that bank balance-sheet strength is an important transmission channel of monetary policy. For example, Kashyap and Stein (2000) and Jiménez, Ongena, Peydró and Saurina (2012) find that illiquid banks reduce more

[9] see Ennis and Wolman (2011) for a study of the US.

(domestic) lending in response to a monetary tightening.

QE may also affects bank credit supply through a risk-taking channel. QE works as the central bank's commitment for a low policy rate in a substantial period (Krishnamurthy and Vissing-Jørgensen, 2011). And the literature shows that a low policy rate tends to encourage bank risk-taking (Jiménez, Ongena, Peydró and Saurina, 2014). Therefore, by anchoring commercial banks' expectations on the low cost of funding in the period, QE may give banks incentive to take risk and expand cross-border lending.

Although QE-induced expansion in liquidity and low yield environment may encourage banks to extend more loans to firms and households, it is not clear to which extent the liquidity and risk-taking channel are still operational during the financial crisis. After all, banks have undergone a process of deleveraging. As mentioned earlier, the MPC did not expect QE working through the bank lending channel for the reason of deleveraging during the financial crisis.

3 Model and Data

Banks receiving more liquidity may be willing to lend more to foreign countries. To study the cross-border credit supply impact of QE, I estimate a model as

$$\Delta L_{ij} = \alpha + \beta QE_i + \phi LENDING_{ij} + F_j + \gamma' Z_i + \epsilon_{ij}, \tag{1}$$

where ΔL_{ij} is the log change of bank i's claims to foreign country j over the QE period, QE_i is a measure of bank i's indirect exposure to QE, $LENDING_{ij}$ are (log) claims of bank i to country j prior to QE, F_j is a country-specific fixed effect, and Z_i is a vector of bank-specific characteristics.

I consider two types of foreign claims: cross-border loans and total foreign claims. Cross-border loans include loans and advances, bills, and claims under sale and repurchase agreements. Total foreign claims consist of cross-border loans, certificates of deposit and commercial paper, and securities holdings. Data are obtained from the CC form (Country Analysis of UK External Claims) submitted by UK-resident banks to the Bank of England. Data are

adjusted for exchange rate movements.[10]

Studying the response of cross-border loans to QE helps to understand the supply side impact of QE on bank loans: Has QE encouraged banks to extend more loans and shifted the loan supply curve outward? A positive β would suggest that QE has stimulated loan supply of banks to foreign countries. Since β captures unambiguously a supply effect, we may infer that QE has increased loan supply in the domestic market as well. Due to abnormal loan demand in the domestic market during the financial crisis, however, the loan supply effect of QE can be difficult to identify using domestic loan data.

A study on changes in banks' total foreign claims is also interesting. Changes in banks' total foreign claims capture how banks respond to QE by reallocating assets internationally. It sheds light on the question of the international transmission of QE through global banking: Do banks that are more exposed to QE tend to hold more foreign assets? A positive β would indicate that banks react to the abundance of liquidity by searching for yield in foreign countries and increasing their holdings of foreign assets.

An important feature of the dataset is that multiple UK-resident banks are present in a recipient country. This feature enables us to include a borrower-specific fixed effect, F_j, to (1) to control for demand effects. The fixed effect helps to answer the question that whether UK-resident banks that experience higher QE exposure supply more credit to a particular foreign country. In other words, we use variations of UK banks within a foreign country to estimate the credit supply effect. A similar identification strategy is found in Khwaja and Mian (2008) and Aiya et al. (2014).

I consider two bank-specific variables: bank size, $SIZE_i$ and changes in stable funding, $\Delta FUNDING_i$.[11] The bank size is measured as the log size of the balance sheet of a bank

[10]Foreign claim data are reported in sterling at the end of each quarter. The reported data are converted to the original foreign currency using the appropriate end-quarter exchange rates. Changes in foreign claims, expressed in the foreign currency, is then converted back to sterling using the average exchange rate of the quarter.

[11]Capital ratios are important determinants for bank credit supply. They are not included in (1) due to data availability.

prior to the launch of QE. And changes in stable funding are measured as log changes in banks' stable funding, defined as the sum of resident deposits and CDs. Definitions of variables used in (1) are shown in Table 1.

Table 1: Variable Definitions

		Definition	Source
Cross-Border Claims			
	Total lending	Cross-border lending of UK-resident bank i to country j	Bank of England reporting form CC
	Lending to banks	Cross-border lending of UK-resident bank i to banks resident in country j	Bank of England reporting form CC
	Lending to non-banks	Cross-border lending of UK-resident bank i to non-banks resident in country j	Bank of England reporting form CC
	Total claims	Total cross-border claims of UK-resident bank i to country j, including lending and portfolio investments	Bank of England reporting form CC
Bank Characteristics			
	QE exposure	QE exposure is measured by liquid assets, including cash, bills, commercial paper and other short-term paper	Bank of England reporting form BT
	Stable funding	Stable funding includes resident sight and time retail deposits and all CDs	Bank of England reporting form BT
	Bank size	Log of total assets of bank i	Bank of England reporting form BT

3.1 Banks' QE Exposure

Banks' exposure to QE is a key variable for the identification. I use changes in banks' liquidity to measure their QE exposure. QE_i is, therefore, defined as the log change in bank i's liquid assets, including cash, bills, commercial paper and other short-term paper (in all currencies). As shown in Figure 2, the expansion of reserves and liquidity is a direct impact of QE on banks. Moreover, banks' liquidity positions are arguably exogenous to their cross-border credit supply. As the Bank of England purchased assets only from non-bank financial institutions, banks passively receive reserves resulting from deposits from sellers. It is very unlikely that banks actively choose the level of reserves to meet their liquidity demand from cross-border banking. Even if banks actively managed their liquidity during the QE period, lending to a particular foreign country (which is a small share of total assets of a bank)

does not seem to be an important determinant of bank liquidity demand. Therefore, reverse causality from cross-border credit supply to banks' QE exposure is not a major concern.

The literature often uses changes in deposits from non-bank financial institutions to measure banks' QE exposure (see, e.g., Joyce and Spaltro (2014) and Butt et al. (2014)). I use changes in liquidity for two reasons. First, bank lending can be constrained by banks' liquidity positions or capital ratios, but not by deposits received. On the contrary, deposits are created simultaneously when banks extend loans. These deposits do not bring liquidity to banks. Second, in the process of portfolio rebalancing changes in bank liquidity capture the impact of QE on bank balance sheets better than deposits from non-bank financial institutions. For example, if a pension fund participating in QE uses its QE money to buy corporate bonds from a company, its bank deposits move to the company that issue the bond. QE exposure of the bank of the company is measured by the increase in liquidity, not by changes in deposits from non-bank financial institutions.

3.2 The Timing of QE

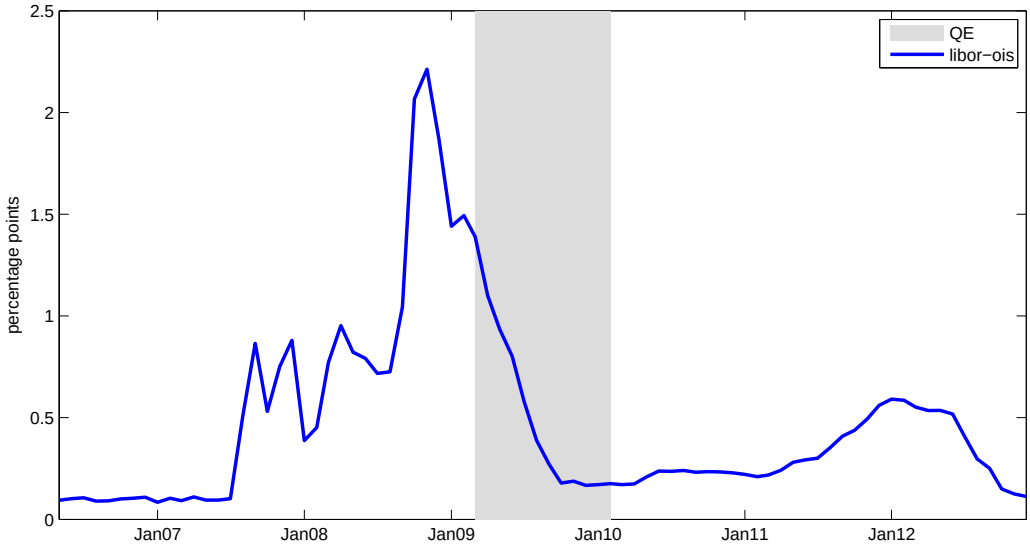
The first round of UK quantitative easing started from March 2009 and ended in February 2010. However, I use a sample from 2009Q2 to 2010Q4 to study the impact of QE on cross-border lending. The sample does not match exactly the timing of QE for two reasons. First, several quarters after the termination of QE are included to the sample to allow cross-border lending to adjust gradually in response to QE liquidity.

Second, 2009Q1 does not seem to be a good base period for studying the lending impact of QE for the reason of the liquidity crunch at the time. As shown in Figure 3, the three-month libor-OIS spread was extremely high since the collapse of Lehman Brothers (September 15, 2008) until 2009 Q2.[12] The interbank market was not functioning, and the banking sector was in a severe liquidity crunch.

[12]An OIS (Overnight Indexed Swap) is a fixed/floating interest rate swap with the floating leg tied to a published index of a daily overnight rate reference, which is usually the Sterling Overnight Index Average (SONIA) for the UK. The libor-OIS spread is the difference between the libor rate and the fixed rate of an OIS with the same maturity. The spread is widely taken as an indicator of interbank liquidity premium.

In the liquidity crunch banks hoard liquidity (Acharya and Merrouche, 2012 and Iyer et al., 2013). For this reason, liquidity positions of banks are less relevant for their lending activities during the liquidity crunch than in normal times. Moreover, using Portuguese loan-level data, Iyer et al. (2013) show that during the crunch liquidity provided by the central bank did not seem to stimulate bank lending. To avoid the complication caused by the liquidity crunch, I use 2009Q2 as the base period. Robustness of the timing is discussed in the next section.

Figure 3: Liquidity Crunch in the Interbank Market during the Financial Crisis



Note: The shaded area indicates the period when the first round of QE was implemented.

4 Results

Descriptive statistics of variables in the baseline estimation are shown in Table 2. Changes in cross-border lending and total foreign claims are very volatile in the period. The standard deviation of the log change in total cross-border lending is 1.88, which is equivalent to a change of 5.55 times. The min and max of log changes in cross-border lending are −9.67

and 12.62. This a very broad range. The log change of foreign claims has similar variations. The mean of log changes in liquidity of the 37 banks is 0.24, which means a 27.1% increase in liquidity. The influence of potential outliers is discussed in the next section.

Table 2: Descriptive Statistics

		Units	Mean	S.D.	Min	Max	Obs
Cross-Border Claims							
	Lending to banks	log diff.	0.19	2.53	-12.25	12.58	1300
	Lending to non-banks	log diff.	0.13	1.55	-10.22	9.86	1908
	Total lending	log diff.	0.20	1.88	-9.67	12.62	2322
	Total claims	log diff.	0.18	1.82	-9.67	12.62	2376
Bank Characteristics							
	QE exposure	log diff.	0.24	1.14	-2.22	4.55	37
	Stable funding	log diff.	0.00	0.51	-1.59	1.00	37
	Size	log	17.58	1.62	14.51	20.88	37

The baseline estimation results are reported in Table 3. The first column shows results for cross-border lending to foreign banks, the second column for lending to foreign non-banks, the third column for total cross-border lending, and the last column for total foreign claims. The impact of QE on cross-border lending is positive and substantial. A one-percent increase in QE exposure leads to a 0.29% increase in total cross-border lending, as shown in the third column. The effect is significant at the 1% level. The effect is also economically significant. A standard-deviation increase in QE exposure leads to a 39.2% increase in total cross-border lending.[13] QE has a greater impact on cross-border lending to foreign-resident banks, than to non-banks. A standard-deviation increase in QE exposure leads to a 68.9% increase in cross-border lending to banks, and a 30.0% increase in lending to non-banks, respectively.

Since demand effects are accounted for by the inclusion of country fixed effects, F_j, the significant impact of QE on cross-border lending suggests a supply side impact of QE. In other words, QE has worked through a bank lending channel. This result is in contrast with the literature on the impact of QE on domestic lending, which usually fails to identify

[13]Since the change is relatively big, I calculate the exact percentage change from parameter estimates. The effect of a standard-deviation increase in QE exposure on total cross-border lending is calculated as $\exp(0.29 \times 1.14) - 1 = 39.2\%$, where 1.14 is the standard deviation of QE exposure.

a significant supply effect. There are two issues that may affect the identification using domestic bank-level data, as in Butt et al. (2014). First, using domestic lending data is difficult to control for demand effects. Second, the domestic demand for loans in the QE period was likely inelastic to borrowing costs. As an extreme example, suppose the demand line for loans is vertical. In this case, the bank lending effect of QE is not identified by linking QE exposure to lending activities.

The international transmission of QE through global banking is also supported by the data. As shown in the last column of Table 3, total claims of UK banks to foreign countries increased in response to higher QE exposure. A standard-deviation increase in QE exposure leads to a 44.0% increase in total foreign claims. It implies that UK-resident banks respond to QE not only by increasing cross-border lending to foreign countries, but also by increasing their holdings of foreign securities. This finding is in line with the literature on the impact of QE and cross-border capital flows (See, e.g., Fratzscher, Lo Duca and Straub, 2013).

Stable funding, which consists of UK-resident deposits and all CDs, has negative effects on cross-border lending after controlling for the change in liquidity. It seems that having better access to deposit financing does not encourage cross-border credit supply. Nevertheless, the size of bank balance sheets has significantly positive effects on cross-border lending. Big banks lent more to foreign residents. The stock of lending prior to QE negatively affects changes in lending during the QE period, which implies that important markets experienced relatively less growth (or more decline) in lending.

5 Robustness

5.1 The Liquidity Crunch

For the reason of the liquidity crunch during the financial crisis, changes in bank balance sheets in 2009Q2 are not considered in the baseline sample, which uses 2009Q2 as the base period for measuring QE exposure and changes in cross-border claims. It is, therefore, interesting to see whether using 2009Q1 as the base period substantially changes the estimation

Table 3: The Impact of QE on Cross-Border Bank Credit Supply

	Bank	Non-bank	Total Lending	Total Claims
QE_i	0.46***	0.23***	0.29***	0.32***
	(0.08)	(0.05)	(0.05)	(0.04)
$FUNDING_i$	-0.64***	-0.01	-0.23***	-0.18**
	(0.21)	(0.08)	(0.09)	(0.08)
$SIZE_i$	0.40***	0.15***	0.24***	0.25***
	(0.05)	(0.03)	(0.03)	(0.03)
$LENDING_{ij}$	-0.27***	-0.13***	-0.20***	-0.19***
	(0.03)	(0.02)	(0.02)	(0.02)
Constant	-4.98***	-1.68***	-2.59***	-2.86***
	(0.82)	(0.47)	(0.50)	(0.41)
fixed effects F_j	yes	yes	yes	yes
R^2	0.15	0.06	0.09	0.09
F	28.9	29.9	44.2	53.9
	(0.00)	(0.00)	(0.00)	(0.00)
Obs	1300	1908	2322	2376
No. country	120	189	197	197

Note: This table reports estimation results for (1). Bank i's exposure to QE, QE_i, is measured by log changes in liquid assets of the bank over the QE period (2009Q2-2010Q4). Changes in four types of foreign claims, ΔL_{ij}, are considered. The first column shows results for cross-border lending to foreign banks, the second column for lending to foreign non-banks, the third column for total cross-border lending, and the last column for total foreign claims. $LENDING_{ij}$ is the log claims of bank i to country j in the pre-QE period. Standard errors are adjusted for country clusters, and reported in parentheses. ** and *** denote significance at the 5% and 1% level, respectively.

results. To this end, I re-estimate (1) using a sample from 2009Q1 to 2010Q4, and report results in Table 4.

The inclusion of 2009Q1 does not qualitatively changes the conclusion, although the estimated impact of QE is weaker than the baseline estimation. The impact is still economically significant: A standard-deviation increase in QE exposure leads to a 18.9% increase in total cross-border lending.[14] The effect is significant at the 1% level. A standard-deviation increase in QE exposure leads to a 25.2% increase in cross-border lending to banks, and a 15.3% increase in lending to non-banks, respectively. Responses of total foreign claims to QE are still significant. A standard-deviation increase in QE exposure leads to a 21.4% increase in total foreign claims.

Table 4: Including the Period of Liquidity Crunch

	Bank	Non-bank	Total Lending	Total Claims
QE_i	0.22***	0.14***	0.17***	0.19***
	(0.07)	(0.03)	(0.04)	(0.04)
$FUNDING_i$	-0.11	0.03	-0.09	-0.03
	(0.17)	(0.09)	(0.09)	(0.08)
$SIZE_i$	0.31***	0.12***	0.18***	0.22***
	(0.06)	(0.03)	(0.03)	(0.03)
$LENDING_{ij}$	-0.29***	-0.16***	-0.21***	-0.22***
	(0.03)	(0.02)	(0.02)	(0.02)
Constant	-3.24***	-1.10***	-1.64***	-2.22***
	(0.89)	(0.48)	(0.51)	(0.46)
fixed effects F_j	yes	yes	yes	yes
R^2	0.11	0.06	0.07	0.07
F	23.5	41.2	42.8	49.2
	(0.00)	(0.00)	(0.00)	(0.00)
Obs	1296	2012	2410	2469
No. country	119	190	196	196

Note: See notes for Table 3. This table reports estimation results for the impact of QE on cross-border bank claims in the period from the end of 2009Q1 to the end of 20104Q4. Compared to the baseline estimation, the base period is changed to 2009Q1.

[14]The standard deviation of QE exposure (log changes in banks' liquidity) is 1.02 for this sample.

5.2 The "Flightiness" of Liquidity

Banks' liquidity positions during the QE period can be "flighty." Butt et al (2014) show that QE-induced increase in deposits to a given bank tends to be short-lived. In other words, liquidity positions of banks during the QE period are volatile. The flightiness may imply that measuring banks' liquidity positions at the end of a given quarter can be a poor estimate for the average change in bank liquidity during the QE period. To account for the problem of the flightiness of liquidity of individual banks, I average banks' liquidity over the pre- and post-QE periods, respectively. And changes in liquidity and foreign claims are calculated as the log differences between the pre- and post-QE averages.

Specifically, the pre-QE period is defined as 2008Q1-2, and the post-QE period is defined as 2009Q3-2010Q4. Quarters between them are intentionally omitted to avoid the problem of liquidity crunch. Table 5 reports estimation results. There are two important differences from the baseline. First, the estimated impact of QE on total cross-border lending and total foreign claims are smaller than the baseline. Banks that have one-standard-deviation higher QE exposure lend 18.9% more to foreign countries.[15] Second, the estimated impact on cross-border lending to banks is still strong, while no impact on lending to non-banks is found. Quantitatively, banks that have QE exposure one standard deviation higher tend to lend 56.3% more to foreign banks. In summary, the impact of QE on cross-border credit supply is confirmed although the liquidity crunch and the flightiness of liquidity seem to have non-negligible effects on the estimated effects.

5.3 Gradual Changes in Cross-Border Lending

As discussed earlier, to allow for cross-border lending to adjust gradually to banks' QE exposure, the end date of the sample in the baseline estimation is set to 2010Q4, three quarters after the termination of QE. To better match the timing of QE-induced changes in bank liquidity, I estimate (1) using instrumental variables. I calculate banks' liquidity changes during the period from June 2009 to the January 2010, and use these changes to

[15]The standard deviation of QE exposure (log changes in banks' liquidity) is 1.44 for this sample.

Table 5: The Flightiness of Liquidity

	Bank	Non-bank	Total Lending	Total Claims
QE_i	0.31***	0.00	0.13***	0.12***
	(0.05)	(0.03)	(0.03)	(0.03)
$FUNDING_i$	0.15	0.15	0.09	0.32***
	(0.11)	(0.11)	(0.08)	(0.08)
$SIZE_i$	0.24***	0.22***	0.18***	0.22***
	(0.04)	(0.03)	(0.03)	(0.03)
$LENDING_{ij}$	-0.28***	-0.17***	-0.21***	-0.21***
	(0.02)	(0.02)	(0.01)	(0.01)
Constant	-2.32***	-2.78***	-1.63***	-2.45***
	(0.75)	(0.58)	(0.50)	(0.46)
fixed effects F_j	yes	yes	yes	yes
R^2	0.17	0.05	0.08	0.08
F	72.4	40.8	61.3	76.1
	(0.00)	(0.00)	(0.00)	(0.00)
Obs	1400	2100	2500	2580
No. country	124	200	206	206

Note: See notes for Table 3. This table reports estimation results for the impact of QE on cross-border bank claims from the pre-QE period (2008Q1-2) to the post-QE period (2009Q3-2010Q4). Quarters between them are intentionally omitted for the problem of liquidity crunch. To account for the flightiness of liquidity, bank liquidity and foreign claims are averaged over the pre- and post-QE periods, respectively.

instrument the QE exposure measure in the baseline estimation.

The instruments are strongly correlated with the measure of QE exposure. The first-state F-statistic is 19.7. Therefore, weak instruments do not seem to be a concern here.

As shown in Table 6, the instrumental estimation results are generally in line with the baseline estimation. Total cross-border lending and total foreign claims respond significantly to QE liquidity. Quantitatively, banks that have one-percent higher liquidity tend to lend 0.17% more to foreign countries. Different from the baseline estimation, however, the instrumental estimation does not find a significant impact of QE on cross-border lending to non-banks, while the impact on lending to banks remains substantial and significant.

Table 6: Gradual Changes in Cross-Border Lending

	Bank	Non-bank	Total Lending	Total Claims
QE_i	0.26**	0.07	0.17***	0.18***
	(0.12)	(0.07)	(0.06)	(0.06)
$FUNDING_i$	-0.54***	0.08	-0.16	-0.09
	(0.21)	(0.09)	(0.10)	(0.08)
$SIZE_i$	0.43***	0.17***	0.25***	0.27***
	(0.05)	(0.03)	(0.03)	(0.02)
$LENDING_{ij}$	-0.27***	-0.14***	-0.20***	-0.19***
	(0.03)	(0.02)	(0.02)	(0.02)
Constant	-5.46***	-1.86***	-2.77***	-3.08***
	(0.79)	(0.45)	(0.52)	(0.40)
fixed effects F_j	yes	yes	yes	yes
R^2	0.14	0.05	0.08	0.08
Wald	109.9	114.7	209.7	209.5
	(0.00)	(0.00)	(0.00)	(0.00)
Obs	1300	1908	2322	2376
No. country	120	189	197	197

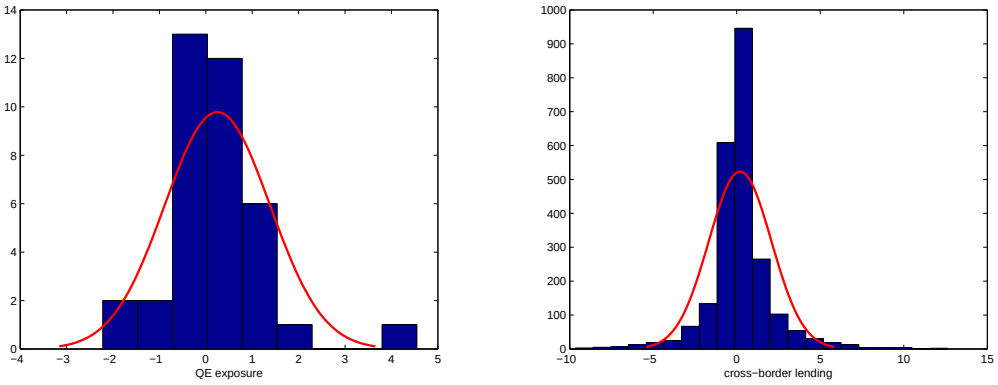
Note: See notes for Table 3. QE_i is instrumented by a variable calculated as banks' liquidity changes during the period from June 2009 to the January 2010. Bootstrapped standard errors are reported in parentheses.

5.4 Outliers

As shown in Table 2, variations in changes in banks' liquidity and cross-border claims are large. Moreover, some observations are distant from the mean. Figure 4 shows histograms

of log changes in liquidity and cross-border lending. It seems that some observations are "extreme" relative to the density from the normal distribution.

Figure 4: Histograms of QE Exposure and Cross-Border Lending



Note: The red lines are fitted normal densities.

To account for undue influence of some extreme observations, I re-estimate (1) using a sample excluding potential outliers. I treat absolute log changes in liquidity greater than 2 as outliers. In other words, banks that experienced a 6.4-time increase or decrease in liquidity are treated as outliers. As a result, 34 banks are left in the sample. I treat absolute log changes in foreign claims greater than 5 as outliers.

Table 7 shows estimation results for the sample excluding extreme observations defined above. Removing extreme observations does not substantially change the main conclusion of the baseline estimation. Total cross-border lending, for example, increases 0.36% resulting from a one-percent increase in QE exposure. The estimated impact of QE on foreign claims is also quantitatively similar to the baseline result.

6 Country Level Evidence

This section studies the impact of QE on banks' foreign claims using country-level data. At the height of the financial crisis, four major economies (the Euro area, Japan, UK and US) employed QE to quiet the financial turmoil and to stimulate the real economy (Fawley and

Table 7: The Influence of Extreme Observations

	Bank	Non-bank	Total Lending	Total Claims
QE_i	0.33***	0.29***	0.36***	0.39***
	(0.09)	(0.04)	(0.05)	(0.05)
$FUNDING_i$	-0.25	0.07	-0.05	-0.03
	(0.15)	(0.06)	(0.07)	(0.07)
$SIZE_i$	0.21***	0.10***	0.13***	0.16***
	(0.04)	(0.02)	(0.02)	(0.02)
$LENDING_{ij}$	-0.13***	-0.08***	-0.09***	-0.10***
	(0.02)	(0.01)	(0.01)	(0.01)
Constant	-2.65***	-1.22***	-1.61***	-2.04***
	(0.69)	(0.38)	(0.38)	(0.34)
fixed effects F_j	yes	yes	yes	yes
R^2	0.08	0.07	0.07	0.08
F	24.6	50.1	41.0	57.0
	(0.00)	(0.00)	(0.00)	(0.00)
Obs	1119	1798	2118	2162
No. country	118	189	194	196

Note: See notes for Table 3. Banks that have QE exposure (the log change in liquidity) greater than 2 are treated as outliers. Absolute log changes in foreign claims that are greater than 5 are treated as outliers.

Neely, 2013). However, QE was implemented with different intensities in the four economies. The Fed and the Bank of England were more enthusiastic about QE than the Bank of Japan and the ECB. The difference in QE strength provides an opportunity to study QE and cross-border bank credit.

So, do banks from countries that experience stronger QE make more (or withdraw less) cross-border lending? To answer this question, I estimate a model as

$$\Delta L_{ij} = \alpha + \beta QE_i + \gamma S_{ij} + \phi' X_i + F_j + \epsilon_{ij}. \tag{2}$$

where ΔL_{ij} is the log change of country i's claims to foreign country j, before and after the implementation of QE; QE_i is the intensity of QE in country i; F_j is a borrower-specific fixed effect; S_{ij} is the log change of lending from country i to j during the financial crisis but before QE;[16] And X_i is a vector of lender's characteristics.

Similar to the bank-level model, there are two advantages. First, it is unlikely that

[16] S_{ij} is included to capture the effect that countries that experienced a more severe shrinkage of cross-

the central bank of country i implements QE based on cross-border lending to a particular country j. Therefore, reverse causality is not a big problem in estimating (2). Second, since multiple countries lend to a foreign country j, it is possible to introduce a borrower-specific fixed effect, F_j, to control for demand effects.

This study uses cross-border lending data of four major economies that experienced QE, namely the Euro area, Japan, UK and US, to 51 developing economies. The list of borrower countries is shown in Appendix A.

As in the case of bank-level data, I define 2009Q2 as the pre-QE period, and 2010Q4 as the post-QE period. Cross-border lending data are obtained from the BIS consolidated banking statistics.[17] L_{ij} capture claims of banks headquartered in country i to a foreign country j. ΔL_{ij} are log changes of foreign claims from the pre-QE to the post-QE period. I measure total foreign claims of banks headquartered in the Euro zone by the sum of foreign claims of banks headquartered in France, Germany, Italy, Netherlands and Spain. I use the size of central bank balance sheets to measure the strength of QE. QE_i is the log change of total assets of central banks during the QE period. Log changes in the balance sheet size of the Bank of England, Bank of Japan, the ECB, and the Fed are $0.14, 0.09, 0.06$ and 0.10, respectively. There are 119 observations for ΔL_{ij}, with mean 0.23, min -2.81, and max 2.71.

I consider two X_i variables, one in a time.[18] The first is country i's GDP growth rate

border lending in the financial crisis may have a stronger rebound when QE was implemented. I use 2007Q1-2 as the base period before the crisis for calculating S_{ij}. Since a more severe shrinkage S_{ij} might motivate a stronger QE_i as counteractive monetary policy, omitting S_{ij} may cause overestimation for β.

[17]Cross-border lending data are foreign claims by nationality of reporting banks (immediate borrower basis), obtained at http://www.bis.org/statistics/consstats.htm. The lending data include foreign claims of banks' own foreign branches and subsidiaries (positions between related offices are netted out). Ideally, measures of foreign claims that capture cross-border claims of all resident banks of the reporting country (including inter-office positions) are more suitable for the study of the impact of QE on cross-border lending, and are more comparable to the bank-level data in this paper. Due to data availability, however, I use consolidated bank statistics instead.

[18]Since we have only 4 QE countries in the sample, variations in QE_i are very limited. For the concern of colinearity, I include one X_i in a time, instead of two variables together.

in 2009, capturing the severity of the crisis in the country. The second is the average three-month libor-OIS spreads of country i during 2008Q3-2009Q2, which measures the severity of the liquidity crunch in the banking sector.

Table 8 reports estimation results. It shows that balance sheet expansion of central banks has significant impacts on cross-border credit supply of banks. Foreign claims of banks headquartered in a country increase by more than 6% in response to a 1% increase in central bank's assets. The estimate is significant at the 1% level. Given the substantial increase of central bank balance sheet during QE, its impact on cross-border credit supply is large. As an example, the 15% increase in the balance sheet size of the Bank of England during the period may have increased foreign claims of bank headquartered in the UK by 131.6%. As we expected, countries that experienced a more severe shrinkage of cross-border lending in the financial crisis before QE have a stronger rebound when QE was implemented.

Table 8: The Impact of QE on Banks' Foreign Claims Using Country-Level Data

	X_i, GDP Growth	X_i, Libor-OIS
QE_i	6.73***	6.06***
	(2.21)	(2.21)
S_{ij}	-0.48***	-0.48***
	(0.17)	(0.17)
X_i	-0.04	0.29
	(0.05)	(0.32)
Constant	-0.53	-0.21
	(0.32)	(0.24)
fixed effects F_j	yes	yes
R^2	0.14	0.14
F	4.8	4.6
	(0.01)	(0.01)
Obs	119	119
No. country	41	41

Note: This table reports estimation results for (2). In the first column, X_i is the GDP growth rate in 2009 of country i. In the second column, X_i is the average libor-OIS rate during the height of the financial crisis (2008Q3-2009Q2). Standard errors are adjusted for borrower country clusters, and reported in parentheses. *** denotes significance at the 1% level.

7 Conclusion

This paper has two main conclusions. First, QE has loan supply effects. Banks that are more exposed to QE extend more loans to foreign residents. A one-percent increase in QE exposure (changes in banks' liquidity) raises cross-border lending by 0.29%. Although the loan supply effect is estimated with cross-border lending data, the unambiguously identified supply effect enables us to infer a similar loan supply impact at home. Second, cross-border banking plays an important role in the international transmission of QE. Banks with higher QE exposure hold more foreign assets. Banks' total foreign claims increase by 0.32% resulting from a one-percent increase in QE exposure.

The identification well accounts for reversal causality and demand effects. The special feature of QE in the UK (the Bank of England purchased assets only from non-bank financial institutions) means that reversal causality is largely avoided. And the fact that multiple UK-resident banks lend to a foreign countries enables us to introduce a borrower-fixed effect to control for demand effects.

Despite these identification advantages, omitted variables can cause biased estimates for the credit supply impact of QE. Ideally, more bank characteristics (for example, capital adequacy and risk exposure) should have been included in the model to control for bank-specific factors that affect cross-border credit supply. The model does not have these variables due to data availability at this moment. An interesting work in the future is to estimate a model with more bank-specific control variables.[19]

Another interesting research following this paper is to study the role of cross-border banking on asset markets of borrower countries during QE. The paper has shown QE encouraged UK-resident banks to hold more foreign assets. The international reallocation of assets has implications on exchange rates and asset markets of recipient countries. It is,

[19]Omitted variables do not seem to be a severe problem. The literature shows that banks' QE exposure is largely determined by their expertise and infrastructure for making large-scale transactions (Butt et al., 2014). It is reasonable to assume that banks' QE exposure is uncorrelated with omitted characteristics, for example, capital adequacy and risk exposure.

therefore, interesting to study how asset reallocation through cross-border banking affects financial markets of recipient countries.

References

[1] Acharya, V. and O. Merrouche, 2012, "Precautionary Hoarding of Liquidity and Interbank Markets: Evidence from the Subprime Crisis," *Review of Finance*, 17(1), 107-160.

[2] Aiyar, S., 2012, "From Financial Crisis to Great Recession: The Role of Globalized Banks," *American Economic Review: Papers and Proceedings*, 102(3), 225-30.

[3] Aiyar, S., C. Calomiris, J. Hooley, Y. Korniyenko and T. Wieladek, 2014, "The International Transmission of Bank Capital Requirements: Evidence from the United Kingdom," *Journal of Financial Economics*, forthcoming.

[4] Bernanke B., 2010, The Economic Outlook and Monetary Policy, Speech at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming.

[5] Bowman, D., F. Cai, S. Davies and S. Kamin, 2011, "Quantitative Easing and Bank Lending: Evidence from Japan," *Working Paper*.

[6] Bowman, D., J. Londono, H. Sapriza, 2011, "US Unconventional Monetary Policy and Transmission to Emerging Market Economies," *Working Paper*.

[7] Butt, N., R. Churm, M. McMahon, A. Morotz and J. Schanz, 2014, "QE and the Bank Lending Channel in the United Kingdom," *Bank of England Working Paper*, No. 511.

[8] Ennis, H. and A. Wolman, 2012, "Large Excess Reserves in the U.S.: A View from the Cross-Section of Banks,", *Federal Reserve Bank of Richmond Working Paper*, No. 12-05.

[9] Fawley, B. and C. Neely, "Four Stories of Quantitative Easing," *Federal Reserve Bank of St. Louis Review*, 95(1), 51-88.

[10] Fratzscher, M., M. Lo Duca and R. Straub, 2013, "On the International Spillovers of US Quantitative Easing,", *ECB Working Paper*, No. 1157.

[11] Jiménez, G., S. Ongena, J. Peydró, and J. Saurina, 2012, "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications," *American Economic Review*, 102(5), 2301-26.

[12] –, 2014, "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk?" *Econometrica*, 82(2), 463-505.

[13] Iyer, R., J. Peydro, S. da-Rocha-Lopes, A. Schoar, 2014, "The Interbank Liquidity Crunch and the Firm Credit Crunch: Evidence from the 2007-09 Crisis," *Review of Financial Studies*, 27(1), 347-372.

[14] Joyce, M., D. Miles, A. Scott and D. Vayanos, 2012, "Quantitative Easing and Unconventional Monetary Policy–An Introduction," *Economic Journal*, 122(564), F271-F288.

[15] Joyce, M. and M. Spaltro, 2014, "Quantitative Easing and Bank Lending: A Panel Data Approach," *Bank of England Working Paper*, No. 504

[16] Kashyap, A. and J. Stein, 2000, "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" *American Economic Review*, 90(3), 407-428.

[17] Khwaja, A. and A. Mian, 2008, "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market," *American Economic Review*, 98(4), 1413-42.

[18] Krishnamurthy, A. and A. Vissing-Jørgensen, 2011, "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy," *NBER Working Paper*, No. 17555.

[19] Rogers, J., C. Scotti and J. Wright, 2014, "Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Cross-Country Comparison," *Working Paper*.

Appendix A: List of Borrower Countries

The borrower countries considered in the analysis using country-level data are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Suriname, Uruguay, Venezuela, Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Russia, Slovakia, Slovenia, Turkey, Ukraine, Armenia, Azerbaijan, Bangladesh, China, Georgia, India, Indonesia, Kazakhstan, Kyrgyz Republic, Mongolia, Myanmar, Pakistan, Philippines, South Korea, Srilanka, Chinese Taipei, Tajikistan, Thailand, Turkmenistan, Uzbekistan, and Vietnam.