The Risk-Taking Channel of Monetary Policy and Foreign Banks

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Abstract

In this paper, I examine heterogeneity in the bank risk-taking channel of monetary policy using a sample of 208 domestic and foreign-owned banks from 22 OECD countries. I introduce a simple, static model advanced by Dell'Ariccia and Marquez (2013) to detail the theoretical underpinnings of this monetary policy transmission channel. I document the existence of the risk-taking channel of monetary policy and, in the main contribution of this paper, I examine whether this transmission channel has heterogeneous effects on foreign-owned versus domestic banks. I find consistent evidence that foreign banks take less risk than domestic banks following a monetary policy easing, which is robust to a variety of risk measures. The results suggest that in tranquil periods, foreign banks are more insulated from the monetary policy conditions of their host country, but that this advantage disappears during crisis periods. The ability of foreign-owned banks to access to parent bank funding via internal capital markets is the most convincing explanation for the differential response to a policy rate reduction.

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1 Introduction

Since the run up to the Global Financial crisis in the late 2000's, the relationship between monetary policy and bank risk has garnered a renewed interest. A central tenet of research on monetary policy has focused on analyzing the link between central banks setting the policy rate and how banks respond to changes in that rate. More specifically, the 2008-2009 crisis spurred a renewed interest in understanding how the low interest rate environment in the run-up to the crisis impacted a bank's risk-taking behavior. While a large amount of literature has been written on how policy rate changes impact bank lending, the attention paid to the quality of these loans has gained a renewed emphasis in the past decade. With the benefit of hindsight, a growing body of literature has put forth a risk-taking channel of monetary policy and contends that the too-low interest rate environment played a fundamental role in the run-up to the crisis (Taylor, 2009; Maddaloni and Peydró, 2011; Stein, 2013) . As interest rates have persisted at all-time lows in the post crisis era, understanding how monetary policy impacts a bank's propensity to take on risk has been brought to the forefront of economic policy debate.

Borio and Zhu (2012) bring attention to this channel of monetary policy and put forth a speculative and exploratory examination of this channel that may manifest itself in three ways. The first is the impact of interest rates on asset valuation and income. Lower interest rates boost collateral value and may increase income, which in turn modifies how banks perceive risk and measure default probability. Secondly, there may be a search-for-yield effect, which occurs through the interaction of market rates and target rates-of-return (Rajan, 2005). For institutions that need to meet some target rate-of-return to fulfill their coming liabilities, prolonged periods of low yields, which are a consequence of lower interest rates, may induce banks to take on more risk in order to meet these obligations. Finally, there may be an effect that works through central bank communication. In particular, with clear and transparent commitment to policy decisions, central banks can compress risk premia. Since the run up to the crisis, and with policy rates staying at low levels in the post crisis era, this transmission channel has been examined both theoretically and empirically, and the literature has found overwhelming evidence of the existence of this channel.

In addition to recent periods of prolonged low interest rates, the past two decades have seen an unprecedented degree of financial integration and globalization. Foreign presence has been

increasing steadily in the banking sector in the past 20 or so years, with a modest interruption during the crisis in 2008-09. One of the distinctive and important features of foreign bank subsidiaries is the intra-bank relationships of affiliates and parent banks. These relationships have been studied for a wide variety of reasons, but the intra-bank channel of particular interest in this paper is the ability of foreign affiliates to buffer adverse host country conditions by relying on parent banks for transfers of liquidity and capital. Empirical studies have provided evidence of such relationships by comparing the lending behaviors of foreign and domestic banks (Wu et al., 2011; De Haas and Van Lelyveld, 2010), while other studies have relied on qualitative, in-depth interviews with high-level bank directors and managers (De Haas and Naaborg, 2005). Whereas adverse host country monetary-policy conditions have significant lending impacts on domestically owned banks, foreign banks do not change lending standards or pull back lending due to host-country monetary policy conditions. The results of this paper provide additional evidence on whether these channels exist by examining the link between risk-taking and ownership structure.

The goal of this paper is to find if and how a reduction in the short-term policy rate impacts a bank's willingness to make risky loans and to determine whether there are heterogeneous responses between foreign and domestic banks. Rajan (2005) discusses the implications of financial uncertainty in the context of monetary policy. The main point of the search-for-yield impact of a policy rate reduction is that prolonged periods of low yields on short-term assets makes it less likely that a financial institution will be able to meet its long-term obligations. This creates some uncertainty of whether or not the bank will be able to pay back its liabilities and thus may be induced to take on more risky assets, so as to yield a higher return if the loan pays back. In this paper, I provide an empirical examination on whether the risk-taking channel of monetary policy operates differently between foreign and domestic banks. Existing literature has provided strong evidence between low interest rates and the willingness of banks to increase their tolerance for risk (see, for example, Gambacorta (2009), Altunbas et al. (2010)), but thus far, little attention has been paid to how bank ownership may influence this channel. As mentioned earlier, internal capital markets allow for foreign affiliates to access capital from parent banks. In this paper, I will examine if these relationships allow for foreign banks to have a differential response to accommodative monetary policy than domestic banks. Low interest rates provide an incentive for banks to maximize their returns by increasing risk, but foreign banks' ability to access capital from parent banks provide

an alternative method for meeting their financial obligations. The results of this paper provides evidence on whether there are heterogenous effects of the risk-taking channel of monetary policy between foreign and domestic banks.

Using quarterly balance sheet data for 208 banks in the 22 OECD countries from 1995 to 2013, I contribute to the literature in the following ways. First, I document the existence of the risk-taking channel that has been supported by the past literature. Secondly, and most importantly, I document the heterogeneity of the risk-taking channel by showing that foreign banks are less inclined to take on risky loans during a monetary policy easing.

The rest of this paper is organized as follows. The next section I review the related literature, and section 3 presents a model introduced by Dell'Ariccia and Marquez (2013) to provide an illustration of how bank risk-taking is impacted by the policy rate. Section 4 presents the data used in the analysis, and section 5 goes over the main econometric specification and discusses the results. Section 6 concludes.

2 Literature Review

In the past decade, a large and growing literature has studied the theoretical underpinnings of this channel and examined the empirical evidence. In the remaining part of this section, I will summarize the main papers that relate to this channel, as well as some literature documenting evidence of internal capital in foreign banks.

2.1 Literature on Bank Risk-Taking Channel

As mentioned previously, the risk-taking channel operates through how banks perceive risk and through a search-for-yield mechanism. Low interest rates influence bank perceptions of risk by changing how banks measure risk. This is due to the inverse relationship between interest rates and asset prices, as asset valuation is dictated by expected future returns. Thus, lower interest rates correspond to higher asset prices and collateral value, which in turn modify how a bank perceives the risk of a given loan. On the other hand, a reduction in the interest rate has the potential to incentivize bank owners and managers to take on more risk. This is the the core of the search-for-yield effect of low interest rates discussed in Rajan (2005). Lower interest rates correspond to lower

rates of return and banks are more tolerant of risk because they can charge higher interest rates on these loans. Altunbas et al. (2010) analyze the risk-taking channel using a database of quarterly balance sheet measures for banks in the US and Europe and find consistent evidence of the existence of a bank risk-taking channel, even when controlling for bank specific characteristics and using a host of different measures for bank risk. Using a similar dataset, Gambacorta (2009) looks at how bank risk changes with a specific emphasis on the global financial crisis. The author finds that in the run up to the crisis, banks that faced relatively low interest rates for a prolonged period of time, measured by a country's number of consecutive quarters below a benchmark policy rate[1], experienced a higher expected default probability during the crisis. While controlling for bank-specific characteristics as well as country-specific macroeconomic conditions, Gambacorta (2009) finds that if interest rates were held below the benchmark for 10 consecutive quarters, the bank's probability of going into default increased by 3.3%. Dell'Ariccia et al. (2010) provides a theoretical foundation for this channel, which will be explored in the following section. The main finding is that the net effect of a monetary policy change on how much a bank monitors its portfolio, a measure of bank risk, is dependent on the pass-through of the policy rate to the lending rate, a risk-shifting effect and a leverage effect. The effects are dependent upon the ability of a bank to adjust its capital structure, as well as the capitalization level of the bank. Seeberg (2015) analyzes the risk-taking channel in Norway and creates a risk measure for each bank using the ratio of the sum of the total risk-weight lending to all industries to the total amount of lending to all industries. The author finds evidence of the bank risk-taking channel, but when dividing the sample by commercial, savings and foreign banks, Seeberg (2015) finds that foreign banks and savings banks do not see a significant impact in their risk-taking following a monetary policy easing.

The bank risk-taking channel has also been examined by looking at a bank's ranking and pricing of individual loans. Ioannidou et al. (2015) look at the pricing and ranking of new loans in Bolivia from 1999 to 2003. Bolivia is almost fully dollarized, but its economy is not synchronized with that of the US economy, which allows for changes in the federal funds rate to be interpreted as exogenous changes in monetary policy. The authors find that lower monetary policy rates in the US translate to a riskier bank portfolio. When the federal funds rate decreases, they observe that

[1]The authors measure the benchmark policy rate as the policy rate implied by a 'Taylor' Rule, as well as the natural rate of interest which is defined as the smoothed trend from a Hodrick-Prescott filter of the rate.

loans are more likely to be granted to ex-ante observable riskier borrowers. In a similar fashion, Jiménez et al. (2014) uses loan-level data from the Spanish credit registry to show the existence of the bank risk-taking channel. They find that a lower overnight interest rate induces banks to make loans that are more likely to default.

2.2 Literature on Internal Capital Markets

This paper is also related to literature on foreign banks and internal capital markets. These areas of literature have garnered an increased interest in recent years due to an unprecedented level of financial integration and low interest rates. The internal capital markets hypothesis relates to multinational banks and posits that foreign subsidiaries are able to access capital from parent companies that insulate them from adverse host county conditions. The ideal situation to understand internal capital markets would involve data on intra-bank transfer data, so empirical evidence has had to rely largely on indirect evidence of this internal relationship. The exception to this, however, is De Haas and Naaborg (2005) who conduct interviews with managers of multinational banks to document the existence of the internal capital markets hypothesis. In examining these intra-bank channels, they find that when subsidiaries struggle to raise funding, their parent banks can transfer capital or liquidity in exchange for shares or debt titles. In other words, foreign banks have access to alternative sources of finance that are not accessible by domestically owned banks, which allow them to better deal with adverse host-country conditions. There are a large number of studies that rely on bank balance-sheet data to document these intra-bank relationships as well. Wu et al. (2011) examine the heterogeneity of the lending channel of monetary policy with respect to foreign and domestic banks and find strong evidence of internal capital markets. The authors find consistent evidence that foreign banks are less responsive to monetary policy shocks by analyzing the loan granting behavior of banks. Gambacorta (2005) examines the bank lending channel and finds that this transmission channel of monetary policy is muted among banks affiliated with multinational banks. They interpret this as evidence of internal capital markets, suggesting these banks are much "larger" than what their total size indicates, insofar as it pertains to their ability to deal with policy induced shocks. Cetorelli and Goldberg (2008) find that evidence supporting the bank-lending channel and show that this channel exists only for those banks that are domestically-owned without international operations. They interpret this as evidence of internal capital markets, where foreign

subsidiaries are able to smooth the effects from host country conditions.

While the topics of bank risk-taking and ownership structure have been examined with great scrutiny separately, there is a limited amount of literature on how these two topics connect. There are two papers that have looked at bank-risk taking with specific respect to ownership structure, and these papers lead to different conclusions. In Chen et al. (2017), they use a sample of over 1000 banks in 29 emerging economies and document the existence of the risk-taking channel. They control for a host of bank-specific and macroeconomic indicators over this time frame, but mention that while controlling for foreign-ownership, they realize "The impact of foreign ownership on financial stability still lacks consensus." In this sample of emerging economies, they find that foreign bank ownership increases the risk of the bank, as measured by the bank's Z-score, but do not test whether the transmission channel varies by foreign or domestic banks. Buch et al. (2014) use survey data from the US Survey of Terms of Business Lending on quarterly reports from 1997-2008. Using a factor-augmented vector autoregression model, they confirm the existence of the risk taking channel and find that foreign banks only increase their risk after domestic banks, and when interest rates were "low for too long." One explanation for this delayed response could be that internal capital markets may play a role in insulating foreign banks from the risk-taking channel, but that this insulation can only be sustained for a certain amount of time. That is, if a monetary policy easing constrains the ability of a bank to meet its liabilities, a foreign parent can provide capital and liquidity for some set amount of time or quantity, but if the adverse conditions continue, the parent bank is less willing to help. This paper contributes to the literature by providing a comprehensive look at the bank risk-taking channel in a set of 22 OECD countries and how it operates alongside ownership structure. Using a sample of quarterly balance-sheet data on 208 foreign and domestic-owned banks, I provide an examination of the risk-taking channel from 1995 to 2013.

3 A Model of the Risk-Taking Channel

3.1 The Dell'Arricia and Marquez (2013) Model

In this section, I will introduce a simple, static model advanced by Dell'Ariccia and Marquez (2013) that identifies the theoretical framework for the bank risk taking channel. In addition, I will extend

the intuition of the search-for-yield channel to foreign and domestic banks, which is where the main hypothesis of this paper emerges.

In this model, loans are the only type of asset and they need to be monitored in order to increase the probability of repayment. We assume a fixed demand for loans, L, so long as the lending rate does not exceed a fixed value of R. The interest rate on loans is r_L and we can think of R as the borrower's reservation rate. In other words, R is the maximum amount the borrower would be willing to pay in interest rate for the loan. Now, bank loans are a risky asset and the bank is endowed with a monitoring technology which allows the bank to exert a monitoring effort, q. We can think of q as the probability of loan repayment. There is a cost, however, to the monitoring technology which is equal to $\frac{1}{2}cq^2$. The degree of risk-taking by a bank will depend on its incentive to monitor its loans.

Next, we look at how a bank finances its loan portfolio. A bank's loan portfolio can be financed through deposits or through the bank owner/manager's money. Let k represent the fraction of bank loans financed by equity, and $1-k$ represent the fraction financed by deposits. In this model, k is set exogenously, so banks do not adjust their capitalization levels in response to a change in r^*. Financing a portfolio of loans is costly. First, we look at the cost of deposits. Banks are protected by limited liability, so they only repay depositors in the case of success. Deposits are uninsured, so depositors must be compensated for the bank's risk taking. In other words, depositors are risk neutral because they want an expected return on deposits equal to the risk-free rate. We let r^* be the economy's reference rate in real terms, which for simplicity can be understood as the real risk-free interest rate. Depositors do not observe q, because that is chosen after deposits are raised, but can observe k and can infer the bank's equilibrium monitoring behavior, $\hat{q}$. Given the opportunity cost, r^*, depositors demand a repayment, r_D, such that $r_D E[q|k] = r^*$, or $r_D = \frac{r^*}{E[q|k]}$. Now, from a bank's perspective, given a quantity of loans L and a capital ratio k, a total of $(1-k)L$ deposits will be raised. The total expected cost of deposits will then be $(1-k)L\frac{r^*}{E[q|k]}$. The other cost for a bank's loan porfolio comes from the fraction of loans financed through equity. The cost of equity financing, r_E, can be interpreted as the opportunity cost for the bank owner/manager investing in the bank, adjusted to reflect the bank's risk. We define $r_E = \frac{r^*+\xi}{q}$, with $\xi \geq 0$. The term ξ represents an equity premium.

Now, given a fixed r^*, a bank chooses the rate at which it loans money and then decides how

much to monitor its portfolio. A bank's expected profits can be written as

$$\Pi = \left(q \left(r_L - r_D \left(1 - k \right) - r_E k \right) - \frac{1}{2} c q^2 \right) L. \tag{1}$$

The bank profit per unit is driven by the return on lending, r_L, while it incurs costs from deposits $r_D(1-k)$, costs from equity financing $r_E k$, and the cost of monitoring $\frac{1}{2}cq^2$. When the portfolio fails, the owner receives no revenue, but because of limited liability, the depositor receives no money. Because $r_E = \frac{r^* + \xi}{q}$, we can rewrite equation 1 as

$$\Pi = \left(q \left(r_L - r_D \left(1 - k \right) \right) - \left(r^* + \xi \right) k - \frac{1}{2} c q^2 \right) L. \tag{2}$$

Now, taking the partial derivative with respect to q, we can show that profits are maximized with respect to q as

$$\hat{q} = \min\{ \frac{r_L - (1-k) r_D}{c}, 1 \}. \tag{3}$$

This immediately shows the variety of effects that a change in the interest rate, r^*, has on the level of monitoring a bank chooses. The interest rate affects both the asset and liability side of a bank's balance sheet. First, there is pass-through effect that operates through r_L, the interest rate the bank charges on loans. An increase in the interest rate increases the yield that a bank receives on its loans (r_L), which would induce banks to increase monitoring, because the return on safe assets and the cost of borrower defaults are both higher. Put differently, a reduction in r^* decreases yields on all assets and reduces the cost of a risky asset not paying back, thus decreasing the incentive to monitor. Losses on risky assets do not cost as much when interest rates are lowered, so banks may be induced to take on more risk in search for higher yield. The impact of r_L on a bank's choice of q is called the pass-through effect. Additionally, there is an opposing force through r_D, the cost of deposits, which is called the risk-shifting effect. A monetary policy reduction reduces the cost of deposits, because r_D decreases. When the cost of deposits decreases, the expected profit for a bank increases, so the incentive to make risky loans could decrease. Finally, there is a leverage effect through $1-k$ where the more leveraged a bank is, the less incentive it has to take on risk. In other words, the more that a bank funds its portfolio by deposits, the more incentive it has to take on risk.

We can now show how a change in the real interest rate will affect a bank's choice of q. If we take $\hat{q}$ and plug into equation 2, we can solve for the lending rate by choosing to set profits equal to zero in the perfect competition setting. After doing this, we find that

$$r_L = r_D(1-k) + \sqrt{2ck(r^* - \xi)}. \tag{4}$$

To find the optimal monitoring rate, we can then plug equation 4 into equation 2 and solve for q^*. It can be shown that

$$q^* = \sqrt{\frac{2k(r^* + \xi)}{c}}. \tag{5}$$

From this, it is evident that an increase in $r*$ would increase a bank's level of monitoring (i.e $\frac{\partial q^*}{\partial r^*} > 0$). That is, for a monetary easing, a bank would choose a lower level of monitoring and thus, take more risk. We have shown that a bank's choice of monitoring depends on three factors - the pass-through effect, a risk-shifting effect, and a leverage effect, and that a bank's monitoring level increases with r^*. I now extend the logic to show how foreign banks may depart from foreign banks in this transmission channel.

3.2 Extension to Foreign Banks

We have shown that there are several different factors that change a bank's monitoring effort - the pass-through effect through r_L, a risk-shifting effect through r_D, and a leverage effect through $1-k$ - and that q is increasing with r^*. Regarding foreign and domestic banks, it may be the case that we see differential responses, which can be more clearly seen when looking at the model under an alternative form. There are two lenses through which we can understand the differential response. I look at the ability of foreign banks to insulate themselves from monetary policy shocks as well as how maturity mismatch in banks may also benefit foreign banks.

First, the risk-taking channel might have less of an impact on foreign banks due to the widely recognized ability of foreign banks to insulate themselves from the monetary policy conditions of the host country. Buch et al. (2014) find that in the risk-taking channel of monetary policy, loan supply effects dominate loan demand effects. That is, the combination of increased loan volumes and reductions in loan rates suggest that loan supply effects are the driving factor of the

risk-taking channel. Moreover, they find that foreign and large banks do not increase their lending activity during policy rate reductions, suggesting that foreign banks can isolate their lending activity from monetary policy shocks. Because foreign banks are not subject to the same loan supply effects of a monetary policy reduction, they do not experience the same risk-taking channel that a small, domestic bank is subject to. Cetorelli and Goldberg (2012) document similar behavior in foreign banks and show that foreign banks are able to insulate themselves from the monetary policy conditions in the host economy. Moreover, they provide direct evidence of active internal capital markets between the parent bank and foreign subsidiaries, which affects the lending behavior of the subsidiary in the host economy. Because foreign bank lending does not respond similarly to domestic bank lending, and Buch et al. (2014) document that the risk-taking channel is driven in large part by an increase in the supply of loans, I hypothesize that foreign banks are insulated from the risk-taking channel of monetary policy. The literature has reached a strong consensus that multinational bank lending is less responsive to host country monetary policy conditions, and while this is not the primary purpose of this paper, it does help form an understanding of why the risk-taking channel might be different for foreign banks. That is, because foreign bank lending is less impacted by monetary policy, the riskiness of a foreign bank's loan portfolio would change less following a policy rate reduction.

Secondly, we can also understand this channel in the context of bank balance sheets. In the discussion thus far, we have operated under the assumption that financial intermediaries can react instantaneously on both the asset and liability sides to changes in the interest rate. However, some financial institutions may be constrained by contractual obligations that restrict their ability to adjust their outstanding assets and liabilities to changes in interest rates. A monetary easing reduces the yield on adjustable-rate short-term bank assets (short-term loans). The bank receives a lower yield on its assets as well as any new loans it makes. If low rates persist for a prolonged period of time, banks may not be able to meet their fixed-rate liabilities. This leads to risk taking because a switch to riskier short-term assets increases the probability of meeting its obligations, conditional on the loans successfully repaying. This effect would depend critically on how the maturity of a bank's balance sheet is structured. Landier et al. (2011) present related evidence in the case of opposite balance sheet maturity mismatch, where a mortgage lender's assets were paid with fixed rates, while they were financed by variable rates. When the Federal Reserve started tightening

monetary policy in 2004, the lender responded by increasing its risk. The simple model described earlier can be modified to account for this effect.

An alternative, but equivalent way of describing this model is that banks have access to a continuum of portfolios characterized by a parameter $q \in [0, 1]$, such that the probability of the portfolio's success is q and the return is $r_L - \frac{1}{2}cq^2$. A higher choice of q implies that a higher probability that the loan would repay (i.e a less risky investment). We otherwise assume everything else is exactly the same - the banks are financed by a fraction k equity and $1 - k$ of debt. Lower q implies a higher return conditional on success, but lower probability of success overall. Under this interpretation of the model, we may see that foreign banks may have a differential response to a change in r^*. Consider the case where a bank has fixed rate liabilities to meet. When banks have to meet their fixed-rate liabilities after a reduction to low interest rates, the logic of the search-for-yield channel would dictate an increase in risk-taking to be able to meet these liabilities. While this is certainly true for domestic banks, foreign bank subsidiaries have an additional source of meeting these liabilities through receiving funding from their parent bank. This intra-bank relationship is the core of the internal capital markets hypothesis that states when a subsidiary requires capital, the parent bank provide inexpensive capital for the subsidiary in exchange for new shares, and, when a subsidiary requires liquidity, the parent bank can provide liquidity in exchange for debt titles. When banks have to meet fixed liabilities, but they have seen a reduction in yields due to low interest rates, domestic banks may take on more risk to meet these liabilities, while foreign banks can at least partially rely on parent bank funding to meet their liabilities. This alternative method of financing liabilities may allow for foreign bank subsidiaries to be somewhat buffered from the risk-taking channel of monetary policy.

The global nature of foreign-owned banks offers them unique benefits which allow them to insulate themselves from monetary shocks in the host country through isolating their lending behavior. Even in the case of maturity mismatch, we would expect to see the risk-taking channel of monetary policy to be less strongly felt by foreign banks.

4 Data

To empirically examine the risk-taking channel and the heterogeneity based on ownership, I use a sample of 208 banks in 22 different OECD countries. I use quarterly balance sheet data from 1995 to 2013. In examining the risk-taking channel, quarterly data is preferred to annual data because it is more appropriate for measuring the short-term impact of monetary policy on the risk-taking behavior of a bank. Balance sheet data on banks is downloaded from Capital IQ and all macroeconomic indicators are downloaded from the OECD statistical database. In the rest of this section, I detail the variables used in the analysis and present descriptive statistics of the final dataset.

4.1 Variables

4.1.1 Bank Risk

The first task in analyzing the bank risk-taking channel is to compose a measure of bank risk. A commonly used metric in examining bank risk is a bank's Z-score (Roy, 1952). Formally, the Z-score is expressed as

$$Z - Score = \frac{ROA + EA}{\sigma_{ROA}}$$

where ROA represents return on assets, EA represents the equity asset ratio, and σROA is the standard deviation of the return on assets. This variable has been used widely in this area of literature (Chen et al., 2017; Laeven and Levin, 2009; Brandao-Marques et al., 2018; Andries et al., 2015). The Z-score measures the distance from insolvency and can be interpreted as the number of standard deviations by which returns would need to fall in order for the bank to lose all of its equity. Thus, a higher bank Z-score indicates a higher level of financial stability or put a different way, a lower bank's Z-score indicates a higher risk of insolvency. In terms of the risk-taking channel, I would expect a higher Z-score to be correlated with tightening of monetary policy, as a higher Z-score indicates a lower probability of insolvency. For each bank in each quarter, I calculate the Z-score using the balance-sheet data from Capital IQ on the sample for 1995-2013. Following the studies of Chen et al. (2017) and Schaeck and Čihák (2010), I use a three-year rolling window to

calculate the standard deviation of the return on assets. Using a rolling window to calculate the standard deviation allows the Z-score to be driven by changes in the variation of the denominator, not just the levels of ROA and EA for a given year.

While the Z-score is a commonly used metric of bank-risk, there are other variables that I test in order to gain a comprehensive understanding of how interest rates influence bank risk. In particular, I use the ratio of non-performing loans to total loans, as well as the allowance for loan loss ratio as dependent variables for measures of bank risk. First, the ratio of non-performing loans to total loans which reflects the quality of a bank's loan portfolio. In the short term, a reduction in interest rates may decrease this rate if the borrowers have a variable rate loan. In the longer term, however, if the bank extends loans to more risky borrowers, we may see this proportion increase because if the risky loans do not pay back. I also use the loan loss allowance ratio of a bank. A bank is required to set aside money to account for loans that do not pay back. A bank's loan loss allowance is an accounting measure that sets aside a certain amount of money and reflect how the bank perceives the riskiness of its loan portfolio. If a bank makes a large amount of risky loans as interest rates get lower in order to get higher yields, we might expect them to put aside larger sums of money in order to account for the riskiness of their portfolio.

4.1.2 Monetary Policy

The main independent variable in the risk-taking channel of monetary policy is a measure of expansionary versus contractionary monetary policy. I consider the first difference in the short-term interest rate. I download all data for short-term interest rates from the economic indicators published on the OECD website. For each country, the short-term rates are defined as the rates at which "short-term borrowings are effected between financial institutions or the rate at which short-term government paper is issued or traded in the market." The short-term interest rates give an appropriate and common measure of monetary policy across countries (Chen et al., 2017; Kaminsky et al., 2004). In this case, the OECD records the data using three-month money market rates, which correlates closely with the prime rate. Formally, the first difference for the short-term

rate is expressed as

$$\Delta i_t = i_t - i_{t-1},$$

which measures the change in the short-term rate from the previous quarter. In this case, a positive value would indicate a monetary tightening, as the short-term rate in the quarter t is greater than the policy rate in quarter t-1. The coefficient on this variable will reflect the immediate response of bank-risk to a monetary tightening, but it may be the case that there is a delayed effect on bank risk such that banks do not immediately adjust their loan portfolio to the previous quarter's short-term rate change. In particular, the study conducted by Buch et al. (2014) finds that foreign bank organizations in the US only adjust their loan portfolio after domestic banks, which suggests that the risk-taking channel may have a delayed effect particularly on foreign banks. To take into account for the delayed reaction of bank risk-taking, I define

$$\Delta i_{t-1} = i_{t-1} - i_{t-2},$$

which accounts for the change in the federal funds last quarter.

4.1.3 Foreign Ownership

In order to perform the empirical analysis, it is also necessary to classify banks according to foreign ownership. I use the Claessens and Van Horen Bank Ownership Database (Claessens and Van Horen, 2014), which is a publicly available database that classifies over 5,000 banks from 1995 to 2013 by their country of ultimate ownership. This is advantageous because Capital IQ gives ownership data only for the most recent year, while this database tracks ownership over time. This also acts as the main constraint on the sample of banks I use in the empirical analysis, because the bank specific data which Capital IQ has does not correlate well with the availability of the ownership data, and hence why the sample size is reduced to approximately 200 banks.

4.2 Data Description

In the remaining part of this section, I will describe some attributes of the dataset. Table 1 presents summary statistics of some of the main variables used in the analysis broken down by foreign versus domestically owned banks. This table consists of quarterly observations from 1995 to 2013. While these statistics vary within each country, this table can do a reasonably good job of describing the overarching trends in the dataset. First, there are some important data-availability notes. As mentioned earlier, this paper will consider a variety of measures for bank-risk. However, some balance sheet items are not available as regularly as the Z-score, which is constructed from two commonly available measures. In particular, the ratio of non-performing loans to total loans and the loan loss allowance ratio greatly reduce the sample size. As best as I can tell, some variables are considered to be generally reported variables, while others, like the non-performing loans ratio, are considered to be supplementary variables. These variables appear to be available more regularly for larger banks, which means that it reduces the sample in a non-random way. Thus, the econometric results for these variables may not generalize which is an important consideration in interpreting the results. Beyond this, there are some interesting statistical differences between domestic and foreign banks. First, there are significant differences between the Z-score and the non-performing loans ratio between foreign and domestic banks. Foreign banks have a higher average Z-score, as well as lower non-performing loans ratios. Moreover, they have a lower loan loss allowance ratio. The loan loss allowance is an expense set aside for loans that do not repay, and can be interpreted as how the bank perceive the risk of its portfolio. This measure is given as a negative value in the data, but I transform it into a positive value for ease of interpretation. A larger loan loss allowance indicates a higher share of money set aside by the bank to account for loans that do not pay back. Based on these values, it appears that foreign banks may be less risky than foreign banks. Second, foreign banks are significantly larger than domestic banks, as proxied by the natural logarithm of total assets. This is not unexpected as, by definition, foreign banks in the US are part of a multinational banking system and likely have experience and large sources of funding in establishing their presence in a foreign country. Moreover, this is relevant for the purposes of this analysis because this may make banks fall into the "too-big-to-fail" effect of risk-taking. In particular, because foreign banks are so large, they may feel that their importance in the banking

Table 1: Descriptive Statistics

	Domestic			Foreign		
Variable	Mean	SD	N	Mean	SD	N
Return on assets	0.5	1.47	6573	0.47	1.24	581
Equity-asset ratio	6.67	3.58	6573	6.51	3.6	581
Short-term rate	2.39	2.06	6573	2.65	2.18	581
Z-score	18.38	16.84	6573	19.93	15.38	581
Log of Total Assets	10.59	2.17	6573	10.84	1.24	581
Log of Total Current Liabilities	10.18	2.25	6573	10.49	1.38	581
Non-performing Loans to Total Loans	2.65	3.42	3893	1.86	1.5	327
Loan Loss Allowance to Gross Loans	1.98	2	5535	1.44	1.15	481

Note: Table 1 reports descriptive statistics on observations from 1995 to 2013, broken down by ownership. Columns (1) - (3) give statistics for domestically owned banks, while columns (4) - (6) report results for foreign owned banks. SD stands for standard deviation and N represents the total number of observations.

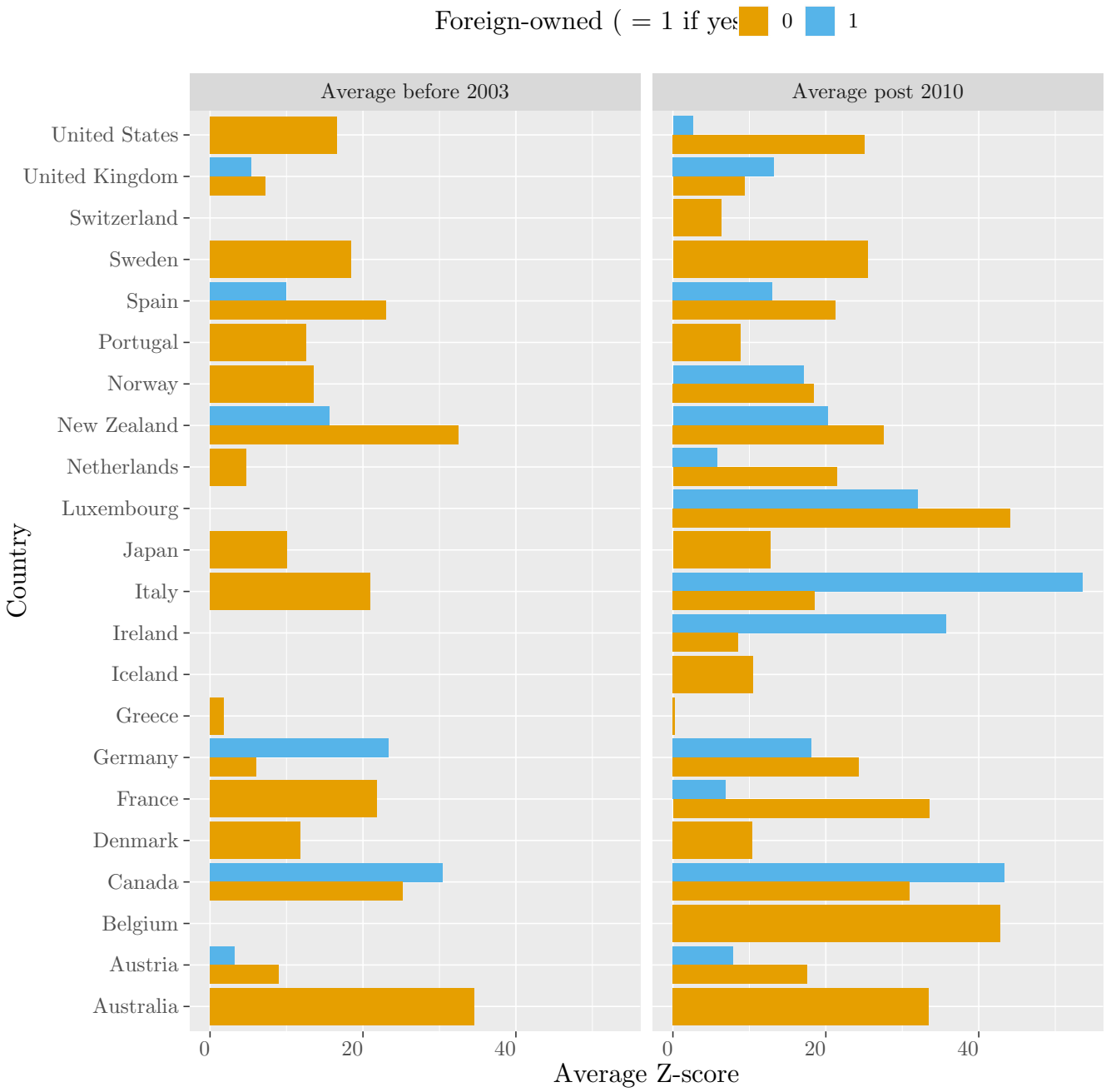
system will force parent banks or the host country government to bail them out in the case that they have trouble meeting their loans. Finally, foreign banks have a significantly smaller amount of total liabilities, which may reflect more conservative banking strategies by foreign banks.

While these statistics are useful to understand static differences in foreign versus domestic banks, it does not account for differences between countries, nor how these variables change over time. In the remaining part of this section, I will present descriptive statistics on how bank risk, as measured by Z-score, varies by country and over time. In figure 1, I plot the average Z-score for foreign banks compared to domestic banks for each of the countries in the sample in two distinct periods. On the left hand-side, the average Z-score for each type of bank is plotted using the average Z-score before 2003. On the right hand side, the bar chart plots the same data but uses observations for only quarters after 2010. This allows us to make some descriptive observations about how bank risk is distributed among foreign versus domestic banks by country and over time. There is not a clear trend in how bank-risk is distributed among foreign versus domestic banks. For example, in the US, foreign banks are, on average, much riskier than domestic banks, but this trend is reversed completely in Italy. Other countries, like Germany and the UK, have fairly similar levels of risk between foreign banks and domestic banks. There is a wide variation not only in the average Z-score for a particular bank in a given country, but also in the composition of banks within each country. This figure does not detail the composition of banks for a given country, but it is

clear that in countries like Portugal and Japan, there are only domestic banks from these countries in our sample.

There is also substantial variation between these two periods, which give an informative representation of the Z-scores in the beginning of our sample period and after our sample period. One immediate observation is that the observations of foreign banks increase over time. In the earlier years of the sample, there are more countries that have only domestic bank observations than countries with both types of banks. this is indicative of the increasing globalization and financial integration of the international financial system. Another interesting dynamic in this data is that foreign bank risk does not shift uniformly across time and within countries. For example, in Germany, foreign banks appear to be substantially less risky in the earlier time frame, but have a lower Z-score in the later period. Conversely, foreign banks in Canada have a higher average Z-score throughout the entire sample period. These time varying and static descriptions of bank risk indicate substantial variation in foreign bank risk-taking between countries and across time. However, given the relatively small sample size, these measures are quite noisy.

Figure 1: Average Z-score for Foreign and Domestic Banks



5 Empirical Strategy and Results

5.1 Econometric Model

The main goal is to identify what, if any, effect foreign ownership has on the risk-taking channel, but there a variety of other factors that influence a bank's risk-taking, including bank-specific variables as well as macroeconomic conditions. The general econometric model is estimated as follows

$$\begin{aligned} Risk_{i,t,k} = \alpha Risk_{i,t-1,k} + \beta_1 MP_{t,k} + \beta_2 OWN_{t,k} + \beta_3 (MP_{t,k} * OWN_{i,t,k}) + \\ \eta_1 MP_{t-1,k} + \eta_2 (MP_{t-1,k}, * OWN_{i,t,k}) + \\ \gamma_1 BankChar_{i,t-1,k} + \gamma_2 (BankChar_{i,t-1,k} * OWN_{i,t-1,k}) + \\ \lambda_1 Macro_{t,k} + \lambda_2 (Macro_{t,k} * OWN_{i,t,k})) + \omega D_i + \nu D_t + \mu_{i,t,k}, \quad (6) \end{aligned}$$

where i indexes bank, t indexes the quarter-year, and k indexes country. $Risk$ is the measure of bank-risk, and I include a lagged measure of the risk-variable, $Risk_{i,t-1,k}$, which accounts for the persistence of the bank risk variable from the previous quarter. This means that the bank-risk measure could be affected by the previous quarter's level of bank-risk. MP is the measure of monetary policy and OWN is an indicator variable for whether or not a bank i was foreign owned at time t in country k. A significant coefficient on MP would provide evidence of the existence of the risk-taking channel. When using the first difference as the monetary policy indicator, a positive and significant coefficient would imply that for a tightening of monetary policy in the previous quarter, a bank would become less risky, as measured by a higher Z-score. Put another way, after a monetary policy easing, a bank would expect to become riskier. The indicator variable, OWN, controls for the baseline difference in risk caused by foreign ownership. As seen in the previous section, it appears that foreign banks are less risky in the overall sample, but this is not a characteristic that is uniformly shared when looking across different countries. I include an interaction term between the monetary policy variable and ownership. This is the variable of interest in this paper and it accounts for heterogeneity in the risk-taking channel between foreign and domestic banks. If foreign bank risk-taking responds differently to a change in monetary policy, this variable will indicate that with a significant coefficient.

5.1.1 Heterogeneous Effects

The coefficient on the interaction between foreign ownership and the change in monetary policy will indicate whether or not there is heterogeneity in the risk taking channel. In this section, I will show explicitly why this is the case. To see how an interaction term between a binary variable and a continuous variable allows me to test for heterogeneous effects, I consider a simpler version of the model, set up as

$$Y_{i,t,k} = \beta_0 + \beta_1 D_{i,t,k} + \beta_2 X_{t,k} + \beta_3 (D_{i,t,k} * X_{t,k}) + u_i, \tag{7}$$

where D is a dummy variable for ownership, X is the monetary policy change, and Y is the risk measure for a bank i at time t in country k. As in regular ordinary least squares regression, β_1 represents the difference in means between the two groups of banks, foreign and domestic banks. Similarly, β_2 represents the expected change in risk for a 100 basis point increase in the policy rate. The interaction term between D_i and X_i allows the effect of a change in the policy rate on bank risk to depend on whether the bank is foreign owned or not. To see this mathematically, we can compute the conditional expectation for each of the subgroups.

Say we are interested in analyzing how the expected change in risk for a domestic bank following a monetary policy change. Recalling that D is a dummy variable equal to one if a bank is foreign-owned, we could express the expected value for a domestic bank risk as

$$E\left(Y_{i,t,k} | D_{i,t,k} = 0\right) = \beta_0 + \beta_2 X_{t,k} \tag{8}$$

because for domestic banks, $D_{i,t,k} = 0$. Similarly, we can express the expected foreign bank risk as

$$\begin{aligned} E\left(Y_{i,t,k} | D_{i,t,k} = 1\right) &= \beta_0 + \beta_1 + \beta_2 X_{t,k} + \beta_3 X_{t,k} \\ &= (\beta_0 + \beta_1) + (\beta_2 + \beta_3) X_{t,k}. \end{aligned} \tag{9}$$

We can see immediately that that by including the interaction term we allow the slope and intercept of the regression function to vary. We can interpret the differences in the sample by looking at equation 8 and 9. The difference in the intercept between the two equations is β_1, which we know is the mean difference in bank risk between foreign and domestic banks. Secondly, the difference in

the slope is β_3. To directly test whether there is a differential effect of the monetary policy variable X, on bank risk, Y, based on whether the bank is foreign-owned, we would test the significance of the coefficient on the interaction term, β_3. If there is no additional effect on foreign-owned banks in the risk-taking channel, then we would say that $\beta_3 = 0$, and the expected bank risk for foreign banks could have a different intercept, but would have the same slope. Thus, the difference in how a monetary policy change effects bank risk may depend on whether banks are foreign-owned or not, and I test this directly by looking at the significance of the coefficient on the interaction term. This simple example can be extended to control for more covariates and more interaction terms, which have been laid out in equation 6.

5.1.2 Covariates

The previous sections have laid out the main variables of interest, but there are a host of other concerns that arise in this regression, including the possibility of lagged effects and omitted variable bias. The rest of this section will be dedicated to detailing how I overcome these challenges.

Based on the work done by Buch et al. (2014), it may be the case that foreign banking organizations in the United States have a more delayed reaction to the risk-taking channel. That is, perhaps it is the case the foreign banks are able to rely on parent bank support, but when policy rates are low for too long, parent banks are less willing to help out and foreign banks take on the same risk as similar domestic banks. To control for this potential delayed reaction of foreign banks, I include a lag of the monetary policy measure and its interaction with the ownership indicator. This allows for the heterogeneity in the bank risk-taking channel to vary based on ownership, as well as with respect to time.

Bank specific variables also have some effect on a bank's risk taking. To account for this, I include a vector of bank-specific controls, $BankChar_{i,t-1,k}$, which include a bank's size, liquidity and capitalization. I use the 1-quarter lagged values for each of these variables in order to account for the endogeneity between bank-specific values and a bank's level of risk. First, to proxy for bank size, I use the natural logarithm of total assets. One reason larger banks may differ from smaller banks in the risk-taking channel is that large banks may increase their risk appetite when they have a "too big to fail" belief (Afonso et al., 2014). That is, larger banks may believe that they are too important to the banking sector to fail, and that in the case where they needed to be bailed

out, the federal government would step in and help them. Additionally, there may be heterogeneity between banks with different levels of liquidity, which is measured here by the ratio of liquid assets to nonliquid assets. A bank with higher levels of liquid assets can more easily deal with maturity mismatch (Sarmiento and Galán, 2014). Finally, a bank's equity-asset ratio is included in order to measure the level of a bank's capitalization. An important note here is that when running the regressions where the Z-score is the dependent variable, I do not include the equity-asset ratio, because the Z-score is a function of this variable. The capitalization of a bank is an inverse measure of bank leverage and has been found to have a negative relationship with risk-taking. For example, Delis and Kouretas (2011) analyze the risk-taking behavior of banks and find that well-capitalized banks are less likely to take on more risk. I also include a series of macroeconomic variables that will control for how the prevailing macroeconomic conditions affect the risk-taking behavior of banks. In particular, output and prices are proxied by real GDP growth and the inflation rate. I include bank fixed effects which account for variation in bank-risk taking that remain constant over time but differ by bank. Bank-specific fixed effects also accounts for differences in countries. Controlling for bank-varying characteristics includes the macroeconomic variables of that country. The bank fixed effects would actually absorb the country-fixed effects if they were to be run with both. By including bank fixed effects, I control for not only the individual differences in banks that remain constant over time, but also for the differences in countries. I have documented that the share of foreign banks and the risk-taking measures vary considerably by country, so including bank fixed effects accounts for the differences in countries that remain constant over time.

5.2 Main Empirical Results

In Table 2, I present the results from the benchmark regression by estimating equation 6. I use a bank's Z-score as the respective measure of bank risk and the first difference in short term interest rates as the monetary policy measure. I include results for various specifications of this benchmark model by showing results with and without year fixed effects, as well as with and without the bank specific characteristics.

The results in table 2 show consistent evidence of a bank risk-taking channel across all specifications of the benchmark model. The coefficient on the change in monetary policy is positive and significant, which indicates that for an 1% increase in the short-term interest rate, we expect

the average bank to increase its Z-score (decrease its risk) by between 0.2 and 0.4, depending on the specification used. This coefficient is significant and positive across all specifications, but its economic importance should be understood relative to the average Z-score, which is around 18 and 19 for foreign and domestic banks. We also find that the lagged change in monetary policy has no significant effect, suggesting that, at least for domestic banks, there is no evidence of a delayed response to a policy rate change.

The main result of this table, however, are the coefficients on the interaction terms between monetary policy and the change in interest rate. First, I find that foreign banks respond less strongly than domestic banks to a reduction in the interest rate. The interaction term between foreign bank ownership and the change in the policy rate is negative and statistically significant at the 1% level across all specifications, which indicates that foreign banks are less responsive to monetary policy. Following a reduction in interest rates, we would expect foreign banks to have a significantly higher Z-score than domestic banks. I also find that foreign bank risk-taking also responds significantly and in the opposite way to a change in the interest rate in the previous quarter, suggesting that the buffering effect of monetary policy by foreign banks can only be sustained for a certain amount of time. The coefficient on the lagged changed in interest rates, the change from 2 quarters ago to the previous quarter, is significant and positive across all specifications which shows that foreign banks have a more responsive, but delayed reaction to an interest rate change 2 quarters ago. These trends remain consistent through all the specifications, even when introducing additional bank-specific controls and interacting these bank controls with foreign ownership. This allows for the transmission channel to have heterogenous responses between bank types, based on their size and liquidity, and even after controlling for this, I find that foreign banks have significantly different response to domestic banks in both their immediate and delayed response to a monetary policy change.

These findings imply that foreign banks take less risk than foreign banks in the immediate response to a monetary policy easing. When interest rates decrease, domestic banks increase riskiness, whereas foreign banks are able to buffer this effect. Interest rate reductions decrease the yield on assets, and in response, domestic banks increase their risk appetite by significantly more than foreign banks. This is evidence consistent with the presence of a risk-taking channel with heterogeneous effects on foreign banks, other than balance sheet characteristics and macroeconomic

conditions. This can be interpreted as evidence of internal capital markets, where foreign banks are insulated from the risk-taking channel, due to multiple reasons. It may be because they are not as worried about meeting liabilities, due to their ability to access funding from parent banks should they not be able to pay back deposits. However, it is also the case that foreign banks have a delayed and more significant response to a monetary policy easing two quarters ago. This suggests that foreign banks are insulated from monetary policy effects for only a limited amount of time, but that a monetary policy easing eventually affects them in the same way, perhaps because funding from parent banks are limited in supply. It could also be interpreted as the ability foreign banks are able to isolate their lending patterns from the monetary policy conditions, due to their ability to access liquidity from parent banks during adverse monetary policy conditions. The important takeaway from these results is that the risk-taking channel incurs banks to take on more risk, but foreign banks are not impacted in the same way.

These results show that not only is the bank risk-taking channel prevalent in this sample of OECD countries, but that its effects are heterogeneously distributed between banks of different ownership structure. In order to test the robustness of these results, I employ a variety of additional tests which include controlling for crisis periods and utilizing various measures of bank risk.

5.2.1 Alternative Measures of Bank Risk

There are a wide variety of measures employed in the literature that measure the effects of bank risk, other than Z-score. In this section, I will test the benchmark specification with alternative measures for bank risk. In particular, I will consider the ratio of non-performing loans to total loans as well as the allowance for loan losses ratio.

As mentioned earlier, alternative measures of bank risk reduce the sample size greatly, and it appears to be in a non-random way. Thus, these estimates should be interpreted with caution. First, I use the ratio of nonperforming loans to total loans as an alternative measure of bank risk. This measures how effective a bank is in receiving payments on its loans. If the bank risk-taking channel exists, then banks would extend loans to riskier borrowers following a reduction in interest rates. The effect on the nonperforming loans ratio may increase following a monetary policy easing if the riskier borrowers have trouble paying back the loans. However, it may also be the case that an interest rate reduction decreases this ratio, depending on if existing borrowers have adjustable

Table 2: Main Regression Results

	Dependent Variable: Z-score		
	(1)	(2)	(3)
Z-score lag	0.523***	0.519***	0.508***
	(0.008)	(0.008)	(0.007)
MP change	0.362***	0.311***	0.207**
	(0.081)	(0.080)	(0.086)
MP change * Own	−1.414***	−1.290***	−1.318***
	(0.269)	(0.266)	(0.263)
Own	1.537***	17.059***	12.657***
	(0.481)	(2.656)	(2.664)
MP Change lag	−0.090	−0.122	−0.089
	(0.079)	(0.078)	(0.087)
(MP Change * Own) lag	0.822***	0.781***	0.754***
	(0.257)	(0.254)	(0.251)
Size		−0.837***	−1.304***
		(0.088)	(0.104)
Liquidity		−0.068	−0.067
		(0.054)	(0.054)
Size * Own		−1.289***	−1.031***
		(0.203)	(0.202)
Liquidity * Own		0.067	0.066
		(0.054)	(0.054)
Real GDP	3.278***	8.117***	5.221***
	(0.348)	(0.573)	(0.858)
Inflation rate	−0.152***	−0.186***	−0.117**
	(0.053)	(0.052)	(0.052)
Bank FE	Yes	Yes	Yes
Year FE	No	No	Yes
Observations	6,753	6,753	6,753
R^2	0.452	0.467	0.483
Adjusted R^2	0.435	0.449	0.465

Note: Table 2 reports regression results from equation 6. Each column uses Z-score as dependent variable. Column (1) includes only macroeconomic controls, and no year fixed effects, while (2) adds bank controls. Column (3) reports the regression when including all FE and all controls. Robust standard errors in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

rate loans and end up having to pay lower interest rates, which would make them less risky. I also use the allowance for loan losses to gross loans dependent variable. Alternative measures, such as provisions for loan losses, reduce the sample size in such a way that there would be no foreign bank observations, so I choose the loan loss allowance ratio as the final alternative measure of bank risk. The allowance for loan loss ratio is defined as the loan loss allowance share of total loans. Loan loss allowances are reserves set aside as an accounting measure in order to account for defaults on assets. If a bank's loan portfolio is viewed as risky, then there would be a larger loan loss allowance set aside. Because of accounting conventions, the loan loss allowances are reported as strictly negative values, but I transform them into positive values for ease of interpretation. A larger loan loss allowance corresponds to a higher amount of reserves set aside for loans that the bank will not correct. Loan loss allowances are set ahead of time as they account for the probability of future losses. This means that we are measuring bank risk as bank's perceive their own risk, which may be influenced in different ways by an interest rate reduction. For example, following an interest rate reduction, a bank that makes loans to more risky borrowers may not perceive them as riskier because their perceptions of default probability have changed. Lower interest rates increase collateral value, and this may modify how banks model the riskiness of a borrower, which in turn may not be reflected in the loan loss allowance reserves. Thus, the influence of an interest rate reduction on bank risk may not have as strong of an effect on loan loss allowances. The results for estimating equation 6 with these new measures of bank risk are reported in Table 3.

These results immediately indicate two main things. First, these results provide additional evidence of a risk-taking channel by using two alternative measures of bank risk. The coefficient on the monetary policy variable is significant in all specifications and negative which indicates that for a tightening of monetary policy, banks would have lower ratios of non-performing loans and set aside less money for loans that don't repay. However, due to the availability of the data, these regressions are run on samples with substantially less observations. The sample is reduced by nearly 50% for the regression using non-performing loans ratio as the dependent variable and by over 20% when using the allowance for losses. Nevertheless, the coefficient on the change in monetary policy largely remains significant and of the expected sign to indicate the risk-taking channel. For a 1 percent reduction in the policy rate, we expect to see the non-performing loan ratio to increase by around 0.1 percentage points, and the allowance for loan loss ratio to increase by 0.4 percentage

Table 3: Alternative Bank Risk Measures

	Non-Performing Loans		Allowance for Loan Loss	
	(1)	(2)	(3)	(4)
Non-performing loans lag	0.919***	0.917***		
	(0.020)	(0.022)		
Allowance for loan loss lag			0.861***	0.859***
			(0.054)	(0.056)
MP change	−0.115***	−0.095***	−0.040**	−0.042**
	(0.026)	(0.025)	(0.017)	(0.018)
MP change * Own	0.107*	0.110*	0.071**	0.068**
	(0.064)	(0.061)	(0.032)	(0.032)
Own	0.183	0.048	0.613	0.089
	(0.739)	(0.717)	(0.676)	(0.556)
MP change lag	−0.008	0.050*	−0.061***	−0.021
	(0.025)	(0.027)	(0.022)	(0.016)
(MP change * Own) lag	−0.075	−0.078	−0.038	−0.026
	(0.055)	(0.058)	(0.045)	(0.044)
Bank FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Observations	3,460	3,460	5,506	5,506
R^2	0.864	0.866	0.737	0.741
Adjusted R^2	0.858	0.859	0.725	0.727

Note: Regression includes bank specific characteristics as well as macroeconomic indicators, which are not reported for succinctness. MP Change refers to the change in the short term interest rate. Columns 1 and 2 report the results using the non-performing loans ratio as the dependent variable, and columns 3 and 4 use the allowance for loan losses as the dependent variable. All columns include the other bank covariates, including bank size and liquidity. Bank capitalization (equity-asset ratio) is not included in this set of regressions, because the dependent variable, Z-score, is a function of the equity-asset ratio. Columns 1 and 3 do not include yearly dummies, while columns 2 and 4 include year fixed effects. Robust standard errors in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

points. Similarly, to the estimates reported in Table 2, there is no evidence of a delayed risk-taking channel where banks respond to the previous quarter's change in monetary policy.

The main result from this table are the interaction coefficients. Even with a reduced sample size, the results show strong evidence of heterogeneity in the risk-taking channel. The results indicate that foreign banks respond differently to a monetary policy reduction, and this differential response is consistent with the evidence provided in Table 2. With regard to the non-performing loans ratio, the coefficient on the interaction term is significant at the 10% level in both specifications. The coefficient has a positive sign, which indicates that for a monetary policy reduction, or a negative change in the policy rate, I would expect to see foreign banks to have a more muted response with respect to risk taking. In particular, a reduction in the policy rate by 1% basis points increases the non-performing loan ratio, but when we account for foreign banks, this effect is completely offset. In the third and fourth columns, I find that this intuition is similar when looking at the effect of a policy rate reduction on the amount of money that foreign banks set aside for loan losses. A monetary policy reduction increases the amount that banks set aside in preparation for loans that they won't collect, but when we account for foreign bank responses, we find a completely opposite effect. However, the lagged effect lose significance in some of these specifications and when interacted with the ownership indicator, it loses significance in all specifications. This suggests that while the contemporaneous effect of a monetary policy change on bank risk holds up to tests of various risk measures, the lagged effect has a more ambiguous effect and the results of the lagged effect in Table 2 should be understood carefully. That said, taking all of these results together suggests that there is a risk-taking channel and accounting for the heterogeneity of this channel with foreign ownership is an important component to understanding how policy rate contemporaneously changes impact the quality of a bank's loan portfolio. In order to further examine this channel, I run additional tests by decomposing the sample into crisis and non crisis periods.

5.2.2 Crisis and Non-Crisis Periods

Thus far, there is strong evidence for the risk-taking channel in this sample of banks from 1995 to 2013 and the differential response of foreign banks to a monetary policy change. However, one area that has yet to be explored in this paper is how crisis periods interact with the risk-taking channel and especially with foreign banks. While the year fixed effects control for the mean differences

in the risk variable for recession and expansionary periods, the sub-sample results will show how monetary policy affects risk in different time periods. Breaking the sample down into crisis and non-crisis periods might yield different results. During financial crises, banks generally incur more risk and central banks usually lower the policy rate. So, there might be a high correlation in crisis periods between a lower interest rate and increased bank risk, but this relationship might be due to overall rise in systemic risk, rather than the search for yield channel that has been analyzed previously.

In order to classify crisis periods, I use the dates provided by Laeven and Valencia (2018). These authors construct an indicator for if a country was in a crisis for each year from 1970 to 2017. I use the indicator for systemic bank crises as the variable to control for how the crisis period effects a bank's risk level. I run the regressions using Z-score as the dependent variable and conduct a subsample analysis in the crisis and non-crisis periods. The results are presented in Table 4.

In column 1, the results show how the risk-taking channel operates in tranquil periods. The results are similar to the results presented earlier. Following a 100-basis point monetary policy reduction, we would expect to see a bank's Z-score drop by 0.377 points, which indicates a higher probability of bank insolvency. The coefficient on the interaction term between the monetary policy change and ownership variable allows for the effect of changing the short-term rate to depend on ownership structure. The results in column 1 indicate that the effect of a monetary policy reduction foreign bank risk has an opposing effect, which confirms the evidence on the heterogeneous effects of this transmission channel. The results in column 2 show the same regression, but including only the years for which a country was indicated to be in banking crisis. The results tell an entirely different story than what was found earlier. While the coefficient on the monetary policy variable is still positive, it is not significantly different than zero. Similarly, the coefficient on the interaction between foreign ownership and monetary policy is still negative, but not significantly different than zero. The contemporaneous change in risk following a policy rate reduction no longer has an effect on banks in general, and foreign banks do not respond differently in crisis periods. These results suggest that this transmission mechanism of monetary policy most clearly operates during tranquil periods. During crisis periods, policy rate reductions have a less clear effect because banks already experience such a high level of risk and a policy rate reduction has a less strong effect on how much risk a bank is willing to take.

Table 4: Crisis versus Non-Crisis Period Results

	Dependent Variable: Z-score	
	Non-Crisis	Crisis
	(1)	(2)
Z-score lag	0.471**	0.712***
	(0.190)	(0.048)
MP change	0.377***	0.005
	(0.137)	(0.112)
MP change * Own	−1.030**	−1.800
	(0.408)	(2.154)
Own	0.657	−7.892
	(1.623)	(14.384)
MP Change lag	−0.261**	0.046
	(0.111)	(0.087)
(MP Change * Own) lag	0.571	0.573
	(0.403)	(0.570)
Bank FE	Yes	Yes
Year FE	Yes	Yes
Observations	5,656	1,097
R^2	0.465	0.347
Adjusted R^2	0.443	0.271

Note: Columns 1 and 2 report the regression results separately for the set of observations in the tranquil periods (column 1) and crisis periods (column 2). In both regressions, bank fixed effects, year fixed effects and other bank covariates are included in the regression results. Bank capitalization (equity-asset ratio) is not included in this set of regressions, because the dependent variable, Z-score is a function of the equity-asset ratio. Robust standard errors are in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

5.3 Discussion

The results thus far have documented strong evidence of the risk-taking channel and how foreign banks are insulated from this effect. A policy rate reduction contemperaneously increases the level of risk a bank faces when looking at a bank's Z-score, non-performing loans ratio and allowance for loan losses ratio. When I allow this effect to depend on whether the bank is foreign owned, I find that foreign banks experience an opposite effect, such that following a policy rate reduction, foreign banks do not take on more risk. Again, these results hold up when looking at different measures of bank risk. However, this effect is isolated to tranquil periods and the mechanism disappears during crisis periods.

The most convincing explanation for this response is the internal capital markets hypothesis, which way manifest itself in multiple ways. Buch et al. (2014) show that the risk-taking channel is dominated by loan supply effects for small and domestically owned banks. What this means is that following a policy rate reduction, loan volumes increase and lending rates fall. Supply effects are an important feature in this transmission channel because how a bank lends following a policy rate reduction will determine its level of risk. For example, following a monetary policy easing, a the risk-taking channel of monetary policy would imply an increase in risk-taking for a variety of reasons mentioned earlier - change in risk perceptions, a search-for-yield effect, or because of central bank communication. These effects all depend on if a bank makes new loans following a policy rate reduction. If a bank is able to insulate its lending behavior from the policy rate reduction, then a bank would experience less risk than it otherwise would. This paper's purpose is not to examine the lending channel of monetary policy, as has been done quite extensively, but there is strong evidence that foreign banks respond less strongly in terms of lending than domestic banks (Wu et al., 2011; Arena et al., 2006; Li and Lee, 2015). Internal capital markets may also play a role in the case that a foreign subsidiary is unable to meet its liabilities, and the parent bank provides liquidity instead of having the foreign bank seek a higher yield through risky loans.

As a whole, the most convincing explanation for the heterogeneity in this channel is the internal capital markets hypothesis, through which parent banks can reallocate funds to foreign offices, so that the lending behavior of the foreign bank does not depend on the host country monetary policy conditions and can rely on parent banks if it needs liquidity. This serves as the most convincing

reason for the results seen throughout this paper, in which foreign banks can isolate their lending from monetary policy conditions and the typical incentives to take on risk, which depend on the policy rate being lowered and the bank making new loans, is significantly lessened for this group of banks.

6 Conclusion

The results indicate that the risk-taking channel is present in this sample of 22 OECD economies, and the effect of foreign ownership through the risk-taking channel has a consistent and opposite effect on bank risk. I find that the risk-taking channel operates strongly in normal times, but when we subset the sample into observations only in crisis periods, the effect of a policy rate reduction has no significant impact on bank risk. The results hold up once looking at a variety of risk measures, and I find that foreign bank risk does not increase as much as domestic banks following a policy rate reduction when looking at a bank's Z-score, non-performing loan ratio, and allowance for loan loss ratio.

The most convincing explanation for this behavior is the ability of foreign banks to insulate their lending from the monetary policy conditions in the host country and provides an additional source of funding for banks to meet their liabilities. In this paper, I have tested and provided direct evidence of heterogeneous effects of the risk-taking channel. Because foreign bank lending is less impacted by monetary policy in the host country, the risk-taking channel is less strongly felt by foreign banks, because it depends on how banks lend.

The existence of the risk-taking channel has increasingly important policy consequences, especially with the recent periods of prolonged interest rates. With central banks in Europe and Japan crossing the zero-lower bound in recent years, understanding how the quality of a bank's loan portfolio evolves with respect to the short term interest rate is crucial to maintaining financial stability. Interest rates since the financial crisis have stayed at low and negative rates for quite some time and policy makers should take into account the relationship between interest rates and bank risk when making policy rate decisions. Moreover, the recent and rapid globalization of the financial world demands that we account for heterogeneous effects of policy rate changes on banks depending on ownership structure. Foreign bank subsidiaries have different ownership structures,

are sometimes subject to different regulations (for example, foreign banking organizations in the US may accept deposits of any size from foreigners, but only deposits excess of $100,000 from U.S. citizens), and may be opened for different reasons in different regions (Claessens et al., 2001). Thus, it is of vital significance to understand if and how the monetary policy decisions of a country have different impacts on foreign and domestic banks.

My paper documents risk-taking channel and its heterogeneous effects on foreign banks on a sample of 208 banks in 22 OECD countries. The research into monetary policy and its effects on bank risk is an exciting area for future studies. I restricted my sample to only countries in the OECD; however, the operations of banks and particularly how multinational banks operate in different regions of the world vary greatly (Van Horen and Claessens, 2012). Examining if and how heterogeneity in risk-taking channel operates in different regions presents itself as an exciting area for future research. Depending on data availability, an additional method for understanding this channel should look at the riskiness of new loans following a policy rate change, rather than the loan portfolio as a whole. This would give a more accurate representation of the way a policy rate reduction impacts how a bank perceives loans. In a world where negative policy rates are becoming increasingly common and interest rates are remaining at low levels for unusually long periods of time, having a concrete grasp of how these changes impact banks and transmit to the economy is of crucial importance.

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