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THREE ESSAYS ON CREDIT MARKETS AND THE MACROECONOMY

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THREE ESSAYS ON CREDIT MARKETS AND THE MACROECONOMY

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Business and Economics at the University of Kentucky

By
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ABSTRACT OF DISSERTATION

THREE ESSAYS ON CREDIT MARKETS AND THE MACROECONOMY

Historically, credit market conditions have been shown to impact economic activity, at times severely. For instance, in the late 2000s, the United States experienced a financial crisis that seized domestic and foreign credit markets. The ensuing lack of access to credit brought about a steep decline in output and a sluggish recovery. Accordingly, policymakers commonly take steps to mitigate the effects of adverse credit market conditions and, at times, conduct unconventional monetary policy once traditional policy tools become ineffective. This dissertation is a collection of essays regarding monetary policy, the flow of credit, financial crises, and the macroeconomy. Specifically, I describe monetary policy's impact on the allocation of credit in the U.S. and analyze the role of upstream and downstream credit conditions and financial crises on international trade in a global supply chain.

The first chapter assesses the impact of monetary policy shocks on credit reallocation and evaluates the importance of theoretical transmission mechanisms. Compustat data covering 1974 through 2017 is used to compute quarterly measures of credit flows. I find that expansionary monetary policy is associated with positive long-term credit creation and credit reallocation. These impacts are larger for long-term credit and for credit of financially constrained firms and firms that are perceived as risky to the lender. This is predicted by the balance sheet channel of monetary policy and mechanisms that reduce lenders' risk perceptions and increase the tendency to search for yield. Furthermore, I find that, on average, the largest increases in credit creation resulting from monetary expansion are to firms that exhibit relatively low investment efficiency. These estimation results suggest that expansionary monetary policy may have a negative impact on future economic growth.

The second chapter evaluates the quantitative effects of unconventional monetary policy in the late 2000s and early 2010s. This was a period when the traditional monetary policy tool (the federal funds rate) was constrained by the zero lower bound. We compute credit flow measures using Compustat data, and we employ a factor augmented vector autoregression to analyze unconventional monetary policy's impact on the allocation of credit during the zero lower bound period. By employing policy counterfactuals, we find that unconventional monetary policy has a positive and simultaneous impact on credit creation and credit destruction and these impacts are larger in long-term credit markets. Applying this technique to analyze the flows of financially constrained and non-financially constrained borrowing firms, we find that unconventional monetary policy operates through the easing of collateral constraints because these effects are larger for small firms or those with high default probabilities. During the zero lower bound period, we also find that unconventional monetary policy brings about increases in credit creation for firms of relatively high investment efficiency.

The third chapter pertains to the global trade collapse of the late 2000s. This collapse was due, in part, to strained credit markets and the vulnerability of exporters to adverse credit market conditions. The chapter evaluates the impact of upstream and downstream credit conditions and the differential effects of financial crises on bilateral trade. I find that upstream and downstream sectors' needs for external financing is negatively associated with trade flows when the exporting or importing country's cost of credit is high. However, I find that this effect is dampened for downstream sectors. I also find that downstream sectors' value of collateral is positively associated with trade when the cost of credit is high in the importing country. High downstream trade credit dependence coupled with high costs of credit in the importing country also cause declines in imports. There are amplifying effects of credit costs for sectors that are highly dependent on external financing when the importing or exporting country is in financial crisis. Further, the magnitude is larger when the exporting country is in financial crisis. Finally, I find that these effects on trade flows are large when the exporting country is a developed economy, but they are muted for developing economies.

KEYWORDS: Credit Constraints; Credit Reallocation; Financial Crisis; International Trade; Monetary Policy Transmission; Zero Lower Bound

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THREE ESSAYS ON CREDIT MARKETS AND THE MACROECONOMY

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Date: August 3, 2018

I dedicate this dissertation my son, Jacob Marc Bianco, who was taken from this world far too soon.

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Chapter 1 Introduction

In the late 2000s, the U.S. experienced a severe financial crisis, which had far-reaching impacts on economic activity. In the U.S., the tightening of credit markets caused a deep and prolonged recession. Other developed economies experienced similar declines in output, including collapses in international trade due to strained credit conditions domestically and abroad. Accordingly, extraordinary policy steps were taken to ease financial markets and unfreeze credit markets. Beyond traditional monetary policy, the Federal Reserve and other Central Banks provided further accommodation through forward guidance and large-scale asset purchases.

A large body of literature has emerged regarding monetary policy's impact on certain macroeconomic outcomes. Still, little is known about how traditional and unconventional monetary policy tools impact the allocation of credit of borrowing firms. Macroeconomic theory suggests that monetary policy will impact the composition of borrowing firms' credit and lenders' loan portfolios. In this dissertation, I analyze the impact of traditional and unconventional monetary policy on the flows of credit of borrowing firms. In addition, I describe the impacts of the cost of credit, vulnerability of sectors to upstream and downstream credit conditions, and financial crises on international trade.

In the first chapter, I examine the role of monetary policy on the allocation of credit among borrowing firms. Macroeconomic theory implies that credit will be reshuffled amongst borrowing firms in response to monetary policy shocks. For example, a monetary easing shock inflates the values of firms' assets, which firms can pledge as collateral for external financing. Accordingly, previously credit constrained firms become able to pledge this collateral, leading to a flow of credit to such firms. Alternatively, monetary easing, in lowering lenders' yields, will cause lenders to lend to increasingly risky borrowers to achieve previous returns. While a robust empirical literature regarding monetary policy and credit markets exists, an underdeveloped topic is the allocation of credit brought about by monetary policy.

I use data from Compustat to compute measures of credit creation and destruction for publicly traded firms over the period 1974:Q1–2017:Q1. I also group firms by measures of financial constraints and create measures of credit creation and destruction for these groups of firms. Using a vector autoregression approach, I find that monetary easing leads to leads to a substantial reallocation of credit, particularly in long-term credit markets. Consistent with the balance sheet and risk-taking channels of monetary policy, I find that monetary easing shocks cause credit creation to increase relatively more for firms classified as financially constrained than non-financially constrained. These results suggest that monetary policy operates through channels that ease collateral constraints, reduce lenders' perceptions of risk, and increase the tendency to search for yield.

In the second chapter, we quantify the impact of unconventional monetary policy on the allocation of credit during the period when the federal funds rate is at the zero lower bound. In late 2008, the Federal Reserve lowered their policy instrument, the federal funds rate, to a range between 0 and 0.25%, thus limiting the use of this rate as a policy instrument. To ease credit markets and stimulate the economy, the Federal Reserve resorted to unconventional policy steps such as large-scale asset purchases and engaged in forward guidance to manage expectations of future policy actions. In recent years, researchers have begun quantifying the impact of this unconventional monetary policy, however the literature does not account for the allocation of credit among heterogenous groups of firms.

As in the first chapter, we compute measures of credit creation and destruction for financially constrained and non-financially constrained firms using data from Compustat. However, in this chapter, we incorporate these measures in estimating a factor augmented vector autoregression to measure the effect of monetary policy shocks on the creation and destruction of credit of these firms. We use policy counterfactuals that (1) shut down the monetary policy shock over the zero lower bound and (2) force the monetary policy to operate such that it is constrained by the zero lower bound to assess the impact of actual unconventional monetary policy. A key finding is that unconventional monetary policy leads to relatively large increases in the long-term credit creation of financially constrained firms. This suggest that, during the zero lower bound, unconventional monetary policy operated through the easing of financial constraints. We also find that unconventional monetary policy caused an increase in short- and long-term credit creation for highly productive firms, likely leading to future capital formation and economic growth.

In the third chapter, I estimate the effects of upstream and downstream credit conditions on international trade and the differential impacts during times of financial crisis. In the late 2000s, trade flows, particularly in manufacturing sectors, collapsed worldwide. This collapse coincided with financial crises occurring in the U.S. and other developed economies. Prior research has shown that strained credit markets in upstream sectors are a key factor in explaining the trade collapse in the U.S. during the U.S. financial crisis. In this chapter, I expand the scope of prior studies and analyze the impact of upstream and downstream financial conditions on international trade and the differential impact during times of financial crisis in the importing and exporting country.

I use bilateral trade data at the sector level for 40 countries over the period 1995–2011, which is a period containing financial crises in Asian and Nordic countries in the 1990s and in the U.S. and European countries in the 2000s. I also use Compustat data to measure sectors' vulnerability to credit markets and interbank rates to measure the cost of credit. Using a triple difference specification, I find that adverse credit conditions in upstream and downstream sectors negatively impact international trade.

Further, these effects are amplified for sectors whose need for external financing is high when the importing country or exporting country is in financial crisis. I also find that the differential effect of exporters' credit conditions when the exporting country is in financial crisis is large and statistically significant when the exporting country is a developed economy. Further, this differential effect is larger in magnitude if the importing country is a developing economy.

Chapter 2 Monetary Policy and Credit Flows

2.1 Introduction

In neoclassical macroeconomic models without financial frictions, credit markets are an afterthought; banks act as inconsequential intermediaries between owners and ultimate users of capital (Jorgenson, 1963; Tobin, 1969). In such models, credit markets are assumed to be fully efficient and capital flows to its most productive use. Monetary policy impacts real economic activity through the "cost-of-capital" channel alone (Bernanke, 2007). In reality, credit markets are not frictionless and can severely affect economic activity. Modern models incorporate financial frictions and have expanded monetary policy channels beyond those influencing market interest rates and bank capital.[1] That is, monetary policy impacts borrowing firms' costs of external financing[2] and lending institutions' tolerance and perception of risk.[3]

While there is a large body of literature investigating the effect of monetary policy on credit market outcomes,[4] a less explored aspect is policy's impact on the reallocation of credit among borrowing firms. Existing theory implies that the composition of credit will adjust following a macroeconomic shock.[5] Because outstanding credit fluctuates and gets reshuffled to others, assessment of credit market conditions through inspection of aggregate net credit changes alone is incomplete and potentially misleading. For instance, if credit extended to one firm increases by 10% but as the result

[1]See Bernanke and Blinder (1988) and Kashyap and Stein (1994).
[2]See Bernanke and Gertler (1989), Bernanke and Gertler (1995), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999).
[3]See Borio and Zhu (2012), Adrian and Shin (2010), Bruno and Shin (2015), Gambacorta (2009), and Dell'Ariccia, Laeven, and Suarez (2017).
[4]See Ramey (2016) for an overview of recent studies.
[5]See for instance, models of homogeneous firms with heterogeneity investment project profitability (Matsuyama, 2007) or heterogeneity in firm quality (Bernanke, Gertler, and Gilchrist, 1994).

of a 10% decrease in credit to another, then the net credit change is zero. Yet, credit has been reshuffled between these two firms. Such reallocation may have important implications for future capital formation and growth (Herrera, Kolar, and Minetti, 2014). Thus, an assessment of monetary policy's impact on credit markets ought to account for this reallocation.

The objective of this chapter is to explore the effect of monetary policy shocks on the allocation of credit. Following Herrera, Kolar, and Minetti (2011), I use Compustat North America data to compute credit flows for borrowing firms. Using Compustat has several advantages. First, credit extended by nonbanks like private equity firms, investment banks, or insurance companies is included in the data.[6] Second, Compustat data contains relevant characteristics of the borrowing firm, which can be used to evaluate the importance of distinct monetary policy transmission mechanisms. For instance, credit flows may be larger and more fluid for firms that are highly dependent on external financing. Therefore, the reallocation of credit among these firms may be of a larger consequence for economic activity than those capable of generating cash flow internally. An additional benefit of Compustat data is that total debt is classified into its short- and long-term components.[7] Typically, short-term debt is used to provide cash flow rather than to finance long-term investment projects. However, short-term, non-intermediated debt can be a relevant source of bridge financing (Kahl, Shivdasani, and Wang, 2015). Further, as Guedes and Opler (1996) document, borrowing (i.e. debt issuance) at both very short and long maturities are common features of large, highly rated firms, which produce a large portion of the U.S. output.

[6]In 2007, the size of the non-bank lending was estimated to be 29.2 trillion U.S. dollars. As of 2015, the size increased to 34.2 trillion U.S. dollar (Financial Stability Board, 2017).

[7]Short-term debt includes bank acceptances, commercial paper, the current portion of long-term debt, etc. Long-term debt includes loans, bonds, lines of credit, etc. maturing in more than one year.

Nevertheless, there are disadvantages to Compustat data. First, the data cannot distinguish between the type of borrowing, other than whether it is short- or long-term credit. Second, Compustat only includes information on publicly traded firms, which tend to be large, developed firms. With Compustat, credit movement among small, non-publicly traded firms is ultimately excluded. Over the period analyzed, Compustat contains an average of 45 percent of U.S. non-financial sector total credit, as reported by the Bank for International Settlements.[8] The coverage has increased over time, rising to an average of 64 percent since the first quarter of 2000. Even though a substantial portion of credit is absent from Compustat, this data provides a good testing ground for exploring the impact of monetary policy on overall credit flows.

The topic of credit reallocation was first addressed by Dell'Ariccia and Garibaldi (2005) using bank lending data. They find that credit expansion and contraction tend to co-move, specifically among banks of comparable size, loan type, and location. Herrera, Kolar, and Minetti (2011) draw similar conclusions by analyzing firm borrowing, rather than bank lending. They find that credit reallocation among borrowing firms is intense, volatile, procyclical, and highly concentrated among firms of comparable size, location, and industry. A connected study by Craig and Haubrich (2013) investigates the substantial bank consolidation in the 1990s and analyzes credit creation, destruction, and reallocation in and out of recessions. They observe that credit creation is higher during expansions and that credit destruction is higher during recessions.[9]

These studies either do not consider the impact of monetary policy on the reallocation of credit or do so only in a tangential manner. In this chapter, I show that

[8] http://www.bis.org/statistics/totcredit.htm

[9] Contessi, DiCecio, and Francis (2014) analyze credit reallocation on both sides - lending and borrowing.

monetary policy's impact on credit flows is large and that the impact depends on specific firm characteristics and the length of debt maturity. The responses are consistent with parts of the balance sheet and risk-taking channels of monetary policy. That is, in response to an expansionary monetary policy shock, credit tends to flow to firms that are generally considered financially constrained or perceived as relatively risky to the lender. Finally, I find the largest increases in the creation of credit due to monetary easing shocks are of firms with relatively low investment efficiency.

This chapter is organized as follows. Section 2.2 describes the construction of credit flows, as well as trends in the credit flow and monetary policy measures. Section 2.3 summarizes the theoretical background for the expected response of credit flows to monetary policy and documents heterogeneity in credit flows. Section 2.4 outlines the empirical framework and discusses the impact of monetary policy's influence on credit flows. Section 2.5 discusses implications for future growth and productivity and Section 2.6 concludes.

2.2 Data Construction and Description

Credit Flows

As in Herrera, Kolar, and Minetti (2011), I compute measures of inter-firm credit flows starting from the balance sheets of all publicly traded U.S. firms reported in Compustat North America. Firms in the "finance, insurance, and real estate" industry groups are removed from the sample given that the aim of this study regards the impact of monetary policy on the less-studied firms that demand credit, instead of those that create credit. I largely follow the definition and measurement of credit flows as in Herrera, Kolar, and Minetti (2011). In particular, (i) the unit of observation is the firm, as Compustat does not provide data on firms' individual projects; (ii) I exclude accounts payable by suppliers from the measure of debt; (iii) I exclude firms for whom the ratio of end-of-period gross capital to end-of-period net capital exceeds

120% to control for existing firms that enter the data-set;[10] and (iv) only exits due to merger, acquisition, liquidation, or bankruptcy are treated as credit subtractions.

In this chapter, I employ quarterly data spanning the period between the first quarter of 1974 and the first quarter of 2017.[11] The use of quarterly data, instead of annual, as in Herrera, Kolar, and Minetti (2011), allows for clearer identification of monetary policy shocks. Furthermore, the lengthy period covered by Compustat allows for the use of structural vector autoregression (SVAR) tools such as historical decomposition when studying the impact of monetary policy (see Kilian and Lütkepohl (2017)).

The quarterly rate of debt growth, g_{it}, for firm i in quarter t is given by

$$g_{it} = \frac{debt_{it} - debt_{it-1}}{(debt_{it} + debt_{it-1})/2}. \tag{2.1}$$

This transformation measures a symmetric and bounded growth rate around zero, thus allowing for a unified treatment of continuing, newborn and dying firms (Davis and Haltiwanger, 1992; Herrera, Kolar, and Minetti, 2011). In particular, $g_{it} \in [-2, 2]$ where -2 corresponds to debt growth of firms that died in the current year, and 2 corresponds to debt growth of newborn firms.

With this rate of growth, I compute aggregate credit creation and destruction for a set of firms s in quarter t as the debt-weighted sum of the rates for expanding or entering firms and the debt-weighted sum of the rates for contracting or exiting firms, respectively. Specifically, aggregate credit creation for group s in time t (POS_{st}) is defined as

$$POS_{st} = \sum_{g_{it}>0, i\in s_t} g_{it} \left(\frac{debt_{it}}{debt_{st}} \right). \tag{2.2}$$

[10] See Ramey and Shapiro (1998) for the use of a similar criteria applied to flows of physical capital and Herrera, Kolar, and Minetti (2011) for a detailed description.

[11] Herrera, Kolar, and Minetti (2011) analyze a period between 1954 and 2007.

Similarly, aggregate credit destruction for group s in time t (NEG_{st}) is defined as

$$NEG_{st} = \sum_{g_{it}<0, i \in s_t} |g_{it}| \left(\frac{debt_{it}}{debt_{st}} \right). \tag{2.3}$$

The first panel of Figure 2.1 plots credit creation and destruction for all publicly traded firms from the first quarter of 1974 through the first quarter of 2017. These two credit flow measures follow dissimilar patterns. Credit creation is highest in the late 1980s, a period when credit destruction is near its mean growth rate. In the late 2000s, credit destruction falls from 5.9 in the third quarter of 2005 to 2.2 percent in the fourth quarter of 2007 once the recession officially begins. Over the same period, credit creation increases from 5.4 percent to 10.3 percent.

I compute gross credit reallocation as the sum of credit creation and destruction ($SUM_{st} = POS_{st} + NEG_{st}$) and net credit change by subtracting credit destruction from credit creation ($NET_{st} = POS_{st} - NEG_{st}$), shown in the second panel of Figure 2.1. Analysis of net credit changes alone may provide an incomplete depiction of the market because it masks the reallocation of credit. For instance, though credit reallocation is high in the late-1990s and early-2000s; these are periods of moderate net credit changes.

I measure excess credit reallocation as the credit reallocation in excess of what is required to accommodate net credit changes ($EXC_{st} = SUM_{st} - |NET_{st}|$). Large movements in credit reallocation can occur due to large increases in either credit creation or destruction. For example, suppose credit creation increases 10%, but credit destruction is unchanged. In this scenario, credit reallocation is 10%, but no credit was truly reallocated from one borrower to another as excess credit reallocation equals zero. In other words, the change in NET and SUM are equivalent. In a more fluid credit market, excess credit reallocation rises with simultaneously expanding and contracting credit. As the second panel of Figure 2.1 shows, excess credit reallocation is consistently non-zero, with an upward trend until the late 1990s. Since then, excess credit reallocation has trended downward.

Table 2.1 provides further detail on these five measures by decade. In line with the findings of Herrera, Kolar, and Minetti (2011), credit reallocation is consistently large and far exceeds what is needed to accommodate net credit changes, particularly in the 1990s and 2000s. This table also shows that credit creation and destruction are quite volatile. Until the 2010s, the volatility of credit creation exceeds that of credit destruction. In the 2010s, credit destruction's volatility exceeds the volatility of credit creation. It is important to note that the magnitudes of these flows are not directly comparable with those of Herrera, Kolar, and Minetti (2011) because I use quarterly rather than annual measures. Further, reliable quarterly data is only available from Compustat starting in the early 1970s.[12]

Monetary Policy Measure, Short-Term Debt, and Long-Term Debt

Empirical investigations into the effect of monetary policy on economic activity have commonly identified the federal funds rate as the primary monetary policy instrument. However, from December 2008 until December 2015, the federal funds rate was effectively at the zero lower bound (ZLB), thus limiting the use of the instrument to stimulate the economy and invalidating its use as the monetary policy variable in SVARs over this period. An alternative measure of the monetary policy stance at the ZLB is proposed by Wu and Xia (2016), who develop an approximation to the forward rate in the multifactor shadow rate term structure model. This can be used to replace the effective federal funds rate in SVARs. They find that unconventional monetary policy has a non-trivial impact on economic activity once the ZLB is reached. Consequently, this measure has become popular in the literature employing SVARs over the ZLB (see Anderson, Malin, Nakamura, Simester, and Steinsson (2017); Mumtaz

[12]See the Appendix for a description of credit flows using annual growth rates that more closely resemble the measures in Herrera, Kolar, and Minetti (2011).

and Surico (2018)). Figure 2.2 plots the effective federal funds rate along with the shadow rate during the ZLB.[13] In my analysis, I employ the effective federal funds rate as the measure of monetary policy, but I replace it with the Wu-Xia shadow rate during the ZLB period.

Figure 2.3 plots the long- and short-term credit flow measures,[14] respectively, along with the monetary policy rate. During the monetary easing of the financial crisis, while long-term credit creation falls once easing starts, it is flat beginning in the early 2010s. Similarly, long-term credit destruction is flat prior to, and following this easing. Short-term credit creation and destruction increase in the early 1990s, as policy rates are relatively low. Because credit flow and monetary policy measures are endogenous, a SVAR approach is utilized to measure the effect of monetary shocks on credit flows.

2.3 The Role of Monetary Policy and the Flow of Credit

In this section, I discuss relevent channels of monetary policy and how the allocation of credit ought to respond to monetary easing shocks. A traditional mechanism through which monetary policy is transmitted to real economic activity is through the supply of loans. That is, during times of expansionary monetary policy, banks have more reserves to lend to firms, leading to capital formation. Accordingly, following monetary policy easing, credit creation is expected to increase. Following analysis on job reallocation by Davis and Haltiwanger (2001), I consider this an "aggregate channel," as it mainly impacts the total amount of credit in the economy. This contrasts with "allocative channels," which alter the flow of credit to correct the mismatch between actual and desired credit positions of lenders and borrowers. The reshuffling

[13] Similar models that aim to capture monetary policy during the ZLB include Krippner (2012) and Bauer and Rudebusch (2016). See the Appendix for a comparison of these measures.

[14] That is, credit creation, credit destruction, net credit change, credit reallocation, and excess credit reallocation.

of credit that takes place through the allocative channel hinges on the existence of firm heterogeneity.

Theoretical Underpinnings

The Balance Sheet Channel

There are three aspects to consider under the balance sheet channel - the cost of external financing, collateral constraints, and cash flows. The two former aspects follow Bernanke, Gertler, and Gilchrist (1994), among others. If a firm's borrowing is constrained by the collateral they pledge, they pay an external finance premium above the market interest rate.[15] Expansionary monetary policy lowers external financing costs by impacting market interest rates and asset values. The latter eases collateral constraints, thereby lowering external finance premia.

Following monetary easing, net credit ought to increase as external financing becomes less costly. This results from an increase in credit creation, particularly for collateral constrained firms. However, theory appears to be silent regarding policy's impact on credit destruction. It may increase as monetary policy enables firms to better meet interest and principal debt payments or induces lenders to forgive debt. Alternatively, credit may fall as loan defaults become less probable. When the change in net credit is positive, an increase in credit creation cannot be offset by a similar increase in credit destruction. Credit reallocation increases when both credit creation and destruction rise. When monetary policy increases credit creation, the sign of the impact on excess credit reallocation will correspond to that of credit destruction.

The third aspect of the balance sheet channel is related to firms' cash flow (Mishkin, 1996). Interest expense on variable rate loans positively co-moves with the monetary policy rate. Traditional monetary easing leads to lower variable rate interest expense

[15] An external finance premium is the agency premium that arises endogenously as the shadow value of relaxing the collateral constraint in Bernanke, Gertler, and Gilchrist (1994).

on loans whose rate is tied to short-term rates via the yield premium. Also, unconventional monetary policy that lowers long-term interest rates will increase firms' cash flows because firms' long-term variable interest expenses are impacted. These policies lower the overall need for external financing to meet interest obligations. In other words, credit creation ought to decrease, particularly for high debt service firms. Credit destruction may increase or decrease for the same reasons as discussed through the easing of collateral constraints. While the impact of monetary policy on net credit and credit reallocation depends on the impact on credit destruction, the excess credit reallocation ought to decrease.

The Risk-Taking Channel

Monetary policy may also impact economic activity through the risk-taking channel.[16] A lender's credit risk tolerance and the ease by which they price credit risk are sensitive to monetary policy. For example, during the 2000s, interest rates in the U.S. were considered by many as "too low for too long" (Taylor, 2009). Even Federal Reserve officials expressed concern over the dangers of keeping policy rates unnecessarily low in the aftermath of the financial crisis (Bullard, 2015). Extended periods of excessively low interest rates may cause asset bubbles and financial sector instability as banks engage in excessive risk-taking.

In times of monetary easing, lenders may engage in "searching for yield" in which the allocation of loans in a lender's portfolio shifts towards high risk, high return loans (Rajan, 2006). Nominal return targets are slow to adjust downward when market interest rates fall. To achieve previous returns, lenders are incented to reallocate the risk composition toward riskier borrowers. This implies that credit creation increases in aggregate and credit destruction increases as lenders reshuffle credit to reallocate

[16] See Borio and Zhu (2012), Adrian and Shin (2010), Bruno and Shin (2015), Gambacorta (2009), and Dell'Ariccia, Laeven, and Suarez (2017).

their risk compositions. However, credit destruction may also decrease as default is less likely. When both measures increase, credit reallocation and excess credit reallocation also increase. Through this mechanism, net credit should rise if the increase in credit creation is not offset by a sufficiently large increase in credit destruction.

The second component of the risk-taking channel is the risk perception mechanism (Borio and Zhu, 2012). This mechanism is related to the balance sheet channel, although it operates through fundamental changes in lenders' risk perceptions, rather than through collateral constraints and agency premia. Monetary easing inflates asset prices and decreases volatility, which tends to lower lenders' perceptions of credit risk (Gambacorta, 2009). In other words, following monetary easing, the marginal borrower, who may not have met previous lending standards, may appear creditworthy, even if their relative riskiness is unchanged.

This mechanism implies that credit creation and net credit increase in response to a monetary easing shock. Although, the response of credit destruction is unclear. Credit reallocation will increase when credit destruction does not decrease by a larger magnitude than the increase in credit creation. The sign of the impact on excess reallocation will correspond to that of credit destruction.

The final mechanism is described by Dell'Ariccia, Laeven, and Suarez (2017) as the "risk-shifting" channel. Bank liabilities, such as wholesale funding and bank deposits, become less costly when monetary policy lowers market interest rates. This increases lenders' margins and induces lenders to shift their allocation of loans away from high risk lending. As opposed to searching for yield, this implies an increase in credit for relatively less risky borrowing. To accommodate shifting loan portfolios, credit destruction is more likely to increase,[17] specifically for risky firms. Like the

[17] Recall that credit destruction may increase through loan repayment or decrease through fewer defaults. Through this channel, the impact of the former is more likely, although the net impact on credit destruction is ambiguous.

other risk-taking mechanisms, I expect an increase in net credit change and credit creation, but the impacts on credit destruction, credit reallocation, and excess credit reallocation are ambiguous.

Measuring Heterogeneity

To examine the importance of these channels in the transmission of monetary policy shocks to credit flows, I must first effectively group firms by relevant characteristics. For the balance sheet channel, firms are classified by their degree of financial constraints and debt service. For the risk-taking channel, firms should be grouped by lenders' risk perceptions of the borrowing firm. Since information on these perceptions is not available, I group firms by characteristics that may reflect perceived risk: default probability, asset size, financial dependence, and debt service.

Table 2.2 shows the number of quarter-firm observations in each grouping. While certain groups may have similar characteristics, these categories do highlight distinct aspects of firms. To illustrate, of the nearly 150,000 observations of high default probability firms across time, the majority are low debt service, non-financially dependent, and small firms. The former two are typical characteristics of non-financially constrained firms, and the latter is a characteristic of financially constrained firms. Next, I briefly discuss the measures of heterogeneity and describe asymmetries in credit flows of these groups.

Financial Constraints and Perceived Riskiness

Researchers have attempted to quantify firms' financial constraints in equity and debt markets in recent years.[18] These measures are typically created by analyzing firms' annual reports (Kaplan and Zingales, 1997), structural modeling (Whited

[18]See Farre-Mensa and Ljungqvist (2016) for a survey of the literature regarding the measurement of financial constraints.

and Wu, 2006), whether a firm has a credit rating (Almeida, Campello, and Weisbach, 2004), or whether they pay a dividend (Fazzari, Hubbard, and Petersen, 1988; Almeida and Campello, 2007). Farre-Mensa and Ljungqvist (2016) find that firms classified as financially constrained by such measures, to a greater extent, are young firms in the growth phase of their life cycle, rather than truly financially constrained firms. Further, they find that firms close to default behave as if they are truly financially constrained.[19] Therefore, I group firms by their default probability. This not only identifies firms more highly constrained in credit markets, which is relevant for the balance sheet channel, but also those that are perceived as relatively risky borrowers, which is relevant for the risk-taking channel.

Corporate default risk is constructed as in Merton (1974) whereby

$$DD_{it} = Distance - to - default_{it} = \frac{log(\frac{E_{it}+F_{it}}{F_{it}}) + r_{it} - 0.5\sigma_{it}^2}{\sigma_{it}} \tag{2.4}$$

where

$$E_{it} = \frac{|prccq| \times cshoq}{10^3} \tag{2.5}$$

$$F_{it} = dlcq + \frac{1}{2}dlttq \tag{2.6}$$

$$\sigma_{it} = [\frac{E}{E+F} \times \sigma_{E,it}] + [\frac{F}{E+F} \times (0.05 + 0.25 \times \sigma_{E,it})] \tag{2.7}$$

and $\sigma_{E,it}$ is the rolling one-year standard deviation of $prccq$ (stock price), r_{it} is the year-over-year stock return, $dlttq$ is total long-term debt, $dlcq$ is short-term debt, and $cshoq$ is common shares outstanding. Following Farre-Mensa and Ljungqvist (2016),

[19] They also find that private firms behave as if they are financially constrained. Compustat only contains income statement and balance sheet data for publicly traded firms, therefore, I do not group firms by whether they are publicly traded.

firms whose probability of default exceeds 25 percent from the cumulative standard normal distribution function are high default probability firms and all others are low default probability firms.

Table 2.3 shows that long-term credit creation, credit destruction, net credit change, credit reallocation, and excess credit reallocation are significantly higher and more volatile for high default probability firms. Short-term credit flow measures for both groups of firms are similar to one another, on average. It is important to note that credit measures are constructed by *growth rates* and even if these rates are higher, the dollar amount of credit created or destroyed is lower than total credit flows of low default probability firms. For instance, over this period, the average share of aggregate credit for all high default probability firms is 6.8 percent. Further, the default probability threshold is static and depending on overall conditions, the number of firms considered high or low default probability fluctuates. In the third quarter of 2008, at the height of the financial crisis, over 28 percent of firms are classified as high default probability firms as compared to just above 4 percent in the fourth quarter of 1978.

Debt Service

I group firms by their leverage ratio (total debt as a percentage of total assets) to measure debt service. I classify a firm as high debt service if its leverage ratio falls in the top tercile of firms in a quarter, and as low debt service if their leverage ratio falls in the bottom tercile in a quarter.[20] Kudlyak and Sanchez (2017) find that during the late 2000s recession, low leverage firms' short-term net credit fell relatively more than high leverage firms. This is consistent with an explanation by Calomiris and Himmelberg (1995), who argue that *low* leverage firms are financially

[20]Kudlyak and Sanchez (2017) limit their analysis to manufacturing firms as in Gertler and Gilchrist (1994).

constrained because external financing is overly costly to obtain in response to adverse macroeconomic shocks.

From Table 2.3, short- and long-term credit creation and destruction are, on average, substantially larger for low debt service firms. Recall that these measures are weighted sums of debt growth rates. Accordingly, low debt service firms may choose to hold little or no debt, thereby having little or zero weight on the group credit measures. Therefore, growth rates of a small number of low debt service firms are utilized in creating group credit flow measures.[21]

Firm Size

In relation to the balance sheet channel, the size of a firm ought to coincide with the degree to which they are collateral constrained. This is shown empirically by Gertler and Gilchrist (1994), who find that during periods of tight credit, that small manufacturing firms are impacted more than large firms. The topic was re-examined by Kudlyak and Sanchez (2017), who find that credit contracted relatively more for *large* firms during the late 2000s recession.

I classify firms whose value of their assets fall in the top tercile as large and those in the bottom tercile as small. Table 2.3 shows credit flow measures for these two groups. Credit creation and destruction are higher for small firms, noting again that the dollar amount of credit is likely higher, on average, for large firms. As a result, credit reallocation and excess credit reallocation is larger for small firms and this holds for short- and long-term credit flows.

[21]In Compustat, 4.22 percent of quarter-firm observations report no holdings of debt.

Financial Dependence

In general, obtaining external financing is costlier than generating cash flow internally through operations. Therefore, firms that are highly dependent on external financing are more likely to be impacted by fluctuating credit market conditions. Through the balance sheet channel, if financially dependent firms are also financially constrained (Rajan and Zingales, 1998; Kudlyak and Sanchez, 2017), then they are susceptible to shocks in the same manner. A widely used measure of financial dependence comes from Rajan and Zingales (1998) in their influential study of the link between financial dependence and economic growth. This measure is the ratio of capital spending less cash flow from operation to capital spending. I classify financially dependent firms as those whose ratio is in the top tercile, while those in the bottom tercile are non-financially dependent.

As shown in Table 2.3, both short- and long-term credit destruction is higher for financially dependent firms. Credit creation of the two groups are similar, especially of long-term credit. Credit reallocation is significantly larger for financially dependent firms, specifically for short-term credit, but excess credit reallocation is significantly larger in both short- and long-term credit for financially dependent firms.

2.4 Monetary Policy Shocks and Credit Flows

Empirical Strategy

To analyze monetary policy's impact on credit flows, I utilize a SVAR, represented as

$$A_0 Y_t = a + \sum_{j=1}^{n} A_j Y_{t-j} + u_t. \tag{2.8}$$

where the vector, Y_t, includes a block of macroeconomic variables (real GDP, unemployment, consumer prices), the monetary policy rate (the effective federal funds rate supplemented by Wu and Xia (2016) shadow rate during the ZLB period), and a block of credit flow measures (credit destruction and creation), with this ordering. The A matrices are matrices of coefficients, a is a vector of constants, and u_t is a vector of structural innovations.

This methodology is comparable to Craig and Haubrich (2013), who specify a VAR with a block of macroeconomic variables, the federal funds rate, and a block of loan flows. However, the specification used in this chapter differs in two aspects. First, to account for the "price puzzle," whereby consumer prices respond unexpectedly to a monetary policy shock, I follow Estrella (2015). I impose a zero restriction on the coefficient of the first quarter lag of the monetary policy rate on consumer prices. For full identification, the A_0^{-1} matrix is assumed to be lower triangular. Through these restrictions, monetary policy does not directly impact the current or the following period's consumer prices.[22] The method utilized by Estrella (2015) is motivated by theoretical analogs of identities for aggregate supply, aggregate demand, and a monetary policy rule. Because I impose the restriction on the lagged coefficient matrix, ordinary least squares equation by equation does not produce efficient estimates of the VAR parameters. Hence, I estimate the VAR via iterated seemingly unrelated regression (SUR), which is equivalent to full information maximum likelihood (Hamilton, 1994).

Second, I order credit destruction before credit creation in Y_t by an assumption that credit creation responds contemporaneously to credit destruction, but not vice versa. This assumption is motivated by the likely ability of borrowers to respond quickly to a credit destruction shock, whereas adjustment of credit destruction to a

[22] Alternative approaches to account for the price puzzle are including commodity prices in the VAR to capture internal information on inflation expectations (For instance, see Christiano, Eichenbaum, and Evans (1999) and Craig and Haubrich (2013)), utilizing a factor-augmented VAR (Bernanke, Boivin, and Eliasz, 2005) to account for monetary policymakers' internal information relevant for monetary policy, or including an omitted variable, the output gap, in a misspecified VAR (Giordani, 2004).

credit creation shock would take time to implement. That is, firms can quickly draw upon existing credit, but the impact of the shock on credit destruction through the maturation or repayment of existing credit is likely to take longer to materialize. Yet, the results are robust to the alternative ordering.

To study the effect across groups of firms, I include an additional block of group credit flows in Y_t. This VAR is estimated separately for total, short-, and long-term credit flows by rotating credit creation and destruction as the final block in Y_t. The results of the VAR are summarized below.

The Effect of Monetary Policy Shocks for All Publicly Traded Firms

To start, the VAR is estimated using credit flow measures of all publicly traded firms. Figure 2.4 shows the impulse responses of Y_t to a one-time, unexpected decrease of 100 basis points in the monetary policy rate.[23] In response to the shock, real GDP increases with a lag, remaining persistently high, while the unemployment rate falls and remains persistently low. While consumer prices fall beyond the first quarter, the statistical significance is eliminated at a 10 percent significance level. Further, the response of consumer prices to this shock relative to a VAR without the restriction as in Estrella (2015), is muted.

Following the monetary policy shock, credit creation increases significantly at quarters 6-12, increasing over 0.10 percentage points at each quarter. The response of credit destruction is larger than credit creation and statistically significant on impact and in the first quarter following the shock. From quarters 5 through 13, the response of credit creation is statistically significant, but smaller compared to credit creation, rising roughly 0.05 percentage points per quarter. The impulse responses of net credit change and excess credit reallocation are plotted in the first panel of Figure

[23]The error bands are the 68 percent mean-bias-corrected residual-based wild bootstrap interval with 2,500 repetitions.

2.5. Because there are notable increases in credit creation and destruction at multiple horizons, credit creation is large and significant at many horizons. The response of net credit is negative and significant on impact as well as 7-12 quarters following the shock. The impact on excess credit reallocation is like that of the net credit change.

The second and third panels of Figure 2.5 plot the responses of long- and short-term credit flows to the monetary policy shock. Like the responses of total credit, long-term credit creation and destruction exhibit statistically significant increases, although the magnitudes are larger. The monetary policy shock also positively impacts the long-term net credit change, credit reallocation, and excess credit reallocation. This simultaneous increase in credit creation and destruction is an example of the reallocation process whereby firms receive long-term credit to pay off existing loans - a "cleansing"effect.

Short-term credit destruction increases a statistically significant 0.1 percentage points in the second quarter following the shock. However, contrary to the responses of long-term credit flows, short-term credit destruction falls significantly at longer horizons. Recall that looser monetary policy may lead to fewer loan defaults, resulting in a decrease in credit destruction. It may also lead to a higher likelihood of loan repayment on aggregate, in which case, credit destruction will increase. The change in the sign of the impact of the monetary policy shock on credit destruction suggests that monetary policy's influence on loan defaults outweighs the impact on repayment of short-term loans over longer horizons. The impact of the shock on credit creation is not statistically significant.

Heterogeneity in Responses of Credit Flows to Monetary Policy Shocks

Table 2.4 provides the cumulative impulse responses at 4, 8, and 12 quarters for the subsets of firms described in Section 2.3. Of the subsets, credit creation significantly increases for high default probability and small firms after 12 quarters following the shock, rising 1.40 and 0.28 percentage points, respectively. Considering that the average total credit reallocation for high default probability firms is 7.54 percentage points, this is non-trivial. The increase is disproportionately larger than the 0.47 percentage point increase for low default probability firms, which is not statistically significant. While I find that the increase in credit creation is larger in magnitude than small firms, the response is not statistically significant for large firms. Credit reallocation increases significantly only at 8 quarter horizons and for high debt service and small firm subsets, rising 0.93 and 0.33 percentage points, respectively.

For all firms' total credit, there is a statistically significant and persistent cumulative increase in credit reallocation by 8 following the shock. The increase is larger and remains statistically significant for long-term credit reallocation as shown in the second panel of Table 2.4. By 8 quarters following the shock, long-term credit reallocation increases 1.15 percentage points. By 12 quarters, the increase is 2.10 percentage points. These are due to statistically significant increases in credit destruction and creation at 8 quarters and a statistically significant increase in credit creation at 12 quarters. Also, as the second and third panels of Table 2.4 show, significant increases in credit reallocation at any horizons only occurs for long-term credit. The largest statistically significant increases in long-term credit reallocation at these horizons tend to occur for high default probability firms, small firms, and high debt service firms.

For both long- and short-term excess credit reallocation, the response is typically, although not exclusively, negative. The largest significant decrease in excess credit reallocation is -11.26 percentage points for non-financially dependent firms in short-term credit, while the largest increase is 0.51 percentage points for low default probability firms in long-term credit. Because excess credit reallocation tends to fall, the amount of credit reallocation needed to accommodate net credit changes is large.

Implications for Credit Channels of Monetary Policy

These results highlight that monetary policy at least operates through the aggregate channel by increasing credit creation.[24] By decomposing the responses of credit reallocation into the contributions from credit creation and destruction, I am also able to shed light on the allocative impact of monetary policy through the aforementioned channels.

All Publicly Traded Firms

Recall that in response to the monetary easing shock, credit creation and destruction increase for total and long-term credit. Credit destruction tends to increase and remain persistently high for long-term credit only and decrease for short-term credit at longer horizons.

For long-term credit, the results are consistent with the collateral constraint and the searching for yield mechanism of the balance sheet channel and some mechanisms of the risk-taking channel. While theory is clear that credit creation should increase due to these mechanisms, the impact on credit destruction is unclear, consistent with these results. From the cash flow mechanism, credit creation should fall as variable interest expenses fall. Because neither short- nor long-term credit creation fall in response to the shock, there is no support for this mechanism. By grouping firms and analyzing their impulse responses, I can provide clearer evidence for these channels, if it exists.

Default Probability Grouping

Recall that the searching for yield mechanism predicts that credit creation should increase for risky (e.g. high default probability) firms. Further, through the risk

[24]Specifically for long-term credit.

perceptions mechanism, credit creation should increase relatively more for these firms. These predictions are confirmed in total and long-term credit because the increase in credit creation is positive and statistically significant for high default probability firms. Increases in total credit creation for low default probability firms are not statistically significant, but the increases in long-term credit creation are significant. However, they are substantially smaller in magnitude compared to high default probability firms as shown in Table 2.4 . Further, theory implies that monetary policy plays an allocative role by reshuffling credit between high and low default probability firms. This is confirmed in long-term credit at all horizons as credit destruction increases for low default probability only.

The risk-shifting channel predicts that lenders will extend relatively more credit to low default probability firms as monetary easing indirectly shrinks lender margins. While long-term credit creation increases at 8 and 12 quarter horizons, they are substantially smaller than the increases for high default probability firms. Therefore, I do not find support for this as a relevant channel of monetary policy.

By the balance sheet channel, following monetary policy easing, financially constrained firms ought to experience a relatively larger increase in credit creation. Further, while the impact on credit destruction is ambiguous, theory predicts that monetary policy should increase net credit. If default probabilities effectively group firms by their degree of financial constraints as Farre-Mensa and Ljungqvist (2016) find, then the responses of total and long-term credit creation, destruction, net credit, credit reallocation, and excess credit reallocation are all consistent with this theory.

Debt Service Grouping

If high debt service firms are financially constrained, then, as with high default probability and financially dependent firms, theory implies that credit creation ought to increase following a monetary policy easing shock that eases financing constraints.

An alternative explanation regards monetary policy's impact on a firm's balance sheet through impacting variable rate interest expense. By this mechanism, the monetary policy shock will lead to a decrease in credit creation for high debt service firms as their variable interest expense falls. From Table 2.4, only short-term credit creation increases significantly by 4 quarters following the monetary policy easing shock, rising 1.64 percentage points. These results do not support the mechanism regarding variable rate interest payments being relevant for monetary policy's transmission.

Asset Size Grouping

By the searching for yield and risk perceptions mechanisms, credit creation ought to increase proportionately more for small firms following a monetary policy easing shock, since they tend to be perceived as riskier. There are no statistically significant increases in credit creation for large firms. For small firms, the only statistically significant increase in credit creation is a 0.28 percentage point increase 12 quarters after the shock. These results provide little evidence for the balance sheet or risk-taking channels. Further, because credit creation of large firms does not increase significantly, these results also do not provide support for the risk-shifting channel.

Financial Dependence Grouping

Long-term cumulative credit creation decreases 0.12 percentage 8 quarters following the shock but increases 0.70 percentage points after 12 quarters. At these horizons, there is no statistically significant change in credit creation for non-financially dependent firms. The increase in credit creation for financially dependent firms is consistent with the collateral constraint mechanism of the balance sheet channel. While this provides support for the channel, it is possible that this financial dependence ratio may not effectively group firms by their degree of financial constraints as the results from Farre-Mensa and Ljungqvist (2016) suggest.

Historical Decompositions

Historical decompositions show how much of the fluctuations of the endogenous variables in the system are caused by the individual structural innovations. Consider the SVAR in (2.8). If Y_t is covariance stationary, then its value in t is a function of previous structural innovations, which also pre-date the initial period. Because the effects of old innovations are small, an innocuous approximation of Y_t is

$$Y_t \approx \widehat{Y}_t = b + \sum_{s=0}^{t-1} \theta_s u_{t-s}. \tag{2.9}$$

The structural MA coefficient matrices, (θ_0, θ_1, ... ,θ_{T-1}), are responses of each element in Y_t to a single u_t shock at the horizon $h = 1, 2, ..., H$, so

$$\frac{\partial Y_{t=h}}{\partial u_t'} = \theta_h \tag{2.10}$$

where θ_h is a $(K \times K)$ matrix. K is the number of variables and therefore the number of structural innovation series in the VAR. Each element of the θ_h is a $(H \times H)$ impulse response matrix.

Figure 2.6 shows the cumulative contribution of monetary policy innovations to the creation and destruction of credit for different subsets of firms across time. For subset of firms, the contributions of credit creation and destruction from monetary policy shocks follow similar patterns. This shows that monetary policy shocks tend to influence credit reallocation and excess reallocation, but the net credit change will be close to zero.

The contributions to credit creation and destruction are highest in the late 1970s and lowest in the early- to mid-1980s. Further, increases in credit creation and destruction due to monetary policy shocks tend to be negative or near zero during the Federal Reserve's conducted rounds of quantitative easing (2009–2014). It was not until monetary policy began to unwind in 2015 that the contribution from monetary policy to these credit flow measures tended to increase.

2.5 Credit Flows and Investment Efficiency

So far, this chapter has focused on the response of firm credit flows to monetary policy shocks. Yet, ultimately the question of interest for policymakers and academics regards whether monetary policy aids or hinders the reallocation of credit from less productive to more productive firms. Because Compustat does not provide detail on investment projects, I am not able to determine if credit is used to finance efficient *projects*. However, I can classify *firms* by their overall investment efficiency using an index by Galindo, Schiantarelli, and Weiss (2007). This index is constructed as

$$I_{it} = \frac{\frac{sales_{it}}{capital_{it}} \frac{debt_{it}}{debt_{st}}}{\frac{sales_{it-1}}{capital_{it-1}} \frac{debt_{it-1}}{debt_{st-1}}}. \tag{2.11}$$

Herrera, Kolar, and Minetti (2014) utilize this index to test the impact of interstate financial deregulation on states' productivity growth through the reallocation of credit. This ratio exceeds one when the debt-weighted sales as a percentage of capital (a proxy for investment efficiency) is growing.

Table 2.5 shows the mean and standard deviation of this index for subsets of firm across time.[25] From this table, it is unclear if investment efficiency tends to be higher for risky and financially constrained firms. Investment efficiency is smallest, on average, for high default probability firms, but is largest for high debt service firms. Nevertheless, as Figure 2.6 shows, the contribution of monetary policy shocks to credit creation was highest in the 1970s for large firms, high debt service firms, and low default probability firms. During this time, as Table 2.5, investment efficiency is relatively high for low default probability firms and high leverage firms, however, it is relatively low for large firms.

[25]The top and bottom 1 percent of indexes are trimmed in the calculation of these statistics.

Credit reallocation will be most beneficial in terms of future productivity growth when credit is contracted from inefficient projects and is instead extended to efficient projects. However, on average, the lowest investment efficiency subset is firms with high default probabilities, whose mean index was as low as 0.985 in the 2000s. As shown in Table 2.4, monetary easing shocks lead to large and significant increases in long-term credit creation for these firms. This implies that monetary easing may have an adverse impact on future capital formation. However, there is also a large and statistically significant increase in short-term credit creation for high debt service firms and a large and statistically significant increase in long-term credit for financially dependent firms. These firms, conversely, have relatively higher investment efficiency than low debt service firms and non-financially dependent firms, respectively.

2.6 Conclusion

This chapter shows that monetary policy easing leads to substantial reallocation of credit amongst firms. This impact is large for high default probability firms in long-term credit. However, the impact is also present to a lesser extent for small firms and financially dependent firms in long-term credit and for high debt service firms in short-term credit. These results are consistent with the easing of collateral constraints that ensues by a monetary expansion, as purported by the balance sheet channel. Yet, such behavior is also implied by the searching for yield and risk perceptions mechanisms of the risk-taking channel.

While I find strong evidence for the relevance of these channels of monetary policy, I do not find support for the cash flow mechanism as a pertinent channel of monetary policy. Monetary easing does not lead to credit creation decreases for high debt service firms. Also, I do not find support that the risk-shifting mechanism is relevant because credit does not flow to firms of relatively low perceived riskiness to the lender.

These results have important implications for future growth and productivity.

While I find that credit creation significantly increases for high default probability firms following a monetary easing shock, these firms also have the lowest investment efficiency of any subsets of firms. However, investment efficiency is relatively high for high debt service firms, financially dependent firms, and small firms whom also tend to experience increases in credit creation following a monetary easing shock. Therefore, it is unclear whether monetary policy has an overall positive or negative impact on future capital formation.

2.7 Tables

Table 2.1: Descriptive Statistics of Quarterly Credit Flow Measures

	Average					**Coefficient of variation**				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
1974:Q1–1979:Q4	2.66	3.86	1.21	6.52	5.07	14.39	55.50	188.12	31.91	11.05
1980:Q1–1989:Q4	3.43	6.17	2.74	9.60	6.70	19.25	48.59	106.40	33.53	19.21
1990:Q1–1999:Q4	3.93	5.89	1.96	9.82	7.79	25.91	28.75	64.79	25.34	25.92
2000:Q1–2009:Q4	4.19	5.93	1.75	10.12	8.17	24.88	28.29	110.44	19.97	22.40
2010:Q1–2017:Q1	2.97	4.26	1.29	7.23	5.74	22.69	16.12	87.92	10.47	19.50

Note: This table reports averages and coefficients of variation of total credit flow measures for all publicly traded firms. POS refers to credit creation, NEG is credit destruction, NET is net credit change ($NET_{st} = POS_{st} - NEG_{st}$), SUM is credit reallocation ($SUM_{st} = POS_{st} + NEG_{st}$), and EXC is excess credit reallocation ($EXC_{st} = SUM_{st} - |NET_{st}|$).

Table 2.2: Frequency of Quarter-Firm Observations

	Low default probability	High default probability	Low debt service	High debt service	Large	Small	Non-financially dependent	Financially dependent
Low default probability	625,925	0						
High default probability	0	143,986						
Low debt service	124,610	124,405	295,641	0				
High debt service	243,317	5,525	0	295,643				
Large	232,392	32,445	41,203	131,131	297,219	0		
Small	187,287	50,884	136,975	80,093	0	297,219		
Non-financially dependent	164,329	46,680	84,357	67,458	71,966	74,991	243,231	0
Financially dependent	156,348	34,413	74,096	85,462	67,113	87,433	0	243,230

Note: This table shows the number of quarter-firm observations per group over the period 1974:Q1–2017:Q1. Firms are subset by their default probability following Farre-Mensa and Ljungqvist (2016), whereby firms for which the default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms. High debt service firms are those for which the leverage ratio is in the top tercile of firms in a given quarter and small firms are those for which their leverage ratio is in the bottom tercile of firms in a given quarter. Financially dependent firms are those for which the ratio of capital spending less operating cash flow as a percentage of capital spending (Rajan and Zingales, 1998) is in the top tercile of firms in a given quarter and non-financially dependent firms are those for which the ratio is in the bottom tercile of firms in a given quarter.

Table 2.3: Descriptive Statistics of Credit Measures by Subset

Average

	Total credit					Short-term credit					Long-term credit				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
All firms	3.54	5.42	1.88	8.96	6.91	7.05	15.11	8.05	22.16	14.06	3.61	5.90	2.29	9.51	7.13
High default probability	4.43	7.54	3.12	11.97	6.75	7.87	15.84	7.97	23.71	13.63	4.23	8.50	4.26	12.73	6.64
Low default probability	3.63	5.17	1.54	8.80	6.99	7.14	15.11	7.97	22.24	14.23	3.72	5.62	1.90	9.34	7.25
	[0.0622]	[0.0000]	[0.0170]	[0.0000]	[0.4497]	[0.1114]	[0.3615]	[0.9961]	[0.1247]	[0.3503]	[0.1698]	[0.0000]	[0.0029]	[0.0000]	[0.0342]
High debt service	3.02	5.53	2.51	8.56	5.94	6.22	15.09	8.87	21.30	12.43	3.34	6.17	2.83	9.51	6.61
Low debt service	11.65	7.44	-4.21	19.09	13.24	8.30	7.31	-0.99	15.61	11.57	9.47	20.46	10.98	29.93	18.25
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.1106]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Large	3.40	5.29	1.89	8.69	6.64	6.87	14.73	7.86	21.60	13.67	3.51	5.76	2.25	9.27	6.92
Small	9.75	12.27	2.52	22.02	18.30	13.09	24.16	11.08	37.25	25.93	8.48	16.41	7.93	24.89	16.80
	[0.0000]	[0.0000]	[0.0846]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Financially dependent	5.16	6.85	1.69	12.01	8.25	8.69	18.36	9.67	27.05	16.00	5.03	7.08	2.05	12.11	8.19
Non-financially dependent	3.67	6.10	2.43	9.77	6.19	7.28	16.30	9.02	23.58	13.12	3.75	7.02	3.27	10.77	6.47
	[0.0000]	[0.1351]	[0.2175]	[0.0001]	[0.0000]	[0.0053]	[0.0668]	[0.6063]	[0.0037]	[0.0001]	[0.0001]	[0.9245]	[0.0980]	[0.0602]	[0.0000]

Coefficient of variation

	Total credit					Short-term credit					Long-term credit				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
All firms	27.96	40.63	111.09	30.11	27.34	23.38	30.36	56.57	23.34	22.67	32.67	41.63	94.28	33.55	32.62
High default probability	123.98	79.88	270.27	65.77	53.88	73.01	58.39	133.42	46.97	56.10	112.06	98.83	238.75	71.29	45.35
Low default probability	30.72	37.45	122.95	28.74	27.90	25.48	34.17	64.87	25.91	24.93	33.60	37.75	95.35	31.83	32.07
High debt service	36.73	52.16	113.49	38.78	36.70	31.17	43.29	12.12	74.46	31.17	40.01	50.55	10.54	90.56	40.21
Low debt service	42.90	72.09	-143.30	44.14	58.67	64.69	60.76	-609.54	49.97	50.80	58.02	54.98	98.33	46.87	54.11
Large	30.24	42.59	113.34	31.90	29.44	23.87	31.49	59.36	23.90	22.93	34.85	43.64	98.37	35.33	34.81
Small	27.08	29.84	170.12	21.48	22.84	28.17	21.02	56.50	16.89	25.89	26.92	32.16	69.59	23.99	26.14
Financially dependent	58.30	71.87	356.15	45.90	39.97	45.15	58.15	122.95	40.05	41.84	69.70	79.93	333.97	53.28	44.81
Non-financially dependent	64.55	71.60	208.85	49.80	51.67	72.61	62.26	129.33	47.58	51.79	60.61	90.67	207.16	62.63	53.96

Note: This table reports averages, p-values of a two-sided t-test for mean equivalence in brackets, and coefficients of variation for subsets of firms. Firms are subset by their default probability following Farre-Mensa and Ljungqvist (2016), whereby firms for which the default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms. High debt service firms are those for which the leverage ratio is in the top tercile of firms in a given quarter and small firms are those for which their leverage ratio is in the bottom tercile of firms in a given quarter. Financially dependent firms are those for which the ratio of capital spending less operating cash flow as a percentage of capital spending (Rajan and Zingales, 1998) is in the top tercile of firms in a given quarter and non-financially dependent firms are those for which the ratio is in the bottom tercile of firms in a given quarter.

Table 2.4: Cumulative Impulse Responses of Credit Flows to a Monetary Policy Easing Shock

Total credit

	After 4 quarters					After 8 quarters					After 12 quarters				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
All firms	0.27	-0.17	-0.43	0.09	-0.49	**0.50**	**0.38**	**-0.13**	**0.85**	**-0.10**	**0.73**	**0.94**	**0.23**	**1.64**	0.31
High default probability	1.38	-0.30	-1.53	0.93	-1.53	1.47	**0.65**	**-0.71**	1.92	-1.55	1.02	**1.40**	**0.61**	2.16	-2.49
Low default probability	0.06	-0.20	-0.26	-0.11	-0.60	0.21	0.14	-0.06	0.37	-0.40	0.39	0.47	0.09	0.89	-0.09
High debt service	**0.39**	-0.28	-0.69	0.10	-0.72	**0.81**	0.12	-0.73	**0.93**	-0.25	**1.21**	0.49	-0.71	1.69	0.24
Low debt service	-0.02	-0.76	-0.83	-0.76	**-2.29**	-0.12	-0.95	-0.92	-1.13	-3.31	-0.19	**-0.46**	**-0.31**	-0.69	-3.56
Large	0.62	0.21	-0.36	0.90	-0.31	1.00	1.44	0.48	2.49	0.44	1.24	2.10	0.86	3.41	0.91
Small	-0.27	-0.09	0.21	-0.25	-1.45	-0.17	0.34	0.54	**0.33**	-1.55	0.28	**0.28**	**0.07**	0.63	-1.81
Financially dependent	**-0.94**	-0.20	0.82	-1.05	**-2.52**	-1.13	-0.08	1.10	-1.14	-3.19	-1.02	0.37	1.36	-0.54	-3.09
Non-financially dependent	0.40	-1.78	-2.22	-1.60	-4.04	0.43	-2.10	-2.58	-1.86	-4.84	0.63	-2.23	-2.93	-1.75	-5.13

Long-term credit

	After 4 quarters					After 8 quarters					After 12 quarters				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
All firms	**0.31**	-0.08	-0.43	0.24	-0.42	**0.63**	**0.53**	**-0.17**	**1.15**	**0.13**	0.91	**1.21**	**0.26**	**2.10**	0.67
High default probability	1.15	1.07	-0.19	2.07	-0.50	1.20	**2.85**	**1.42**	**3.86**	-0.43	**0.79**	**4.14**	**3.23**	4.59	**-1.27**
Low default probability	**0.28**	-0.32	-0.64	0.01	-0.69	**0.67**	**0.09**	-0.64	**0.81**	**-0.09**	**0.99**	**0.72**	**-0.36**	**1.78**	**0.51**
High debt service	**0.27**	-0.18	-0.49	0.09	-0.59	**0.85**	0.34	-0.53	**1.15**	0.13	**1.36**	0.86	-0.47	**2.16**	0.90
Low debt service	0.27	**-3.96**	**-4.41**	**-3.84**	**-8.09**	0.01	-4.69	-4.76	-4.91	-10.05	0.01	-4.14	-4.19	-4.41	-10.34
Large	0.90	-0.97	-1.74	-0.04	-2.30	1.49	0.09	-1.30	1.61	-1.38	1.83	0.71	-0.94	2.54	-0.90
Small	0.30	**0.79**	**0.46**	**1.13**	-0.32	0.40	1.70	1.19	**2.18**	-0.26	**0.78**	1.58	**0.63**	2.45	-0.63
Financially dependent	-1.08	-0.53	0.61	-1.59	**-2.90**	-0.97	**-0.12**	0.97	**-1.06**	-2.87	-0.69	**0.70**	**1.51**	**0.08**	-2.37
Non-financially dependent	0.42	-1.89	-2.33	-1.43	-3.87	**0.77**	-1.96	-2.80	-1.16	-4.16	**1.25**	-1.78	-3.09	-0.52	-3.94

Short-term credit

	After 4 quarters					After 8 quarters					After 12 quarters				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
All firms	-0.04	0.34	0.41	0.27	**-0.52**	**-0.55**	0.59	1.19	0.00	**-1.74**	-0.86	0.41	1.34	-0.47	**-2.72**
High default probability	1.22	0.44	-0.52	1.67	-0.68	1.18	-0.06	-1.03	1.15	-2.26	1.05	-0.73	-1.56	0.20	-4.11
Low default probability	**-0.20**	0.47	0.71	0.26	**-1.10**	**-0.89**	0.66	1.62	-0.19	**-2.72**	**-1.45**	0.36	1.81	-0.99	**-4.26**
High debt service	-0.02	**1.64**	**1.74**	1.57	-0.60	-0.53	2.24	2.91	1.68	**-1.81**	-0.75	1.95	2.90	1.17	-2.99
Low debt service	**-2.53**	**-1.18**	**1.34**	**-3.68**	**-5.34**	-3.59	-1.71	1.93	-5.30	-7.63	-3.40	-1.69	1.73	-5.18	-7.87
Large	0.03	1.86	1.75	1.94	-1.65	-0.15	7.05	7.32	6.82	-2.24	-0.02	9.43	9.45	9.37	-2.14
Small	**0.35**	0.22	-0.21	0.42	-1.14	**1.07**	0.78	-0.46	1.69	-0.51	**1.73**	1.23	-0.69	2.86	0.04
Financially dependent	**-0.84**	0.01	0.72	**-0.59**	**-4.54**	**-1.89**	-0.93	0.87	-2.66	**-7.67**	-2.19	-1.07	1.12	-3.14	-8.77
Non-financially dependent	-0.37	-2.17	-1.98	-2.32	**-5.33**	**-1.10**	-3.77	-2.99	-4.61	**-8.89**	-1.57	-4.84	-3.54	-6.10	**-11.26**

Note: This table shows the cumulative percentage point response of credit flows to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the shadow federal funds rate, and two credit flow measures. It includes a constant and two lags, as chosen by BIC. Bold responses are those that fall within the 68 percent mean-bias-corrected residual-based wild bootstrap interval. Firms are subset by their default probability following Farre-Mensa and Ljungqvist (2016), whereby firms for which the default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms. High debt service firms are those for which the leverage ratio is in the top tercile of firms in a given quarter and small firms are those for which their leverage ratio is in the bottom tercile of firms in a given quarter. Financially dependent firms are those for which the ratio of capital spending less operating cash flow as a percentage of capital spending (Rajan and Zingales, 1998) is in the top tercile of firms in a given quarter and non-financially dependent firms are those for which the ratio is in the bottom tercile of firms in a given quarter.

Table 2.5: Heterogeneity of Investment Efficiency

	High default probability		**Low default probability**	
	Mean	Std. dev.	Mean	Std. dev.
1974:Q1–1979:Q4	1.033	0.345	1.041	0.308
1980:Q1–1989:Q4	1.022	0.429	1.059	0.437
1990:Q1–1999:Q4	1.003	0.480	1.076	0.462
2000:Q1–2009:Q4	0.985	0.444	1.071	0.469
2010:Q1–2017:Q1	1.017	0.428	1.072	0.457

	High debt service		**Low debt service**	
	Mean	Std. dev.	Mean	Std. dev.
1974:Q1–1979:Q4	1.057	0.301	1.025	0.359
1980:Q1–1989:Q4	1.091	0.458	1.021	0.476
1990:Q1–1999:Q4	1.095	0.446	1.011	0.538
2000:Q1–2009:Q4	1.088	0.448	0.983	0.529
2010:Q1–2017:Q1	1.088	0.448	0.991	0.519

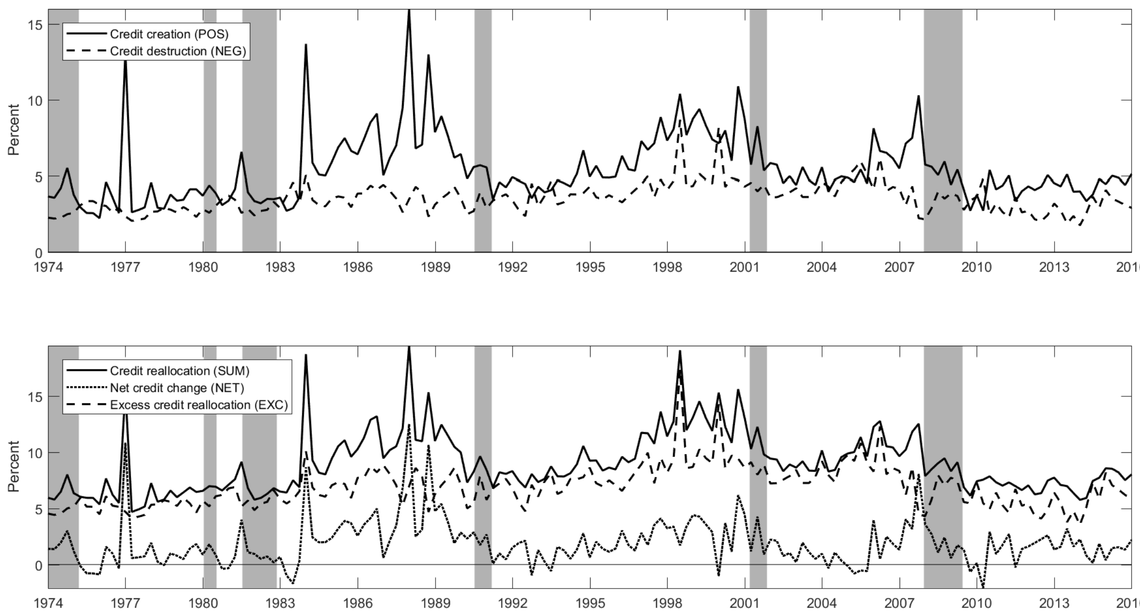
	Large		**Small**	
	Mean	Std. dev.	Mean	Std. dev.
1974:Q1–1979:Q4	1.033	0.244	1.045	0.359
1980:Q1–1989:Q4	1.039	0.357	1.087	0.544
1990:Q1–1999:Q4	1.054	0.376	1.100	0.581
2000:Q1–2009:Q4	1.042	0.367	1.115	0.606
2010:Q1–2017:Q1	1.041	0.342	1.144	0.646

	Financially dependent		**Non-financially dependent**	
	Mean	Std. dev.	Mean	Std. dev.
1974:Q1–1979:Q4	1.054	0.280	1.035	0.291
1980:Q1–1989:Q4	1.103	0.544	1.055	0.460
1990:Q1–1999:Q4	1.098	0.516	1.069	0.479
2000:Q1–2009:Q4	1.080	0.495	1.062	0.477
2010:Q1–2017:Q1	1.083	0.485	1.074	0.467

Note: This table provides the averages and standard deviation of the investment efficiency index (Galindo, Schiantarelli, and Weiss, 2007) by subsets of firms across time. The index is the change in debt-weighted sales as a percentage of capital, where the top and bottom one percent are trimmed in calculation of these statistics. Firms are subset by their default probability following Farre-Mensa and Ljungqvist (2016), whereby firms for which the default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms. High debt service firms are those for which the leverage ratio is in the top tercile of firms in a given quarter and small firms are those for which their leverage ratio is in the bottom tercile of firms in a given quarter. Financially dependent firms are those for which the ratio of capital spending less operating cash flow as a percentage of capital spending (Rajan and Zingales, 1998) is in the top tercile of firms in a given quarter and non-financially dependent firms are those for which the ratio is in the bottom tercile of firms in a given quarter.

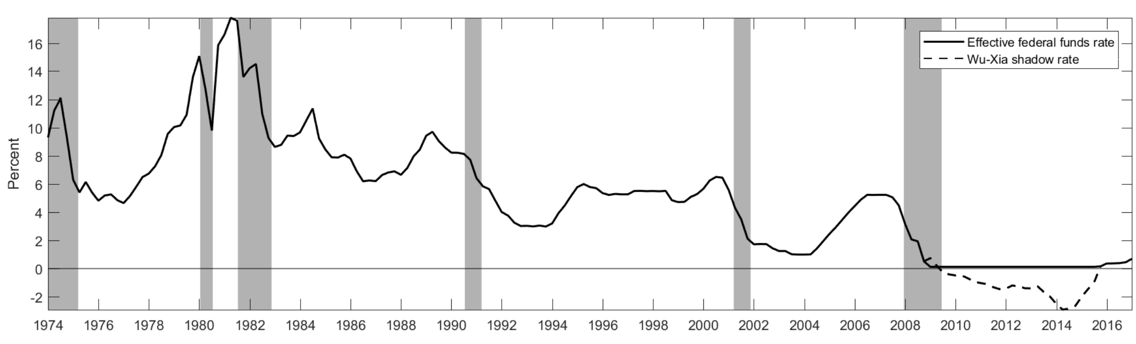
2.8 Figures

Figure 2.1: Total Credit Measures of All Publicly Traded Firms



Note: POS refers to credit creation, NEG is credit destruction, NET is net credit change ($NET_{st} = POS_{st} - NEG_{st}$), SUM is credit reallocation ($SUM_{st} = POS_{st} + NEG_{st}$), and EXC is excess credit reallocation ($EXC_{st} = SUM_{st} - |NET_{st}|$) for total credit for all firms. Shaded bars indicate NBER recessions.

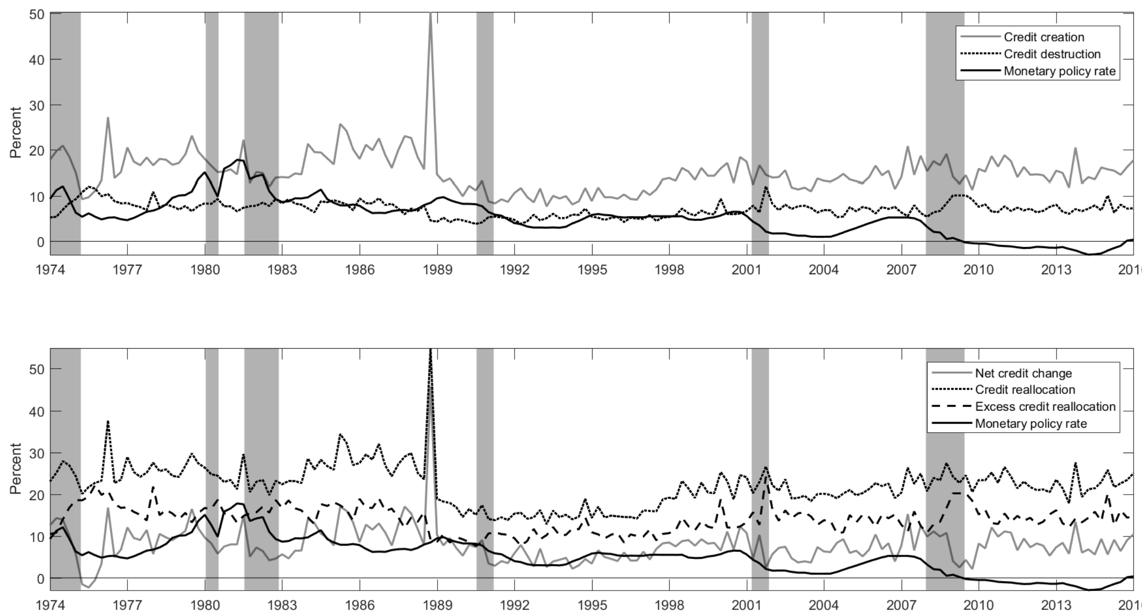
Figure 2.2: The Shadow Rate and Effective Federal Funds Rate



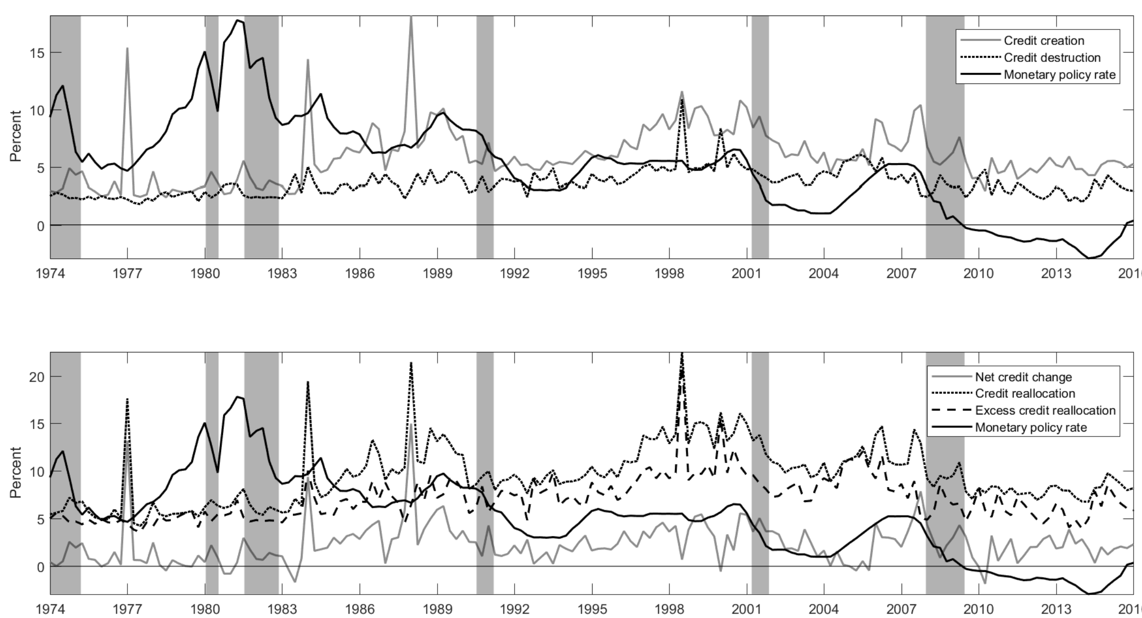
Note: The effective federal funds rate comes from the Federal Reserve Board's H.15 release and the Wu Xia shadow rate comes from the Federal Reserve Bank of Atlanta. Shaded bars indicate NBER recessions.

Figure 2.3: The Monetary Policy Rate and Credit Flow Measures

a) Short-term credit

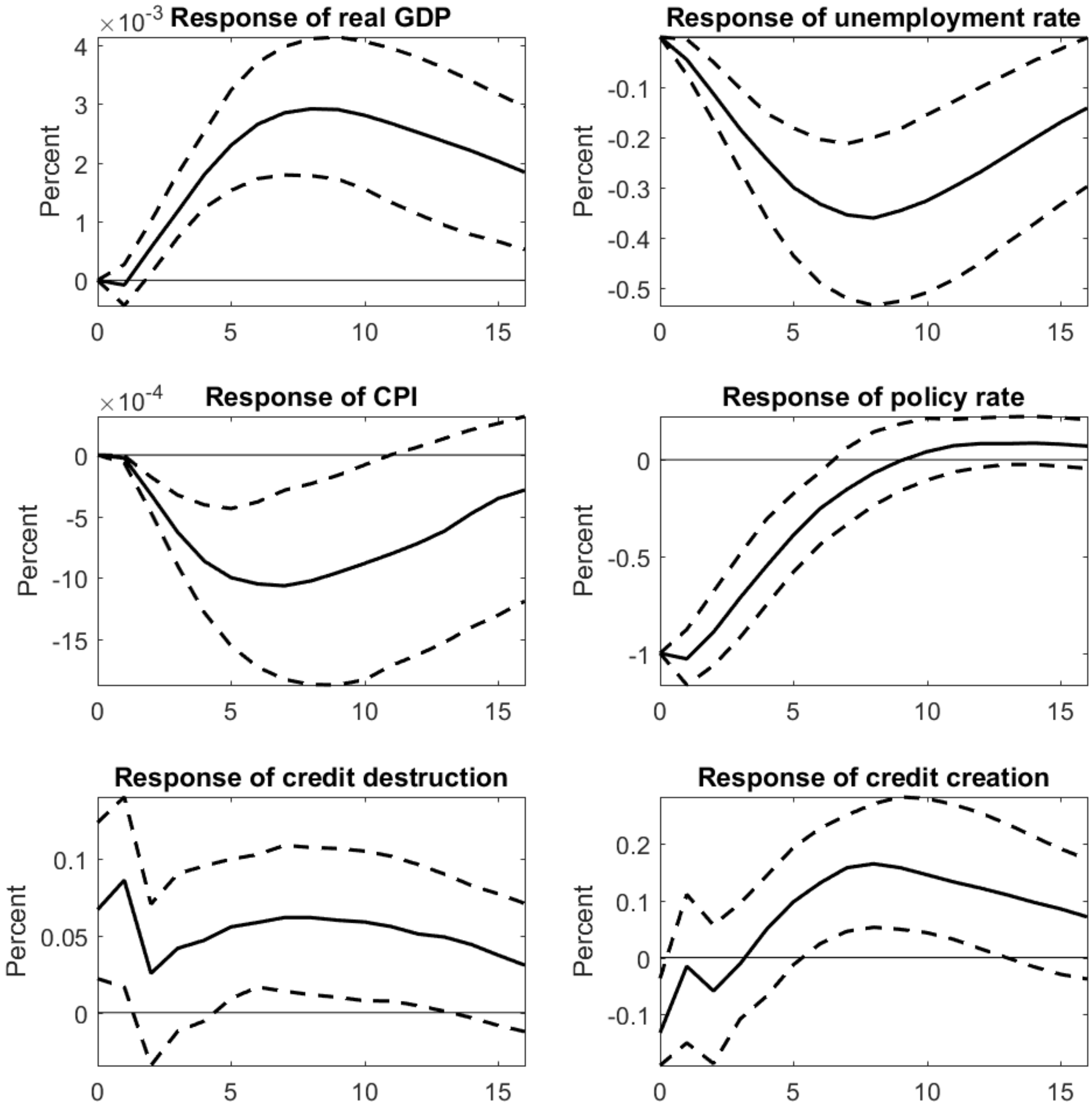


b) Long-term credit



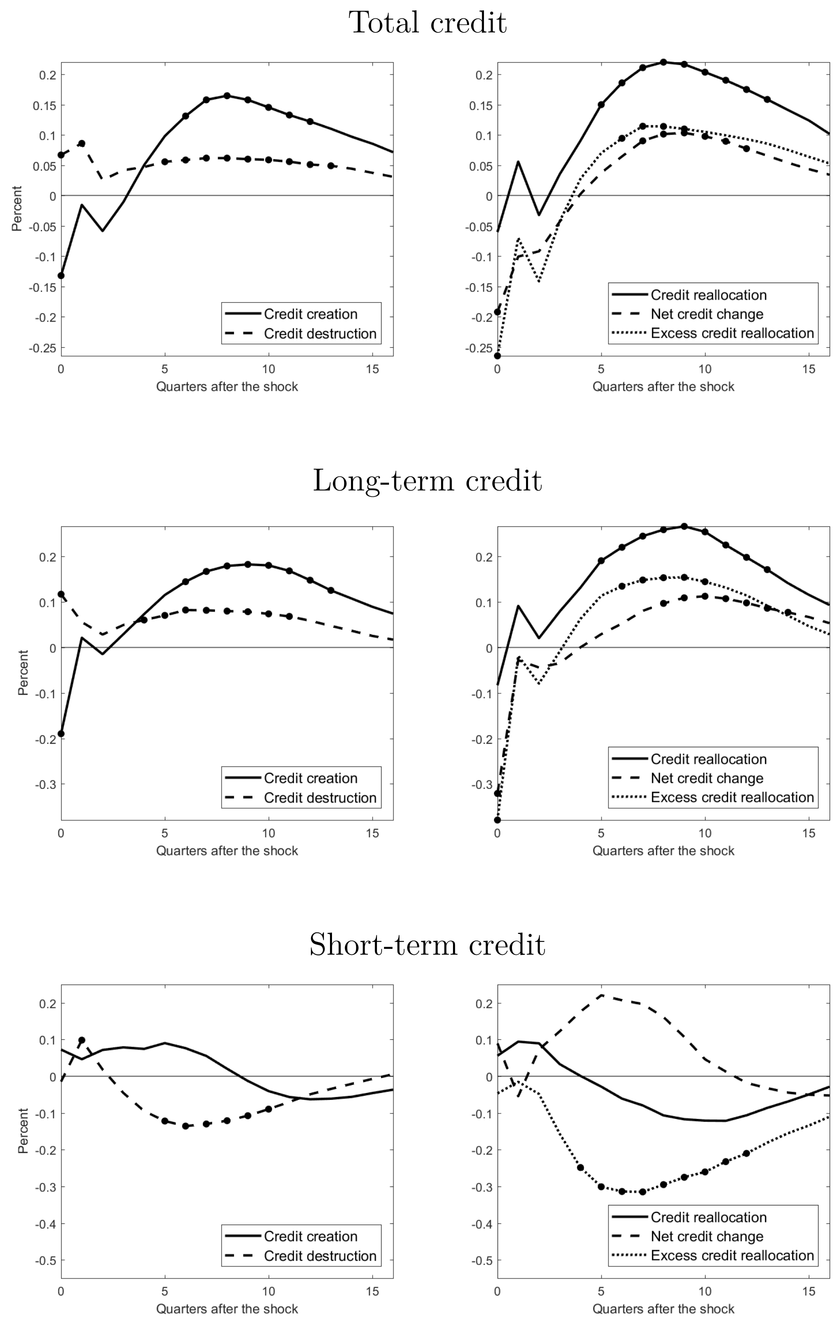
Note: This monetary policy rate is the effective federal funds rate during normal times, but the Wu-Xia during the zero lower bound period. Shaded bars indicate NBER recessions.

Figure 2.4: Impulse Responses to an Expansionary Monetary Policy Shock



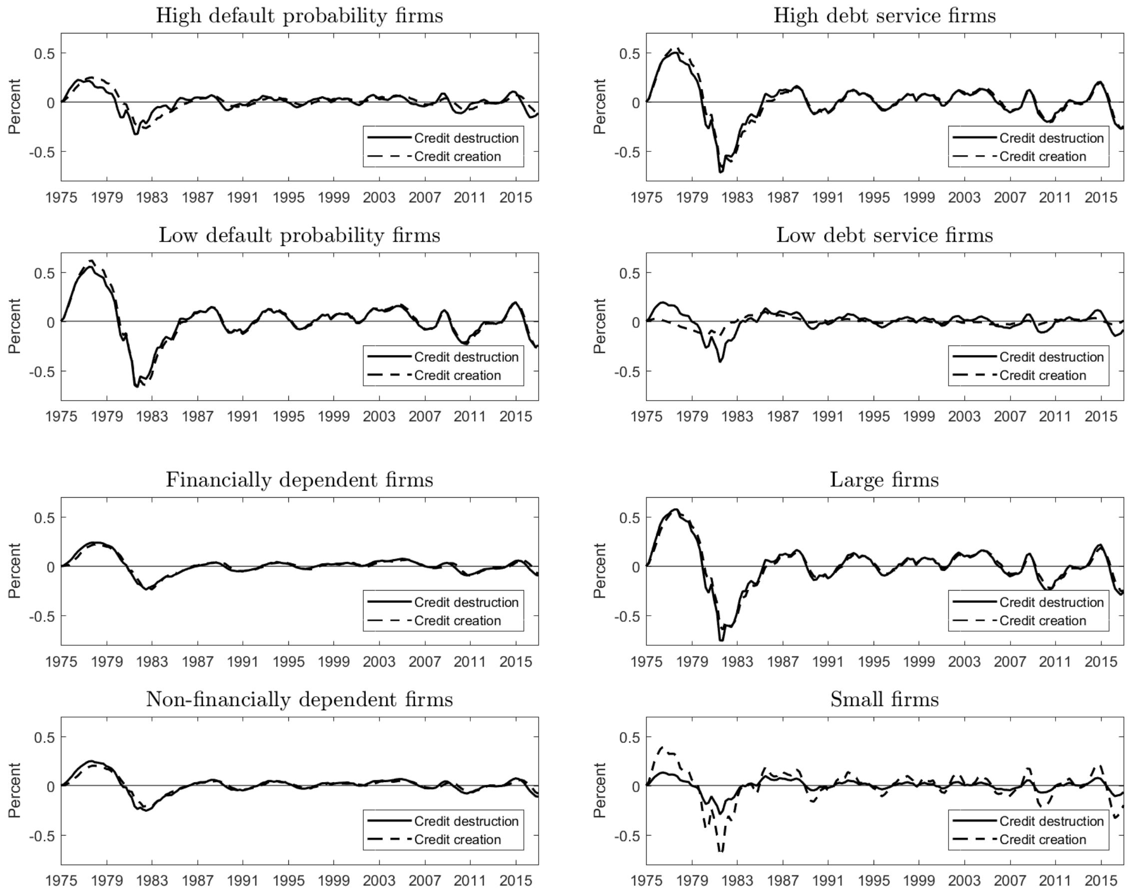
Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the monetary policy rate, and two credit flow measures. It includes a constant and two lags, chosen by BIC. The bands represent the 68 percent mean-bias-corrected residual-based wild bootstrap interval.

Figure 2.5: Impulse Responses of Credit Flows to an Expansionary Monetary Policy Shock



Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the monetary policy rate, and two credit flow measures. It includes a constant and two lags, chosen by BIC. The dots indicate 68 percent statistical significance using the mean-bias-corrected residual-based wild bootstrap method.

Figure 2.6: Historical Contribution of Monetary Policy Shocks to Credit Flows



Note: These graphs shows the cumulative historical contribution of monetary shocks to credit flow measures. These results are derived from a VAR that includes a block of macroeconomic variables, the monetary policy rate, two aggregate credit flow measures, and two group credit flow measures. The VAR includes a constant and two lags, chosen by BIC. High default probability firms are those for which the default probability exceeds 25 percent at a point in time. High debt service firms are those for which the quarterly leverage ratio falls in the top tercile of firms. Large firms' total assets fall in the top tercile of firms. Financially dependent firms are those for which the quarterly need for external financing falls in the top tercile of firms.

Chapter 3 The Effect of Unconventional Monetary Policy on the Creation and Destruction of Credit

joint with Ana María Herrera

3.1 Introduction

In December 2008, the Federal Open Market Committee (FOMC) established a target range for the federal funds rate of 0 to 0.25%. In the following years, with this rate effectively at the zero lower bound (ZLB), the Federal Reserve resorted to unconventional policy methods to stimulate the economy. By November 2014, the Federal Reserve purchased nearly $4 trillion of mortgage-backed securities, agency debt, and long-term U.S. Treasuries. Moreover, throughout the ZLB, Federal Reserve officials engaged in forward guidance to shape expectations of the course of future monetary policy. These unprecedented actions were intended to ease strained financial markets, which were hampering economic growth due to tight credit standards. In this chapter, we evaluate the impact of these policies on the allocation of credit among firms during the ZLB.

Empirically assessing the effect of unconventional monetary policy has proved to be difficult for policymakers and academics alike. A notable challenge has been the measurement of monetary policy once the ZLB is reached. However, in recent years, researchers have developed methods to account for the Federal Reserve's large-scale asset purchases and forward guidance in quantifying the stance of U.S. monetary policy (Krippner, 2012; Bauer and Rudebusch, 2016; Wu and Xia, 2016). In particular, Wu and Xia (2016) employ a factor augmented vector autoregression (FAVAR) in the spirit of Bernanke, Boivin, and Eliasz (2005) to investigate the impact of unconventional monetary policy on unemployment, industrial production, consumer prices, capacity utilization, and housing starts. They find that monetary policy actions taken during the ZLB lowered the unemployment rate by 1 percentage point more than if the Federal Reserve followed a Taylor rule. While an analysis of monetary policy's impact on credit markets is absent from their study, their method is appropriate to assess the allocation of credit among borrowing firms.

During the Great Recession and the start of the ZLB period, certain borrowers were more adversely impacted than others. This is documented by Kudlyak and Sanchez (2017), who revisit an earlier empirical study by Gertler and Gilchrist (1994) to show that short-term credit of small firms declined substantially less than the credit of large firms during the 2008–09 period. This result is surprising because small firms typically have relatively fewer assets than large firms to pledge as collateral for external financing. By this constraint, small firms are more susceptible to adverse macroeconomic conditions (Kiyotaki and Moore, 1997; Bernanke, Gertler, and Gilchrist, 1999). Kudlyak and Sanchez (2017) conclude that the tightening of collateral constraints did not play a notable role in describing credit markets of borrowing firms during the Great Recession. However, from their analysis, it is unclear whether unconventional monetary policy was effective at easing these constraints during the ZLB. Accordingly, we estimate the impact of these policies on credit flows of financially constrained and non-financially constrained firms during the ZLB.

Using firm-level Compustat data, Kudlyak and Sanchez (2017) show that median short-term net credit changes are negative in the 2008–09 period. In other words, the median firm's dollar amount of credit destruction exceeds credit creation. Borrowing firms' credit holdings can decrease, for instance, through debt repayment, maturation, default, or forgiveness. As this occurs, lenders have more funds to extend to other borrowers that may have distinctive characteristics. For example, during an economic downturn, lenders may choose to extend credit to higher quality, non-financially constrained firms that are better able to pledge collateral for external financing (Bernanke, Gertler, and Gilchrist, 1994). To measure credit flows of borrowing firms, we follow Herrera, Kolar, and Minetti (2011) and construct separate measures of aggregate credit creation and destruction. We also construct credit flow measures for financially constrained and non-financially constrained groups of firms. Next, we analyze the impact of unconventional monetary policy separately on these flows of credit to uncover how policy actions cause credit to reshuffle amongst firms during the ZLB.

We find that unconventional monetary policy had a positive impact on aggregate credit creation and destruction of borrowing firms during the ZLB, specifically in long-term credit. During quantitative easing, our results suggest that the Federal Reserve positively impacted credit markets through the easing of firms' credit constraints. That is, actual increases in credit creation caused by unconventional monetary policy were markedly larger for financially constrained firms. This was most evident for the long-term credit of small firms or those with high default probabilities. We also find that unconventional monetary policy prompted substantial flows of credit to relatively productive firms during the ZLB.

This chapter is organized as follows. Section 3.2 describes the data used in analysis and the evolution of credit flows during the ZLB. Section 3.3 describes the empirical methodology. Section 3.4 provides the results of the counterfactual analysis during the ZLB, including the rounds of quantitative easing and Section 3.5 concludes.

3.2 Data Description

Credit Flows

As in Herrera, Kolar, and Minetti (2011) (hereafter HKM), we compute measures of inter-firm credit flows starting from the balance sheets and income statements of all publicly traded U.S. firms reported in the Standard and Poor's Full-Coverage Compustat tapes. Firms in finance, insurance, and real estate industry sectors are removed from the sample given our aim to study the impact of unconventional monetary policy on the (less studied) firms that demand credit, instead of firms that create credit. Using this data to study the effect of monetary policy shocks on credit reallocation presents some advantages and shortcomings. A clear shortcoming is that Compustat only includes publicly traded firms, which tend to be large. Thus, small private firms that have been found to exhibit larger declines in short-term credit and sales than large firms when faced by tighter monetary policy (see Gertler and Gilchrist (1994)) are excluded. However, recent work by Kudlyak and Sanchez (2017) finds that large firms exhibited a greater contraction in sales and short-term credit than small firms in 2008–09. This finding suggests that understanding how credit is reallocated among large firms is essential in evaluating the impact of unconventional monetary policy during and after the Great Recession. However, a key advantage of Compustat is the lengthy period of time covered in the data. This allows us to use structural vector autoregression (SVAR) tools such as historical decomposition when studying the impact of monetary policy (see Kilian and Lütkepohl (2017)).

We follow HKM's definition and measurement of credit flows in most aspects. In particular: (i) our unit of observation is the firm, as we do not have data on the firm's individual projects; (ii) we exclude accounts payable by suppliers from the measure of credit; (iii) we exclude firms for which the ratio of end-of-period gross capital to end-of-period net capital exceeds 120% to control for existing firms that enter the data-set;[1] (iv) only exits due to merger or acquisition, liquidation or bankruptcy are treated as credit subtractions.

We depart from HKM in using quarterly, instead of annual, data and we expand the sample to include the ZLB.[2] High frequencies over long periods allow for clearer

[1]See Ramey and Shapiro (1998) for the use of a similar criteria applied to flows of physical capital and Herrera, Kolar, and Minetti (2011) for a detailed description.

[2]Herrera, Kolar, and Minetti (2011) compute annual credit flows using Compustat over the period 1952–2007. Reliable quarterly data is only available from Compustat starting in the early 1970s. See the Appendix for descriptive statistics for annual credit flows that resemble those by Herrera, Kolar, and Minetti (2011).

identification of monetary policy shocks. We compute the rate of debt growth, g_{it}, for firm i in quarter t as

$$g_{it} = \frac{debt_{it} - debt_{it-1}}{(debt_{it} + debt_{it-1})/2}. \tag{3.1}$$

This measure is symmetric around zero and bounded, thus allowing for a unified treatment of continuing, newborn and dying firms (Davis and Haltiwanger, 1992; Herrera, Kolar, and Minetti, 2011). In particular, $g_{it} \in [-2, 2]$, where -2 corresponds to debt growth of firms that died in the current year and 2 is debt growth of newborn firms.

With the rate of growth defined as above, we proceed to compute aggregate credit creation and credit destruction for a set of firms s in quarter t. These are weighted sum of the rates of debt growth for expanding or entering firms and the weighted sum of the rates of debt growth for contracting or exiting firms, respectively. Specifically, aggregate credit creation for group s in t (POS_{st}) is defined as

$$POS_{st} = \sum_{g_{it}>0, i \in s_t} g_{it} \left(\frac{debt_{it}}{debt_{st}} \right). \tag{3.2}$$

Similarly, credit destruction (NEG_{st}) is defined as

$$NEG_{st} = \sum_{g_{it}<0, i \in s_t} |g_{it}| \left(\frac{debt_{it}}{debt_{st}} \right). \tag{3.3}$$

Furthermore, we compute gross credit reallocation as the sum of credit creation and credit destruction ($SUM_{st} = POS_{st} + NEG_{st}$). We obtain net credit growth by subtracting credit destruction from credit creation ($NET_{st} = POS_{st} - NEG_{st}$) and excess credit reallocation as $EXC_{st} = SUM_{st} - |NET_{st}|$.

Aggregate Credit Flows

We start by examining the magnitude and volatility of aggregate credit flows of borrowing firms. Table 3.1 reports the average credit creation, destruction, reallocation, net credit change, and excess credit reallocation for the 1974:Q1–2017:Q1 period. From panel (a), average credit creation is 5.4% and credit destruction is 3.5%, amounting to a net credit change of 1.9% and gross and excess credit reallocation of 9.0% and 6.9%, respectively. This confirms HKM's finding that the intensity of inter-firm credit flows far exceeds the reallocation needed to accommodate net credit changes. Also, the volatility of credit creation is substantially larger than credit destruction. A possible explanation is that firms are better equipped to adjust the dollar amount of credit upward over short periods of time. For instance, firms often draw upon lines of credit with little or no notice, leading to more volatile credit creation.

A benefit of creating credit flow measures from firm-level data is that we can separately analyze the allocation of short- and long-term credit of firms. Panels (b) and (c) of Table 3.1 provides credit flow averages and coefficients of variation of short-term[3] and long-term credit. Average short-term credit creation and destruction are notably higher than long-term creation and destruction. The relatively large short-term credit destruction may stem from firms' incentives to repay such credit as to maintain their reputations as good borrowers (Diamond, 1989). Indeed, average short-term credit creation and credit destruction over the period is 15.1 and 7.1 percent, respectively, compared to 5.9 and 3.6 percent, respectively, for long-term credit.

[3]Short-term credit refers to credit maturing in less than 12 months and the portion of long-term credit maturing in less than 12 months.

Group Credit Flows

To explore the effect of monetary policy on the allocation of credit of firms with varying degrees of financial constraints, we construct credit flows for certain subgroups of borrowing firms. We begin by constructing alternative measures of financial constraints used in the extant literature. These are (i) asset size (Gertler and Gilchrist, 1994; Kudlyak and Sanchez, 2017), (ii) debt service (i.e. leverage) (Mishkin, 1996), (iii) need for external financing (Rajan and Zingales, 1998), and (iv) default probabilities (Farre-Mensa and Ljungqvist, 2016). A firm's leverage ratio is that of total debt to total assets. The need for external financing is a firm's capital spending less operating cash flow as a percentage of capital spending (Rajan and Zingales, 1998). Default probabilities are calculated following Merton (1974) such that

$$DD_{it} = Distance - to - default_{it} = \frac{log(\frac{E_{it}+F_{it}}{F_{it}}) + r_{it} - 0.5\sigma_{it}^2}{\sigma_{it}} \tag{3.4}$$

where

$$E_{it} = \frac{|prccq| \times cshoq}{10^3} \tag{3.5}$$

$$F_{it} = dlcq + \frac{1}{2}dlttq \tag{3.6}$$

$$\sigma_{it} = [\frac{E}{E+F} \times \sigma_{E,it}] + [\frac{F}{E+F} \times (0.05 + 0.25 \times \sigma_{E,it})] \tag{3.7}$$

where $\sigma_{E,it}$ is the rolling one-year standard deviation of *prccq* (stock price), r_{it} is the year-over-year stock return, *dlttq* is total long-term debt, *dlcq* is short-term debt, and *cshoq* is common shares outstanding. Default probabilities are obtained from the cumulative standard normal function.

We classify firms as financially constrained if a firm's (i) assets value falls in the bottom tercile of firms in a given quarter, (ii) leverage ratio falls in the top tercile of firms in a given quarter, (iii) need for external financing falls in the top tercile of firms in a given quarter, or (iv) default probability exceeds 25 percent as in Farre-Mensa and Ljungqvist (2016).[4]

Table 3.2 shows the percentage of time that firms are classified in specific groups at time t, conditional on classifications in time $t-1$. While these are alternative measures of financial constraints, they do capture different aspects of firms. For instance, default probabilities tend to fluctuate with equity prices and are therefore noisy measures. If a firm is classified as having a high default probability in $t-1$, then it is likely to remain in the same group in t only 48.7 percent of the time. In other words, a firm is more likely to be classified as having a low default probability in t. However, a low default probability firm in $t-1$ is substantially more likely to remain a low default probability firm in t (88.7 percent) than becoming a high default probability firm. Firms' asset prices tend to be more stable across time, therefore, firms that are classified as small in $t-1$ are also small in t 80.6 percent of the time. Of the remaining 19.4 percent, firms transition to large only 1.8 percent of the time. In fact, small firms are less likely to remain small (80.6 percent) than large firms are to remain large between $t-1$ and t (84.9 percent).

Table 3.3 provides the change in the credit flow measures for financially constrained and non-financially constrained firms from 2009:Q3 through 2015:Q3, the period after the recession when unconventional monetary policy was conducted. For short-term maturities, the largest increase in net credit wass for high default probability firms (8.06 percentage points). For this group, credit creation increased 9.70 percentage points and credit destruction increased 1.64 percentage points. While credit reallocation was high for these firms (11.34 percentage points), the intensity of

[4]Our empirical results are robust to alternatively grouping firms by default probability terciles. These results are shown in the Appendix.

credit reallocation, as measured by excess credit reallocation, did not increase substantially. This wass the result of a one-sided, rather than simultaneous and intense increase in credit creation and credit destruction.

Recall that Kudlyak and Sanchez (2017) find that median short-term credit for large firms contracted more than small firms during the Great Recession. After this time and during the ZLB, short-term net credit of firms also increased relatively more for those classified as large, rising 2.37 percentage points. Short-term net credit for small firms decreased 0.62 percentage points. However, this decline in short-term net credit masked the large and intense reallocation of short-term credit of these firms occurring during the ZLB. Short-term credit creation of small firms increased 4.35 percentage points, but short-term credit destruction increased 4.97 percentage points. While the short-term net credit change was negative, short-term credit reallocation and excess credit reallocation were 9.32 and 8.70 percentage points, respectively. The change in excess credit reallocation during this period was larger for small firms than any other subset under analysis.

Small firms also experienced a large increase in long-term credit creation (9.96 percentage points) relative to large firms (-0.15 percentage points). Long-term credit creation also increased disproportionately more for financially dependent firms (3.88 percentage points) and high default probability firms (4.64 percentage points). These results are consistent with easing of collateral constraints that likely occurred during the ZLB. However, we also find that long-term credit creation increased for low debt service firms (3.73 percentage points) but decreased for high debt service firms (-0.38 percentage points). These results are not consistent with this channel of monetary policy. However, credit destruction increased for high debt service firms, suggesting that these firms engaged in deleveraging during the ZLB.

Monetary Policy Measure

Empirical investigations into the effect of monetary policy shocks on economic activity commonly identify the federal funds rate as the monetary policy instrument. However, from December 2008 until December 2015, the federal funds rate was effectively at the ZLB, thus limiting the use of the instrument to stimulate the economy and invalidating its use as the monetary policy variable in SVARs. An alternative measure of the monetary policy stance at the ZLB has been proposed by Wu and Xia (2016), who develop an approximation to the forward rate in the multifactor shadow rate term structure model. This rate can be used to replace the effective federal funds rate in SVARs during the ZLB period. The Wu-Xia shadow rate has been shown to work well in FAVAR models and their data is made available by the Federal Reserve Bank of Atlanta. Thus, we employ the effective federal funds rate as our measure of monetary policy, but we replace it with the Wu-Xia shadow rate during the ZLB period.

Other Variables

As in Bernanke, Boivin, and Eliasz (2005), we include a large set of economic variables to capture the information available to Federal Reserve policymakers in determining the course of monetary policy. The variables included in this study cover broad markets such as labor, consumption, housing, exchange rates, etc. As in Wu and Xia (2016), we utilize 97 of the 120 original series used by Bernanke, Boivin, and Eliasz (2005), and we update these series beyond the ZLB, through 2017:Q1. We also include aggregate credit creation and destruction measures, for a total of 99 series. Unless these variables are rates or indices, they are typically expressed as logged differences to induce stationarity.

3.3 Empirical Methodology

Kudlyak and Sanchez (2017) do not use an econometric model; rather, they analyze credit aggregates and median credit growth rates for subsets of borrowing firms around NBER recession dates and "tight money dates" (Romer and Romer, 1989, 1990). To study the effect of monetary policy shocks, we utilize a FAVAR approach as in Bernanke, Boivin, and Eliasz (2005). We conduct policy counterfactuals like Wu and Xia (2016) to quantify the direct effect that unconventional monetary policy shocks had on credit flows during the ZLB.

Let r_t be the observed monetary policy instrument and let F_t be a vector of unobserved factors that jointly follow the vector autoregression:

$$\begin{bmatrix} F_t \\ r_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ r_{t-1} \end{bmatrix} + \upsilon_t \tag{3.8}$$

where $\Phi(L)$ is a lag polynomial and υ_t is mean zero with a covariance matrix, Q. The unobserved factors are estimated from the large set of macroeconomic variables, X_t, described in the previous section. The observed variables are related to the unobserved factors and observed policy rate such that,

$$X_t = \Lambda F_t + \lambda r_t + e_t \tag{3.9}$$

where Λ is the matrix of factor loadings. From (3.9), we obtain $\widehat{F}_t$ to estimate the FAVAR in (3.8), where we impose recursive restrictions that the factors respond to the monetary policy shock with a lag. Following Wu and Xia (2016), we include three estimated factors[5] in the estimation of (3.8). We regress each macroeconomic variable

[5] The estimated factors are plotted in the Appendix.

of interest[6] on the observed policy rate and estimated factors using least squares to obtain a b matrix.[7] From b, we obtain the impulse responses at horizon h, expressed as

$$\Psi_h^{r,i} = b_i^{x^1} \frac{\partial F_{t+h}^1}{\partial \upsilon_t^r} + b_i^{x^2} \frac{\partial F_{t+h}^2}{\partial \upsilon_t^r} + b_i^{x^3} \frac{\partial F_{t+h}^3}{\partial \upsilon_t^r} + b_i^r \frac{\partial r_{t+h}}{\partial \upsilon_t^r} \tag{3.10}$$

where the partial derivatives are the impulse responses from the estimated FAVAR.

The variables of interest are a function of all past shocks and initial conditions. Accordingly, we decompose each variable into the contributions of the shocks across time. This allows us to construct policy counterfactuals to describe the path that the economy would have taken had certain scenarios occurred as in Sims and Zha (2006). We analyze the contribution of monetary policy shocks to credit creation and destruction of borrowing firms over the period where the shadow rate was negative (2009:Q3–2015:Q3). We apply two policy counterfactuals as in Wu and Xia (2016). In the first counterfactual, we supplement the column of the matrix of structural shocks that corresponds to the shadow federal funds rate with zero. In effect, this forces the actual shadow federal funds rate to a hypothetical rate that is fully determined by lags in the FAVAR during the counterfactual period. In other words, the monetary shock is shut down. In the second counterfactual, we supplement the monetary policy shock series with one that forces the shadow federal funds rate to the ZLB during the counterfactual period. This is achieved by adding the difference between the observed shadow rate and 0.25 to the monetary shock series. Doing so, we quantify how credit flows would have responded had monetary policy been constrained by the ZLB. We

[6] As in Wu and Xia (2016), the variables of interest we use are the industrial production index, consumer price index, capacity utilization, unemployment, and housing starts, in addition to the credit flow measures.

[7] In this matrix, we impose restrictions that that the policy rate has no contemporaneous impact on any variable in the system other than housing starts. In other words, all other variables of interest are slow-moving (see Bernanke, Boivin, and Eliasz (2005) for the complete classification of fast- and slow-moving variables).

proceed by creating artificial historical decompositions that show the contributions of these hypothetical monetary policy shocks to the creation and destruction of credit of borrowing firms. As in Wu and Xia (2016), we create counterfactual wedges between the actual and counterfactual values of the variables of interest at time τ such that

$$wedge_{\tau}^{i} = Y_{\tau}^{i} - \sum_{s=t_1}^{\tau} \Psi_{s}^{r,i} \upsilon_{s}^{cf} \tag{3.11}$$

where $t1$=2009:Q3. In the first counterfactual, we let $\upsilon_s^{cf} = 0$. In the second counterfactual, we let $\upsilon_s^{cf} = \upsilon_s + 0.25 - r_s$.

3.4 The Effect of Monetary Policy on Credit Flows at the Zero Lower Bound

Figure 3.1 shows the impulse responses of the variables of interest to a -25 basis point shock to the monetary policy rate. As in Wu and Xia (2016), we find quantitatively similar increases in industrial production, capacity utilization, and housing starts and decreases in unemployment and consumer prices following the shock. Also, we find that aggregate credit creation and credit destruction of borrowing firms increase in response to the shock. The response of credit destruction is statistically significant between the second and eighth quarter following the easing shock and the response of credit creation is statistically significant between the third and ninth quarters following the shock. The increase in credit creation reaches over 4 percent, while the increase in credit destruction just surpasses 2 percent. Credit reallocation (that is, the sum of credit creation and destruction) accordingly increases over 6 percent, while the net credit increases to roughly 2 percent over the horizon. Compustat does not disclose why firms' credit changes from one period to the next. However, unconventional monetary policy may induce borrowers to deleverage (i.e. repay debt or allow debt to mature), such as to reduce the overhang of debt (Eggertsson and

Krugman, 2012).

Figure 3.2 plots the actual and counterfactual variables of interest as in Wu and Xia (2016) and of total credit creation and credit destruction of firms. Had monetary policy been conducted such that the monetary policy shock was shut down or such that monetary policy was bounded by the ZLB, unemployment and consumer prices would have been higher than observed. Also, industrial production, capacity utilization, and housing starts are lower in the counterfactuals than observed. The differences between the actual and counterfactual values of credit destruction are similar. However, unconventional monetary policy leads to a substantial increase in credit creation, specifically in the counterfactual bounding monetary policy to the ZLB. In other words, had the Federal Reserve not implemented the policy observed at the ZLB, credit creation among firms would have fallen.

The wedges between the actual and the counterfactual credit flows are reported in Table 3.4. In both counterfactuals, unconventional monetary policy positively impacted total credit reallocation as both observed credit creation and destruction measures were higher than their counterfactual values. Total credit creation increased 0.20 percentage points and credit destruction increased 0.06 percentage points in the first counterfactual; this results in a 0.26 percentage point increase in credit reallocation. The impact was larger in the second counterfactual as actual credit creation was 0.89 percentage points higher and credit destruction was 0.38 percentage points higher than if monetary policy was bounded by the ZLB. The impacts of unconventional monetary policy over this period were non-trivial, considering that average credit creation and destruction are 5.4 and 3.5 percentage points, respectively, over the whole period.

The positive impact of unconventional monetary policy shocks in the second counterfactual on aggregate short-term credit creation was smaller in magnitude (0.51 percentage points) than on long-term credit creation (0.88 percentage points). Further, from Table 3.1, short-term credit flows are, on average, substantially higher than long-term credit flows. While unconventional monetary policy caused long-term credit destruction to increase, the impact on short-term credit destruction was a decline of 0.26 percentage points.

Unconventional Monetary Policy's Heterogenous Impact on Credit Flows

We repeat this analysis using credit creation and credit destruction for financially constrained and non-financially constrained groups of firms as described in Section 3.2. We re-estimate the FAVAR with the addition of these measures in Y_t, then we compute the two counterfactuals during the ZLB.

We begin by analyzing the policy counterfactuals of financially dependent and non-financially dependent firms, shown in Table 3.4. If financially dependent firms are also financially constrained, then unconventional monetary policy ought to ease these constraints, leading to relatively larger increases in credit creation than for financially dependent firms. During the ZLB, unconventional monetary policy caused increases in credit creation and credit destruction for both groups, relative to the counterfactuals. However, as the results show, the increase in total credit creation due to unconventional monetary policy was larger for non-financially dependent firms. Additionally, in the second counterfactual, the increases in long-term credit creation due to unconventional monetary policy are comparable for the two groups.

During the Great Recession, Kudlyak and Sanchez (2017) find that the median decrease in short-term credit was relatively large for non-financially dependent firms. As Table 3.4 highlights, during the ZLB, short-term credit creation of financially dependent firms was 0.68 percentage points higher than if the monetary policy shock was shut down, although the counterfactual credit destruction was only 0.09 percentage points higher for these firms. This amounts to a 0.59 percentage point net credit increase during the ZLB relative to the first counterfactual, compared to a mere 0.01

percentage point net credit increase for non-financially dependent firms. However, in the second counterfactual, both credit creation and destruction fell relative to what would have occurred had the Federal Reserve been constrained by the ZLB. Yet, the net credit change for financially dependent firms was positive (0.11 percentage points), whereas the net credit change for non-financially dependent firms was negative (-0.14 percentage points).

Next, we examine monetary policy counterfactuals for high and low default probability firms. Total credit creation increased 1.26 percentage points for high default probability firms and 0.89 percentage points for low default probability firms compared to if the Federal Reserve was constrained by the ZLB. Further, actual credit destruction was 0.79 percentage points higher for high default probability firms and 0.44 percentage points higher for low default probability firms compared to the counterfactual. These amount to nearly identical net credit changes for these groups of firms. However, actual monetary policy induced a far larger and more intense credit reallocation for high default probability firms during the ZLB. These effects were present for long-term credit flows, however short-term credit creation fell for high default probability firms. These differences in counterfactual credit flows during the ZLB suggests that unconventional monetary policy was effective at easing collateral constraints for long-term credit.

Table 3.4 summarizes the results of the counterfactuals for small and large firms. As the table shows, monetary policy at the ZLB caused increases in short-term credit creation for large and small firms. Actual short-term credit creation increased 1.07 percentage points for small firms compared to if monetary policy was constrained by the ZLB. The increase in short-term credit creation for large firms was only 0.21 percentage points. This suggest that unconventional monetary policy operated through the easing of firms' financial constraints for short-term credit.

Lastly, we analyze the counterfactual credit flows of high and low debt service firms. According to Calomiris and Himmelberg (1995), high debt service firms are those for which external financing is overly costly and marginally difficult to obtain (that is, they are financially constrained). As displayed in Table 3.4, for both short- and long-term credit of borrowing firms, unconventional monetary policy caused large increases in credit creation for high debt service firms. Relative to policy that was constrained by the ZLB, short-term credit creation of high debt service firms increased 0.94 percentage points and this group's long-term credit increased 1.18 percentage points. A comparison of the actual credit flows to those if the monetary policy shock was shut down shows that credit creation increased for high debt service firms but fell for low debt service firms. It is important to note that low debt service firms hold little or no debt whatsoever, and by our classification, 4.22 percent of quarter-firm observations in Compustat report no holdings of debt. Accordingly, each firm considered as low debt service that has positive debt receives a relatively large weight in the overall measure of credit creation and destruction for this group. Nevertheless, low debt service firms are those who are not likely financially constrained so monetary policy, operating through channels that ease financial constraints, ought to not substantially impact this group's flow of credit.

Unconventional Monetary Policy and Rounds of Quantitative Easing

Between November 2008 and October 2014, the Federal Reserve conducted several rounds of quantitative easing, referred to as QE1 (Q3:2009–2010:Q1),[8] QE2 (2010:Q4–2011:Q2), operation twist (2011:Q3–2012:Q4), and QE3 (2012:Q3–2014:Q4). These were created to lend to certain financial institutions, provide liquidity to credit markets, and purchase long-term securities. We quantify the impact of these rounds of quantitative easing on the allocation of credit among borrowing firms. As before,

[8] While QE1 started in 2008:Q4, we start the counterfactual period in 2009:Q3 as in Wu and Xia (2016) because the shadow rate does not become negative until this quarter.

we compute wedges between actual credit creation and credit destruction and their counterfactual values between the start and conclusion of each round of quantitative easing.

QE1

The period known as QE1 began in November 2008 and ended in March 2010. During this time, the Federal Reserve Board established the Term Asset-Backed Securities Loan Facility (TALF). This was created to lend (non-recourse) to holders of AAA-rated asset-backed securities that were backed by new or recent loans. Initially, up to $180 billion was funded by the Federal Reserve and $20 billion from the Troubled Asset Relief Program (TARP). This amount later increased to $1 trillion with expanded acceptable collateral. The Federal Reserve also agreed to purchase up to $200 billion in agency debt, $1.25 trillion in agency mortgage-backed securities, and $300 billion in long-term Treasury securities.

Table 3.5 reports the counterfactuals for QE1 when the shadow rate is negative (2009:Q3–2010:Q1). In the second counterfactual, actual monetary policy shocks contributed to 0.07 and 0.10 percentage point increases in long-term credit destruction and credit creation, respectively. While small in magnitude, long-term credit creation and credit destruction only increased 0.43 and 0.88 percentage points during the ZLB period, respectively. The impacts of unconventional monetary policy on short-term credit creation and credit destruction are negligible compared to the actual changes in these credit flows during the ZLB.

Through TALF and the purchases of agency mortgage-backed securities, policymakers provided funding to holders of toxic assets to ease credit markets. During QE1, unconventional monetary policy caused relatively large increases in short-term credit creation for low debt service and small firms compared to high debt service and large firms. However, we find that increases in long-term credit creation due to unconventional monetary policy were greatest for financially constrained firms. Specifically, we find that small firms' credit creation increased 0.22 percentage points and high debt service firms' credit creation increased 0.12 percentage points due to unconventional monetary policy. This was the likely result of the Federal Reserve's purchases of long-term Treasury securities, aimed at lowering long-term yields to stimulating long-term lending.

QE2

QE2 began in November 2010 and concluded in June 2011. This round of quantitative easing included monthly $75 billion purchases of Treasury securities, up to a total of $600 billion. At the end of QE2, the Federal Reserve continued to reinvest principal payments of their holdings. In a sense, QE2 was aimed at providing funding to lenders in the same manner as QE1. Hence, the question that arises is whether this policy effected the reallocation of credit among firms.

Table 3.6 provides credit flow policy counterfactuals for the QE2 period (2010:Q4–2011:Q2). In the second counterfactual, we find that actual long-term credit destruction and credit creation increased 0.06 and 0.12 percentage points, respectively during QE2. These magnitudes are like those during QE1. Conversely, the contributions to aggregate short-term credit creation and credit destruction due to QE2 were negligible.

During the ZLB, unconventional monetary policy caused an increase in long-term credit creation for high debt service firms (1.18 percentage points), but a decrease in credit creation for low debt service firms (-0.83 percentage points). This divergence was not yet borne during QE1, however, over the QE2 period, we find that long-term credit creation increased 0.16 percentage points and low debt service firms' credit creation fell 0.03 percentage points compared to if the Federal Reserve was constrained by the ZLB. Also, we find that there was a proportionately large monetary policy-induced increase in the short-term credit of small firms compared to large firms.

Operation Twist

In September 2011, the Federal Reserve announced that they would hold more long-term Treasuries relative to short-term Treasuries, popularly referred to as operation twist. This would be achieved by simultaneously purchasing $400 billion of 6-30 year Treasuries and selling $400 billion of Treasuries with maturities of 3 years or less. In effect, this would put downward pressure on long-term yields to boost credit markets more broadly than prior policy steps. The Federal Reserve also agreed to purchase additional agency mortgage-backed securities from their holdings. While the simultaneous purchase and sale of Treasuries concluded in December 2012, the purchase of additional mortgage-backed securities continued beyond this time.

Even though these actions were intended to lower the cost of long-term credit, we do not find that unconventional monetary policy caused a notably large increase in long-term credit reallocation during operation twist compared to QE1 and QE2. Unconventional monetary policy caused long-term credit creation to increase 0.15 percentage points and short-term credit creation to increase 0.12 percentage points compared to if the Federal Reserve was constrained by the ZLB (see Table 3.7). Further, we find minor impacts of unconventional monetary policy on credit destruction during this time.

Operation twist made lenders' holding of long-term Treasuries less appealing because of their smaller yield. In effect, the policy steps may have induced lenders to seek higher returns elsewhere (Rajan, 2006). As a result, as shown in Table 3.7, actual increases in long-term credit creation of firms due to unconventional monetary policy increased relatively more for high debt service firms (0.22 percentage points) and high default probability firms (0.27 percentage points). These are firms that are more likely to be perceived as risky to lenders. We also find that short-term credit creation increased substantially more for financially dependent firms, but only in the counterfactual when the monetary shock was shut down. In this counterfactual, unconventional monetary policy caused a 0.64 percentage point increase in the short-term credit of financially dependent firms; this was substantially larger than the increase of 0.28 percentage points for non-financially dependent firms.

QE3

In September 2012, during operation twist, the Federal Reserve announced their plans for the final round of quantitative easing (QE3). During this round, the Federal Reserve purchased $40 billion of agency mortgage-backed securities and $45 billion of long-term Treasuries per month. At this time, they also announce that they will continue these purchases until conditions improve. By early 2014, the Federal Reserve reduced purchases by $5 and $10 billion each month, eventually concluding QE3 by October 2014.

During QE3, unconventional monetary policy caused a substantial reallocation of long-term credit, as Table 3.8 shows. Actual long-term credit creation and credit destruction increased 0.40 and 0.23 percentage points, respectively, due to unconventional monetary policy in the second counterfactual. A similar result holds when the monetary shock was shut down. However, in short-term credit markets during QE3, monetary policy caused similar increases in short-term credit creation (0.17 percentage points) as decreases in credit destruction (-0.21 percentage points) of firms in the second counterfactual.

During this time, unconventional monetary policy caused long-term credit creation to increase for financially constrained firms, specifically for high debt service firms, high default probability firms, and small firms. These increases also tended to be larger than any other round of quantitative easing. However, notable increases in short-term credit creation were also experienced by firms less likely to be financially constrained. For instance, in the first counterfactual, monetary policy caused a 0.46 percentage point increase in short-term credit creation for low debt service firms. In the second counterfactual, monetary policy caused relatively large increases in short-term credit creation for low default probability and low debt service firms as well as for small firms.

Unconventional Monetary Policy and Investment Efficiency

Up to now, we have grouped firms to analyze unconventional monetary policy's impact on financially constrained and non-financially constrained firms. A less studied aspect of credit markets and unconventional monetary policy deals with how credit is reallocated among firms of varying levels of investment efficiency. This is a topic of interest to policymakers as credit extended to firms of high investment efficiency ought to lead to higher economic growth.

As in Herrera, Kolar, and Minetti (2014), we use an investment efficiency index by Galindo, Schiantarelli, and Weiss (2007), constructed as

$$I_{it} = \frac{\frac{sales_{it}}{capital_{it}} \frac{debt_{it}}{debt_{st}}}{\frac{sales_{it-1}}{capital_{it-1}} \frac{debt_{it-1}}{debt_{st-1}}}. \tag{3.12}$$

A ratio exceeding one indicates that a firm's investment, on average, is efficient because the debt-weighted sales as a percentage of capital is growing. Many firms tend to have indexed close to one, so we classify firms in the top tercile as productive firms and firms in the bottom tercile as less productive firms to analyze dissimilarities in credit flows of such firms across time.

A priori, it is unclear if firms of high or low investment efficiency are likely to be financially constrained. Table 3.9 describes these two groups in terms of the average default probabilities, leverage ratios, asset size, and need for external finance. Across time, we find that high productivity firms tend to have lower default probabilities than low productivity firms on average. We also find that low productivity firms tend to have less need for external financing across time, although for both groups of firms, because the need for external financing ratio is negative, this implies that firms on both ends of the investment efficiency index spectrum tend to generate a relatively large amount of cash flow. While a brief analysis of the average default probabilities and need for external finance would suggest that low productivity firms are also financially constrained, we also find that these firms tend to have lower leverage and higher asset values. Therefore, it is unclear if a relationship exists between investment efficiency and financial constraints.

We compute credit flow measures for high and low investment efficiency firms (i.e. productive and less productive firms), shown in Table 3.10. At short and long maturities, credit creation of productive firms exceeds the credit creation of less productive firms and the credit destruction of less productive firms exceeds that of productive firms. Credit destruction for less productive firms exceeds credit creation, leading to negative net credit changes on average. Because credit creation is so large for productive firms, the net credit change is substantially larger than that of all firms.

During the ZLB, both long- and short-term credit creation fell for less productive firms, falling 0.13 and 5.56 percentage points, respectively. For productive firms, short-term credit also fell, but less severely (-0.85 percentage points). The long-term credit creation of productive firms increased appreciably at 3.52 percentage points. While it is unclear how much of this was due to unconventional monetary policy, this suggests that credit flowed to firms that are efficient in their investment, positively impacting future economic growth.

Table 3.12 shows the policy counterfactuals during the rounds of quantitative easing from a FAVAR estimated using credit flows of productive and less productive firms. We find that, in both counterfactuals, QE3 had the largest positive impact on short- and long-term credit creation of productive firms. Compared to the counterfactual where the Federal Reserve is constrained by the ZLB, long-term credit creation increased 1.28 percentage points and short-term credit creation increased 1.37 percentage points. The credit creation of less productive firms was minimally impacted during the rounds of quantitative easing. However, in each round, the contribution of unconventional monetary policy on long-term credit destruction was positive and had a larger magnitude than that of productive firms.

3.5 Conclusion

In this chapter, we show that unconventional monetary policy has a large and persistent impact on the allocation of credit among borrowing firms during the ZLB. Compared to if monetary policy is constrained by the ZLB, total credit creation increased 0.89 percentage points and credit destruction increased 0.38 percentage points. This was driven mainly by increases in long-term credit creation and destruction, although unconventional monetary policy did cause substantial increases in short-term credit creation and destruction as well. This reallocation of credit is not accounted for when analyzing the impact of monetary policy shocks on net credit changes alone.

By computing credit flow of financially constrained and non-financially constrained firms, we analyze the impact of unconventional monetary policy on the allocation of credit for these firms during the zero lower bound. The increase in short-term credit creation was relatively large for small firms and high debt service firms, both of which are characteristics of financially constrained firms. However, we find that the increase due to unconventional monetary policy was relatively large for low default probability firms. Accordingly, it is unclear whether unconventional monetary policy was effective during the ZLB at easing financial constraints. However, in long-term credit markets, unconventional monetary policy caused relatively large increases in credit creation for high default probability firms, small firms, and high debt service firms. This suggest that unconventional monetary policy was effective at easing financial constraints of firms in long-term credit.

Because unconventional monetary policy was conducted in rounds of quantitative easing, we separate the contribution of monetary policy shocks to credit creation and destruction during these periods. We find that the QE3 period had the largest positive impact on the allocation of credit among firms, as aggregate credit creation increased 0.42 percentage points and aggregate credit destruction increased 0.20 percentage points. We also find that long-term credit creation increased substantially more for groups of firms classified as financially constrained during this round of quantitative easing, implying that unconventional monetary policy was effective at easing financial constraints of borrowing firms.

Finally, we find that during the ZLB, both short- and long-term credit creation increased substantially more for productive firms due to unconventional monetary policy. We measure a firm's productivity by the change in firms' debt weighted sales as a percentage of capital. For long-term credit flows, the increases in long-term credit creation due to unconventional monetary policy were largest in QE3 and operation twist, rising 1.28 and 0.47 percentage points, respectively. The same holds in short-term credit markets as credit creation increased 1.37 percentage points during QE3 and 0.55 percentage points during operation twist. This suggest that unconventional monetary policy conducted during the ZLB not only resulted in the reshuffling of credit toward financially constrained firms, but also to those better equipped to lead to future growth and productivity through productive use of capital.

3.6 Tables

Table 3.1: Descriptive Statistics for Financially Constrained and Non-Financially Constrained Firms (1974:Q1–2017:Q1)

		Average					Coefficient of variation				
		POS	NEG	NET	SUM	EXC	POS	NEG	NET	SUM	EXC
(a) Total credit	All firms	5.4	3.5	1.9	9.0	6.9	40.6	28.0	111.1	30.1	27.3
	Financially dependent firms	6.1	3.7	2.4	9.8	6.2	71.6	64.5	208.9	49.8	51.7
	Non-financially dependent firms	6.8	5.2	1.7	12.0	8.2	71.9	58.3	356.1	45.9	40.0
	High default probability firms	7.5	4.4	3.1	12.0	6.8	79.9	124.0	270.3	65.8	53.9
	Low default probability firms	5.2	3.6	1.5	8.8	7.0	37.4	30.7	123.0	28.7	27.9
	Large firms	5.1	3.2	1.9	8.2	6.1	49.1	36.3	121.1	37.8	35.6
	Small firms	8.0	6.2	1.8	14.2	11.9	33.5	28.6	129.4	27.3	27.0
	High debt service firms	5.5	3.0	2.5	8.6	5.9	52.2	36.7	113.5	38.8	36.7
	Low debt service firms	7.4	11.7	-4.2	19.1	13.2	72.1	42.9	-143.3	44.1	58.7
(b) Short-term credit	All firms	15.1	7.1	8.1	22.2	14.1	30.4	23.4	56.6	23.3	22.7
	Financially dependent firms	16.3	7.3	9.0	23.6	13.1	62.3	72.6	129.3	47.6	51.8
	Non-financially dependent firms	18.4	8.7	9.7	27.0	16.0	58.1	45.2	122.9	40.1	41.8
	High default probability firms	15.8	7.9	8.0	23.7	13.6	58.4	73.0	133.4	47.0	56.1
	Low default probability firms	15.1	7.1	8.0	22.2	14.2	34.2	25.5	64.9	25.9	24.9
	Large firms	13.6	6.5	7.1	20.1	12.8	38.1	25.7	73.6	28.0	25.4
	Small firms	27.3	11.4	15.8	38.7	22.9	19.9	18.6	34.6	15.9	18.6
	High debt service firms	15.1	6.2	8.9	21.3	12.4	43.3	31.2	72.0	33.8	31.2
	Low debt service firms	7.3	8.3	-1.0	15.6	11.6	60.8	64.7	-609.5	50.0	50.8
(c) Long-term credit	All firms	5.9	3.6	2.3	9.5	7.1	41.6	32.7	94.3	33.6	32.6
	Financially dependent firms	7.0	3.8	3.3	10.8	6.5	90.7	60.6	207.2	62.6	54.0
	Non-financially dependent firms	7.1	5.0	2.1	12.1	8.2	79.9	69.7	334.0	53.3	44.8
	High default probability firms	8.5	4.2	4.3	12.7	6.6	98.8	112.1	238.8	71.3	45.4
	Low default probability firms	5.6	3.7	1.9	9.3	7.3	37.8	33.6	95.3	31.8	32.1
	Large firms	5.5	3.3	2.2	8.8	6.4	48.8	40.0	105.4	40.3	41.4
	Small firms	8.8	5.6	3.1	14.4	11.2	36.9	30.4	85.5	30.8	29.6
	High debt service firms	6.2	3.3	2.8	9.5	6.6	50.6	40.0	100.4	40.7	40.2
	Low debt service firms	20.5	9.5	11.0	29.9	18.3	55.0	58.0	98.3	46.9	54.1

Note: Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.2: Transitions Between Classifications

t-1 \ t	High default probability	Low default probability	Large	Small	High debt service	Low debt service	Financially dependent	Non-financially dependent
High default probability	0.487	0.113						
Low default probability	0.513	0.887						
Large			0.849	0.019				
Small			0.018	0.806				
High debt service					0.637	0.115		
Low debt service					0.114	0.651		
Financially dependent							0.594	0.147
Non-financially dependent							0.151	0.558

Note: This table provides probabilities that a firm belongs to a certain classification in time t conditional on the classification in $t-1$. In classifying firms by terciles, the omitted probability corresponds to the probability of being in the middle tercile conditional on being in the top or bottom tercile in the previous quarter. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.3: Change in Credit Flows During the Zero Lower Bound (2009:Q3–2015:Q3)

	Short-term credit				
	POS	NEG	NET	SUM	EXC
Small firms	4.35	4.97	-0.62	9.32	8.7
Large firms	0.20	-2.17	2.37	-1.97	-4.34
Financially dependent firms	-1.73	-5.12	3.39	-6.85	-10.24
Non-financially dependent firms	0.13	-1.28	1.41	-1.15	-2.56
High default probability firms	9.70	1.64	8.06	11.34	3.28
Low default probability firms	0.10	-2.29	2.39	-2.19	-4.58
High debt service firms	-1.68	-0.33	-1.35	-2.01	-3.36
Low debt service firms	-0.28	0.73	-1.01	0.45	-0.56
	Long-term credit				
	POS	NEG	NET	SUM	EXC
Small firms	9.96	-1.76	11.72	8.20	-3.52
Large firms	-0.15	1.00	-1.15	0.85	-0.30
Financially dependent firms	3.88	-1.56	5.44	2.32	-3.12
Non-financially dependent firms	-1.65	1.00	-2.65	-0.65	-3.30
High default probability firms	4.64	-0.28	4.92	4.36	-0.56
Low default probability firms	-0.36	0.93	-1.29	0.57	-0.72
High debt service firms	-0.38	1.36	-1.74	0.98	-0.76
Low debt service firms	3.73	-2.98	6.71	0.75	-5.96

Note: This table provides the change in credit flow measures over the period 2009:Q3–2015:Q3. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.4: Policy Counterfactuals During the Zero Lower Bound (2009:Q3–2015:Q3)

	(a) Counterfactual 1: no monetary shock						**(b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
All firms	+0.06	+0.20	+0.02	+0.19	+0.07	+0.20	+0.38	+0.89	−0.26	+0.51	+0.43	+0.88
Financially dependent firms	+0.13	+0.26	+0.09	+0.68	+0.17	+0.28	+0.50	+0.75	−0.46	−0.35	+0.57	+0.77
Non-financially dependent firms	+0.19	+0.34	+0.19	+0.20	+0.16	+0.38	+0.65	+0.94	−0.36	−0.50	+0.63	+0.83
High default probability firms	+0.03	+0.35	−0.05	+0.02	−0.01	+0.39	+0.79	+1.26	+0.27	−0.10	+0.57	+1.30
Low default probability firms	+0.10	+0.24	+0.03	+0.26	+0.12	+0.28	+0.44	+0.89	−0.29	+0.67	+0.48	+0.86
Large firms	+0.08	+0.26	−0.08	+0.01	−0.08	+0.01	+0.40	+0.99	−0.34	+0.21	−0.34	+0.21
Small firms	−0.08	−0.04	−0.09	+0.25	−0.05	−0.14	+0.15	+0.70	−0.10	+1.07	+0.23	+0.54
High debt service firms	+0.07	+0.30	+0.04	+0.40	+0.11	+0.35	+0.37	+1.21	−0.34	+0.94	+0.46	+1.18
Low debt service firms	−0.12	−0.17	−0.29	−0.14	−0.19	−0.32	+0.25	−0.42	−1.10	+0.40	+0.33	−0.83

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.5: Policy Counterfactuals During QE1 (2009:Q3–2010:Q1)

	(a) Counterfactual 1: no monetary shock						**(b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
All firms	−0.01	−0.01	+0.01	+0.01	+0.00	−0.01	+0.06	+0.10	−0.07	−0.01	+0.07	+0.10
Financially dependent firms	+0.00	+0.00	+0.02	+0.04	+0.00	+0.00	+0.04	+0.02	−0.16	−0.47	+0.04	+0.02
Non-financially dependent firms	−0.01	−0.01	+0.01	+0.03	+0.00	−0.01	+0.03	+0.01	−0.19	−0.24	+0.07	−0.02
High default probability firms	−0.01	−0.01	−0.01	+0.01	+0.01	−0.01	+0.18	+0.08	+0.09	−0.04	+0.15	+0.08
Low default probability firms	+0.00	+0.00	+0.00	+0.01	+0.01	+0.01	+0.05	+0.08	−0.08	+0.00	+0.06	+0.07
Large firms	+0.00	+0.00	+0.00	+0.00	+0.01	+0.01	+0.06	+0.10	−0.03	+0.04	+0.07	+0.09
Small firms	+0.00	+0.00	−0.01	−0.03	+0.01	+0.02	+0.10	+0.21	+0.04	+0.13	+0.09	+0.22
High debt service firms	+0.00	+0.01	+0.01	+0.01	+0.02	+0.03	+0.06	+0.13	−0.10	−0.03	+0.06	+0.12
Low debt service firms	−0.03	−0.01	+0.00	−0.02	+0.00	−0.01	+0.16	+0.03	−0.05	+0.19	+0.21	+0.01

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.6: Policy Counterfactuals During QE2 (2010:Q4–2011:Q2)

	a) Counterfactual 1: no monetary shock						**b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
All firms	+0.05	+0.08	-0.06	+0.01	+0.06	+0.08	+0.05	+0.11	−0.04	+0.03	+0.06	+0.12
Financially dependent firms	+0.04	+0.02	−0.13	−0.46	+0.04	+0.02	+0.06	+0.08	−0.09	−0.18	+0.06	+0.09
Non-financially dependent firms	+0.03	−0.01	−0.20	−0.22	+0.07	−0.04	+0.06	+0.09	−0.09	−0.13	+0.07	+0.08
High default probability firms	+0.16	+0.07	+0.07	−0.03	+0.14	+0.06	+0.12	+0.14	+0.05	−0.02	+0.09	+0.15
Low default probability firms	+0.05	+0.07	−0.08	+0.03	+0.06	+0.07	+0.06	+0.11	−0.05	+0.05	+0.07	+0.11
Large firms	+0.05	+0.08	−0.04	+0.04	+0.06	+0.08	+0.06	+0.13	−0.03	+0.03	+0.07	+0.12
Small firms	+0.08	+0.19	+0.01	+0.01	+0.08	+0.22	+0.05	+0.13	+0.01	+0.15	+0.06	+0.13
High debt service firms	+0.05	+0.12	−0.09	+0.02	+0.06	+0.11	+0.06	+0.16	−0.06	+0.05	+0.07	+0.16
Low debt service firms	+0.13	+0.01	−0.07	+0.15	+0.19	−0.03	+0.09	+0.00	−0.08	+0.10	+0.11	−0.03

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.7: Policy Counterfactuals During Operation Twist (2011:Q3–2012:Q4)

	(a) Counterfactual 1: no monetary shock						**(b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
All firms	−0.02	−0.01	+0.06	+0.07	−0.04	−0.02	+0.05	+0.15	−0.01	+0.12	+0.06	+0.15
Financially dependent firms	+0.03	+0.09	+0.15	+0.64	+0.04	+0.10	+0.10	+0.17	−0.01	+0.24	+0.11	+0.18
Non-financially dependent firms	+0.04	+0.12	+0.25	+0.28	+0.00	+0.16	+0.13	+0.23	+0.05	+0.04	+0.11	+0.23
High default probability firms	−0.13	+0.06	−0.09	+0.04	−0.13	+0.06	+0.07	+0.25	+0.00	+0.00	+0.03	+0.27
Low default probability firms	+0.00	+0.02	+0.08	+0.08	−0.02	+0.03	+0.07	+0.16	−0.02	+0.15	+0.08	+0.17
Large firms	-0.02	+0.01	+0.01	−0.04	−0.03	+0.00	+0.06	+0.18	−0.06	+0.02	+0.07	+0.18
Small firms	−0.11	−0.19	−0.06	+0.00	−0.11	−0.27	−0.02	+0.03	−0.04	+0.21	+0.00	−0.01
High debt service firms	−0.02	+0.00	+0.09	+0.14	−0.02	+0.01	+0.05	+0.21	−0.02	+0.22	+0.07	+0.22
Low debt service firms	-−.16	−0.08	−0.06	−0.19	−0.25	−0.12	−0.04	−0.11	−0.21	−0.03	−0.05	−0.19

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.8: Policy Counterfactuals During QE3 (2012:Q3–2014:Q4)

	(a) Counterfactual 1: no monetary shock						**(b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
All firms	+0.14	+0.24	−0.17	−0.01	+0.16	+0.24	+0.20	+0.42	−0.21	+0.17	+0.23	+0.40
Financially dependent firms	+0.09	+0.04	−0.38	−1.16	+0.09	+0.04	+0.20	+0.23	−0.39	−0.94	+0.22	+0.23
Non-financially dependent firms	+0.10	+0.04	−0.48	−0.58	+0.16	−0.07	+0.26	+0.27	−0.46	−0.55	+0.29	+0.15
High default probability firms	+0.45	+0.23	+0.22	−0.09	+0.38	+0.20	+0.56	+0.51	+0.23	−0.09	+0.44	+0.48
Low default probability firms	+0.13	+0.20	−0.20	+0.02	+0.14	+0.14	+0.20	+0.38	−0.23	+0.25	+0.23	+0.32
Large firms	+0.15	+0.24	−0.08	+0.11	+0.16	+0.19	+0.21	+0.43	−0.17	+0.14	+0.23	+0.38
Small firms	+0.23	+0.53	+0.10	+0.30	+0.21	+0.56	+0.18	+0.55	+0.01	+0.42	+0.19	+0.51
High debt service firms	+0.14	+0.34	−0.24	−0.02	+0.15	+0.27	+0.19	+0.55	−0.27	+0.31	+0.22	+0.49
Low debt service firms	+0.37	+0.04	−0.15	+0.46	+0.49	−0.01	+0.30	−0.14	−0.51	+0.43	+0.40	−0.33

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table 3.9: Characteristics of Productive and Less Productive Firms

	Default probability	
	High productivity firms	Low productivity firms
1970s	1.27	1.39
1980s	2.37	3.19
1990s	3.69	5.35
2000s	5.52	7.99
2010s	4.98	6.96

	Leverage	
	High productivity firms	Low productivity firms
1970s	89.98	83.80
1980s	56.75	50.78
1990s	41.65	38.12
2000s	37.11	32.29
2010s	40.29	33.20

	Asset size	
	Productive firms	Less productive firms
1970s	156,457	178,095
1980s	341,879	416,061
1990s	673,115	855,561
2000s	2,039,329	2,375,676
2010s	4,018,495	4,994,604

	Need for external financing	
	Productive firms	Less productive firms
1970s	-157.21	-165.12
1980s	-288.46	-272.90
1990s	-670.41	-642.25
2000s	-801.73	-707.82
2010s	-1104.39	-874.50

Note: This table provides the 1 percent trimmed means of default probabilities, leverage ratio (total debt as a percentage of total assets), real assets in 2014 dollars, and the need for external financing (capital spending less cash flow from operations as a percentage of capital spending) for high and low productivity firms. Productive firms are those whose index of the change in debt-weighted sales as a percentage of capital (Galindo, Schiantarelli, and Weiss, 2007) is in the top tercile of firms at a point in time and less productive firms are those in the bottom tercile at a point in time.

Table 3.10: Descriptive Statistics of Productive and Less Productive Firms' Credit Flows (1974:Q1–2017:Q1)

		Average				
		POS	NEG	NET	SUM	EXC
Productive firms	Total credit	13.3	2.1	11.2	15.4	4.2
	Short-term credit	27.2	5.5	21.7	32.7	10.9
	Long-term credit	13.7	2.6	11.0	16.3	5.2
Less productive firms	Total credit	1.9	7.1	-5.3	9.0	3.7
	Short-term credit	10.6	12.3	-1.8	22.9	19.0
	Long-term credit	2.6	6.2	-3.6	8.7	5.0
		Coefficient of variation				
		POS	NEG	NET	SUM	EXC
Productive firms	Total credit	42.6	43.5	49.2	38.7	43.5
	Short-term credit	36.3	32.2	45.6	31.0	32.2
	Long-term credit	46.0	43.2	54.6	41.3	43.2
Less productive firms	Total credit	43.0	34.4	-46.6	29.9	43.0
	Short-term credit	44.8	31.0	-307.6	29.1	30.7
	Long-term credit	46.7	42.0	-75.1	34.4	41.6

Note: Productive firms are those whose index of the change in debt-weighted sales as a percentage of capital (Galindo, Schiantarelli, and Weiss, 2007) is in the top tercile of firms and less productive firms are those in the bottom tercile.

Table 3.11: Change in Productive and Less Productive Firms' Credit Flows during the Zero Lower Bound (2009:Q3–2015:Q3)

		POS	NEG	NET	SUM	EXC
Productive firms	Total credit	2.79	-0.26	3.05	2.53	-0.53
	Short-term credit	-0.85	-0.35	-0.49	-1.20	-0.70
	Long-term credit	3.52	-0.23	3.75	3.29	-0.46
Less productive firms	Total credit	-0.06	-0.76	0.70	-0.83	-0.13
	Short-term credit	-5.56	-0.88	-4.68	-6.44	-11.12
	Long-term credit	-0.13	-0.02	-0.11	-0.16	-0.27

Note: Productive firms are those whose index of the change in debt-weighted sales as a percentage of capital (Galindo, Schiantarelli, and Weiss, 2007) is in the top tercile of firms and less productive firms are those in the bottom tercile.

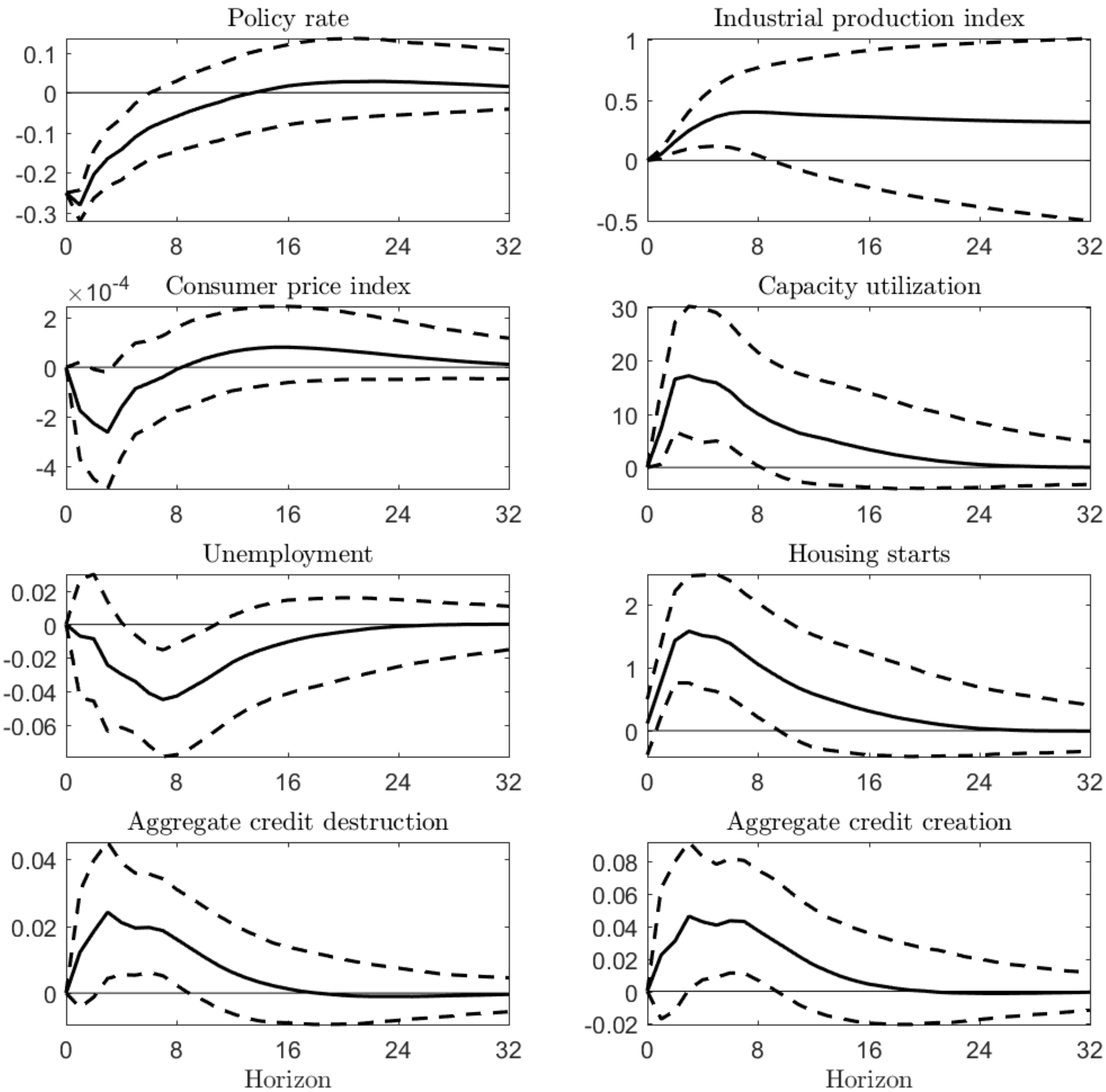
Table 3.12: Policy Counterfactuals During the Zero Lower Bound for Productive and Less Productive Firms (2009:Q3–2015:Q3)

		(a) Counterfactual 1: no monetary shock						**(b) Counterfactual 2: zero lower bound**					
		Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
		NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
QE1	Productive firms	+0.00	−0.02	+0.00	−0.04	+0.00	+0.02	+0.05	+0.32	−0.03	+0.20	+0.05	+0.34
	Less productive firms	−0.01	+0.00	+0.00	+0.00	+0.00	−0.01	+0.07	+0.01	−0.10	+0.00	+0.08	−0.02
QE2	Productive firms	+0.04	+0.24	−0.03	+0.18	+0.04	+0.29	+0.04	+0.36	−0.02	+0.28	+0.04	+0.38
	Less productive firms	+0.06	+0.01	−0.11	+0.02	+0.07	−0.02	+0.10	+0.02	−0.06	−0.02	+0.11	+0.01
Operation twist	Productive firms	−0.01	−0.01	+0.01	+0.11	−0.02	−0.05	+0.04	+0.45	−0.02	+0.55	+0.05	+0.47
	Less productive firms	+0.04	+0.02	+0.12	−0.04	+0.01	+0.04	+0.15	+0.04	+0.00	−0.05	+0.15	+0.04
QE3	Productive firms	+0.11	+0.79	−0.07	+0.58	+0.11	+0.81	+0.16	+1.27	−0.12	+1.37	+0.16	+1.28
	Less productive firms	+0.17	+0.03	−0.24	+0.00	+0.18	−0.06	+0.32	+0.07	−0.25	−0.04	+0.34	−0.03

Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Productive firms are those whose index of the change in debt-weighted sales as a percentage of capital (Galindo, Schiantarelli, and Weiss, 2007) is in the top tercile of firms at a point in time and less productive firms are those in the bottom tercile at a point in time.

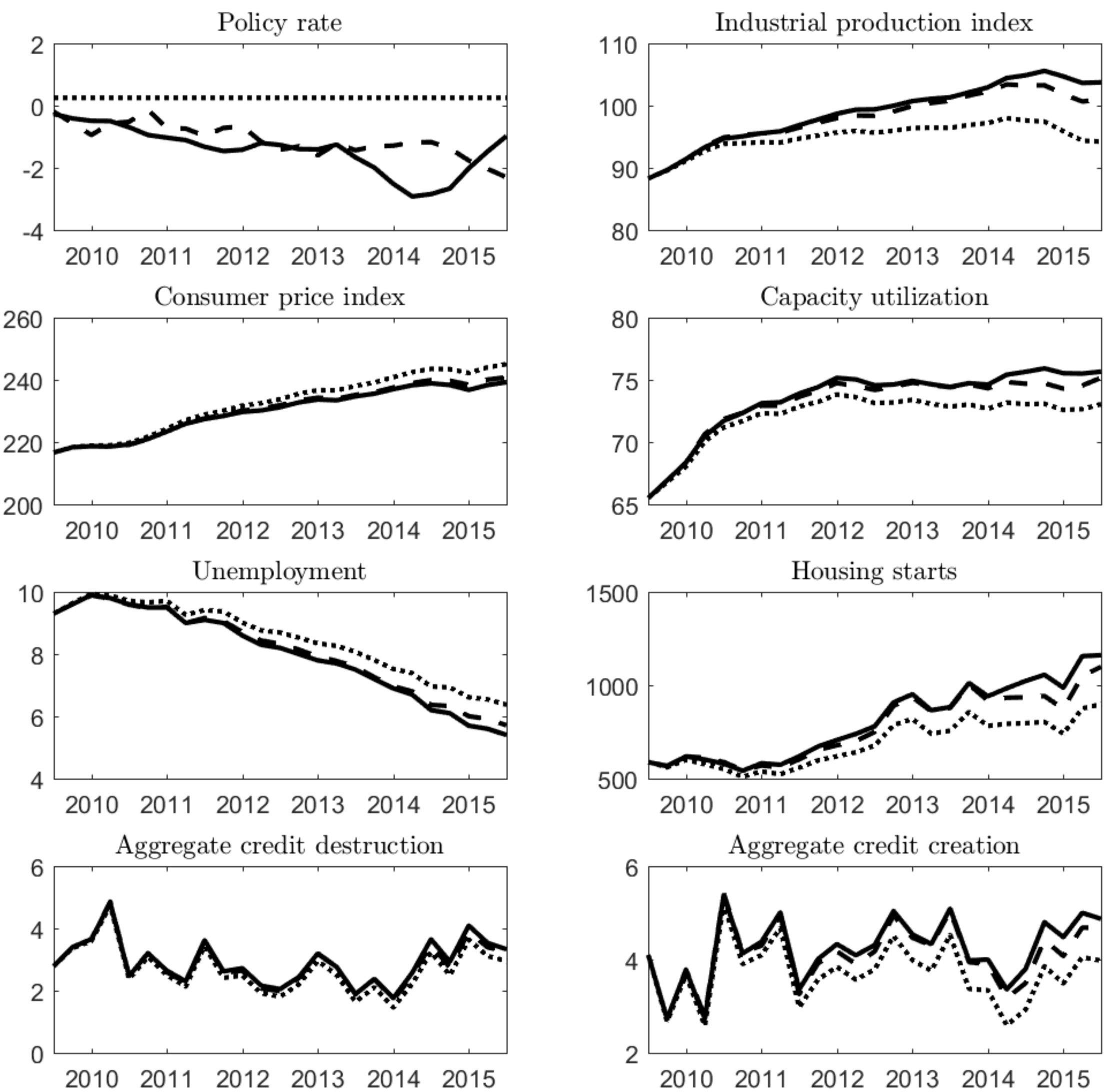
3.7 Figures

Figure 3.1: Impulse Responses to an Expansionary Monetary Policy Shock



Note: These graphs plot quarterly impulse responses to a -25 basis point monetary policy shock using the sample, 1974:Q1–2017:Q1, in a FAVAR(4) setting. The x-axis is number of quarters following the monetary easing shock. The policy rate, aggregate credit destruction, and aggregate credit creation are percentage points and all remaining are percentage deviations from the steady state.

Figure 3.2: Policy Counterfactuals During the Zero Lower Bound



Note: The solid lines are the observed economic variables between 2009:Q3 and 2015:Q3. The dashed lines are the values if the monetary shocks were shut down and the dotted lines are the values of these variables if the shadow policy rate were at the zero lower bound.

Chapter 4 Trade Flows and Credit Shocks in Global Supply Chains

4.1 Introduction

Following the global financial crisis of the late 2000s, there was a severe collapse in trade flows worldwide. In the U.S., real exports of goods and services contracted nearly 12 percent on a year-over-year basis in 2009 alone, while real GDP declined only 3.4 percent. During this time, other economies experienced declines in real exports of goods and services up to 30 percent. In the U.S. and other developed economies, trade collapses were concentrated in manufacturing goods, while trade flows of services were virtually unscathed (Baldwin, 2009; Ariu, 2016). A fundamental difference between exporters of manufacturing goods and exporters of services is that the former tends to be more dependent upon and vulnerable to credit markets. These markets were severely strained in the late 2000s and there is evidence of large differential effects of adverse credit market conditions during this financial crisis (Chor and Manova, 2012).[1]

Previous research highlights that trade between upstream exporters and downstream importers is jointly sensitive to credit conditions in origin and destination countries in a global supply chain. For instance, Chor and Manova (2012) show that exporting countries' cost of credit and upstream sectors' vulnerability to adverse credit conditions are key factors explaining the global trade collapse of the late 2000s. Further, Niepmann and Schmidt-Eisenlohr (2017) find that adverse credit conditions in downstream sectors cause sizable declines in upstream exports (Niepmann

[1] Amiti and Weinstein (2011); Greenaway, Guariglia, and Kneller (2007); Blanchard, Das, and Faruqee (2010); Görg and Spaliara (2018); among others.

and Schmidt-Eisenlohr, 2017).[2] Therefore, in this chapter, I estimate the effects of upstream and downstream credit conditions on international trade and the differential impacts during times of financial crisis. Previous literature establishes the link between credit conditions and international trade during the global financial crisis. However, links during less severe or wide-spread financial crises in exporting *and* importing countries in a global supply chain is largely unexplored. In this chapter, I also aid in explaining the magnitude of international trade declines in crisis periods such as in Japan and Nordic countries in the 1990s, in addition to the crises of the late 2000s.[3]

Exporters are exposed to adverse credit conditions for several reasons. First, exporting firms bear substantial default risk in international transactions and rely on credit default insurance provided by financial institutions. As financial conditions deteriorate, this insurance becomes uncharacteristically scarce or costly, making exporting less profitable. Second, exporting requires large production and transportation costs. Thus, exporting firms depend on ample working capital to compensate for lags between transaction and payment (Amiti and Weinstein, 2011). While exporting firms tend to be large and highly productive relative to domestic producers, firms often are not capable of raising financial capital internally, and therefore rely on domestic and international credit markets. Third, exporting firms require upfront fixed costs to learn about distribution and regulatory environments abroad and to learn of the potential profitability of entering into trade. As credit conditions weaken and external financing becomes costly, exporting profitability decreases. Finally, adverse financial and economic conditions impact the demand for imports, either as inputs to further production or for final use.

[2] Others have addressed the topic of trade between one country and many partners (e.g. Behrens, Corcos, and Mion (2013) and Bricongne, Fontagné, Gaulier, Taglioni, and Vicard (2012)).

[3] See Romer and Romer (2017) for a thorough discussion of these and other lesser-known crises that span this time period.

As in Chor and Manova (2012), I measure a sector's financial vulnerability by their need for external financing, trade credit dependence, and value of collateral. Consistent with previous literature, I find that the need for external financing is negatively associated with trade flows when credit costs are high, and that the effect is amplified during financial crises.[4,5] However, I find that the magnitude is larger when the financially vulnerable sector is upstream, especially in developed economies. Next, I find that international trade is negatively impacted when the downstream sector is dependent on trade credit and the importer's cost of credit is high. Conversely, when the upstream sector is similarly dependent on trade credit and the exporter's cost of credit is low, then international trade flows are positively impacted. Finally, I find mixed results on whether the value of collateral is a relevant factor to explain international trade.

This chapter is organized as follows. Section 4.2 describes the data and methodology. Section 4.3 describes the empirical procedure and estimation results, and Section 4.4 concludes.

4.2 Data Description and Descriptive Statistics

To estimate the effects of upstream and downstream credit conditions on trade flows and differential effects during times of financial crisis, I combine data from several sources. Trade flow data comes from the World Input-Output Database (WIOD) and sectoral financial vulnerability measures are constructed using Compustat North America data. Country-specific financial crisis indicators come from independent classifications of specific crises from Reinhart and Rogoff (2011), Laeven and Valen-

[4] I use bilateral trade data between upstream and downstream sectors for 40 countries using the World Input-Output Database (WIOD).

[5] Related studies, such as Zavacka and Iacovone (2009), highlight that exporters' reliance on external finance negatively contributes to export volumes in normal times and in crisis. Görg and Spaliara (2018) show that exporters, specifically those reliant on external financing, tended to exit the market during the global financial crisis.

cia (2012), and Romer and Romer (2017). Finally, data on countries' costs of credit come from various sources. The resulting panel contains data on for 40 countries, 14 upstream sectors, and 34 downstream sectors over the period 1995-2011.

World Input-Output Database

Detailed information on countries' supply and use of goods and services is needed to analyze the impact of credit conditions in an increasingly complex supply chain. WIOD contains bilateral flows of the use of inputs and production of goods and services at the upstream and downstream sector level from 1995 to 2011. In the 2013 release,[6] 27 EU countries and 13 other countries, such as Australia, Canada, China, and USA, who collectively constitute the majority of world GDP, are included. Using ISIC Rev. 3 from the United Nations, firms are grouped into 35 sectors, offering ample coverage of goods and services produced in an economy.[7]

Analysis of WIOD highlights the severity of the coordinated trade collapse of the late 2000s. The average growth rate of aggregate trade between 1996 and 2008 was a robust 6.7 percent.[8] In 2009, 36 of the 40 countries experienced aggregate declines in upstream export production. Lithuania and Russia experienced 29.3 and 24.8 percent declines, respectively, while the growth rate exceeded 9 percent for China and Indonesia. For downstream consumption, the hardest hit country was Lithuania, falling 30.8 percent. India (3.2 percent), China (9.4 percent), and Indonesia (10.1 percent) were the only countries that experienced growth in downstream consumption in 2009. Figure 4.1 plots the imports of goods and services and exports of manufacturing goods around financial crises as classified by Laeven and Valencia (2012). The first panel

[6]As of this writing, the 2016 release is available for the period 2000-2014, although the release excludes the period of severe financial crisis in Asian countries in the 1990s.

[7]See the Appendix for the WIOD–ISIC Rev. 3 concordance.

[8]Aggregate trade is the sum of aggregate upstream production and is equal to aggregate downstream consumption.

shows that small counties' exports were more severely impacted after financial crisis compared to large countries. Conversely, imports of small countries did not fall as severely as large countries after a crisis. The second panel shows that for all countries, trade flows collapse in the period after the beginning of the crisis, on average. It is not until three years after the start of the crisis that these flows reach pre-crisis levels. Further, the decline in flows for the U.S., while severe, rebounded quicker and reached pre-crisis levels quicker than average over the period.

The U.S. financial crisis coincided with a global financial crisis and a worldwide trade flow collapse. The Asian crisis of the late 1990s was also a period of severe financial crisis that impacted trade flow, although this was a more geographically concentrated financial crisis. The second panel of Figure 4.1 plots average trade flows for countries in financial crisis in the late 2008 and Asian countries' trade around financial crisis in the late 1990s. This figure shows that the increase in trade increased more rapidly prior to the financial crises, the decline in trade was larger, and the recovery was slower. While Asian countries reached pre-crisis levels three quarters after the start of the crises, on average, trade for countries impacted by the global financial crisis still have not reached pre-crisis levels.

Sectoral Financial Vulnerability

I measure a sector's financial vulnerability using firm-level income statement and balance sheet information from Compustat North America. Following Chor and Manova (2012), financial vulnerability is measured as the need for external financing, dependence of trade credit, and the value of collateral. I measure financial vulnerability as the time-invariant median for all firms in a sector over the period 1996-2005.

These are constructed as follows:

$$Need\ for\ external\ financing_k = Median\left\{\frac{capital\ expenditures_{jkt} - cash\ flow\ from\ operations_{jkt}}{capital\ expenditures_{jkt}}\right\} \tag{4.1}$$

$$Trade\ credit_k = Median\left\{\frac{\Delta(accounts\ payable_{jkt})}{\Delta(total\ assets_{jkt})}\right\} \tag{4.2}$$

where the change is over a 10-year period.

$$Value\ of\ collateral_k = Median\left\{\frac{net\ value\ of\ property,\ plant,\ and\ equipment_{jkt}}{total\ assets_{jkt}}\right\} \tag{4.3}$$

where firms,*j*, in sectors, *k*, are mainly U.S. firms across time, *t*. These measure global conditions by the assumption that firms in in the sample are generally large and likely have access to advanced financial systems. Therefore, the financial vulnerability of sectors in the U.S. ought to measure optimal strategies of sectors abroad. Further, the *ordering* of financial vulnerability among sectors is the main information needed to identify effects on trade flows.

While I restrict the upstream sectors to manufacturing because these goods are typically tradable, I include all downstream sectors.[9] These additional sectors produce both tradable and non-tradable goods and services. I group firms into 34 sectors using the North American Industry Classification System (NAICS), and by the United Nations Statistics Division concordance,[10] multiple sectors from ISIC Rev. 3 are subsets of certain NAICS codes.[11]

[9]The one exception is 'private households with employed persons' because financial data does not exist for this sector.

[10]http://unstats.un.org/unsd/cr/registry/regso.asp?Ci=28&Lg=1.

[11]See the Appendix for a mapping of the sectors in WIOD and NAICS

The need for external financing measures the degree to which capital expenditures are financed with sources other than internal cash flow. As Figure 4.2 shows, sectors with the largest need for external financing over this period are ‘renting of machinery and equipment and other business activities,’ ‘coke, refined petroleum, and nuclear fuel,’ and ‘chemicals and chemical product.’ Among those with minimal external financing reliance are ‘financial intermediation,’ ‘textiles and textile product’ manufacturing, and ‘wholesale trade and commission trade.’

Trade credit, while not typically used to finance long-term investment (Rajan and Zingales, 1995), is an alternative source of funding. As Figure 4.3 shows, sectors among the most reliant on trade credit are ‘wholesale and commission trade,’ ‘motor vehicles, motorcycles, and fuel sales,’ and ‘retail trade and repair of household goods.’ Agriculture and manufacturing sectors are virtually equally reliant on trade credit.

The value of collateral measures firms’ credit worthiness and ability to pledge collateral for external financing. Among sectors with lowest values, and therefore most exposed to adverse credit conditions through this channel, are ‘financial intermediation and real estate’ as shown in Figure 4.4. Sectors with the highest overall value of collateral and therefore most able to pledge collateral are ‘water transport,’ ‘hotels and restaurants,’ and ‘inland transportation.’

Credit Conditions

To measure the cost of credit within a country, I use the three-month interbank rate from OECD Main Economic Indicators.[12] Of the 40 countries in the sample, interbank rates are available for the entire period for 22 countries. Bulgaria and Cyprus, whom are included in WIOD, do not have available data and Brazilian interbank rates are only available over the period 1997-2003. Interbank rates for the

[12] http://stats.oecd.org/Index.aspx?DataSetCode=MEI_FIN. When this data is unavailable, I supplement with Bloomberg data.

remaining countries are available starting between 1996 and 2005, through 2011. See Table 4.1 for a complete list of country interbank rate availability.

Over time and on average, interest rates have fallen considerably in response to the global financial crisis, as Table 4.2 shows, although the timing of expansionary policies differed. Japan experienced low interest rates throughout the period, while countries such as Turkey, Romania, and Hungary experienced substantially higher rates. Towards the end of the period, even these countries' rates have fallen considerably. To further illustrate, Figure 4.5 plots the average interest rate per period with selected countries' interest rates.

According to Chor and Manova (2012), an ideal measure of credit conditions incorporates actual costs of trade financing because interbank rates may not coincide precisely with the actual cost of doing business. While Compustat contains firm-level data on the break out of short- and long-term debt, firm-level information on individual costs of credit is not available. I utilize interbank rates as an imperfect measure because the actual cost of external financing ought to mirror this rate.

Financial Crisis Indicators

Chor and Manova (2012) use a financial crisis dummy variable that takes a value of 1 from September 2008 through August 2009. Because this study spans a longer period and analyzes trade between several countries, a broader financial crisis measure is needed. Reinhart and Rogoff (2011) and Laeven and Valencia (2012) create annual country-specific banking crisis indicators through 2010 and 2011, respectively. The former measure covers 30 of the 40 WIOD countries, and the latter covers 35 WIOD countries. Romer and Romer (2017) use real-time analysis to classify episodes of financial crisis in countries semiannually through 2012 and provide narrative for each episode. Their measure covers 24 countries, all of which are OECD countries, of which 20 of the 40 WIOD countries are included in their classification. For robustness, each of these measures will be utilized separately.

4.3 The Role of Upstream and Downstream Financial Conditions on Trade Flows

I estimate the effects of upstream and downstream credit conditions on trade flows in normal times, and the differential effects in times of financial crisis using a triple difference specification. The treatment is whether an importer or exporter is in financial crisis, and the intensity of treatment is a sector's financial vulnerability. In identifying the effects of credit conditions on trade flows in normal times, I exploit variation in importer and exporter credit costs over time, variation between credit costs at a point in time, and variation in financial vulnerability across sectors. I also exploit variation in financial crises over time and across countries in identifying the differential effect of credit conditions in financial crisis.

Empirical Procedure

To estimate the effects of credit conditions on trade flows across countries and sectors, I utilize the following triple difference specification:

$$
\begin{aligned}
log(exports)_{eiudt} = \beta_1(Vuln_u \times IB_{et}) + \beta_2(Vuln_d \times IB_{it}) + \\
\beta_3(Vuln_u \times IB_{et} \times Financial\ crisis_{et}) + \beta_4(Vuln_d \times IB_{it} \times Financial\ crisis_{it}) \\
+ \alpha_{et} + \gamma_{it} + \delta_{ud} + \epsilon_{eiudt} \quad (4.4)
\end{aligned}
$$

for exporting country e, importing country i, upstream sector u, and downstream sector d, where t indicates time. $Vuln_u$ and $Vuln_d$ are the upstream and downstream measures of financial vulnerability, respectively. IB_{et} and IB_{it} are interbank rates for the exporting country and importing country, respectively, and $Financial\ crisis_{et}$ and

$Financial\ crisis_{it}$ are country measure of financial crisis for exporting and importing countries, respectively.

I include an exporting country-time fixed effect (α_{et}) that captures fluctuations, over time, in production conditions in the exporting country and the impact of exchange rate fluctuations on aggregate production. An importing country-time fixed effects (γ_{it}) captures aggregate country and time specific shocks, such as import demand for products in the importing country. An upstream-downstream sector fixed effect (δ_{ud}) accounts for time invariant dependencies that exist between sectors. Standard errors are clustered at the exporting country and importing country levels to account for correlation of error terms across country clusters. While errors may also be correlated across countries within sectors, for multi-way clustering, I cluster at the highest level of aggregation.

Core Results

Need for External Financing

The estimation results of (4.4), utilizing the need for external financing as the financial vulnerability indicator, are shown in the second columns of Tables 4.3, 4.4 and 4.5. The estimates of β_1 and β_2 in each table differ solely by country sample and period, based on availability of financial crisis indicators from their sources, as described in Section 4.2. β_1 ranges from -0.025 to -0.017, indicating that when interbank rates increase one standard deviation in an exporting country, exports from the country's upstream sector whose need for external financing is one standard deviation above the mean, fall 1.7 to 2.5 percent. In comparison, when downstream sectors have similar needs for external financing and the importing country's interbank rate rises similarly (as measured by β_2), exports to the country-sector fall between 0.7 and 1.1 percent.

While β_2 is smaller in magnitude than β_1, the impact of downstream credit conditions on trade flows in normal times, as expressed by β_2, is non-trivial. When the importer's cost of credit is high, downstream sectors that are highly dependent on external financing may have difficulty raising funds or these funds are overly costly. The ensuing lack of cash flow in these downstream sectors leads to falling production in the importing country, and, therefore, falling demand for imports for the upstream product.

How does the magnitude of these effects change during times of financial crisis, both domestically and abroad? A negative estimate for β_3 or β_4 will provide evidence that these effects of credit conditions on trade flows are amplified during financial crisis in the exporting or importing country, respectively. From Tables 4.3, 4.4 and 4.5, while β_3 and β_4 are negative, they are not statistically different from zero when utilizing the financial crisis indicators by Laeven and Valencia (2012) and Reinhart and Rogoff (2011). Instead, utilizing the sample of countries and financial crisis indicator by Romer and Romer (2017), I find that the sign of β_3 and β_4 is negative and statistically significant. This evidence is similar to Chor and Manova (2012), who find a negative and statistically significant coefficient of the triple interaction measure when the importing country is the U.S.[13]

The joint impact of exporter credit conditions and the upstream sector's need for external financing is larger in times of crisis than for the importer-downstream counterpart using the financial crisis indicator and sample of countris from Romer and Romer (2017). During times of exporter financial crisis, when the upstream sector's need for external financing is one standard deviation above the mean, a one standard deviation increase in exporter interbank rates leads to a decline in upstream exports of 5.8 percent.[14] When the same conditions are met for the downstream sector-

[13]The coefficients from Chor and Manova (2012) are not directly comparable to the results presented in Tables 4.3, 4.4 and 4.5 because I standardize the financial vulnerability measures and interbank rates.

[14]This is $(\beta_1 + \beta_3) \times 100$

importing country, the sector's exports fall an additional 1.9 percent. This effect is magnified if the importing and exporting countries are both in financial crisis. When upstream and downstream sectors are jointly highly dependent on external financing (e.g. one standard deviation above the mean), and when interbank rates rise one standard deviation in each country, the impact on trade between these sectors is -7.6 percent. This is similar in magnitude to actual declines in trade flows in 2009.

Value of Collateral

Beyond the need for external financing, trade between sectors may be sensitive to the value of importing and exporting firms' physical assets. These assets can be pledged as collateral to finance production of goods, therefore sectors with ample physical assets are less vulnerable to adverse credit market conditions (Claessens and Laeven, 2003). Even when a firm has adequate collateralizable assets, they may be exposed to adverse credit conditions through declining asset values of their trading counterpart. For instance, upstream production is dependent on downstream demand for a good. If a downstream firm either does not have access to credit or only has access to costly credit because of their lack of collateral, they will be forced to lower production (i.e. a contagion effect).

To test the importance of this characteristic, I re-estimate (4.4) using the value of collateral for the upstream and downstream sectors as the measure of financial vulnerability. Tables 4.3, 4.4 and 4.5 show that β_2, the joint impact of the upstream sector's collateral values and exporter interbank rates, is positive and statistically significant across the samples. β_1 is significant only for the countries included in the Romer and Romer (2017) sample, although the sign is negative. The sign and significance of β_2 indicates that when the importing country's interbank rate rises one standard deviation and the downstream sector's value of collateral is one standard deviation *below* the mean, exports to this sector fall 1.2 or 1.3 percent, depending on the financial crisis indicator and sample country used in estimation. In times of importer or exporter financial crisis, there is little support to suggest that this effect is amplified. Only in the sample and crisis indicator from Reinhart and Rogoff (2011) is β_3 of the expected sign and statistically significant.

Trade Credit Dependence

There are conflicting explanations regarding the impact of trade credit on economic activity (Petersen and Rajan, 1997). Considerable trade credit usage may result from exhaustion of traditional credit, indicating that these sectors are more exposed to adverse credit conditions. Alternatively, trade credit is a substitute for traditional credit, and firms that are highly dependent on trade credit are *less* exposed to adverse credit markets. The former explanation implies that the sign of β_1 and β_2 are negative, while the latter implies positive coefficients.

Because trade credit dependence can either contribute positively or negatively to trade flows (i.e. the sign of the coefficients in (4.4) with trade credit dependence is unclear), this topic can be addressed empirically. Tables 4.3, 4.4 and 4.5 show that β_1 is positive for all samples, and that β_1 is positive and statistically significant using the country sample from Romer and Romer (2017). β_2 is consistently negative and statistically significant along all samples. These results suggest that importers are more likely than exporters to utilize trade credit because they have exhausted traditional financing. Therefore, trade falls from an upstream exporter to a downstream importer when interbank rates are high in the importing country and both sectors are dependent on trade credit. Using the Romer and Romer (2017) country sample, exporters are more likely to be isolated from their country's adverse credit markets, as a positive value of β_1 implies.

Chor and Manova (2012) find a positive coefficient for the impact of trade credit interacted with financial vulnerability during times of crisis. This implies that when interbank rates are high in the exporting country and the upstream sector is heavily reliant on trade credit, exports to the U.S. fall during the global financial crisis. For this specification, β_3 and β_4 are not statistically significant, and I do not find support for an amplifying or attenuating effect during financial crisis.

Developed and Developing Countries

I test for the presence of asymmetries in the impact of credit conditions on international trade, which may depend upon the size of the importing and exporting country. I rank economies by real GDP per capita in 2011 and classify firms as "developed" if they fall in the top half of countries and "developing" otherwise. Next, I re-estimate (4.4) where trade flows between importers and exporters are restricted to (*i.*) developed to developed economies, (*ii.*) developed to developing economies, (*iii.*) developing to developed economies, and (*iv.*) developing to developing economies separately. Tables 4.6, 4.7 and 4.8 provides results using the sample of countries and financial crisis indicators by Romer and Romer (2017), Reinhart and Rogoff (2011), and Laeven and Valencia (2012), respectively.

In re-estimating (4.4) using the need for external financing as the financial vulnerability measure, I find that the impact of credit conditions on international trade during non-crisis periods is only significant if the importing or exporting country are both developed. Among developed exporting countries, the magnitude of credit conditions on international trade is larger when they export to developing economies. The effects of downstream credit conditions for developed economies are only statistically significant when the importing country is a developed economy, although the magnitude is larger if the exporter is a developed economy.

The size and significance of the effect of credit conditions during financial crisis depends on which financial crisis indicator and sample of countries is used in the estimation of (4.4). For upstream exporters in developed economies, the effect of upstream credit conditions during times of financial crisis is -2.2 percent if the downstream importer is a developed economy, but -4.1 percent if the country is developing using the Romer and Romer (2017) financial crisis indicator and sample of countries. By instead estimating (4.4) using the Reinhart and Rogoff (2011) crisis indicator and country sample, the differential effect of importer credit conditions during times of financial crisis is -2.8 percent if both the upstream exporter and downstream importer are from developed economies. The effect of importer credit conditions during times of financial crisis is negative and statistically significant when the upstream exporter is a developing economy using the Romer and Romer (2017) and Reinhart and Rogoff (2011) financial is measures and country samples. Using the Laeven and Valencia (2012) financial crisis measures and country sample, if the exporting country is in financial crisis, trade falls an additional 5.0 and 5.5 percent when the upstream exporter is a developed and undeveloped economy, respectively.

Using the value of collateral as the measure of financial vulnerability, the effect of importer credit conditions on international trade out of financial crisis is consistently positive and statistically significant when the importing country is developed. However, the effect of upstream credit conditions on trade is large and statistically significant between developing economies. When interbank rates rise one standard deviation and the downstream sector of a developed importer has a value of collateral that is one standard deviation above the mean, trade falls between 0.9 and 1.0 percent, regardless of whether the upstream exporter is of a developed or undeveloped economy. However, the magnitude of upstream credit conditions is 11.8 percent using the Reinhart and Rogoff (2011) country sample and crisis indicator and 4.3 percent using the Laeven and Valencia (2012) crisis measures and sample when both countries are developing.

For importing sectors in developing economies, there is an amplifying effect of credit conditions whether the upstream exporter is from a developed or developing economy. This effect ranges from 1.1 to 2.3 percent depending on the sample of countries and financial crisis indicator used in estimation of (4.4). However, there is a sign reversal for the effect of credit conditions during financial crisis when the importer or exporter is developing. Recall that the financial vulnerability measures come from firm-level balance sheet and income statement data of North American firms. Therefore, in general, sectors with ample collateralizable assets are identified effectively for the U.S., however these may not identify sectors correctly for developing economies. This can account for the sign reversals; however, I am not able to remedy this due to the lack of reliable firm-level data for foreign firms.

For the specification with trade credit dependence as the financial vulnerability measure, I find that the effect of credit conditions on trade flows in normal times depends on whether the sector is upstream or downstream. Worsening upstream credit conditions lead to decreases in trade flows but increases for downstream importers. A typical result, as seen in Tables 4.6, 4.7 and 4.8, is that the effect of credit conditions during times of importer or exporter financial crisis tends to be negative when statistically significant. For upstream exporters, the differential effect during times of exporter financial crisis is only present for developed economies.

4.4 Conclusion

This chapter documents that adverse upstream and downstream credit conditions negatively affect global trade flows. For downstream sectors, when a country's cost of credit rises and a downstream sector is financially vulnerable to adverse credit markets (measured by the sector's need for external financing, trade credit dependence, or value of collateral), then this negatively impacts trade flows to these sectors. For upstream sectors, the impact of adverse domestic credit conditions is significant when utilizing a sector's need for external financing to measure sectoral financial vulnerability. In addition, the magnitude of the impact of adverse credit conditions (as measured by the need for external financing) on trade flows is larger for upstream sectors. That is, when the interbank rate rises one standard deviation in the importing country, imports to a downstream sector fall between 0.7 and 1.1 percent. Conversely, when the interbank rate rises one standard deviation in the exporting country, exports from an upstream sector fall between 1.7 and 2.5 percent.

I find an amplifying effect of credit conditions on international trade for sectors whose need for external financing is high, using the financial crisis measure and sample of countries from Romer and Romer (2017). During times of financial crisis in the importing country, imports fall an additional 1.1 percent when the interbank rate in the importing country and the downstream sector's need for external financing is one standard deviation above the mean. During financial crisis in the exporting country, exports fall an additional 3.3 percent when the upstream sector's need for external financing and the exporting country's interbank rates is one standard deviation above the mean.

By splitting the sample by GDP per capita, I find asymmetries in effects of credit conditions on international trade flows and differential effects during times of financial crisis. For developed importers and exporters, there is a negative impact of upstream credit conditions, as measured by the interaction between the sector's need for external financing and the exporting country's interbank rate on trade flows, regardless of whether the trading partner is from a developed or undeveloped economy. By estimating the impact of credit conditions on trade flows using the value of collateral to measure of a sector's financial vulnerability, I find that adverse credit conditions of downstream importers lead to declines in exports to the sector if the importer is from a developed economy. Further, adverse upstream credit conditions lead to substantial declines in trade flows between developing economies. For trade credit utilization to measure financial vulnerability, I find that the differential effect of credit conditions in times of financial crisis is only present for developed upstream exporters.

4.5 Tables

Table 4.1: Availability of Country Interbank Rates

1995-2011:	AUS, AUT, BEL, CAN, CZE, DEU, DNK, ESP, FIN, FRA, GBR, HUN, IRL, ITA, JPN, KOR, NLD, POL, PRT, SWE, TUR, USA
1996-2011:	EST, SVK
1997-2011:	MEX, RUS
1998-2011:	CHN, IDN, LVA, ROU
1999-2011:	LUX
2001-2011:	GRC
2002-2011:	IND, LTU
2004-2011:	MLT
2005-2011:	TWN
1997-2003:	BRA
Unavailable:	BGR, CYP

Source: OECD, Bloomberg.

Table 4.2: Descriptive Statistics of Interbank Rates

	Average	Std. dev	Min	Max
1995	12.84	18.36	0.55 (JPN)	88.28 (TUR)
1996	11.32	19.53	0.62 (JPN)	99.22 (TUR)
1997	13.07	19.35	0.63 (JPN)	100.76 (TUR)
1998	14.95	19.35	0.77 (JPN)	89.82 (TUR)
1999	12.19	18.53	0.28 (JPN)	79.80 (ROU)
2000	9.06	9.96	0.30 (JPN)	50.74 (ROU)
2001	9.25	13.12	0.16 (JPN)	69.96 (TUR)
2002	7.35	9.14	0.09 (JPN)	49.40 (TUR)
2003	5.64	6.75	0.09 (JPN)	33.75 (TUR)
2004	4.42	4.62	0.09 (JPN)	21.95 (TUR)
2005	3.74	2.91	0.09 (JPN)	14.84 (TUR)
2006	4.56	3.23	0.31 (JPN)	17.47 (TUR)
2007	5.19	2.52	0.73 (JPN)	16.71 (TUR)
2008	5.73	2.99	0.85 (JPN)	17.39 (TUR)
2009	3.32	3.60	0.40 (SWE)	13.05 (RUS)
2010	2.15	2.26	0.31 (USA)	7.40 (TUR)
2011	2.56	2.23	0.30 (USA)	8.55 (TUR)

Source: OECD, Bloomberg.

Table 4.3: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Using Laeven and Valencia (2012) Measures

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.023***	-0.017*	0.009	0.005	0.009	0.012
$Vuln_d \times IB_{it}$	-0.010**	-0.007**	0.012**	0.013**	-0.009**	-0.009**
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.032		0.024		-0.019
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.019		-0.001		0.001
Observations	7893757	7893757	7893757	7893757	7893757	7893757
R-squared	0.645	0.645	0.645	0.645	0.645	0.645

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crises on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The financial crisis indicator takes a value of 1 if the country is in a systemic banking crisis according to Laeven and Valencia (2012), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

Table 4.4: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Using Reinhart and Rogoff (2011) Measures

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.025***	-0.022***	0.018	0.010	0.007	0.012
$Vuln_d \times IB_{it}$	-0.014**	-0.011**	0.012**	0.012**	-0.009**	-0.010**
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.012		0.042*		-0.025
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.012		0.002		0.006
Observations	5358618	5358618	5358618	5358618	5358618	5358618
R-squared	0.639	0.639	0.639	0.639	0.639	0.639

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crises on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The financial crisis indicator takes a value of 1 if the country is in a banking crisis according to Reinhart and Rogoff (2011), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

Table 4.5: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Using Romer and Romer (2017) Measures

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.031***	-0.025***	-0.004	-0.010**	0.027***	0.031***
$Vuln_d \times IB_{it}$	-0.010***	-0.008***	0.011***	0.013***	-0.011***	-0.010***
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.033**		0.027		-0.021
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.011*		-0.007		-0.006
Observations	2863711	2863711	2863711	2863711	2863711	2863711
R-squared	0.706	0.706	0.705	0.706	0.706	0.706

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crises on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The financial crisis indicator takes a value of 1 if the country is in a credit disruption, minor crisis, moderate crisis, or major crisis according to Romer and Romer (2017), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

Table 4.6: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Among Developing and Developed Countries Using Laeven and Valencia (2012) Measures

(a) Developed countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.024***	-0.020***	0.009	0.004	-0.005	-0.001
$Vuln_d \times IB_{it}$	-0.013**	-0.011**	0.011**	0.009**	-0.004	-0.003
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.023		0.029		-0.028
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.011		0.010		-0.003
Observations	2565804	2565804	2565804	2565804	2565804	2565804
R-squared	0.632	0.632	0.632	0.632	0.632	0.632

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Developed countries to developing countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.027***	-0.023**	0.005	0.002	-0.000	0.002
$Vuln_d \times IB_{it}$	-0.010	-0.005	0.009	0.014	-0.017***	-0.018***
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.024		0.018		-0.013
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.050**		-0.051		0.015
Observations	1977435	1977435	1977435	1977435	1977435	1977435
R-squared	0.692	0.692	0.691	0.692	0.691	0.691

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(c) Developing countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.022	-0.013	0.025	0.022	0.028*	0.031**
$Vuln_d \times IB_{it}$	-0.011*	-0.009**	0.012*	0.009*	-0.004	-0.004
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.077		0.027		-0.024
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.013		0.011**		-0.002
Observations	1982147	1982147	1982147	1982147	1982147	1982147
R-squared	0.688	0.688	0.688	0.688	0.688	0.688

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(d) Developing countries to developing countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.013	-0.004	0.052***	0.043**	0.042**	0.039**
$Vuln_d \times IB_{it}$	-0.008	-0.003	0.008	0.014	-0.018***	-0.019***
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.071		0.078		0.029
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.055**		-0.062		0.018
Observations	1368371	1368371	1368371	1368371	1368371	1368371
R-squared	0.592	0.592	0.592	0.592	0.592	0.592

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crises on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The top half of countries by GDP per capita in 2011 are considered developed while the bottom half are considered developing. The financial crisis indicator takes a value of 1 if the country is in a systemic banking crisis according to Laeven and Valencia (2012), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

Table 4.7: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Among Developing and Developed Countries Using Reinhart and Rogoff (2011) Measures

(a) Developed countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.025***	-0.024***	0.010	0.004	-0.005	0.003
$Vuln_d \times IB_{it}$	-0.013**	-0.010**	0.012**	0.009**	-0.004	-0.006
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.011		0.062		-0.081***
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.028*		0.020*		0.016
Observations	2406860	2406860	2406860	2406860	2406860	2406860
R-squared	0.633	0.633	0.632	0.633	0.632	0.633

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Developed countries to developing countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.027***	-0.026***	0.006	-0.001	-0.000	0.007
$Vuln_d \times IB_{it}$	-0.018**	-0.021	0.011	0.017	-0.017**	-0.025**
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.014		0.068		-0.068**
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		0.005		-0.011		0.015*
Observations	1213503	1213503	1213503	1213503	1213503	1213503
R-squared	0.668	0.668	0.667	0.668	0.668	0.668

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(c) Developing countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.022	-0.003	0.048***	0.069**	0.033	0.048
$Vuln_d \times IB_{it}$	-0.010	-0.007*	0.011*	0.009**	-0.006	-0.008*
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.031		-0.035		-0.025
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.028*		0.023*		0.013
Observations	1215023	1215023	1215023	1215023	1215023	1215023
R-squared	0.678	0.678	0.679	0.679	0.678	0.679

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(d) Developing countries to developing countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1) exports	(2) exports	(3) exports	(4) exports	(5) exports	(6) exports
$Vuln_u \times IB_{et}$	-0.021	0.001	0.082***	0.118***	0.053**	0.072*
$Vuln_d \times IB_{it}$	-0.017*	-0.019	0.006	0.011	-0.016**	-0.023**
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.038		-0.061**		-0.031
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		0.003		-0.008		0.012
Observations	523232	523232	523232	523232	523232	523232
R-squared	0.618	0.618	0.620	0.620	0.619	0.619

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crises on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The top half of countries by GDP per capita in 2011 are considered developed while the bottom half are considered developing. The financial crisis indicator takes a value of 1 if the country is in a banking crisis according to Reinhart and Rogoff (2011), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

Table 4.8: Impact of Financial Vulnerability, Credit Conditions, and Financial Crises on Trade Flows Among Developing and Developed Countries Using Romer and Romer (2017) Measures

(a) Developed countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.026***	-0.022***	-0.000	-0.004	0.020**	0.023***
$Vuln_d \times IB_{it}$	-0.011***	-0.010***	0.010***	0.010***	-0.007**	-0.005*
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.022**		0.023		-0.019
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.007		0.000		-0.012*
Observations	1061803	1061803	1061803	1061803	1061803	1061803
R-squared	0.702	0.702	0.701	0.702	0.702	0.702

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

(b) Developed countries to developing countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.037***	-0.028***	-0.004	-0.008	0.022**	0.025***
$Vuln_d \times IB_{it}$	-0.063*	-0.026	-0.017	0.042	0.025	-0.009
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.041***		0.018		-0.015
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.052		-0.081**		0.046
Observations	711272	711272	711272	711272	711272	711272
R-squared	0.736	0.736	0.735	0.735	0.735	0.735

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

(c) Developing countries to developed countries

	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.097	-0.071	0.009	-0.068	-0.104	-0.097
$Vuln_d \times IB_{it}$	-0.009***	-0.007**	0.008***	0.009***	-0.008**	-0.005*
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.036		0.105		-0.010
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.009*		-0.002		-0.011*
Observations	708762	708762	708762	708762	708762	708762
R-squared	0.686	0.686	0.686	0.686	0.686	0.686

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

(d) Developing countries to developing countries

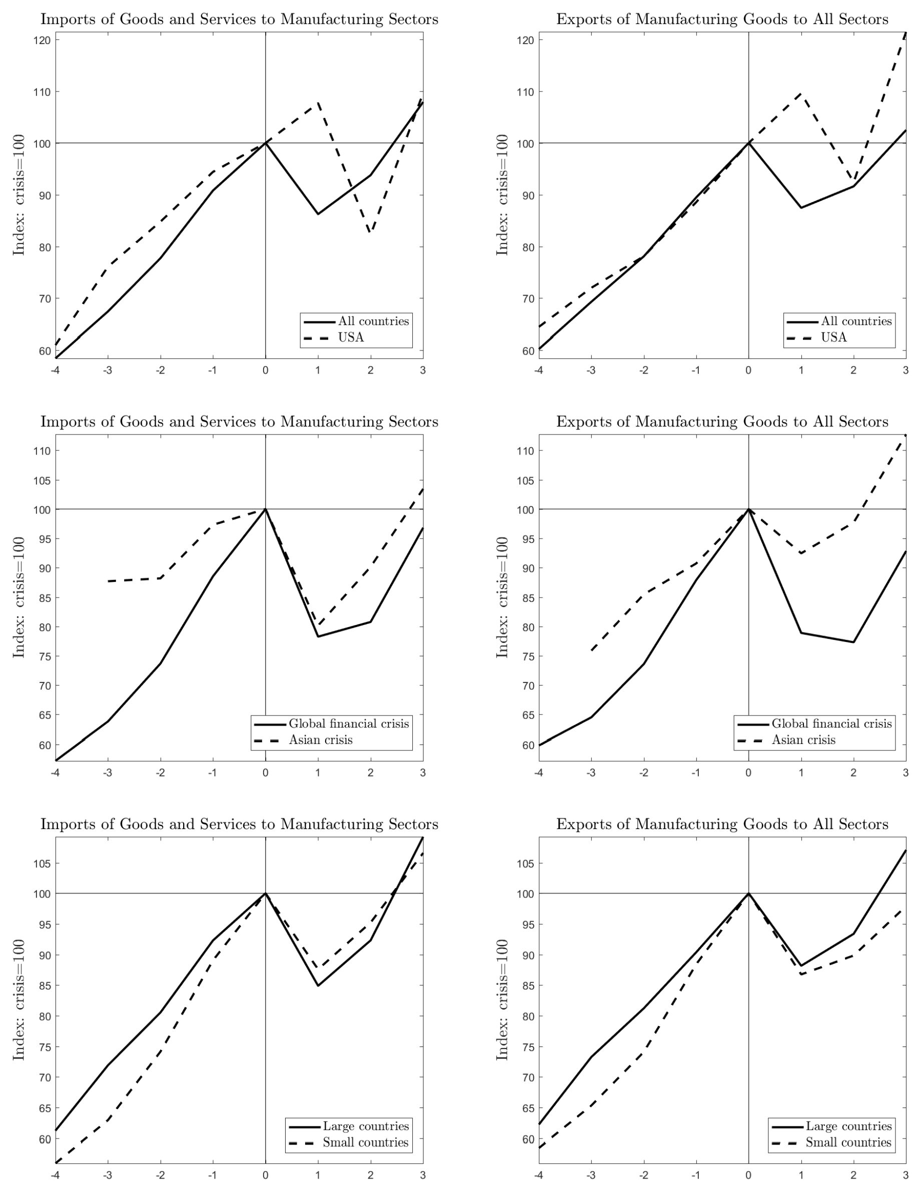
	Need for external financing		Value of collateral		Trade credit dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	exports	exports	exports	exports	exports	exports
$Vuln_u \times IB_{et}$	-0.179	-0.143	0.027	-0.064	0.027	0.030
$Vuln_d \times IB_{it}$	-0.039	-0.006	-0.067	-0.005	0.028	0.001
$Vuln_u \times IB_{et} \times Financial\ crisis_{et}$		-0.047		0.116		-0.004
$Vuln_d \times IB_{it} \times Financial\ crisis_{it}$		-0.042		-0.079**		0.034
Observations	381874	381874	381874	381874	381874	381874
R-squared	0.675	0.675	0.674	0.675	0.674	0.674

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Note: This table reports the impact of financial vulnerability and financial crisis on trade flows over 1995–2011. Data spans 35 countries from the World Input Output Database, 14 downstream sectors, and 34 downstream sectors from Compustat North America. The top half of countries by GDP per capita in 2011 are considered developed while the bottom half are considered developing. The financial crisis indicator takes a value of 1 if the country is in a credit disruption, minor crisis, moderate crisis, or major crisis according to Romer and Romer (2017), and zero otherwise. The dependent variable is the log of trade flows from the exporting country to the importing country, standardized to a mean of zero and standard deviation of one. The first set of specifications utilizes the need for external financing as the measure of financial vulnerability, followed by a set for the value of collateral and trade credit dependence as in Chor and Manova (2012), standardized to a mean of zero and standard deviation of one. The measure of financial vulnerability and the standardized interbank are omitted due to collinearity. Standard errors are clustered at the exporting country and importing country level.

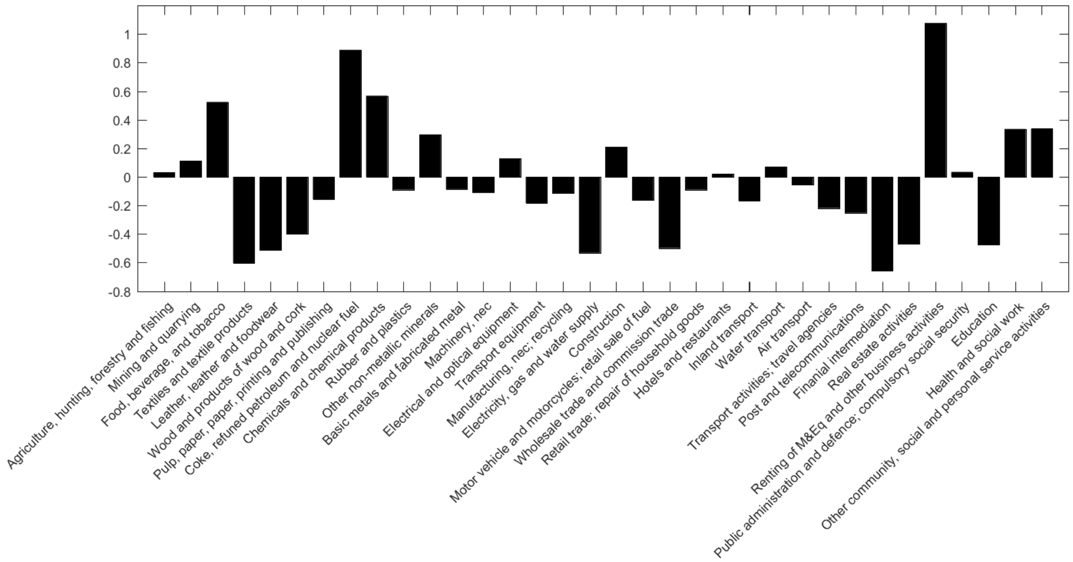
4.6 Figures

Figure 4.1: Trade Flows Around Financial Crises



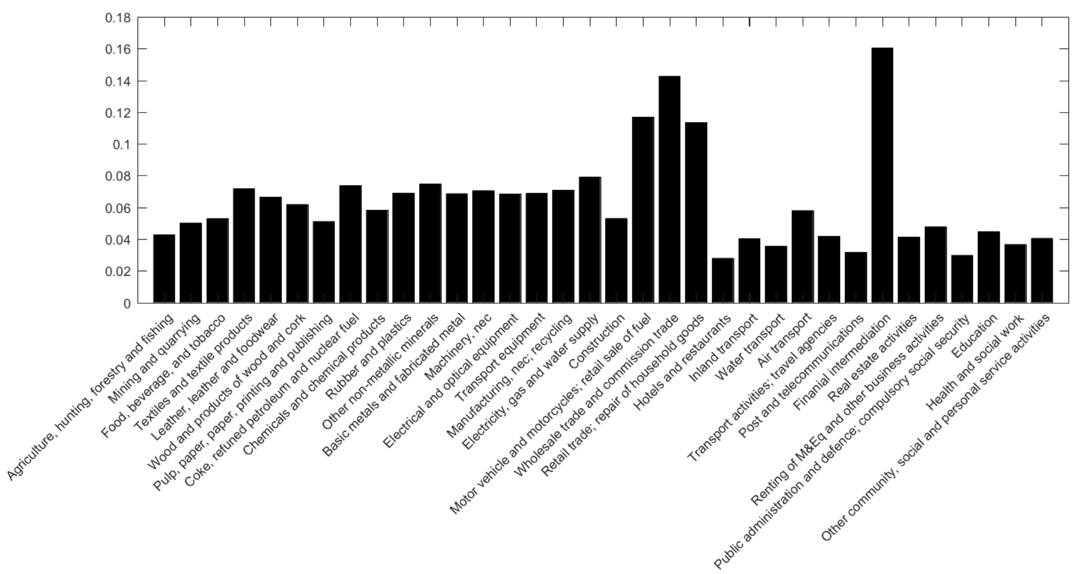
Source: WIOD; Laeven and Valencia (2012).

Figure 4.2: Need for External Financing



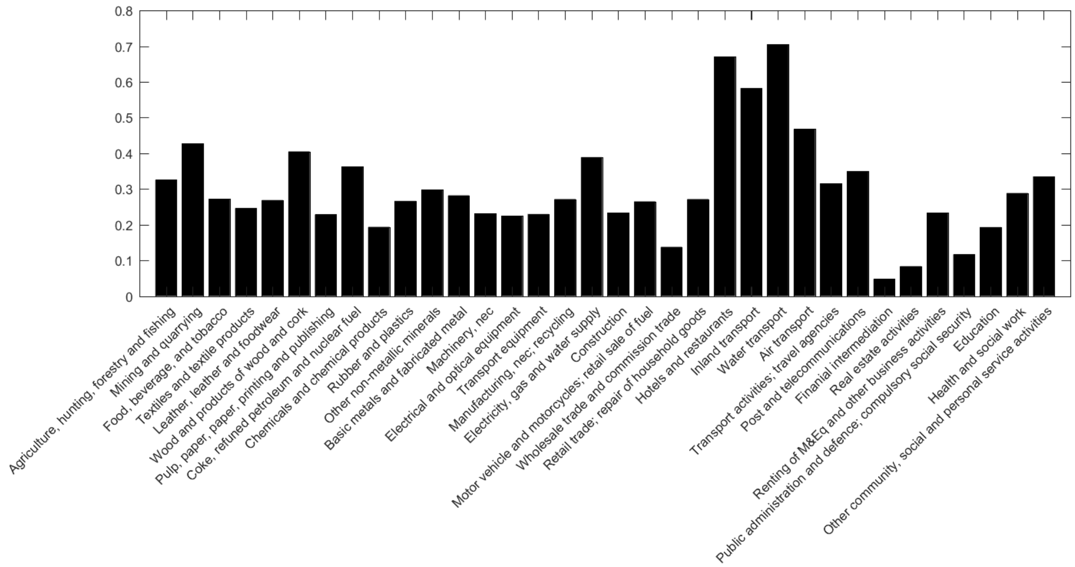
Note: A sector's need for external financing is the median value of the ratio of capital expenditures less cash flow from operations to capital expenditures over the period 1996–2005.

Figure 4.3: Reliance on Trade Credit



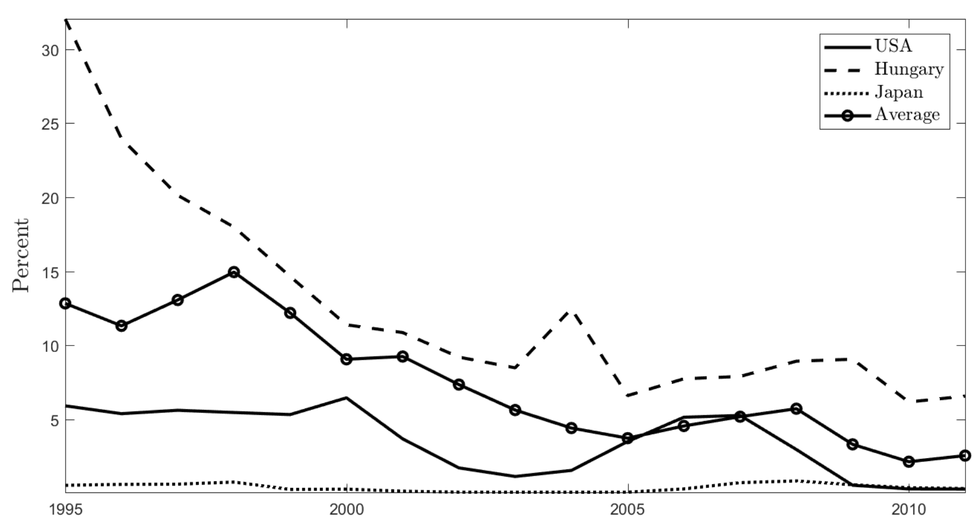
Note: A sector's reliance on trade credit is the median value between 1996 and 2005 of the ratio of the change in accounts payable over this period and the change in total assets over this period.

Figure 4.4: Value of Collateral



Note: A sector's value of collateral is the median ratio of net value of property, plant, and equipment to total assets over the period 1996–2005.

Figure 4.5: Select Interbank Rates



Source: OECD, Bloomberg.

Appendix A

A.1 Chapter 1 Appendix

Alternative Credit Flow Measure

Credit flow measures are calculated using quarterly growth rates of debt from Compustat North America. This follows Herrera, Kolar, and Minetti (2011), who measure credit flow measures using annual growth rates over a longer horizon. The following table presents averages and coefficients of variation by decade using year-over-year growth rates. These more closely resemble credit flow measures constructed with annual data.

Table A.1: Descriptive Statistics of Quarterly Credit Flow Measures

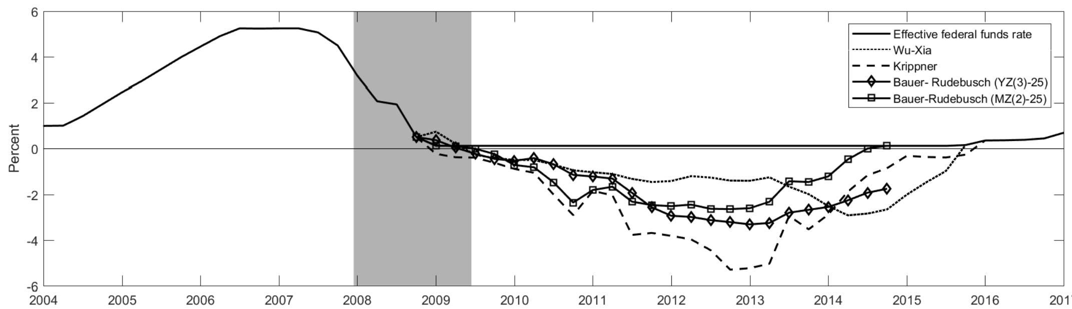
	Average					**Coefficient of variation**				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
1974:Q1–1979:Q4	5.55	10.83	5.27	16.38	10.85	25.50	52.71	116.87	34.08	22.86
1980:Q1–1989:Q4	7.01	19.77	12.76	26.77	13.80	23.67	54.82	84.69	41.52	21.56
1990:Q1–1999:Q4	7.50	15.16	7.65	22.66	14.89	33.06	38.35	69.38	31.72	32.87
2000:Q1–2009:Q4	8.41	17.55	9.14	25.96	16.70	24.90	32.80	72.49	21.51	23.87
2010:Q1–2017:Q1	6.55	13.34	6.79	19.90	13.07	23.45	14.42	40.69	10.65	22.96

Note: This table reports averages and coefficients of variation for of credit measures for all publicly traded firms. POS refers to credit credit creation, NEG is credit destruction, NET is net credit change ($NET_{st} = POS_{st} - NEG_{st}$), SUM is credit reallocation ($SUM_{st} = POS_{st} + NEG_{st}$), and EXC is excess credit reallocation ($EXC_{st} = SUM_{st} - |NET_{st}|$).

Alternative Monetary Policy Rates

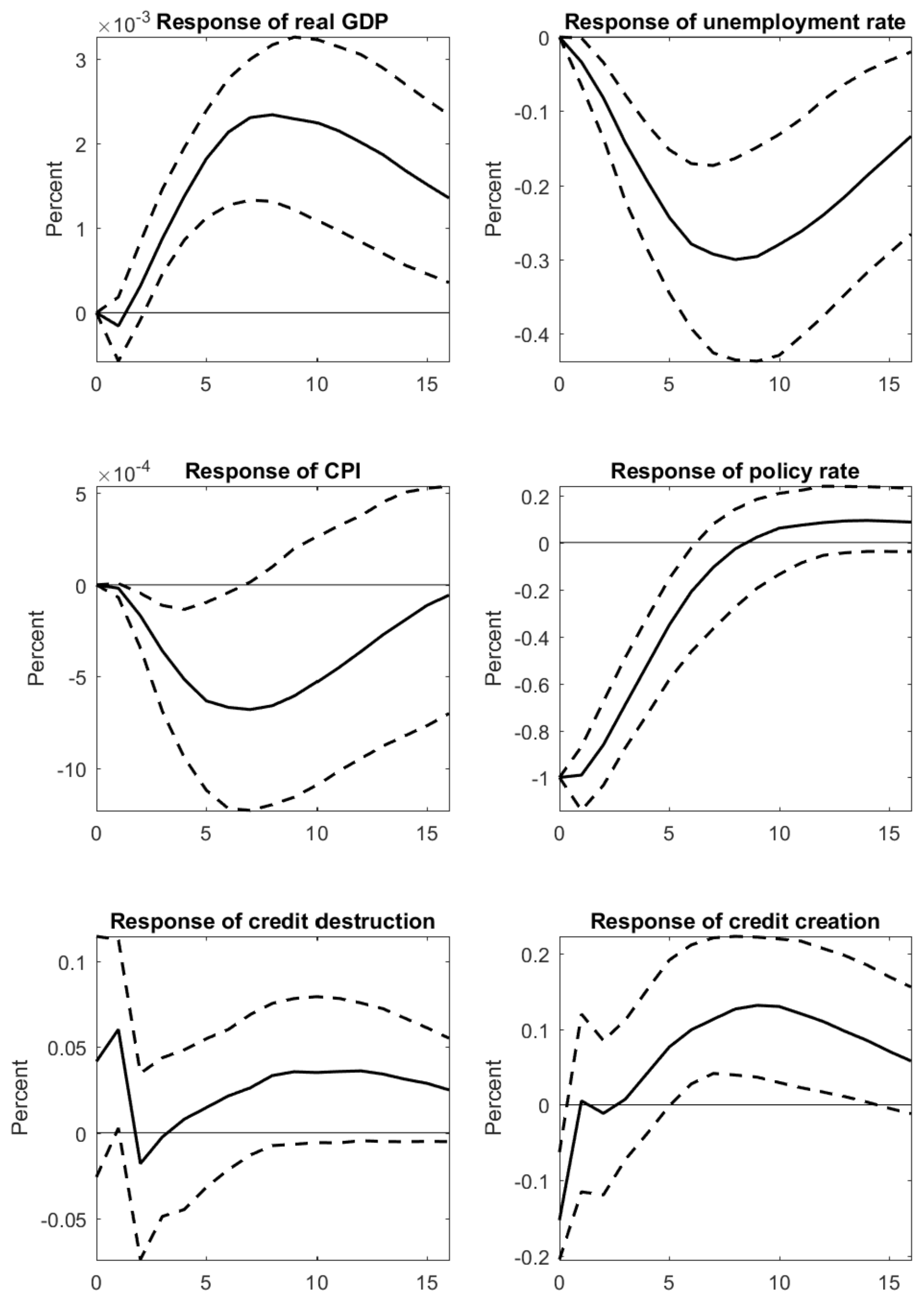
In the empirical analysis of the effect of monetary policy on credit flows, I utilize the effective federal funds rate in normal times and the Wu-Xia shadow rate during the ZLB. Alternative measures of monetary policy during the ZLB are by Krippner (2012) and Bauer and Rudebusch (2016). The following plots these rates along with the effective federal funds rate and the impulse responses derived from a VAR utilizing these alternative measures as the monetary policy rate.

Figure A.1: Alternative Monetary Policy Rates



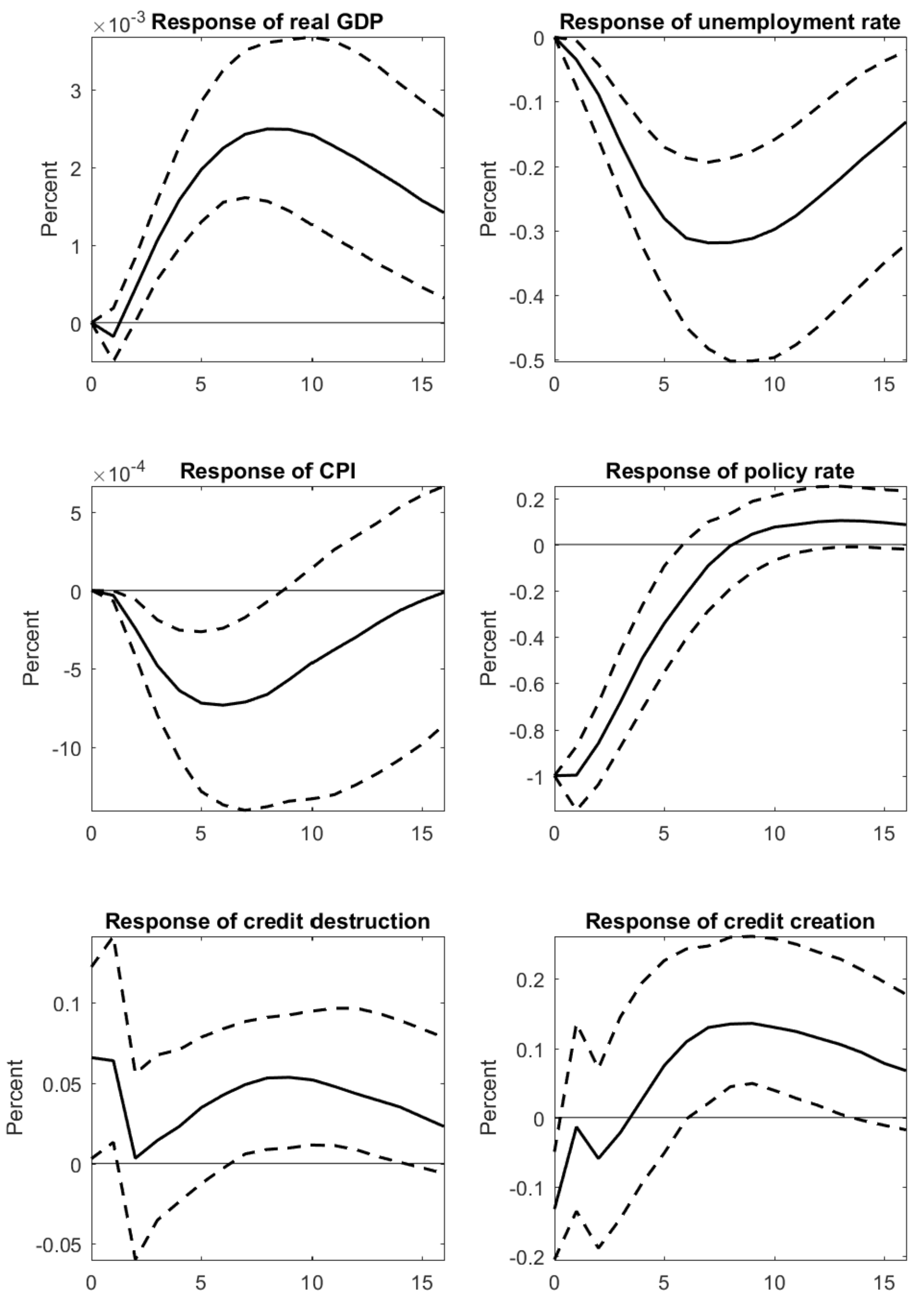
Source: Federal Reserve Board; Federal Reserve Bank of Atlanta; Federal Reserve Bank of San Francisco; Reserve Bank of New Zealand. The shaded bar indicates an NBER recession.

Figure A.2: Impulse Responses to an Expansionary Monetary Policy Shock Using the Policy Rate From Krippner (2012)



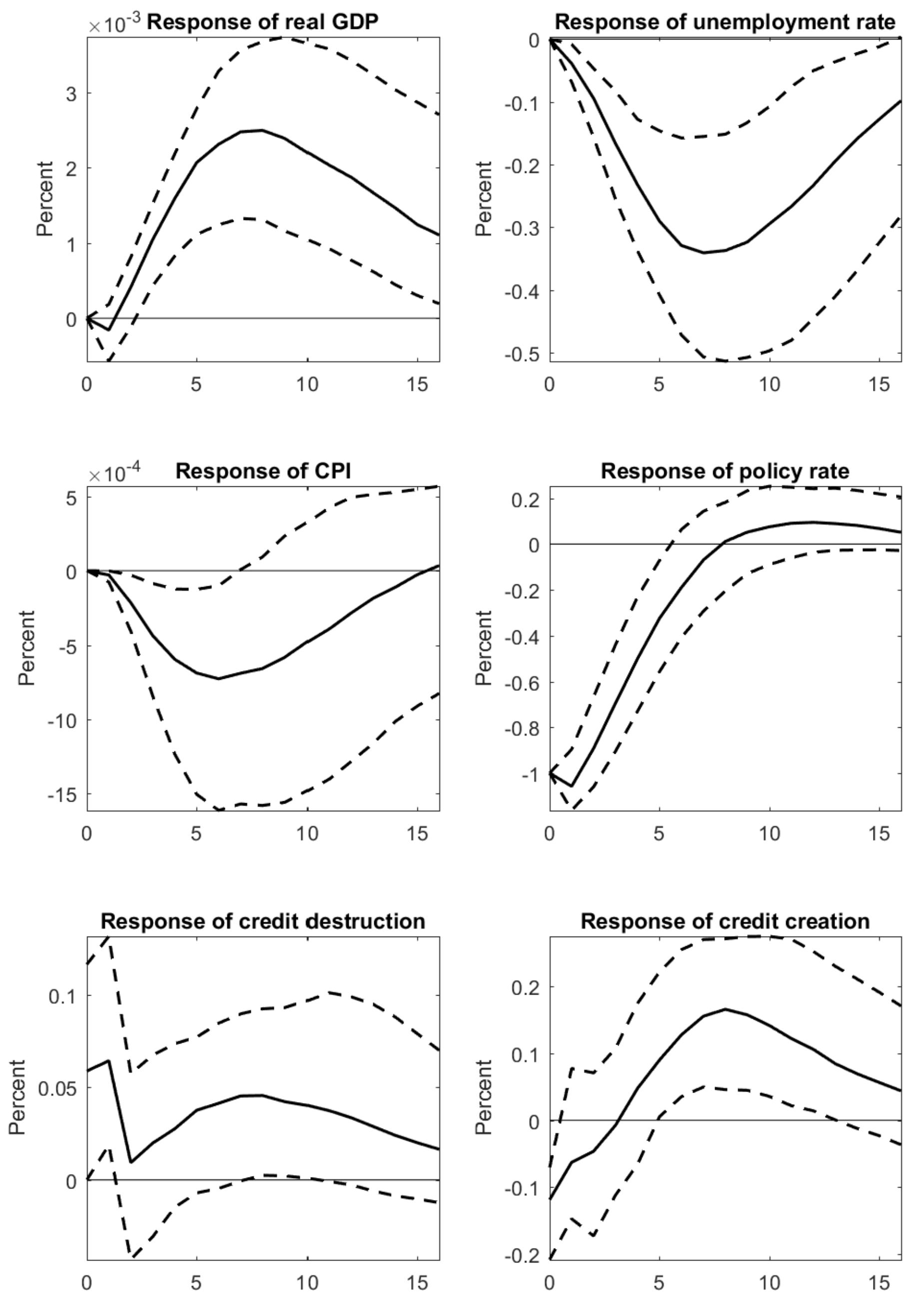
Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the shadow short rate (Krippner, 2012), and two credit flow measures. It includes a constant and two lags, chosen by BIC. The bands represent the 68 percent mean-bias-corrected residual-based wild bootstrap interval.

Figure A.3: Impulse Responses to an Expansionary Monetary Policy Shock Using the YZ(3)-25 Policy Rate By Bauer and Rudebusch (2016)



Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the YZ(3)-25 policy rate (Bauer and Rudebusch, 2016), and two credit flow measures. It includes a constant and two lags, chosen by BIC. The bands represent the 68 percent mean-bias-corrected residual-based wild bootstrap interval.

Figure A.4: Impulse Responses to an Expansionary Monetary Policy Shock Using the MZ(2)-25 policy Rate by Bauer and Rudebusch (2016)



Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes a block of macroeconomic variables, the MZ(2)-25 policy rate (Bauer and Rudebusch, 2016), and two credit flow measures. It includes a constant and two lags, chosen by BIC. The bands represent the 68 percent mean-bias-corrected residual-based wild bootstrap interval.

Identification Through External Instruments

Following Gertler and Karadi (2015), consider a VAR using monthly data with the following order

$$Y_t = \begin{bmatrix} \text{log(consumer prices}_t) \\ \text{log(industrial production}_t) \\ \text{Excess bond premium}_t \\ \text{1-year Treasury rate}_t \end{bmatrix} = \begin{bmatrix} CPI_t \\ IP_t \\ EBP_t \\ GS1_t \end{bmatrix} \tag{A.1}$$

and the SVAR is represented by

$$A_0 Y_t = \sum_{j=1}^{12} A_j Y_{t-j} + \mathcal{E}_t. \tag{A.2}$$

The reduced-form VAR is

$$Y_t = \sum_{j=1}^{12} B_j Y_{t-j} + u_t. \tag{A.3}$$

Full identification can be achieved by assuming A_0^{-1} is lower triangular. From A_0, the structural innovations can be backed out through the identify that

$$\hat{\mathcal{E}}_t^{Chol} = \hat{A}_0 u_t \tag{A.4}$$

where the structural innovation of interest corresponds to the policy variable, the one-year Treasury rate, $\hat{\mathcal{E}}_{GS1,t}^{Chol}$.

Timing restrictions are problematic because monetary policy is likely to influence and respond to the system's economic and financial variables. Following Gertler and Karadi (2015), surprises in federal funds futures on FOMC dates (Z_t) with the following characteristics

$$E[Z_t \mathcal{E}'_{GS1,t}] \neq 0 \tag{A.5}$$

$$E[Z_t \mathcal{E}'_{-GS1,t}] = 0 \tag{A.6}$$

are used as external instruments. The structural innovation, $\mathcal{E}_{GS1,t}$, and the reduced-form innovations (η_t) can be represented such that

$$\eta_{GS1,t} = \phi_{EBP}\eta_{EBP,t} + \phi_{IP}\eta_{IP,t} + \phi_{CPI}\eta_{CPI,t} + \mathcal{E}_{GS1,t} \tag{A.7}$$

where each reduced-form innovation is a function of all structural innovations. From the assumptions in (A.5) and (A.6), the instrument is only correlated with the structural innovation for the policy indicator, although they may be correlated with the reduced-form innovations. In the first step, estimate the following

$$\eta_{GS1,t} = \pi Z_t + e_t \tag{A.8}$$

and obtain the fitted value $\hat{\eta}_{GS1,t}$. Regress each reduced-form residual other than for GS1 on the fitted value

$$\eta_{EBP,t} = \delta_{EBP}\hat{\eta}_{GS1,t} + v_{EBP,t} \tag{A.9}$$

$$\eta_{IP,t} = \delta_{IP}\hat{\eta}_{GS1,t} + v_{IP,t} \tag{A.10}$$

$$\eta_{CPI,t} = \delta_{CPI}\hat{\eta}_{CPI,t} + v_{CPI,t} \tag{A.11}$$

Next, regress the reduced-form residual for GS1 on $v_{-GS1,t}$ and obtain unbiased estimates of ϕ_{-GS1}

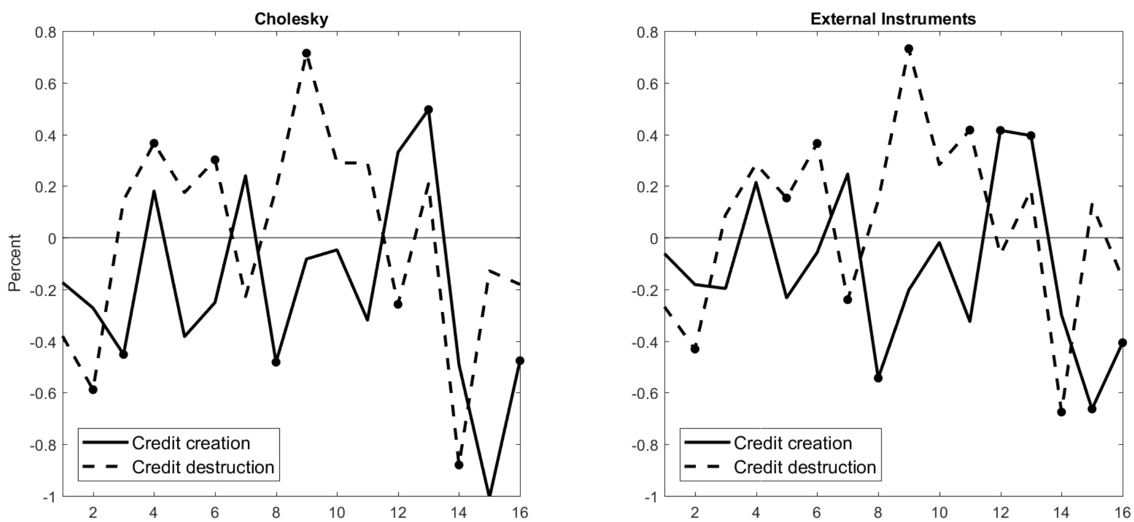
$$\eta_{GS1,t} = \phi_{EBP}v_{EBP} + \phi_{IP}v_{IP} + \phi_{CPI}v_{CPI} + e_t \tag{A.12}$$

and

$$\hat{\mathcal{E}}_t^{IV} = \eta_{GS1,t} - \hat{\phi}_{EBP}\eta_{EBP,t} - \hat{\phi}_{IP}\eta_{IP,t} - \hat{\phi}_{CPI}\eta_{CPI,t} \tag{A.13}$$

By expanding Y_t to include credit destruction and creation,[1] the following shows the response to an unanticipated 100 basis point decrease in the monetary policy rate. The first graph shows the responses of total credit flows for all firms where monetary policy shocks are identified through Cholesky. The second shows the impulse responses when shocks are identified through external instruments.

Figure A.5: Impulse Responses with Cholesky and External Instruments



Note: These graphs plot quarterly impulse responses to a -100 basis point monetary policy shock. The impulse responses are derived from a VAR that includes consumer prices, industrial production, excess bond premium, and 1-year Treasury rate. Monetary policy shocks are identified using Cholesky. The bands represent the 68 percent interval using the residual-based wild bootstrap method.

[1]The data is transformed from monthly to quarterly because credit flow is calculated using quarterly Compustat data.

A.2 Chapter 2 Appendix

Table A.2: Descriptive Statistics of Quarterly Credit Flow Measures

	Average					Coefficient of variation				
	NEG	POS	NET	SUM	EXC	NEG	POS	NET	SUM	EXC
1974:Q1–1979:Q4	5.55	10.83	5.27	16.38	10.85	25.50	52.71	116.87	34.08	22.86
1980:Q1–1989:Q4	7.01	19.77	12.76	26.77	13.80	23.67	54.82	84.69	41.52	21.56
1990:Q1–1999:Q4	7.50	15.16	7.65	22.66	14.89	33.06	38.35	69.38	31.72	32.87
2000:Q1–2009:Q4	8.41	17.55	9.14	25.96	16.70	24.90	32.80	72.49	21.51	23.87
2010:Q1–2017:Q1	6.55	13.34	6.79	19.90	13.07	23.45	14.42	40.69	10.65	22.96

Note: This table reports averages and coefficients of variation for of credit measures for all publicly traded firms. POS refers to credit credit creation, NEG is credit destruction, NET is net credit change ($NET_{st} = POS_{st} - NEG_{st}$), SUM is credit reallocation ($SUM_{st} = POS_{st} + NEG_{st}$), and EXC is excess credit reallocation ($EXC_{st} = SUM_{st} - |NET_{st}|$).

Table A.3: Common Observations Between Groups (1973:Q1–2017:Q1)

	High default probability	High debt service	Financially dependent	Small	Productive	Less productive
High default probability	15.4%					
High debt service	0.6%	31.5%				
Financially dependent	3.7%	9.1%	25.0%			
Small	5.4%	8.5%	9.3%	31.7%		
Productive	1.2%	10.3%	6.8%	7.1%	24.6%	
Less productive	1.9%	7.8%	6.3%	7.3%	0.0%	24.6%

Note: Following Farre-Mensa and Ljungqvist (2016), high default probability firms are those which the default probability exceeds 25 percent at a point in time and all others are low default probability firms. High debt service firms are those which the leverage ratio is in the top tercile of firms in a given quarter and low debt service are those for which the leverage ratio is in the bottom tercile of firms in a given quarter. Firms are large if the value of their total assets is in the top tercile of firms in a given quarter and are small if the value of their total assets is in the bottom tercile of firms in a given quarter. Financially dependent firms are those which the need for external financing (Rajan and Zingales, 1998) is in the top tercile in a given quarter and are non-financially dependent if this ratio is in the bottom tercile of firms in a given quarter.

Table A.4: Descriptive Statistics with Static and Dynamic Thresholds (1973:Q1–2017:Q1)

		Average					Coefficient of variation				
		POS	NEG	NET	SUM	EXC	POS	NEG	NET	SUM	EXC
(a) Total credit	High default probability firms	7.5	4.4	3.1	12.0	6.8	79.9	124.0	270.3	65.8	53.9
	High default probability firms (top tercile)	6.4	4.1	2.4	10.5	7.5	50.1	42.1	154.3	34.3	31.1
	Low default probability firms	5.2	3.6	1.5	8.8	7.0	37.4	30.7	123.0	28.7	27.9
	Low default probability firms (bottom tercile)	4.2	3.5	0.7	7.7	6.1	46.0	41.0	298.3	33.9	31.9
(b) Short-term credit	High default probability firms	15.8	7.9	8.0	23.7	13.6	58.4	73.0	133.4	47.0	56.1
	High default probability firms (top tercile)	15.1	7.2	7.9	22.3	14.1	45.2	31.1	89.1	32.8	29.9
	Low default probability firms	15.1	7.1	8.0	22.2	14.2	34.2	25.5	64.9	25.9	24.9
	Low default probability firms (bottom tercile)	16.0	7.6	8.3	23.6	15.3	32.5	33.3	60.1	27.4	33.1
(c) Long-term credit	High default probability firms	8.5	4.2	4.3	12.7	6.6	98.8	112.1	238.8	71.3	45.4
	High default probability firms (top tercile)	7.1	4.2	2.9	11.3	7.8	55.8	44.3	152.8	38.5	33.4
	Low default probability firms	5.6	3.7	1.9	9.3	7.3	37.8	33.6	95.3	31.8	32.1
	Low default probability firms (bottom tercile)	4.6	3.5	1.1	8.1	6.4	47.9	45.0	209.4	37.5	33.9

Note: Firms are subset first by their default probability following Farre-Mensa and Ljungqvist (2016) whereby firms whose default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms.

Table A.5: Group Transitions for Static and Dynamic Thresholds

	High default probability	Low default probability	High default probability (top tercile)	Low default probability(bottom tercile)
High default probability	0.487	0.113		
Low default probability	0.513	0.887		
High default probability (top tercile)			0.558	0.169
Low default probability (bottom tercile)			0.225	0.648

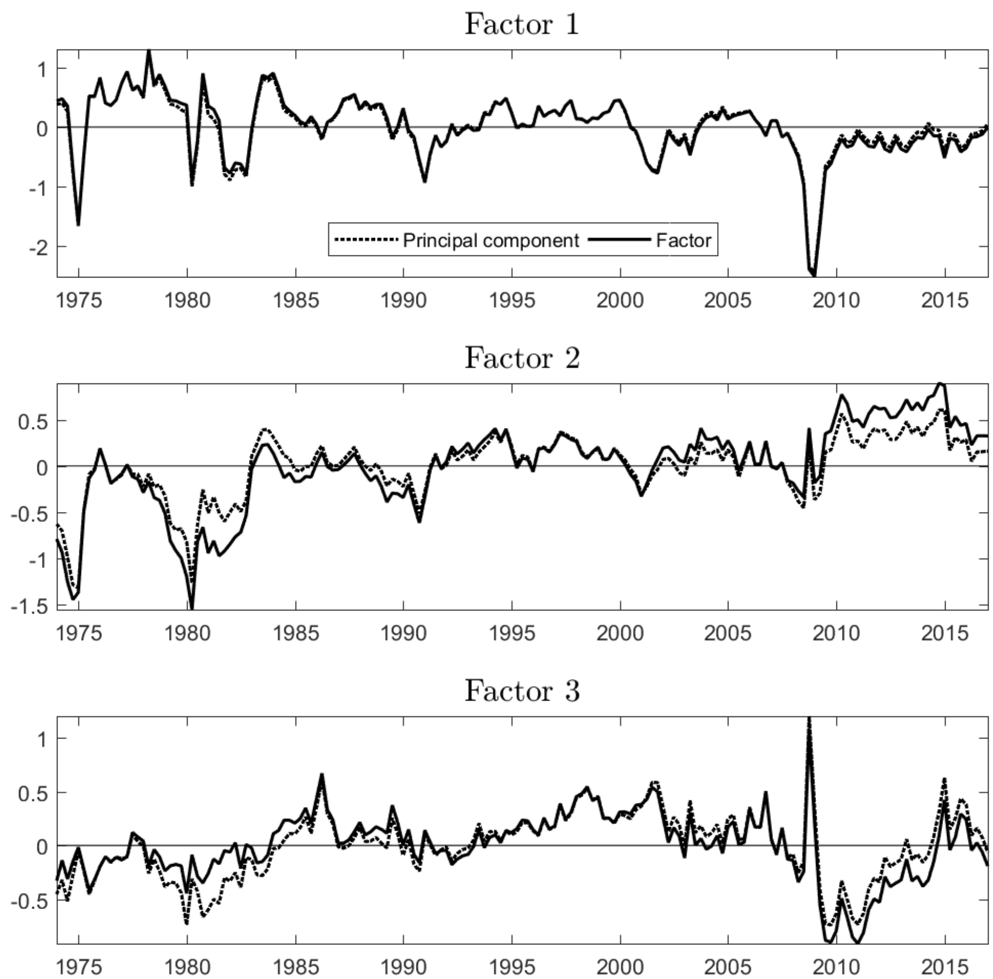
Note: This table provides probabilities that a firm belongs to a certain classification in time t conditional on the classification in $t-1$. For firms classified as high or low default probability firms based on terciles, the omitted probability corresponds to the probability of being in the middle tercile conditional on being classified as a high or low default probability firm in the previous quarter.

Table A.6: Policy Counterfactuals Using a Dynamic Default Probability Threshold

	a) Counterfactual 1: no monetary shock						**b) Counterfactual 2: zero lower bound**					
	Total credit		Short-term credit		Long-term credit		Total credit		Short-term credit		Long-term credit	
	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS	NEG	POS
Zero lower bound (2009:Q3–2015:Q3)												
High default probability firms (top tercile)	+0.06	+0.23	+0.03	+0.09	+0.04	+0.24	+0.48	+0.79	−0.03	+0.11	+0.47	+0.75
Low default probability firms (bottom tercile)	+0.13	+0.19	+0.08	+0.39	+0.14	+0.21	+0.46	+0.74	−0.11	+0.85	+0.48	+0.69
QE1 (2009:Q3–2010:Q1)												
High default probability firms (top tercile)	+0.00	−0.01	+0.00	+0.01	+0.01	−0.01	+0.08	+0.04	−0.02	−0.03	+0.09	+0.03
Low default probability firms (bottom tercile)	+0.00	+0.00	+0.01	+0.00	+0.01	+0.01	+0.04	+0.08	−0.07	−0.05	+0.05	+0.06
QE2 (2010:Q4–2011:Q2)												
High default probability firms (top tercile)	+0.06	+0.03	−0.02	+0.00	+0.08	+0.02	+0.07	+0.09	−0.01	−0.01	+0.07	+0.09
Low default probability firms (bottom tercile)	+0.04	+0.07	−0.06	−0.05	+0.04	+0.06	+0.06	+0.09	−0.03	+0.05	+0.07	+0.09
Operation twist (2011:Q3–2012:Q4)												
High default probability firms (top tercile)	−0.04	+0.06	+0.03	+0.05	−0.06	+0.06	+0.06	+0.17	+0.01	+0.04	+0.05	+0.17
Low default probability firms (bottom tercile)	+0.01	+0.01	+0.09	+0.18	+0.00	+0.01	+0.08	+0.13	+0.02	+0.24	+0.09	+0.13
QE3 (2012:Q3–2014:Q4)												
High default probability firms (top tercile)	+0.20	+0.11	−0.05	−0.06	+0.23	+0.06	+0.28	+0.28	−0.05	+0.02	+0.30	+0.22
Low default probability firms (bottom tercile)	+0.09	+0.18	−0.18	−0.13	+0.10	+0.13	+0.19	+0.33	−0.17	+0.17	+0.20	+0.27

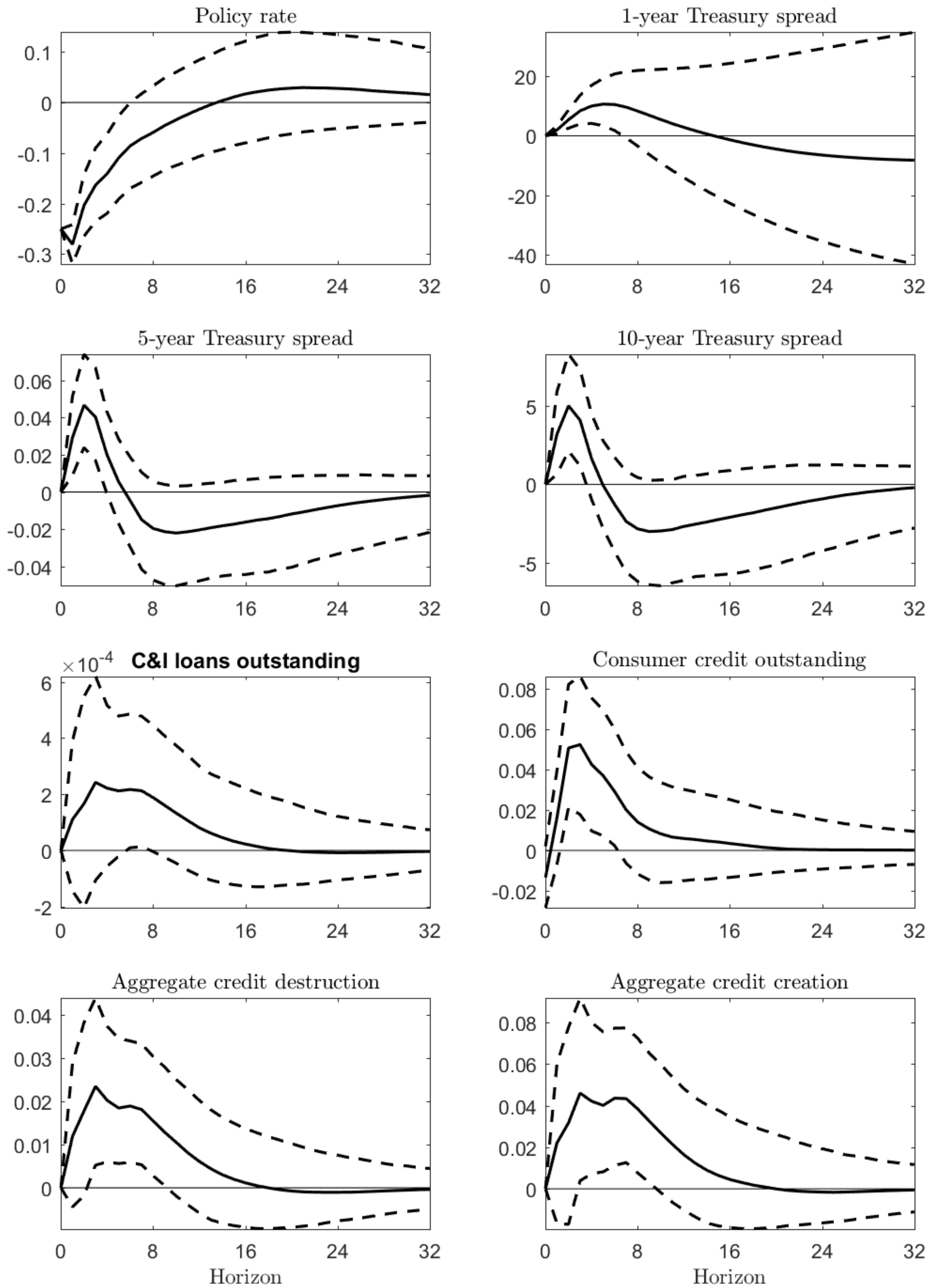
Note: This table shows the percentage difference in how credit destruction (NEG) and credit creation (POS) would respond to monetary policy counterfactuals. Counterfactual 1 is a scenario absent of monetary policy innovations and Counterfactual 2 is a scenario whereby monetary policy innovations are such that the policy rate (shadow federal funds rate as in Wu and Xia (2016)) is at the zero lower bound. The table presents the wedge between the contribution of the counterfactual monetary policy innovations and the actual innovations. A positive number suggests that the actual monetary policy contributed positively to the credit flow measure relative to the counterfactual. Firms are subset first by their default probability following Farre-Mensa and Ljungqvist (2016) whereby firms whose default probability exceeds 25 percent at a point in time are considered high default probability firms and all others are low default probability firms as well as separating them into top and bottom terciles.

Figure A.6: Estimated Factors



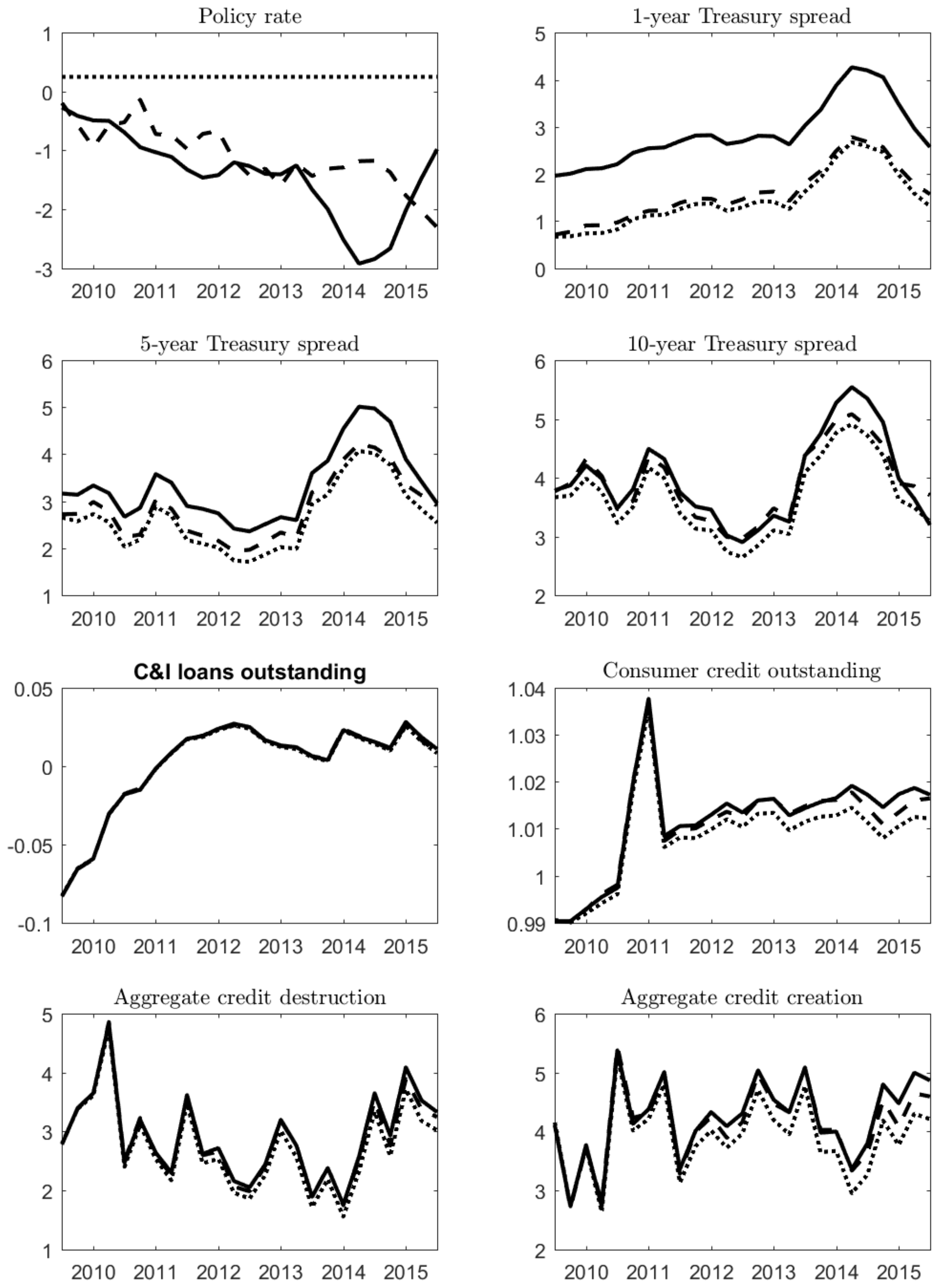
Note: The principal components are extracted using 99 quarterly macroeconomic series over the period Q1:1974–Q1:2017. The factors are obtained by removing the impact of the monetary policy rate on the principal components.

Figure A.7: Impulse Responses of Credit Market Indicators to a Monetary Easing Shock



Note: These graphs plot quarterly impulse responses to a -25 basis point monetary policy shock using the sample, 1974:Q1–2017:Q1, in a FAVAR(4) setting. The x-axis is number of quarters following the monetary easing shock. C&I loans outstanding and consumer credit outstanding are percentage deviations from the steady state and all remaining variables are percentage points.

Figure A.8: Policy Counterfactuals During the Zero Lower Bound for Credit Market Indicators



Note: The solid lines are the observed economic variables between 2009:Q3 and 2015:Q3. The dashed lines are the values if the monetary shocks were shut down and the dotted lines are the values of these variables if the shadow policy rate were at the zero lower bound.

A.3 Chapter 3 Appendix

Table A.7: WIOD–ISIC Rev. 3 Concordance

Industry	Sub-industry	WIOD	ISIC rev. 3
Agriculture, Hunting, Forestry and Fishing	Agriculture, hunting and related	c1	01
	Forestry, logging and related service activities	c1	02
	Fishing, fish hatcheries and farms	c1	05
Mining and Quarrying	Mining of coal and lignite; extraction of peat	c2	10
	Extraction of crude petroleum and natural gas	c2	11
	Mining of uranium and thorium ores	c2	12
	Mining of metal ores	c2	13
	Other mining and quarrying	c2	14
Food, Beverages, and Tobacco	food products and beverages	c3	15
	tobacco products	c3	16
Textiles and Textile Products	textiles	c4	17
	wearing apparel; dressing and dyeing of fur	c4	18
Leather, Leather and Footwear	leather; luggage, handbags, saddlery, harness and footwear	c5	19
Wood and Products of Wood and Cork	wood, wood and cork products, straw, plaiting materials	c6	20
Pulp, Paper, Paper, Printing and Publishing	paper and paper products	c7	21
	Publishing, printing and reproduction of recorded media	c7	22
Coke, Refined Petroleum and Nuclear Fuel	coke, refined petroleum products and nuclear fuel	c8	23
Chemicals and Chemical Products	chemicals and chemical products	c9	24
Rubber and Plastics	rubber and plastics products	c10	25
Other Non-Metallic Mineral	other non-metallic mineral products	c11	26
Basic Metals and Fabricated Metal	basic metals	c12	27
	fabricated metal products, except machinery and equipment	c12	28
Machinery, Nec	machinery and equipment n.e.c.	c13	29
Electrical and Optical Equipment	office, accounting and computing machinery	c14	30
	electrical machinery and apparatus n.e.c.	c14	31
	radio, television and communication equipment and apparatus	c14	32
	medical, precision and optical instruments, watches and clocks	c14	33
Transport Equipment	motor vehicles, trailers and semi-trailers	c15	34
	other transport equipment	c15	35
Manufacturing, Nec; Recycling	furniture; manufacturing n.e.c.	c16	36
	Recycling	c16	37
Electricity, Gas and Water Supply	Electricity, gas, steam and hot water supply	c17	40
	Collection, purification and distribution of water	c17	41
Construction	Construction	c18	45
Motor Vehicles and Motorcycles; Retail Sale of Fuel	Sale, Maintenance and Repair; Retail Sale of Fuel	c19	50
Wholesale Trade and Commission Trade	Wholesale Trade and Commission Trade	c20	51
Retail Trade; Repair of Household Goods	Retail Trade; Repair of Household Goods	c21	52
Hotels and restaurants	Hotels and restaurants	c22	55
Inland transport	Land transport; transport via pipelines	c23	60
Water transport	Water transport	c24	61
Air transport	Air transport	c25	62
transport activities; travel agencies	transport activities; travel agencies	c26	63
Post and telecommunications	Post and telecommunications	c27	64
Financial intermediation	Financial intermediation, except insurance and pension funding	c28	65
	Insurance and pension funding, except compulsory social security	c28	66
	Activities auxiliary to financial intermediation	c28	67
Real estate activities	Real estate activities	c29	70
Renting of M&Eq and Other Business Activities	Renting of machinery and equipment	c30	71
	Computer and related activities	c30	72
	Research and development	c30	73
	Other business activities	c30	74
Public administration and defense; compulsory social security	Public administration and defence; compulsory social security	c31	75
Education	Education	c32	80
Health and social work	Health and social work	c33	85
Other community, social and personal service activities	Sewage and refuse disposal, sanitation and similar activities	c34	90
	Activities of membership organizations n.e.c.	c34	91
	Recreational, cultural and sporting activities	c34	92
	Other service activities	c34	93
Private households with employed persons	Private households with employed persons	c35	95

Note: The first column is the industry classification from WIOD and the second column are the corresponding sub-industries by ISIC rev. 3.

Table A.8: WIOD–NAICS Concordance

	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18	c19	c20	c21	c22	c23	c24	c25	c26	c27	c28	c29	c30	c31	c32	c33	c34	c35
111	✓	✓	✓																																
112	✓	✓																																	
113	✓	✓				✓																													
114	✓	✓																																	
115	✓	✓										✓																					✓		
211		✓																																	
212		✓																																	
213		✓																✓												✓					
221		✓															✓																	✓	
236																		✓																	
237																		✓											✓						
238												✓	✓	✓	✓	✓		✓												✓					
311	✓	✓	✓						✓																										
312	✓	✓	✓														✓																		
313				✓						✓																									
314				✓	✓					✓						✓																			
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316				✓	✓											✓																			
321					✓	✓				✓						✓																			
322				✓			✓			✓	✓	✓				✓																			
323				✓			✓					✓																		✓					
324		✓				✓		✓			✓																								
325			✓					✓	✓	✓	✓			✓		✓														✓					
326					✓					✓				✓	✓	✓																			
327											✓					✓																			
331								✓				✓	✓	✓	✓																				
332				✓					✓	✓		✓	✓	✓	✓	✓																			
333												✓	✓	✓	✓	✓																			
334							✓		✓	✓				✓	✓																				
335				✓						✓	✓		✓	✓																					
336				✓						✓	✓		✓	✓	✓	✓																			
337				✓		✓				✓		✓		✓	✓	✓																			
339				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓																			
423																✓			✓	✓															
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488		✓													✓	✓			✓				✓		✓	✓				✓				✓	
491																											✓								
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533																												✓							
541	✓	✓																								✓		✓		✓	✓		✓		
551																												✓		✓					

WIOD–NAICS Concordance cont.

	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18	c19	c20	c21	c22	c23	c24	c25	c26	c27	c28	c29	c30	c31	c32	c33	c34	c35
561	✓	✓		✓														✓		✓	✓					✓			✓	✓	✓			✓	
562								✓								✓																		✓	
611																														✓		✓	✓	✓	
621																																	✓		
622																																	✓		
623																																	✓		
624																															✓		✓		
711																✓														✓				✓	
712																																		✓	
713																										✓								✓	
721																						✓													
722																						✓												✓	
811				✓		✓						✓	✓	✓	✓	✓		✓	✓		✓									✓					
812																					✓					✓	✓			✓				✓	
813																												✓						✓	
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927																															✓				
928																															✓				

Agriculture, forestry, fishing, and hunting
111: crop production; 112: animal production; 113: forestry and logging; 114: fishing, hunting, and trapping; 115: support activities for agriculture and forestry
Mining
211: oil and gas extraction; 212: mining (except oil and gas); 213: support activities for mining
Utilities (221)
Construction
236: construction of buildings; 237: heavy and civil engineering construction; 238: specialty trade contractors
Manufacturing
311: food manufacturing; 312: beverage and tobacco product manufacturing; 313: textile mills; 314: textile product mills; 315: apparel manufacturing; 316: leather and allied product manufacturing; 321: wood product manufacturing; 322: paper manufacturing; 323: printing and related support activities; 324: petroleum and coal products manufacturing; 325: chemical manufacturing; 326: plastics and rubber products manufacturing; 327: nonmetallic mineral product manufacturing; 331: primary metal manufacturing; 332: fabricated metal product manufacturing; 333: machinery manufacturing; 334: computer and electronic product manufacturing; 335: electrical equipment, appliance, and component; manufacturing; 336: transportation equipment manufacturing; 337: furniture and related product manufacturing; 339: misc. manu.
Wholesale trade
423: merchant wholesalers, durable goods; 424: merchant wholesalers, nondurable goods; 425: wholesale electronic markets and agents and brokers
Retail trade
441: motor vehicle and parts dealers; 442: furniture and home furnishings stores; 443: electronics and appliance stores; 444: building material and garden equipment and supplies dealers; 445: food and beverage stores; 446: health and personal care stores; 447: gasoline stations; 448: clothing and clothing accessories stores; 451: sporting goods, hobby, book, and music stores; 452: general merchandise stores; 453: misc. store retailers; 454: nonstore retailers
Transportation and warehousing
481: air transportation; 482: rail transportation; 483: water transportation; 484: truck transportation; 485: transit and ground passenger transportation; 486: pipeline transportation; 487: scenic and sightseeing transportation; 488: support activities for transportation; 491: postal service; 492: couriers and messengers; 493: warehousing and storage
Information
511: publishing industries (except internet); 512: motion picture and sound recording industries; 515: broadcasting (except internet); 516: internet publishing and broadcasting; 517: telecommunications; 518: internet service providers, web search portals, and data processing services; 519: other information services
Finance and insurance
521: monetary authorities - central bank; 522: credit intermediation and related activities; 523: securities, commodity contracts, and other financial investments and related activities; 524: insurance carriers and related activities
Real estate and rental and leasing
531: real estate; 532: rental and leasing services; 533: lessors of nonfinancial intangible assets (except copyrighted works)
Professional, scientific, and technical services (541)
Management of companies and enterprises (551)
Administrative support and waste management and remediation services
561: administrative and support services; 562: waste management and remediation services
Educational services (611)
Health care and social assistance
621: ambulatory health care services; 622: hospitals; 623: nursing and residential care facilities; 624: social assistance
Arts, entertainment, and recreation
711: performing arts, spectator sports, and related industries; 712: museums, historical sites, and similar institutions; 713: amusement, gambling, and recreation industries
Accommodation and food services
721: accommodation; 722: food services and drinking places
Other services (except public administration)
811: repair and maintenance; 812: personal and laundry services; 813: religious, grantmaking, civic, professional, and similar organizations; 814: private households
Public administration
921: executive, legislative, and other general government support; 922: justice, public order, and safety activities; 923: administration of human resource programs; 924: administration of environmental quality programs; 925: administration of housing programs, urban planning, and community development; 926: administration of economic programs; 927: space research and technology; 928: national security and international affairs

Note: c1 through c35 represent WIOD classifications and the first row represents NAICS. ; *Source:* United Nations Statistics Division.

WIOD Construction

The construction of WIOD is extensive and its methodology is described by Dietzenbacher, Los, Stehrer, Timmer, and De Vries (2013) and Timmer, Dietzenbacher, Los, Stehrer, and Vries (2015). An illustration of the WIOD time series creation from their work as it relates to data used in this paper follows.

WIOD construction occurs through the creation of input-output tables for countries at specific points in time. Building the WIOD requires data from national accounts (NA), international trade statistics (ITS), and supply and use tables (SUTs). Data from NA and ITS are available at regular intervals and contain country-specific publicly available information. NA commonly consists of data on aggregate imports and exports, sectoral value-added and output, and a country's final demand for a product. ITS, such as UN Comtrade or IMF trade statistics, contains formal bilateral trade data of goods and services.

Price Conversion

By combining bilateral trade and country use tables, one can derive the shares of imports used for production for each product in a specific country. Use tables are denominated in purchasers' prices although supply tables are denominated in basic prices (i.e. the prices reflected as the cost to producer). Accordingly, use table data needs to be converted to basic prices. This is done through the creation of a valuation matrix that contains trade and transportation margins as well as taxes, driving a wedge between the amount paid by the purchaser and the cost to the producer. This is information also contained in SUTs when available. After conversion, the SUTs are both measured in basic prices. From the use table converted to basic prices, by using industry demand from NA one can obtain a domestic use table. Also from the use table at basic prices, by using the bilateral shares of imports for use one can determine the import use from each country. These last two are what is needed to create the input-output table for each country.

Creation of Time Series

An unfortunate shortcoming of WIOD is the need to interpolate SUTs as they are available intermittently across countries and across time. This makes creating a time series impossible without interpolation because construction requires data from NA, ITS, and SUTs. The SUTs aid in the creation of country input-output tables and subsequently world input-output tables. The interpolation process is described by Timmer, Dietzenbacher, Los, Stehrer, and Vries (2015), where they also highlight that U.S. has annual SUTs from 1998-2010 although Mexico, Russia, and Cyprus only have SUTs for one year. Several EU countries and the BEA have begun releasing annual SUTs with revisions which will allay the need to interpolate as much in the future.

To impute the SUT coefficients, WIOD uses the RAS method as in Temurshoev and Timmer (2011) and described for WIOD by Dietzenbacher, Los, Stehrer, Timmer, and De Vries (2013). At a given point of time for each country, there is available information from NA, such as aggregate industrial production, imports, exports, inventories, and taxes. A country's aggregated value-added, sector-level value-added, and aggregated final use is also available regularly. As a preliminary step, the sector measures of imports, exports, inventories, taxes, and trade and transportation margins are estimated.

The SUTs are interpolated using the RAS method. In rudimentary form and focusing only on supply and use for sectors, the method is rather simple. Given that aggregated supply and use data exists, the estimates of the sectoral supply and use data can be updated based on aggregate supply and use information. Suppose that for a country the SUTs are available in 2000 and 2002 but missing for 2001. In 2001, total supply and total use by sector are known but the contributions to and from each sector are unknown. Tables A.9 and A.10 show the process of estimating the SUT for 2001. This is an iterative process starting with the last known SUT and updating the weights based on estimated sectoral totals relative to actual sectoral totals for total supply and then for total use and so on. In this example, there will be an estimate of the SUT for 2001 using the 2000 SUT table as a starting guess. The same will be done using the next available SUT, which is 2002. Following the same process there are two estimates of the SUT for 2001 of which WIOD uses the simple average. Table A.10 shows a simple example of this method using the 2000 SUT as a starting guess.

Table A.9: Sample SUT with Missing Data

2000			Use			
			Sector 1	Sector 2	Sector 3	Actual supply
	Supply	Sector 1	a	b	c	(a+b+c)
		Sector 2	d	e	f	(d+e+f)
		Sector 3	g	h	i	(g+h+i))
		Actual use	(a+d+g)	(b+e+h)	(c+f+i)	
2001			Use			
			Sector 1	Sector 2	Sector 3	Actual supply
	Supply	Sector 1	unknown	unknown	unknown	known
		Sector 2	unknown	unknown	unknown	known
		Sector 3	unknown	unknown	unknown	known
		Actual use	known	known	known	
2002			Use			
			Sector 1	Sector 2	Sector 3	Actual supply
	Supply	Sector 1	j	k	l	(j+k+l)
		Sector 2	m	n	o	(m+n+o)
		Sector 3	p	q	r	(p+q+r)
		Actual use	(j+m+p)	(k+n+q)	(l+o+r)	

Note: This is a sample WIOD with missing data for 2001.

Table A.10: Estimation of SUT for 2001

Step 1

		Use Sector 1	Sector 2	Sector 3	Estimated supply	Actual supply
Supply	Sector 1	a	b	c	(a+b+c)	S1
	Sector 2	d	e	f	(d+e+f)	S2
	Sector 3	g	h	i	(g+h+i)	S3
	Estimated use	(a+d+g)	(b+e+h)	(c+f+i)		
	Actual use	U1	U2	U2		

Step 2

		Use Sector 1	Sector 2	Sector 3	Estimated supply	Actual supply
Supply	Sector 1	$\frac{a \times S1}{(a+b+c)} = SU11$	$\frac{b \times S1}{(a+b+c)} = SU12$	$\frac{c \times S1}{(a+b+c)} = SU13$	(SU11+SU12+SU13)	S1
	Sector 2	$\frac{d \times S2}{(d+e+f)} = SU21$	$\frac{e \times S2}{(d+e+f)} = SU22$	$\frac{f \times S2}{(d+e+f)} = SU23$	(SU21+SU22+SU23)	S2
	Sector 3	$\frac{g \times S2}{(g+h+i)} = SU31$	$\frac{h \times S2}{(g+h+i)} = SU32$	$\frac{i \times S2}{(g+h+i)} = SU33$	(SU31+SU32+SU33))	S3
	Estimated use	(SU11+SU21+SU31)	(SU12+SU22+SU32)	(SU13+SU23+SU33)		
	Actual use	U1	U2	U2		

Step 3

		Use Sector 1	Sector 2	Sector 3
Supply	Sector 1	$\frac{SU11 \times U1}{(SU11+SU21+SU31)}$	$\frac{SU12 \times U1}{(SU12+SU22+SU32)}$	$\frac{SU13 \times U1}{(SU13+SU23+SU33)}$
	Sector 2	$\frac{SU21 \times U1}{(SU11+SU21+SU31)}$	$\frac{SU22 \times U1}{(SU12+SU22+SU32)}$	$\frac{SU23 \times U1}{(SU13+SU23+SU33)}$
	Sector 3	$\frac{SU31 \times U1}{(SU11+SU21+SU31)}$	$\frac{SU32 \times U1}{(SU12+SU22+SU32)}$	$\frac{SU33 \times U1}{(SU13+SU23+SU33)}$

and iterate...

Note: This is a sample WIOD with missing data for 2001 highlighting the iteration process.

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Vita

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Education

MS in Economics, University of Kentucky	2015
MA in Economics, Bowling Green State University	2008
BSBA in Economics and Finance, Bowling Green State University	2006

Publications

Oet, Mikhail, Timothy Bianco, Dieter Gramlich, and Stephen Ong (2013). SAFE: An Early Warning System for Systemic Banking Risk. *Journal of Banking and Finance* 37(11), 4510-4533.

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Federal Reserve Publications

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Bianco, Timothy, Mikhail Oet, and Stephen Ong (2012). The Cleveland Financial Stress Index. *Economic Commentary* 2012-04. Federal Reserve Bank of Cleveland.

Bianco, Timothy and Filippo Occhino (2011). Household Balance Sheets and the Recovery. *Economic Commentary* 2011-05. Federal Reserve Bank of Cleveland.

Haubrich, Joseph and Timothy Bianco (2010). Inflation: Noise, Risk, and Expectations. *Economic Commentary* 2010-05. Federal Reserve Bank of Cleveland.

Professional Experience

Research Assistant	2015 – 2018
Center for Business and Economic Research	
University of Kentucky	
Teaching Assistant	2013 – 2015
Department of Economics	
University of Kentucky	
Economic Analyst	2011 – 2013, Summer 2014
Federal Reserve Bank of Cleveland	
Research Analyst	2009 – 2011
Federal Reserve Bank of Cleveland	
Instructor of Economics	2008 – 2009
Department of Economics	
Bowling Green State University	
Graduate Assistant	2007 – 2008
Department of Economics	
Bowling Green State University	

Teaching Experience

University of Kentucky

ECO 201: Principles of Economics I	Summer 2016, 2017
ECO 202: Principles of Economics II	Summer 2014 – Spring 2015
ECO 391: Economic and Business Statistics	Summer 2015

Bowling Green State University

ECON 200: Introduction to Economics	Fall 2008 – Spring 2009
ECON 203: Principles of Macroeconomics	Fall 2008 – Spring 2009

Honors and Awards

Gatton Doctoral Fellowship, University of Kentucky, 2015 – 2017
Luckett Fellowship, University of Kentucky, 2016 – 2017
Chris Moore Spirit of Innovation Award, Federal Reserve Bank of Cleveland, 2012

Professional and Invited Presentations

Centre College, Economics Department, 2017
Kentucky Economics Association Conference, Western Kentucky University, 2017
Kentucky Economics Association Conference, University of Kentucky, 2016
Bank of Canada, Financial Markets Department, 2013
Federal Reserve Bank of Chicago, Fifth Annual Risk Conference, 2012
Federal Reserve Board, Financial Stability Division, 2012
24th Australasian Finance and Banking Conference, Sydney, Australia, 2011