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Monetary Policy at the Zero Lower Bound: Implications of High Costs of Credit during a Recession

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Monetary Policy at the Zero Lower Bound:
The Implications of High Costs of Credit during a Recession

By

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Abstract

This thesis examines the challenges policymakers (and firms) encounter when confronted by a recession at the zero lower bound, when traditional monetary policy is ineffective in the face of deteriorated balance sheets and high costs of credit. Within the larger body of literature, this paper focuses on the cost of credit during a recession, which constrains smaller firms from borrowing and investing, thus magnifying the contraction. Extending and revising a model originally developed by Walker (2010) and estimated by Pandey and Ramirez (2012), this study uses a Vector Error Correction Model to analyze the effects of relevant economic and financial factors on the cost of credit intermediation for small and large firms in order to test whether large firms have advantageous access to credit, especially during recessions. From the results, the paper assesses alternative ways in which the central bank can respond to a recession facing the zero lower bound.

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Introduction

Prior to 2008 many economists and policymakers saw the zero lower bound (ZLB), in which nominal short-term interest rates hit a floor of zero and the central bank cannot further lower rates, as something to be taught in a macroeconomics course, but unlikely to ever pose a serious problem to actual economies. Japan's implementation of a zero interest rate policy in 1999 was seen as an anomaly. John Maynard Keynes (1936) had identified the risk of a liquidity trap, caused by the zero lower bound, in his General Theory of Employment, Interest, and Money. He believed that the use of monetary policy in response to a deep recession at the ZLB would be ineffective, in part because during recessions banks and individuals are more likely to increase savings or hoard money; under such circumstances, an increase in the money supply causes little change in the level of investment and spending (see Bernanke, 2017; Knoop 2008, p. 81). However, discussion of liquidity traps and the zero lower bound appeared to have fallen out of fashion in the second half of the twentieth century. For example, Nobel-Prize winning economist Paul Krugman pointed out that since the end of World War II, economists considered the risk of such an event taking place a thing of the past. In response to Japan's 1990s recession, however, Krugman revived the topic and warned of the importance of understanding the underlying reasons for a liquidity trap, foreshadowing, "if this can happen in Japan, it can happen elsewhere" (Krugman 1998, p. 138).

In 2008 and 2009, the United States Federal Reserve Bank and other central banks of developed countries awoke to the reality of the zero lower bound as many were forced to cut interest rates to zero in response to the Great Recession of 2007-09. A study conducted by Federal Reserve board members Michael Kiley and John Roberts found that the lower bound is now likely to constrain monetary easing policies around 40% of the time for an average of two

and a half years (Kiley 2017, p. 8). Thus, many prominent economists, such as Ben Bernanke and other Federal Reserve members, have since put an emphasis on the importance of alternative monetary policies to maintain central bank effectiveness in the future. A decade following the Great Recession, interest rates remain low globally. If a recession were to hit, many central banks would be left with little room for traditional monetary action through open market operations. An understanding of the causes of the zero lower bound and the effectiveness of alternative monetary policies undertaken in response to the zero lower bound remains an important debate among economists and policymakers.

Three economic contractions in history have given way to the zero lower bound: the Great Depression of the 1930s, Japan's 1990s-2000s recession, and the Great Recession of 2007-09. Each of these economic downturns share similarities with regard to the deterioration of balance sheets in the wake of the onset of the crises. Each episode experienced a decline in assets that devalued the net worth of firms and banks, increasing the need for credit while reducing access. A decline in spending and investment, due to both an increase in savings by firms and households and a decrease in credit supply by financial institutions, perpetuated the economic contractions. Central banks responded to the contractions through traditional open market operations, which were ineffective at spurring investment. Nominal short-term rates declined all the way to zero and the economies were stuck in the zero lower bound, limiting the scope for further monetary policy action.

Extending a 2012 study by Pandey and Ramirez, this paper analyzes the effect of balance sheet deterioration and credit restrictions on small and large firms during recessions to explore the disparity in credit access and reduced effectiveness of the federal funds rate to guide interest rates to firms and individuals. Despite low interest rates during the Great Recession, asymmetric

information in the form of adverse selection and moral hazard may have caused small firms to face high costs of credit, thus making them unable to borrow and invest, leading the economy further into a downward spiral.

Alternative monetary policies eventually lifted the United States and other nations out of the worst recession since the Great Depression, mainly through the use of large-scale asset purchases to lower long-term rates and an eventual restoration of confidence by market participants (see Bernanke 2017). However, the recession was still extensive and agonizing. The crux of the problem causing the ineffectiveness of open market operations remains a debated and important topic as the risk of recessions and episodes at the zero lower bound haunt the future of monetary policy.

Literature Review

I. Combinations of Crises

As seen throughout history, financial crises are difficult to avoid, often occurring in combination with other crises. Financial crises frequently spin out from banking and exchange rate crises, which can occur from an individually rational standpoint throughout business cycles, and thus can be hard to avoid. In a bank run, as Anil Kashyap (2014) explains from Diamond and Dybvig's research, a chain reaction may take place from an individually rational perspective if depositors think others will ask for withdrawals, risking their own ability to withdraw their funds and causing them to ask for their deposits back as well. In addition, the requirements of an exchange rate system, depending on what regime a country adopts (fixed or flexible), can magnify the effects of the shock on the economy, thereby creating further tension and leading to a full-blown recession (Gertler, 2007).

Todd Knoop addresses the instances of bank runs, asset bubbles and banking crises, which are difficult to foresee or avoid and often precede financial crises. The belief-based models of banking crises seek to explain how changes in expectations of future financial and macroeconomic conditions cause bank failures and are not necessarily linked to any financial fundamentals. The fundamentals-based models of banking crises hold that changes in net worth, cash flows, and bank profits throughout business cycles cause bank failures (Knoop 2008, p. 165-166).

Martin Gavin and Ricardo Hausmann explain in their article "The Roots of Banking Crises: The Macroeconomic Context" that since banks take on relatively short-term deposit liabilities and hold longer-term loan assets, banks fail due to a failure to deliver funds that depositors demand. The two components that make up a banking crisis are a shock to the real

value of assets and liabilities, viz., the magnitude of net resource transfers that the banking system is required to make, and the threshold level of liabilities over assets above which banks will fail. Macroeconomic shocks can come from many external forces, such as oil crises, declines in terms of trade, poor real estate conditions and other pressures on national income, as well as from monetary shocks. As domestic income falls, it decreases borrowers' capacities and negatively affects bank assets. Lowered bank liquidity can then usher in banking crises through the financial accelerator mechanism, discussed later. If a bank is vulnerable, "relatively small shocks to income, asset quality or liquidity either make the bank insolvent or sufficiently illiquid." The chain of effects also causes households and businesses to reduce their spending and income, thus leading to a renewed drop in assets and net worth, creating a vicious cycle (Gavin 1996, p. 7-12).

Pressure from the interaction between monetary and exchange rate regimes also affect the impact of adverse shocks to a country. As Gavin and Hausmann explain, financially fragile countries may benefit from some degree of exchange rate flexibility to mitigate the effects of an adverse monetary shock and avoid a banking crisis by addressing the nominal values and influencing real exchange rates. Under a fixed exchange rate regime, taxpayers will be required to pay for a recapitalization of the banking system in response to an external shock (Gavin 1996, p. 10). The shock will reduce the domestic money supply and increase domestic interest rates, thus generating a chain reaction of pressures on borrowers fulfilling their debts to banks and banks' abilities to extend credit to borrowers. Under shocks driven by real variables, such as a fall in the terms of trade, a fixed exchange rate causes a decline in the demand for domestic money and the central bank must exchange foreign currency for domestic money, thus further exacerbating the shock (Calvo & Mishkin 2003, p. 7). A flexible exchange rate regime in this

situation is able to respond to an external shock through exchange rate depreciation and an increase in the domestic price level. The depreciation will decrease the real value of banks' assets to levels that are more likely to be paid and lower the real value of the banks' liabilities in order to protect them from insolvency (Gavin 2008, p. 10, 16-17).

Models have additionally tied currency crises to bank runs, modeled by Chang and Velasco "as a self-fulfilling loss of confidence that forces financial intermediaries to liquidate their investments prematurely." Krugman (1999, p. 460) offers a "third generation" model for speculative attacks, which incorporates "the role of companies' balance sheets in determining their ability to invest, and that of capital flows in affecting the real exchange rate." In the creation of a financial crisis, capital outflows or a reduction in capital inflows negatively affects domestic balance sheets. Borrowing capabilities are impaired, further reducing capital inflows. However, some of the domestic balance sheets hold foreign denominated debt, which depends on the real exchange rate and the actual levels of borrowing occurring. Thus, the expected level of investment, which affects the real exchange rate and balance sheets, determines how much credit banks grant domestic firms (Krugman 1999, p. 467). The chain of events spirals into impaired balance sheets of banks and borrowers, decreased confidence in the financial system, and a contraction in a range of economic variables as a recession sets in.

II. Theories of Economic Crises

A number of theories of finance analyze where and how panics originate. Whether through bank runs, exchange rate crises or otherwise, a generalized panic is often the root cause of recessions. Theorists debate how the panic arises and magnifies into a crisis and each theory

offers potential ways in which to respond. Todd Knoop's book, entitled *Modern Financial Macroeconomics,* addresses the evolution of these theories throughout time.

John Maynard Keynes developed his General Theory in the 1930s, which held that a level of uncertainty about future economic conditions could lead to speculative behavior, increasing risk (Knoop 2008, p. 76-77). The theory stipulates that "recessions actually begin during expansions, when animal spirits fuel the speculative behavior that creates lending, investment, and asset booms," which increases leveraged financial conditions. In turn, this makes firms and households more vulnerable to a perceived economic slowdown, thereby reducing confidence. Keynes speaks of these "animal spirits" as "a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities." In a "crisis of confidence," instability by speculation is compounded by instability due to human nature in which "a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation" (Keynes 1936, ch 12). Thus, an overall change to pessimistic views about the future leads to decreased investment and consumption, exacerbated through the multiplier effect, which in turn lowers aggregate income and spending. The ensuing large drop in aggregate demand results in a recession, particularly if it adversely affects the net worth of firms and households. According to the General Theory, a recession can end through a spontaneous increase in confidence, an eventual fall in nominal wage demands and a move back to full employment, or the use of macroeconomic policies to stimulate the economy. However, Keynes largely dismissed monetary policy on the grounds that investment demand was not sensitive to changes in interest rates and acknowledged the challenges of a liquidity trap when increases in the money supply translate into savings rather than spending and investment (Knoop 2008, p. 79).

Post-Keynesian economist Hyman Minsky developed the Financial Instability Hypothesis model, which "asserts that capitalist economies are inherently flawed and unstable because financial systems are inherently unstable." Dividing financial strategies into hedged, speculative and Ponzi finance, ordered from least risky to most, Minsky holds that during good times investors act exuberantly and in bad times they shift to the opposite end of the spectrum in a panic. In this chain of events, excessively optimistic investments peak on the shock of a negative event and business confidence disappears in the panic, leading to declines in credit, investment, profits and output. Lending falls as a result of stricter practices, panicked investors sell assets, and the economy falls into recession. Much like Keynes, Minsky highlights psychology and financial fragility as the key drivers of the business cycle in this model. The post-Keynesian perspective focuses on pressuring governments to discourage risky behavior through stringent financial sector regulation in order to avoid financial bubbles that burst and bring about recessions (Knoop 2008, p. 84-85).

The Monetarist model, developed in part by Milton Friedman, reasserts Classical theory principles with a more inclusive explanation of business cycles. Monetarists believe "fluctuations in aggregate demand have real effects on output and drive business cycles" and the aggregate demand shocks that cause business cycles are created by "the erratic monetary policies followed by misguided central bankers," such as the contraction in the money supply during the early 1930s. Monetarists hold three principles: "prices and wages are perfectly flexible, but perfect information does not exist"; "changes in aggregate demand do not affect real output in the long run, but they do affect real output in the short run"; and, "fluctuations in the money supply drive fluctuations in aggregate demand and are responsible for business cycles." In their theory, there is a direct relationship between the amount of circulated money and the level of nominal

aggregate spending, such that the supply of money multiplied by the velocity of money equals the price level multiplied by the real aggregate expenditure (MV = PY). Thus, changes in the money supply cause business cycles through fluctuations in aggregate demand responses to recessions. Monetarists believe central banks should focus on monetary stabilization rather than economic stabilization in order to avoid policy swings and eliminate business cycles (Knoop 2008, p. 86-89).

Neoclassical economist Robert Lucas, along with Thomas Sargent, developed the Rational Expectations model, which holds that individuals make rational decisions based on the benefits versus the costs of an activity. The decisions are made according to all "currently available information" about the structure and past performance of the economy and future government policies, which is often not perfect information. The model states that "business cycles are temporary deviations from the natural rate of output caused by unanticipated changes in aggregate demand" or "new" information. In terms of policy responses, according to Lucas' theory, monetary and fiscal policies are negative for the economy because changes in government policy destabilize the economy and cause erratic swings in the business cycle. Other Neoclassical theorists also denounce government policies, believing them to reduce incentive to work, invest or innovate and do not believe monetary policy has an impact on real macroeconomic activity in the long run (Knoop 2008, p. 91-95).

New Institutional theories of finance fall within New Keynesian models and represent more recent attempts to explain crises by focusing on market failure and asymmetric information. These models focus on the macroeconomic effects of exogenous shocks on business cycles and the amplification mechanism of market failures, such as price rigidity. New Institutional theories of finance incorporate four aspects of financial systems: "The study of

macroeconomic implications of finance has to begin from the study of microeconomic behaviors of banks, financial markets, firms, and households"; "When examining financial activity, the primary focus should be on the provision of credit and not just on the total amount of liquidity or the money supply"; "The most important reason that financial transactions are imperfectly competitive is that financial information is imperfect"; and, "There is no mechanism to ensure that the supply of credit equals the demand for credit." Work within the New Institutional theories of finance framework has produced important models that examine risk and costs of credit intermediation, financial accelerator mechanisms, and credit rationing, some of which will be incorporated in this paper (Knoop 2008, p. 102-106).

III. The Financial Accelerator Model

Within the New Institutional theories of finance framework, Ben Bernanke, Mark Gertler and Simon Gilchrist (1996) developed a neoclassical model of business cycles that focuses on the effects of balance sheet conditions on output, the so-called financial accelerator. Focusing on borrower net worth, Bernanke et al. assert that due to asymmetric information between borrowers and lenders, financing agreements often impose agency costs that cause higher costs to borrowers. It is found that higher net worth decreases agency costs, while lower net worth, prevalent during economic contractions, increases agency costs and thus the cost of borrowing. Through cheaper access to credit during booms and more costly access to credit during busts, shocks to balance sheets can act as a source of fluctuations.

The financial accelerator aggravates a recession by which an unexpected fall in the money supply, a decline in expectations that reduces consumption or investment, or greater perceived risk causes a fall in aggregate demand. The fall deepens as higher risk increases the

cost of credit intermediation, reducing credit, investment and consumption, then causing a fall in short run aggregate supply as the risk of production increases and capacity declines. Bernanke et al. understand that if the market is caught in a "pessimism trap" and other costs of lending remain high, changes in interest rates through monetary policy may not reduce the costs of credit intermediation and will not stimulate lending (Knoop 2008, p. 108-111).

The financial accelerator mechanism can additionally address issues between the exchange rate regime and monetary policy in the face of a recession. As found in a study by Mark Gertler, Simon Gilchrist and Fabio Natalucci (2007) under a fixed exchange rate regime, a shock causes the country to increase the borrowing premium, leading to a sharp rise in domestic nominal interest rates, and additionally an increase in the real interest rate due to nominal price rigidities, thus creating a contraction in output. Through the financial accelerator, "a rise in real interest rates causes a contraction in asset prices, which raises the leverage ratio and thus the external finance premium," further dampening investment and output. Output, employment and labor productivity are all affected by a magnified amount and the country faces significantly higher welfare losses. The authors suggest a flexible inflation targeting policy "characterized by floating exchange rates and a well-formulated Taylor rule that has the nominal interest rate adjust to stabilize CPI inflation and deviations of output from a steady state." An early advocate of inflation targeting, Bernanke's policy recommendations, and eventual implementation, would thus be more applicable under a flexible exchange rate regime.

IV. The Credit Rationing Model

Other New Institutional theories of finance involve models of credit rationing. Joseph Stiglitz and Andrew Weiss' paper (1981) explains a Credit Rationing Model in which credit

supplies are restricted to certain borrowers due to imperfect information. Stiglitz and Weiss'

model asserts that interest rates can affect the riskiness of loan applicants due to the adverse

selection effect or the incentives affect. Borrowers have varying probabilities of repaying their

loans. Since it is costly and inefficient to measure each individual's probability of repayment,

interest rates can act as a screening device, in which borrowers who are willing to pay a higher

interest rate may carry higher risk. In addition, projects funded by higher interest rate loans,

while lowering the probability of success due to higher riskiness, can increase the payoff when

successful, incentivizing borrowers to acquire the loans.
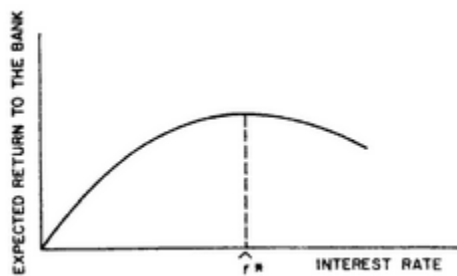
Fig. 1 Interest rate at which banks maximize
      expected return (Stiglitz & Weiss, 1981)
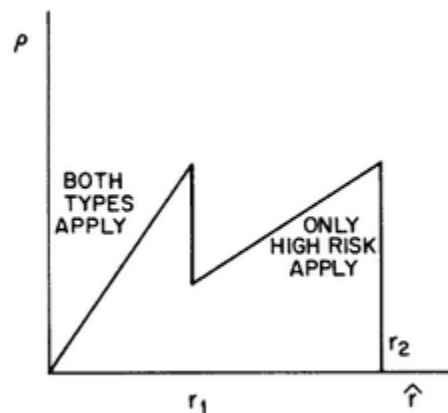
Fig. 2 Optimal interest rate
      (Stiglitz & Weiss, 1981)

Stiglitz and Weiss' model shows that among loan applicants who appear identical, some

receive loans while others do not as lenders create default risk perceptions of individual

borrowers. Specifically in times of financial distress, the most financially fragile borrowers who

need access to credit the most are more likely to have their credit constrained. This, in turn,

initiates the financial accelerator mechanism, lowers access to credit, reduces investment and

consumption, and increases contractions in output (Knoop, p. 125-126).

Stiglitz and Weiss note the direct effects that interest rates have on the quality of loans. The higher the interest rate, the more risk involved with the loan (Figure 2) because a high interest rate will discourage safe investors and draw in more risky investors with projects with lower probabilities of success, potentially decreasing bank profits (Figure 1). Rather than limiting the size of each loan granted or increasing the interest rate as the size of the loan increases, credit is restricted through a limited number of loans granted by the credit-rationing bank (Stiglitz & Weiss, 1981).

V. Zero Lower Bound

For many decades, economists considered the zero lower bound an improbable instance, with Japan's 1990's situation seen as a "special case." Paul Krugman (2000), however, remained an early skeptic of this conventional view and highlighted the risks of a liquidity trap for all countries. His paper focuses on Japan's liquidity trap but extends the applicability of his work to other countries who may face a similar challenge in the future, as a number of countries did during the 2007-2009 financial crisis. In a liquidity trap, when monetary policy lowers nominal interest rates to or near zero, "bonds and money become in effect equivalent assets, so conventional monetary policy, in which money is swapped for bonds via an open-market operation, changes nothing." Referencing the multiplier process, an interest rate of zero causes an excess supply of savings, which through the multiplier process accelerates the depression of the real economy.

Krugman suggests inflation targeting, fiscal stimulus or unconventional open market operations in response to a liquidity trap, depending on the causes of the trap. He outlines the possible causes as structural problems, a specific event or shock that gives way to a self-fulfilling

pessimism spiral, or the burdens of debt barring companies from further investments opportunities (Krugman 2000). Eggertson and Woodford (2003) also published a seminal piece focusing on Japan's zero interest rate situation and warned of the risk to U.S. monetary policy faced with a federal funds rate of one percent at the time.

VI. Modern Monetary Policy Responses

More recently, economists and scholars have questioned the effectiveness of monetary policy. Research by Biovin and Giannoni "find that changes in the federal funds rate have become less correlated with changes in output and inflation over time," however, they attribute this to a greater effectiveness of monetary policy. Economists, such as New Institutional theorists who believe there is no direct link between the money supply and real economic activity, propose that monetary authorities can implement alternative tools to stabilize credit. Additionally, the last global recession challenged economists' beliefs that the zero lower bound was merely a textbook example as countries saw nominal interest rates touch zero and real interest rates become negative, eliminating the central banks' ability to engage in traditional monetary policy (Knoop 2008, p. 149-155).

Knoop reports empirical evidence that shows "the increased use and effectiveness of monetary policy is the most important factor in explaining both duration stabilization and the decline in output volatility." However, "the Federal Reserve's excessive use of expansionary monetary policy has created inflation cycles that have destabilized output" (Knoop 2008, p. 159-160). Eduardo Cavallo and Eduardo Fernandez-Arias (2012) note that financial resolution is more likely to be successful when countries can stimulate the economy through macroeconomic stimulus. However, timing and knowing the cause of the crisis are key points when enacting

policy changes. Additionally, cyclical versus structural differences and causes may pose challenges to policy response.

In the wake of the 2008 recession, further policy complications became apparent. The world saw and economists came to appreciate the reality (and gravity) of the zero lower bound, previously a textbook possibility with a highly unlikely probability of occurring. Alternative policy responses were required as central banks lost access to their traditional tool of targeting their overnight interbank rates when interest rates hit zero. Economists began working on new approaches to monetary policy and economic theories.

Frederic Mishkin (2011), in a paper entitled "Monetary Policy Strategy: Lessons from the Crisis," offers an analysis of new options for monetary policy strategies in the face of changes to the economic environment. He outlines the following "nine basic principles" of economic theory: a focus on inflation as a monetary phenomenon, the importance of price stability, the lack of a tradeoff between unemployment and inflation in the long run, the importance of expectations in the macro-economy, the requirement of the Taylor Rule for price stability, the issue of time-inconsistency, the benefits of central bank independence, the importance of a credible commitment to a nominal anchor to promote price and output stability, and the role of financial frictions in the business cycle. Mishkin, after highlighting certain aspects of pre-crisis monetary policy models, recognizes the changes that the 2007-2009 crisis created for the analysis of monetary policy. Five lessons for monetary policy should be garnered from the crisis: the financial sector and shocks to that system have important implications on economic activity; a linear-quadratic model of economic theory for monetary policy is inapplicable in economic downturns, as adverse shocks can skew uncertainty and may exhibit kurtosis, or tail risk; the zero lower bound is and will be a greater challenge than previously thought, requiring the use of non-

conventional monetary policy tools; the costs of cleaning up a financial crisis are very high; and price and output stability do not ensure financial stability. Mishkin, who worked closely with Bernanke on these issues, concludes that, in the face of these new realities, a new framework is required. He highlights the need for a framework that accounts for tail risk in a nonlinear format and recognizes the prominence of the financial sector and the interaction between monetary policy and financial stability policy.

In a 2010 speech at the Jackson Hole Symposium, Fed Chairman Ben Bernanke discussed the economic outlook and monetary policy options going forward. By this point the economic contraction had ended, with much assistance from "concerted government efforts to restore confidence in the financial system, including aggressive provision of liquidity by central banks" and the help of fiscal stimulus. However, bank credit remained tight and the country continued to face problems involving financial reform, fiscal deficits, and debt and trade imbalances in global trade and current accounts. Bernanke outlined the central concerns of the Fed as maintaining price stability and a long period of high unemployment. Thus far, the Fed had lowered the Federal Funds Rate to a range between zero and 25 basis points, improved market expectations through transparent communication and forward guidance offering more specific outlooks for future monetary policy actions in public statements, and enacted large-scale asset purchases of agency mortgage backed securities and long-term Treasury securities. Bernanke recognized that additional policies for further monetary easing might be in the Fed's future. He called for conducting additional purchases of longer-term securities, modifying the FOMC's communication, reducing the interest paid on reserves, or increasing inflation goals as available tools for additional monetary accommodation.

Additionally, being a firm believer in inflation targeting, Bernanke continuously championed explicit inflation targeting to firmly "anchor" the expectations of the private sector throughout the 1990s and 2000s. In a 1997 article, coauthored with Mishkin, Bernanke argued that an official inflation target would express the central bank's goal of low and stable inflation, as well as improve communication with the public and increase accountability of their actions. In a 2004 panel discussion, Bernanke highlighted that in contrast to the past, when the Fed faced high inflation such as in the 1970s, the country had achieved price stability with low inflation rates. Foreseeing that "at very low inflation rates, the zero lower bound on the policy interest rate is more likely to become relevant," he argued that the FOMC should announce its optimal long-run inflation rate (OLIR), given that the Committee believes the stated rate is optimal for output, employment and price stability in the long run, and the rate is regarded as a long-run objective with no set time frame for achievement. The benefits of a stated OLIR may include clarification of the long-run objective of the Fed and provision of a long-run anchor to monetary policy, improvement to the efficiency of pricing long-term bonds and other assets, reduced inflation risk in financial markets, and broader stability in the long-term inflation expectations, thus making short-run stabilization policy more effective. Bernanke achieved his goal of adopting inflation targeting by the Federal Reserve in 2012 and beyond (Bernanke 2010, p. 165-167).

Economists have studied and debated the efficiency and success of the Fed's actions in response to the recession at the zero lower bound. Prior to the late 2000s financial crisis, work by Krugman (2000) and Eggertson and Woodford (2003) outlined potential responses to the zero lower bound. Krugman suggested three responses: fiscal policy, quantitative easing or unconventional monetary policy, or inflation targeting. Fiscal policy provides potential in two cases when the additional support can help shoulder the burden temporarily—if the trap is

expected to be short-lived and monetary policy can soon function again, or if the fiscal stimulus gives firms extra support to get their balance sheets corrected. If the trap requires a credible commitment to continued monetary expansion in the future despite inability to further lower the interest rate, Krugman suggests unconventional open market operations through purchases of longer-term assets that can have success in lowering the currency and long-term interest rate— the key rate for stimulating investment in plant, machinery and equipment. Thirdly, inflation targeting can provide central bankers with a credible commitment to future monetary expansion.

Eggertson and Woodford (2003) argue against the implementation of unconventional monetary policy and, rather, in favor of the management of expectations of future policy to fight deflation and combat the zero lower bound. Their model finds that "neither the extent to which quantitative easing is employed when the zero lower bound binds, nor the nature of the assets that the central bank may purchase through open-market operations, has any effect on whether a deflationary price-level path will represent a rational-expectations equilibrium." They argue for the importance of choice in what commitments are made under fully credible commitments by policymakers.

In contrast to Eggerston and Woodford's paper, which does not incorporate portfolio-balance effects into their model, a 2003 paper by Clouse *et al.* explores the ability of open market operations to spur aggregate demand at the zero lower bound. Explaining the perfect substitution of Treasury bills and money when interest rates are zero in relation to portfolio balance and wealth effects, the authors state that open market operations cannot affect the sum of private-sector portfolios or the value of financial assets. However, when viewing bonds as imperfect substitutes, changes in the risk premium can affect bond rates through bond purchases.

This "portfolio-balance" effect incorporates risk averse investors and "preferred habitats" (see Clouse 2003, p. 19, 28).

The Federal Open Market Committee employed large-scale asset purchases of agency mortgage backed securities (MBS) and long-term Treasury securities, one of their main unconventional strategies, in an attempt to reduce longer-term yields and spur investment when they could no longer lower short-term rates through the Federal Funds Rate mechanism. Taeyoung Doh (2010) examines the effectiveness of the large-scale asset purchases, basing his argument on this preferred-habitat model, which "assumes that some investors have preferences for bonds of specific maturities." In contrast, the expectations hypothesis "assumes that current and expected yields of short-term bonds determine yields of long-term bonds, while the supply of the bonds do not affect yields... based on the view that when the expected return of one asset is higher than that of another, investors will trade those assets to make a profit." According to this hypothesis, large-scale asset purchases would not be effective in lowering longer-term yields. The hypothesis, however, assumes investors are risk-neutral with a goal of maximizing return and there is no risk premium associated with long-term bonds. Doh argues that in reality "investors are risk averse and demand term premia." Doh concludes that "when arbitrage activities of financial markets are disrupted, and deteriorating macroeconomic conditions warrant lower long-term interest rates, long-term asset purchases by the central bank can be an effective policy tool" (Doh 2010, p. 5-8, 18).

Joseph Gagnon, Matthew Raskin, Julie Remache and Brian Sack (2011) also study the effectiveness of large-scale asset purchases, and find that the policy of the Fed had the desired effects of reductions in term premiums and risk premia on a range of securities. Through the "portfolio-balance" effect, the Fed purchases increase the price of the asset by decreasing its

supply, thus lowering its yield. The purchases additionally helped restore liquidity to markets, narrowing the spreads on agency debt and MBS. Gagnon et al. conclude that large-scale asset purchases by the Federal Reserve "did lower longer term private borrowing rates, which should stimulate the economy" as longer-term rates are important for private investment spending on long-term projects.

A study by C. Reinhart and V. Reinhart in their paper, entitled "After the Fall," (2010) analyzes real GDP, unemployment, inflation, bank credit and real estate prices in the decades before and following a financial recession. All recessions share resemblances with regard to real GDP, unemployment, inflation, bank credit and real estate prices in the decades prior to and following the contraction, with stark differences between the two periods. Their studies find that in the aftermath of a severe economic dislocation, economies face a drop in growth, heightened unemployment and balance sheet effects. Reactions and responses to a contraction in an effort to get the economy back on its feet can itself create the delays and sluggish return to normalcy, as policymakers grapple with the drastic changes in the state of the economy and move forward cautiously. Reinhart and Reinhart suggest that "monetary policy makers need to reconsider the benefits of an inflation buffer to protect from the zero lower bound to nominal interest rates" (Reinhart & Reinhart 2010, p. 38-39).

Despite changes in the economic environment after the recent global recession, the level and growth of real GDP, the unemployment rate, and inflation remain the important variables to policymakers. In the face of a recession, they will look to alleviate the stresses on these factors in order to right the economy. Their decisions will be aimed at the remediation of the economic variables they are charged with maintaining. In the evolving economic environment, what are the most effective responses of policymakers to contractions and alterations in these factors? Were

large-scale asset purchases the more effective response? We may glean policy lessons from the

U.S. and other countries that faced severe economic recessions after 2008 and grappled with

policy tools at the zero lower bound, but it appears there is no certain answer to this new

dilemma.

Historical Cases

Three instances in history have exposed economies to the zero lower bound: The Great Depression, Japan's 1990s-2000s recession, and the Great Recession. Each economic contraction followed a similar path: preceded by a credit or stock market and real estate boom, an asset-price decline and increased uncertainty about the economy caused a decline in net worth that deteriorated firms' balance sheets, which held assets that had lost value. At the same time, banking crises due to increased uncertainty, combined with asymmetric information, adverse selection and moral hazard, restricted the credit supply of financial intermediaries to firms and individuals. Through the financial accelerator mechanism, decreased spending and investment due to greater saving and less access to credit perpetuated and exacerbated the economic contraction. Central banks stepped in with traditional monetary policy tools to lower the interest rate. The monetary stimulus was ineffective at spurring spending and the central banks eventually lowered short-term nominal rates all the way to zero, limiting further actions and leading central banks to engage in unconventional monetary policy, such as QE1-QE3 in the US. These three contractions saw prolonged and drastic downturns in the economy, which not even traditional monetary policy could solve.

I. The Great Depression

The largest economic contraction in United States history occurred during the Great Depression, which gripped the world from 1929 to 1939. Following a previous economic downturn in 1920, the United States economy boomed, with stock prices doubling between 1928 and 1929. To curb the excessive speculation apparent in the bullish market, the central bank imposed contractionary monetary policy by raising interest rates. However, the policymakers got

more than they had hoped when the stock market bubble popped on October 19, 1929 and the nation saw the stock market crash, falling 40% over the following months. By 1932, the market was at only 10% of its peak 1929 value. At this time, the U.S. Federal Reserve System employed open market operations and changes to the discount rate, the rate at which member banks could borrow to meet reserve requirements, to affect the money supply. In response to the 1929 crash, the Federal Reserve conducted open market purchases of U.S. securities and lowered the discount rate from 6 percent to 4.5 percent (see Friedman & Schwartz, 1963).

The collapse caused widespread panic and uncertainty. Despite a brief recovery following the crash, a series of defaults on the heels of the stock market crash, as well as a troubled agricultural sector, spelt trouble for banks. Depositor withdrawals soon gave way to a run on banks and a subsequent banking panic. Between 1929 and 1933, more than one-third of the nation's commercial banks had failed before President Roosevelt called a national bank holiday in March. Individuals and firms faced mounting debt troubles as deflationary pressures increased the real value of their debt, causing defaults and bankruptcies to skyrocket. Aggregate output plummeted as investment and spending declined (Mishkin, 2016).

Prior to the banking holiday, the Federal Reserve System was hesitant to respond to the panics. The New York Federal Reserve Bank purchased securities and lowered the discount rate to 2 percent. However, other member banks tended to lean in a more contractionary direction. Some economists and policymakers attributed the Fed's failures to poor management and banking practices. The hesitancy of the Fed could also be understood in relation to the requirements of the gold standard, under which the Fed had to hold adequate U.S. gold reserves. Gold outflows required that the Fed increase the discount rate and sell or reduce purchases of U.S. securities, engaging in contractionary policy—a procyclical policy. Even the New York

Fed, the member bank most actively calling for expansionary monetary policy to respond to the

crisis, raised the discount rate to 3.5 percent after Britain left the gold standard in 1931. Finally,

due to growing pressure to act from members of Congress, the Fed purchased over $1 billion in

U.S. government securities between February and June of 1932. They then reverted to their

passive management when immediate improvement did not result (Bernanke, 1983; Friedman &

Schwartz, 1963).

The financial crisis reduced the number of financial intermediaries and increased fears of

moral hazard and risky borrowers. Despite low nominal short-term interest rates, financial

intermediaries charged firms much higher rates due to risk of credit losses from defaults. The

credit spread, the difference between corporate bonds and risk-free Treasury bonds, increased to

almost 8%. In addition, price levels declined 25%, weighing on the balance sheets of debt

holders and resulting in massive declines in the net worth of firms and individuals. More costly

credit supplies and less creditworthy balance sheets led borrowers to face trouble accessing

credit, further declining investment and spending and perpetuating the economic downturn.

Between 1929 and 1933, commercial loans fell by half and investment spending plummeted

90%. The stock of money fell by over one-third (see Mishkin, 2016, p. 272-274; and Friedman &

Schwartz, 1963, p. 299).

Changes away from ineffective monetary and banking policy did not arrive until the New

Deal period. In 1933, the government passed legislation to reopen and strengthen banks closed

by the banking holiday, alter the commercial banking and financial system, and redesign the

structure and powers of the Federal Reserve System. Once the country was off the gold standard,

the stock of money in the U.S. grew between 1934 and 1936 due to the devaluation of the dollar

and a flow of gold into the country from Europe. Between 1933 and 1937, the Fed cut the

discount rate from 3.5 percent to 1 percent, while rates in real terms were negative. The Fed's

balance sheet held $2.5 billion in securities through open market operations. The recovery,

however, was cut short by the financial crisis that hit the country from 1937 to 1939 due to the

mistaken decision to tighten monetary policy and reduce the fiscal deficit in 1937-38 based on

perceived fears of inflationary pressures (see Bernanke, 1989; and Fishback, 2010).

Due to definitional academic disputes, there has been a debate ever since over whether

the United States was stuck in a liquidity trap during the Great Depression; namely, a situation

that arises when nominal interest rates are close to zero and people prefer to hold cash instead of

bonds, thus eliminating the control the central bank has over the interest rate. When explaining a

liquidity trap in his 1936 *General Theory of Employment, Interest and Money,* Keynes states, "I

know of no example of it hitherto" (Keynes, 1936, p. 207). Krugman, however, holds that "at the

end of the 1930s interest rates were hard up against the zero constraint" (Krugman 1998, p. 1).

Effectively, from 1934 to 1939 short-term nominal interest rates were zero. Rather than active

action by the central bank and engagement in alternative monetary policies, the tides of the

economy changed with the massive fiscal stimulus resulting from the onset of World War II.

II. Japan

In a similar series of events as those witnessed during the Great Depression, Japan's

economy saw spectacular growth through the 1980s, largely achieved through new technologies

and financial innovations. Between the 1950s and the mid-1970s, real GDP growth averaged

around 10% per year. Growth levels then stabilized through 1990 around 4% annually. By the

1990s, however, the world's second largest economy saw growth rates slow, averaging just 1%

growth between 1992 and 1999. Japan's economy faced lengthy stagnation, with deflation and low growth (Yoshikawa, 2002, p. 8-9).

In 1985, Japanese policymakers met with policymakers from four other developed nations to discuss currencies and exchange rates. In the agreement reached, known as the Plaza Accord, Japan and Germany agreed to appreciate their currencies against the U.S. dollar in order to appease the United States in the midst of a trade dispute over its growing and relatively large current account deficit. The fateful decision led to a decline in Japan's economy, with GDP falling to 1.9% in 1986. In response to the decline in economic conditions, the Bank of Japan lowered the official discount rate to 2.5%. Expansionary fiscal policy turned around the decline and Japan saw real GDP growth of 6.1% in 1987. The asset price bubble, causing land and stock prices to soar, was pricked by the BOJ in 1989 after a shift in governorship to Yasushi Mieno, who was pressured to lower land prices. With a rate hike of the official discount rate from 2.5% in May 1989 to 6% in August 1990 and a 3% consumption tax imposed in April 1989, the asset bubble burst by 1990. The country faced a deterioration of firms and individuals' balance sheets, thus leading to massive deleveraging of the private sector (Wakatabe 2015, p. 23-25).

The Bank of Japan responded to the burst of the asset bubble and subsequent crisis by lowering the policy interest rate from 6 percent in 1990 to 0.25 percent in 1998, effectively reaching the zero lower bound. Japan faced a severe financial crisis in the mid-1990s as excess debt and deteriorated balance sheets led to a series of failures of major financial institutions. Financial intermediation was squeezed and the country faced a credit crunch, as well as deflation. By the worst period of the contraction, the central bank had depleted its traditional monetary policy toolkit. During this time, the Bank of Japan acted as a lender of last resort and supplied liquidity by injecting capital into banks in 1998 and 1999 to calm the financial market.

The Bank of Japan had the unprecedented challenge of employing unconventional policies in an attempt to right the economy, which the U.S. Federal Reserve would also conduct in 2008-2009 under QE1 (see Ito & Mishkin, 2006; Nasako, 2016).

In the face of a liquidity trap, the Bank of Japan implemented a zero interest rate policy (ZIRP) in 1999, in which they lowered the overnight call rate "as low as possible" to virtually zero percent. In 2001, the central bank engaged in quantitative easing (QE), in which they targeted the current account balances of financial institutions, rather than the short-term interest rate. The policy focused on stabilizing the financial market by providing adequate liquidity and avoiding a deflationary spiral. QE aided the financial system in a time of severe stress; however, it proved more difficult to reverse the deflationary pressures (Nasako, 2016).

The Bank of Japan employed further unconventional policies between 2010 and 2016, including quantitative and qualitative easing policies (QQE) in 2013, in an attempt to achieve the 2 percent inflation target. QQE included a steadfast commitment by the Bank to achieve the inflation target, as well as an unprecedented scale of asset purchases in an attempt to lower nominal interest rates along the entire yield curve. The Fed adopted similar policies in September 2011 when it bought $400 billion of Treasuries with a maturity between six and thirty years in attempt to "flatten" the yield curve. The Bank of Japan hoped to lower real interest rates and stimulate private investment and spending. In 2016, the Bank even adopted negative interest rates to put further downward pressure on yields (Nasako, 2016).

Japan's use of quantitative easing appeared to have relieved pressures and improved conditions in the real economy. The trend in inflation was slow to respond to these actions, but eventually improved, with the economy sustaining inflation by 2013. Although Japan's economy continues to face low inflation and slow growth, the responses of the central bank to the zero

lower bound were useful lessons as the world economy faced a similar situation in the late 2000s global recession.

III. The Great Recession

The United States faced the worst economic contraction since the Great Depression during the global economic crisis of 2007 to 2009. As was the case in the prior two instances, the Great Recession saw rapid growth in the run up to the collapse. Financial innovation in mortgage markets increased access to credit and an asset price bubble formed with rising residential and non-residential property prices. The growth of the subprime mortgage market along with low interest rates on residential mortgages inflated the housing market, as well as the commercial real estate market, and brought in many risky investors without accounting for the level of risk going into the mortgage market. Home prices first plateaued in 2005 and began declining in 2006, falling by over 30% by 2009. The decline in home prices caused defaults on mortgages to skyrocket. The defaults devalued mortgage-backed securities and collateralized debt obligations, which had been rated "AAA" by the rating agencies, and deteriorated the balance sheets of financial institutions. The situation took a turn for the worse when BNP Paribas, France's largest bank, barred investors from withdrawing their money from its subprime mortgage funds—investors now came to the general realization that these supposedly highly rated subprime mortgage assets were in serious trouble. In turn, a run on the shadow banking system ensued, further declining the value of these financial assets. The run on these institutions, which comprised an unregulated and uninsured banking system including investment banks, hedge funds, and other non-bank financial institutions like money market funds, and which at one point held $9.3 trillion in assets, set off the crisis. Lending to the wholesale funding market, which

financed many of the structured securities through commercial paper and repurchase agreements, drastically declined. Lenders withdrew their investments or required financial institutions to provide greater collateral to compensate for the quality of their balance sheets, causing the institutions to liquidate assets at fire sale prices, further worsening the conditions of their balance sheets (Bernanke, 2017, p. 401-405; Mishkin, 2016, p. 278-9).

The pressure generated by the financial crisis impaired some large firms to such an extent that they were forced to consolidate or file for bankruptcy, causing further panic to ensue in the financial markets. The third, fourth and fifth largest investment banks, Merrill Lynch, Lehman Brothers and Bear Stearns, as well as insurance giant AIG, faced massive losses due to the plunge in the subprime market. By the second half of 2008, Bear Stearns sold itself to J. P. Morgan for one-tenth of their year-to-date worth, Lehman Brothers filed for the largest bankruptcy in U.S. history, Merrill Lynch sold itself to Bank of America for less than half of its worth from the year before, and AIG faced a severe liquidity crisis due to a credit rating downgrade and losses stemming from its credit default swaps (see Bernanke, 2017; Financial Crisis Inquiry Report, 2011; Mishkin, 2016, p. 280-281).

The Federal Reserve faced no easy options in dealing with the problems of these and other large and interconnected firms. In an attempt to contain panic and protect other large investment banks from runs that could follow a bankruptcy filing of Bear Stearns, the Federal Reserve invoked Section 13(3) of the Federal Reserve Act (established during the Great Depression, which extended the Reserve Banks' lending capabilities to any creditworthy person or entity) to allow the New York Fed to lend to JPMorgan in order to extend credit to Bear Stearns. The Federal Reserve again invoked Section 13(3) to lend to Fannie Mae and Freddie

Mac, government-sponsored entities highly involved in the mortgage market (Bernanke, 2017, p. 215-235).

When the Fed faced the Lehman Brothers' crisis, public backlash against government bailouts of Wall Street was widespread. The bailouts did pose controversial uses of taxpayer money as well as risks of moral hazard if all firms determined the Fed and Treasury would offer bailouts despite excessively risky behavior. However, the Fed was strongly aware of the consequences of a Lehman bankruptcy. Despite desperately searching for a buyer for Lehman, when Bank of America and subsequently Barclays backed out, given the company's greater losses and more extensive undervaluation of assets than previously believed, the Fed knew bankruptcy was inevitable. They prepared for the short-term lending market freeze, hoarding of cash, and general panic from the announcement of Lehman's bankruptcy by increasing funding available from the Fed. During the same weekend, the Fed also had to deal with the problems involving AIG's subsidiary, AIG Financial Products, which had developed a large stake in the derivatives market. Despite the large losses AIG suffered due to their risky investments, the Fed saw no alternative than to bailout the company. The Fed extended $85 billion in credit to AIG. These failures, takeovers and bailouts prompted the worst financial conditions since the Great Depression, demonstrated by volatile and illiquid markets that would require unprecedented monetary action (for further details, see Bernanke, 2017, p. 249-291; Financial Crisis Inquiry Report, 2011; Mishkin, 2016, p. 280-281).

In response to the crisis, the Federal Reserve began by employing traditional monetary policy, conducting open market operations, operating discount lending facilities, acting as a lender of last resort, and changing reserve requirements and interest on reserves. Through open market purchases, the Fed first reduced the federal funds rate in September 2007 in response to

the mortgage market meltdown. Between September 2007 and December 2008, the Fed cut rates from 4.75% to between 0 and 0.25%—effectively reaching the zero lower bound. From a historical perspective, the actions of the Federal Open Market Committee were rapid and proactive (Bernanke, 2009). When open market purchases were unsuccessful at lifting the economy out of the recession and the central bank found itself constrained by the zero lower bound, the Fed had to employ additional measures. In addition to lowering interest rates with the objective of encouraging borrowing and investment, the Fed also aided credit markets by improving liquidity conditions. As a lender of last resort, the Fed is tasked with preventing bank failures by ensuring banks and financial institutions have sufficient liquidity and access to short-term credit. In August 2007, the Fed lowered the spread between the discount rate and the federal funds rate from 100 basis points to 25 basis points and increased discount window loan terms to 90 days (Bernanke, 2009; Mishkin, 2016, p. 351-352).

The central bank also had to employ a series of unconventional policies. The Fed created new credit auctioning facilities and allowed primary securities dealers and banks to borrow from the Fed's discount window. Banks, however, are reluctant to do this because of the stigma associated with borrowing from the Fed, so the Fed made an effort to keep lending auctions anonymous. The Term Auction Facility was created in 2007 to increase borrowing from the Fed. The Term Securities Lending Facility was established in 2008 to allow primary dealers to borrow Treasury securities against less liquid collateral. The Fed also implemented a number of other lending facilities as well as swap facilities to provide liquidity to different financial intermediaries, including dollar swaps with the Bank of England, Bank of Japan and European Central Bank to contain the crisis and protect the economy from contagion stemming from a more disastrous outcome in foreign economies. Liquidity provision from the central bank

ensures financial intermediaries will not have to sell assets at fire sale prices. Liquidity was also provided directly to borrowers and investors to improve the functioning of key credit markets (Bernanke, 2009; Mishkin, 2016, p. 357).

The economy appeared to hit a major turning point with the implementation of bank stress tests in 2009. Despite striving for anonymity in lending programs, the tests that were designed to calculate banks' losses in certain stress scenarios publicly revealed weak banks. If banks measured significant capital gaps in their results, they were required to raise the capital needed to buffer the losses. If they were unable to do so privately, the Treasury would step in to provide capital through the Capital Assistance Program. Investors gained confidence from the stress tests as they received credible information about the conditions of financial intermediaries as well as a guarantee from the Treasury that it would be ready to extend capital to those in need (Bernanke, 2017, p. 392; Gorton, 2015, p. 977, 988).

The Fed also expanded their open market operations beyond short-term government securities with their large-scale asset purchases. In 2008, the Fed purchased $1.25 trillion in mortgage-backed securities. In 2010, the Fed purchased $600 billion in long-term Treasury securities in an attempt to lower longer-term interest rates in a program called QE2 (Quantitative Easing 2). In 2012, the Fed announced QE3, in which they would purchase $40 billion in mortgage-backed securities and $45 billion in long-term Treasuries. The large-scale asset program quadrupled the size of the Fed's balance sheet. The non-traditional efforts, coupled with forward guidance and a commitment to future policy actions, appear to have lowered longer-term interest rates and stimulated investment and spending to impel the economy forward (Bernanke, 2017; Mishkin, 2016, p. 357-8).

IV. Credit Access

In addition to a similar series of events and the presence of the zero lower bound in the three economic contractions discussed, the three historical episodes also faced challenges to credit access. In the run-up to each crisis, private debt levels increased both absolutely and relatively, especially in the U.S. in the 1920's and in Japan during the 1980's. However, in the wake of collapses in asset prices, the deflationary pressures decreased the real values of debt for individuals and firms with debt contracts written in nominal terms. As decreased net worth and deteriorated balance sheets set off defaults and bankruptcies, it became harder and more expensive for firms to access credit. The challenges faced by firms in terms of access to credit varied between small and large firms in each historical episode. For example, between 1930 and 1933, according to Bernanke (1983), after-tax corporate retained earnings were negative. However, corporations with assets over fifty million dollars reported positive profits. Corporations with assets less than $50,000 and between $50,000 and $100,000 faced losses of 33% and 14%, respectively, in 1932. Smaller firms faced much higher rates of bankruptcies than larger firms.

The aftermath of Japan's asset bubble collapse exposed the country's problem with on-performing loans. The bubble allowed for massive debts to emerge and, as seen during the Great Depression, deflation during the crisis increased the real value of these debts and weighed on the balance sheets of individuals and firms. By the time of the banking crisis in 1997, the country faced a credit crunch, in which banks restricted access to loans. Yoshikawa and Stewart (2001, p. 50) report that small and medium firms, especially, expressed strong discontent over financial institutions' cautionary lending standards.

The U.S. also faced struggles involving high debt levels and access to credit during the Great Recession as the massive and rapid deleveraging reduced the supply of credit from banks. Wider credit spreads and tighter lending standards increased the cost of credit to firms and households, who also experienced balance sheet deterioration in the wake of the crash in housing and stock prices. The condition of the economy worsened as investment and spending declined. According to the Financial Crisis Inquiry Report (2011, p. 395), despite the 2008 establishment of the Commercial Paper Funding Facility, which aimed to support the credit market to non-financial firms, "nearly 70% of banks tightened credit standards and lending in the fourth quarter of 2008." Most of this shortage was placed on small firms, which employ almost 40% of the country. Economists recognized the unequal burden small firms faced in accessing affordable loans during the recession, despite firms' creditworthiness (for further details, see Bernanke, 2017, p. 401-405; and Mishkin, 2016, p. 278-9).

Each of the three crises discussed faced restricted credit access that affected smaller firms more adversely than large firms. Despite driving short-term interest rates to zero, investment and spending were unable to increase because financial intermediaries were charging smaller firms much higher costs to access credit. Thus, the economic contractions were prolonged and painful, leaving traditional monetary policy ineffective and forcing policymakers to take unconventional and unprecedented actions.

Data, Methodology & Results

I. Data

In order to examine why low to zero interest rates do not sufficiently stimulate economic activity to lift the economy out of a contraction, this paper will test whether smaller firms face higher costs of credit than larger firms, particularly during a severe recession. From the results, the paper hypothesizes that despite zero interest rates imposed by the Federal Reserve and other central banks, smaller firms faced a higher cost of credit during the 2007-2009 recession, reducing the level of accessible loans and further squeezing investment and spending to worsen the economic downturn.

By extending and revising a model originally run by Pandey and Ramirez (2012), which follows the lead of Walker (2010), the model will incorporate variables that represent the cost of credit intermediation for both small and large firms. The data is measured in monthly and quarterly terms. The monthly and quarterly prime rate (PRIMONTH and PRIQ), obtained from the Federal Reserve, are used to measure the cost of credit for large firms. The actual monthly interest rate paid by small businesses on short-term loans (INTRM), released by the National Federation of Independent Businesses, is used to measure the monthly cost of credit to small firms. The quarterly interest rate on credit cards (CREDCARDQ), also obtained from the Federal Reserve, is used to measure the cost of credit to small firms on a quarterly basis. The variables used to explain changes in the monthly data, based on price and quantity, include FFM (the monthly Federal Funds Rate, released by the Federal Reserve), INDEXM (the monthly Business Borrowing Index, measured as the business manufacturing index plus the retail sales index, released by the Federal Reserve), and QBORSM (the monthly percentage of firms borrowing at least once every quarter, from the NFIB). For the quarterly data, the explanatory variables

include FFQ (the quarterly Federal Funds Rate, released by the Federal Reserve), INDEXQ (the quarterly Business Borrowing Index, released by the Federal Reserve), and QCARDQ (total credit card borrowing, measured as the quantity of revolving credit plus the quantity of non-revolving credit, released in the Federal Reserve's G19). The model is estimated with data from January 1998 to December 2015, thus extending the time period of Pandey and Ramirez's paper to include years that were still affected by the Great Recession.

II. Methodology

The monthly and quarterly variables are tested for non-stationarity. If the variables are non-stationary, running the model using ordinary least squares will produce a spurious regression in which the results appear to show a significant relationship when in fact there is none. The Augmented-Dickey Fuller (1981) test is used to test for the presence unit roots, or non-stationarity. Following the Doldado et al. (1990) procedure, the variables are tested from least restrictive to most restrictive:

1. A random walk with drift around a trend, which includes a constant and trend:
    $$\Delta Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + \varepsilon_t$$
2. A random walk with drift, which includes a constant:
    $$\Delta Y_t = \beta_1 + \beta_2 Y_{t-1} + \varepsilon_t$$
3. A random walk:
    $$\Delta Y_t = \beta_1 Y_{t-1} + \varepsilon_t$$

Each equation is run until the null hypothesis of non-stationarity can be rejected, first in level form and then for first differences. If the null hypothesis of non-stationarity cannot be rejected in level form for each of the equations following the Doldado procedure, the variable is said to follow a random walk. When the variable can be made stationary by taking the first difference, it is said to be integrated of order one, or I(1), whereas stationary series are integrated of order zero, I(0).

If the variables are found to be non-stationary and integrated of the same order, the quarterly and monthly time series must be tested for cointegration in order to avoid spurious regressions. If the variables are non-stationary, but the difference of their residual series is stationary, they are said to be cointegrated. Tests for cointegration will be used to determine whether a vector error correction (VEC) model or vector autoregression (VAR) model should be used. Diverging from the original methodology of Pandey and Ramirez, this study tested for the presence of cointegration using the Johansen (1988; 1990) methodology and following the Pantula (1989) principle. The latter entails the use of standard models 2, 3 and 4, from most restrictive to least restrictive, and determines from the trace and the Max-Eigen statistics when the null hypothesis of no cointegration cannot be first rejected. If the monthly or quarterly time series are found to be cointegrated, a vector error correction model is used to measure the short-run and long-run behavior of the variables. If the series are not cointegrated, the vector autoregression (VAR) model can be used.

After testing the variables for non-stationarity and cointegration, the models are run with all of the variables treated as endogenous variables, then using the Granger Causality/Block Exogeneity tests it is determined which variables are endogenous and which ones are exogenous (see Sims, 1980). Depending on the results of the cointegration tests, a VAR or VEC model will be used to analyze the relationship between the endogenous and exogenous variables for the monthly and quarterly data. If the variables are I(1) and their residual series is I(1), a VAR model can be used. A VAR model is a system in which each variable is a function of its own lags and the lags of the other variables in the model. The variables are taken as their first differences ($\Delta Y_t = Y_t - Y_{t-1} = \varepsilon_t$).

When the variables are I(1) but the residual series is I(0), a VEC model, a restricted version of the VAR model, is used to allow for the underlying relationship among the variables in the long run as well as the changes in these variables in the short run. The variables are again taken as their first differences, and an Error Correction term is included.

As a VAR model, the estimated equation for the monthly data (if PRIMONTH and INTRM are determined to be the endogenous variables as in Ramirez and Pandey's model) is given by:

$$\Delta PRIMONTH_t = \beta_0 + \beta_1 PRIMONTH_{t-k} + \beta_2 INTRM_{t-k} + \beta_3 X_{t-k} + \varepsilon_t$$

$$\Delta INTRM_t = \alpha_0 + \alpha_1 INTRM_{t-k} + \alpha_2 PRIMONTH_{t-k} + \alpha_3 X_{t-k} + \varepsilon_t$$

where X is an exogenous variable, taken in their level or difference form depending on the results of their unit root tests.

As a VEC model, the estimated equation would include an Error Correction term:

$$\Delta PRIMONTH_t = \beta_0 + \beta_1 PRIMONTH_{t-k} + \beta_2 INTRM_{t-k} + \beta_3 X_{t-1} + \beta_4 EC_{t-k} + \varepsilon_t$$

$$\Delta INTRM_t = \alpha_0 + \alpha_1 INTRM_{t-k} + \alpha_2 PRIMONTH_{t-1} + \alpha_3 X_{t-k} + \alpha_4 EC_{t-k} + \varepsilon_t$$

where $EC_{t-k} = PRIMONTH_{t-k} + \mu_0 + \mu_1 INTRM_{t-k}$

A dummy variable for the 2007-2009 recession is also included in order analyze the effects of the Great Recession on the cost of credit. The dummy variable R has a value of 1 during the most serious months of the Great Recession, from September 2008 during the bankruptcy of Lehman Brothers to June 2009. The selection of the optimal time period for this variable was determined, in part, via the use of the Gregory-Hansen cointegration test with structural breaks (see below). R is incorporated into the model as both an intercept and interactive variable. The results from the inclusion of R can be compared to the results when a dummy variable, R1, is included to account for the far less severe 2001 recession.

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III. Results

a. Unit Root Tests

Using the Augmented-Dickey Fuller test and following the Doldado et al. procedure, the variables were tested for the presence of unit roots, first in level form, to determine whether the series were stationarity. The ADF values for the monthly and quarterly data are given below in Tables 1 and 2.

Table 1 Unit root test results for monthly data

	$\Delta Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + \varepsilon_t$	$\Delta Y_t = \beta_1 + \beta_2 Y_{t-1} + \varepsilon_t$	$\Delta Y_t = \beta_1 Y_{t-1} + \varepsilon_t$	**First difference**
5% critical value	-3.431	-2.874	-1.942	-3.431
PRIMONTH	-1.984	-1.688	-1.382	-6.022
INTRM	-2.718	-1.818	-1.131	-21.210
INDEXM	-2.264	-1.970	0.899	-5.390
FFM	-1.964	-1.631	-1.725	-6.170
QBORSM	-5.538*	-2.757	-0.557	-13.027

Table 2 Unit root test results for quarterly data

	$\Delta Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + \varepsilon_t$	$\Delta Y_t = \beta_1 + \beta_2 Y_{t-1} + \varepsilon_t$	$\Delta Y_t = \beta_1 Y_{t-1} + \varepsilon_t$	**First difference**
5% critical value	-3.475	-2.904	-1.946	-3.475
PRIQ	-2.831	-2.113	-1.387	-3.798
CREDCARDQ	-1.720	-1.751	-1.384	-6.640
INDEXQ	-2.954	-2.434	0.556	-3.721
FFQ	-3.622*	-1.982	-1.907	-4.395
QCARDQ	-1.121	0.599	3.668	-4.766

*Given the contradictory results, the presence of a unit root in level form is assumed and QBORSM and FFQ can be taken in differenced form

Under the null hypothesis of non-stationarity, at the five percent level of significance each variable is non-stationarity in level form, thus they follow a random walk, but stationary when taken as first differences. Thus, when incorporated into the model, the variables will be considered in their differenced form.

b. Tests for Cointegration

i. Monthly Data

INTRM, PRIMONTH, FFM, INDEXM and QBORSM are non-stationary, so tests for cointegration are used to determine whether their residual series is stationary, I(0), or non-stationary, I(1). The Johansen test following the Pantula principle is used to determine the existence of cointegration. The null hypothesis is that the series are not cointegrated. The results for the monthly data are given below in Table 3.

Table 3 Johansen cointegration test results for monthly data

R	Trace statistics			Max-Eigen statistics		
	Model 2	Model 3	Model 4	Model 2	Model 3	Model 4
None	**84.422** **(76.973)**	**79.882** **(69.819)**	**108.796** **(88.804)**	**49.057** **(34.806)**	**48.999** **(33.877)**	**52.064** **(38.331)**
At most 1	35.365 (54.079)	39.883 (47.856)	56.732 (63.876)	15.109 (28.588)	15.082 (27.584)	28.021 (32.118)
At most 2	20.256 (35.193)	15.801 (29.797)	28.711 (42.915)	10.367 (22.299)	9.797 (21.162)	15.012 (25.823)
At most 3	9.889 (20.262)	6.003 (15.495)	13.699 (25.872)	7.770 (15.892)	4.152 (14.265)	9.553 (19.387)
At most 4	2.118 (9.165)	1.851 (3.741)	4.146 (12.517)	2.118 (9.165)	1.851 (3.845)	4.146 (12.517)

R = number of cointegrating vectors
( ) 0.05 Critical Value

The results show that in Model 2, 3 and 4 the null hypothesis of no cointegration can be rejected for one cointegrating vector. Thus, the monthly series is cointegrated and an error correction model must be used to obtain unbiased results. The best model to use can be determined by looking at the Schwarz Criterion and Akaike Information Criterion given in the VECM output.

ii. Quarterly Data

PRIQ, CREDCARDQ, FFQ, INDEXQ and QCARDQ are non-stationarity, so tests for cointegration are used to determine whether their residual series is stationary or not. Again, the Johansen test and the Pantula principle are used to determine cointegration. The null hypothesis is that the series are not cointegrated. The results for the quarterly data are given below in Table 4.

Table 4 Johansen cointegration test results for quarterly data

R	Trace statistics			Max-Eigen statistics		
	Model 2	Model 3	Model 4	Model 2	Model 3	Model 4
None	**101.145** **(76.973)**	**92.578** **(69.819)**	**121.995** **(88.804)**	**40.923** **(34.806)**	**40.703** **(33.877)**	**69.120** **(38.331)**
At most 1	60.221 (54.079)	**51.876** **(47.856)**	52.875 (63.876)	25.158 (28.588)	25.101 (27.584)	25.223 (32.118)
At most 2	35.063 (35.193)	26.774 (29.797)	27.652 (42.915)	19.314 (22.299)	18.674 (21.132)	18.977 (25.823)
At most 3	15.749 (20.262)	8.100 (15.495)	8.674 (25.872)	10.270 (15.892)	6.118 (14.265)	6.152 (19.387)
At most 4	5.479 (9.165)	1.982 (3.841)	2.522 (12.518)	5.479 (9.165)	1.982 (3.841)	2.522 (12.518)

R = number of cointegrating vectors
( ) 0.05 Critical Value

Again, the results show that in Model 2, 3 and 4 the null hypothesis of no cointegration can be rejected for one cointegrating vector. The null hypothesis for Model 3 can also be rejected for two cointegrating levels according to the Trace statistic but not the Max-Eigen statistic. It can be concluded that there is cointegration within the quarterly series and an error correction model must be used to obtain unbiased results. The model to use can be determined by looking at the Schwarz Criterion and the Akaike Information Criterion given in the VECM output. The results are an improvement over the model run by Pandey and Ramirez (2012) because cointegration in the quarterly data was found to be present in the extended time frame, whereas in the earlier

model it was not. Thus, the quarterly data can be analyzed in a VEC model, rather than the previously used VAR model.

iii. Gregory-Hansen Tests

As a significant extension to the papers by Pandey and Ramirez and Walker, this study also tested the data for cointegration allowing for endogenously determined structural breaks in the sample period in level (intercept) shifts or regime (intercept and slope) shifts. The Johansen tests do not allow for structural breaks in the sample and thus have the potential to reduce the power of these cointegration tests and lead to a higher likelihood of failure to reject the null of no cointegration. The Gregory-Hansen (1996) offers a more powerful test in order to avoid committing a Type II error.

Gregory-Hansen cointegration tests were performed, treating all variables as endogenous, with a level shift and a regime shift for the quarterly and monthly data, thus offering a significant improvement over the results considered only under the Johansen tests. Under the null hypothesis of no cointegration in the presence of an endogenously determined structural break, the results, shown in Table 5 below, confirm the presence of cointegration for both the monthly and quarterly data. The break date is found by estimating the cointegrating relationships for all possible break dates in the sample period. The Rats 9.0 program uses an algorithm that selects the break date where the modified ADF*= inf ADF test statistic is at its minimum. The number of lags, determined endogenously by the Schwarz Criterion, was 0 for all tests except the test for the monthly data with a level shift, which was tested with 1 lag.

Table 5 Gregory-Hansen Cointegration Test Results

	Minimum t-statistic	1% Critical Value	5% Critical Value	Break Date
Monthly, Level break	-8.807	-6.050	-5.560	2008-06
Monthly, Full break	-9.179	-6.920	-6.410	2008-08
Quarterly, Level break	-5.920	-6.020	-5.560	2009-01
Quarterly, Full break	-8.259	-6.920	-6.410	2009-01

For the monthly data, the results reject the null hypothesis of no cointegration (in the presence of a structural break) in both the intercept and full break cases. The break date for the level break (intercept shift) is June 2008, while the break date for the full break (intercept and slope of cointegrating vector) is August 2008.

For the quarterly data, the results reject the null hypothesis of no cointegration (in the presence of a structural break) at the 5 percent level with an intercept break and at the 1 percent level in the case of the regime (full) break. The break date changes to the first quarter of 2009 for both tests.

c. VEC Monthly Model

Given the presence of cointegration in the monthly data, even in the presence of structural breaks, a vector error correction model can be used to estimate the equation, which estimates the short-run and long-run relationships among the variables. The VECM is run initially treating all variables as endogenous and allowing the data to determine which variables are endogenous and which ones are exogenous (see Sims, 1980).

An unrestricted VEC model is estimated including PRIMONTH, INTRM, INDEXM, FFM and QBORSM as endogenous variables (data for the error correction terms can be found in

Appendix A). The model is estimated using Model 2 with 1 lag, based on the Akaike Information

Criterion and the Schwarz Criterion, which are lowest for this model. From the results, it can be

determined (based on insignificant t-ratios for the error correction terms, available upon request)

that PRIMONTH, INDEXM and QBORSM are exogenous. These results can be confirmed by

imposing zero restrictions on the error correction coefficients for the assumed exogenous

variables. The null hypothesis is that the variables can be set to zero (meaning exogenous), thus

to reject the null hypothesis implies that the variables are endogenous. In the model with zero

restrictions on PRIMONTH, INDEXM and QBORSM, the null hypothesis cannot be rejected

and it can be concluded that the variables are exogenous.

As further evidence determining which variables are exogenous, the graphs included

below in Figure 3 offer a visual depiction of the reaction of the dynamic system to an external

change. Given that the often-used Cholesky decomposition is arbitrary and sensitive to the

ordering of the variables, this study uses instead the generalized decomposition first proposed by

Pesaran and Shin (1998)—one in which the orthogonal set of innovations does not depend on the

VECM ordering. The general impulse response functions show how the five variables in

question react to both a one standard deviation (SD) innovation (shock) in their own values and

that of the other variables in the model over a ten quarter period.

Fig. 3 Impulse responses of monthly data
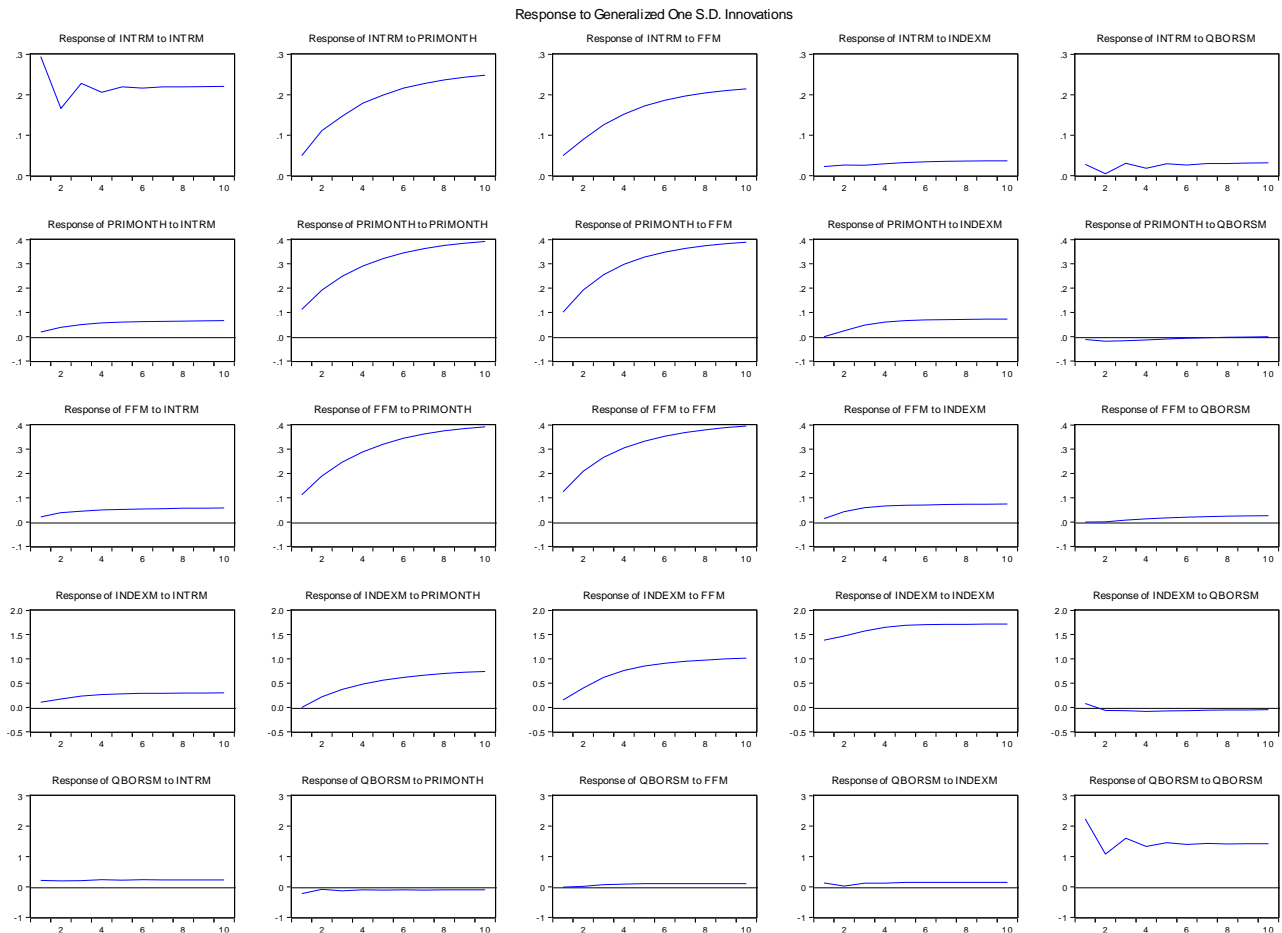
The response of INTRM to one standard deviation (SD) innovation in PRIMONTH and FFM appear to be positive and sustained. The reverse causations appear to be weaker between these variables. There appears to be a strong response of PRIMONTH to one SD innovation in FFM, as well as a strong reverse causation in the response of FFM to a shock to PRIMONTH, which is also positive and sustained. There appears to be positive and sustained responses of INDEXM to one SD innovation in both PRIMONTH and FFM.

Based on these results, the VEC model was then run with INTRM and FFM as endogenous variables and PRIMONTH, INDEXM and QBORSM as exogenous variables. The variables are taken in their differenced form based on the presence of unit roots found in the

series. In addition, a dummy variable for the Great Recession, R, was included in the fully

specified model in order to account for the significant shock that occurred during this time

period. In the results, shown in Table 6, the cointegrating equation is:

$EC_{t-1} = INTRM_t - 5.4200 - 0.7444FFM_{t-1}$

$$(-25.618)$$

Table 6 VECM results for monthly data

Error Correction:	D(INTRM)	D(FFM)
CointEq1	-0.296260	0.005529
	(0.05200)	(0.01085)
	[-5.69723]	[0.50942]
D(INTRM(-1))	-0.304211	0.009089
	(0.06222)	(0.01299)
	[-4.88912]	[0.69985]
D(FFM(-1))	-0.029605	-0.048107
	(0.17902)	(0.03737)
	[-0.16537]	[-1.28739]
D(PRIMONTH)	0.372605	0.995453
	(0.17277)	(0.03606)
	[2.15660]	[27.6026]
D(INDEXM)	0.026595	0.006361
	(0.01477)	(0.00308)
	[1.80011]	[2.06284]
D(QBORSM)	0.010406	0.001503
	(0.00757)	(0.00158)
	[1.37521]	[0.95141]
R	0.260008	-0.000232
	(0.10128)	(0.02114)
	[2.56733]	[-0.01097]
R-squared:	0.3480	0.8907
Adj. R-squared:	0.3291	0.8875
F-statistic:	18.412	281.209
Akaike AIC:	0.3234	-2.810
Schwarz SC:	0.4335	-2.700

The coefficients of the variables represent the short-run elasticities, while the coefficient of the error correction term represents the speed of adjustment back to the long-run relationship among the variables. Since the model determined that PRIMONTH was exogenous rather than endogenous, the monthly model only estimates results that can be interpreted for the cost of credit to small firms, INTRM.

The results show that, as anticipated, the effect of the Great Recession increases the cost of credit to small firms. These results can be compared to a dummy variable included to account for the 2001 recession, which when included in the model is not significant in terms of its impact on the cost of credit to small firms (results available in Appendix B).

The results for ΔINDEXM and ΔQBORSM relate to the effects of the quantity of credit borrowed on the cost of credit. ΔINTRM has a significant positive relationship with ΔINDEXM, as anticipated, in which for a 10% increase in INDEXM, the monthly Business Borrowing Index, the cost of credit to small firms increases 2.66%, holding all other variables constant. ΔINTRM has a significant negative relationship with the coefficient of the error correction term, which offers some evidence of reversion back to the long-run equilibrium when there is a shock to the system. If there is a 10% deviation from the mean, there will be a 2.96% reversion back to equilibrium on a monthly basis, *ceteris paribus*.

d. VEC Quarterly Model

Given the presence of cointegration in the quarterly data, even in the presence of structural breaks, a vector error correction model can also be used to estimate the equation for the quarterly data. This is contrary to Ramirez and Pandey's study and is a significant finding, probably due to the extended time period. An unrestricted VEC model is estimated including

PRIQ, CREDCARDQ, INDEXQ, FFQ and QCARDQ as endogenous variables (data for the error correction terms in Appendix A). The model is estimated using Model 2 with 1 lag, based on the Akaike Information Criterion and the Schwarz Criterion. From the estimated results (based on t-ratios on the error correction terms), it can be determined that INDEXQ, FFQ and QCARDQ are exogenous—at this juncture, it should be observed that this results in the same equation used in Pandey and Ramirez' model, which determined the endogenous and exogenous variables based on a theoretical assumption and economic analysis; however, the present model uses a vector error correction model rather than a vector autoregression model, a major finding. These results can be confirmed by imposing zero restrictions on the error correction coefficients for the assumed exogenous variables. The null hypothesis is that the variables can be set to zero (exogenous), thus rejecting the null hypothesis means that the variables are endogenous. In the model with zero restrictions on INDEXQ, FFQ and QCARDQ, the null hypothesis cannot be rejected and it can be concluded that the variables are exogenous.

As further evidence determining which variables are exogenous, the graphs included below in Figure 4 offer a visual depiction of the reaction of a dynamic system to an external change. Again, the generalized impulse responses show how each of the five variables reacts to a one standard deviation (SD) shock in its own value and to that of other variables in the model.
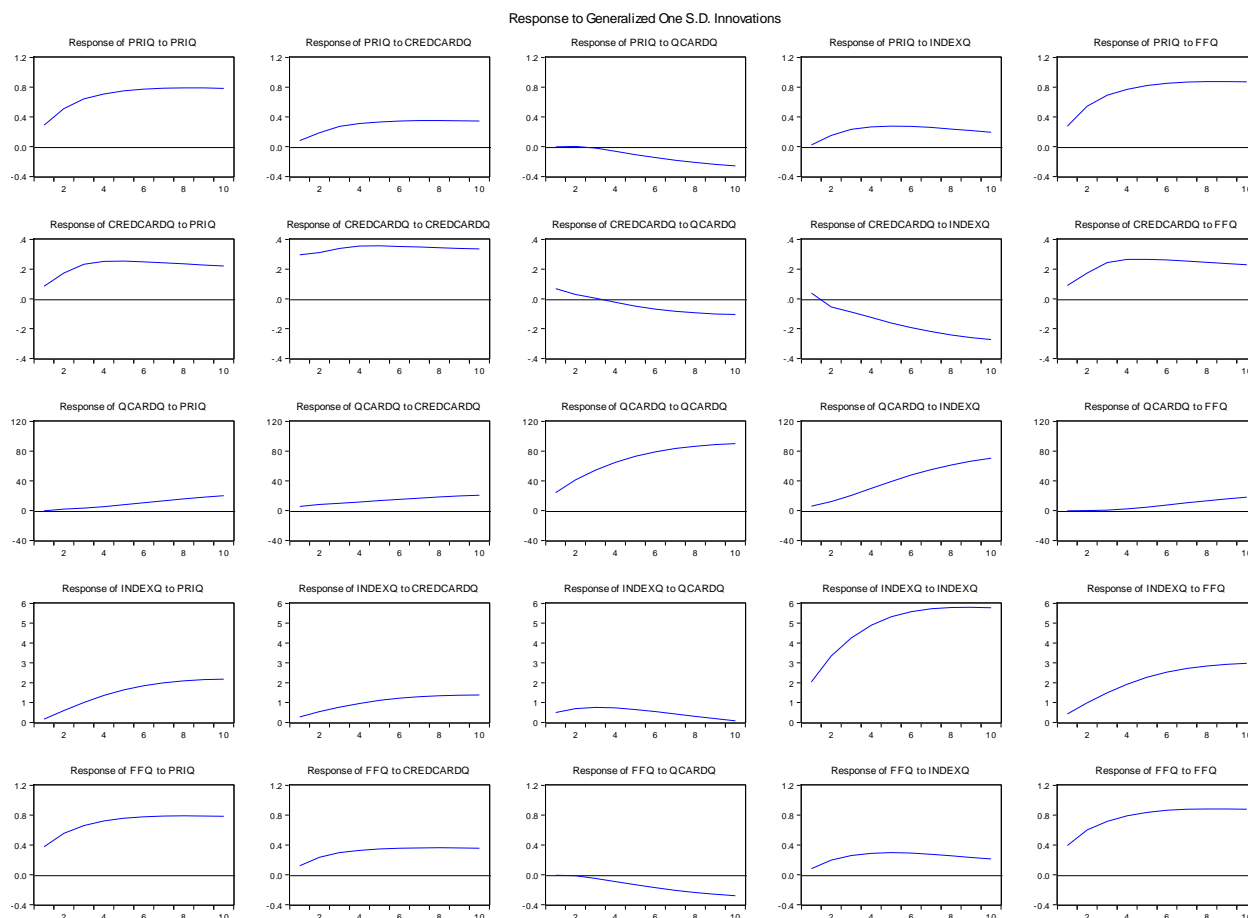
Fig. 4 Impulse responses of quarterly data

PRIQ appears to respond to one standard deviation (SD) innovation in QCARDQ after three

quarters, which is negative and sustained. The reverse causation between the variables appears to

be weaker. There appears to be a positive and sustained response of PRIQ to one SD innovation

in FFQ. The reverse causation of the response of FFQ to a shock to PRIQ also appears to be

positive, but levels off after five or six periods. The response of CREDCARDQ to INDEXQ

appears to be negative and sustained, with a weaker reverse causation. QCARDQ appears to

have a positive and sustained response to one SD innovation in INDEXQ. INDEXQ appears to

have a positive and sustained response to one SD innovation in FFQ.

Based on these results the VEC model was then run with PRIQ and CREDCARDQ as

endogenous variables and FFQ, INDEXQ and QCARDQ as exogenous variables. The variables

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are taken in their differenced form based on the presence of unit roots found. From the results,

shown in Table 7, the cointegrating equation is: $EC_{t-1} = PRIQ_t + 15.885 - 1.795CREDCARDQ_{t-1}$

$$(-3.315)$$

Table 7 VECM results for quarterly data

Error Correction:	D(PRIQ)	D(CREDCARDQ)
CointEq1	-0.016189	0.039403
	(0.00815)	(0.01743)
	[-1.98716]	**[2.26071]**
D(PRIQ(-1))	0.292321	0.142612
	(0.04772)	(0.10209)
	[6.12635]	[1.39698]
D(CREDCARDQ(-1))	-0.031678	-0.088527
	(0.05567)	(0.11910)
	[-0.56908]	[-0.74333]
D(FFQ)	0.793101	0.194120
	(0.04229)	(0.09048)
	[18.7528]	**[2.14536]**
D(INDEXQ)	-0.026595	0.031530
	(0.01040)	(0.02225)
	[-2.55760]	[1.41722]
D(QCARDQ)	-0.000463	0.000252
	(0.00051)	(0.00109)
	[-0.90658]	[0.23089]
R	-0.231817	1.017408
	(0.11874)	(0.25404)
	[-1.95231]	**[4.00489]**
R-squared:	0.9188	0.3554
Adj. R-squared:	0.9111	0.2940
F-statistic:	118.83	5.7891
Akaike AIC:	-1.097	0.4240
Schwarz SC:	-0.872	0.6488

The coefficients of the variables represent the short-run elasticities, while the coefficient of the

error correction term represents the speed of adjustment back to the long-run relationship

between the variables. The estimates determined that FFQ, INDEXQ and QCARDQ were exogenous, so the model was run with PRIQ and CREDCARDQ as the endogenous terms and the results can be interpreted to analyze the cost of credit for both small and large firms.

Turning to the dummy variable R, the effects of the Great Recession have a significant negative relationship with ΔPRIQ and a significant positive relationship with ΔCREDCARDQ. As anticipated, the results imply that during the Great Recession the cost of credit to large firms decreased while the cost of credit to small firms increased. These results can be compared to a dummy variable included to account for the 2001 recession, which when included in the model is not significant in terms of the cost of credit to either large or small firms (results available in Appendix C).

The variables FFQ, INDEXQ and QCARDQ can be analyzed to examine the effects of price and quantity on the cost of credit to firms. Both ΔPRIQ and ΔCREDCARDQ have a significant positive relationship with ΔFFQ, however, the effect is about four times larger for large firms than for small firms. For a 10% increase in federal funds rate (equivalent to, for example, a quarter percentage point increase in the federal funds rate from 2.5% to 2.75%), the cost of credit to large firms increases 7.9% on a quarterly basis, holding all other variables constant. For a 10% increase in the federal funds rate, the cost of credit to small firms increases 1.9% on a quarterly basis, holding all other variables constant. However, during the 2007-2009 recession, the federal funds rate was reduced from 5.25% to between 0 and 0.25%. Thus, interpreting the results, for a decline in the federal funds rate, as occurred during the recession, larger firms faced a larger decline in the cost of credit than smaller firms, *ceteris paribus*.

ΔCREDCARDQ does not have a significant relationship with ΔINDEXQ or ΔQCARDQ. ΔPRIQ does not have a significant relationship with ΔQCARDQ. However, ΔPRIQ has a

significant negative relationship with ΔINDEXQ, which contradicts the anticipated results. Theoretically, it is assumed that for an increase in the quantity of credit, the cost of credit should increase. Further analysis of this anomaly is required, but it could be due to the fact that this variable may be representing the supply of credit rather than demand, causing a potential identification problem.

ΔPRIQ has a significant negative relationship with the coefficient of the error correction term, which offers some evidence of reversion back to the long run equilibrium when there is a shock to the system. If there is a 10% deviation from the mean, there will be a 0.16% reversion back to equilibrium on a quarterly basis. ΔCREDCARDQ has a significant positive relationship with the coefficient of the error correction term, which signifies an explosive relationship in which a shock to the system causes a move away from the mean equilibrium. Thus, it can be inferred that economic shocks create a more unstable environment for small firms.

e. Recessionary Effects

The dummy variable R was also included in the model as an interactive variable in order to analyze the effects of the recession in relation to the effects of the other exogenous variables. The interactive dummy variables, R*D(FFQ), R*D(INDEXQ) and R*D(QCARDQ) were run sequentially in separate models in order to avoid multicollinearity. The results and net effects of the interaction between the Great Recession and the exogenous variables are shown below in Table 8.

Table 8 Results of interactive dummy variable R

	Cost to Large Firms			Cost to Small Firms		
	Exogenous Variable	**Interactive Variable**	**Net Effect on PRIQ**	**Exogenous Variable**	**Interactive Variable**	**Net Effect on CREDCARDQ**
D(FFQ)	0.8255	-0.2201	0.6054	0.1880	-0.0115	0.1765
	(17.518)	(-1.911)		(1.710)	(-0.042)	
D(INDEXQ)	-0.0318	0.0306	-0.0012	0.0357	-0.1038	-0.0681
	(-2.740)	(2.153)		(1.376)	(-3.271)	
D(QCARDQ)	-0.0001	-0.0001	-0.0002	-0.0004	-0.0302	-0.0306
	(-0.299)	(-0.027)		(-0.414)	(-2.735)	

( ) t-statistics

The recession appears to have reduced the positive effect the federal funds rate had on the cost of credit to both large and small firms. Since the federal funds rate was reduced during the Great Recession, the decrease caused a smaller decrease in cost for larger firms and for smaller firms than it otherwise would have; however, the effect of the rate cut on the cost of credit to larger firms was still significantly higher than for smaller firms. The relationship between $\Delta CREDCARDQ$ and $R*\Delta FFQ$, however, is insignificant. The recession appears to have neutralized the effects that $\Delta INDEXQ$ had on $\Delta PRIQ$ and somewhat lowered the effects that $\Delta INDEXQ$ had on $\Delta CREDCARDQ$, such that for an increase in the quantity of credit borrowed, the cost of credit to small firms increases by less than it would have in normal times. The relationship between $\Delta CREDCARDQ$ and $\Delta INDEXQ$, however, is not significant. The relationships between $\Delta PRIQ$ and $\Delta QCARDQ$, $\Delta PRIQ$ and $R*\Delta QCARDQ$, and $\Delta CREDCARDQ$ and $\Delta QCARDQ$ are not significant. However, there appears to be a significant negative relationship between the interaction of the recession and $\Delta QCARDQ$ on the cost of credit to small firms, reducing the cost of credit for an increase in quantity of credit by more than during times of economic normalcy. Overall, the results imply that the recession reduced the positive effects of price on the cost of credit to both small and large firms and caused an inverted

relationship between the quantity of credit and the cost of credit to both small and large firms, however, only minimally.

Due to the extended time period and the improvement in the test methodology used, these results are somewhat different from those of Ramirez and Pandey and Walker. Ramirez and Pandey's study found that the cost of credit decreases in a recession for both large and small firms, however, the reduction is more pronounced for large firms. This study found that a severe recession actually increases the cost of credit to small firms while decreasing the cost of credit to large firms. The disparity between results may be due to the fact that this study's R variable considered only the most intense periods of the Great Recession as suggested by the Gregory-Hansen (GH) tests, rather than any recessionary month or quarter throughout the seventeen-year time period. The present model also captured separately the effects of a less severe recession, the 2001 recession, which did not have a significant effect on the cost of credit to small or large firms. The results of the monthly data's Gregory-Hansen tests also revealed a structural break in August of 2008, which correlates closely with the bankruptcy of Lehman Brothers in early September of 2008, a significant moment during the Great Recession. The estimates for the quarterly data using the GH methodology reveal that a full break occurred during the first quarter of 2009—this was a period during which the effects of the severe recession intensified in terms of output and employment losses. The results of the G-H tests confirming cointegration in the presence of endogenously determined structural breaks in the model represent a significant improvement over the results found by Pandey and Ramirez and Walker.

The results for the exogenous variables were similar to those of Ramirez and Pandey. Both studies found minimal and variant evidence on the relationship between the quantity of credit borrowed and the cost of credit. It was found in both studies that the Federal Funds Rate

had the most significant relationship with the cost of credit but had a larger effect on large firms than small firms. Thus, the traditional tool of central banks, open market operations to affect the Federal Funds Rate, is effective in altering the cost of credit to firms and individuals. However, during a severe recession, the relative efficacy of this tool is reduced. The result offers insight into why severe recessions may face the zero lower bound, as the impact of the Federal Funds Rate on the cost of credit is diminished.

Conclusion

The federal funds rate is supposed to have a relatively prompt effect on the cost of credit to businesses and consumers. Lowering the federal funds rate in theory should create a low interest rate environment for borrowers and thus encourage business expansion and capital investments. However, as seen during the Great Recession, as well as during Japan's 1990s-2000s recession and the Great Depression, central banks can lower the interest rate to zero without stimulating aggregate spending in the economy. As seen from both anecdotal evidence and the empirical model conducted in this study, the decline in the cost of credit that businesses should have experienced due to the rate cuts was not felt by smaller firms, who actually faced higher costs of credit. However, during less severe recessions, such as the 2001 recession in the U.S., the recessions do not appear to significantly affect the cost of credit.

During the Great Recession, "of the twenty-five largest financial institutions at the start of 2008, thirteen failed (e.g., Lehman, WaMu), received government help to avoid failure (Fannie, Freddie, AIG, Citi, BoA), merged to avoid failure (Countryside, Bear, Merrill, Wachovia), or transformed their business structure to avoid failure (Morgan Stanley, Goldman)" (Gorton 2014, 255-6). The TED Spread, the difference between short-term rates on government debt and interbank loans, which during times of economic normalcy is generally small, spiked as banks charged high interest rates on loans to other banks and limited their loans to each other (see Figure 5). Despite the Federal Reserve's efforts to lower interest rates and pump liquidity into the financial system through emergency lending and discount auction programs, banks appeared to have hoarded their reserves, not knowing which major bank or financial institution
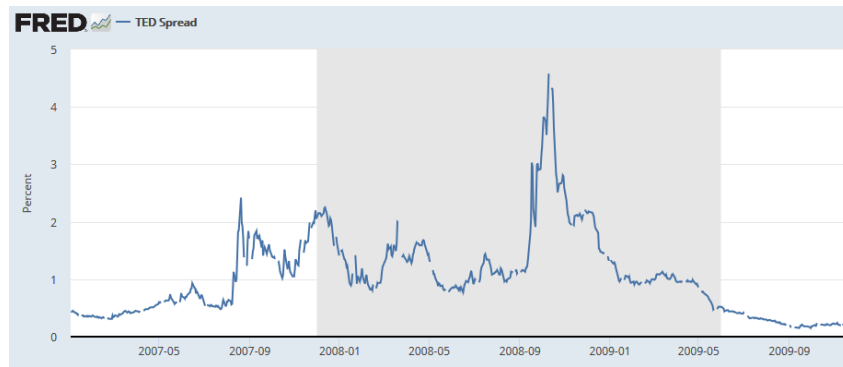
Fig. 5 TED Spread (Federal Reserve Bank of St. Louis)

may be the next domino to fall. While interbank loans evaporated, loans to firms and individuals

followed suit. Information asymmetries could account for part of the disparity in the cost of

credit to small and large firms. Amidst the panic and uncertainty, banks were unsure of the true

value of borrowers' balance sheets and the risk involved in loaning during a period of such

economic turmoil, requiring additional information on the quality of the businesses' balance

sheets and more collateral in order to gain access to loans. Smaller firms, with less capital and a

greater reliance on personal assets, are in a more difficult position to supply additional

information and collateral, especially during adverse economic conditions.

      According to a testimony by Federal Reserve Bank Governor Randall Kroszner (2008),

the reduction in credit to small businesses was the result of a mix of reduced credit supply and

demand. Financial intermediaries were less willing to lend to small businesses during the period

of credit market instability, the deterioration of the balance sheets of small businesses reduced

their creditworthiness and demand for small businesses' products and services declined. As for

the demand side, small businesses cut their plans for expansion. Clearly, small businesses were

targeted for reduced access to credit, through either reduced supply or through prohibitively high

costs of credit. In turn, these small businesses, who account for nearly half of non-farm business

GDP and employ over half of private-sector workers, faced lay-offs and bankruptcies, which in

turn had a toxic effect on the economy. Had these small businesses received greater accessibility to credit, the recession may have had a less detrimental and lengthy effect. During the Great Recession, the limited availability of credit, especially to small firms, mainly due to increased costs of credit intermediation, was likely a key factor in reaching the zero lower bound. Despite reducing interest rates, financial intermediaries continued to charge high costs to borrowers, thus reducing access to credit and limiting the scope for capital investment and expansion that would have aided the recovery of the economy.

Responses to future economic contractions will likely continue to face the risk or challenge of the zero lower bound. Given the results, future monetary policymakers should assess the type of economic contraction occurring when making policy decisions. Of the dozen post-World War II U.S. recessions, only the Great Recession of 2007-2009 encountered the zero lower bound. Prior recessions, more or less, responded accordingly to interest rate cuts and the central bank did not need to pursue extensively untraditional monetary policies. The Great Recession, however, left the Fed and the Treasury scrambling to impose effective unconventional policy, such as large-scale asset purchases and forward guidance. Despite their greatest efforts, the recession remained a long and painful experience felt around the globe.

The similarities in the three historical cases can offer evidence of future signals to watch for that may foreshadow the challenge of the zero lower bound. The presence of the zero lower bound may signal the reduced effectiveness of traditional open market operations. Thus, central banks should focus their efforts on alternative monetary policy actions. Policymakers should be wary of credit booms, which tend to precede financial panics, and any form of a run on major financial institutions. Panic and uncertainty cause investors to pile into only the safest assets and a sharp decline in riskier assets reduce the net worth of firms and individuals. As credit tightens,

investment, spending and hiring come to a halt. The economy falls into the depths of a recession that a reduction in the federal funds rate cannot overcome.

The alternative monetary policy tools employed by central banks facing the ZLB, specifically large-scale asset purchases and quantitative easing, appear to have eventually eased borrowing conditions for longer-term assets and aided the recovery of the economy. However, a greater effort to open credit access to small businesses may have additionally lessened the effects of the recession. Under the Term Asset-Back Security Loan Facility (TALF) the Fed extended credit to investors who would buy AAA-rated securities backed by credit card loans, student loans, auto loans, commercial mortgages and loans guaranteed by the Small Business Administration. Over the course of its functioning, it generated nearly 900,000 loans to small businesses between 2008 and 2010. TALF appeared to have been a successful program, which aided small businesses and households (Bernanke, 2017). The continuation of programs like TALF will be important in future recessions where small firms face constrained access to credit by financial intermediaries.

The Federal Reserve recognized the tightening credit environment for small businesses and released a statement in November 2008 encouraging banks to "fulfill their fundamental role in the economy as intermediaries of credit to businesses, consumers and other creditworthy borrowers." People argue that reduced credit to small businesses during the recession was mostly due to reduced demand for credit by small businesses. The demand side was certainly in play, but clearly higher costs that weighed on the ability of small businesses to invest is a fact that cannot be dismissed. An emphasis on the recognition of tighter credit standards to small businesses and a commitment by the Fed and Treasury to ease these conditions will remain important in the future.

The Fed made a concerted and great effort to respond properly to the Great Recession. However, the shock caused by the presence of the zero lower bound as a legitimate situation, not a "special case" as it was considered in Japan's recession or an argued or even unrecognized fact as it was during the Great Depression, created an environment of uncertainty regarding how to address the recession. Central banks entered unchartered territory as they explored the use of unconventional monetary policy. The efforts became a melting pot of attempts to ease economic conditions—ex post facto making the discernment of which efforts were actually successful a bit difficult.

Not realizing that traditional open market operations would offer little relief to the actual cost of credit extended to a large majority of businesses and individuals, the Fed may have over-concentrated their efforts to reduce the Federal Funds Rate. Had they known they would reach the ZLB without much recourse, they may have been able to focus their practices on alternative monetary policies earlier and with greater exertion, potentially lessening the severity of the recession. The experience with the ZLB and alternative monetary policy actions will hopefully allow for a smoother response to another encounter with the loss of traditional monetary tools, a scenario many economists agree we are likely to encounter again in the future.

Appendix

Appendix A

Monthly data error correction table

	D(INTRM)	D(PRIMONTH)	D(FFM)	D(INDEXM)	D(QBORSM)
Error correction coefficient	-0.4486	-0.0227	-0.0774	0.0424	-0.6151
Standard error	0.0637	0.0263	0.0291	0.3302	0.5230
t-statistic	-7.0473	-0.8666	-2.6642	0.1283	-1.1762
R-squared	0.384607	0.577256	0.506593	0.054897	0.256271
Adj. R-squared	0.369814	0.567094	0.494732	0.032178	0.238393
Akaike AIC	0.2562	-1.5158	-1.3119	3.5488	4.4682
Schwarz SBC	0.3506	-1.4215	-1.2175	3.6431	4.5626

Results show that EC terms for D(PRIMONTH), D(INDEXM), and D(QBORSM) are insignificant for a one-tailed test, suggesting these variables should have zero restrictions

Quarterly data error correction table

	D(PRIQ)	D(CREDCARDQ)	D(INDEXQ)	D(FFQ)	D(QCARDQ)
Error correction coefficient	-1.0886	-0.7423	76.472	2.1801	-0.1511
Standard error	0.5306	0.5270	40.2837	3.6191	0.7228
t-statistic	-2.0517	-1.4086	1.8983	0.6024	-0.2091
R-squared	0.6138	0.3392	0.3544	0.5019	0.3600
Adj. R-squared	0.5770	0.2762	0.2929	0.4544	0.2990
Akaike AIC	0.4626	0.4489	9.1220	4.3025	1.0808
Schwarz SBC	0.6874	0.6737	9.3468	4.5274	1.3057

Results show that EC terms for D(INDEXQ), D(FFQ), and D(QCARDQ) are insignificant for a one-tailed test, suggesting these variables should have zero restrictions

Appendix B

Results from VECM monthly data with 2001 recession
$$EC_{t-1} = INTRM_t - 5.4840 - 0.7389FFM_{t-1}$$

Error Correction:	D(INTRM)	D(FFM)
CointEq1	-0.262083	0.007542
	(0.05199)	(0.01067)
	[-5.04140]	[0.70664]
D(INTRM(-1))	-0.318487	0.007781
	(0.06311)	(0.01296)
	[-5.04617]	[0.60046]
D(FFM(-1))	-0.038866	-0.054952
	(0.18369)	(0.03771)
	[-0.21158]	[-1.45705]
D(PRIMONTH)	0.315486	0.987876
	(0.17766)	(0.03648)
	[1.77579]	[27.0832]
D(INDEXM)	0.012532	0.006705
	(0.01397)	(0.00287)
	[0.89682]	[2.33724]
D(QBORSM)	0.010826	0.001535
	(0.00766)	(0.00157)
	[1.41267]	[0.97576]
R1	**-0.114579**	**-0.026993**
	(0.10865)	**(0.02231)**
	[-1.05460]	**[-1.21010]**

Appendix C

Results from VECM quarterly data with 2001 recession
$EC_{t-1} = PRIQ_t + 28.5535 - 2.5172CREDCARDQ_{t-1}$

Error Correction:	D(PRIQ)	D(CREDCARDQ)
CointEq1	-0.006486	0.029785
	(0.00886)	(0.02016)
	[-0.73174]	[1.47727]
D(PRIQ(-1))	0.274034	0.137144
	(0.04838)	(0.11006)
	[5.66376]	[1.24609]
D(CREDCARDQ(-1))	-0.061284	0.085227
	(0.05469)	(0.12440)
	[-1.12064]	[0.68512]
D(QCARDQ)	0.000112	-0.001116
	(0.00050)	(0.00114)
	[0.22391]	[-0.98109]
D(INDEXQ)	-0.012304	-0.017549
	(0.00849)	(0.01931)
	[-1.44930]	[-0.90877]
D(FFQ)	0.790265	0.188996
	(0.04788)	(0.10892)
	[16.5039]	[1.73516]
R1	**-0.004694**	**0.009549**
	(0.10139)	**(0.23063)**
	[-0.04630]	**[0.04140]**

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