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Did Smaller Firms Face Higher Costs of Credit During the Great Recession? A Vector Error Correction Analysis with Structural Breaks

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Abstract

This paper examines the challenges firms (and policymakers) 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 with structural breaks to analyze the effects of relevant economic and financial factors on the cost of credit intermediation for small and large firms. Specifically, it tests whether large firms have advantageous access to credit, especially during recessions. The findings suggest that during the Great Recession of 2007-09 the cost of credit rose for small firms while it decreased for large firms, *ceteris paribus*. From the results, the paper assesses alternative ways in which the central bank can respond to a recession facing the zero lower bound.

Keywords: Cost of credit; Granger causality test; Great Recession; Gregory Hansen single-break cointegration test; Johansen cointegration test; KPSS unit root test; Vector error correction model (VECM); and Zero lower bound (ZLB).

J.E.L. Codes: C22, E50, G01

1. 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 to the level of investment and spending (see Bernanke, 2017; and Knoop, 2008). 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, 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, 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, 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 of 2007-09, 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 (see Bernanke, 2017; and Gertler et al., 2007).

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 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 (see Stiglitz and Weiss, 1981). Thus, the recession was protracted, extensive, and painful. This paper is organized as follows: Section 2 discusses some of the voluminous literature associated with monetary policy at the zero lower bound. Section 3 presents the data, methodology, and results for the estimated VEC models. Section 4 summarizes the main conclusions and suggests some policy recommendations.

2. The 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 that may face a similar challenge in the future, as a number of countries did during the 2007-2009 financial crisis (see Wakatabe, 2015). 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."

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, favor the management of expectations about 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, 19, 28).

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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 (see Bernanke, 2017). 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, 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 paper by C. Reinhart and V. Reinhart (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 study finds 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" (2010, 38-39).

Despite changes in the economic environment after the recent global recession, the level and growth of real GDP, 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 (see Kiley, 2017).

3. Data, Methodology & Results

3.1 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 percentage of firms borrowing at least once every quarter per month, 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.

3.2 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:

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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 at the 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) 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 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 time period for this variable was determined endogenously via 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.

3.3 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

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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	-2.622	-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 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.(Note 1) Thus, when incorporated into the model, the variables will be considered in their differenced form.

b. Tests for Cointegration

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 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**	**79.882**	**108.796**	**49.057**	**48.999**	**52.064**
	(76.973)	**(69.819)**	**(88.804)**	**(34.806)**	**(33.877)**	**(38.331)**
At most 1	35.365	39.883	56.732	15.109	15.082	28.021
	(54.079)	(47.856)	(63.876)	(28.588)	(27.584)	(32.118)
At most 2	20.256	15.801	28.711	10.367	9.797	15.012
	(35.193)	(29.797)	(42.915)	(22.299)	(21.162)	(25.823)
At most 3	9.889	6.003	13.699	7.770	4.152	9.553
	(20.262)	(15.495)	(25.872)	(15.892)	(14.265)	(19.387)
At most 4	2.118	1.851	4.146	2.118	1.851	4.146
	(9.165)	(3.741)	(12.517)	(9.165)	(3.845)	(12.517)

R = number of cointegrating vectors
( ) 0.05 Critical Value

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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 was determined by using the Schwarz Criterion and Akaike Information Criterion given in the VECM output.

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 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**	**92.578**	**121.995**	**40.923**	**40.703**	**69.120**
	(76.973)	**(69.819)**	**(88.804)**	**(34.806)**	**(33.877)**	**(38.331)**
At most 1	60.221	**51.876**	52.875	25.158	25.101	25.223
	(54.079)	**(47.856)**	(63.876)	(28.588)	(27.584)	(32.118)
At most 2	35.063	26.774	27.652	19.314	18.674	18.977
	(35.193)	(29.797)	(42.915)	(22.299)	(21.132)	(25.823)
At most 3	15.749	8.100	8.674	10.270	6.118	6.152
	(20.262)	(15.495)	(25.872)	(15.892)	(14.265)	(19.387)
At most 4	5.479	1.982	2.522	5.479	1.982	2.522
	(9.165)	(3.841)	(12.518)	(9.165)	(3.841)	(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 chosen model was determined by using 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.

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3.4 Gregory-Hansen Tests

As a significant extension (and improvement) 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 a la Sims (1980), 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 endogenoulsy 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.

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3.5 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).

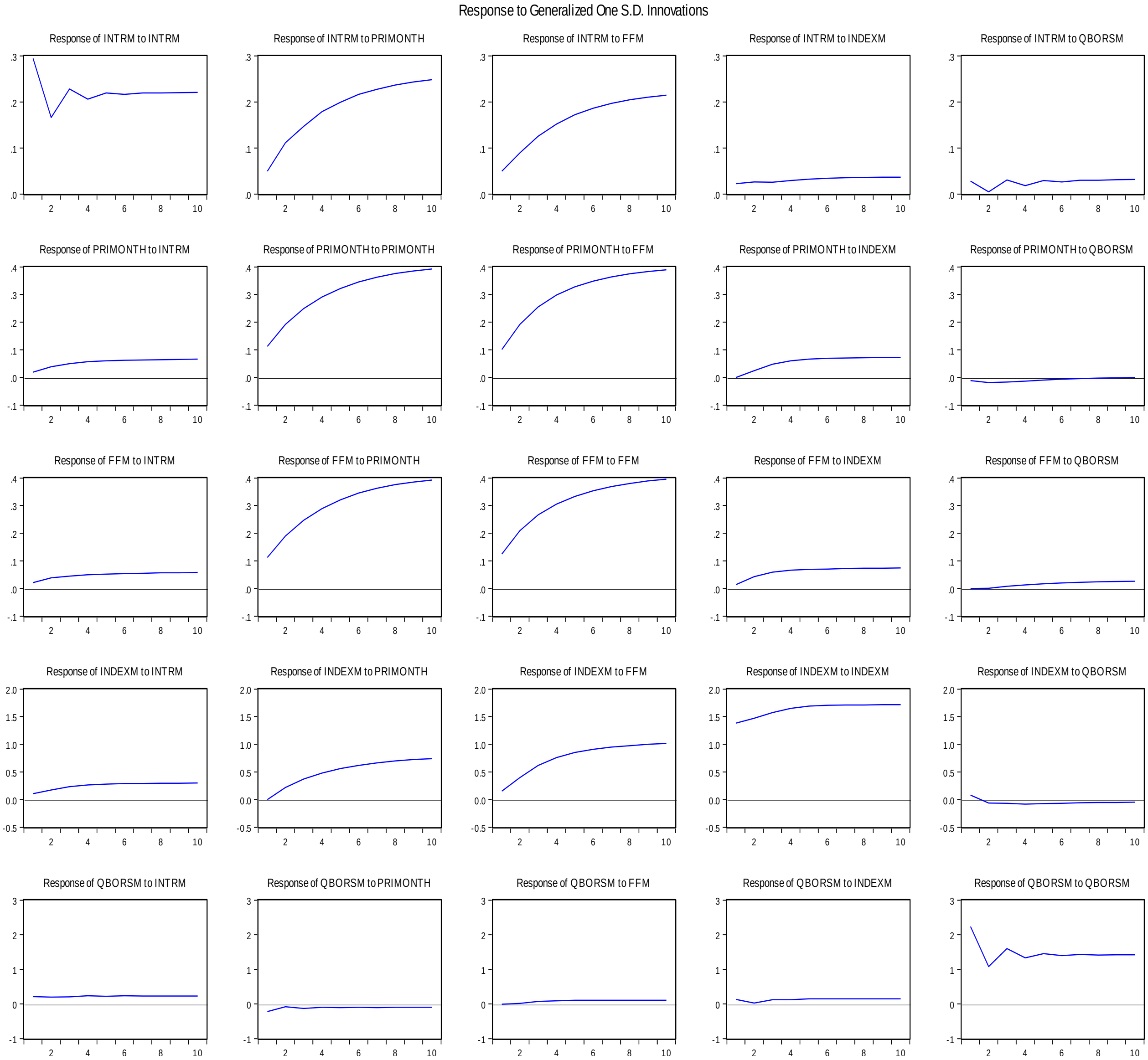

Figure 1. Impulse Responses of Monthly Data

An unrestricted VEC model is estimated including PRIMONTH, INTRM, INDEXM, FFM and QBORSM 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, 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 weakly exogenous.

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

As further evidence for determining which variables are exogenous, the graphs included below in Figure 1 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 month period.

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 (weakly) 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 above, the cointegrating equation is:

$$EC_{t-1} = INTRM_t - 5.4200 - \underset{(-25.618)}{0.7444}FFM_{t-1}$$

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.*

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a. 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.

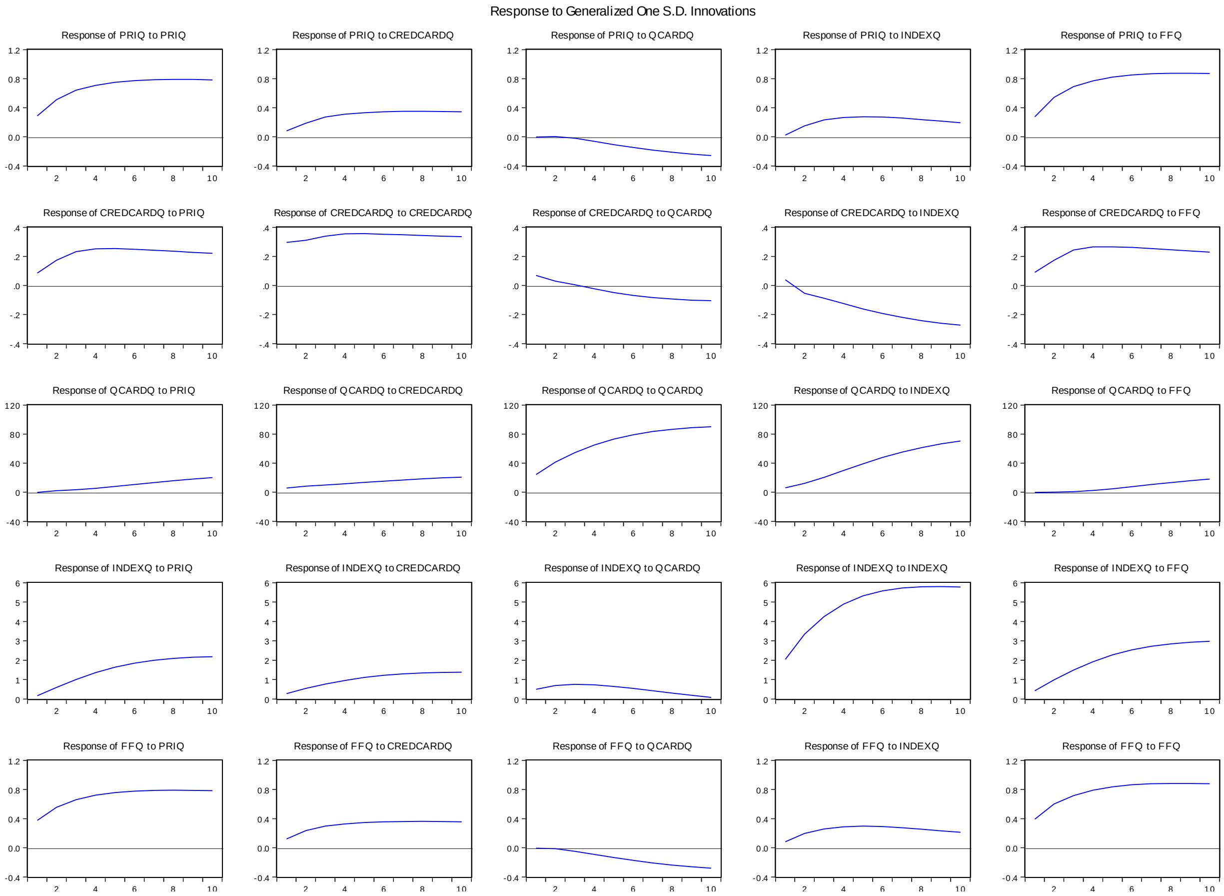

Figure 2. Impulse Responses of Quarterly Data

As further evidence determining which variables are exogenous, the graphs included above in Figure 2 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.

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

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

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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 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:

$$EC_{t-1} = PRIQ_t + 15.885 - 1.795CREDCARDQ_{t-1}$$

$$(-3.315)$$

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.

b. 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 small decrease 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 ΔCREDCARDQ and R*ΔFFQ, however, is insignificant. The recession appears to have neutralized the effects that ΔINDEXQ had on ΔPRIQ and somewhat lowered the effects that ΔINDEXQ had on ΔCREDCARDQ, 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 ΔCREDCARDQ and ΔINDEXQ, however, is not significant.

The relationships between ΔPRIQ and ΔQCARDQ, ΔPRIQ and R*ΔQCARDQ, and ΔCREDCARDQ and ΔQCARDQ are not significant. However, there appears to be a significant negative relationship between the interaction of the recession and ΔQCARDQ 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.

4. Conclusion

Due to the extended time period and the improvement in the test methodology used, the findings in this study 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 recession 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 recession (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 June of 2008, which corresponds to the bankruptcy of Lehman Brothers, a significant moment during the Great Recession. The results of the G-H tests confirming cointegration in the presence of structural breaks in the model represent a significant improvement over the results found by Pandey and Ramirez and Walker.

The results of 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.

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. In prior recessions, the economy responded to interest rate cuts and the central bank did not need to pursue extensively non-traditional monetary policies. The Great Recession, however, left the Fed and the Treasury scrambling to find novel ways of stimulating the economy, such as large-scale asset purchases and forward guidance. Despite their greatest efforts, the recession remained a protracted and painful experience felt around the globe.

The alternative monetary policy tools employed by central banks facing the ZLB eventually eased borrowing conditions for longer-term assets and aided the recovery of the economy. However, a greater effort to extend credit to small businesses may have lessened the effects of the recession (see Kroszner, 2008). 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 (see 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.

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Note

Note 1. This study also undertook the confirmatory Kwiatkowski-Phillips-Schmidt-Shin (KPSS 1992) stationary (no unit root) test and rejected the null hypothesis of stationarity at the 5 percent level for the variables in level form. However, the null hypothesis of stationarity was not rejected for the variables in difference form at the 5 percent level. The results are available upon written request.

Appendix

Appendix A: Tables A1 and A2

Monthly data error correction Table A1

	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

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Quarterly data error correction Table A2

	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: Table B1

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: Table C1

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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