Are Credit Shocks Supply or Demand Shocks?

Bijapur, Mohan

London School of Economics

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Mohan Bijapur [a]

London School of Economics

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Abstract

This paper provides new insights into the relationship between the supply of credit and the macroeconomy. We present evidence that credit shocks constitute shocks to aggregate supply in that they have a permanent effect on output and cause inflation to rise in the short term. Our results also suggest that the effects on aggregate supply have grown stronger in recent decades.

Keywords: Financial crisis; Potential output; Inflation; Credit crunch.
JEL classification: E31, E32.

I. Introduction

The relationship between the supply of credit and economic activity has been a long-standing question in modern macroeconomics, and has recently been brought to the fore of the policy debate given the ongoing global credit crunch. A vast empirical literature has emerged which attempts to shed light on this and related issues. However, several important questions remain unanswered. For instance, although the existence of a credit channel has been widely established, it is much less understood whether shocks to the supply of credit primarily affect aggregate supply or aggregate demand. This paper addresses this question.

The channels through which credit shocks can impact on aggregate demand have received much attention in the literature[1]. However, as shown in Blinder (1987), credit

[a] Department of Economics, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK.
E-mail address: M.Bijapur@lse.ac.uk

rationing can also affect aggregate supply by restricting the availability of working capital for firms (who need to borrow as they must pay their factors of production before receiving revenues from sales), and also reducing future production by constraining investment spending and thus reducing the future capital stock. If the supply effect predominates, then the resulting excess demand will give rise to inflationary pressures.

We model the macroeconomy as a structural vector autoregression with 4 endogenous variables: output, inflation, real interest rates and credit supply. The purpose of using a structural approach is to disentangle the effects of different shocks, which we decompose into 4 sources of innovations: expenditure, inflation, monetary and credit supply shocks. We impose identifying restrictions using a recursive ordering (Cholesky decomposition) approach. By generating structural impulse response functions on our estimated model, we answer the following questions. First, we investigate whether each of our component shocks have permanent or transitory effects on output, and thus constitute supply as opposed to demand shocks in the sense of Blanchard and Quah (1989). Furthermore, a typical negative supply shock such as an oil shock would also generally have a positive impact on inflation, due to the resulting reduction in productive potential. We estimate whether credit shocks also display a similar inflationary response, thus providing further supportive evidence on the supply effects of credit shocks.

Our results provide material evidence for a supply effect of credit shocks. In particular, a comparison of the long run effects on output of expenditure shocks (which we interpret as pure aggregate demand shocks) and credit shocks is quite revealing. We find that expenditure shocks exhibit a GDP response typical of transitory demand shocks, with GDP growth initially falling below trend but subsequently increasing above trend around 6 quarters after the initial impulse, such that the cumulative impact on the long run level of GDP is relatively small. A negative credit shock (i.e. tighter credit), however, exhibit GDP responses typical of a negative supply shock, with output initially falling below trend. Although growth eventually recovers, the initial

[1] In addition to the direct channel through which credit rationing to households and firms restricts consumption and investment spending, broader financial market disruption and asset price volatility can reduce consumption through wealth effects and also through households increasing precautionary savings in response to greater uncertainty. Firms might also reduce investment spending in response to greater uncertainty on future demand conditions.

downturn is never fully offset, with the result that output converges in the long run to a permanently lower level.

The results on the inflation response provide further evidence on the supply effects of credit shocks. A negative expenditure shock exhibits the typical response of an aggregate demand shock, with slower growth inducing a period of falling inflation. In contrast, a negative credit shock behaves more like a supply shock, with slower growth accompanied by a period of rising inflation in the short term.

We then extend the analysis to investigate whether the nature of credit shocks has changed during the era of the "Great Moderation" experienced during the past two decades. Our motivation here is driven by the proponents in the debate who argue that the marked reduction in volatility seen during the past two decades is in part attributed to improvements in the efficiency of monetary policy[2] or other structural shifts in the global economy. These shifts may have also changed the operation of the credit propagation mechanisms. Interestingly, we do find evidence of such a structural break, in that the long run effect on output of credit shocks seems to have become stronger in recent decades. However, the inflation response has become weaker. We interpret these findings in the context of the broader debate on the causes of the "Great Moderation".

Our results also inform the ongoing policy debate during the global credit crunch. A key question being raised by policymakers is to what extent the current downturn constitutes a shock to productive potential and thus will not be offset during the recovery phase, and how this might affect the formulation of an optimal policy response over the medium term. The findings of our paper suggest that credit shocks do have supply effects, with the implication that the appropriate policy response to a credit shock may not be the same as to a pure aggregate demand shock.

The role of credit in business cycle fluctuations and in the monetary transmission mechanism, know loosely as the credit channel, has been examined extensively in the existing literature, with its theoretical foundations lying in the seminal works of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) who formalize the role of credit market imperfections and balance sheet effects in the propagation of transitory shocks. A vast empirical literature has provided evidence supporting the existence of a

[2] Cecchetti et al. (2006) find evidence of improvements in monetary policy-making across a large sample of OECD countries.

credit channel, some key contributions including Kashyap et al. (1993), Gertler and Gilchrist (1994), Hubbard (1995), Lang and Nakamura (1995) and Morgan (1998). More recently, Greenlaw et. al (2008) highlight the role of leverage and mark-to-market accounting in the propagation mechanism, and provide evidence that contractions in financial institutions' balance sheets cause a reduction in real output. Lown and Morgan (2006) undertake VAR analysis which reveals a significant correlation between lending standards (as measured by the Federal Reserve's Senior Loan Officer (SLO) survey) and real output. Bijapur (2010) investigates the effectiveness of monetary policy during a credit crunch, and finds evidence of impairment in the operation of the credit channel. The contributions of this paper are different, in that we investigate a different aspect of the credit channel. We disentangle the relationship between credit and output in order to understand whether shocks to credit primarily affect aggregate supply or aggregate demand. Bijapur (2012) also investigates the effects of credit shocks on potential output, but the focus of that paper is on inflation.

The rest of the paper is structured as follows. Section II outlines the econometric model and data issues. Section III presents the results and discusses their implications. Section IV concludes the paper.

II. Model Estimation

We model a small closed macroeconomy with 4 endogenous variables: output (y), inflation (π), real interest rates (r) and the supply of credit (η). Given that the focus of our interest is on understanding the differing impacts of various shocks to key macroeconomic aggregates, we believe the best approach is to model a structural vector auto regression (SVAR). This technique essentially reformulates the macroeconomic model in terms of the dynamic relationships between different structural disturbances, and is therefore ideally suited to studying the transmission mechanism of shocks. It is superior to a simple reduced form VAR, which suffers from the problem of contemporaneous correlation in the innovations, making it difficult to

shed light on the true causal relationships between the different variables. Our economic interpretation of the shocks is based on Stock and Watson's (2002) benchmark model, with shocks to the output (y), inflation (π), and real interest rates (r) equations designated as expenditure, aggregate supply and monetary policy shocks. We extend their model by including shocks to the supply of credit.

The central problem of identification which arises in estimation of macroeconomic models is how to recover the underlying structural parameters from the estimated reduced form, i.e. the identification problem. In order to be exactly identified, it is necessary to impose N(N-1) identifying restrictions, where N denotes the number of endogenous variables. Hence, we require 12 restrictions. The SVAR methodology takes care of 6 restrictions, by imposing mutual orthogonality between the structural innovations. For the remaining 6 restrictions, we use the recursive ordering (Cholesky decomposition) approach, which boils down to specifying the order in which the shocks enter each equation. Although this approach has been somewhat criticized in the empirical literature due to the arbitrary nature of identifying restrictions, we aim to ensure that the restrictions we make have sound theoretical foundations.[3]

The complete structural VAR model can be characterized by three components[4]: (1) the matrix of structural parameters (denoted A), (2) the matrices of lag coefficients (denoted Φ), and (3) the variance-covariance matrix of the structural innovations (denoted Ω), giving:

$$AX_t = \Phi(L)X_t + \varepsilon_t, \qquad E(\varepsilon\varepsilon') = \Omega$$

where X_t is the vector of endogenous variables and ε_t is the vector of structural innovations. The exclusion restrictions are applied to matrix A, which through the Cholesky decomposition has an upper triangular form, i.e.

[3] An alternative technique commonly used in SVAR estimation is to impose long run restrictions a la Blanchard-Quah. However, this approach is not suitable for our purposes, given that we are setting out to determine which shocks have long run effects and which have short run effects, hence it makes no sense to impose these restrictions a priori.

[4] A more detailed exposition of the structural VAR model is given in Appendix A.

$$A = \begin{pmatrix} 1 & . & . & . \\ 0 & 1 & . & . \\ 0 & 0 & 1 & . \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

We estimate two versions of this model with different orderings[5]:

$$X_1 = \begin{pmatrix} \pi & y & \eta & r \end{pmatrix}' \qquad X_2 = \begin{pmatrix} \pi & \eta & y & r \end{pmatrix}'$$

These orderings are chosen in order to impose a similar structure to Stock and Watson's benchmark model. Ordering X_1 implies to the following structural model:

$$\pi_t = \delta_1 y_t + \delta_2 \eta_t + \delta_3 r_t + lags + \varepsilon_{\pi t} \quad (1)$$
$$y_t = \theta_1 r_t + \theta_2 \eta_t + lags + \varepsilon_{yt} \quad (2)$$
$$\eta_t = \alpha_1 r_t + lags + \varepsilon_{\eta t} \quad (3)$$
$$r_t = lags + \varepsilon_{rt} \quad (4)$$

where equations (1)-(4) represent the (1) IS equation, (2) Phillip's curve, (3) Taylor monetary policy rule and (4) credit supply equation, with 4 endogenous variables: output (y), inflation (π), real interest rates (r) and credit supply (η)[6]. The ε's are taken to be mutually orthogonal structural innovations. The model retains key features of Stock and Watson[7]: inflation is a function of output in the Phillips equation and output is a function of real interest rates in the IS equation. It also extends Stock and Watson by including a credit supply equation, in which we allow for an interest rate effect in order to capture a potential credit channel of monetary policy.

In ordering X_2, the positions of credit and output are interchanged in order to allow output shocks to enter the credit supply equation. We include this variation in order to

[5] A standard convention in SVAR methodology is to refer to the ordering of the shocks, which is the converse of the ordering of the endogenous variables. Hence, in X_1, interest rate shocks are ordered first, with inflation shocks ordered last.

[6] The term "lags" denotes unrestricted lags of all endogenous variables.

[7] Some differences from Stock and Watson are: (1) We do not include a separate equation for commodity price shocks, instead allowing these to be captured by the inflation shock, (2) Our Taylor rule and Phillip's equation are not forward-looking, (3) We allow all structural parameters to be freely estimated, whereas they impose some parameters consistent with external estimates in the empirical literature.

investigate the causality between credit and output, i.e. whether innovations in credit cause innovations in output or vice versa[8].

III. Data issues

The model is estimated on US quarterly data. Variables are specified as follows: output (log GDP at constant prices), inflation (first differenced log GDP deflator) and real interest rates (Federal Funds target rate minus inflation rate). We estimate two versions of the reduced form VAR with different credit variables, in one we use the TED spread[9], and in the other we use the SLO credit standards series for large firms[10]. GDP and GDP deflator data are taken from the EcoWin database, and Federal Funds, commercial bank loans, SLO credit standards, Eurodollar and Treasury bill interest rates are taken from the Federal Reserve Board database. We estimate over sample period 1972Q2-2007Q2, given that Eurodollar deposit rates were only available from 1971, and the current credit crunch represents an incomplete cycle to date. ADF tests indicated that all variables were non-stationary, hence all were first differenced such that non-stationarity was no longer detected.

For our credit variable we use the TED spread and SLO survey data rather than actual loans data – both series show significant correlation with real loan growth, but we argue that they serve as cleaner proxies for identifying shifts in the supply of credit. The problem with using actual loan volumes is that these are affected by shifts in loan demand as well as loan supply, for example, during a recession firms and households tend to reduce their demand for credit, resulting in lower lending volumes. Using raw

[8] We investigate the causality between credit and output by estimating the SVAR using ordering X_2, then testing the over-identifying restriction in which output is excluded from the credit equation. Failure to reject this restriction would lend support to the view that innovations in credit are causing innovations in output.

[9] The TED spread, defined as the difference between the 3-month Eurodollar deposit rate and the yield on 3-month Treasury bills is a widely used indicator of credit risk, given that it measures the difference between an unsecured deposit rate and a proxy for the risk-free interest rate.

[10] The credit standards series is based on responses to the following question put to a sample of senior loan officers at large US banks: "Over the past three months, how have your bank's credit standards for approving loan applications for C&I loans or credit lines—excluding those to finance mergers and acquisitions—changed? 1) Tightened considerably 2) tightened somewhat 3) remained basically unchanged 4) eased somewhat 5) eased considerably." The survey data is constructed as a net percentage balance (i.e. percentage of respondents indicating tightening minus those indicating easing), weighted according to score given and lender's market share. The time series originally begins in 1968, but the question was dropped during 1984-1990.

loans data in the VAR could therefore potentially create an endogeneity bias. The TED spread and SLO survey data are less prone to this sort of problem. The TED spread measures the credit risk premium between an unsecured deposit rate and a government-backed obligation – it is reasonable to assume that such premia are relatively unaffected by shifts in loan demand. Rather, movements in the TED spread are traditionally associated with shocks to the banking system. Such episodes are likely to experience shortages of credit availability, as has happened recently, with banks which have suffered credit losses retrenching from lending in order to replenish their depleted capital. Thus, we argue that the TED spread is more correlated with shifts in loan supply than loan demand. As for the SLO survey data, survey questionnaire is designed in order to measure changes in the tightness of loan standards holding constant the price.[11]

Lags (quarters)	**SLO credit standards[1]**	**TED spread[1]**
1	-0.35 (***)	-0.21 (**)
2	-0.48 (***)	-0.25 (***)
3	-0.48 (***)	-0.28 (***)
4	-0.43 (***)	-0.26 (***)

[1] Correlations with quarterly growth in total commercial bank lending deflated by the GDP deflator. *** ≡ significant at 1% level; ** ≡ significant at 5% level; * ≡ significant at 10% level.

Table 1: Correlations with real loan growth.

[11] Lown and Morgan (2006) raise the concern that the endogeneity problem may not be completely resolved with the standards variable. There could be an omitted variable which is correlated with both output and borrowers' demand for loans, for example, expectations on economic conditions. If banks tighten lending standards in anticipation of deteriorating economic conditions, then the observed correlation between standards and output could in part reflect a reduction in the demand for bank loans as well as the supply.

III. Results

Reduced form VAR estimation

Before proceeding to a discussion of the results of the structural model, it is useful to outline the results of the reduced form VAR estimation in order to confirm that underlying relationships in the data are broadly consistent with theoretical predictions, and also to provide preliminary evidence on the questions we are interested in. We estimate two VAR models, one for each credit variable, using 4 lags of each variable in our preferred specification[12] [13] [14]. Table 2 below gives the sums of co-efficients in both reduced form VARS.

The results accord well with theory, with key macroeconomic relationships displaying the correct signs – higher real interest rates lead to lower GDP growth and inflation, faster GDP growth leads to higher inflation, and faster GDP growth and inflation lead to higher real interest rates.

A key point of interest is the estimated relationships between credit and output. We find a highly significant negative relationship between GDP growth and lagged credit variables in both versions of the VAR. On the contrary, we do not find evidence of a negative relationship between credit and lagged GDP growth, indeed with the exception of the first lag of GDP growth on the TED spread, all lags are actually positive. The results therefore support the view that innovations in credit that cause innovations in output, rather than vice-versa.

Another point of interest is the estimated effects of credit on inflation. Using the TED spread, we do find evidence of a positive and significant relationship between inflation and lagged credit, suggesting preliminary evidence of a supply effect. However, it is difficult to infer the causality, as we also find evidence for a positive and significant relationship between credit and lagged inflation. In the version with the standards

[12] A battery of diagnostic tests indicated the optimal lag order to be between 3-8 lags. We chose 4 lags in our preferred specification in order to conserve degrees of freedom. The analysis was replicated using 8 lags, with little difference to the key results.

[13] The preliminary estimation revealed large residuals in the GDP equation in 1978q2 and in the credit equation in 1974q2-q3, 1974q4, 1978q4, 1979q1, 1980q3-q4 and 1987q4, hence time dummies were inserted in order to exclude these outliers.

[14] In line with standard SVAR methodology, we do not impose any restrictions on the lagged co-efficients, preferring these to be determined purely by the data.

variable, lagged credit is not significant in the inflation equation, and lagged inflation is only weakly significant in the credit equation (although Granger causality tests indicate the relationship is not significant).

Furthermore, higher real interest rates lead to tighter credit in both estimations, although with standards variable the effects are somewhat lagged. These results are consistent with the credit channel of monetary policy, which argues that monetary policy operates through changes in the quantity of as well as the price of credit. Finally, the results indicate that tighter credit tends to be followed by an offsetting monetary policy response, suggesting that the Fed responds to fluctuations in credit, to an extent, in setting monetary policy.

	(1) TED spread Dependent variable:				**(2) SLO credit standards** Dependent variable:			
Independent variable:	GDP	Inflation	Interest rates	Credit	GDP	Inflation	Interest rates	Credit
GDP	0.54 ***	0.21 ***	-0.11 **	0.05	0.57 ***	0.12 ***	0.06 *	5.67 **
Inflation	0.00	-1.14 ***	2.22 ***	0.92 **	-1.87 ***	-0.61 ***	1.33 ***	-2.62 *
Interest rates	-1.13 ***	-0.25 **	0.65 ***	0.44 ***	-2.48 ***	0.16 *	-0.10 *	10.08 **
Credit	-1.58 ***	0.18 **	-0.57 **	-.069 ***	-0.03 *	0.00	-0.01 *	0.12

The table reports the sums of co-efficients on lags of each independent variable for the two VAR estimations, with results of Wald tests on joint significance in brackets: *** ≡ significant at 1% level; ** ≡ significant at 5% level; * ≡ significant at 10% level.

Table 2: Sums of co-efficients in reduced form VARS

Structural VAR estimation

We investigate the impact of the four different sources of shocks by computing impulse response functions from the structural VAR model outlined in section II above.

The results suggest significant evidence of a credit channel, with credit shocks having material and long-lasting effects on output. On average, the effect of credit shocks on GDP growth peaks after 5 quarters, and continues to have a negative impact on GDP growth for up to 10 quarters. Also noticeable are the significant lags - the impact of a credit shock does not feed through to GDP growth until after three quarters on average.

Over our sample period, credit shocks have been a non-trivial source of output fluctuations, although less significant than aggregate supply shocks and real interest rate shocks. Looking at the forecast error variance decomposition of output fluctuations two years ahead, supply shocks and interest rate shocks together account for around 60% of fluctuations whereas credit shocks account for around 10-20%. This provides reasonable evidence that innovations in credit cause innovations in output.

Supply vs. demand shocks

We investigate whether the different types of shocks constitute supply or demand shocks in the sense of Blanchard and Quah (1989), i.e. whether they have permanent effects on the level of GDP and thus constitute shocks to trend output as opposed to cyclical fluctuations around trend. We do this by computing the impulse response functions for the different shocks[15].

Expenditure shocks exhibit cyclical responses which one would typically associate with a demand shock. A negative expenditure shock initially results in period of below trend GDP growth and falling inflation for around 6 quarters. This prompts a monetary policy response and is followed by a period of above trend growth and rising inflation. Hence, the down-phase in growth is offset by an up-phase, such that the long run impact on the level of GDP is relatively small.[16]

Aggregate supply shocks exhibit responses typical of a supply shock. A negative aggregate supply shock results in falling GDP growth and rising inflation. Growth does not subsequently rebound, instead GDP converges to permanently lower long run equilibrium.

Monetary policy shocks resemble more closely supply rather than demand shocks. There is a significant negative impact on the long run level of GDP. A positive shock to real interest rates results in lower growth, and in the short run rising inflation, although inflation subsequently falls.[17]

Credit shocks resemble more closely supply shocks than demand shocks. A negative credit shock (i.e. tighter credit) results in slower growth, and also increasing inflation. Although inflation starts to fall back after 3 quarters, it remains higher compared to a pure aggregate demand shock. There is a significant impact on the long run level of GDP, furthermore the initial tightening in the credit variables is never fully reversed, suggesting that credit conditions converge to a permanently lower level in the long run.

[15] IRFs are usually estimated by setting the size of the impulse equal to the standard deviation of the structural innovations on the relevant equation in the VAR. However, given that the standard deviations are different for different shocks, we normalise the impulses to 1% GDP in order to make the response functions directly comparable.

[16] We estimate the long run impacts by generating cumulative IRFs up to 40 quarters after the impulse.

[17] This surprising effect of a monetary tightening leading to rising inflation, commonly referred to as the "price puzzle", has been widely reported in the empirical literature.

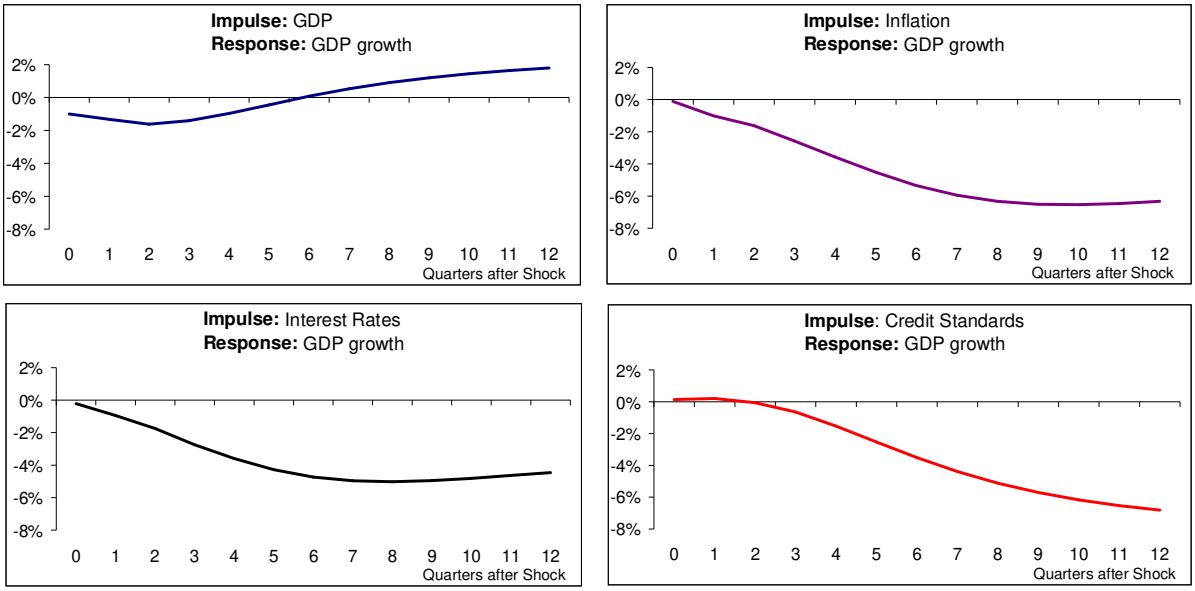

Chart 1: Cumulative impulse response functions

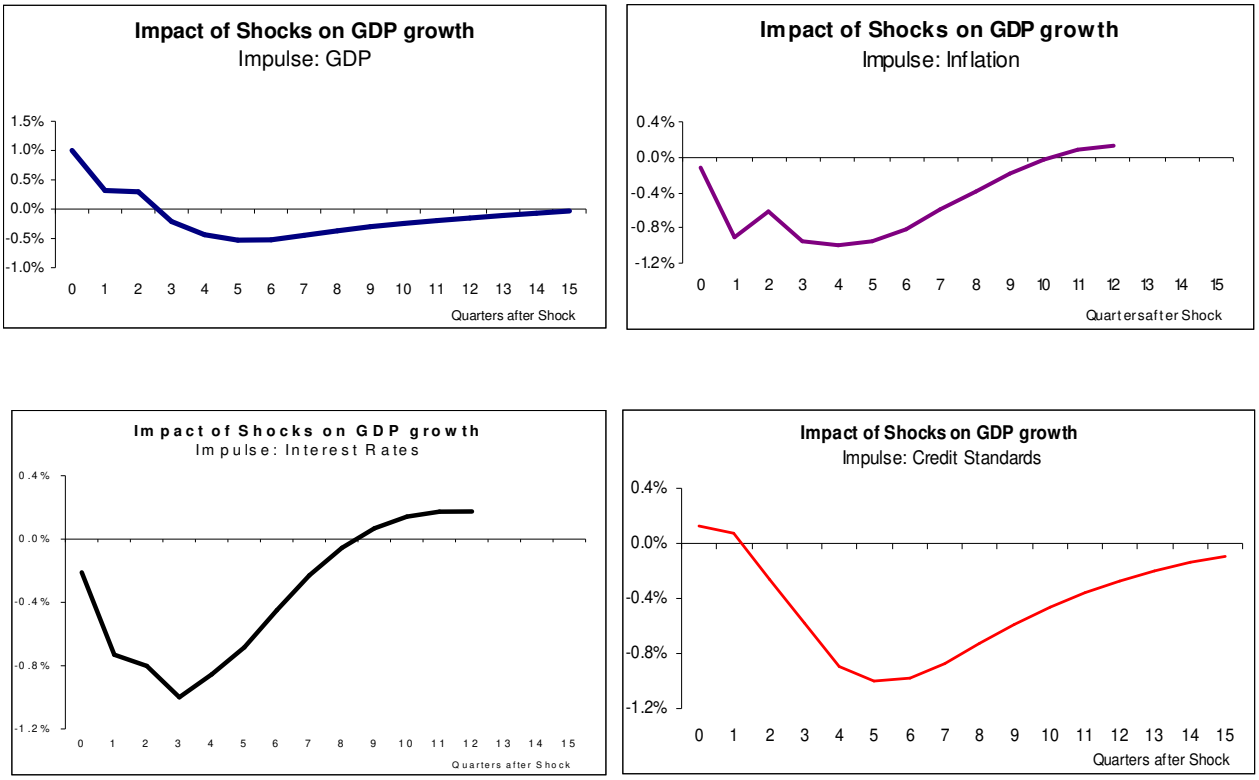

Chart 2: Impulse response functions

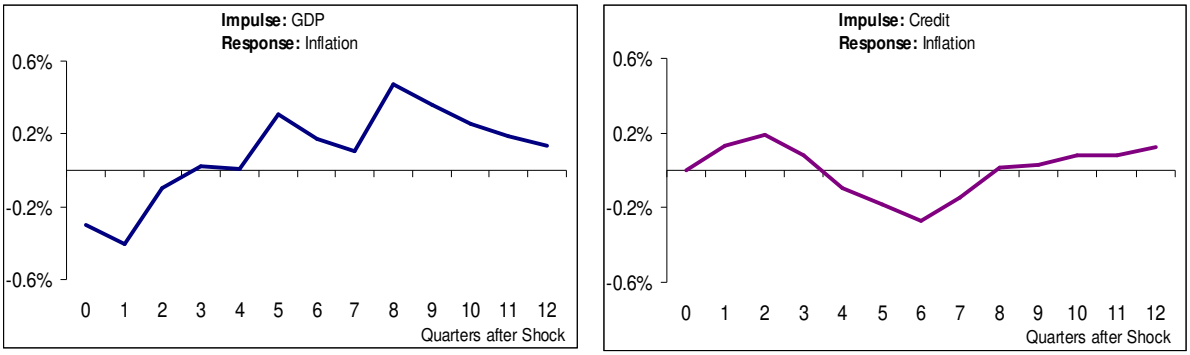

Chart 3: Inflation responses

IV. Conclusions

This paper provides new insights into the relationship between the supply of credit and the macroeconomy. Our results suggest that credit shocks constitute shocks to aggregate supply rather than aggregate demand in that they have a permanent effect on output and cause inflation to rise in the short term.

Our results have important implications for the current debate on the optimal policy response to the ongoing global credit crunch. Our findings that credit shocks are supply shocks has important implications for medium term projections on the output gap and inflation. They imply that a downturn in growth would be associated with a smaller output gap than would arise with a negative expenditure shock, as although aggregate demand weakens, so does aggregate supply. The implications in terms of current events are that, as economic recovery ensues, the risk of inflationary pressures emerging is greater due to the erosion of productive potential during the credit crunch. Our findings also contribute to the ongoing debate on whether more elaborate policy measures might be justified during a credit crunch over and above a straight-forward monetary easing, such as direct lending by the central bank to the corporate sector, in order to relieve the constraints on working capital requirements and thus mitigate the destructive effects on aggregate supply.

We also find evidence of a structural break, in that the long run effect on output of credit shocks seems to have become stronger in recent decades. However, the inflation response has become weaker. Our interpretation of these results is ambiguous. It could be argued that the greater role of credit shocks in driving business cycle fluctuations since the early 1990s has made it easier to identify the long run effects on output. An alternative hypothesis is that the underlying credit propagation mechanisms have changed since the onset of financial deregulation and abolition of quantity controls on credit, which have led to a significant increase in the credit GDP ratio. An implication of this is that the greater reliance of firms on easy access to credit means that when this access is restricted during a credit crunch, the effects on productive potential are more pronounced. As for the more muted inflation response, this could be related to the broader story of improvements in monetary policy-making. Some proponents in the debate have argued that the reduction in volatility in recent decades is not simply due to an absence of supply shocks, but more that a greater credibility of the monetary policy framework has helped to dampen the propagation mechanisms of supply shocks.

A potential direction for future research lies in applying our model to the ongoing policy debate on the reform of prudential regulation. It has recently been argued that credit shocks have played a greater role in driving business cycle fluctuations over the past couple of decades, since the onset of financial deregulation and the abolition of quantity controls on credit. However, it is not well understood whether the variance of credit shocks has increased significantly since the early 1990s, or whether it is the propagation mechanisms of credit shocks that have grown stronger. Indeed, several commentators have argued that financial deregulation has led to an amplification of credit growth and leveraging during boom phases, which has thus precipitated a more severe process of deleveraging and impacts on the real economy during the bust phases.

A fruitful direction would be to use counterfactual VAR methodology a la Stock and Watson (2002), in order to test if, had the variance of credit shocks remained the same throughout history, would the variance of GDP growth attributed to credit shocks have increased significantly? This finding might actually be encouraging in terms of policy reform, given that there is little scope for policy to reduce the incidence of

exogenous shocks. However, there is a potential role for policy in dampening the propagation of credit shocks, either through central bank asset price/credit targeting or through reforms to the prudential regulation of the banking system, for example, the adoption of pro-cyclical capital requirements. A detailed analysis of such reforms is beyond the scope of this paper, and is left for future work.

Appendix A

A Formal Exposition of the SVAR Model

$$AX_t = \Phi(L)X_t + \varepsilon_t, \qquad E(\varepsilon\varepsilon') = \Omega \tag{1}$$

$$A = \begin{pmatrix} 1 & . & . & . \\ 0 & 1 & . & . \\ 0 & 0 & 1 & . \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$A(I - A^{-1}\Phi(L))X_t = \varepsilon_t,$$

Assuming matrix $(I - A^{-1}\Phi(L))$ is invertible gives

$$X_t = B(L)u_t$$

where $u_t = A^{-1}\varepsilon_t$ and $B(L) = (I - A^{-1}\Phi(L))^{-1}$

Matrix B(L) is estimated from the data using OLS regressions. Note that the u's are linear combinations of the underlying structural disturbances ε, hence impulse response functions generated from shocking the reduced form will not be meaningful in terms of determining the true structural dynamics of the model. In order to do this, identifying restrictions must be imposed on matrix A. The variance-covariance matrix of reduced form disturbances is given by:

$$E(uu') = E(A^{-1}\varepsilon\varepsilon'(A^{-1})')$$

$$= A^{-1}\Omega(A^{-1})'$$

The SVAR methodology requires that identifying restrictions are imposed on matrix Ω. The diagonal elements are normalized to 1 (giving the structural disturbances unit variances), and all off diagonal elements are set to zero (which implies mutual orthogonality between the structural disturbances), hence Ω becomes the identity matrix. Note that there exists a one to one mapping between restrictions imposed on matrix Ω and corresponding restrictions on matrix A (e.g. for a 4 variable model, the assumption of mutual orthogonality implies 6 restrictions on Ω, which requires only 6 further restrictions on matrix A for the system to be exactly identified).

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