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Tight Money, Tight Standards

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Tight Money, Tight Standards

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Abstract

This paper uses a structural vector autoregressive model (SVAR) to study the effect of monetary policy and bank lending standards on business loans. The results are consistent with a dynamic model of bank behaviour that explicitly considers a bank's soundness position. According to the results of the empirical estimation and prediction of the theoretical model, increases in loans, particularly non-performing loans or delinquency rates due to a monetary policy shock, deteriorate a bank's health, causing it to apply more stringent lending standards. Thus, the results show that banks raise their lending standards in response to the tightness of money, defined as increases in the demand for the bank's loans while its resources (reserves or deposits) remain constant. Furthermore, lending standards dominate loan rates in explaining loans and output dynamics.

Keywords: Monetary Policy, Credit Standards, Bank Behaviour, SVAR model

1. Introduction

This paper investigates the dynamic relationship between monetary policy, bank lending standards and loans. Two variables, the Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS) and the percentage of non-performing loans or delinquency rate, closely monitored by the Federal Reserve, are used as proxies for banks' credit standards and soundness level, respectively. Luckett [33] presents a model of the banking firm and some empirical evidence to justify shifting lending standards as a rational bank

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response to tight and easy monetary conditions but fails to address the role of monetary policy. I extend his work by specifying a dynamic model that captures the relationship between monetary policy, loans, credit standards, and a soundness requirement imposed by an external regulator of a bank. I then employ a structural vector autoregressive model (SVAR) to test the model's predictions empirically. The SVAR model is identified with an external instrument and the methodology is closely related to proxy vector autoregressive models (pVAR) of Stock and Watson [45], Mertens and Ravn [35], Pfiffer [39], Coibion [13] and Ramey [40].

Two potential endogeneity problems can complicate the empirical investigations conducted in this paper. One such problem is identified by Bassett et al. [3]. First, many macroeconomic disturbances influencing a bank's loan supply likely have other independent real effects. For instance, any unanticipated change in the stance of monetary policy may change the interest rate on (or quantity of) bank loans but may, at the same time, also affect production and spending through its impact on expectations and prevailing interest rates in other markets. Therefore, a key empirical challenge in analysing transmission channels lies in correctly identifying and disentangling loan demand from loan supply. In other words, one needs to correctly identify the independent effect of credit standards on the loan quantity. Second, monetary policy stance, particularly for studies that focus on the United States, is often identified with the effective federal funds rate. This approach raises concern over another endogeneity problem for this study, particularly when the percentage of non-performing loans to total loans (or delinquency rates) is used as a proxy measure for soundness.

Pfiffer [39] notes that the above identification strategy is not straightforward as one needs to establish that the federal funds rate is exogenous to non-performing loans or delinquency rates. Therefore, two conflicting arguments arise. On the one hand, the federal funds rate is deemed exogenous to expected future defaults as central banks do not explicitly target future defaults. On the other hand, although not set directly as a function of future defaults, the federal funds rate is likely to respond indirectly to expected future defaults, given that default risks are often correlated with economic activity. Hence, a prediction of declines in non-performing loans upon an expansionary monetary impulse may still be driven by the fact that the Federal Reserve acted in such a manner in anticipation of a possible downturn in economic activity.

To address the identification challenge discussed above, I estimate an SVAR model identified with an external instrument, covering the period between 1979:Q3 and 2008:Q4. I use a hybrid instrument for monetary policy shocks, combining two-stage least-squares estimation of the instrument generated by the literature's most widely used approach. Specifically, I use a cumulative version of Romer and Romer shocks [42] (developed by Romer and Romer 2004 and extended by Breitenlechner [9]). To deal with the endogeneity problem that relates to loan supply and demand, I use the changes in bank lending standards for business loans (loans to middle-sized and large firms) as reported on the Federal Reserve Board's quarterly Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS), as a proxy for bank credit standards.

The paper's theoretical part specifies a dynamic version of Luckett's [33] and Peek and Rosengren [38] static models in order to throw more light on the relationship between bank soundness, loans and lending standards. Luckett's model echoes how, for example, a restrictive monetary policy will affect all sectors of the economy differently. The model shows how banks adjust their credit standards in response to tight or easy monetary conditions. Peek and Rosengren's analysed how capital-constrained and unconstrained banks react differently to both monetary policy and capital shocks.

This paper's results confirm previous literature findings and unveil some novel features. First, shocks to credit standards significantly affect loans and output growth. In particular, upon a one standard deviation shock to standards, standards tighten by 7% on impact. As a result, loan growth and output decline immediately and substantially. Second, standards initially ease in response to changes in the monetary policy stance, identified with shocks to either the federal funds rate or cumulative Romer and Romer series, but it subsequently overshoots. Thus, for the sample period considered in this study, changes in standards are significantly endogenous to the policy process.[1] Third,

[1] Lown, Morgan and Rohatgi [32] find federal funds rate to cause some tightening of standards, but the impact is short-lived and barely significant. However, Lown and Morgan [31] and Lown and Morgan [30] find credit standards not very sensitive to shocks to the federal funds rate.

monetary policy shock reduces output once standards are accounted for in the model specification. Fourth, business loans show a muted response to a contractionary monetary policy shock on impact but gradually increase for about a year before trending downwards. Non-performing loans increase and peak at 5% by the tenth quarter. Fifth, on impact, banks tighten their standards by 3% upon a shock to non-performing loans. It takes about five quarters before banks commence easing of standards. Finally, Tight money leads to tight standards. Thus, shocks to loan demand or loan growth cause banks to tighten standards on impact.

Conventional monetary models often hypothesise that the banking sector or credit market broadly is an important source of - and propagation mechanism for economic shocks. Many of such studies dedicate considerable attention to assessing monetary policy's causal effect by identifying unexpected variations in the policy stance similar to classic approaches (Bernanke and Blinder [4]; Christiano, Eichenbaum, and Evans [12]. Some focus on the risk-taking activities of banks following a monetary impulse (Maddaloni, Peydró, and Scopel [34]; Jimenez et. al.[25]; Ioannidou, Ongena and Peydró [23]; Dell'Ariccia, Laeven, and Suarez [15]). Others focus on bank lending and bank capital channel effects (Gambacotra and Mistrulli [18]; Repullo [41]; Kishan and Opiela [29].[2] Very few studies have attempted to examine the interrelationship between loans, lending standards and monetary policy effects from the bank's perspective and within their goals. This paper's approach is closely related to those few studies that focus on banks' credit standards and are conducted along the lines of the almost forgotten "availability doctrine" of the 1950s and credit rationing theories.[3] Almost all such studies use the Senior Loan Officer Opinion Survey data for their estimations.[4]

Lown and Morgan [30] investigate the correlation between reported changes in commercial credit standards and fluctuations in lending and spending in the U.S. Their VAR

[2]See Borio and Zhu [8] for a survey of both theoretical and empirical studies.

[3]For studies on how monetary policy influences credit availability (see, for example, Jaffee and Modigliani [24] and Kane and Malkiel [26]).

[4]The Federal Reserve's Senior Loan Officer Survey is conducted four times yearly, and up to 60 U.S. commercial banks participate in each survey.

analysis reveals that shocks to lending standards are significantly correlated with innovations in commercial loans at banks and real output. They find lending standards to strongly dominate loan rates in explaining variation in business loans and output.[5] Bassett et al. [3] assess the macroeconomic effects of shocks to the supply of bank-intermediated credit, using a standard monetary VAR that includes a measure of unexplained changes in lending standards. They find that innovations in their loan supply measure (cross-sectional average of the “unexplained" changes in banks' reported lending standards) have an economically large and statistically significant effect on output and core lending capacity in the U.S.

I contribute to the literature by extending Luckett's theoretical model to capture the effects of monetary policy on bank behaviour. Luckett's model posits two conditions that may cause a shift in the banks' minimum credit standards. First, a bank with a deteriorating balance sheet or soundness position will apply more stringent credit standards. I report evidence of broader effects. I find that a contractionary monetary policy increases non-performing loans or delinquency rates. This finding is consistent with Bernanke, Gertler, and Gilchrist [5], Buch, Eickmeier, and Prieto [11], Jimenez et. al.[25] and Pfiffer [39], who find evidence of a positive relationship between monetary policy and non-performing loans or delinquency rate. The results also show that increases in non-performing loans (represented by a one-standard-deviation shock) deteriorate the banks' health and cause them to tighten their standards. Second, Luckett's model hypothesises that the minimum credit standards imposed by a bank will rise due to increased “tightness - increases in loan demand" as perceived by the bank. I report findings that lend support to the validity of this hypothesis. Specifically, shocks to loan growth cause tightening in the banks' credit standards on impact. Extending the analysis and interpreting the results within the context of a credit cycle, such tightening of standards

[5] In a series of papers, Harris ([20]; [22]; [21]) reports a significant, positive correlation between commercial credit standards, loan rates and other non-price terms. The author, however, does not investigate the relationship between credit standards, lending, and output. Unlike Harris, Lown, Morgan and Rohatgi [32]; Lown and Morgan [31] consider such relationships and their role in the monetary transmission mechanism

would significantly affect business loans and output and subsequently cause easing of standards, followed by higher spending and loan levels, and so on and on. The latter results are consistent with Lown, Morgan and Rohatgi [32], Lown and Morgan [31], and Lown and Morgan [30], who find standards to have a significant effect on loans and output.

The remainder of the paper is organised as follows: Section two specify the model employed for the analysis and discuss the theoretical framework; Section three conducts the empirical analysis and discusses the data used, the identification strategy, and the estimation results. Section four offers some concluding observations.

2. Theoretical Framework

In this section, I present a stylised two-period version of Luckett [33] and Peek and Rosengren [38] static models of bank portfolio behaviour to briefly analyse the interrelationships between monetary policy, loans, lending standards and a soundness constraint imposed by an external regulator of a bank. The model is partial equilibrium in nature, and the bank is assumed to operate in a monopolistic competitive environment with assumptions as in Baglioni [2]; and Peek and Rosengren [38]. Thus, the mean interest rate in the loan market has a bearing on the interest rate that the bank charges. The bank is assumed to obtain funds from deposits (both time and demand) and invest in loans and government securities.

The bank is bound by a soundness constraint imposed by an external regulator in its decision-making process. Moreover, the bank's level of soundness today affects its risk-taking activities tomorrow and vice versa. In the first period, the bank observes the demand for deposits and loans, and based on this information, it decides on how much loans to make and what rate to charge. First-period decisions are also assumed to have a bearing on second-period decisions.

The basic framework developed in this section provides the theoretical background for the empirical investigations.

2.1. A Simple Model of Bank Behaviour

Assume that the bank's balance sheet is hypothesised as below:

$$R_j + G_j + L_j = D_j + T_j \quad j = 1,2 \tag{2.1}$$

where R_j is required reserves, G_j is government securities, L_j is loans, D_j is demand deposit, T_j is time deposit and the subscript j is the time period.

The above balance sheet constraint is an ex-ante definition as in period one ($j = 1$), the bank can set its loan rate at any desired level and choose how many loans to make.

The bank holds a fraction α of demand deposit (D_j) in required reserves (R_j) but no excess reserves.

$$R_j = \alpha D_j \quad j = 1,2 \tag{2.2}$$

The bank's primary source of funds is deposits. I separate deposits into demand deposit (D_t) and time deposit (T_t), as shown in equation (2.1). Demand deposit in each period is inversely related to the federal funds rate and positively to a nonprice deposit term (ω_{d_j}).

$$D_1 = d_{01} - d_{11} r_{f_1} + d_{21} \omega_{d_1} \tag{2.3}$$

$$D_2 = d_{02} - d_{12} r_{f_2} + d_{22} \omega_{d_2} \tag{2.4}$$

Assume further that time deposit T_t in each period serves as a marginal source of funds for the bank. Hence, the bank can expand total deposits by offering rates above the mean-market rate ($\bar{r}_{T_1}$). The competitive nature of the banking industry and, to a broader extent, the financial sector suggest that the sensitivity of time deposit inflows or outflows (t_{11}) to changes in the rate of such deposits would be high. The demand for time deposits is also positively related to their maximum possible decline (ω_{t_j}).

$$T_1 = t_{01} + t_{11}(r_{T_1} - \bar{r}_{T_1}) + t_{21} \omega_{t_1} \tag{2.5}$$

$$T_2 = t_{02} + t_{12}(r_{T_2} - \bar{r}_{T_2}) + t_{22} \omega_{t_2} \tag{2.6}$$

The bank also chooses how much government securities (G_j) to buy each period. I follow Peek and Rosengren [38] by assuming that securities are a fixed proportion of demand deposits (h) net of required reserves (R_j). This approach captures the buffer stock motive for holding securities, whereby banks maintain securities for liquidity in the event of a run on transaction deposits.

$$G_1 = h_{01} + h_{11}D_1 - R_1 \tag{2.7}$$

$$G_2 = h_{02} + h_{12}D_2 - R_2 \tag{2.8}$$

Portfolio separation holds that the bank's choice of deposits, loans, and reserves is independent of one another, with necessary adjustments to G to satisfy the balance-sheet constraint.

The behavioural equations that characterise the stylised nature of the loan market are discussed below.

2.1.1. Soundness

Soundness generally refers to the ability of the bank to perpetuate itself under distressed conditions. In other words, it refers to the ability of the bank to withstand shocks and absorb unexpected losses. The soundness constraint captures the bank's asset and liability positions and the credit standards to which loan recipients are subjected. Thus, it assesses the bank's strength by comparing its weighted quantities of assets to weighted liabilities. The bank's subjective weights on the asset are assigned based on its best estimates of the realizable value in case of forced liquidation and sizeable potential losses arising from default. Similarly, the subjectively assigned weights to liabilities are based on an estimated maximum possible paydown or decline in its liabilities (principally deposits). It is also assumed that these weights are known and agreed on by all members of the banking industry and the regulatory bodies. The bank's soundness level cannot be lower than the difference between its weighted assets and its weighted liabilities. Thus, the soundness constraint that binds at each period is defined as[6]

$$\tau_j \geq \omega_{g_j} G_j + \omega_{l_j} L_j - \omega_{d_j}(D_j - R_j) - \omega_{t_j} T_j \quad t = 1, 2 \tag{2.9}$$

where $\omega_{g_j}, \omega_{l_j}, \omega_{d_j}$ and ω_{t_j} represents the weights associated with the balance sheet items. These weights are positive, and it is assumed that $\omega_{d_j} > \omega_{g_j} > \omega_{l_j}$. ω_{l_j} is assumed to be an index of loan quality. Hence, for a bank with given total assets, a rise in loans (L_j) necessarily comes at the detriment of government securities (G_j), resulting in a decline in its soundness level (τ_j).[7] Greater deposits $(D_j$ and $T_j)$ imply less soundness unless the deposits are held entirely in the form of cash. Ideally, a bank that maximises profit subject to a soundness constraint imposed by the regulatory authority must consider the effect of all balance sheet items on soundness and profit. However, for brevity, I confine myself to Luckett's approach by not imposing additional market constraints.

2.1.2. Loan Market

The Bank is free to set its loan rate (r_{L_j}) at any desired level. It can increase (or decrease) loans by setting r_{L_j} below (or above) the market rate $(\bar{r}_{L_j})$, which is taken as given. The loan demand function for periods one and two can be written as

$$L_1 = g_{01} - g_{11}(r_{L_1} - \bar{r}_{L_1}) - g_{21}\omega_{l_1} \tag{2.10}$$

$$L_2 = g_{02} - g_{12}(r_{L_2} - \bar{r}_{L_2}) - g_{22}\omega_{l_2} + g_{32}L_1 \tag{2.11}$$

[6] See, for example, Baglioni [2] for a model with capital requirement constraint. Any of these constraints are consistent with the Basel Accords. One could argue that even if the soundness constraint is not binding in period one, a bank with a low level of soundness may optimally forego profitable lending opportunities in period one to lower the risk of insolvency in period two.

[7] (G) could be thought of as being adjusted as and when it becomes necessary in order to satisfy the balance-sheet constraint.

The above formulation of the loan demand equation is standard because price and quantity have an inverse relationship. Potential borrowers factor price into their decision-making process and face some costs when switching banks. This also means, implicitly, that the bank can act (locally) as a discriminating monopoly: can ration credit availability among potential borrowers by either raising or lowering its credit standards (ω_{l_j}).[8] In other words, equations (2.3) and (2.4) mean that the quantity of loans L_j is assumed to not only vary inversely with interest rate (r_{L_1}) but also the quality of loans or the creditworthiness of potential borrowers ω_{l_j}. It follows that a change in the bank's credit standards will alter its loan demand function.

Besides internally generated funds, both big and small firms finance (partly and largely) their production with bank loans. Therefore, the sensitivity of loan demand (g_{11}) to a change in the interest rate charged by the bank is likely to be high.[9]

Following Van Loo [47], I assume that period two amount of loans demanded depends on the bank's stock of loans outstanding in the first period. Such formulation also implicitly means that the bank's standards in period one influence period two loans.

The market interest rates on time deposits, loans, and securities are each assumed to be a function of a market-specific effect (a_0, b_0 and c_0) and an effect (positively) related to the federal funds rate (r_{f_j}).[10]

$$\bar{r}_{L_j} = a_0 + \phi r_{f_j} \tag{2.12}$$

$$\bar{r}_{T_j} = b_0 + \phi r_{f_j} \tag{2.13}$$

[8] Jaffee and Modigliani [24] discuss equilibrium rationing and dynamic rationing and how they affect banks profits.

[9] see, for example, Brito and Mello [10] for a study about how growth and survival of firms is affected by the evolution of the lender-borrower relationship when multiple sources of asymmetrical information exist.

[10] To simplify the algebra, we assume that each market interest rate changes by the same amount ϕ for a given change in the federal funds rate (see, for example, Peek and Rosengren [38] and Kishan and Opiela [28].)

$$\bar{r}_{G_j} = c_0 + \phi r_{f_j} \quad (2.14)$$

2.1.3. Bank's Profits Maximization

The bank maximizes its profits (π) subject to the balance sheet and soundness constraints of equations (2.1) and (2.9), respectively. In this formulation, the bank's profits are simply the sum of interest income from loans (r_{L_j}) and interest received from securities holdings (r_{G_j}), minus both interest paid on demand deposits (r_{D_j}) and on time deposit deposits (r_{T_j}). Thus, the profit function can be written as follows:[11]

$$\pi = r_{G_1}G_1 + r_{L_1}L_1 - r_{D_1}D_1 - r_{T_1}T_1 + \beta\left[r_{G_2}G_2 + r_{L_2}L_2 - r_{D_2}D_2 - r_{T_2}T_2\right] \quad (2.15)$$

where β is the discount factor and is assumed to be constant for simplicity's sake. The necessary assumptions, particularly regarding the balance sheet identity, definition of soundness and required reserves hold in both periods.

The maximization problem is formed with the Lagrangian, and the profit function, equation (2.15), is maximized with Lagrangian multipliers associated with the soundness constraints that bind in each period. My interest is in L_j, r_{f_j} and ω_{l_j} so equations (1)-(8) is used to eliminate r_{L_j}, r_{T_j}, G_j, R_j, T_j and D_j. The Lagrangian equation is maximised with respect to L_j and ω_{l_j} to obtain the first-order necessary conditions. I then use the first-order conditions to solve for L_j and the Lagrangian multiplier λ_j.

The testable hypotheses concerning both the responsiveness of loans to changes in monetary policy and standards are then obtained by taking derivatives of L_j with respect to r_{f_j} and ω_{l_j}.[12]

$$\frac{\partial L_1}{\partial r_{f_1}} = -\frac{[g_{11}(1-h_{11})d_{11}]}{g_{11}+t_{11}} < 0 \quad (2.16)$$

[11]Bank profits can also be specified as the difference between revenue and costs. Luckett's simple formulation ignores the cost component (see, for example, Mingo and Wolkowitz [36] for a model that considers the cost of capital and deposit). His assumption on deposits is that the bank is so constituted in a manner that service charges on deposits precisely offset the costs of servicing them.

[12]See Appendix A for a derivation of the result.

$$\frac{\partial L_1}{\partial w_{l_1}} = -\beta \frac{g_{11} g_{21} g_{32}^2 t_{11}}{2 g_{12}[g_{11} + t_{11}]} < 0 \tag{2.17}$$

$$\frac{\partial L_2}{\partial r_{f_2}} = -\frac{[g_{12}(1 - h_{12}) d_{12}]}{g_{12} + t_{12}} < 0 \tag{2.18}$$

$$\frac{\partial L_2}{\partial w_{l_2}} = -\frac{[1 - \beta] t_{12} g_{22}}{2[g_{12} + t_{12}]} < 0 \tag{2.19}$$

assuming $h_j, \beta < 1$.

It can be seen from the above derivatives (equations (2.16) and (2.18)) that in both periods, loans (L_j) will rise in response to an expansionary monetary policy shock as long as $h_j < 1$. However, it can be seen from equation (2.9) that a rise in loans will lead to a decline in the bank's soundness position (τ). The rate at which τ declines depends on the quality of loans that the bank issues. In other words, the bank can expand loans and, at the same time, maintain a constant level of soundness only by raising its standards (ω_{l_j}). In both periods one and two, the interest sensitivity of loans and time deposits are important determinants of the magnitude of the response of loans to a change in the monetary policy rate.

Remember, we hypothesized that the second-period loan amount depends on the bank's stock of loans outstanding during the first period (see equation (2.11)). The implication of this can be seen from equation (2.17), where the interest sensitivity of loans and time deposits are not the only important determinants of the response of loans to a change in standards but also the bank's ability to predict second-period loans. This is expected since the bank foresees that a large stock of outstanding loans or high non-performing loans in period one tends to worsen its soundness position in the future (if not current), and the bank will tend to mitigate this by raising its lending standards. This suggests an inverse relationship between the bank's soundness position and credit standards.

Overall, the intuition suggested by this dynamic model is that all things equal, if soundness matters to the bank at all, particularly in periods of easy and tight money conditions, then the only rational response of the bank to enable it to achieve its new equilibrium position will be to shift its credit standards.

3. Empirical Estimation and Analysis

This section discusses the data employed as proxies for soundness, credit standards, and the macroeconomy. It then introduces the external instrument used to identify monetary policy shock in an SVAR model. It concludes with a discussion of the estimated results and the robustness test.

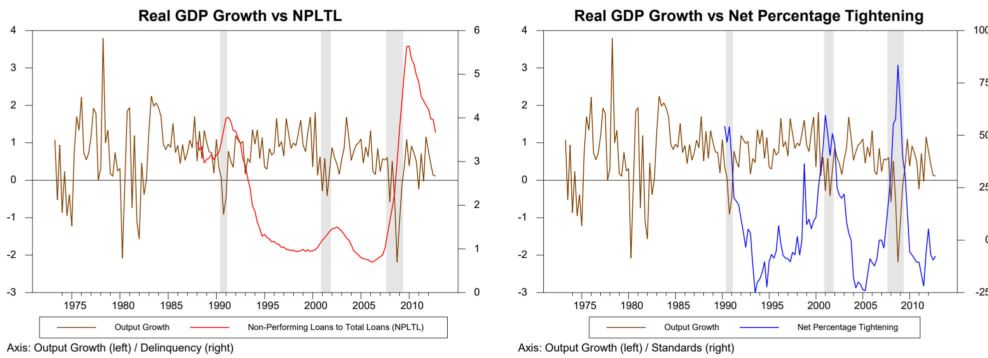
3.1. The Data Set and Stylized Facts

In this paper, the Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS) data - net percentage of domestic banks tightening standards for business loans and Federal Reserves data on non-performing loans to total loans (percentages) or delinquency rate are used as proxies for credit standards and soundness, respectively. The Federal Reserve's Senior Loan Officer Opinion Survey, which is conducted each quarter, asks participating banks whether, since the previous quarter, they have "tightened" or "eased" their standards for making commercial loans. Data on the net percentage of domestic banks tightening standards business loans are available starting from 1990q2.[13]

Appendix B reports the descriptive statistics of these and other macroeconomic variables included in the SVAR. It is intriguing to note in passing that the simple correlation between business loan growth and standards is weak, though negative. The correlation between economic activity and standards is strong and negative. Appendix C describes the variables and their sources. All the series are quarterly.

[13] I use non-performing loans to total loans (percentages) as a proxy measure for soundness. This measure is one of the four main indicators (financial soundness indicators) used by the IMF in analysing and assessing the financial systems' strengths and vulnerabilities. Gambacorta and Marques-IbanezKlein [17] use regulatory (tier 1) capital to risk-weighted assets ratio (which determines a bank's potential solvency by measuring its available capital as a percentage of its risk-weighted assets) in their regression model, and find that well-capitalised banks show a significantly higher supply of lending, especially during the period of a financial crisis. This series could have also been used as a proxy measure for soundness and perhaps examine the soundness constraint from a regulatory viewpoint. However, the series available on both Federal Reserve and IMF (financial soundness indicator) sites are all of a shorter span.

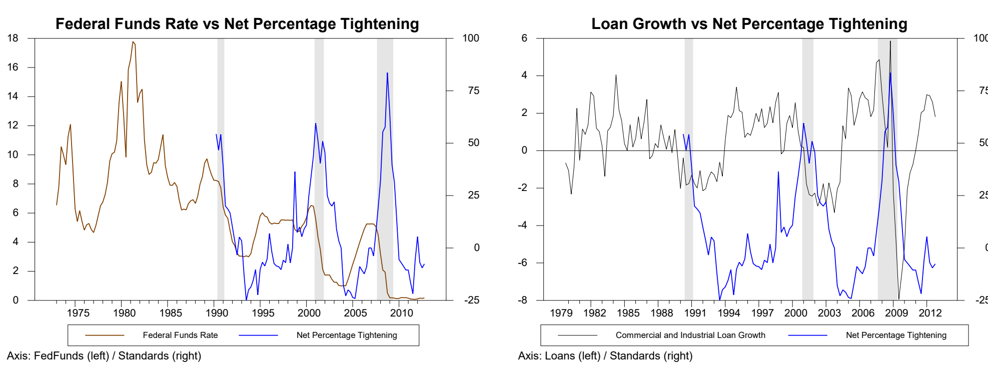
Figure 1: Real GDP Growth vs. NPLTL, and Real GDP Growth vs. Changes in Commercial and Industrial Lending Standards



Note: Shaded areas represent U.S. recession periods. NPLTL is the percentage of non-performing loans to total loans.

Figures 4, 5 and 6 show the evolution of the variables of interest used in the analysis. Figure 4 shows the countercyclical nature of non-performing loans and net percentage tightening series.[14] Figure 4 also shows that banks swiftly tighten standards in the period leading to recessions. Figure 5 shows that tighter loan standards positively correlate with the federal funds rate.

Figure 2: Federal Funds Rate vs. Changes in Commercial and Industrial Lending Standards, and Loan Growth vs. Changes in Commercial and Industrial Lending Standards

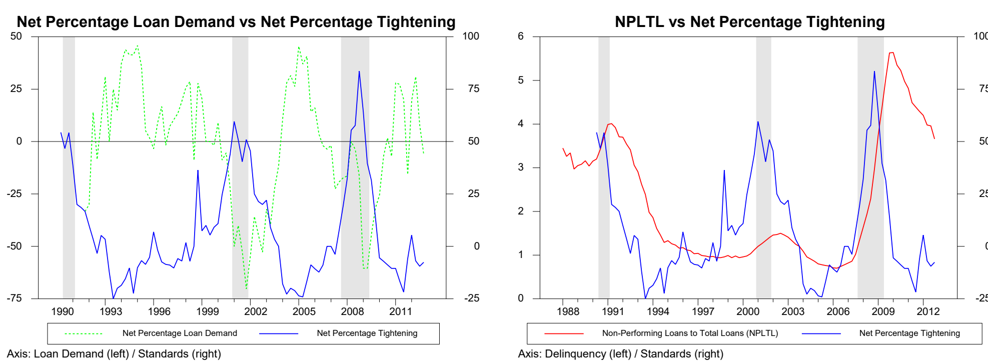


Note: Shaded areas represent U.S. recession periods.

[14]The net percentage tightening is given by the number of banks tightening less the number easing, divided by the number reporting.

Figure 6 (on the right) shows that tighter standards usually precede high-default (delinquency build-ups) periods. It also shows (left figure) that loan officers tend to report weaker demand for commercial and industrial loans at the same time that they report tightening standards. Lown, Morgan and Rohatgi [32] emphasise this point with a business cycle scenario, where loan demand falls during contraction periods when cautious banks are less willing to lend and rises in expansion periods when, for example, firms demand more loans and banks are more willing to lend. This can also seen from the second figure of Figure 5. Thus, loan growth slows and declines in periods when loan officers report tightening standards. This is more evident in the early periods (quarters) of 1990, 2000 and 2008, where rapid declines follow sharper tightening in loan growth.[15] The ensuing periods witnessed a relatively rapid growth in loan demand due to less tightening and easing of standards by loan officers.

Figure 3: Changes in Commercial and Industrial Loan Demand vs. Changes in Commercial and Industrial Lending Standards, and NPLTL vs. Changes in Commercial and Industrial Lending Standards, and



Note: Shaded areas represent U.S. recession periods. NPLTL is non-performing loans to total loans (percentages).

The use of non-performing loans to total loans (percentages) as a proxy measure (or determinant) for soundness in this study renders the choice of an appropriate measure for identifying the causal effect of a monetary shock tricky. Pfiffer [39] points out that proper identification requires isolating fluctuations in the federal funds rate that is exoge-

[15] These periods of rapid loan growth declines coincide with those immediately preceding U.S. recession periods.

nous to the Federal Reserve's expectations of future delinquency rates. Therefore, I use the time series of the most widely used instrument for a monetary shock in the literature, Romer and Romer shocks [42]. The Romer and Romer shocks are obtained as residuals from regressing an index of the federal funds rate's intended changes on the Federal Reserve's Greenbook forecasts of output growth, GDP deflator, and unemployment rate. Pfiffer reiterates that it is reasonable to expect that the Romer and Romer shocks are at least in part exogenous to the Federal Reserve's forecast of defaults since future GDP is realistically correlated with the future financial position of borrowers. It could also be argued that the senior loan officers consider the current monetary stance when deciding on their lending standards. Afanasyeva and Güntner [1] echo that the Federal Reserve conducts the SLOOS in a manner that results are available before the quarterly meetings of the Federal Open Market Committee (FOMC). Such timing is consistent with the identification scheme employed in this paper.

I follow the approach of Coibion [13] and Ramey [40], by using a hybrid version (cumulative) of Romer and Romer shocks (series extended by Breitenlechner [9]).[16]

The empirical estimations (baseline) are conducted over the sample period 1992q1 to 2007q4. The baseline estimation excludes the period after 2007q4 because after the collapse of Lehman Brothers, the U.S. monetary policy hit the zero lower band and operated through the balance sheet of the Federal Reserve rather than through the Federal Funds rate. The stationarity properties of the series are examined using the augmented Dickey-Fuller test. The tests are estimated in levels and first differences, with and without a trend and constant. Table 2 of Appendix B reports the results of the tests. Except for real GDP, which is I(0) in levels under the first two tests, and log of GDP deflator, which is I(0) in levels under the first test, the rest of the variables are I(0) in the first difference. As part of an extensive robustness check of the model's results, I extend the sample period to cover the GFC period, thus, from 2007q4 to 2012q4.

[16] Coibion's [13] hybrid specification finds monetary policy shocks to have "medium" effects, result which is consistent with other specifications including GARCH estimates of Taylor Rules (see, for example, Hamilton [7] and Sims-Zha [44]) and time-varying parameter models (see, for example, Boivin [6] and Coibion and Gorodnichenko [14]).

3.2. Estimation: Proxy SVAR Model and Identification

The empirical estimation begins with a test of the hypotheses stemming from Luckett's theoretical model discussed under section 2 of this paper. Thus, the hypotheses that credit standards vary directly with the tightness of money and that soundness and credit standards are inversely related. I later proceed to examine the response of the variables of interest to a monetary policy shock.[17]

I follow the literature by specifying a parsimonious SVAR model comprising of core variables: the log of real GDP, the log of GDP deflator, the log of commodity prices, and the federal funds rate, and one additional variable that changes for each model equation. [18] In particular, the proxy SVAR considered here follows the methodology of Stock and Watson [45], Mertens and Ravn [35] and Pfiffer [39]. I describe the adopted methodology below.

Let Y_t be a vector of endogenous variables under consideration, A and C_l $\forall\ l \geq 1$ coefficient matrices, and ε_t a vector of structural shocks with $E\left[\varepsilon_t\right] = 0$, $E\left[\varepsilon_t \varepsilon_t'\right] = I$, $E\left[\varepsilon_t \varepsilon_s'\right] = 0$ for $s \neq t$ where I is the identity matrix. l denotes the order of the VAR model and is selected based on the Bayesian information criterion. Alternative lag selection are chosen for robustness check. The general structural representation can then be written as

$$AY_t = \sum_{l=1}^{p} C_l Y_{t-l} + \varepsilon_t \tag{3.1}$$

The above specification, for the sake of brevity, excludes deterministic terms and exogenous regressors.

Multiplying each side of equation (9) by A^{-1} yields an equivalent reduced form rep-

[17] Luckett fails to address the main hypothesis of his theoretical model. Moreover, the problem of data availability is evident in his work.

[18] These variables represent key aggregates of the macroeconomy: output (real GDP), the price level (GDP deflator), “supply" (commodity prices), and “demand" (fed funds rate).

resentation as

$$Y_t = \sum_{l=1}^{p} \delta_l Y_{t-l} + u_t \tag{3.2}$$

The reduced form residuals are related to the structural shocks by

$$u_t = B\epsilon_t \tag{3.3}$$

where $\delta_l = A^{-1}C_l$, $B = A^{-1}$.

Rewrite the (shocks) equation (11) as

$$u_t = c\epsilon_t^{mp} + B^*\epsilon_t^* \tag{3.4}$$

where ϵ_t^{mp} denotes the monetary policy shock and ϵ_t^* captures the remaining $k-1$ structural shocks. The identification of the monetary shock consists of estimating the $k \times 1$ vector c in equation 11.

To achieve proper identification with an external instrument, suppose m_t represent an external variable satisfying the following conditions:

$$E\left(m_t\epsilon_t^{mp}\right) \neq 0 \tag{3.5}$$

$$E\left(m_t\epsilon_t^*\right) = 0 \tag{3.6}$$

The variable m_t is a valid instrument for identifying the shock if it is contemporaneously correlated with the policy shock of interest, ϵ_t^{mp} (that is, relevance condition given by equation (4) is satisfied) and if it is contemporaneously uncorrelated with all other structural shocks (that is, exogeneity condition given by equation (5) is satisfied).

Equations (12) to (14) imply that $E\left(u_t m_t\right) = c \cdot E\left(m_t\epsilon_t^{mp}\right)$. The instrument m_t thus identifies c up to a scale and sign.

Let j be the equation with federal funds rate as a dependent variable. A relative impulse vector $\tilde{c}$ can then be defined as c/c_j, with c_j being the *j-th* element of the absolute impulse vector c. $\tilde{c}$ allows for generating impulse responses to ϵ_t^{mp} by a unit impulse in the federal funds rate.

With $E(u_t m_t) = c \cdot E\left(m_t \epsilon_t^{mp}\right)$, $\tilde{c}$ can be estimated using $\hat{E}(u_t m_t) / \hat{E}\left(u_{jt} m_t\right)$, where $\hat{E}\left(u_{jt} m_t\right)$ represent the method of moments estimator of $E\left(u_{jt} m_t\right)$. c can then be recovered by combining the information contained in $\tilde{c}$ with the identifying covariance restrictions $\Sigma = BB'$ that uniquely determines B ($B = [c, B^*]$). Given estimates for c, the impulse responses of any variable in Y_t to a one-standard-deviation shock can be computed.

I consider a univariate case ($k = 1$), and the identification strategy is through instrumental variable (IV) regression. I test the strength of the instrument (Romer and Romer shock) by estimating the following [19]

$$u_{it} = \zeta + \beta m_t + \xi_{it} \tag{3.7}$$

testing the null hypothesis $\beta = 0$ using F test.[20]

I follow the conservative approach of Lown and Morgan [30] by ordering credit standards last. The credit market variables are also ordered after the macroeconomic variables: log(real GDP), log(GDP deflator), log(global commodity prices), federal funds rate (or Cumulative Romer and Romer shock as the instrument), log(real business loans) and credit standards. However, I place loans after the federal funds rate, and I also model the credit market with three variables: business loans, credit standards and delinquency rate. When I examine Luckett's model's hypotheses, I order the percentage of non-performing loans to total loans (a proxy for soundness) just before standards. The implicit assumption with such ordering is that soundness has an immediate effect on credit standards.

3.3. *Estimation Results*

The estimation begins with a test of the instrument's strength as specified in equation (15), where the federal funds rate enters as a dependent variable. The weak identification test reports Cragg-Donald Wald F statistic and Kleibergen-Paap rk Wald F statistics of 31.721 and 14.369, respectively. These results suggest that the Romer and Romer series is

[19] See, for example, Stock and Watson [45], Mertens and Ravn [35], Gertler and Karadi [?], and Pfiffer [39] for a discussion on the use of multiple instruments.

[20] I use Kleibergen-Paap [?] underidentification test and Cragg-Donald [?] weak identification test.

a strong instrument.[21]

I now discuss the response of the variables to a one-standard deviation shock. In the interest of brevity and given that this paper's primary focus is on the response of standards to certain macroeconomic and credit variables, I restrict myself, in most cases, to the discussion of the impulse response functions of standards to those specific variables. This notwithstanding, impulse response functions of other variables to a shock in standards are depicted by respective figures.[22] The reported impulse responses show the point estimates and the 95% confidence bands for different SVAR model specifications.

Figure 7 below plots impulse responses for the model, which includes business loans as the only credit variable (in addition to the core macroeconomic variables). Upon a one-standard-deviation shock, the federal funds rate rises on impact by about 22 basis points, reaching 40 basis points by the third quarter. The persistent effect stays up for about six quarters after the shock. Real GDP shows no response to impact but increases slightly in the early quarters and then sets up a downward trend. This persistent effect is consistent with Christiano, Eichenbaum and Evans [12] and Romer and Romer [42]. The GDP deflator is flat for about four quarters after the federal funds' shock, after which it declines. This absence of result of the price puzzle reported by Eichenbaum [16] and Sims [43] is due to the inclusion of the global commodity prices in the model. Loans rise in response to a real GDP shock, but this is marginally significant. The response of loans to the federal funds rate is negligible.

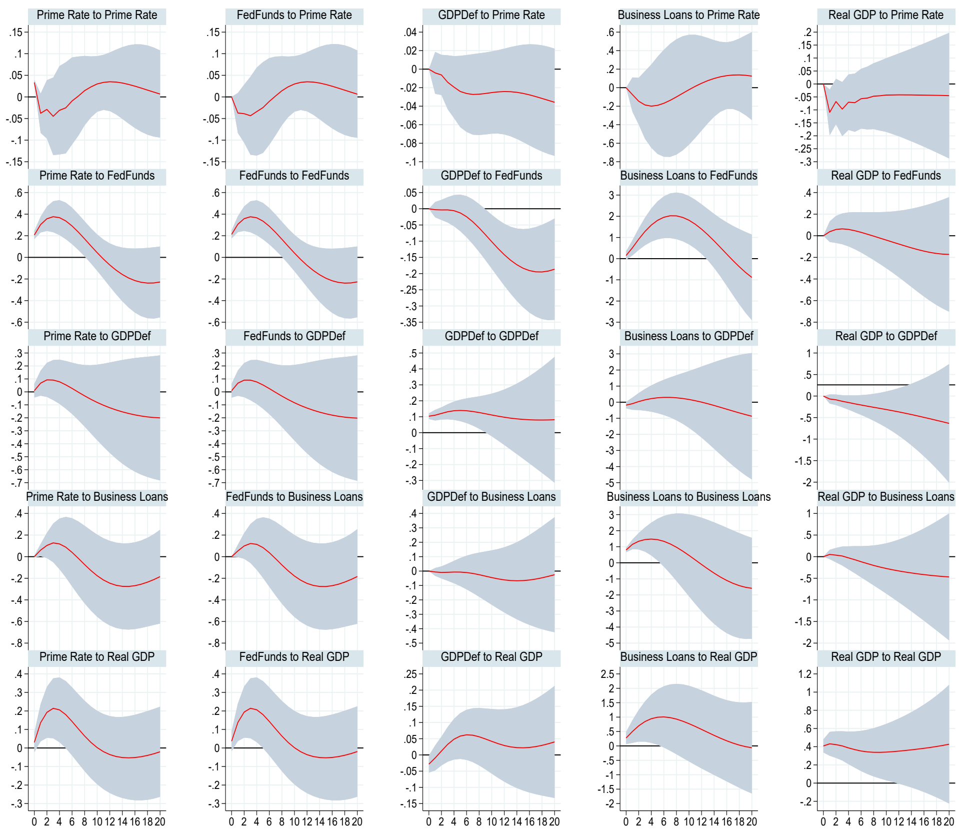
Figure 8 shows the impulse responses for the SVAR model, including standards but not business loans. Standards, upon a monetary tightening, immediately decline. It subsequently overshoots and cumulates till about the sixteenth quarter, when easing commences. Upon a standards shock, Lenders immediately tighten standards by about 7% (on the net). This tightening continues for about six quarters (note that these are

[21]Stock and Yogo [46] provides the critical values that depend on the number of endogenous regressors, the number of instruments, the maximum bias and the estimation procedure applied. The authors also discuss the methods (bias versus size) for selecting the cut-off point.

[22]See, for example, Lown and Morgan [30], [32], [31] for a more detailed discussion of the effect that shocks to credit variables have on the macroeconomy.

Figure 4: Impulse Responses for SVAR Model 1

Responses of:



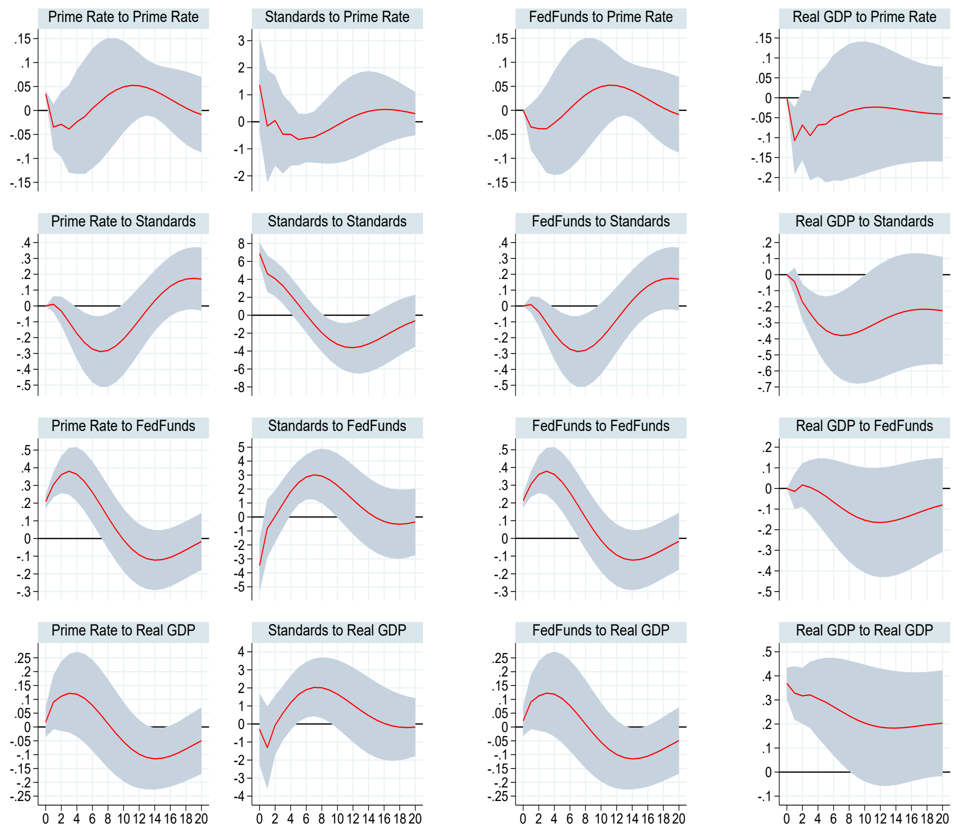
Note: The panels of the figure depict impulse response functions of the SVAR model that include the variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, FedFunds = the federal funds rate, Business Loans = log of commercial and industrial loans. The ordering of the variables in the SVARs is as reported above. The shaded bands represent 95% confidence bands.

changes in standards), and then easing commences, a crucial step to undo the tightening in previous quarters. Real GDP falls substantially on the impact of a standard shock, reaching over 0.3% at its trough about seven quarters after the shock. Supply shocks, such as an unanticipated rise in global commodity prices, cause some tightening in standards.

Figure 9 presents the impulse response functions for the SVAR model, which includes

Figure 5: Impulse Responses for SVAR Model 2

Responses of:



Note: The panels of the figure depict impulse response functions of the SVAR model that include the variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, FedFunds = the federal funds rate, Standards = net percentage of lenders tightening standards. The ordering of the variables in the SVARs is as reported above. The shaded bands represent 95 percent confidence bands.

both business loans and standards.[23] Shock to standards amounts to about 7% (net) tightening, cumulating for about six quarters where lenders commence easing. Upon a monetary policy shock, standards ease by 3% in a statistically significant way but sub-

[23] I exclude loan rate (prime rate) because once I account for standards, loans stay flat in response to a loan rate shock. Moreover, loan rates are unresponsive to shocks to loans. Lown and Morgan (2002) find similar evidence. The authors find loan rates to have no additional power for explaining loans.

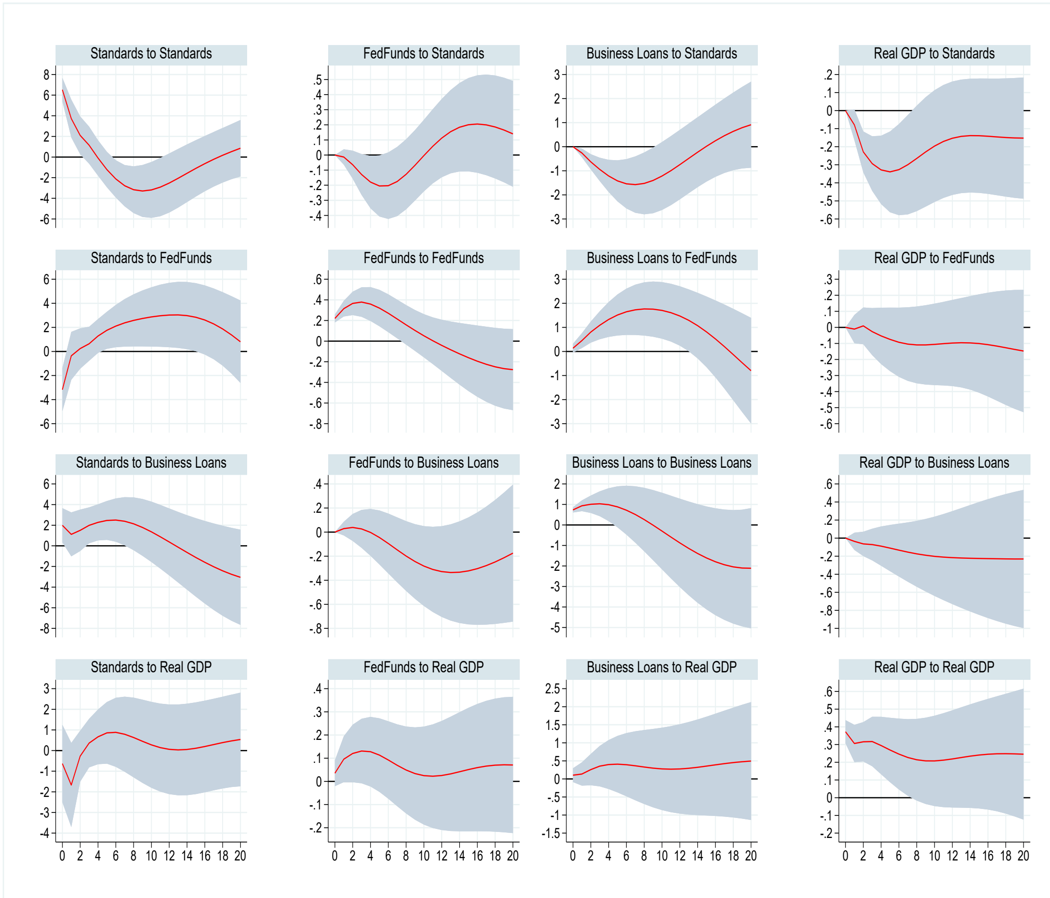
sequently overshoot. The peak of this subsequent tightening, about 3%, materialises around seven quarters after the shock. Lown and Morgan [30] likewise find an explanatory role of the federal funds rate for standards when they exclude the 1980q3 to 1982q4 easing period from their sample. Shock to loans causes, in a statistically significant way, an immediate tightening in standards of about 2%. Similarly, Lown and Morgan find evidence of reverse causality that runs from loans to standards: higher past loan levels are associated with tighter future standards. As shown by plots in Figure 8 (model 2), standards immediately decline following a positive real GDP shock, but this relationship is insignificant. However, there is an indirect link via the positive relationship between output and loans: higher output leads to higher loans, hence tighter standards.[24]

Figure 10 presents impulse response functions for the proxy SVAR model with three credit variables: loans, standards and non-performing loans to total loans (percentages). Consistent with previous model results of this study, a shock to standards amounts to about 7% (net) tightening, cumulating for about six quarters, after which lenders commence easing. Standards ease by 2% upon innovation in the cumulative Romer and Romer shock but subsequently overshoots. It reaches its peak value (almost 2.5%) by six quarters after the shock. After about fourteen quarters, bankers commence easing. Standards immediately decline following a positive real GDP shock, but this is negligible. A significant tightening in credit standards of 3% immediately follows shocks to non-performing loans. This cumulates for about six quarters, after which bankers commence easing. The percentage of non-performing loans decline immediately in a statistically significant way following a positive shock in real GDP. A monetary contraction leads to an increase in non-performing loans. The initial effect is muted, but the response reaches its peak value of about 4.5% around nine quarters after the shock. This result is consistent with the work by Buch, Eickmeier and Prieto [11] and Pfiffer [39].

[24] Having both loans and standards does not alter, in terms of statistical significance, the response of standards to other variables in a model that included them separately.

Figure 6: Impulse Responses for SVAR Model 3

Responses of:



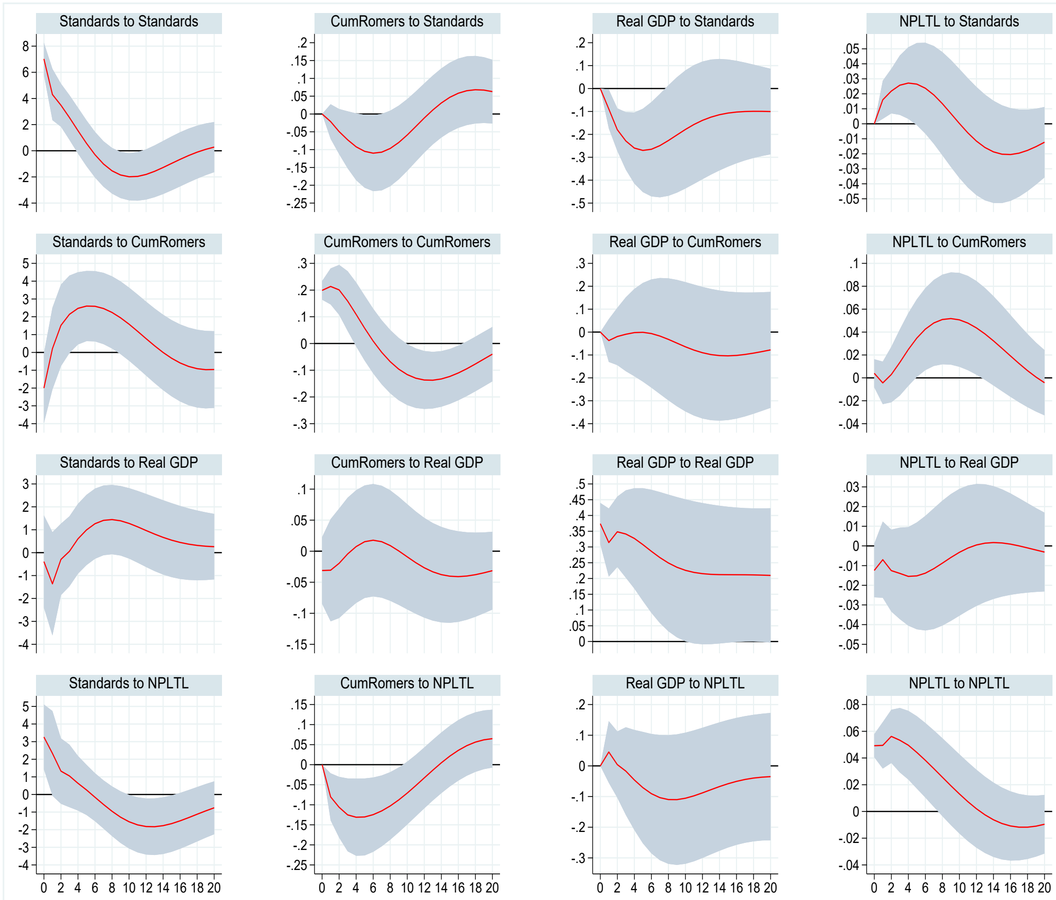
Note: The panels of the figure depict impulse response functions of the SVAR model that include the variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, FedFunds = the federal funds rate, Business Loans = log commercial and industrial loans, Standards = net percentage of lenders tightening standards. The ordering of the variables in the SVARs is as reported above. The shaded bands represent 95% confidence bands. To conserve space, I do not report the effects of the shock on the two indices (GloComPri and GDPDef), which are statistically and economically insignificant.

3.4. Robustness

I check the robustness of the results along four dimensions. First, I extend the lag length to generate more dynamics. Second, I use a first-differenced series of variables to address the (non) stationarity concern. Third, I extend the sample size to cover a more recent period and examine whether including the GFC of 2007-2008 alters the results. I

Figure 7: Impulse Responses for SVAR Model 4

Responses of:



Note: The panels of the figure depict impulse response functions of SVAR model that include the variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, CumRomers = cumulative Romer and Romer Shock, NPLTL = total non-performing loans to total loans (percentage), Standards = net percentage of lenders tightening standards.

use bootstrap procedures based on 1000 replications to construct the confidence bands. Fifth, I use a different ordering of the variables in the SVAR. Apart from standards that are ordered last in all models, I order the rest of the credit variables before the monetary policy variable.

Appendix D documents the results obtained for models 1-4 under the various robustness checks. Figures 11-14 display the impulse response of the variables estimated with a lag length of three. In general, the results are fairly robust regarding the increase in lag length, except for some cases where the confidence bands widen. To account for possible non-stationarity of the series figures 15-18 display impulse response functions for the model estimated with first-difference variables. The prize puzzle is now evident in the result. Contractionary monetary policy shock now produces expansionary effects in the early periods of the shock. Figures 19-22 report impulse responses with 95% confidence bands computed using a bootstrap procedure. Except for wide confidence bands for some impulse response functions, the results do not change, particularly their statistical significance.

Finally, I examine how much the results change when the sample period is extended. The baseline specification uses data for the period 1992:q1–2007:q4. Figures 23-26 show that the responses, in general, are mildly affected when the period is extended to 2012q4. The prize puzzle is not evident. However, a contractionary monetary policy shock has expansionary effects in the shock's early periods (about eight quarters). A shock to standards still amounts to 7% per cent (net) tightening, which cumulates for about three quarters, after which lenders commence easing. Standards ease immediately by 3% upon a contractionary monetary policy shock but then overshoot. Another noticeable difference is the initial overshooting response of standards to a real GDP shock. However, this effect is negligible. Extending the sample size widens the confidence bands for model 4 but does not alter the results' qualitative features or statistical significance. Moreover, changes in the ordering of the credit variables did not substantively change any results. Figures 27-32 display impulse responses for models with different ordering of the variables.

All in all, a check for robustness along the dimensions mentioned earlier shows that the results are not altered substantively. The two main hypotheses under consideration and tested in this study are still valid. Thus, the result that standards tighten upon a shock to either loans or the percentage of non-performing loans (delinquency rate) remains statistically significant. The immediate effect on standards of a one-standard-deviation shock to non-performing loans is more than that of a one-standard-deviation shock to loans.

3.5. *A Comparison to the Theoretical Model*

Despite the stylised nature of the theoretical model, some of the features outlined in the comparative analysis under section 2 are consistent with the empirical results of the SVAR model employed in this paper. Below, I briefly analyse the two main hypotheses I sought to test.

Under Section 2.1.3, we saw from the profit maximisation outcome the sensitivity of current and future lending to monetary policy effects. The empirical results and the prediction of the theoretical model regarding such a relationship are harder to outline. The SVAR results (see figure 6) suggest that after a contraction in monetary policy shock, the response of business loans (commercial and industrial) is muted on impact but gradually begins to increase, reaches its peak at about eight quarters and after that begins to decline. Gertler and Gilchrist [19], Christiano, Eichenbaum and Evans [12] and Kashyap and Stein [27] all find similar evidence that short-term business borrowing rises, and not fall, for roughly a year or so after a monetary contractionary, and then declines. Some of these authors note that these movements primarily reflect changes in the short-term liabilities of firms, while others argue that such responses reflect the need for firms to finance the rise in inventories that occurs at the beginning of a recession.

The theoretical model also predicts an inverse relationship between bank soundness and lending standards. Thus, as a bank becomes less (or more) sound (fall in τ) as a result of increases (or decreases) in loans (L_j), it will compensate for this by raising its minimum credit standards (ω_{l_j}). The empirical test results are consistent with this hypothesised inverse relationship between a bank's soundness and credit standards. The results (see Figure 10) show that a one-standard-deviation shock to the percentage of non-performing loans to total loans leads to an immediate tightening of standards of 3% in the baseline estimation.

4. Conclusions

Notwithstanding the vast body of literature on bank lending channels of monetary policy transmission, limited attention has been paid to the question of what factors or situations, other than capital constraints, restrain banks from lending. Opoku [37] estimates the interest elasticity of saving for a sample of OECD economies and finds that the income effect dominates the substitution effect in the short run. The author's finding suggests that in the short run, a significant portion of households face credit constraints of a form that conventional models fail to capture. This result could be extended to firms. Brito and Mello [10] analysed how a binding liquidity constraint can significantly affect aggregate output when a firm's prospects and balance sheets deteriorate, especially in countries where most firms are small and under-capitalised. Lown and Morgan [30] find that shocks to the federal funds rate do not cause changes in credit standards and that lenders raise loan rates more or less in step with the funds rate. The authors find additional evidence of diminished output response to a monetary policy shock when standards are accounted for in their model specification. These findings do not downplay the crucial role of banks in the transmission mechanism but cast doubts on the strength of the narrow or traditional credit channel that focuses on the financial frictions stemming from banks' balance-sheet position.

To shed new light on this issue, I use a dynamic version of Luckett's theoretical model to analyse a bank's behaviour towards monetary policy shocks and a change in its soundness position. The intuition suggested by the model is that increases in low-quality loans deteriorate the bank's health, particularly its soundness position, and hence cause a rise in its minimum credit standards. Moreover, all things equal, an increase in loan demand, without a corresponding change in the bank's resources, leads to tightening bank credit standards.

I specify an SVAR model to empirically test the theoretical model's hypotheses and provide further evidence. In contrast with Lown and Morgan [30], I find an inverse relationship between the federal funds rate and standards for the sample period considered in this paper. However, causality runs from the federal funds rate to standards. Even for using an external instrument such as the Romer and Romer shocks, standards are still responsive to policy changes in a statistically significant manner. This result suggests that changes in credit standards are endogenous to the policy process.

Moreover, I find evidence of broader effects and a feedback effect that could be described within the context of a credit cycle. First, an increase in non-performing loans (perhaps due to monetary policy changes - see, for example, Bernanke, Gertler, and Gilchrist [5], Buch, Eickmeier, and Prieto [11] and Pfiffer [39]) deteriorates the bank's soundness position and causes banks to apply more stringent standards. Second, tight money leads to tight standards: shocks to loan growth cause tightening in banks' credit standards, perhaps due to lenders' perceived lax standards. Tighter credit standards would then adversely affect spending decisions and loan levels, which would cause an easing of credit standards and higher spending and loan levels, and so on.

Finally, another important implication of the findings is that standards matter more than bank loan rates in explaining credit dynamics. This result is consistent with the credit rationing hypothesis of Luckett's model, which states that frictions in credit markets and those resulting from banks' balance-sheet positions cause banks to ration credit via changes in credit standards more than through changes in bank loan rates.

Appendix A SOLVING THE MODEL

Model

A) The problem is formed as follows:

$$\mathcal{L} = r_{G_1}G_1 + r_{L_1}L_1 - r_{D_1}D_1 - r_{T_1}T_1 + \lambda_1[\tau_1 - (\omega_{g_1}G_1 + \omega_{l_1}L_1 - \omega_{d_1}(D_1 - R_1) - \omega_{t_1}T_1)]$$
$$+ \beta\left[r_{G_2}G_2 + r_{L_2}L_2 - r_{D_2}D_2 - r_{T_2}T_2 + \lambda_2[\tau_2 - (\omega_{g_2}G_2 + \omega_{l_2}L_2 - \omega_{d_2}(D_2 - R_2) - \omega_{t_2}T_2)]\right] \quad \text{(A.1)}$$

The F.O.C's are

First period:

$$\frac{\partial \mathcal{L}}{\partial L_1} = \frac{g_{01} + g_{11}\bar{r}_{L_1} - g_{21}\omega_{l1} - 2L_1}{g_{11}} - \frac{2R_1 + 2G_1 + 2L_1 - 2D_1 - t_{01} + t_{11}\bar{r}_{T_1} - t_{21}\omega_{t1}}{t_{11}} - \lambda_1\omega_{l1} + \beta\frac{g_{32}}{g_{12}}L_2 = 0 \quad \text{(A.2)}$$

$$\frac{\partial \mathcal{L}}{\partial \omega_{l_1}} = -\frac{g_{21}}{g_{11}}L_1 - \lambda_1 L_1 = 0 \quad \text{(A.3)}$$

$$\lambda_1 = -\frac{g_{21}}{g_{11}} \quad \text{(A.4)}$$

Second period:

$$\frac{\partial \mathcal{L}}{\partial L_2} = \beta\left\{\frac{g_{02} + g_{12}\bar{r}_{L_2} - g_{22}\omega_{l2} + g_{32}L_1 - 2L_2}{g_{12}} - \frac{2R_2 + 2G_2 + 2L_2 - 2D_2 - t_{02} + t_{12}\bar{r}_{T_2} - t_{22}\omega_{t2}}{t_{12}} - \lambda_2\omega_{l2}\right\} = 0 \quad \text{(A.5)}$$

$$\frac{\partial \mathcal{L}}{\partial \omega_{l_2}} = -\beta\frac{g_{22}}{g_{12}}L_2 - \lambda_2 L_2 = 0 \quad \text{(A.6)}$$

$$\lambda_2 = -\beta\frac{g_{22}}{g_{12}} \quad \text{(A.7)}$$

We assume the soundness constraint is always binding ($\lambda_j \neq 0$), we can therefore derive the testable hypothesis from the following derivatives

$$\frac{\partial L_1}{\partial r_{f_1}} = -\frac{[g_{11}(1 - h_{11})d_{11}]}{g_{11} + t_{11}} < 0 \quad \text{(A.8)}$$

$$\frac{\partial L_1}{\partial w_{l_1}} = -\beta \frac{g_{11} g_{21} g_{32}^2 t_{11}}{2 g_{12} [g_{11} + t_{11}]} < 0 \tag{A.9}$$

$$\frac{\partial L_2}{\partial r_{f_2}} = -\frac{[g_{12}(1 - h_{12}) d_{12}]}{g_{12} + t_{12}} < 0 \tag{A.10}$$

$$\frac{\partial L_2}{\partial w_{l_2}} = -\frac{[1 - \beta] t_{12} g_{22}}{2[g_{12} + t_{12}]} < 0 \tag{A.11}$$

assuming $h_j, \beta < 1$

Appendix B Descriptive Statistics and Preliminary Tests

Table 1: Summary

Variable	Period	Observations	Mean	Standard Deviation	Minimum	Maximum
Real GDP Growth	1992q1-2012q4	84	2.592	2.515	−8.750	7.258
GDP Deflator	1992q1-2012q4	84	1.978	0.780	−0.582	3.914
Gobal Commodity Prices	1992q1-2012q4	83	5.895	30.334	−176.98	60.884
Loan Growth	1992q1-2012q4	84	2.504	9.577	−27.434	20.395
Prime Rate	1992q1-2012q4	84	6.231	2.096	3.250	9.500
Standards	1992q1-2012q4	84	5.410	23.885	−25.00	83.6
Demand	1992q1-2012q4	84	−2.645	21.064	−55.100	39.400
NPLTL	1992q1-2012q4	84	1.997	1.454	0.700	5.640
Fed Funds Rate	1992q1-2012q4	84	3.221	2.136	0.073	6.520

All variable (original) are in real and natural logs except federal funds rate, prime rate, delinquency rate, loan standards, loan demand and soundness measure. NPLTL is the ratio of non-performing loans to total loans.

Table 2: Augmented Dickey-Fuller Unit-root Test

Variable	ADF Test 1	ADF Test 2	ADF Test 3
	no constant, no trend	constant, no trend	constant, trend
log(Real GDP)	9.160	-3.681	-0.159
log(GDP Deflator)	22.943	-0.360	-0.852
log(Gobal Commodity Prices)	1.748	-0.111	-1.968
Fed Funds Rate	-1.036	-0.431	-1.366
Δ log(Real GDP)	-3.764	-5.693	-6.337
Δ log(GDP Deflator)	-1.617	-4.715	-4.684
Δ log(Gobal Commodity Prices)	-5.936	-6.051	-6.054
Δ Fed Funds Rate	-3.891	-3.881	-3.898
Critical Value, 5%	-1.950	-2.904	-3.467
Critical Value, 1%	-2.607	-3.534	-4.077

The table shows the Augmented Dickey-Fuller statistics for the test that the macroeconomic variables included in SVAR specifications follow a unit root process. The top part of the table presents the ADF test results for specification in levels, while the lower part presents specification in first differences. The tests report results when no constant nor trend term is included in the regression, when a constant but no trend is included in the regression, and when a constant and a trend are included in the regression. The table also shows the corresponding critical values.

Appendix C DATA DESCRIPTION, CODES AND SOURCE(S)

Real Gross Domestic Product - $rgdp$: The total income earned domestically or expenditure on domestic goods and services, billions of chained 2012 dollars, inflation adjusted value. Source: U.S. Bureau of Economic Analysis.

GDP Deflator - $gdpdef$: Ratio of nominal GDP to real GDP. Source: U.S. Bureau of Economic Analysis.

Commodity Prices - gcp: Global price index of all commodities index 2016 = 100. Prices are period averages in nominal U.S. dollars. Source: IMF.

Loans - *rbl*: Commercial and industrial loans, all commercial banks. Source: Federal Reserve Board.

Prime Rate - *bpr* : Bank prime rate is one of several base rates used by banks to price short-term commercial and industrial loans. Source: Federal Reserve Board.

Standards - *cisc* : Net percentage of domestic banks reporting tighter/easier standards for commercial and industrial loans. Federal Reserve Board: Senior Loan Officer Opinion Survey.

Demand - *cid* : Net percentage of domestic banks reporting stronger/weaker demand for commercial and industrial loans. Federal Reserve Board: Senior Loan Officer Opinion Survey.

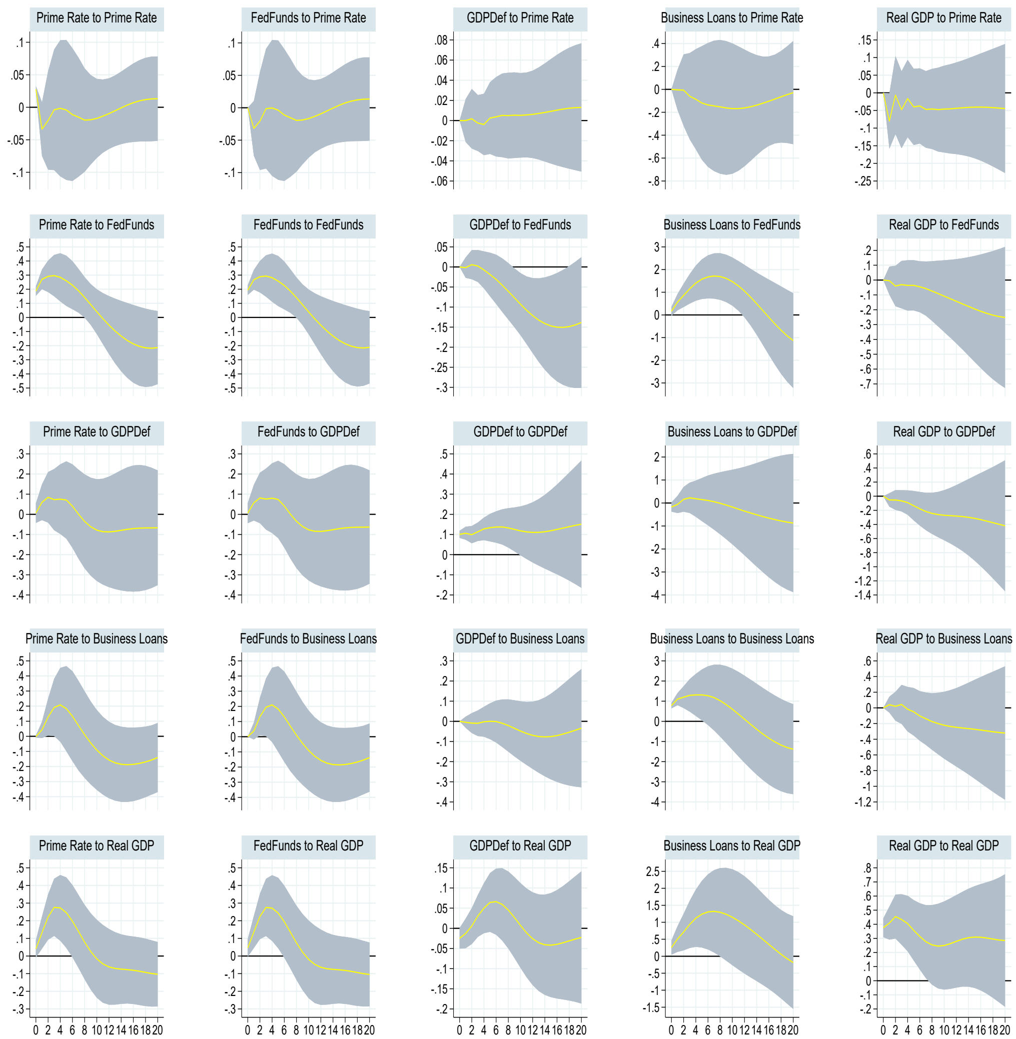
Soundness - $npltl$: Non - performing loans to total loans or Delinquency rate (on all loans) which is the ratio of delinquent loans (loans whose repayment is past thirty days) to total loans is used as a proxy for soundness. Source. Source: Federal Reserve Board.

Fed Funds Rate - ffr : Effective overnight interbank lending rate. Source: Federal Reserve Board.

Appendix D ROBUSTNESS CHECK

Figure 8: SVAR Model 1 - Increasing p to 3

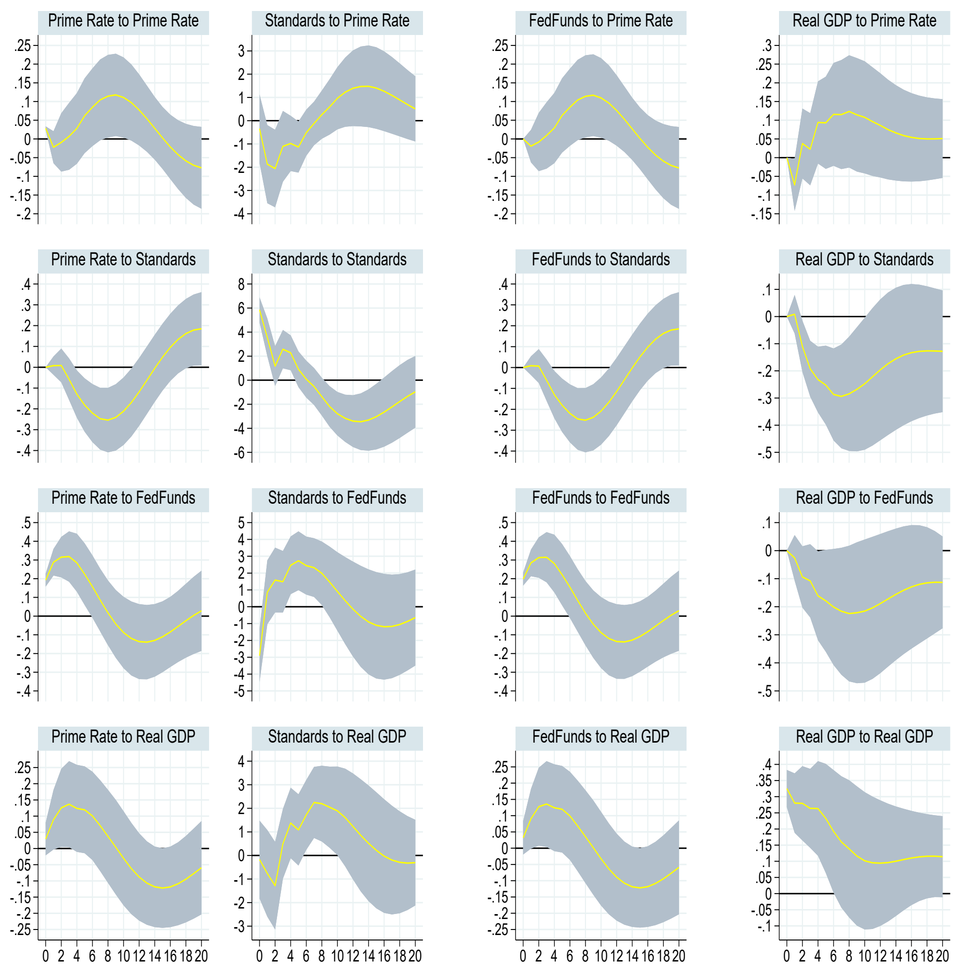
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 9: SVAR Model 2 - Increasing p to 3

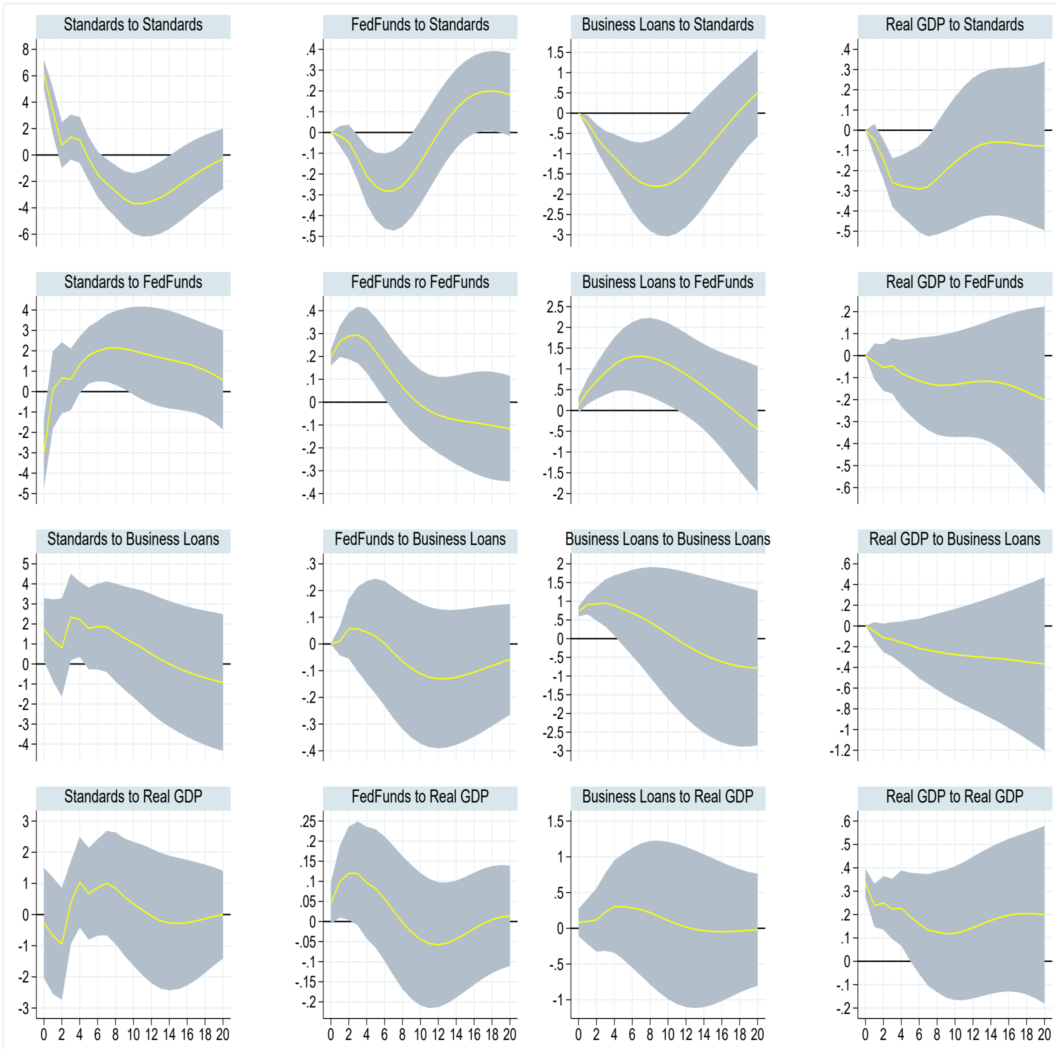
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 10: SVAR Model 3 - Increasing p to 3

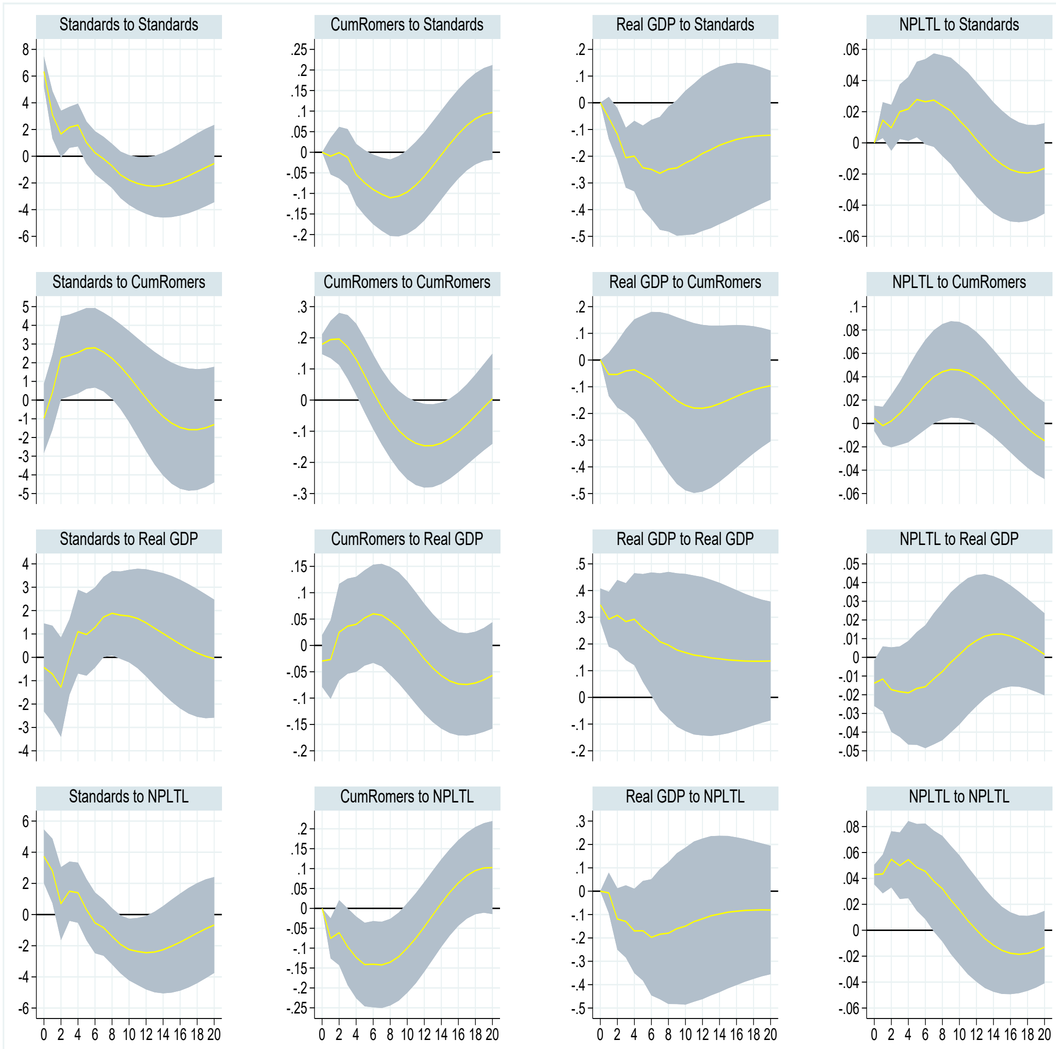
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 11: SVAR Model 4 - Increasing p to 3

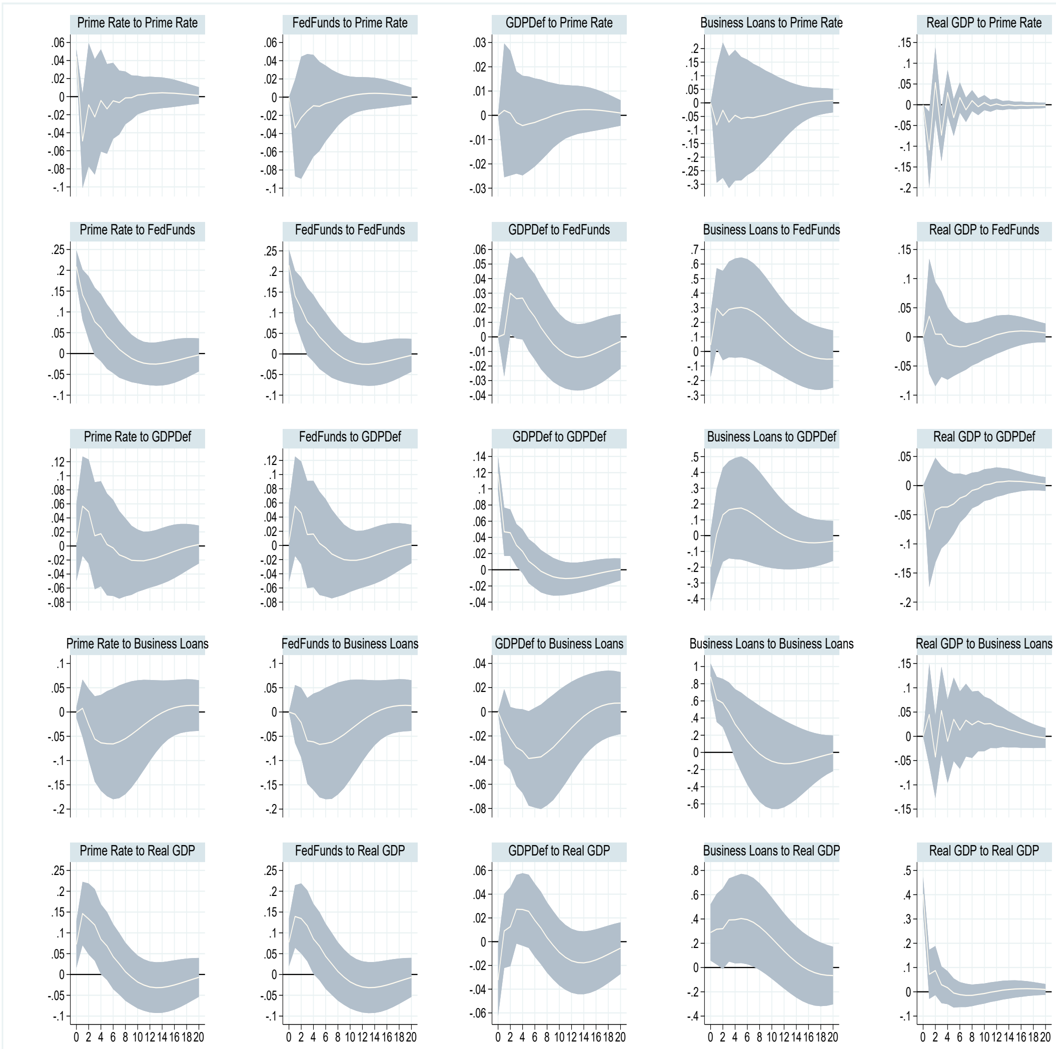
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 12: SVAR Model 1 - Using First-difference Variables

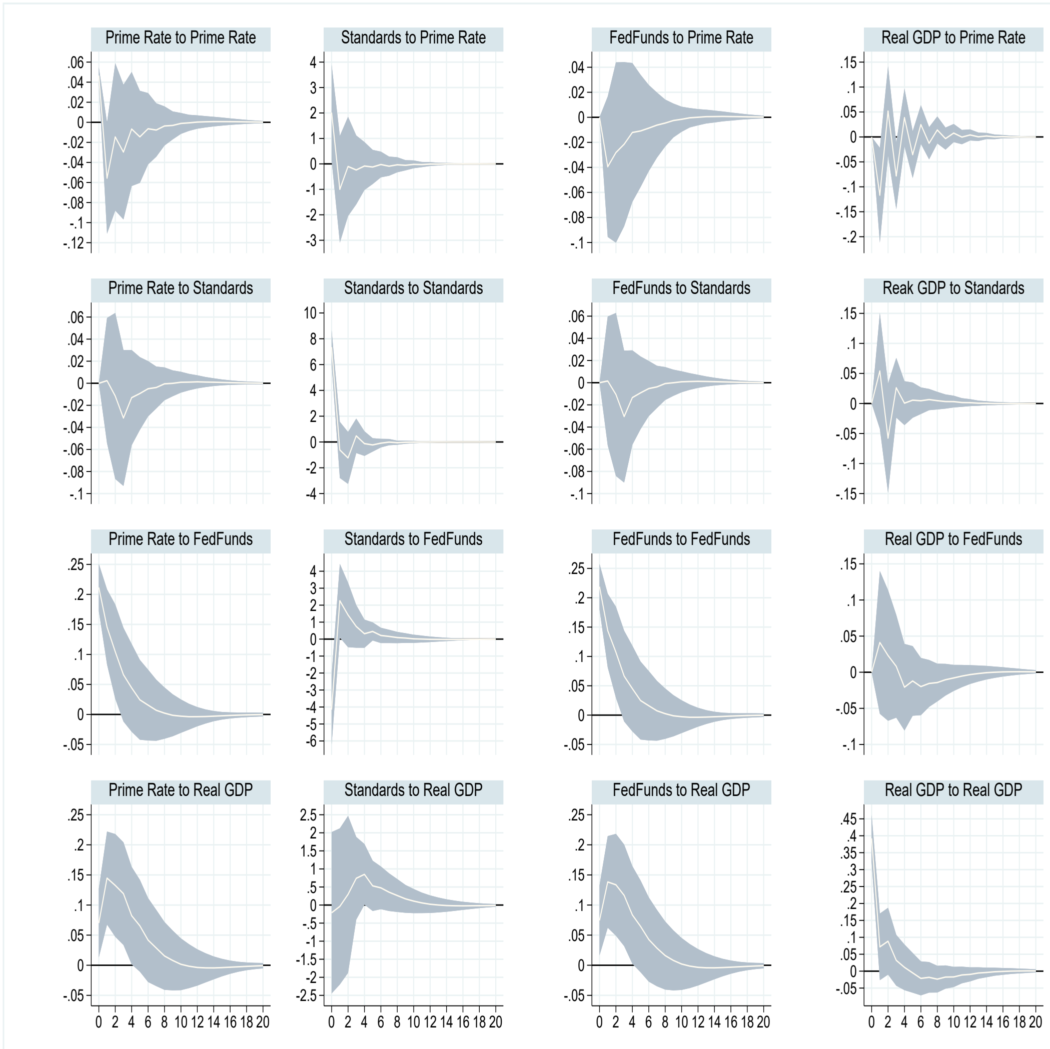
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 13: SVAR Model 2 - Using First-difference Variables

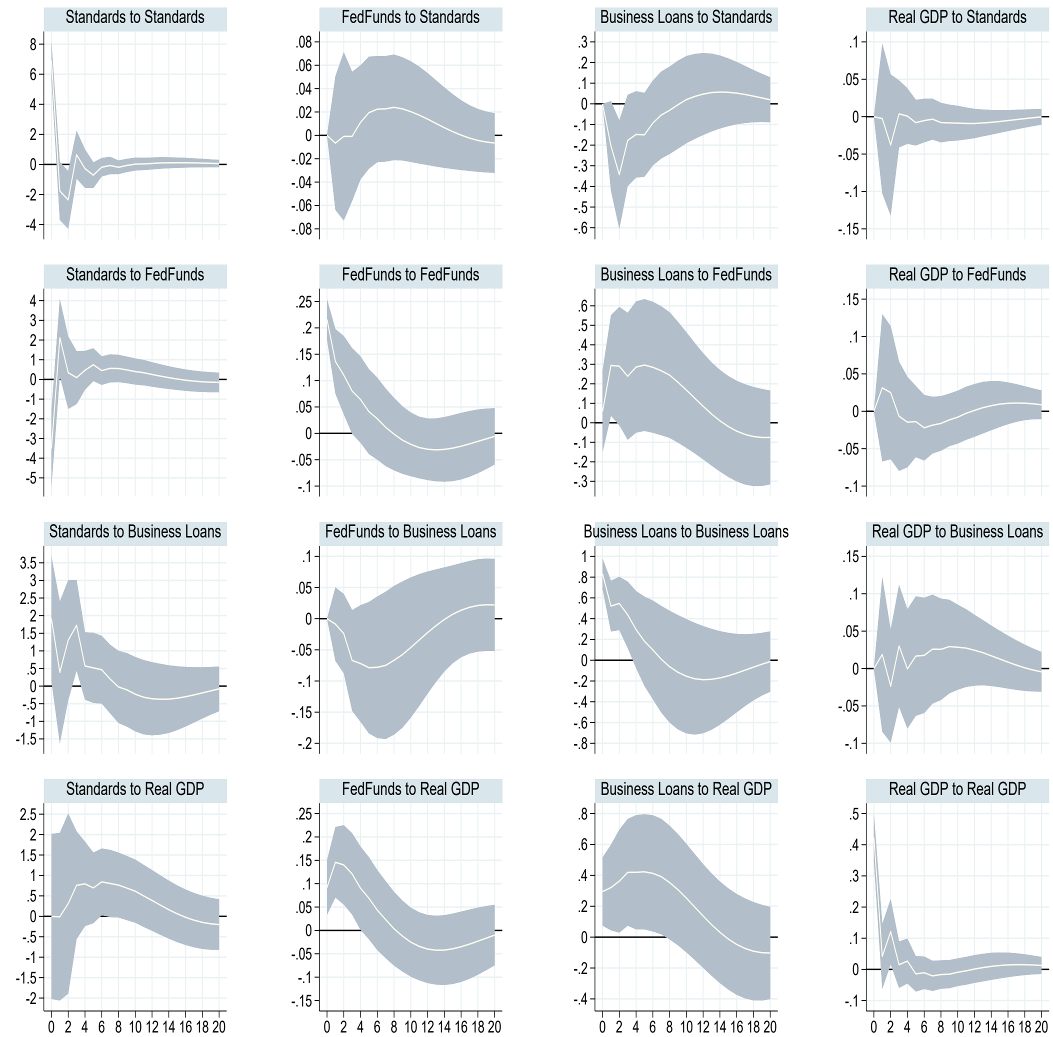
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 14: SVAR Model 3 - Using First-difference Variables

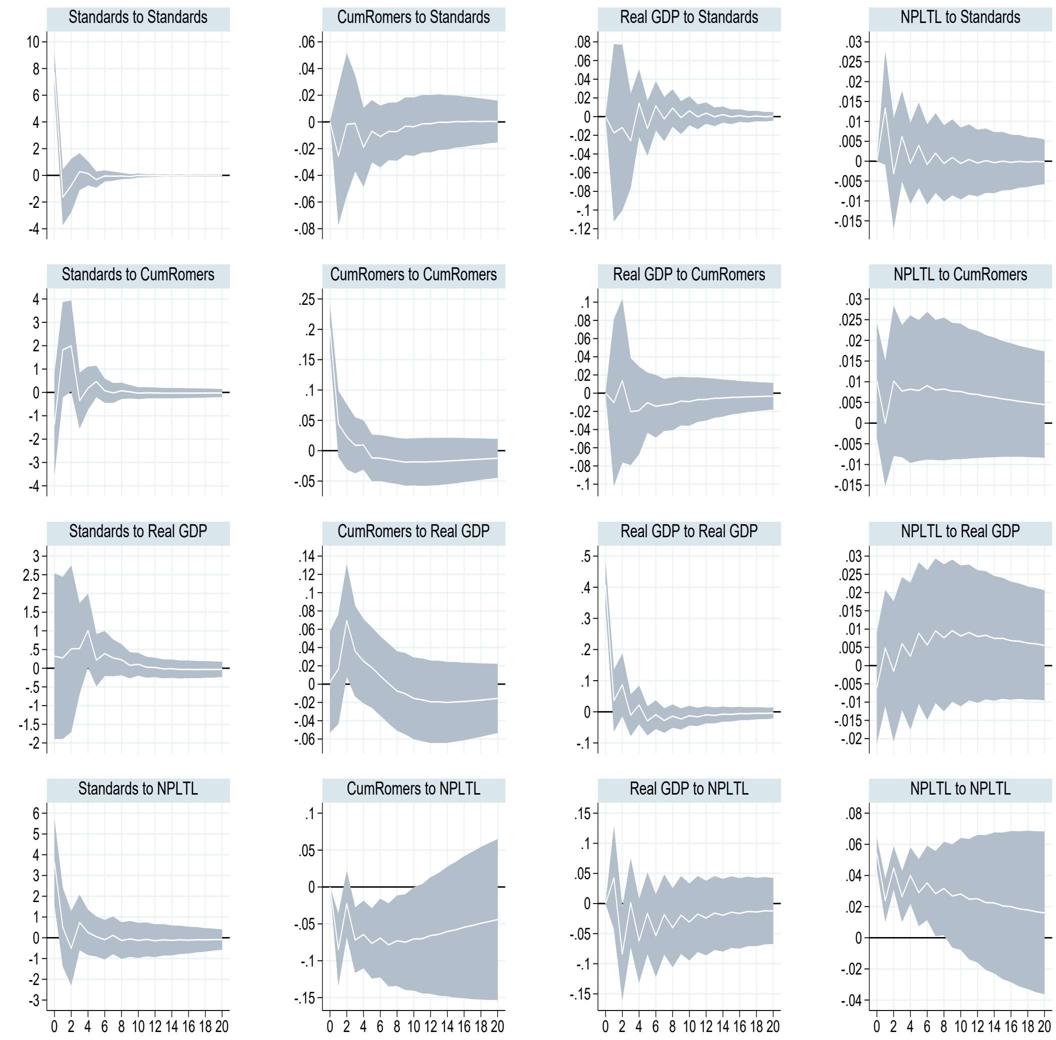
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 15: SVAR Model 4 - Using First-difference Variables

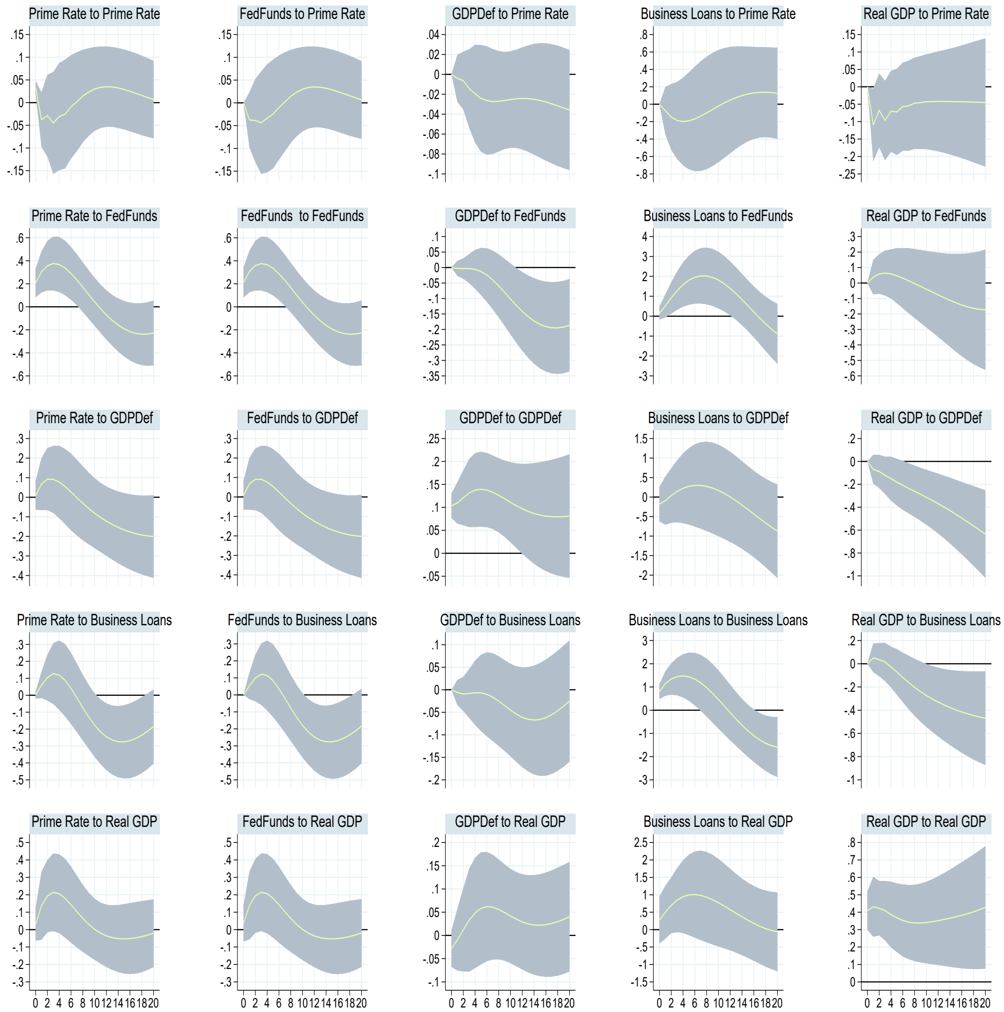
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 16: SVAR Model 1 - Bootstrap 95 percent Confidence Interval

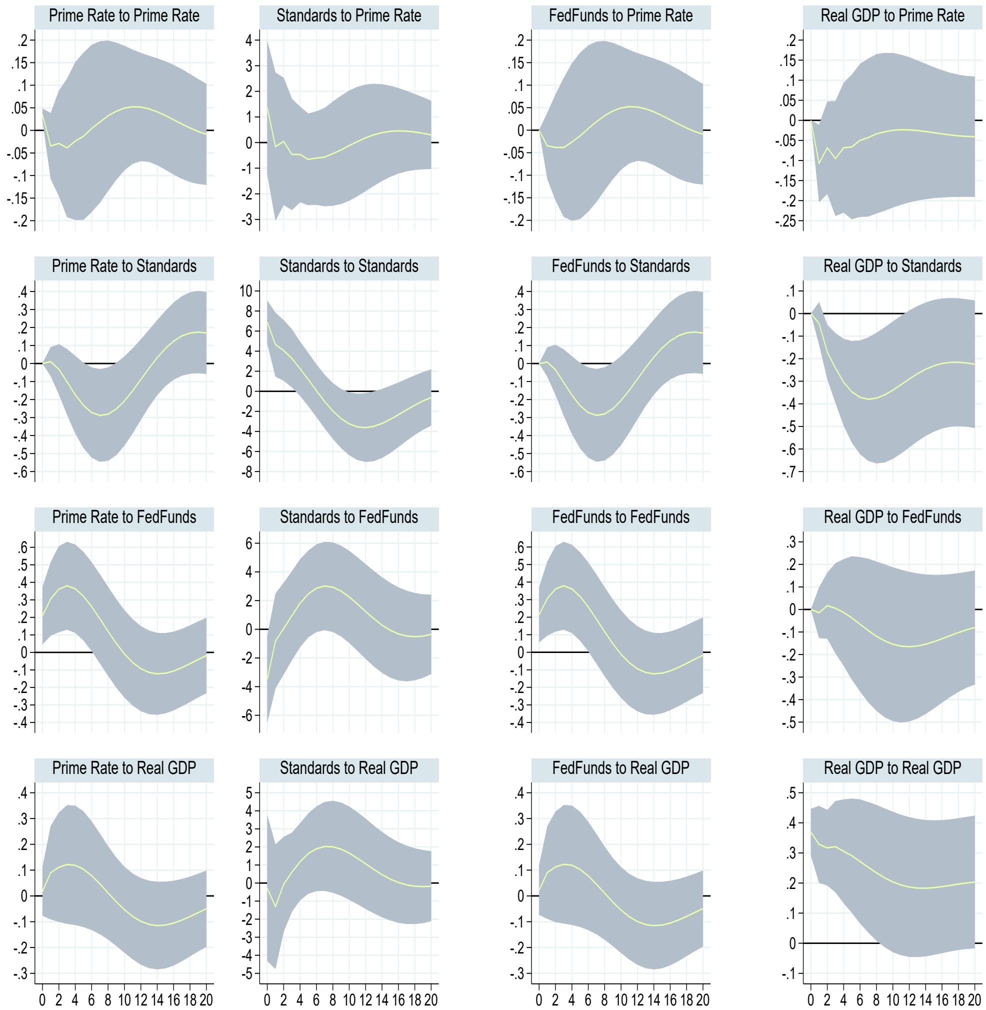
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 17: SVAR Model 2 - Bootstrap 95 percent Confidence Interval

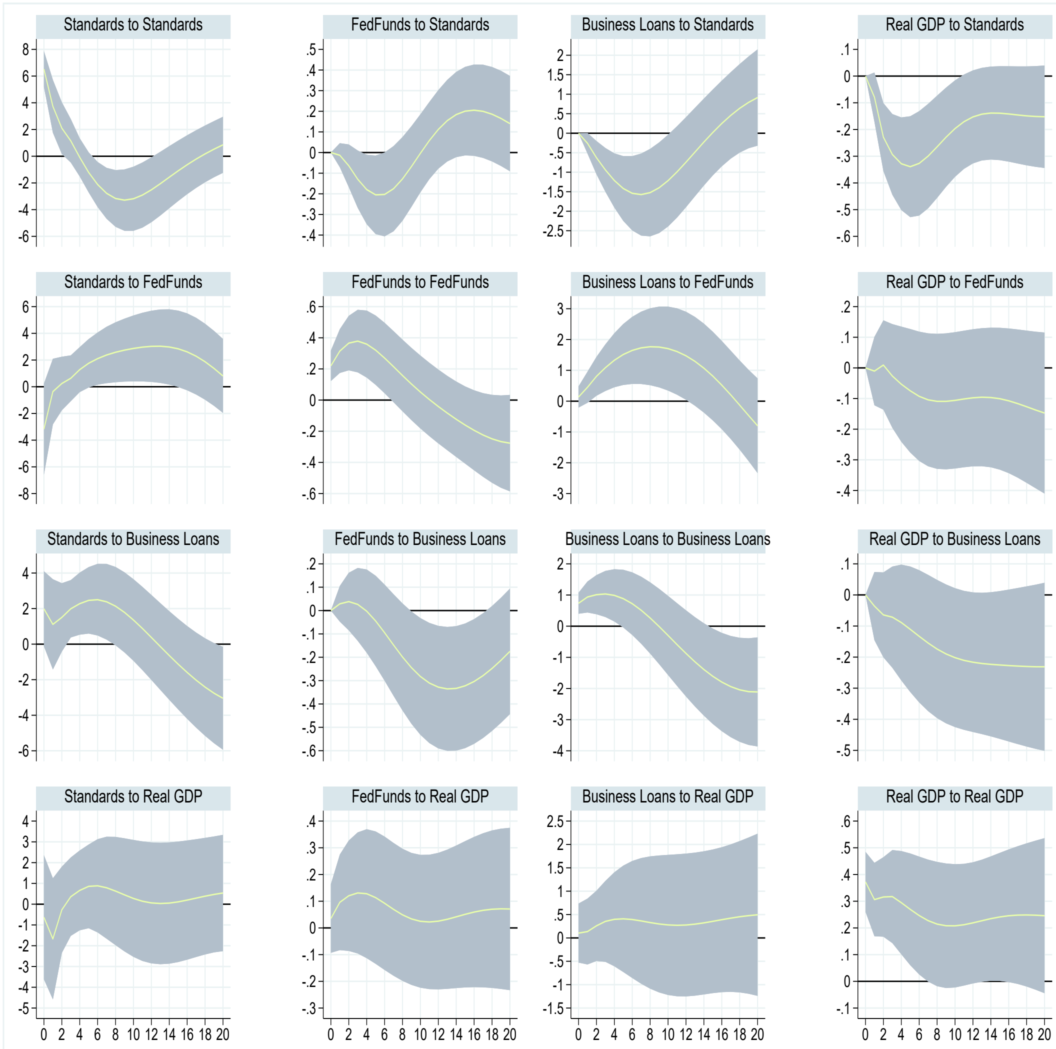
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 18: SVAR Model 3 - Bootstrap 95 percent Confidence Interval

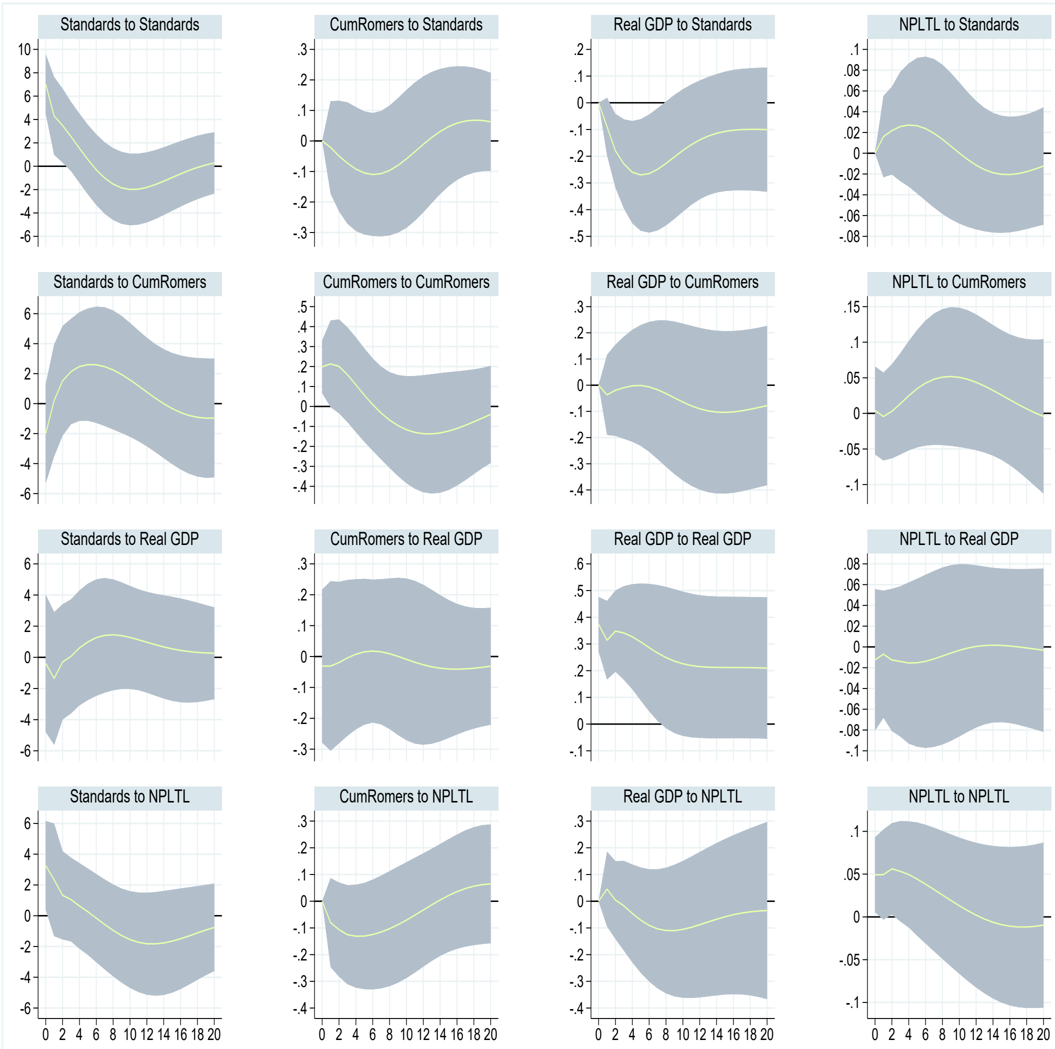
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 19: SVAR Model 4 - Bootstrap 95 percent Confidence Interval

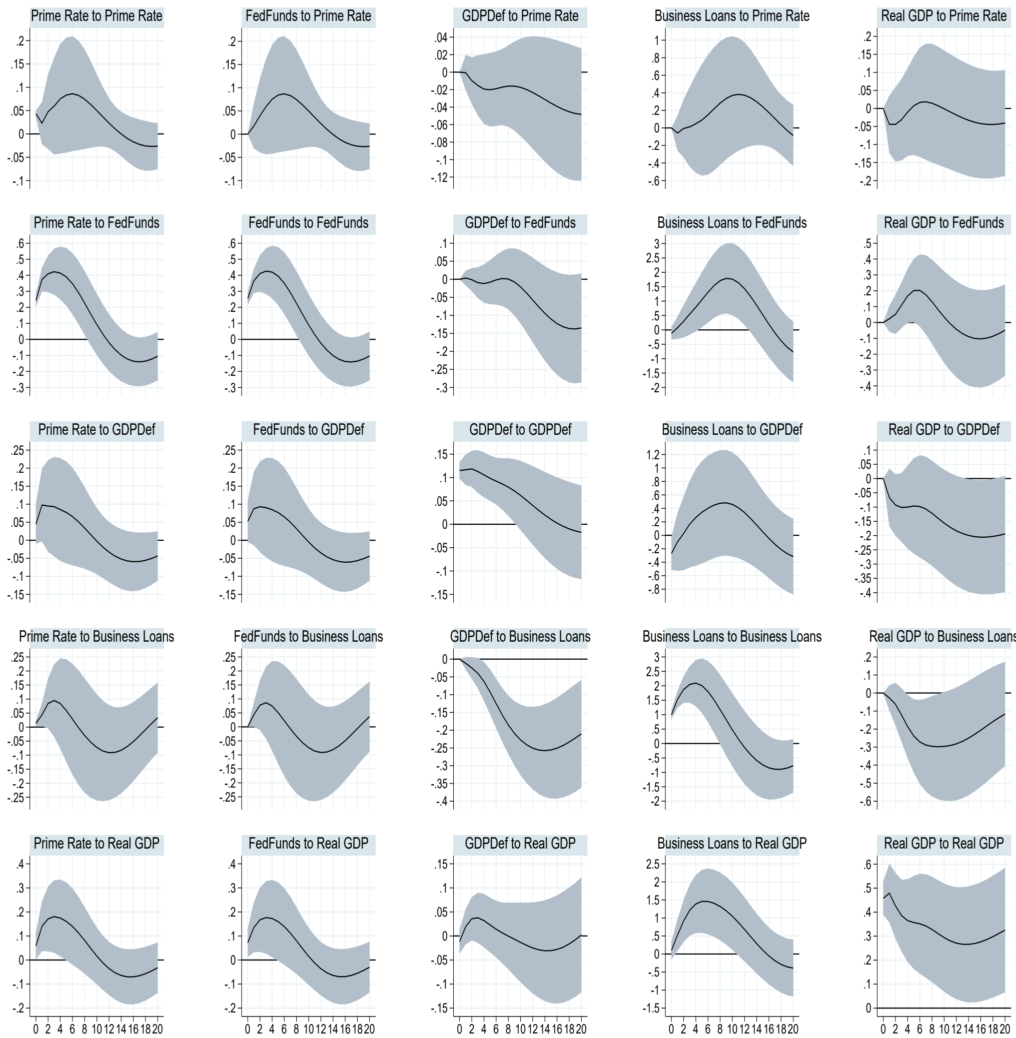
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 20: SVAR Model 1 - Extended Sample Size 1992q1-2012q2

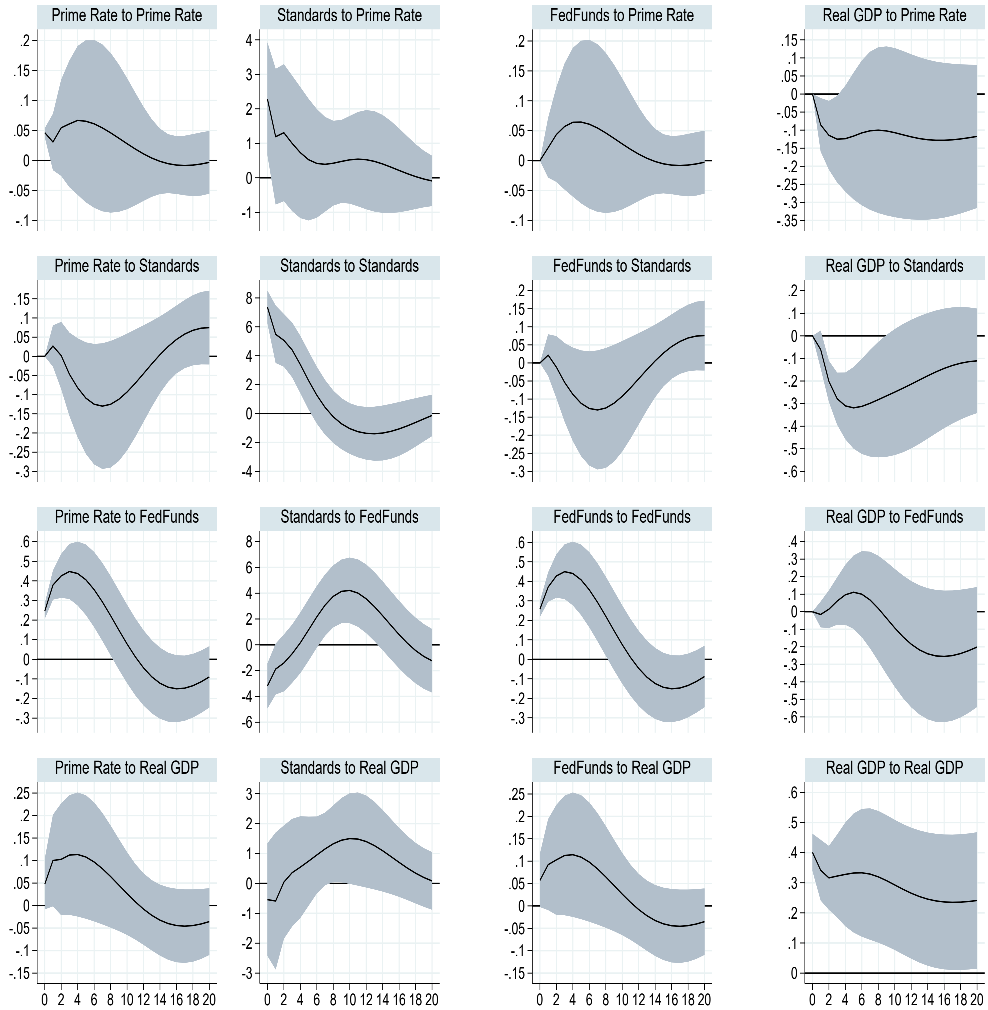
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 21: SVAR Model 2 - Extended Sample Size 1992q1-2012q2

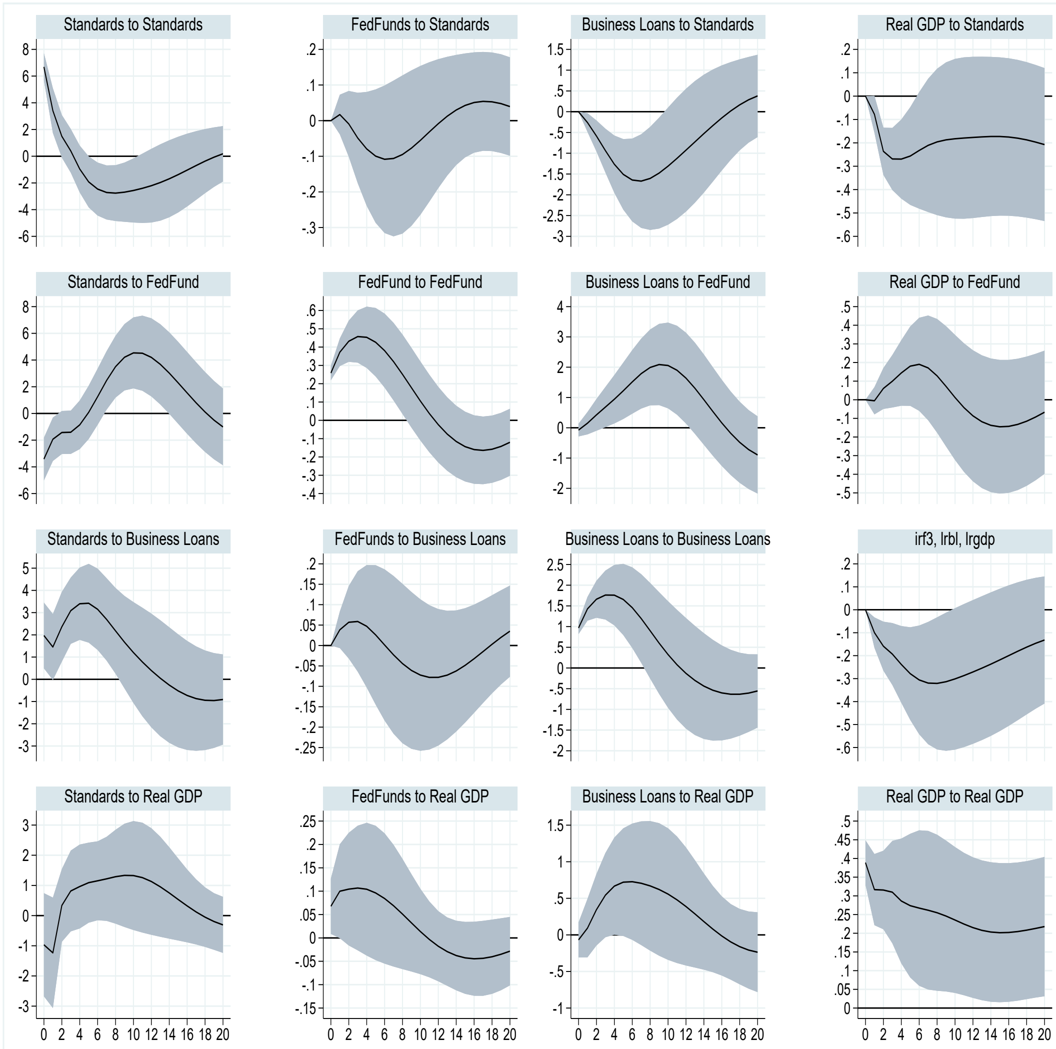
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 22: SVAR Model 3 - Extended Sample Size 1992q1-2012q2

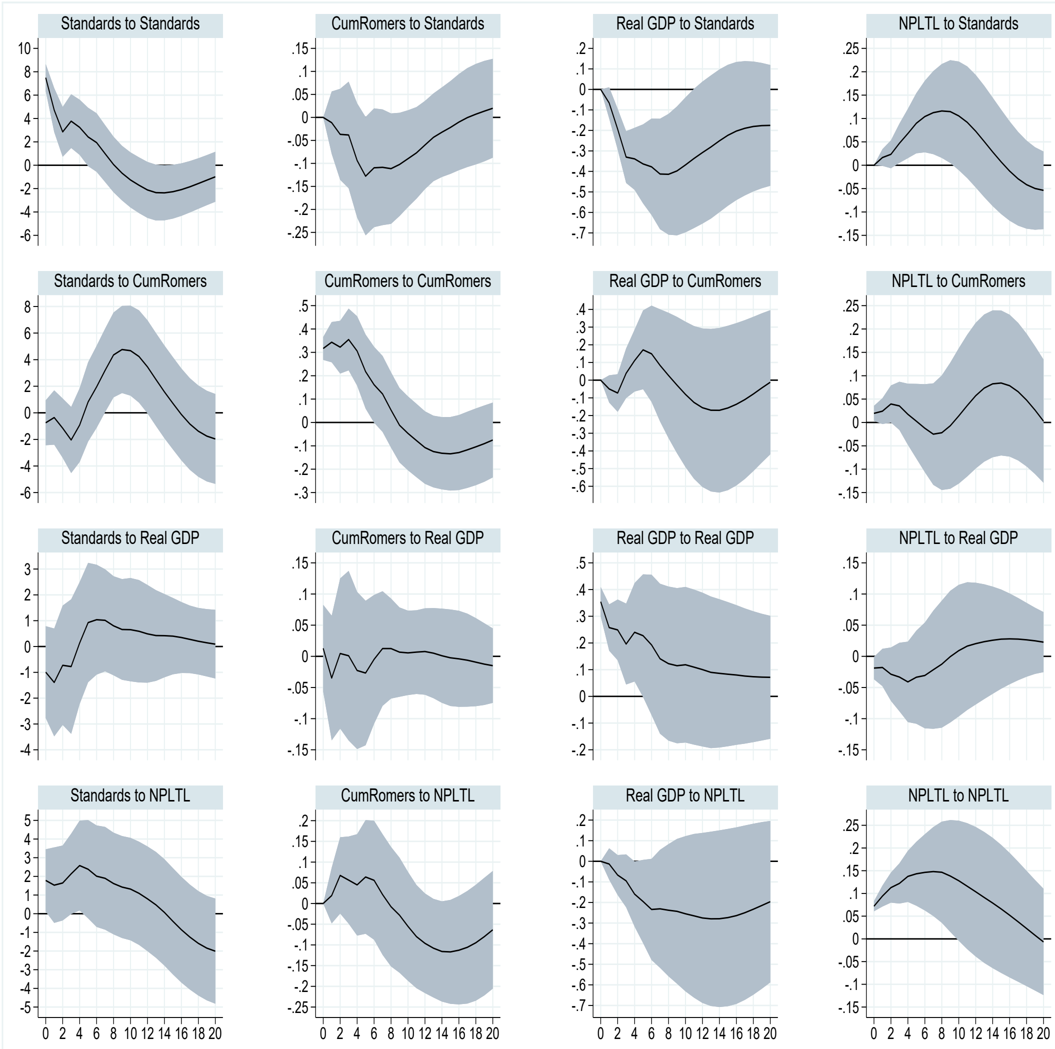
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 23: SVAR Model 4 - Extended Sample Size 1992q1-2012q2

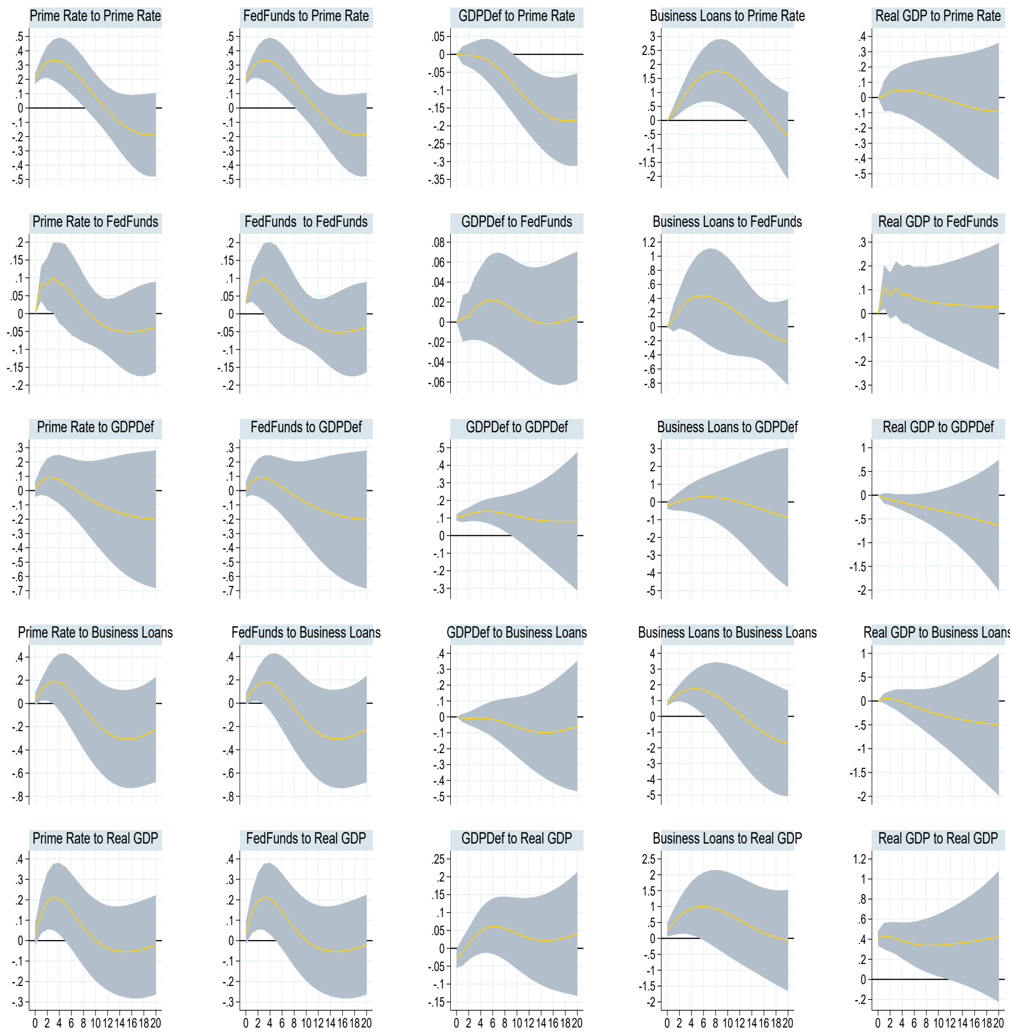
Responses of:



Note: The shaded bands represent 95 percent confidence bands.

Figure 24: SVAR Model 1 - Different Ordering of Variables

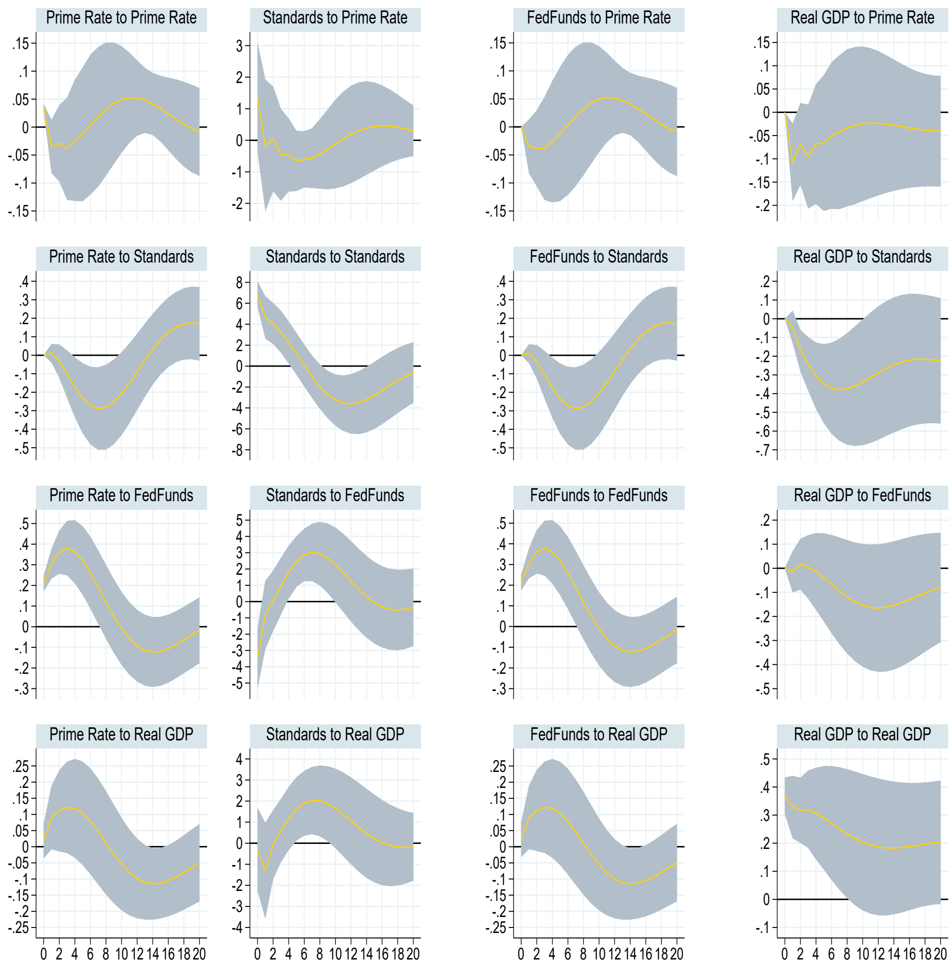
Responses of:



Note: The shaded bands represent 95 percent confidence bands. The order of variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, Business Loans = log commercial and industrial loans, FedFunds = the federal funds rate.

Figure 25: SVAR Model 2 - Different Ordering of Variables

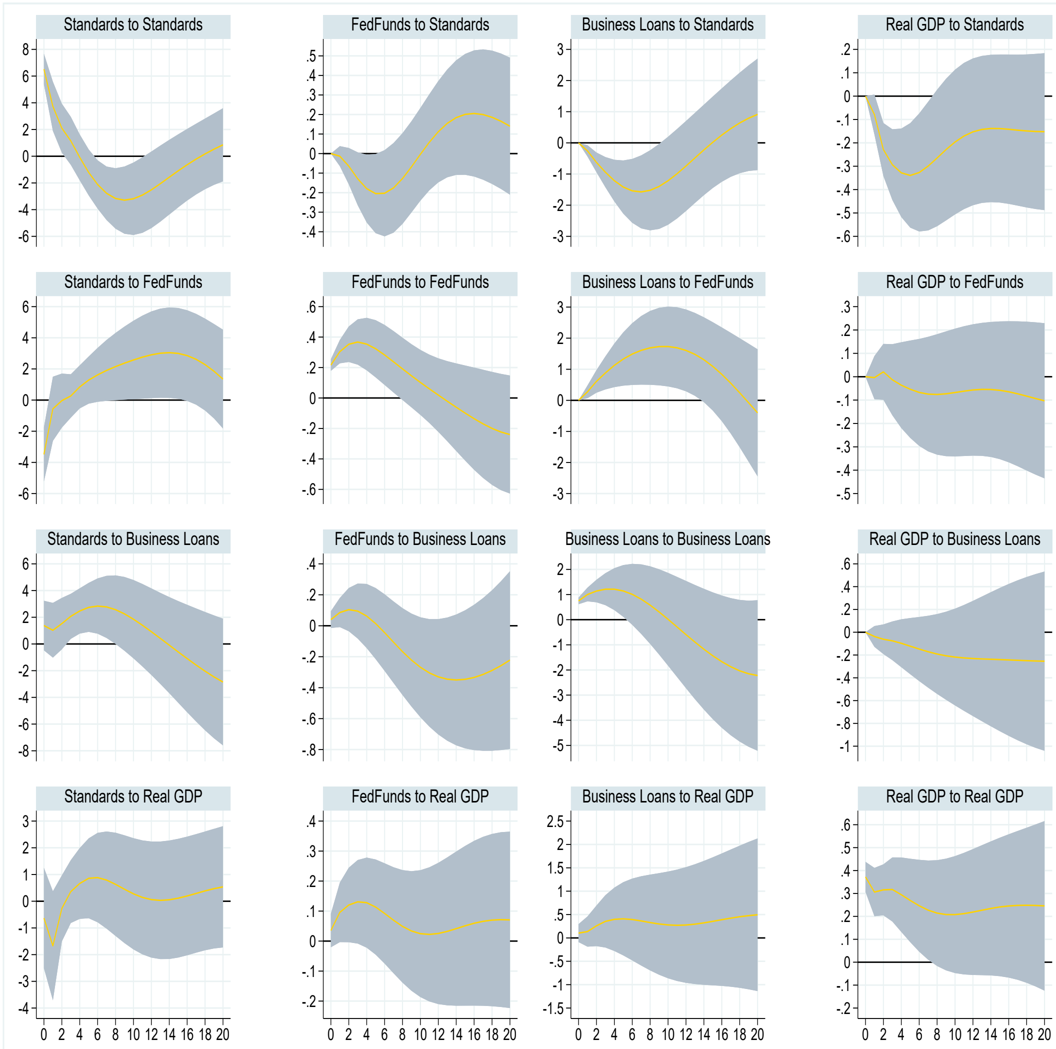
Responses of:



Note: The shaded bands represent 95 percent confidence bands. The order of variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, FedFunds = the federal funds rate, Standards = net percentage of lenders tightening standards

Figure 26: SVAR Model 3 - Different Ordering of Variables

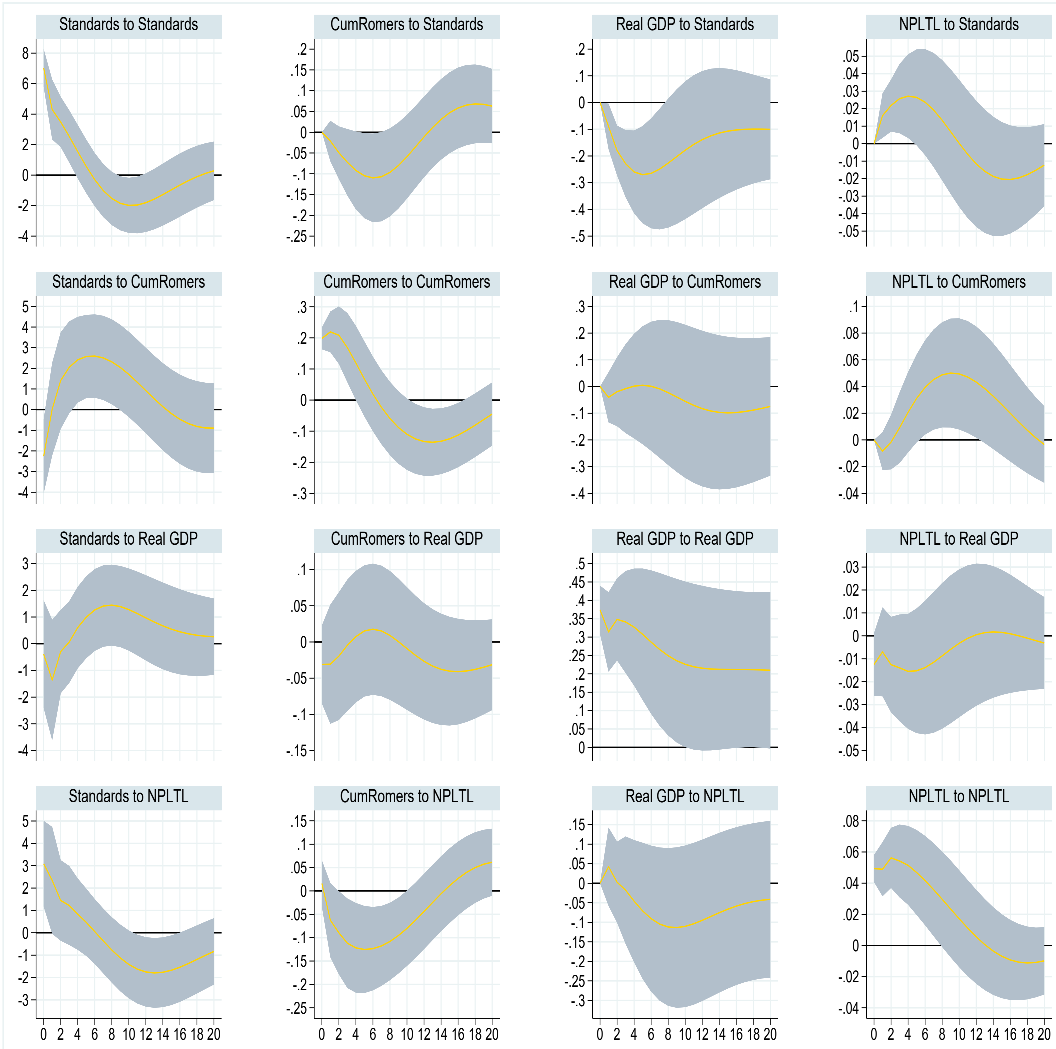
Responses of:



Note: The shaded bands represent 95 percent confidence bands. The order of variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, Business Loans = log commercial and industrial loans, FedFunds = the federal funds rate, Standards = net percentage of lenders tightening standards

Figure 27: SVAR Model 4 - Different Ordering of Variables

Responses of:



Note: The shaded bands represent 95 percent confidence bands. The order of variables: Real GDP = log of real GDP, GDPDef = log of GDP deflator, GloComPri = log of global commodity prices, NPLTL = total non-performing loans to total loans (percentage), CumRomers = cummulative Romer and Romer Shock, Standards = net percentage of lenders tightening standards.

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