Essays on the Credit Channel of Monetary Policy

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Submitted 03 September 2002

Revised 07 July 2003

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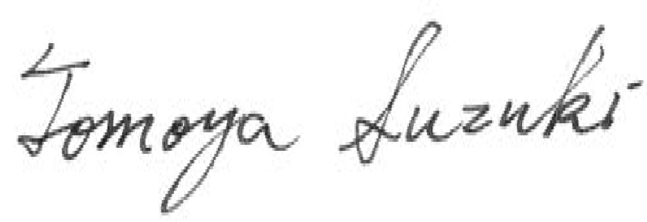
A thesis submitted for the degree of Doctor of Philosophy of the Australian National University.

Declaration

The thesis represents my original work except where otherwise acknowledged in the text.

Tomoya Suzuki



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Acknowledgements

I would like to thank my supervisor, Dr Graeme Wells, for all his advice and direction during my time as a PhD student at the Australian National University. I have received insights, ideas, and encouragement from him. Without his patient support, I would have been unable to complete this thesis.

I learnt a lot from different people at different stages. Over the past few years, Dr Mardi Dungey has helped my econometric works. Chapters 2 and 3 have enormously benefited from her comments and suggestions. When I was writing Chapter 4 three years ago, Dr Paul Lau was the main person with whom I discussed my study. I received much help from Professor Peter Drysdale and Dr Luke Gower at the early stage of my PhD. I am thankful to each of them for her or his support.

Also appreciated are comments from the participants of conferences and seminars: the Australasian Macroeconomic Workshop at the Adelaide University, the 30th annual conference of the Economic Society of Australia at the University of Western Australia, the PhD Conference in Economics and Business at the University of Western Australia, the 60th anniversary meeting of the Japan Society of Monetary Economics at the Hitotsubashi University, and seminars at the Australian National University, the Canterbury University, the Curtin University of Technology, the Griffith University, the Monash University, and the University of Western Australia. Comments and suggestions from Professor Ron Bewley, Professor Adrian Pagan, and Dr Alfred Guender were particularly helpful. Dr Peter Stemp thoroughly read Chapter 3 as the discussant at the PhD Conference, providing useful comments.

Chapters 2 and 3 utilise the data which are not readily available. These data are indispensable in the empirical analyses of these chapters. I am grateful to the Bank of Japan, the Australian Chamber of Commerce and Industry, and the Westpac Banking Corporation for providing their survey data on my request.

My understanding of economics and econometrics has greatly benefited from tutoring experience at the School of Economics with Dr Matt Benge, Dr Robert Breunig, Dr Trevor Breusch, Dr Chris Jones, and Professor Don Poskitt. Encouragement and criticism from many students in my tutorial classes were also helpful.

I received financial support for my study at the Australian National University. I acknowledge the scholarship from the Hitotsubashi University in Japan.

The revision of this thesis has benefited from the comments of three examiners. I am thankful to Dr Graham Voss for providing the data on my request, which are used for a check of robustness in the appendix of the thesis.

Last, but not least, I would like to thank my family members for their tolerance and continuous support through my PhD.

Summary

A long-standing macroeconomic issue is how monetary policy affects the real economy. In modern economies, contraction of bank loans often coincided in timing with adverse macroeconomic developments after tightening monetary policy. Chapter 1 discusses its interpretations. A standard argument is that a monetary tightening decreases aggregate demand, thereby shifting the demand schedule for bank loans left (i.e., the "money view"). The reverse causality is consistent with those coincident events, however. A monetary tightening can affect the real economy by shifting the supply schedule of bank loans left. Such views are collectively called the "credit view." The credit contraction is consistent with the credit view as well as the money view. The observational equivalence is called the "supply-versus-demand puzzle".

Chapter 2 provides empirical resolution of the supply-versus-demand puzzle in the context of Japan. Within a framework of VAR models, this chapter shows that embedding both the price and quantity of bank loans reduces the supply-versus-demand puzzle to a problem like the resolution of simultaneous equation bias. The simulation results imply that the supply schedule of bank loans shifts left after a monetary tightening, which provides evidence for the credit view.

The credit view consists of two different views, however. The "bank-lending view" is that banks cut back on lending in the wake of tight money because they have less money to lend even though there are perfectly good loans to be made, which implies an independent impact of bank lending on the real economy. On the

other hand, the "balance sheet view" is that banks cut back on lending because monetary tightening causes firm balance sheets to weaken, which implies no independent impact of bank lending on the real economy. Thus, the two credit views have different implications, and hence Chapter 2 also tests the balance sheet view.

The importance of the credit channel may be dependent on institutional characteristics of the financial market. Chapter 3 identifies the shifts of the demand and supply schedules in the Australian loan market. The results are not supportive of the credit view. This chapter further examines characteristics of Australian bank behaviour which make the credit view less plausible. An important finding is that Australian banks raise loan funds from the international financial market when money is tightened.

The difference in the results between Chapters 2 and 3 implies that the importance of the credit channel is likely to diminish over time due to ongoing internationalisation of banking activities. There may be institutional changes that make credit channel more important, however. An example of such institutional changes is the implementation of the risk-based capital standards under the Basle Accord. The Accord allows Japanese banks to count 45% of latent capital gains from their stock holdings toward bank capital, which implies that monetary policy may shift the supply schedule of bank loans by affecting stock prices. Within a framework of costly-state-verification models, Chapter 4 examines the effects of the implementation of the risk-based capital standards on the credit channel.

Chapter 5 concludes by discussing the topics for future studies.

Contents

Chapter 1

Introduction

Adverse macroeconomic developments have sometimes coincided in timing with banking problems in modern economies. A notable example is provided by the recent experience of the Japanese economy. As will be discussed shortly, slowdowns of bank lending have accompanied protracted recessions since the early 1990s. A possible explanation of these coincident events is that banks responded to inward shifts of the demand schedule for bank loans, which reflected the declines in aggregate output. The opposite direction of causality is also consistent with those coincident events, however. The disrupted activities of banks impaired the flow of funds from lenders to borrowers, resulting in undesirable macroeconomic consequences. That is, the slowdowns of bank lending protracted the recessions by constraining the availability of funds to firms and households. The latter direction of causality implies that the banking sector can amplify impacts of exogenous shocks on the real economy. Such a role of banks in the macroeconomy is the focus of this thesis. In particular, the thesis examines the credit view that monetary policy shocks can have impacts on the real economy by affecting the credit market conditions.

The credit view has important implications. First, a credit aggregate may be a better indicator of monetary policy than monetary aggregates or interest rates. Second, a monetary tightening can have distributional consequences. While large firms have access to a variety of financial sources, bank loans are a primary source of finance to small firms. Thus, small firms bear the brunt of monetary contraction to the extent that it shifts the supply schedule of bank loans left. Such distributional side effects, if any, should be taken into consideration when policy is formulated. Third, the credit view suggests that a policy maker should observe the financial condition of the banking sector. Suppose that banks' capital was depleted in a recession. In such a case, an attempted expansionary monetary policy will be stalled because banks can hardly increase loans. In extreme cases, the injection of financial capital into the banking sector may be a better option than standard prescriptions for recessions. For these implications, it is of fundamental importance, particularly to policy makers, to study the credit view.

This introduction provides general background for the discussion in the chapters that follow. The first section briefly reviews the recent experience of the Japanese economy. Emphasis will be placed on co-movements between aggregate output and bank credit. As is mentioned above, this thesis examines a view that the banking sector amplifies impacts of exogenous shocks on the real economy. In particular, the thesis examines how the impacts of monetary policy shocks are transmitted onto the economy through the banking sector. That is, the focus of this thesis is the credit view. The second section discusses the credit view. The credit view will be empirically examined and theoretically expanded in the following chapters of this thesis. The third section provides an overview of the thesis.

1.1 Experience of the Japanese Economy

The Japanese financial system was characterised by heavy intervention from the government during most of the post-war period. Under circumstances of capital shortage after the defeat of World War II, the government regulated the financial system as part of its industrial policy in an attempt to direct household savings to the non-financial business sector. These regulations took several forms. First, the government restricted international capital flows and managed exchange rates to insulate the domestic financial sector from international market forces. Second, most interest rates were under control of the government, which prevented the evolution of money and capital markets, thereby delegating a major role in the flows of funds to the banking sector. Third, the financial system was highly segmented, and the banks were separated by different categories, which protected the banking sector from competition with other financial institutions as well as competition within the banking sector. It was not until the late 1980s to the early 1990s that these regulations were abolished.

With the regulatory approach of the government, the bank-centred financial system, which is known as the "main bank system", ensued.[1] While a non-financial firm borrows from more than one bank, its transaction and settlement account is usually concentrated at a particular bank, which is called the main bank. As Aoki, Patrick, and Sheard (1994) point out, the relationship between a firm and its main bank extends beyond lending. It is not uncommon for a firm that its main bank is the largest shareholder. When a firm issues bonds, the main bank also serves as trustee of the collateral or as the guarantor. As

[1] There is a large literature on the evolution of the Japanese financial system. See, for instance, Aoki, Patrick, and Sheard (1994), Hoshi and Patrick (2000), and references therein.

such, the non-financial sector highly depended on the domestic banking sector. In 1989, for instance, 94.9% of outstanding funds raised by the non-financial sector was via the domestic market, and 66.8% was bank loans (see Table 1.1). The dependence of the non-financial sector on the banks implies the possibility that the banks' disrupted activities have more severe macroeconomic consequences than in other economies.

Table 1.1: Funds raised by the Domestic Non-financial Sector (Stock)

100 million yen

Year	A	B	C	D
1989	7,792,643	10,480,095	15,681,476	16,532,711
1990	8,515,246	11,230,421	16,861,217	17,737,971
1991	8,910,578	11,699,960	17,362,481	18,282,860
1992	9,237,929	12,219,546	17,480,622	18,273,583
1993	9,543,704	12,814,742	18,860,969	18,176,397
1994	9,768,843	13,199,399	19,399,064	18,715,145
1995	9,946,412	13,709,448	19,643,823	20,407,557
1996	10,060,108	14,072,604	19,759,490	20,616,372
1997	10,258,495	14,467,158	20,003,886	20,863,822
1998	10,196,603	14,717,528	19,872,874	20,690,706
1999	10,081,990	15,127,133	20,571,317	21,363,070
2000	9,908,501	15,376,571	21,029,960	21,753,042

A: Outstanding bank loans

B: A plus securities held by the domestic financial sector

C: B plus funds raised from the domestic non-financial sector

D: Total funds (C plus funds raised from the overseas sector)

Source: Reference to Flow of Funds, the Bank of Japan

Web address: www.boj.or.jp/en/siryo/siryo_f.htm

The economy of Japan has experienced substantial fluctuations since the mid-1980s.

After the Plaza Accord of 1985, the Japanese yen sharply appreciated against the U.S. dollar, which resulted in the "Endaka" recession (see the upper two graphs of Figure 1.1)[2] According to the Economic Planning Agency, the economy bottomed out in November 1986 and expanded until February 1991 (i.e., the "Heisei" boom). The Heisei boom was the second longest after World War II, and an average annual growth rate of industrial production during the boom was 7.2%. As the lower two graphs of Figure 1.1 shows, asset prices rose sharply and substantially at the same time. The rise in the stock price index of Nikkei 225, for instance, accelerated in 1986 reaching a peak at the end of 1989, which was 3.1 times higher than the level in September 1985. Following the rise in the Nikkei 225, the Urban Land Price Index hit a peak in the third quarter of 1990, which was nearly four times higher than the level at the time of the Plaza Accord of 1985. With hindsight, the asset prices boom is recognised as a bubble. The asset price bubble improved the balance sheet of the business sector, thereby enabling it to raise funds with ease. As a consequence, fixed investment accounted for nearly 20% of nominal GDP in the late 1980s to the early 1990s. The increase in the ratio of fixed investment to output coincided in timing with the sizable expansion of money and credit (see Figure 1.2 on a later page).[3]

Movements in money and credit may be affected by monetary policy. When the Japanese economy plunged into recession after the Plaza Accord of 1985, expansionary monetary policy was promoted. Consequently, the supplies of money and credit began increasing (see the third graph of Figure 1.2). Despite the overheating of economic ac-

[2] Sources of the data on GDP and the land prices are the IMF and the Japan Real Estate Institute, respectively. Source of the other data is the BOJ.

[3] Sources of the data on CPI and the ratio of private non-financial investment to nominal GDP are the IMF and the Economic Planning Agency, respectively. Source of the other data is the BOJ.

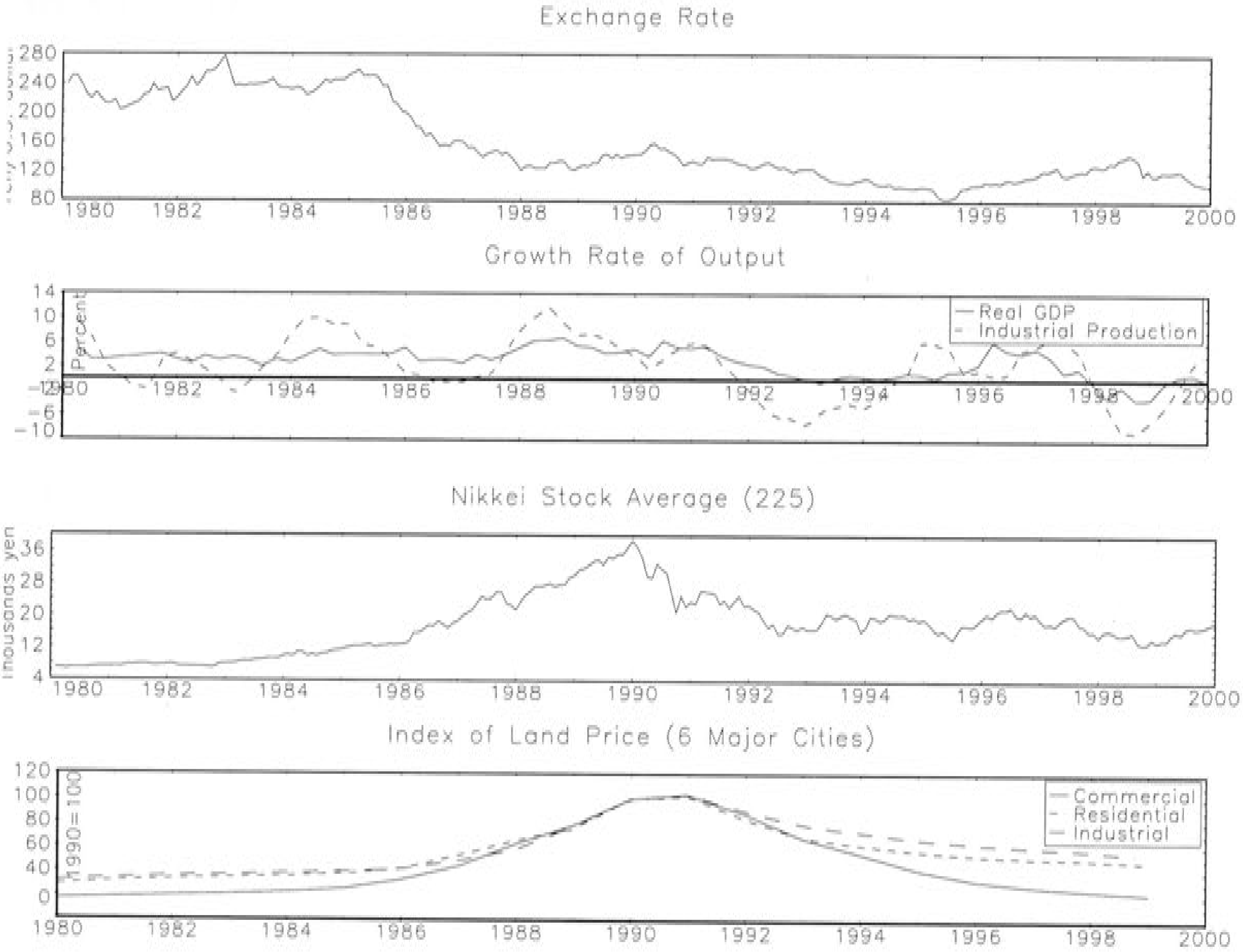

Figure 1.1: Financial and Macroeconomic Conditions I

tivities in the late 1980s, the Bank of Japan (BOJ) maintained the official discount rate at 2.5%, which was at that time the lowest level since the end of WWII, for a protracted period. This was partly because general prices were relatively stable at the outset of the asset price bubble (see the second graph of Figure 1.2). The BOJ policy accelerated the growth of money and credit. It was not until May 1989 that the BOJ shifted to a monetary tightening. The shift was unexpected and rapid. The official discount rate was raised five times to 6.0% over the short period of May 1989 to August 1990. The sharp rises of the official discount rate were followed by the burst of the bubble, and the Japanese economy plunged into recession in the second quarter of 1991 after the 51-month long expansion.[4] Although the economy began to recover from recession in the first quarter of 1994, the recovery was sluggish and the economy plunged into another adjustment phase three quarters later. As Figures 1.1 and 1.2 show, the adverse developments in real output coincided in timing with the slowdowns of credit.

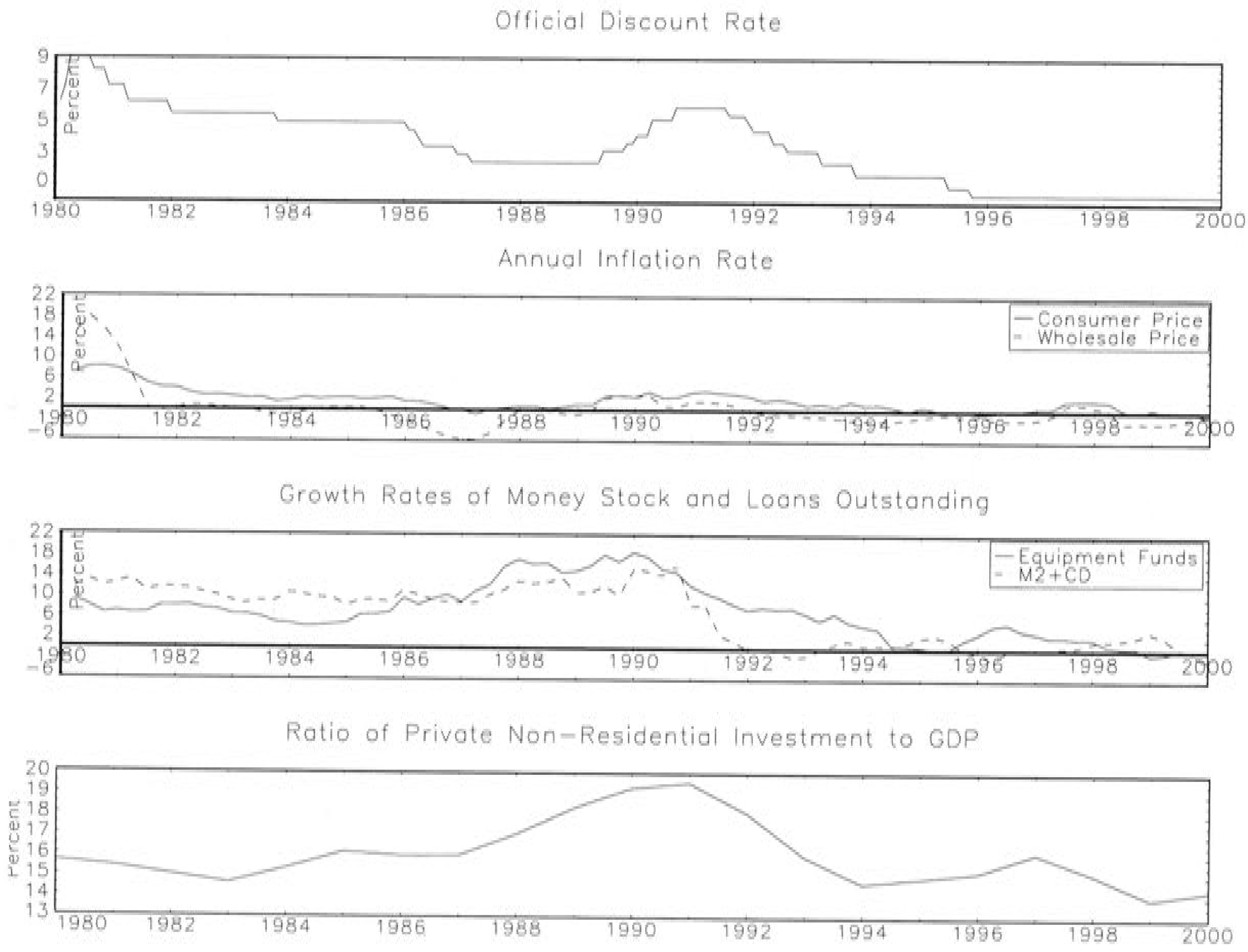

Figure 1.2: Financial and Macroeconomic Conditions II

The impacts of the collapse of the asset price bubble on the banking sector were more

[4]There is a perception that the monetary tightening caused the collapse of the asset price bubble, thereby resulting in the protracted recession. Cargill (2000), for instance, says "Bank of Japan policy after 1986 contributed to asset inflation, and the subsequent collapse of asset prices generated recession and non-performing loan problem; thus, Bank of Japan policy can be regarded as a 'cause' of the banking crisis."

than the slowdowns of credit. Non-performing loans ensued as a serious financial problem, which is argued to have prevented the economic recovery by disrupting activities of the banking sector. In September 1995, for instance, the government decided to provide an economic stimulus package worth 14 trillion yen. At the same time, the Bank of Japan lowered its official discount rate to 0.5%. These attempts were, however, stalled by the troubles of housing loan companies (the *Jûsen*) that were non-bank financial institutions established by banks in the 1970s to engage in mortgage loans. By 1995, 75% of *Jûsen* loans were non-performing, which eventually forced the founder banks to bear 3.5 trillion yen of losses, other banks 1.7 trillion yen, agricultural credit cooperatives 530 billion yen, and taxpayers 680 billion yen (see Hoshi and Patrick 2000). The *Jûsen* crisis was followed by the failures of the largest regional bank and two large credit unions. At the end of March 1999, non-performing assets of major Japanese banks amounted to 20.3 trillion yen (4.1% of nominal GDP).[5]

The recent experience of Japan seems to imply an important link between the activities of the banking sector and the macroeconomy. What is the interpretation of the recent experience of the Japanese economy? While a bad macroeconomic condition can cause damage to the banking sector, it is also likely that the malfunction of the banking sector protracts recession. In other words, impacts of exogenous shocks on the economy may be amplified by the banking sector. It is the latter view, with emphasis on monetary policy shocks, that the thesis examines.

[5]There is a growing literature on the banking problems of Japan in the 1990s. See Suzuki (1996) and Taniuchi (1997) for succinct description of the banking problems in Japan. Cargill (2000), Hoshi (2001), and Ueda (2000) also provide historical analysis of the causes of the problems. Bayoumi (2001) and Woo (1999) econometrically analyse the impacts of the banking problems on economic activities.

1.2 The Credit View

The mechanism for the transmission of monetary policy to the real economy is a long-standing macroeconomic issue. While there are many kinds of monetary policy channels, a standard argument is that a monetary authority uses the leverage over a short-term interest rate to influence the cost of capital (see Mishkin 1995 for a survey on a variety of monetary transmission processes). This is called the money view. In terms of the banks' balance sheets, the money view focuses on the liability side. There have been economists who have stressed importance of the role played by bank loans (i.e., the asset side of the banks' balance sheets) in the transmission process of monetary policy, however. Their views are collectively called the "credit view".[6]

The credit view makes a distinction between credit and other non-monetary financial variables. From firms' point of view, the distinction is made either between bank loans and non-bank funds or between internal funds and external funds including bank loans. The former distinction and the latter one pertain to the "bank-lending view" and the "balance sheet view", respectively. The credit view consists of these two views. As will be shown shortly, the two views have different implications.

1.2.1 Bank-Lending Channel

In a standard IS-LM model, for instance, bank loans are lumped together with other financial instruments in a bond market, which is conveniently suppressed by Walras' Law.

[6] Early references include Fisher (1933) and Gurley and Shaw (1955). Gertler (1988) provides a survey of the early literature on the credit view. With the development of information economics and time series econometrics, the credit view has been resurrected over the past two decades. See, for instance, Bernanke, Gertler, and Gilchrist (1996) and Walsh (1998, Ch 7) for a recent literature survey.

Therefore, it is necessary to abandon the assumption of perfect substitutability between bank loans and bonds in order to study the macroeconomic role of bank lending within a framework of IS-LM models. By distinguishing bank loans from bonds, Bernanke and Blinder (1988) succinctly illustrate the essence of the bank lending view in a variant of the IS-LM model.[7] Under the assumption that the loan market is cleared by the price, they suppress the bond market by Walras' Law, examining the interaction among three markets: goods, money, and bank loans.

In the bank loan market, banks are suppliers. Given the deposits D and the reserve ratio τ, the banks allocate their available funds to three assets: bonds (B^s), bank loans (L^s), and excess reserves (E). Their constraint is written as

$$B^b + L^s + E = D(1 - \tau).$$

The banks determine the proportion of bank loans in their portfolio, depending on the interest rates on loans (ρ) and bonds (i). Let λ denote this proportion. Then, the supply function of bank loans can be expressed as:

$$L^s = \lambda(\rho, i) \cdot D(1 - \tau); \ \lambda_\rho > 0 \text{ and } \lambda_i < 0,$$

where λ_ρ and λ_i denote the partial derivatives of λ with respect to ρ and i, respectively. Similarly, borrowers demand for bank loans in this market. They have two sources of finance, namely bank loans and bonds. Therefore, the demand for bank loans depends on

[7] Although the IS-LM model of itself is no longer regarded as a serious model in the recent literature, the Bernanke and Blinder (1988) model has been a workhorse for the bank-lending view. See, for example, Bårdsen and Klovland (2000), Catão and Rodriguez (2000), Spiegel (1995), and Wu (1999). In the empirical chapters of this thesis, their model will be utilised for the specification of the equation system to be estimated.

ρ and i:

$$L^D = L(i, \rho, Y); \; L_i > 0, \; L_\rho < 0, \text{ and } L_Y > 0,$$

where Y is output included to capture the transactions demand for credit. Thus, the equilibrium in the bank loan market is given by

$$L(i, \rho, Y) = \lambda(\rho, i) \cdot D(1 - \tau). \tag{1.1}$$

The money market is described by a conventional LM curve. The demand for deposits is a function of i and Y: $D(i, Y)$ where $D_i < 0$ and $D_Y > 0$. Under the assumption that the ratio of banks' excess reserves to their assets (ϵ) depends on i, the supply of deposits is assumed to be equal to bank reserves (R) times the money multiplier, $m(i) = [\epsilon(i) \cdot (1 - \tau) + \tau)]^{-1}$, where $m_i > 0$. Thus, the money market equilibrium is expressed as

$$D(i, Y) = m(i) \cdot R. \tag{1.2}$$

As R is assumed to be exogenous, the monetary authority can influence money supply by changing the quantity of reserves.

The remaining market is the goods market. The goods market equilibrium is summarised by a variant of IS curve:

$$Y = Y(i, \rho); \; Y_i < 0, \text{ and } Y_\rho < 0. \tag{1.3}$$

Unlike the conventional IS curve, output negatively depends on the two interest rates, namely i and ρ. This is due to the assumption of imperfect substitutability between bonds and bank loans. Note that equation (1.3) expresses the usual IS curve when output is irresponsive to the interest rate on loans (i.e, $Y_\rho = 0$).

Equations (1.1) to (1.3) summarise the economy where monetary policy operates through the bank-lending channel. By substituting equation (1.2) to equation (1.1), the equilibrium condition for the loan market can be rewritten as

$$L(i, \rho, Y) = \lambda(\rho, i) \cdot (1 - \tau) \cdot m(i) \cdot R, \tag{1.4}$$

which shows that an exogenous change in reserves influences the amount of loanable funds in the banking sector, thereby affecting the equilibrium condition of the loan market. In other words, the clearing price of the loan market depends on the level of reserves as well as the interest rate on bonds and the level of output:

$$\rho = \phi(i, Y, R); \; \phi_i > 0, \; \phi_Y > 0, \text{ and } \phi_R < 0. \tag{1.5}$$

Substitution of equation (1.5) into the equilibrium condition of the goods market (1.3) closes the model:

$$Y = Y(i, \phi(i, Y, R)), \tag{1.6}$$

which expresses the relationship with i and y that is consistent with the equilibria in the goods market and the bank loan market. This relationship is called the "CC curve" where CC denotes commodity and credit. The CC curve corresponds to the IS curve in the conventional IS-LM model, and has a downward slope in the $Y - i$ space.

Equation (1.6) shows that an exogenous change in R affects the real economy by changing the conditions of the goods market and the bank loan market. Suppose that the monetary authority tightens money. Equation (1.2) illustrates that an exogenous decrease in R reduces the supplied money, which shifts the LM curve left in a conventional way. As equation (1.4) shows, however, the decrease of R also decreases the loanable funds in the banking sector, which shifts the supply schedule of bank loans left. In response to the leftward shift of the supply schedule of bank loans, the price of bank loans rises to clear the loan market (see equation 1.5). As is clear from equation (1.6), the rise of the loan rate decreases the commodity demand, thereby shifting the CC curve left. This is the bank-lending channel of monetary policy. Graphically, an exogenous change in R shifts the CC and LM curves in the same direction. Thus, the bank-lending channel makes the impact of monetary policy on the real economy larger than in the standard IS-LM model.

There are cases, however, where monetary policy does not operate through the bank-lending channel. A crucial assumption of this model is that bank loans and bonds are imperfect substitutes either to borrowers and lenders. Suppose that these two financial assets are perfect substitutes for borrowers. Then, the price elasticity of the demand for bank loans is minus infinity, making the demand curve for bank loans horizontal. Consequently, the clearing price of the bank loan market is uniquely determined, regardless where the supply schedule of bank loans lies. Similarly, suppose that bank loans and bonds are imperfect substitutes for lenders. Then, the price elasticity of the supply of bank loans is infinity, which means that the supply curve of bank loans is horizontal. As a consequence, the clearing price of the loan market is again independent of the location of the demand schedule for bank loans. As a change in R has no impact on the loan rate in these two cases, the bank-lending channel will not be operative. Finally, suppose that the commodity demand is irresponsive to a change in the loan rate. Then, the level of output does not depend on the loan market condition at all, which makes the bank-lending channel irrelevant. In summary, there are three necessary conditions for monetary policy to operate through the bank-lending channel:

$$L_\rho = -\infty, \ \lambda_\rho = \infty, \text{ and } Y_\rho = 0.$$

Kashyap and Stein (1994) stress the importance of the first two of the three necessary conditions. These two conditions may be vulnerable to ongoing financial innovation and/or deregulation, however. If banks are allowed to raise funds from a variety of financial sources that are not subject to reserve requirements, it is less likely that a monetary authority can affect the supply of bank loans. Similarly, the importance of bank loans to firms will diminish if firms have access to a variety of non-bank financial sources. As such, it seems that, with financial deregulation and innovation, "the importance of the traditional bank lending channel has most likely diminished over time" (Bernanke and Gertler 1995).

1.2.2 Balance Sheet Channel

The other credit channel is the balance sheet channel, which is formalised by Bernanke and Gertler (1989). Their model assumes profit maximization of economic agents under asymmetric information between lenders and borrowers. In their model, a borrower can observe the outcome of his/her investment project without cost, whereas costly auditing is required for others to observe the outcome. Under asymmetric information, a borrower has an incentive to default by misreporting a good outcome as a bad outcome. Since the auditing is costly, however, a lender requires loans to be fully collateralised by a borrower's net worth. Thus, the credit availability to a firm (or a household) depends upon its net worth. If monetary policy changes the net worth of firms and/or households, it can have impacts on the real economy by affecting the availability of funds to them.[8]

In their model, Bernanke and Gertler (1989) assume two heterogeneities among borrowers. First, some borrowers require more inputs to undertake their investment projects than others. Second, some borrowers have higher savings than others. These hetero-

[8]The Bernanke and Gertler (1989) model of the balance sheet channel is a variant of the "costly state verification" model of Townsend (1979). In Chapter 4, this thesis extends the costly state verification model to examine the effects of the introduction of the capital adequacy requirements on banking behaviour.

geneities imply three situations. First, a borrower can raise external funds to undertake her project, if her net worth is greater than the principal and interest regardless of the project outcome. This is full collateralisation. Second, a borrower, whose net worth is lower than the principal and interest even when the project outcome is successful, cannot raise external funds at all. In this case, the investment project should be abandoned. Third, a borrower may or may not be able to obtain external funds, if her net worth is greater than the principal and interest only when the project outcome is successful. This is the situation of incomplete collateralisation.[9]

Under such circumstances, any shock that affects borrowers' balance sheets will have significant impacts on the real economy. Suppose that an exogenous shock reduced borrowers' net worth. Some of the 'good' borrowers whose loans are fully collateralised will become 'fair' borrowers whose loans are incompletely collateralised. Similarly, some of the 'fair' borrowers who may be lucky enough to invest will be no longer able to raise funds. Consequently, bank loans will contract, which in turn will force borrowers with weaker balance sheets to cut back on investment expenditures. In such a way, the exogenous shock affects the balance sheets of borrowers (e.g. firms), thereby decreasing the aggregate level of investment. This propagation mechanism of business fluctuations is called the "financial accelerator" (Bernanke, Gertler, and Gilchrist 1996).

In order to extend the argument of the financial accelerator to include the balance sheet channel of monetary policy, it is necessary to show that a monetary tightening

[9] Bernanke and Gertler (1989) assume the savings lottery among borrowers in the case of the incomplete collateralisation. Funds are transferred from those who won the lottery to those who lost. As a consequence, some borrowers can invest, but others cannot.

weakens firms' balance sheets.[10] A possible explanation is that a monetary tightening causes a higher real interest rate, thereby, reducing the present value of the future cash flows to firms. The discussion implies that firms have difficulty in obtaining *any* sort of external funds when their balance sheets are weaker. That is, the argument of the financial accelerator is not restricted to the bank lending. For this reason, the balance sheet channel is also called the "broad credit channel" (Ramey 1993).

Closely related with the balance sheet view or the broad credit view is the theory of credit cycles, which is proposed by Kiyotaki and Moore (1997). They focus on the role of durable assets (such as land) as collateral, the supply of which is fixed. It is again assumed that external funds need to be collateralised because of imperfect information. They assume that only durable assets can be collateral. In their model, two types of economic agents are considered: farmers and gatherers. The farmers borrow from the gatherers to increase their land holding. The farmers are credit constrained, however. That is, the farmers' land holding is assumed to be less than the socially optimal level in equilibrium.

The transmission mechanism of exogenous shocks is as follows. Suppose that a negative temporary shock reduced the productivity of farmers. Net worth of the farmers falls, and the credit constraint facing them becomes tight. Being unable to borrow more, the farmers

[10] Hubbard (1994) and Kashyap and Stein (1995) justify the bank-lending view by the financial accelerator theory. They argue that a monetary tightening worsens banks' balance sheets, thereby making it difficult for the banks to raise funds for bank loans from the financial market. To test this argument statistically, Kashyap and Stein (2000) examine the micro data on the U.S. banks' balance sheets. While their argument is convincing, it is not tested in this thesis. This is primarily because the micro data are too expensive. Testing their argument, for instance, in the context of Japan or Australia can further the literature.

need to cut their expenditures, including investment in land. As the supply of land is fixed, the price of land must fall so as to increase the gatherers' demand for land. (Note that the gatherers are not credit constrained.) The fall of land price still further reduces the net worth of the farmers. Again, the farmers are forced to cut their investment in land, which in turn causes further fall of land price. As the farmers' landholding decreases, aggregate output decreases. The knock-on effects continue, and the impacts of an exogenous shock are amplified over time. By modelling the feedback from a change in asset prices to the net worth of borrowers, Kiyotaki and Moore (1997) show that a small shock can have substantial impacts on economic activities for a protracted period.

The theory of credit cycle seems particularly true of the Japanese economy in the sense that land is primary collateral for bank loans. As is discussed above, the deterioration of the real property market, which was initiated by the burst of the asset price bubble, coincided in timing with the adverse developments in the macroeconomy as well as the slowdown of bank loans. Although the direction of the causality is not clear, the recent experience of the Japanese economy is not inconsistent with the theory of credit cycle. In a later chapter of this thesis, the theory of credit cycle will be hypothesised and tested in a statistical way.

As is clear from the above discussion, a main characteristic of the bank-lending view and the balance sheet view is that the supply schedule of bank loans shifts left following a monetary tightening.[11] Their economic implications are totally different, however. The

[11] A leftward shift of the supply schedule of bank loans would lead to contraction of bank loans. Contraction of bank loans is consistent with the credit view as well as the other views of the monetary transmission mechanisms, however. Any of the other views supposes that a monetary tightening decreases aggregate demand, which in turn shifts the demand schedule for bank loans left, thereby, leading to contraction of

existence of the bank lending channel implies that banks cut back on lending in the wake of tight money simply because they have less money to lend. This cutback can have impacts on the economy so long as there are perfectly good loans to be made. On the other hand, the existence of the balance sheet channel does not necessarily imply that the cutback on lending has independent impacts on the economy. Banks cut back on lending because firms are in bad shape. That is, banks endogenously respond to developments of economic conditions. In this case, it is imprudent for banks to lend. As such, the distinction between the two credit channels boils down to the question whether banks play an independent role in the economy, and hence it is of importance to identify which credit channel, if any, is operative.

1.3 Empirical Work with Time-Series Data

In the empirical literature, time series data are often examined to study how a monetary policy shock is transmitted to the economy over time. Sims (1980) proposes to approximate the economy by a system of linear equations:

$$\mathbf{B}_0\mathbf{y}_t = \mathbf{k} + \mathbf{B}_1\mathbf{y}_{t-1} + \mathbf{B}_2\mathbf{y}_{t-2} + \cdots + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \tag{1.7}$$

where $\mathbf{y}$ is an $(n \times 1)$ vector of macroeconomic variables, $\mathbf{k}$ is an $(n \times 1)$ vector of constants, $\mathbf{B}$s are $(n \times n)$ coefficient matrices, and $\mathbf{u}_t$ is an $(n \times 1)$ vector white noise. In his model, $\mathbf{y}$ consists of output, price, money, and an interest rate. Clearly, equation (1.7) is a simultaneous equations model. If $\mathbf{B}_0$ is non-singular, the reduced form can be expressed

bank loans.

as a vector auto-regression (VAR) model:

$$\mathbf{y}_t = \mathbf{c} + \mathbf{\Phi}_1 \mathbf{y}_{t-1} + \mathbf{\Phi}_2 \mathbf{y}_{t-2} + \cdots + \mathbf{\Phi}_p \mathbf{y}_{t-p} + \mathbf{e}_t, \tag{1.8}$$

where

$$\begin{aligned} \mathbf{c} &= \mathbf{B}_0^{-1}\mathbf{k} \\ \mathbf{\Phi}_i &= \mathbf{B}_0^{-1}\mathbf{B}_i \text{ for } i = 1, \cdots, p \\ \mathbf{e}_t &= \mathbf{B}_0^{-1}\mathbf{u}_t. \end{aligned}$$

Under the identifying assumption that $\mathbf{B}_0$ is lower triangular, he estimates the model, thereby simulating responses of the macroeconomic variables to a shock associated with the interest rate.[12] This approach is called the "structural VAR approach".

The structural VAR approach has been employed in the empirical literature on the credit view in the U.S. context. Using the aggregate time-series data, Bernanke and Blinder (1992) estimate a structural VAR model for the U.S. to investigate impacts of a monetary tightening on the composition of the U.S. banks' balance sheet. In their analysis, the federal funds rate is assumed to measure the stance of Federal Reserve policy. Importantly, they find that increases in the federal funds rate are followed by slowdowns of bank loans, which is consistent with the bank lending view that a monetary tightening reduces the availability of bank loans, thereby affecting economic activities. Kashyap and Stein (1994) estimate the same VAR model for a different sample period, confirming the robustness of the Bernanke and Blinder's finding. A similar finding is reported by Romer

[12]Although Sims (1980) assumes a recursive system for the purpose of identification, there are other types of identifying restrictions. See, for instance, Bernanke (1986), Blanchard and Quah (1989), and Sims (1986).

and Romer (1990) who date shifts in policy by studying the language in the Federal Open Market Committee directives.

As will be explained in Chapters 2 and 3, however, the Bernanke and Blinder (1992) finding is consistent with the money view as well as the credit view. It might be the case that slowdowns of bank loans reflect decreased aggregated demand caused by tight money. For the resolution of this identification problem, Kashyap, Stein, and Wilcox (1993) emphasise that a reduction in the availability of bank loans will force borrowers to substitute away from bank loans to other debts. By examining the ratio of business bank loans to the sum of business bank loans and commercial paper issuance, they find that a monetary tightening is followed by an increase of commercial paper issuance relative to bank loans, thereby concluding that monetary policy of the Fed operates through the credit channel.[13] As commercial paper issuance is available only to large firms, however, Gertler and Gilchrist (1994) and Oliner and Rudebusch (1996) replace commercial paper issuance with a wider range of financial debts. They find that the results are sensitive to the choice of the external finance other than bank loans. They also argue that heterogeneity of the demand for external funds between large firms and small firms undermines the interpretation of the Kashyap, Stein, and Wilcox (1993) results.

The U.S. literature inspired empirical work on the bank-lending channel in Japan. Following Bernanke and Blinder (1992), Ueda (1993) estimates a similar structural VAR model where the policy stance of the BOJ is measured by the call rate. By examining the response of bank loans to a hike of the call rate with aggregate time-series data, he

[13] Kashyap, Stein, and Wilcox (1993) use two different measures of a monetary tightening. One is the Romer and Romer (1990) dates of shift in policy. The other is the federal funds rate, which Bernanke and Blinder (1992) propose.

concludes that bank loans play an important role in the transmission policy in Japan. Hoshi, Scharfstein, and Singleton (1993) calculate the ratio of industrial loans from banks to total industrial loans with Japanese data. Examining the response of the ratio to a change in the call rate in a structural VAR model, they find that the ratio drops following a hike of the call rate. Although their focus is not particularly on the test of the bank-lending view, their method and result are similar to those of Kashyap, Stein, and Wilcox (1993) in the U.S. study. Those works on the bank-lending channel are subject to the same criticism made in the U.S. literature, and the following chapters try to provide an alternative way to test the bank-lending view.

The protracted economic slump after the collapse of the asset price bubble has resulted in the growing literature on the balance sheet view in the context of Japan as well as the bank-lending view. Ogawa (2000), for instance, estimates a standard macroeconomic structural VAR model with the market value of land held by the private corporate sector, finding that an increase in the market value of land is followed by significant increases of total loans and fixed investments. His finding is consistent with the theory of credit cycle. He also finds that fixed investment contracts for a protracted period following a hike of the overnight call rate. In a similar study, Kwon (1998) also finds that a hike of the call rate is followed by a persistent land price fall, which is consistent with the theory of credit cycle. Focusing on the episode in the 1990s, Morsink and Bayoumi (2001) estimate a series of structural VAR models for the Japanese economy, finding that a negative shock to bank loans leads to contraction of business investment. Arguing that bank weaknesses explain a substantial part of the negative shocks to bank loans, they conclude that strengthening banks is required to restore the effective transmission process of monetary policy. In relation to testing the balance sheet channel, this thesis employs a method similar to those works.

1.4 Overview of the Thesis

Chapter 2 empirically examines the credit view in the context of Japan. Section 2.1 provides a survey of the literature on the credit view, clarifying the difficulty in the empirical studies. Section 2.2 discusses how to overcome the difficulty. Particular attention is paid to the shifts of the demand and supply schedules in the bank loan market. Section 2.3 sets up the econometric model to test the credit view. At this stage, the thesis does not make distinction between the bank-lending channel and the balance sheet channel. If the credit view is supported by the test results, an attempt to distinguish the two credit channels will be made. As will be shown in section 2.4, the test results are supportive of the credit view. Therefore, Chapter 2 further tests the balance sheet channel. Empirical distinction between the two credit views is a difficult task, however. Section 2.5 tests the theory of credit cycle, which is closely related with the balance-sheet channel. As is explained above, land plays an important role in this theory. The theory of credit cycle is tested via examining the effects of a monetary tightening on land prices. The results are not inconsistent with the theory of credit cycle.

Acceptance of a hypothesis for one country does not imply acceptance of the same hypothesis for other countries. It is likely that the quantitative importance of the credit channel is vulnerable to the institutional characteristics of the financial markets. The financial market of Australia, for instance, differs from that of Japan in the sense that it allows banks to have more diversified portfolios. Chapter 3 tests the credit view for

Australia. The structure of this chapter is similar to that of the preceding chapter. To take into account the openness of the Australian financial market, however, an open-economy structural VAR model is specified and estimated. The results are not supportive of the credit view. To find factors that make the credit channel less important, responses of Australian banks' balance sheets to a monetary tightening are examined. Among others, an important finding is that the Australian banks borrow from overseas to mitigate the impacts of a monetary tightening on their supply schedule of loans.

While the results of Chapters 2 and 3 imply that financial deregulation and/or reforms may undermine the importance of the credit view, there are institutional changes that may make the credit channel of monetary policy transmission important. Such an example is the Basle Accord of 1988. Following the Basle Accord, the Bank for International Settlements (BIS) has required central banks of developed countries to impose risk-based capital adequacy requirements on the activities of commercial banks in those countries. The BIS classifies the asset items of banks for these requirements. When the denominator of the risk-based capital-to-asset ratio is calculated following the BIS' rule, a weight is given to each item on the asset side of a bank's balance sheet. Government bonds are given zero weight, while commercial loans are given a higher weight. The definition of the risk-based capital-to-asset ratio differs among the countries. The Japanese banks usually hold stocks of non-financial companies, and they are allowed to count a certain proportion of those stocks as capital. If stock prices fall substantially, the risk-weighted capital-to-asset ratios of the Japanese banks will fall, and they will cut back on their loans in order to maintain the required minimum level of the capital-to-asset ratios. Under the Basle Accord, monetary policy of the BOJ can have impacts on the bank lending, thereby affecting the real economy, to the extent it can influence stock prices. Chapter 4 examines the effects of the Basle Accord on the credit channel of monetary policy transmission. More specifically, the chapter introduces the risk-based capital adequacy requirements of the BIS type into the costly-state-verification model, which underlies the balance-sheet channel.

The results and conclusions of the three chapters are summarised in Chapter 5. It also discusses topics for future studies. Technical details about the structural VAR approach, which the empirical chapters of this thesis employ, are provided in the Appendix.

Chapter 2

Credit Channel of Monetary Policy in Japan: Resolving the Supply versus Demand Puzzle

2.1 Overview: the Supply versus Demand Puzzle in Japan

In search of evidence for the credit view, researchers have investigated the behaviour of credit aggregates following a monetary tightening. In an influential paper, Bernanke and Blinder (1992) estimate a multivariate time series model (i.e., a structural VAR model) for the U.S. over the period 1959 to 1978, which consists of the federal funds rate, the unemployment rate, the consumer price index, and three bank balance-sheet variables (deposits, securities, and loans). Arguing that an orthogonalised shock in the federal funds rate represents monetary policy of the Federal Reserve Bank, they calculate the impulse response functions of the variables in the model to a shock in the federal funds rate. From the impulse responses, they find that an unexpected hike of the federal funds rate is followed by contraction of loans and a rise of the unemployment rate.

The finding, that contraction of loans follows a monetary tightening, is certainly consistent with the credit view: a monetary tightening affects the real economy by shifting the supply schedule left in the loan market. A problem is that similar results can be obtained even if the credit channel is not operative at all. Suppose that a monetary tightening depressed aggregate demand through the conventional money channel. Then, the consequent decrease of the demand for loans would lead to a decline in bank lending. Thus, contraction of bank loans does not, of itself, indicate whether the supply schedule of bank loans shifts left or the demand schedule for bank loans shifts left. A reduction in the supply of bank loans can decrease output, or a decline in output can decrease the demand for bank loans. The difficulty in detecting the direction of causality has been recognised in the literature. Gibson (1995), for instance, says "No convincing resolution of the reverse causality problem in aggregate data, $\cdots$, has yet emerged." This observational equivalence is called the "supply-versus-demand puzzle" (Bernanke 1993), and the aim of this chapter is to provide an empirical resolution of the puzzle in the context of Japan.

While empirical works on the credit view are scarce in Japan compared to the U.S., the supply-versus-demand puzzle can be found in the Japanese literature. Kim and Moreno (1994), for instance, examine the balance sheet channel within a framework of structural VAR models. Their hypothesis is that a fall of stock prices reduces the supply of bank loans. They estimate five-variable structural VAR models over different sample periods, each of which is comprised of bank loans, industrial production, consumer price index, Nikkei index of stock prices, and the call rate. From the estimated models, they calculate the impulse response functions of bank loans to shocks in the stock price index. The impulse responses imply that bank loans contract following an unexpected fall of stock prices, which is not inconsistent with their hypothesis. As they admit, however, the contraction of bank loans does not necessarily reflect a leftward shift of the supply schedule of bank loans. A fall of stock prices may signal the deterioration of economic conditions in future, thereby inducing firms and households to curtail their expenses. Therefore, they conclude in a somewhat moderate way: the credit contraction following a fall of stock prices partly reflects supply factors.

The empirical work of Bayoumi (2001) suffers from the same problem. He estimates a macroeconomic structural VAR model for Japan over the period of 1980:Q1 to 1998:Q1. The model includes output gap, government spending, taxes net of transfers, the interest rate, the exchange rate, stock prices, land prices, and bank loans. While his main focus is on the causes of the extended slump in Japanese economic activity over the 1990s, he also investigates the interactions between bank loans, stock prices, and land prices. The calculated impulse response functions show, for instance, that bank loans expand following a positive shock in stock prices. He interprets this result as suggesting "the importance of domestic asset prices in the behaviour of banks". Such an interpretation holds, however, only if movements in bank loans reflect shifts of the supply schedule. It may be true that the movements in bank loans reflect shifts of the demand schedule for bank loans.

In a similar research, Ogawa (2000) places emphasis on the role played by land in the credit channel of monetary policy. His hypothesis is that a monetary tightening lowers the market value of land held by borrowers, which may serve as collateral, thereby reducing the amount of external funds available to them for a given level of assets. He estimates structural VAR models over the period 1975:Q1 to 1998:Q1, each of which includes inflation rate, the call rate, sales, the market value of land held by the non-financial firms, total loans, and fixed investment. From the estimated model, he calculates the impulse response functions of loans and fixed investment to a shock to the market value of land. Consistent with his hypothesis, the calculated impulse responses imply that an unanticipated fall of the market value of land is followed by a decline in investment and contraction of loans. This result can be obtained, however, even if the credit channel is not operative. Since land serves as a factor of production, a fall of land prices may reflect decrease of the firms' demand for land, which in turn implies decrease of their demand for loans. As such, his finding does not provide unambiguous support for the credit view.

To examine the bank-lending channel of monetary policy, Morsink and Bayoumi (2001) estimate a structural VAR model for Japan (in their empirical study on a variety of monetary transmission mechanisms). The model consists of private demand, consumer price index, the call rate, broad money, bank loans, and banks' holdings of securities. They estimate the model over the sample period of 1980:Q1 to 1998:Q3. Under the assumption that the call rate is a good indicator of the Bank of Japan's monetary policy, the impulse response functions of these variables to a shock in the call rate are calculated from the estimated model. Consistent with the bank-lending view, the impulse response function of bank lending to a positive shock in the call rate is significantly decreasing. Although they interpret the result as statistical evidence for the bank-lending view, it is not clear whether the contraction of bank loans is due to a leftward shift of the supply schedule of bank loans.

Thus, the supply-versus-demand puzzle is ubiquitous in the Japanese literature on the credit view. An existing way to resolve the puzzle is to follow the procedure of Kashyap, Stein, and Wilcox (1993). They propose to examine the behaviour of commercial paper and business bank loans in the wake of tight money. They define the "mix" variable as the ratio of business bank loans to the sum of business bank loans and commercial paper. The intuition is as follows. A leftward shift of the supply curve of bank loans will force borrowers to substitute away from bank loans into commercial paper, so that the mix variable will drop. Hoshi, Scharfstein, and Singleton (1993) apply this methodology to the Japanese study, finding that the mix variable falls following a monetary tightening. A fall of the mix variable, however, does not necessarily imply a leftward shift of the supply curve of bank loans. Suppose that the sales of bank-dependent small firms fluctuate more over the business cycle than those of large firms with access to a variety of financial sources. Then, the demand of small firms for bank loans will decrease more after monetary contraction than the demand of large firms for commercial paper, which will lead to a fall of the mix variable. Thus, heterogeneity in credit demand across firms, if any, can blur the interpretation of movements in the mix variable.[1] Instead of observing the quantity of bank loans relative to other finances, this chapter proposes to directly identify the shifts of the supply and demand schedules in the bank loan market after a monetary tightening. The alternative approach to an empirical resolution of the supply-versus-demand puzzle is discussed in the following sections.

The structure of this chapter is as follows. Section 2.2 discusses how to resolve the supply-versus-demand puzzle. As will be shown shortly, embedding both the price and

[1] See Friedman and Kuttner (1993), Gertler and Gilchrist (1993), and Oliner and Rudebusch (1996) for the ambiguities concerning the interpretation of the Kashyap, Stein, and Wilcox (1993) results.

quantity of bank loans in a dynamic simultaneous equation model (i.e., a structural VAR model) reduces the supply-versus-demand puzzle to a problem like the resolution of simultaneous equation bias. Section 2.3 provides a description of the structural model and the data selection. A difficulty is how to measure the price of loans. This chapter utilises two types of data. These are the interest rate on new loans and the diffusion index of financial institutions' lending attitude. This section also formalises the credit view in a testable form. Based on the estimated model, impacts of a monetary tightening on the economy (including the bank loan market) are simulated. Simulation results are presented in section 2.4. The main novelty of the chapter is that we are able to establish that, in Japan, a monetary tightening is followed by a leftward shift of the supply schedule of bank loans. As is mentioned in section 1.2, however, there are two different credit channels, namely the bank lending channel and the balance sheet channel. Stressing that these two credit channels have different implications, section 2.5 tries to distinguish between the bank lending channel and the balance sheet channel. For this purpose, the theory of credit cycles, which is closely associated with the latter channel, is tested. Section 2.6 provides a summary and conclusion of this chapter.

2.2 Empirical Resolution of the Supply versus Demand Puzzle

This section provides an alternative original approach to resolve the supply-versus-demand puzzle. An important assumption is that an observable quantity of bank loans is the equilibrium value given by the intersection of the demand and supply curves in the bank loan market. A change in the quantity may be associated with a shift of the demand curve, a shift of the supply curve, or both. A decline in the quantity, for example, is not necessarily a consequence of a leftward shift of the supply curve. Observing the price of loans will help us identify the shifts of the supply and demand curves behind the change in the quantity.[2]

The approach can be well illustrated using a simple demand-supply model. Suppose that an exogenous shock occurred. Such a shock will shift the supply schedule and/or the demand schedule, so that the price (P) and/or quantity (Q) will change. There are four possible changes:

- Case I: Q increases, while P does not fall,
- Case II: P rises, while Q does not increase,
- Case III: Q decreases, while P does not rise,
- Case IV: P falls, while Q does not decrease.

As for testing the credit channel, Case II is of interest in the sense that it occurs only if the supply schedule shifts left. Suppose that the supply schedule shifted from S to S′ in Figure 2.1. Then, one would expect to observe a rise of P and a fall of Q so long as the demand curve lies within a range between D′ and D″. (When the demand schedule shifts to D′, Q does not change.) Case IV is a mirror image of Case II. As such, a negative correlation in movements between the price and quantity identifies a shift of the supply schedule. By analogy with this, a positive correlation in movements between the price and

[2] A difficulty lies in measuring the price of bank loans. The construction of the price of bank loans will be discussed in the next section.

quantity identifies a shift of the demand schedule. This idea is introduced to a structural VAR approach to identify shifts of the demand and supply schedules in the loan market after monetary contraction.

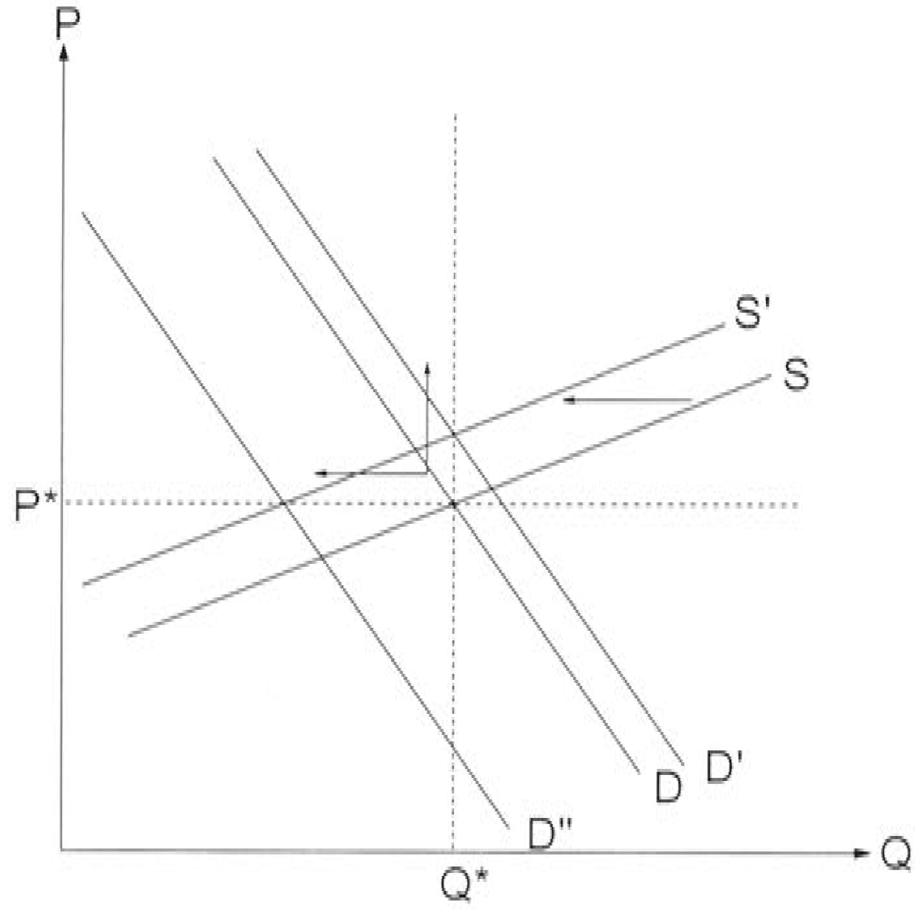

Figure 2.1: Case II: P rises, while Q does not increase.

2.3 Model and Estimation

This section employs a structural VAR approach, which was discussed in section 1.3, to test the credit view that monetary contraction is followed by a leftward shift of the supply schedule of bank loans. The procedure is as follows. The economy is approximated by a system of linear equations, which comprises macroeconomic variables including the price and quantity of loans. The set of variables also includes the short-term interest rate. The parameters of the system equations are estimated, and the estimated model is used to simulate responses of the price and quantity of loans to a hike of the interest rate. As is shown in section 2.2, the credit view will be supported if the responses of the price and quantity of loans are in the opposite direction.

2.3.1 Structural Model

A structural VAR approach approximates the economy by a system of linear equations. Let $\mathbf{y}_t$ denote a vector containing the values that the variables of interest assume at date t. Then, a structural model is generally written in vector form with constant terms and linear time trends being included:

$$\mathbf{B}_0\mathbf{y}_t = \mathbf{k}_0 + \mathbf{k}_1 t + \mathbf{B}_1\mathbf{y}_{t-1} + \cdots + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \tag{2.1}$$

where $\mathbf{u}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{D})$ and $\mathbf{D}$ is a diagonal matrix. This structural model is a simultaneous equations model.

In the macroeconomic literature, a structural VAR model often includes four variables: output, price, a short-term interest rate, and money. These are the variables of a standard IS-LM model. In the literature, an equation associated with the interest rate is conventionally given a structural interpretation as a policy reaction function of the monetary authority, and a positive innovation to the interest rate is assumed to represent unexpected monetary contraction (e.g. Bernanke and Blinder 1992 and Sims 1992).[3] This

[3] As the debate between Rudebusch (1998) and Sims (1998) shows, this common practice may be contentious, particularly in the U.S. literature. Examining the information set of the Federal Reserve Bank, Rudebusch argues that a standard equation of the federal funds rate in a structural VAR model for the U.S. does not correctly model its reaction, and that the structural VAR approach is subject to issues such as time invariance, linearity, and variable selection. Sims criticises critiques made by Rudebusch as unconstructive quibbles, however.

chapter follows the convention. Once a model is estimated, responses of the other macroeconomic variables to a positive innovation in the interest rate are simulated to study how a monetary tightening affects the economy.

The first task is to choose a set of variables to model. For selection of the variables, this chapter utilises the model of Bernanke and Blinder (1988) discussed in Chapter 1, which is a building block of the bank-lending view. As their model is an extension of an IS-LM model including the bank loan market, it suggests that interaction among three markets (i.e., goods, money, and loans) be examined. Therefore, the set of variables should include the prices and quantities of the three markets: output (Y), price (P), an interest rate (R), money (M), the quantity of loans (LQ), and the price of loans (LQ). Additional variables are required, however. For an equation in (2.1) to be interpreted as the policy reaction function of a monetary authority, the set of variables must span its information set. As a monetary authority observes inflationary pressures from overseas, Sims (1992) suggests that the exchange rate (XR) and the commodity price (CP) be included in a structural VAR model of monetary policy. Arguing that monetary authorities in non-U.S. countries observe the monetary policy action of the Federal Reserve Bank, Kim and Roubini (2000) suggest that the U.S. interest rate (R^{US}) be included in structural VAR models for those countries. Following these suggestions, XR, CP, and R^{US} are added to the set of variables. In terms of system equations (2.1), a minimal set of variables to model is

$$\mathbf{y}_t' = (Y_t, P_t, M_t, R_t, LQ_t, LP_t, CP_t, XR_t, R_t^{US})'.$$ [4]

[4]The data on these variables are possibly integrated. Even when the variables are non-stationary, however, the parameters of a dynamic model like (2.1) can be estimated consistently by applying OLS to its reduced form. See, for instance, Banerjee *et al.* (1993, Ch 6). For this reason, this chapter and the

2.3.2 Data Selection

The next task is to choose data to proxy the nine variables in the model. It is relatively straightforward to choose data for the variables except for the price and quantity of bank loans. Output (Y) and price (P) are conventionally measured by the log of industrial production, which is a measure of private sector output, and the log of CPI, respectively. The overnight call rate is chosen for the interest rate (R), as it is the policy instrument of the Bank of Japan (BOJ).[5] R is measured in per cent. Nominal money (M) is measured by the log of base money. Base money is chosen in an attempt to avoid possible problems caused by correlation between money and bank credit. In addition, for instance, McCallum (1999) argues that the monetary base is an essential variable for evaluating the Japanese monetary policy. The exchange rate (XR) is the log value of the U.S. dollar measured in Japanese yen, so that a fall of XR means an appreciation of the Japanese currency against the U.S. currency. Commodity price (CP) is measured by the log of world non-fuel commodity price index. The federal funds rate measures the U.S. interest rate (R^{US}). See Appendix A.1 for the sources of these data.

How should we measure the quantity of loans (LQ)? In the literature, LQ is usually measured by total loans outstanding (e.g. Kwon 1998 and Ogawa 2000). Such data correspond to the stock of loans. To identify shifts of the demand and supply schedules

following one estimate the structural VAR models using the level of the variables.

[5] The Bank of Japan (BOJ) now officially announces that the overnight call rate is its operating target. See minutes of the Monetary Policy Meeting, which are available in English. Not until the late 1990s did the BOJ disclose how it implemented monetary policy. Nevertheless, there have been economists who have argued that the BOJ always attempted to control the overnight call rate. See, for example, Okina (1993), Ueda (1993), and Yoshikawa (1995).

in the loan market, however, the quantity of interest is "new loans issued" rather than loans outstanding. In Japan, data on "new loans for equipment funds" are available from 1970:Q1 onward in the BOJ's quarterly economic survey of enterprises, TANKAN. It is this series of data which this chapter utilises to measure the quantity of loans. Among others, the data on new loans to the manufacturing industry are chosen for consistency with the output series.

Now turn to the data for the price of bank loans (i.e., the marginal cost of bank loans to borrowers). A candidate is an interest rate on new loans. The data on "average contracted interest rates on new loans and discounts" are available from March 1980 onward. The price of bank loans extends beyond the interest rate, however. The loan rate cannot capture non-price terms of lending (such as collateral requirements). An alternative measure of the marginal cost of loans to borrowers is the diffusion index of "financial institutions' lending attitude" in the BOJ's survey of enterprises, TANKAN. The BOJ calculates the diffusion index by asking non-financial firms about financial institutions' lending attitude. Suppose that banks required higher interest rates or more collateral for additional loans. Then, the firms would perceive banks being reluctant to lend. As such, the diffusion index of financial institutions' lending attitude may be correlated with the unobservable price of loans (see Appendix A.1 for further discussion on the diffusion index). In the following estimation, both the interest rate on new loans and the diffusion index of financial institutions' lending attitude are utilised.

2.3.3 Testable Hypotheses

Once the structural model (2.1) is estimated with the data, the credit view is tested. For this purpose, the credit view is formalized in a testable form. A distinctive implication of the credit view is that a monetary tightening is followed by a leftward shift of the supply schedule of bank loans. As is shown in section 2.2, a rise in the price of loan identifies a leftward shift of the supply schedule in the bank loan market unless the quantity of bank loans increases (see Figure 2.1). Following a monetary tightening, the credit view is accepted if:

H1 The quantity of bank loans (LQ) does not increase.

H2 The price of bank loans (LP) rises.

H3 Real output (Y) decreases.

The first two and the last one are associated with identifying the supply schedule in the loan market and testing the effectiveness of monetary policy, respectively.

Under the assumption that a short-term interest rate (R) is a good indicator of the monetary policy of the Bank of Japan, H1 to H3 can be tested by simulating responses of LQ, LP, and Y to a shock in R. Such simulation is conducted by calculating impulse response functions from the estimated model (2.1). For instance, the impulse response function of LQ to a positive shock in R is defined as

$$\frac{\partial\ E(LQ_{t+i}|I_t)}{\partial\ u_t^R} \text{ for } i = 0, 1, \cdots, \tag{2.2}$$

where $E(LQ_{t+i}|I_t)$ and u_t^R denote the expected value of LQ_{t+i} conditional on the set of information available at date t and the component of $\mathbf{u}_t$ associated with R, respectively.

The impulse response analysis crucially depends on the assumption that R is a good indicator of monetary policy. This assumption will be plausible if the central bank supplies reserves elastically at the targeted level of the interest rate, which may be true of the Japanese monetary policy. Okina (1993), for instance, emphasizes the institutional fact that the Japanese reserve accounting system is a lagged reserve system.[6] Under such a reserve system, the demand for reserves is predetermined each month. As Japanese banks hold almost no excess reserves, the BOJ faces a nearly vertical demand curve for reserves in the short-run. To prevent the interest rate from fluctuating, the BOJ must supply reserves passively at the targeted level of the interest rate. As such, u^R may be interpreted as the monetary policy action of the BOJ, and this chapter examines the impulse response functions of LQ, LP, and Y to u^R to test the hypotheses H1 to H3.

To test H1 to H3 statistically, confidence intervals for the estimated impulse response functions are to be presented. In practice, confidence intervals for impulse responses are often numerically generated. Following Runkle (1987), this chapter employs an approach based on "bootstrapping." The procedure is as follows. First, the model (2.1) is estimated, and the estimated coefficients and the fitted residuals are saved. Then, the residuals are reshuffled with replacement, and the data set is artificially created using the estimated model as the true data-generation process. In the analysis of this chapter, a series of 1,000 such simulations are undertaken. With each of the 1,000 synthetic data sets, the same model is re-estimated and the impulse response functions are calculated. 90% confidence intervals for the originally estimated impulse response functions are inferred from the ranges that include 90% of the values for the 1,000 simulated impulse responses. In the

[6] In Japan, banks are required to maintain reserves, which are the product of the reserve ratio and average deposits outstanding in each calendar month, during the period from the 16th of that month to the 15th of the next month.

next section, the calculated impulse response functions are shown with the 90% confidence intervals.[7]

2.4 Simulation Results

In this section, the structural model (2.1) is estimated to simulate impacts of an unanticipated hike of the call rate on the economy including the bank loan market. For computational convenience, a recursive structure is imposed on $\mathbf{B}_0$ in equation (2.1), so that the system is just identified. The ordering of the variables is CP, R^{US}, P, Y, M, R, XR, SP, LQ, and LP.[8] All the domestic variables are placed after P. This reflects the Keynesian argument that prices slowly respond to economic developments. Y is placed after M and R under the assumption that money and the interest rate influence aggregate demand with a lag. This assumption is consistent with the monetarists' argument that monetary policy affects real economy only with a lag (so that fine-tuning is difficult). The position of M before R reflects the fact that the BOJ takes into account the current demand for

[7] There are alternative methods to calculate confidence intervals for the impulse response function. Among others, Monte Carlo integration has been popular in the empirical literature. This popularity is largely due to computational convenience. An econometric computer package, RATS, utilises Monte Carlo integration as a default method to construct confidence intervals for the impulse response function. This method is the Bayesian approach in the sense that a researcher has to specify a prior distribution of parameters of a VAR model. As the classical approach is adopted throughout this chapter, Monte Carlo integration is not employed. See Appendix B.3 for technical details.

[8] A different ordering can have major consequences on the estimation results. See, for instance, Christiano, Eichenbaum, and Evans (1999). The results are robust to different orderings, however. See Suzuki (2001) for robustness checks. Non-recursive identifying restrictions have been also used in the VAR literature on the BOJ's monetary policy. See Kasa and Popper (1997), Kwon (1998), and Shioji (2000).

the monetary base when it chooses the targeted level of the call rate. L and LP are placed after R because the BOJ obtains information about the bank loan market with a delay through its quarterly economic survey (TANKAN). In the following estimations, the loan price is measured by either the interest rate on new loans or the diffusion index of financial institutions' lending attitude.

2.4.1 Results: Loan Rate as the Price of Loans

First, the structural model (2.1) is estimated with the price of loans measured by the interest rate on new loans. The regression is run over the period 1981:Q1 to 2000:Q4. The beginning of the sample is dictated by the availability of the data on the interest rate on new loans, which are available from 1980:Q1 onward. From the estimated model, the impulse response functions of various variables to a positive shock in the call rate, which is defined as equation (2.2), are calculated.

In each graph of Figure 2.2, the solid line and the dotted lines are the point estimate of the impulse response function to a one-standard-deviation shock in the cash rate and its 90% confidence interval, respectively.[9] A one-standard-deviation shock to the cash rate is calculated as an increase of approximately 0.25 percentage point. The loan rate is measured in percentage. As the other variables shown in Figure 2.2 are measured in logs and multiplied by 100, the impulse responses approximate the percentage change of those variables in response to a 0.25-percentage point hike of the call rate. For instance, the

[9]The impulse response functions shown in this chapter are calculated from the estimated model with two lags. The model was also estimated with lags 3 and 4. As for identifying the supply and demand schedules in the bank loan market, however, the results were robust to the choice of lags. See Suzuki (2001), which is attached to this thesis.

quantity of loans is expected to decrease by approximately 3.55% after a quarter following an unanticipated 0.25 percentage point rise of the call rate. Note that scale differs among the graphs. The response of the quantity of new loans is greater than those of the other variables, and the response of the CPI is smaller than those of the other variables.

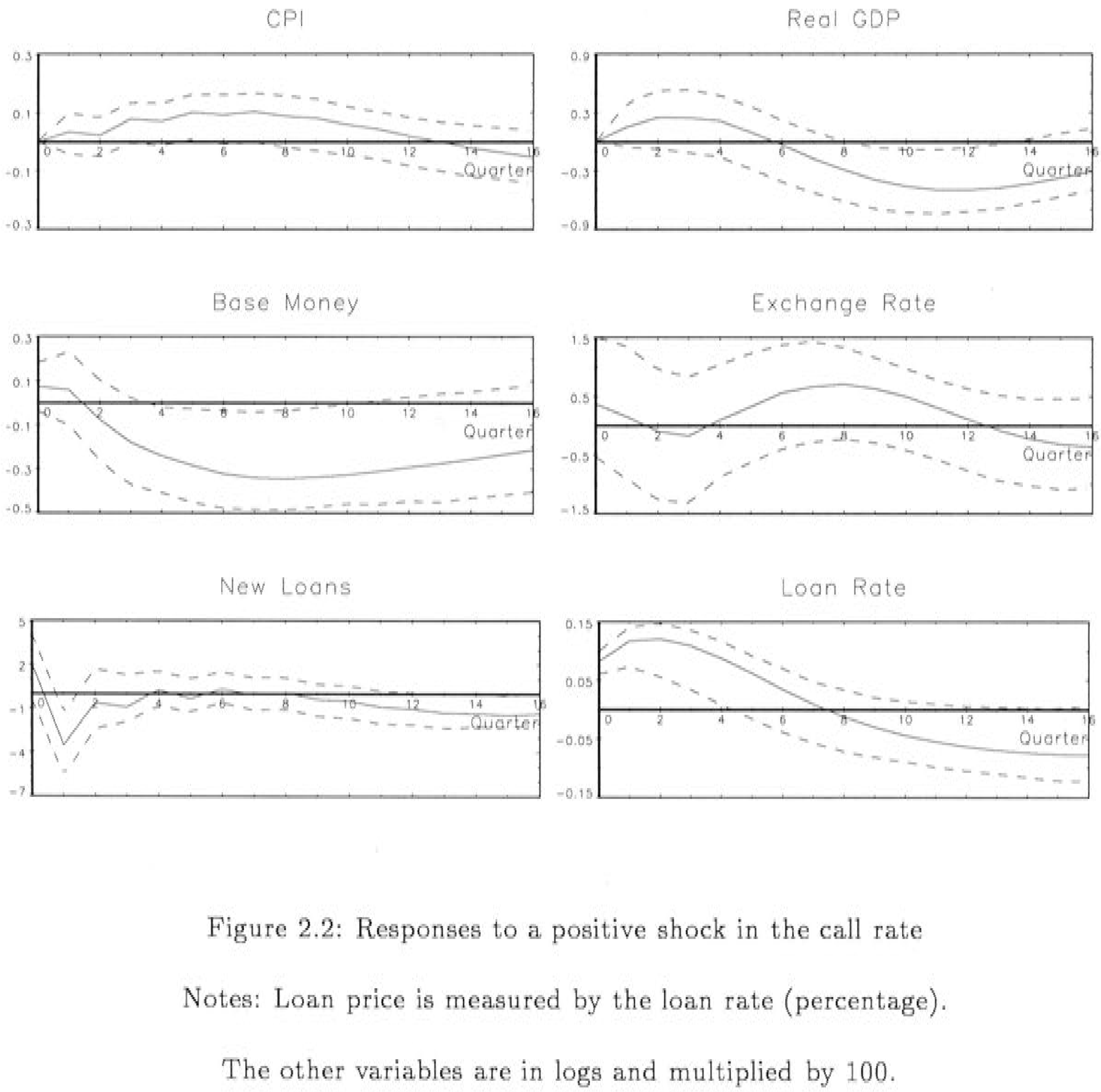

Figure 2.2: Responses to a positive shock in the call rate

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

The upper two graphs in Figure 2.2 indicate impacts of an unexpected hike of the call rate on the CPI and real GDP. While the CPI rises in response to a monetary tightening, the size of the response is small and insignificant. The point estimate implies that the

CPI rises at most by approximately 0.1% in the fifth quarter after a 0.25 percentage point hike of the cash rate, and the response is not significantly different from zero. The result may be interpreted as suggesting that a monetary tightening successfully cancels out inflationary pressures. The responses of real GDP are greater than those of the CPI. The point estimate implies that real GDP falls by approximately 0.5% in the 11th and 12th quarters after the same monetary tightening. Those responses are significantly different from zero at 5% significance level, so that H3 (i.e., the effectiveness of monetary policy) is accepted.

In the centre two graphs of Figure 2.2, the responses of base money and the exchange rate are plotted. Base money falls by approximately 0.3% in the fifth quarter following a 0.25 percentage point hike of the call rate, and the responses are significantly different from zero at 5% significance level over the period of the fourth quarter to the ninth quarter after the hike of the call rate. This finding is consistent with economic theory. In contrast, the impulse response function of the exchange rate is inconclusive. The response of the exchange rate is not significantly different from zero at any point of time shown in the graph.

As for the credit view, the lower two graphs of Figure 2.2 are of central interest. The quantity of new loans decreases in the first quarter after the hike of the call rate. The contraction of new loans is substantial. The point estimate implies that new loans contract by more than 3.5% following a 0.25 percentage point hike of the call rate, and this response is significantly different from zero at 5% significance level. Obviously, H1 is accepted. At the same time, the interest rate on new loans rises. For the first five quarters, the response of the loan rate is significantly positive, so that H2 is accepted. Therefore, we can conclude that the supply schedule of bank loans shifts left in the first quarter. Together with the acceptance of H1, the results are supportive of the credit view.

Note that the initial positive response of the loan rate is smaller than the hike of the call rate. The point estimate implies that the interest rate on new loans rises by less than 0.1 percentage point while the call rate rises by 0.25 percentage point.[10] That is, the loan rate is stickier than the policy instrument. It has been theoretically shown that the interest rate on loans can be sticky under asymmetric information between lenders and borrowers. Stiglitz and Weiss (1981), for instance, argue that since a higher loan rate reduces the probability of repayment (by the adverse selection effect and/or the incentive effect), lenders may not make loans even if borrowers are willing to pay a higher interest rate, which results in credit rationing with a sticky loan rate. Thus, the result is consistent with the implication of a theoretical model of credit market imperfection.

2.4.2 Results: Diffusion Index as the Price of Loans

Now the structural model (2.1) is estimated with the price of loans measured by the BOJ's diffusion index of financial institutions' lending attitude. In this subsection, the diffusion index is utilised to capture non-price components of the marginal cost of loans to borrowers.[11] The regression is run over a longer sample period - 1973:Q1 to 2000:Q4.

[10] The model (2.1) was re-estimated with the loan rate replaced by the spread between the loan rate and the call rate. The calculated impulse response function showed that the spread between the two interest rates significantly shrank over quarters in response to a hike of the call rate.

[11] In the survey, the Bank of Japan asks non-financial firms whether financial institutions' lending attitude is "accommodative", "not so severe", or "severe". The BOJ calculates the diffusion index by subtracting the percentage of the firms answering "severe" from the percentage of those answering "accommodative". In the estimation, the diffusion index is multiplied by -1, so that it may be positively correlated with the

The beginning of the sample reflects a prior that the Japanese economy experienced a structural break by the time of the first oil embargo (see, for instance, Yoshikawa 1995). In each graph of Figure 2.3, the solid line and the dotted lines are the impulse response function of the variable to a positive shock in the call rate and its 90% confidence interval.

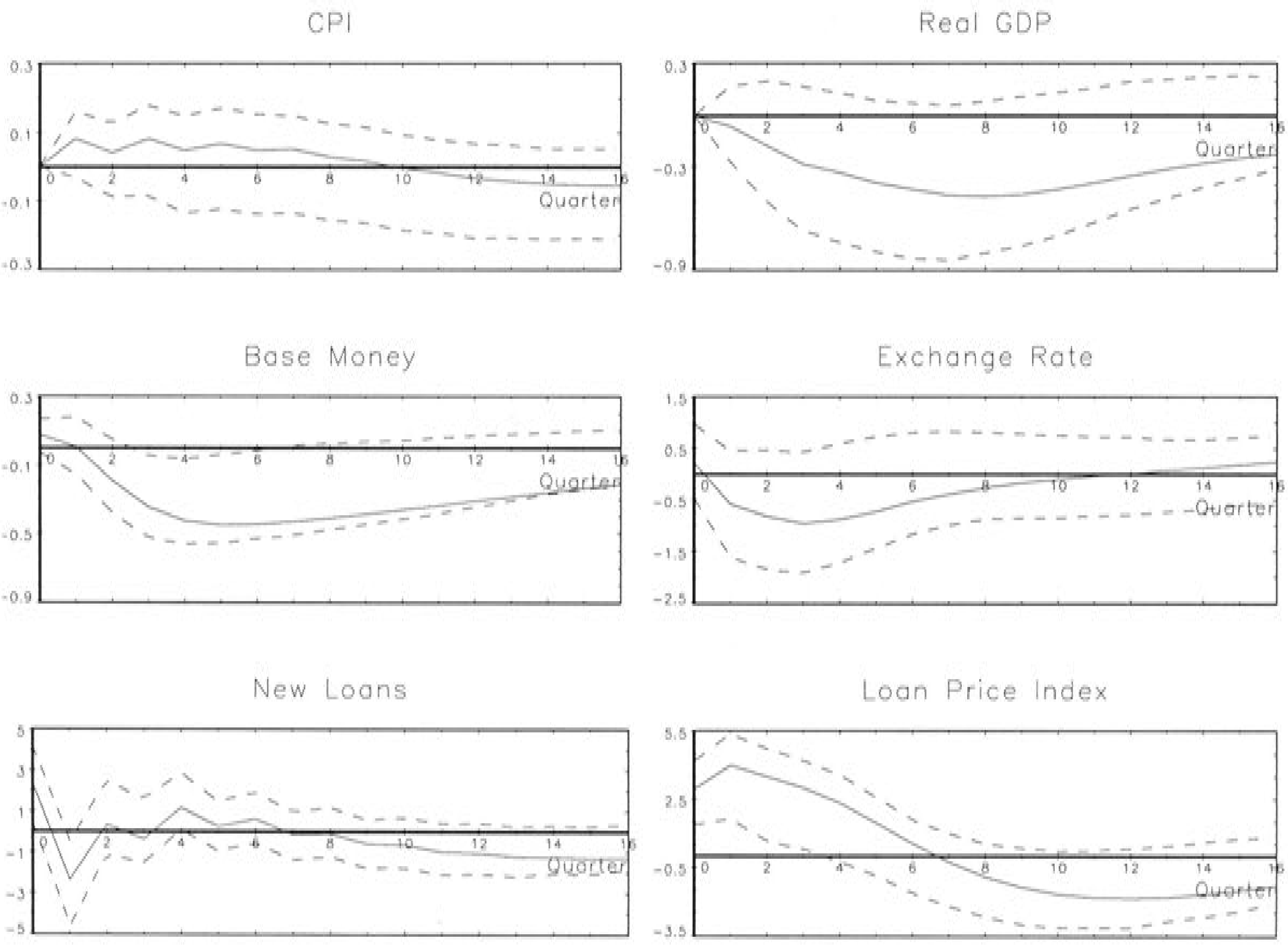

Figure 2.3: Responses to a positive shock in the call rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

The upper two graphs of Figure 2.3 indicate impacts of a hike of the call rate on the

unobservable price of loans. See Appendix A.1 for further discussion on the diffusion index.

CPI and real GDP. The response of the CPI is again tiny. While the CPI eventually falls, the response is not significantly different from zero. The insignificant response of the CPI is consistent with the result of the preceding subsection. Real GDP also decreases, but the negative response is similarly insignificant at 5% significance level. The insignificance of the response of real GDP is in contrast with the result of the preceding subsection. The negative response of real GDP is significant from the fifth quarter to the ninth quarter at 10% significance level, however. Therefore, H3 (i.e., the effectiveness of monetary policy) is now accepted at 10% significance level.

The centre two graphs of Figure 2.3 show the responses of base money and the exchange rate. As is consistent with economic theory, base money falls in response to a hike of the call rate, and the negative response is significant from the third quarter to the eighth quarter. The impulse response function of the exchange rate is again inconclusive, however. The response of the exchange rate is not significant at any point of time shown in the graph.

The lower two graphs of Figure 2.3 are to identify shifts of the demand and supply schedule in the loan market. The quantity of new loans significantly decreases in the first quarter, which is consistent with the result of the preceding subsection. H1 is accepted. At the same time, the loan price index rises, implying that financial institutions' become less willing to lend. The positive response of the loan price index is significant for the first four quarters, and H2 are accepted at 5% significance level. Thus, the results again imply that the supply schedule of loans shifts left in the first quarter, and the conclusion is robust to the choice of the measure for the price of loans. Since the effectiveness of monetary policy is accepted at 10% significance level, we may also conclude that the credit channel of monetary policy is operative in Japan.[12]

2.5 Lending Channel or Balance Sheet Channel?

The preceding section provides clear evidence for the existence of the credit channel in Japan. There are two different credit channels, namely the bank-lending channel and the balance sheet channel. As is discussed in section 1.2, the bank-lending channel and the balance sheet channel have different macroeconomic implications. Nonetheless, no distinction has been made so far between the two credit channels. Then, a question arises. Which credit channel is operative in Japan? Since the bank-lending channel and the balance sheet channel are both characterised by a leftward shift of the supply schedule of bank loans following a monetary tightening, it is difficult to identify one channel from the other in a direct way. For this reason, this section tests the credit cycle theory, which is closely associated with the balance sheet channel.

Stressing that durable assets serve as collateral for loans as well as being factors of production, Kiyotaki and Moore (1997) argue that a temporary shock to asset prices can generate persistent fluctuations in output by affecting credit limits of liquidity-constrained firms. Their argument is as follows. A fall of asset prices (such as land price) weakens the balance sheets of firms, and liquidity-constrained firms have to cut back on investment. A decrease of investment implies a leftward shift of the demand schedule for durable assets. Asset prices fall further, which weakens the balance sheets of the firms. The firms have to cut back on investment further, which again decreases the demand for durable assets

[12] A variety of robustness checks were conducted, and the results are essentially robust. These results are reported in an earlier version of this chapter. See Suzuki (2001).

and causes a further fall of asset prices. This process continues. In this way, a temporary shock to asset prices causes persistent fluctuations in output. This theory is consistent with the balance sheet channel to the extent that monetary policy affects prices of durable assets.

A crucial assumption of the credit cycle theory is that the debts of firms are secured, and business investment financed by bank loans is usually secured by land in Japan. Therefore, the land price index (LD) is included in the set of variables to measure prices of durable assets, and the structural model (2.1) is estimated. In an attempt to correct for the effects of the asset price bubble in the late 1980s, stock price (SP) is also included in the set of variables. An eleven-variable VAR is estimated. With the price of loans measured by the diffusion index, the model is estimated over the period 1973:Q1 to 2000:Q4. The ordering of the variables are essentially the same as in the model of section 2.3, and SP and LD are placed between XR and LQ.

First, impacts of an unexpected fall of land price on the economy are simulated. Figure 2.4 shows the impulse response functions to a negative shock to land price and the 90% confidence interval. All the variables shown in Figure 2.4 are measured in logs and multiplied by 100 except for the call rate and the loan price index. A temporary shock to the land price is followed by a persistent fall of the land price. The negative response of land price is significant at 5% significance level, and consistent with the theory of credit cycles. As the theory of credit cycles predicts, real GDP and the loan quantity decrease persistently at the same time. Those negative responses are significantly different from zero at 5% significance level. Thus, the results are supportive of the credit cycle theory that a temporary fall of durable asset prices causes a persistent decline in output by

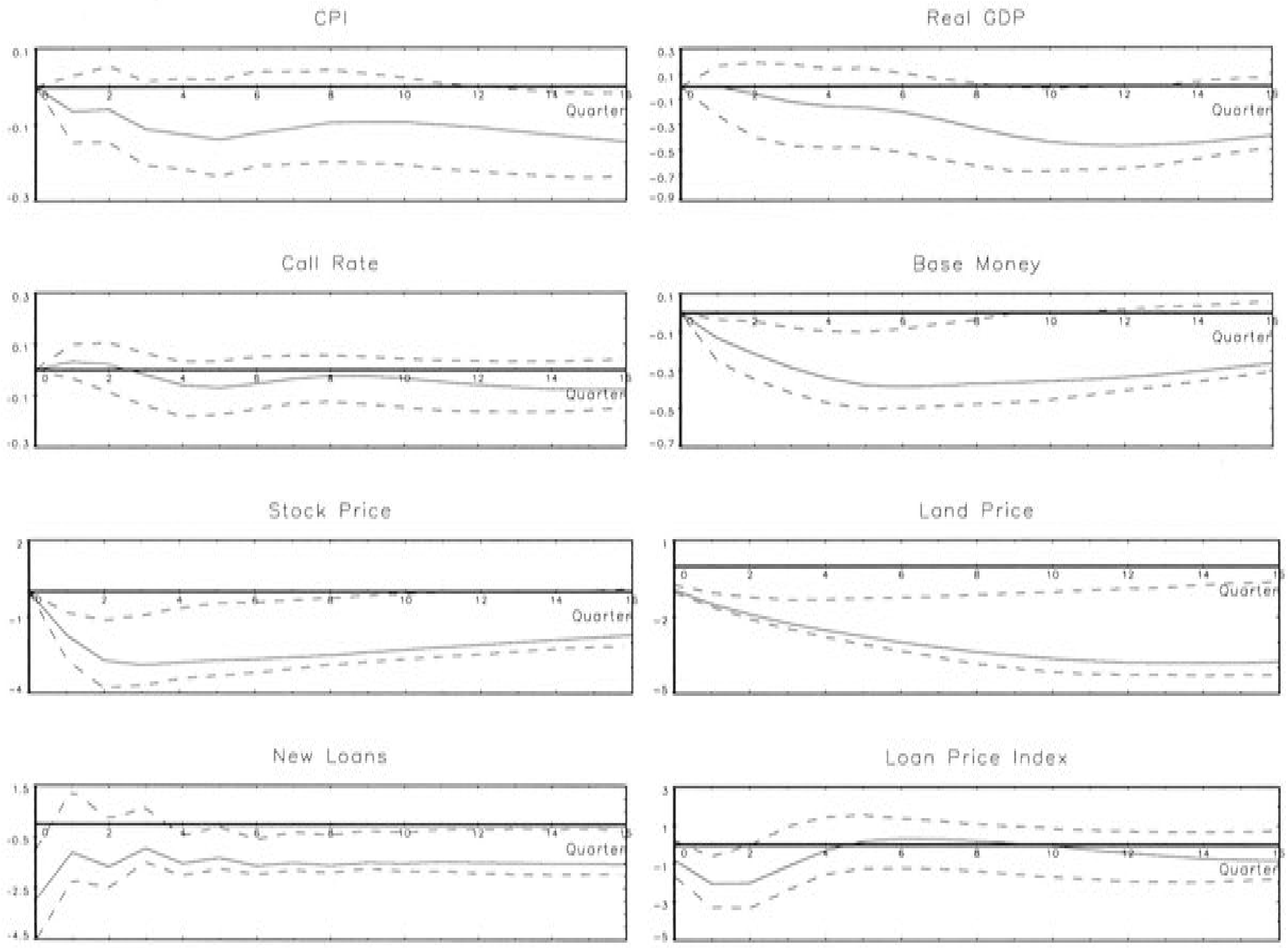

Figure 2.4: Responses to a negative shock in land price

Notes: Loan price is measured by the diffusion index (percentage point).

Call rate is measured in per cent.

The other variables are in logs and multiplied by 100.

affecting credit limits of firms.[13]

Similar results are obtained by Ogawa (2000) who estimates a six variable VAR (inflation rate, the call rate, sales of firms, land stock, total loans outstanding, and fixed investment) over the period 1975:Q1 to 1998:Q1. In his paper, "land stock" means the

[13]The results are essentially robust to the choice of the loan price. When the loan price is measured by the interest rate on loans, the persistent negative responses of real GDP and the loan quantity are significant at 10% significance level.

market value of land held by the private corporate sector. His findings are as follows. First, a hike of the call rate is followed by long-lasting significant contraction of fixed investment. This implies the effectiveness of monetary policy. Second, a positive shock to land stock is followed by significant increases of total loans and fixed investment. The latter finding is supportive of the credit cycle theory, and consistent with the simulation results of this chapter.

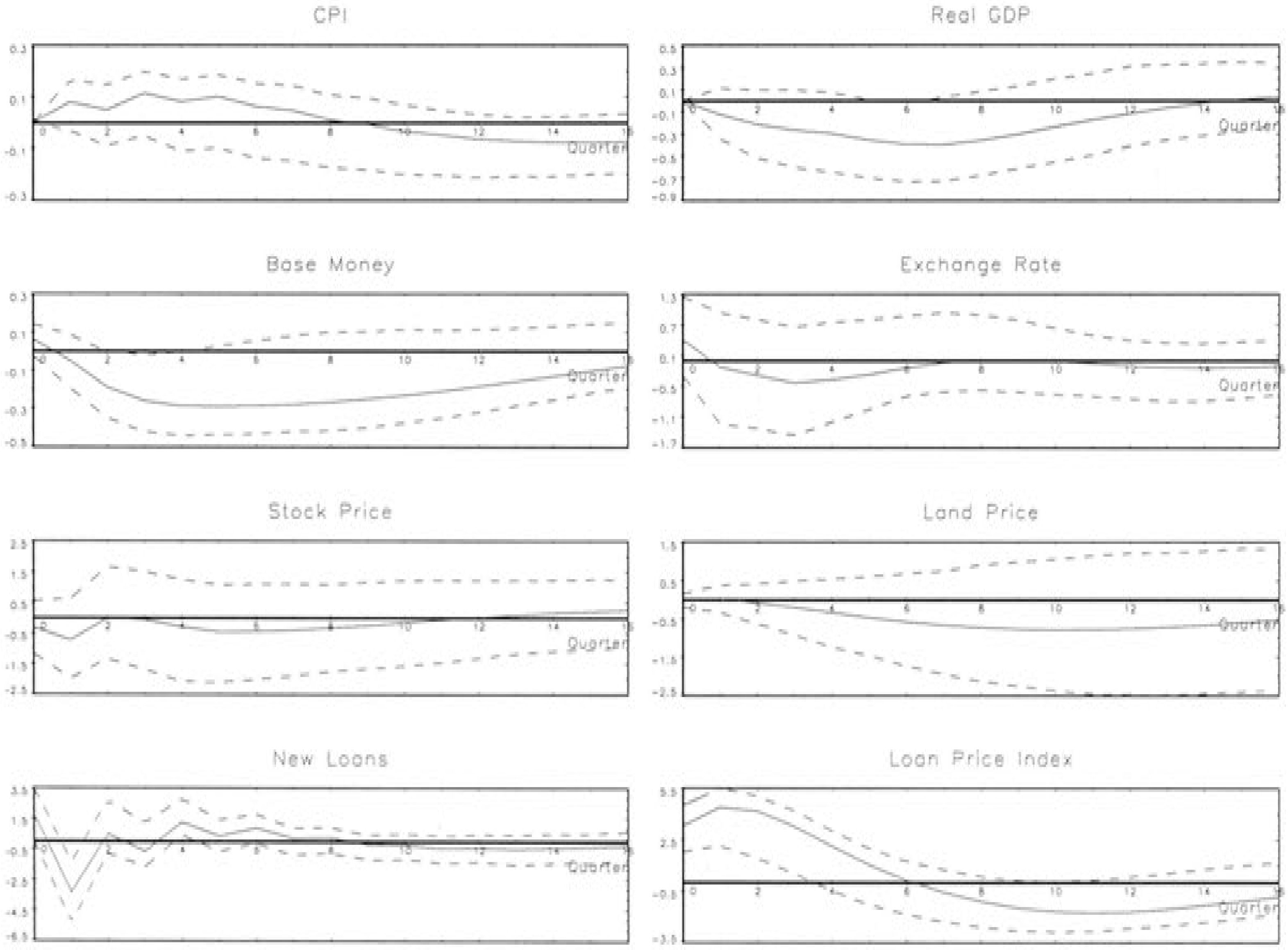

Figure 2.5: Responses to a positive shock in the call rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

Accepting the credit cycle theory does not, of itself, imply the existence of the balance sheet channel, however.[14] The next task is to confirm that a monetary tightening causes a fall of prices of durable assets. With the same estimated model, impacts of a hike of the call rate on the economy are simulated. Figure 2.5 shows the impulse response functions to a positive shock in the call rate. As in the results of the preceding section, the hypotheses H1 to H3 are accepted, and the credit view is supported. As for the response of land price, the point estimate implies that a hike of the call rate is followed by a fall of land price. Although this is consistent with the hypothesis of the balance sheet channel, the confidence interval is too wide to establish the significance of this shift. So, our conclusion must be put in a slightly weaker form - that our results are not inconsistent with the view that a monetary tightening operates through the balance sheet channel by affecting land price.[15]

2.6 Conclusion

The objective of this chapter is to test the credit view, for Japan, that a monetary tightening affects the real economy by shifting the supply schedule of bank loans. Although bank loans contract following a monetary tightening, it is not clear whether the contraction is due to a leftward shift of the supply schedule or a leftward shift of the demand schedule in the bank loan market. In an attempt to resolve the observational equivalence problem,

[14]Ogawa (2000) concludes that the balance sheet channel is operative in Japan, even though he does not show that monetary policy has impacts on the market value of land held by the private corporate sector.

[15]Kwon (1998) estimates a nine-variable structural VAR model for Japan over the period 1963:Q1 to 1993:Q4. The variables in his model are essentially the same as the ones used in this section except for the credit variables. He finds that a persistent fall of land price following a monetary tightening is significant. His finding complements the results of this chapter.

which is known as the supply-versus-demand puzzle, this chapter proposes to observe the responses of the quantity and price of bank loans to a monetary tightening. This chapter measures the price of bank loans by either the interest rate on new loans or the diffusion index of financial institutions' lending attitude. The results are supportive of the credit view and robust to the choice of the measure for the price of bank loans.

Although the bank-lending channel and the balance sheet channel are collectively called the credit channel, these two channels have different economic implications. This chapter tests the credit cycle theory, which is closely related with the balance sheet channel, that a temporary fall of prices of durable assets generates a persistent decline in output by affecting credit limits of firms. Since business bank loans are usually secured by land in Japan, this chapter uses land price as an index of prices of durable assets, finding that a fall of land price is followed by decreases of real GDP and the quantity of loans. Thus, the results are supportive of the credit cycle theory. Another finding is that a monetary tightening is followed by a persistent fall of land price. The impact of a monetary policy on land price is not significantly different from zero, however. Consequently, the conclusion of this chapter is that the results are not inconsistent with the existence of the balance sheet channel. Clear empirical distinction between the two credit channels would be able to further the literature on this topic.

Chapter 3

Is the Lending Channel of Monetary Policy Important in Australia?

3.1 Overview: the Supply versus Demand Puzzle in Australia

A building block of the lending view is the theoretical work of Bernanke and Blinder (1988). In an IS-LM type model, they show that draining bank reserves reduces the amount of loanable funds in the banking sector, which means a leftward shift of the supply schedule of bank loans, thereby forcing bank-dependent borrowers to cut bank on their investment expenditures. A crucial assumption of their model is that there are bank-dependent borrowers in the economy. This assumption is plausible in Australia. The Australian corporate sector makes little use of direct forms of financing. At the end of September

2000, for example, the ratio of outstanding short-term securities issued by the private non-financial corporate sector (A$ 21.956 billion) to outstanding bank loans to the same sector (A$ 136.411 billion) is 16.9 %.[1] Thus, the Australian economy satisfies a necessary condition for the bank-lending channel to be operative. This chapter aims to test the lending view for Australia.

Over the past decade, a number of papers have resurrected the bank-lending view in the empirical literature, particularly in the U.S. context. Nevertheless, unambiguous evidence for or against the bank-lending view has rarely been provided. Primarily, this is because bank loans and money are highly correlated. In an influential work, for instance, Bernanke and Blinder (1992) estimate a structural VAR model for the U.S. economy, over the period 1959:8 to 1979:9, including the federal funds rate, the unemployment rate, the consumer price index (CPI), and bank balance-sheet variables (deposits, securities, and loans) all deflated by the CPI. They calculate various impulse response functions, reporting that money and bank loans contract following a positive innovation to the funds rate. While the contraction of bank loans is consistent with the lending view, the decrease of money makes another interpretation plausible: a monetary tightening depresses aggregate demand through the standard money channel, resulting in a leftward shift of the demand schedule for bank credit. The positive correlation between bank loans and money blurs the distinction between the alternative views, namely the bank-lending view and the standard money view. This is the supply-versus-demand puzzle discussed in Chapter 2.

By estimating a similar structural VAR model for Australia, we can reproduce the finding of Bernanke and Blinder (1992) that money and bank loans contract following

[1] Figures are taken from Tables B2 and D4 of the *Bulletin* of the Reserve Bank of Australia.

a monetary tightening. The variables are in order: the cash rate, the log levels of each of three bank balance-sheet variables (deposits, securities, and loans) all deflated by the CPI, the unemployment rate, and the log of the CPI itself. This chapter utilises the "CPI excluding housing".[2] As a set of identifying restrictions, recursive structure is imposed on the system. Two lags of each variable are included. Constant terms are also included. The VAR is estimated over the period 1985:Q1 to 2000:Q2. The beginning period reflects the abolition of monetary targeting in Australia (see MacFarlane 1999). The end of the period is chosen to avoid possible problems caused by the introduction of the goods and services tax (GST) in July 2000. In what follows, regressions are run over the same period, so long as the availability of data allows.

Figure 3.1 shows the calculated impulse response functions of the bank balance-sheet variables and the unemployment rate to an innovation to the cash rate. As in the Bernanke and Blinder (1992) paper, a positive innovation in the cash rate is assumed to represent an unanticipated monetary tightening of the Reserve Bank of Australia (RBA). Since the cash rate is the policy instrument of the RBA, this assumption may be justified. Bank loans do not contract but expand slightly for the first three quarters following a monetary tightening. Contraction of bank loans is preceded by reduction in the holdings of public securities, which may be interpreted as indicating that banks hold public securities as a buffer stock. While the banks rebuild the holdings of public securities, they eventually reduce loans. Consistent with the lending-view, the credit contraction coincides in timing with the rise of the unemployment rate. Figure 3.1 also shows, however, a fall of deposits (i.e., money) following a hike of the cash rate, which may be interpreted as implying that

[2] See Appendix A.2 for further discussion on the data.

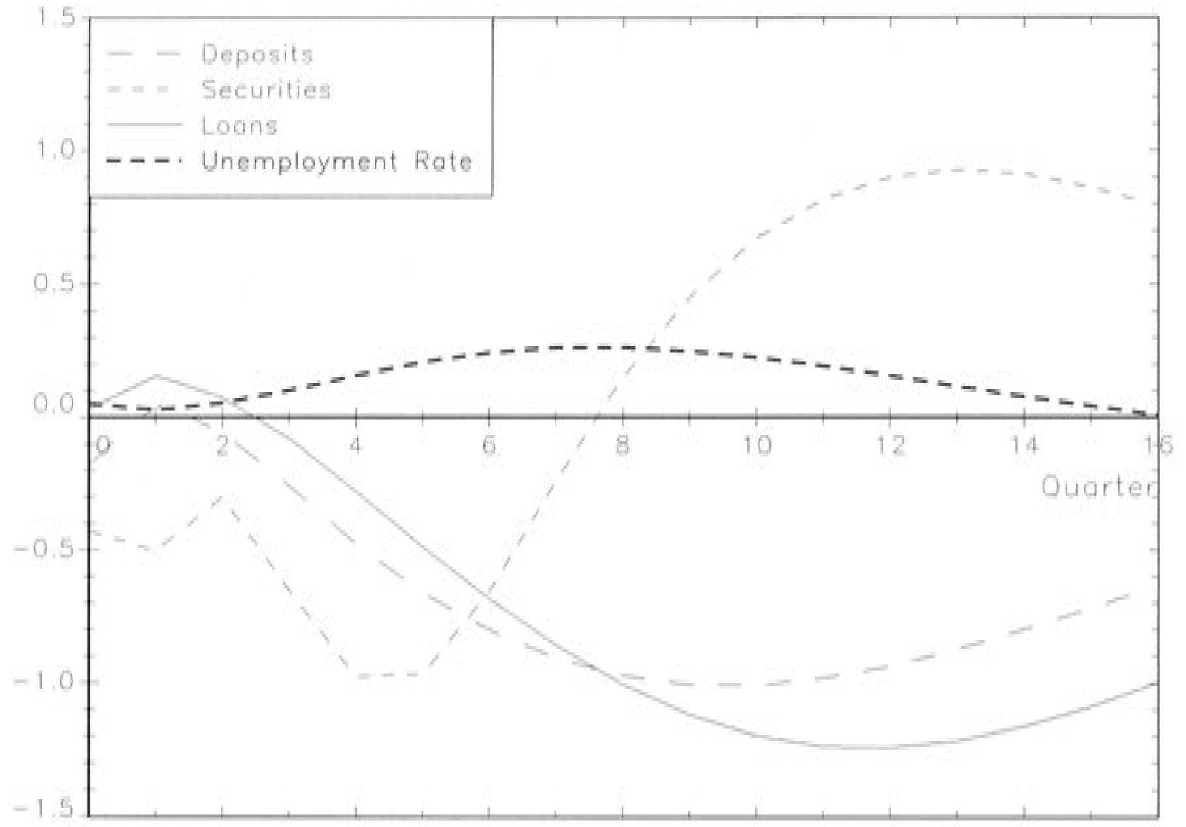

Figure 3.1: Responses to a Shock to the Cash Rate

Notes: Unemployment rate is measured in per cent.

The other variables are in logs and multiplied by 100.

a monetary tightening decrease the demand for credit by depressing aggregate demand through the money channel. As such, the supply-versus-demand puzzle can be found with the Australian data.

Section 3.2 aims to provide empirical resolution to the supply-versus-demand puzzle in the Australian context. In this section, two approaches are employed. One is the Kashyap, Stein, and Wilcox (1993)'s approach that has been employed in the U.S. empirical literature. The other is the original approach discussed in Chapter 2. As will be shown shortly, the results in section 3.2 are not supportive of the bank-lending view, which are in contrast to those in the preceding chapter. Section 3.3 examines characteristics of the Australian bank behaviour in an attempt to identify causes that make the lending channel of monetary policy less important. Section 3.4 provides summary and conclusion of this chapter.

3.2 Empirical Resolution of the Supply versus Demand Puzzle

3.2.1 Kashyap, Stein, and Wilcox (1993) Approach

To deal with the supply-versus-demand puzzle, Kashyap, Stein, and Wilcox (1993) propose to examine the responses of bank loans and alternative forms of credit to a monetary tightening.[3] Their intuition is as follows. If the lending channel of monetary policy is operative, the leftward shift of the supply curve of bank loans will force borrowers to substitute from bank loans into other forms of credit, decreasing bank credit relative to non-bank credit. On the other hand, if monetary policy operates through the conventional money channel, the dampened aggregate demand will shift the demand curve for all forms of credit left, decreasing bank credit and non-bank credit alike. Based on this intuition, they define the "mix" variable of non-equity finance as the ratio of business bank loans to the sum of business bank loans and commercial paper outstanding. Their argument is that a drop of the mix variable identifies a leftward shift of the supply curve of bank loans.[4]

[3]The method of Kashyap, Stein, and Wilcox (1993) has been applied in a variety of contexts. Miron, Romer, and Weil (1994) employ this method to analyse the historical importance of the bank-lending channel in the U.S. economy. Guender (1998) and Hoshi, Scharfstein, and Singleton (1993) employ the method with the New Zealand data and the Japanese data, respectively.

[4]A fall of the mix variable does not necessarily imply a leftward shift of the supply schedule of bank loans. See the discussion in section 2.1 and references therein for the ambiguity of the interpretation of

The Kashyap, Stein, and Wilcox (1993) definition of the mix variable is contentious, however. Commercial paper issuance is available only to large firms. Oliner and Rudebusch (1996) suggest that the denominator of the mix variable should include all forms of non-bank sources of credit to borrowers. Following their suggestion, the mix variable is defined in this chapter as bank loans to the non-financial private corporate sector divided by non-equity financial liabilities of the same sector. In Australia, there is a variety of non-bank sources of credit. At the end of March 2000, for instance, the composition of the financial liabilities for the private non-financial corporate sector is summarized as in Table 3.1. Commercial paper is called a promissory note in the Australian Bureau of Statistics' publications. Bonds are classified as long-term debt securities. Other accounts payable include trade credit and interest accruals. This chapter considers three types of the mix variable. The first, MIX^S, is the ratio of bank loans outstanding to short-term financial debt. The second, MIX^T, is the ratio of bank loans outstanding to total financial debt including long-term debt securities. The third, MIX^O, includes trade credit in the denominator. The movements of the three mix variables are plotted in Figure 3.2.

Kashyap, Stein, and Wilcox (1993) investigate the response of the mix variable after the "Romer dates," which Romer and Romer (1990) identify as the dates on which Federal Reserve Bank shifted to tighter policy. This identification was achieved by reading the minutes of the Federal Open Market Committee. In order to follow the methodology, changes in the policy stance of the Reserve Bank of Australia (RBA) need to be dated. Fortunately, the RBA has officially announced the changes in its policy stance, as reflected

movements in the mix variable. In the following sections, an alternative approach to resolve the supply-versus-demand puzzle is employed to complement the result of this section.

Table 3.1: Financial Liabilities for Private Non-Financial Corporations, March 2000

Items:	*$ Billions*
Loans and Placements (L)	228.6
from Banks (BL)	130.3
Bills of Exchange (BE)	59.7
Promissory Notes (PN)	17.0
Bonds (B)	33.6
Other accounts payable (O)	60.1
Ratio of bank loans:	
$MIX^S (\equiv BL/(L + BE + PN))$	0.43
$MIX^T (\equiv BL/(L + BE + PN + B))$	0.38
$MIX^O (\equiv BL/(L + BE + PN + O))$	0.36

Source: Australian Bureau of Statistics, Catalogue No. 5232.0., September 2000.

in the level of the cash rate, since January 1990. While the RBA does not make these data available prior to 1990, Dungey and Hayward (2000) estimate the dates of changes in the policy stance after January 1985. The targeted level of the cash rate is plotted in Figure 3.2. Like the central banks in other developed countries, the RBA raises the short-term interest rate a number of times before lowering it again. In this subsection, the first of the consecutive series of hikes in the targeted level of the cash rate is regarded as the date of an unanticipated monetary tightening. As a consequence, five dates are identified as the episodes of tight money: 31 July 1986, 6 January 1987, 23 April 1988, 17 August 1994, and 3 November 1999. Due to the availability of the data on the mix variables, however, only the episodes of August 1994 and November 1999 can be examined.

To have a closer look at the movements in the mix variables around the dates of tight money, Figure 3.3 plots the deviations of the mix variables from their own sample trends

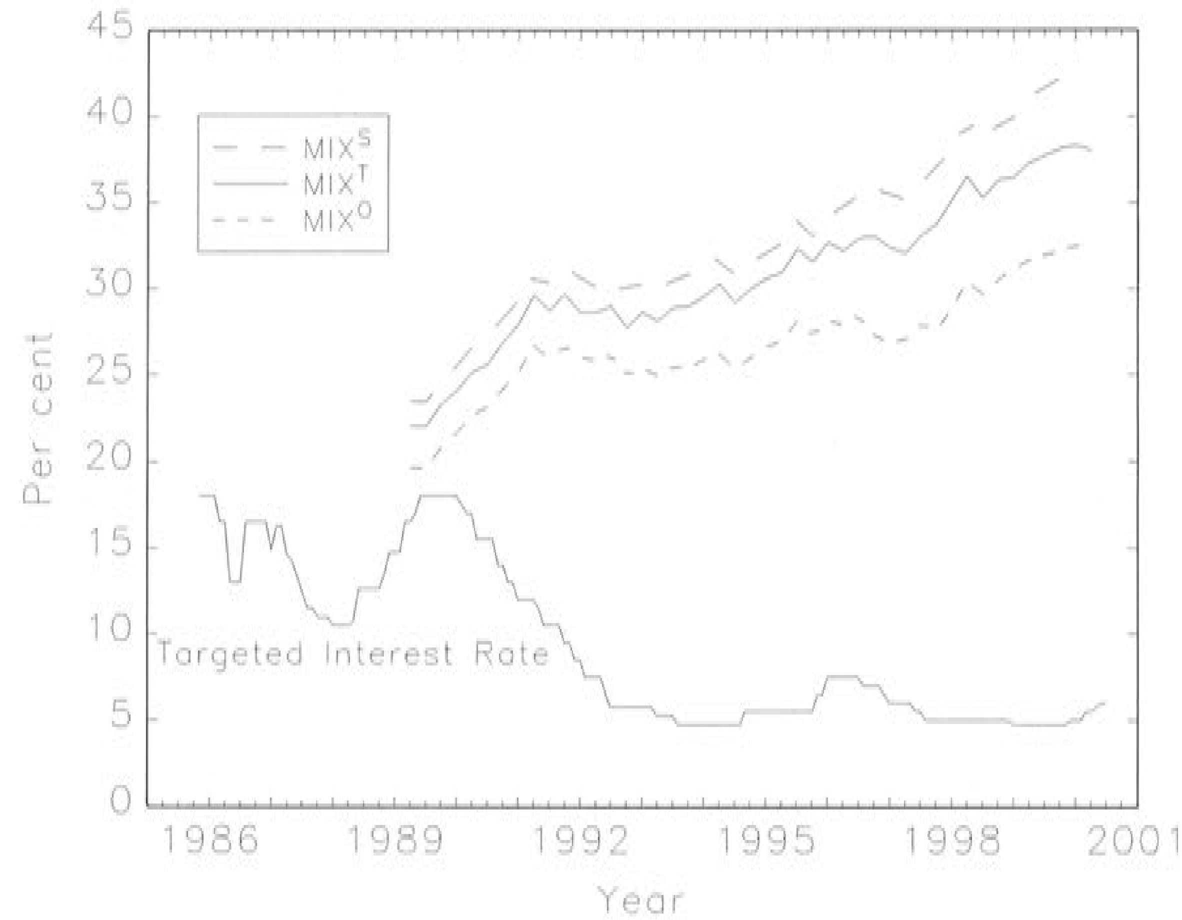

Figure 3.2: Ratio of Bank Loans to Financial Liabilities

(Private Non-financial Corporate Sector)

around the dates of tightening of money. While the mix variables fell after November 1999, they increased after August 1994. Such movements in the mix variables provide an impression that monetary policy is irrelevant for the composition of the financial liabilities for the non-financial private corporate sector. These findings contrast with those of Kashyap, Stein, and Wilcox (1993) who document that the U.S. mix variable fell after the Romer dates.

To quantify the impact of monetary contraction on the mix variable, Kashyap, Stein, and Wilcox (1993) regress a change in the mix variable on lags of itself and current and lagged indicators of monetary contraction which take the value one on the Romer date and zero otherwise. They also estimate the equation adding lags of GNP growth on the right-hand-side in an attempt to control for cyclical factors that might affect the mix variable.

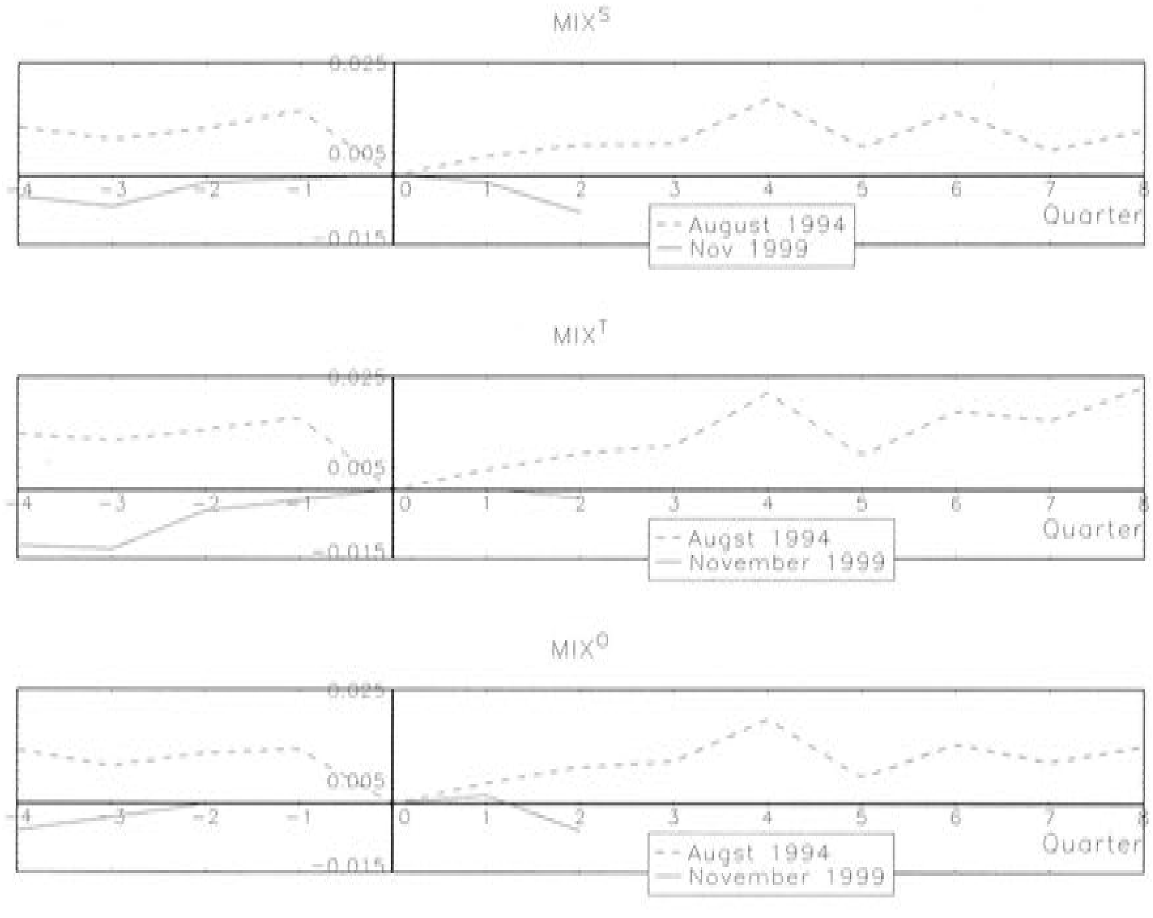

Figure 3.3: Changes in Ratio of Bank Loans to Financial Liabilities

(Deviation from Trend around Monetary Tightening)

In this subsection, each of the three mix variables defined above is regressed on lags of itself, and current and lagged indicators of monetary contraction. Due to the availability of data on MIXs, the whole sample is from 1989:Q2 to 2000:Q2. As an indicator of monetary contraction, this chapter creates a dummy variable, which equals one in August 1994 and November 1999, and zero otherwise. Let MP denote the dummy variable for monetary contraction. Then, the following equation is estimated:

$$\Delta MIX_t^j = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta MIX_{t-i}^j + \sum_{i=0}^{p} \gamma_i MP_{t-i} + e_t, \text{ for } j = S, T, \text{ and } O, \qquad (3.1)$$

where

$$\Delta MIX_t^j = MIX_t^j - MIX_{t-1}^j.$$

The variables are differenced to avoid problems caused by possible unit roots. Equation (3.1) is also estimated by including current and lagged values of the log difference of real GDP. The regressions are run for different numbers of lags: two, four, and six.[5] Following the Kashyap, Stein, and Wilcox argument, the null hypothesis for the lending view is formalized as follows:

$$\gamma_i = 0 \text{ for all } i.$$

Table 3.2 summarises the results. In line with the impression from Figure 3.3, we cannot reject the null hypothesis in any of the regressions at any conventional significance level. An indicator of monetary contraction, MP, does not significantly affect any of the mix variables representing the non-equity financing pattern of the private non-financial corporate sector. In other words, the corporate sector does not substitute away from bank-credit to non-bank credit, even when the Reserve Bank of Australia opts for a shift to tighter policy. Clearly, the lending view is not supported.

The above approach may be subject to criticisms. One is that difference in size between the hikes of the cash rate is not taken into account. The increases of the cash rate in August 1994 and in November 1999 are 0.75-percentage point and 0.25-percentage point, respectively. Despite the 0.5-percentage point difference, the same weights are given to MP for both periods. Another one, which seems more important, is that MP may not be an appropriate indicator of an "exogenous" monetary policy shock. MP concerns only the dates when the RBA raised its targeted level of the cash rate. However, it is not uncommon for a central bank to change the targeted level of its policy instrument to accommodate developments in economic conditions. Such an accommodative change

[5] In each regression, additive seasonal dummies and a dummy for a series break between 1996:Q3 and Q4 are also included.

Table 3.2:
Causality Tests Between the MIX and a Monetary Policy Indicator

Dependent Variable:	MIX^S	MIX^T	MIX^O
p-value:			
Lags = 2			
excl. real GDP	0.390	0.656	0.648
incl. real GDP	0.620	0.848	0.749
Lags = 4			
excl. real GDP	0.404	0.642	0.584
incl. real GDP	0.955	0.972	0.918
Lags = 6			
excl. real GDP	0.762	0.865	0.668
incl. real GDP	0.708	0.960	0.856

Note: The p value is the lowest significance level at which the null hypothesis can be rejected.

should be distinguished from exogenous monetary policy shocks. It is the latter with which we are concerned. Nevertheless, MP makes no distinction between accommodative changes in the targeted level of the cash rate and exogenous monetary policy shocks.

A standard way to overcome the problem of identifying exogenous monetary policy shocks is to adopt a structural VAR approach, where an equation associated with the policy instrument is interpreted as a reaction function of the central bank and hence its residuals are regarded as exogenous monetary policy shocks. For this reason, Oliner and Rudebusch (1996) investigate the mix variable in a macroeconomic VAR model. Due to the over-parameterised nature of a VAR model, however, the sample period of the Australian mix variables may be too short.[6] In addition, the sample of the MIXs include only two

[6] A macroeconomic VAR model was estimated over the period 1989:Q4 to 2000:Q2 including (in order)

episodes of monetary tightening. The next subsection advocates an alternative structural VAR approach by introducing a variable that enables us to identify shifts of the demand and supply schedules in the bank loan market.

3.2.2 An Original Approach: A structural VAR model

This subsection employs the approach discussed in Chapter 2. The dynamics of the Australian economy is described by a small number of linear equations. Let $\mathbf{y}_t$ denote a vector containing the values that the variables of interest assume at date t. With constant terms and linear time trends being included, the structural model is written in a matrix form:

$$\mathbf{B}_0\mathbf{y}_t = \mathbf{k}_0 + \mathbf{k}_1 t + \mathbf{B}_1\mathbf{y}_{t-1} + \cdots + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \tag{3.2}$$

and $\mathbf{u}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{D})$ where $\mathbf{D}$ is a diagonal matrix. In what follows, it is also assumed that a linear model such as (3.2) describes the dynamics of the economy. $\mathbf{y}_t$ includes the short-term interest rate, as it is the policy instrument of the monetary authority. Given the estimated structural model (3.2), dynamic responses of the variables to a positive innovation in the interest rate, which is interpreted as an unanticipated monetary tightening, can be simulated.[7] As is discussed in section 2.2 of the preceding chapter, we can reduce the

the commodity price index, the CPI, real GDP, the cash rate, the exchange rate, and the mix variable MIX^S. In order to secure meaningful degrees of freedom, the number of lags was set to two. As in section 3.1, an innovation to the cash rate was interpreted as an unanticipated hike of the cash rate. The calculated impulse response functions showed that MIX^S did not drop in response to a positive innovation to the cash rate. Therefore, the results were not supportive of the lending view. In the results, however, the price puzzle, which will be discussed in the next subsection, was evident.

[7]Structural VAR models of the Australian macroeconomy have become popular. In the Australian literature, it is commonly assumed that a shock to the cash rate represents unexpected monetary policy. See, for example, Brischetto and Voss (1999), Dungey and Fry (2000), and Dungey and Pagan (2000).

supply versus demand puzzle to a problem like simultaneous equation bias by embedding the price and quantity of bank loans in a structural VAR model (see Figure 2.1).

The selection of variables to model is essentially same as in Chapter 2. Output (Y), price (P), money (M), and the interest rate (R) are included, as these are the variables in the standard IS-LM model. Sims (1992) shows, however, that a four-variable VAR often produces a "price puzzle", which is a sustained rise of the price level following a positive innovation in an interest rate. To avoid the puzzling results, he suggests that the exchange rate (XR) and the commodity price (CP) should be added to the set of variables.[8] Following his suggestion, this chapter includes these two variables. The chapter further expands the VAR by adding the loan price (LP) and the loan quantity (LQ). The addition of the credit variables is justified by Bernanke and Blinder (1988)'s theoretical model. As their model is an extension of an IS-LM model including the credit market, it suggests that the dynamic interaction among three markets (goods, money, and credit) be examined. Thus, a minimal set of variables consists of the prices and quantities in the three markets, the exchange rate, and the commodity price. In terms of the system equations (3.2),

$$y_t' = (P_t, Y_t, R_t, M_t, LP_t, LQ_t, XR_t, CP_t)'^{9}$$

This chapter follows the convention. The common practice may be contentious, however, particularly in the U.S. literature. See the discussion in section 2.3 of Chapter 2.

[8] Inclusion of the exchange rate and the commodity price in a set of variables does not always eliminate the price puzzle. In the results of Sims (1992) for France or Japan, the price puzzle is still evident even after including these two variables. In Chapter 2, the price puzzle is evident when the structural VAR model is estimated with the interest rate on loans as the price of loans (see Figure 2.2). When the loan interest rate is replaced with the diffusion index, however, the price puzzle is not significant (see Figures 2.3 and 2.5).

[9] The set of the variables for the model of this subsection is same as the one for the basic model in

The next task is to choose data to measure the eight variables. P and Y are conventionally measured by the log of CPI and the log of real GDP, respectively. M is measured by the log of base money. Base money is chosen in an attempt to avoid possible problems caused by high correlation between money and bank credit. The cash rate is chosen for R, as it is the policy instrument of the Reserve Bank of Australia. R is measured in per cent. A positive innovation to R is interpreted as an unanticipated monetary tightening. XR is the log value of the Australian dollar measured in the U.S. dollars. Therefore, a rise in XR means an appreciation of the Australian currency against the U.S. currency. CP is measured by the log of world non-fuel commodity price index. LQ is the log of loans and advances by Australian banks. See Appendix A.2 for the sources of data and further discussion on the data.

Measuring LP is not straightforward. A candidate for the loan price (i.e., the marginal cost of loans to borrowers) is an interest rate on new loans. Although data on the weighted average interest rate on total credit are available from 1993:Q4, there is no series available which gives the interest rate on new loans. An alternative candidate is the diffusion index in the "Survey of Industrial Trends" conducted by the Australian Chamber of Commerce and Industry (ACCI) and the Westpac Banking Corporation. Question 4-b of the survey is "Do you find it is now harder, easier or the same as it was three months ago to get finance?" The diffusion index is calculated by subtracting the percentage of the firms answering "Easier" from the percentage of those answering "Harder." Suppose that the marginal cost of loans to borrowers rose due to a leftward shift of the supply curve of

Chapter 2, except for the U.S. interest rate. The next subsection explicitly takes into consideration the effects of the U.S. shocks on the domestic sector.

loans, a rightward shift of the demand curve for loans, or both. Then, firms would find it "Harder" to get finance. Consequently, one would observe a rise of the diffusion index. As such, the marginal cost of loans to borrowers and the ACCI-Westpac diffusion index may be positively correlated. Data on the diffusion index are available from 1966:Q2. In addition to providing a longer time series of data, the diffusion index is also expected to capture non-price components of the marginal cost of loans to borrowers such as collateral, or in extreme cases, the cost of being rationed out of the bank loan market. For these two advantages, the ACCI-Westpac diffusion index is utilized to measure LP (see Appendix for further discussion on the ACCI-Westpac diffusion index).

With the above-mentioned data, the structural model (3.2) is estimated over the period 1985:Q1 to 2000:Q2. As mentioned in section 3.1, the beginning and the end of the period reflect the abolition of monetary targeting and the introduction of GST, respectively. As the model is a simultaneous equation model, identifying restrictions are required. For computational convenience, $\mathbf{B}_0$ is restricted to be lower triangular. That is, a recursive structure is imposed on the system. The order of the variables is CP, P, Y, M, R, XR, LP, and LQ. XR is placed after R in order to capture the immediate response of the exchange rate to an unanticipated change in the cash rate. The position of P is consistent with the Keynesian argument that prices adjust slowly to the action of monetary policy. The lag length p is set as two. From the estimated model, impulse responses of the variables to a positive shock in R are calculated. For instance, the impulse response function of LQ is defined as

$$\frac{\partial\ E(LQ_{t+i}|I_t)}{\partial\ u_t^R} \text{ for } i = 0, 1, \cdots,$$

where $E(LQ_{t+i}|I_t)$ and u_t^R denote the expected value of LQ_{t+i} conditional on the set of information available at date t and the component associated with R in $\mathbf{u}_t$, respectively. As measures of the statistical reliability, confidence intervals for the estimated impulse responses are also presented.[10]

In each graph of Figure 3.4, the solid line and the dotted lines are the point estimate of the impulse response function to a one-standard-deviation shock in the cash rate and its 90% confidence interval, respectively. A one-standard-deviation shock to the cash rate is calculated as an increase of approximately 0.47 percentage point. A proxy for the loan price is measured in percentage point. Impulse responses of the other variables measured in logs are multiplied by 100, so that the impulse responses approximate the percentage change of those variables in response to a 0.47 percentage point hike of the cash rate. For instance, the quantity of loans is expected to increase by approximately 0.58% after a quarter in response to an unanticipated 0.47 percentage point rise of the cash rate. To ease comparison across the graphs, the same scale is employed.

The upper two graphs in Figure 3.4 indicate effects of an unexpected hike of the cash rate on the price and output. Impacts of a change in the cash rate on the price level and output are clearly negligible. The point estimate implies that real GDP falls by approximately 0.02% in 16 quarters after an unanticipated 0.47 percentage point hike of the cash rate. Is the ineffectiveness of monetary policy consistent with the results of other Australian studies? Dungey and Pagan (2000), for instance, estimate an open-economy structural VAR model, which will be discussed shortly, over the period 1980:Q1 to 1998:Q3. The maximum effect is a decline of nearly 0.3% in real GDP in the seventh

[10]As in the analysis of section 2.3 in Chapter 2, confidence intervals are calculated by bootstrapping. See Appendix B.3 for technical details.

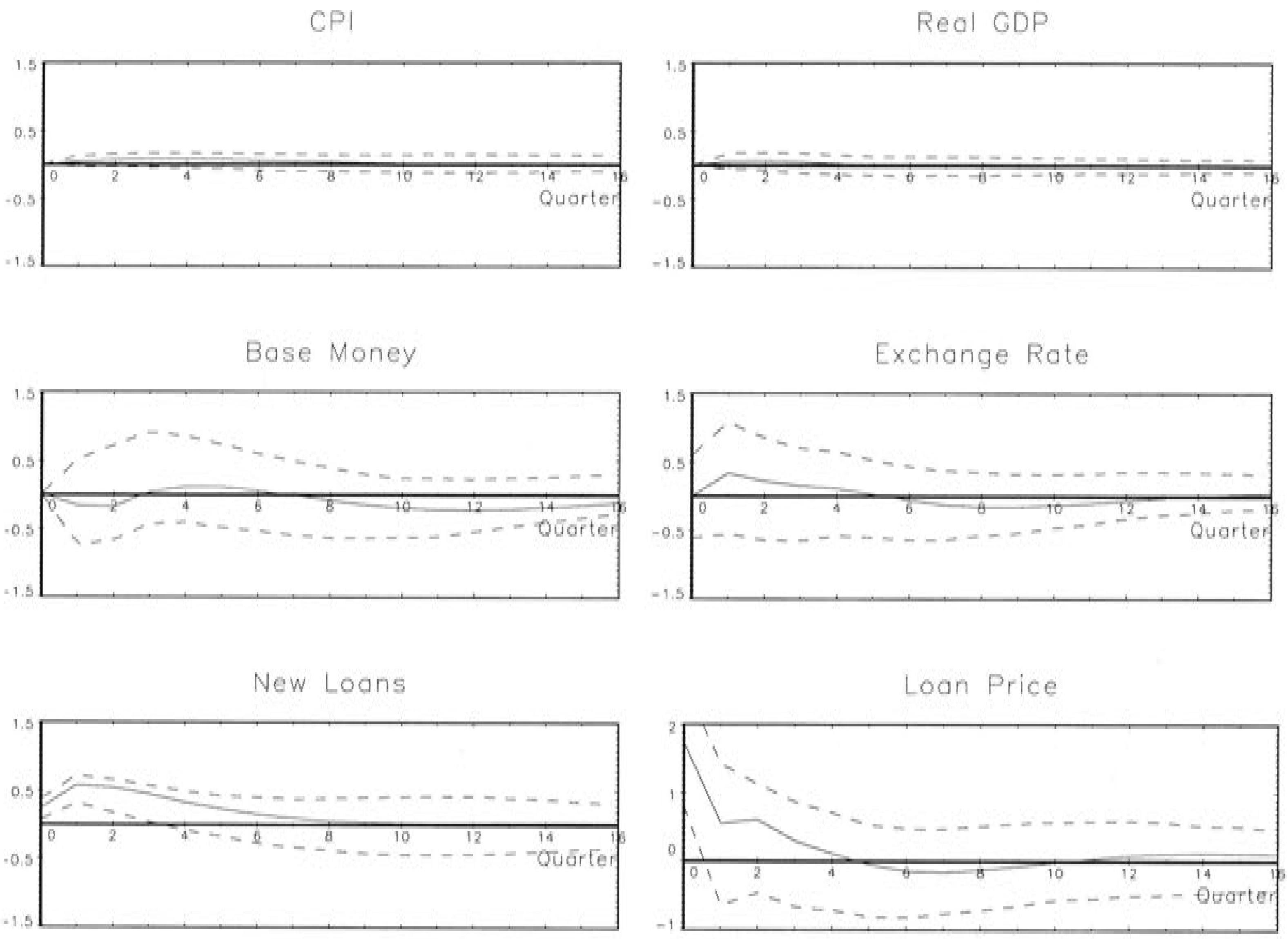

Figure 3.4: Responses to a shock in the cash rate

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

quarter following an unanticipated 1.4 percentage point hike in the cash rate. Although the response of real GDP is significant (with a 90% confidence interval) in their analysis, the size of the response is small. Brischetto and Voss (1999) similarly estimate a seven-variable VAR (real GDP, the CPI, M1, the cash rate, the exchange rate, the world oil prices, and the U.S. interest rate) over the period 1980:Q1 to 1998:Q4 finding that an unexpected 0.25 percentage point rise of the cash rate is followed by a decline of approximately 0.2% in real GDP in 12 quarters. The response of real GDP is not significant (with a 90% confidence interval) in their analysis. Thus, the impacts of monetary policy on economic activities are estimated to be small in the Australian VAR literature.[11]

The centre two graphs of Figure 3.4 show how base money and the exchange rate respond to a positive shock in the cash rate. If a central bank raises the short-term interest rate, money will have to fall as a consequence of its monetary operation. The left graph confirms that base money actually falls in response to an unexpected hike of the cash rate. The right graph is similarly consistent with economic theory, as the contraction in base money is associated with an appreciation of the domestic currency. Neither of these instantaneous responses is statistically significant, however.

As for the lending view, the lower two graphs in Figure 3.4 are of central interest. These graphs indicate impacts on the bank loan market of an unexpected rise in the cash rate. In response to the hike of the cash rate, the price and quantity of bank loans initially increase. In addition, the initial positive responses of the price and quantity of bank loans are significant.[12] These initial responses imply that the demand schedule for

[11] Within a framework of single equation models, Gruen, Romalis, and Chandra (1999) find that a one-percentage point rise in the short-term *real* interest rate is followed by a decline of nearly 0.8% in the domestic output in 14 quarters. Thus, the effect of monetary policy on output is estimated larger in their study than in this chapter. These results are not comparable, however. A single equation model does not take into account the feedback of economic developments on the interest rate, so that their measure of monetary policy is contaminated. Furthermore, it is the nominal interest rate that the RBA targets, and monetary policy cannot permanently change the real interest rate in the open economy.

[12] More rigorously, we can reject at the 5% (not 10%) significance level the null hypotheses that

$$\frac{\partial E(LQ_{t+i}|I_t)}{\partial u_t^R} \leq 0 \text{ for } i = 0, 1, \text{ and } 2,$$

and that

$$\frac{\partial E(LP_{t+i}|I_t)}{\partial u_t^R} \leq 0 \text{ for } i = 0,$$

bank loans shifts right. Such a temporary rightward shift of the demand schedule for bank loans is commonly found in the U.S. literature. Gertler and Gilchrist (1993), for instance, argue that U.S. firms temporarily increase the demand for bank loans in order to smooth reductions in their cash flows in the wake of tight money. Their argument may apply to the Australian case. After an initial increase, the quantity of bank loans begins to decrease. Importantly, the contraction of loans accompanies a fall of the loan price. This pattern of co-movements implies that the contraction of bank loans is largely due to a leftward shift of the demand schedule for bank loans. As such, the lower two graphs show that fluctuations in bank loans are dominated by shifts of the demand curve in the Australian bank loan market. Therefore, the lending view is not supported.

While the results shown in Figure 3.4 are not anomalous, the model of this subsection may be subject to a criticism: it is not fully an open-economy model, even though the exchange rate and the commodity price are included.[13] Taking into account the openness of the Australian economy, however, it would be better to capture the interaction between the Australian economy and the rest of the world explicitly. For instance, no one would deny that a change in the federal funds rate in the U.S. could affect the monetary policy action of the RBA. The next subsection expands the model to the context of the open economy.

where I_t and u_R denote the set of information about the model as of date t and a structural shock to the cash rate, respectively.

[13]Another possible criticism is that a structural VAR approach deals with monetary expansion and monetary contraction symmetrically. Lim (2001) argues that Australian banks adjust their loan and deposit rates at a faster rate during periods of monetary easings than during periods of monetary tightenings. This asymmetric behaviour of banks implies that impacts of monetary contraction may not be a mirror image of those of monetary expansion.

3.2.3 An open-economy structural VAR model

Applying a closed-economy model for the non-U.S. countries often results in puzzles. A notable one is the price puzzle, arising when a sustained rise in the price level follows a positive innovation in the short-term interest rate. The price puzzle might suggest that an innovation in money rather than the short-term interest rate should be regarded as the monetary policy action (see, for example, Eichenbaum 1992). A positive innovation in money is often followed by a rise of the interest rate, however. This is known as the liquidity puzzle. While including the exchange rate may resolve the price puzzle, it often results in the exchange rate puzzle - that a depreciation of the domestic currency against the U.S. dollar follows a positive innovation in the short-term interest rate. Kim and Roubini (2000) estimate structural VAR models for the non-U.S. G7 countries, finding that the inclusion of the U.S. interest rate can eliminate these anomalous results. Their modelling is applied to the Australian studies. Brischetto and Voss (1999) find that the inclusion of the U.S. interest rate resolves those puzzles in the Australian VAR analysis.[14]

The U.S. interest rate is not the only overseas variable which may affect a small open economy. In the open economy literature, it has recently been becoming common to model interdependence between economies. In the first attempt of its kind, Cushman and Zha (1997) estimate an open-economy structural VAR model for Canada including the U.S. industrial production, the U.S. consumer price index, the federal funds rate, and the

[14]This is the approach employed in Chapter 2. For Japan, however, an overseas section is not explicitly modelled. There are two reasons. First, the sample is from 1973 to 1993. It was not until the late 1980s that various restrictions on the overseas activities of Japanese banks were abolished. Second, the Japanese model includes two additional variables, namely the indexes of stock prices and land prices, which consumes degrees of freedom to a great extent.

commodity price index in the U.S. dollar as the overseas variables. In a similar spirit, Dungey and Pagan (2000) estimate an open-economy structural VAR model for Australia treating the U.S. as the rest of the world. The set of U.S. variables in their model consists of GDP, a real interest rate, the terms of trade, a measure of asset prices, and real exports. Dungey and Fry (2000) extend this modelling philosophy into a three country model. They estimate a three-country structural VAR model treating the U.S. and Japan as the rest of the world to Australia. Following these works, this chapter estimates an open-economy structural VAR model where the U.S. is assumed to be the rest of the world to Australia. In particular, the U.S. output, the U.S. price, and the U.S. interest rate are added to the set of variables in the previous subsection.

The set of variables now consists of the domestic variables and the overseas variables. To reiterate, the domestic variables are the log of price (P), the log of output (Y), the log of money (M), the short-term interest rate (R), the log of the exchange rate (XR), the log of the quantity of bank loans (LQ), and the proxy for the price of bank loans (LP). The overseas variables are the log of the commodity price (CP), the log of the U.S. price (P^U), the log of the U.S. output (Y^U), and the U.S. interest rate (R^U). Let x_t denote an (11 x 1) vector containing the values that the 11 variables assume at date t.

$$\mathrm{x}_t' = (\mathrm{x}_t^{o\prime}, \mathrm{x}_t^{d\prime})',$$

where x^o and x^d are the vector of the overseas variables and that of the domestic variables, respectively. The structural model is again expressed by a linear system of simultaneous equations (3.2).

Including the overseas variables inevitably makes the dimension of a structural VAR model large. To secure meaningful degrees of freedom, it is not uncommon to restrict the coefficients of the domestic variables in the equations of the overseas variables to be zero. If the coefficient matrices in the model (3.2) are partitioned conformably with $\mathbf{x}_t$ as

$$\mathbf{B}_j = \begin{pmatrix} \mathbf{B}_{11}^j & \mathbf{B}_{12}^j \\ \mathbf{B}_{21}^j & \mathbf{B}_{22}^j \end{pmatrix} \text{ for } j = 0, \cdots, p,$$

the restriction is equivalent to

$$\mathbf{B}_{12}^j = \mathbf{0} \text{ for } j = 0, \cdots, p. \tag{3.3}$$

In other words, the variables in $\mathbf{x}^o$ are assumed to be block-exogenous with respect to the variables in $\mathbf{x}^d$. The restriction of block exogeneity is consistent with a prior that Australia is a small open economy.

A hypothesis about block exogeneity can be tested in a multivariate context of Granger-causality. For this purpose, a reduced form model is estimated:

$$\mathbf{x}_t = \mathbf{c}_0 + \mathbf{c}_1 t + \mathbf{\Phi}_1 \mathbf{x}_{t-1} + \cdots + \mathbf{\Phi}_{t-p} \mathbf{x}_{t-p} + \mathbf{e}_t, \tag{3.4}$$

with $\mathbf{e}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{\Omega})$ where

$$\mathbf{\Phi}_j = \mathbf{B}_0^{-1} \mathbf{B}_j \text{ for } j = 1, \cdots, k.$$

The restriction (3.3) is equivalent to

$$\mathbf{\Phi}_{12}^j = 0 \text{ for } j = 1, \cdots, k, \tag{3.5}$$

where $\mathbf{\Phi}_{12}^j$ is the (4 x 7) upper-right part of $\mathbf{\Phi}_j$ when it is partitioned as

$$\mathbf{\Phi}_j = \begin{pmatrix} \mathbf{\Phi}_{11}^j \mathbf{\Phi}_{12}^j \\ \mathbf{\Phi}_{21}^j \mathbf{\Phi}_{22}^j \end{pmatrix} \text{ for } j = 1, \cdots, p.$$

Let $\mathbf{\Pi}'$ denote the following matrix:

$$\mathbf{\Pi}' \equiv [\mathbf{c}_0 \ \mathbf{c}_1 \ \mathbf{\Phi}_1 \ \cdots \ \mathbf{\Phi}_{t-p}].$$

The null hypothesis for testing the restriction (3.5) can be written as a general linear form:

$$\mathbf{R}\pi = 0 \tag{3.6}$$

where $\pi = vec(\mathbf{\Pi})$. The Wald test statistic for the null hypothesis (3.6) is constructed as

$$W = T[(\mathbf{R}\pi)'(\mathbf{RZR}')^{-1}(\mathbf{R}\pi)] \tag{3.7}$$

where T and $\mathbf{Z}$ are the number of observations and a consistent estimator of covariance matrix of π, respectively.

As is well known, however, the standard asymptotic theory is not applicable to Granger-causality tests when series are integrated or cointegrated (see Sims, Stock, and Watson 1990). In fact, augmented Dickey-Fuller tests indicate that all the data series except for LP are possibly integrated of order one or two. P and P^U, in particular, are suspected to be integrated of order two. A practical way to avoid the problem caused by unit roots is to follow the procedure proposed by Toda and Yamamoto (1995). Their procedure is as follows. If the true lag length of a VAR is p, then a $(p+d)$th-order VAR is to be estimated where d is the maximal order of integration that might occur in the process. If the true lag length of a VAR is two and the series are integrated of order one, for instance, a third order VAR should be estimated. They show that by adding the extra lags the standard Wald test statistic applied to a Granger-causality test in the VAR is asymptotically valid and can be evaluated in the usual way.

To test the hypothesis about block exogeneity, the reduced form model (3.4) is estimated over the period 1985:Q1 to 2000:Q2. Based on the results of likelihood ratio tests, p is determined as two. The maximal order of integration of the variables is assumed to be two. Therefore, a four-lag VAR is estimated. Given the estimated VAR, the Wald test statistic is calculated as 695.71 with 56 degrees of freedom. The test statistic is suspiciously large, however. This might reflect severeness of small-sample bias. Sims (1980), for instance, finds that in a VAR model small-sample bias makes likelihood ratios larger. For this reason, he proposes to replace the usual likelihood ratio test statistic $T(\log|D_R| - \log|D_U|)$ with $(T-k)(\log|D_R| - \log|D_U|)$ where D_R and D_U are the matrix of cross products of residuals of the restricted model and the same matrix for the unrestricted model, respectively. T and k are the number of observations and the number of coefficients in each equation of the unrestricted model, respectively. When T is small, the difference between the two statistics can be substantial. By analogy with his finding, small-sample bias is suspected to affect the Wald test statistic. If T is replaced with $T-k$ in equation (3.7), the Wald test statistic is reduced to 179.54. Nevertheless, the Wald test statistic is still large, and the hypothesis about block exogeneity is rejected at any conventional level of significance.

The result of testing block exogeneity may be unreliable. Although the coefficients of a VAR model are estimated consistently, the estimators are biased in a finite sample. The finite-sample bias affects the residuals, from which the Wald test statistic is calculated. Since the Toda and Yamamoto (1995) procedure employed above requires adding extra lags, the finite-sample bias is likely to become severe.[15] In addition, Abadir, Hadri, and Tzavalis (1999) prove that adding extraneous variables to a VAR has more serious negative consequences in integrated time series than in ergodic time series. Since the data series used for the estimation are integrated, the failure to accept the null hypothesis that

[15]See Yamada and Toda (1998) for the Monte Carlo simulation of the small-sample performance of the Toda and Yamamoto (1995) procedure. See also Caporale and Pittis (1999) for a survey on causality tests in VAR models.

Australia is a small open economy may reflect severeness of the finite-sample bias. Based on the theorem derived, they also recommend parsimonious modelling. Following their recommendation, zero restrictions will be imposed shortly on the coefficients of the parameters of the domestic variables in the equations of the foreign variables. At the moment, however, the test result is taken for granted.

What does the rejection of the null hypothesis about block exogeneity mean? While the hypothesis is consistent with a prior that Australia is a small open economy, its rejection does not necessarily mean that Australia is not a small open economy. As is well known, a Granger-causality test is related with the ability of a model to forecast future values of a variable(s). Suppose that there is an important leading indicator of the U.S. economy, which is highly correlated with some Australian variables in the model. If the leading indicator is not included in the model, the Australian variables will improve the ability of the model to forecast future movements in the U.S. variables. In such a case, Granger causality will be detected from the Australian variables to the U.S. variables, even though fluctuations in the Australian variables do not cause those in the U.S. variables in an economic sense.

Given the rejection of the hypothesis about block exogeneity, the unrestricted eleven-variable VAR is estimated. As is mentioned, the likelihood tests suggest that the number of lags is two.[16] The impulse response functions of the variables to a positive shock in the cash rate are again calculated. In each graph of Figure 3.5, the solid line and the dotted lines are the impulse response function of each variable to a positive shock in the

[16]This chapter shows the results from models with two lags. The results are essentially robust to the choice of lags, however. See Suzuki (2003) attached to this thesis.

cash rate and the 90% confidence interval, respectively. The size of the shock to the cash rate is one-standard-devation, which is calculated as an increase of approximately 0.55 percentage point in the cash rate. The loan price is measured in percentage point. The other variables are in logs and multiplied by 100, so that the impulse response functions approximate the percentage change of these variables in response to an unexpected 0.55 percentage point hike of cash rate. The same scale is used for all the variables except for the loan price.

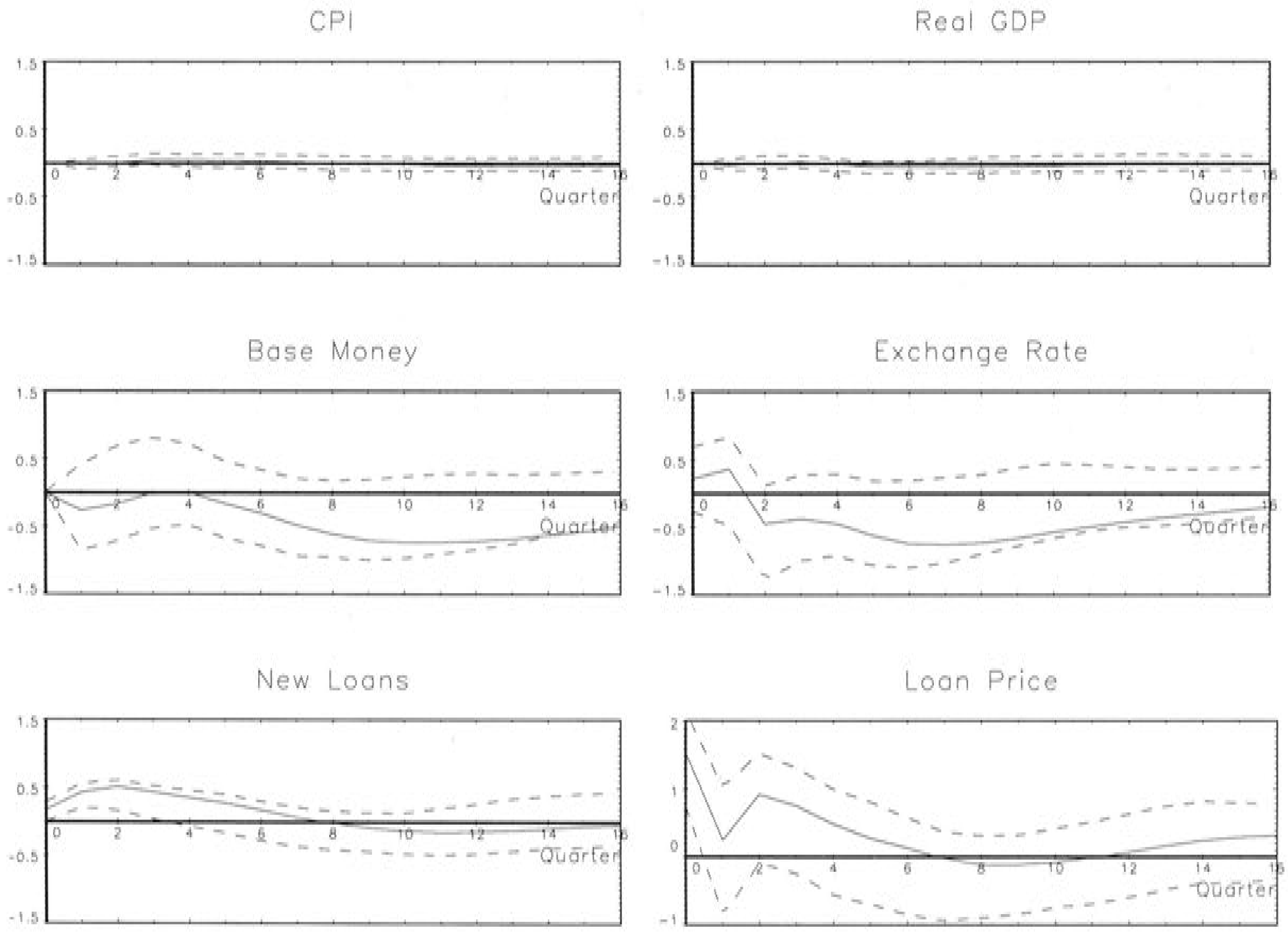

Figure 3.5: Responses to a cash rate shock (the unrestricted model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

In Figure 3.5, the upper two graphs imply that impacts on the price and output of a change in the cash rate are negligible. The point estimate implies that the maximum effect is a decline of approximately 0.06% in real GDP in the seventh quarter following an unanticipated 0.55 percentage point rise of the cash rate. The left of the centre graphs shows that base money initially falls by nearly 0.3% in response to the unexpected hike of the cash rate. The negative initial response of base money is reasonable. The right of the centre graphs shows that the Australian dollar immediately appreciates by approximately 0.4% against the U.S. dollar following the same change in the cash rate. Neither of the responses of money and the exchange rate is significant, however. These results are consistent with those in the previous subsection.

The lower two graphs in Figure 3.5 show that the lending view is again not supported. The quantity and price of bank loans initially increase. As mentioned earlier, this pattern of co-movements implies that the demand schedule for bank loans shifts right in response to a monetary tightening. In the first quarter after a positive innovation in the cash rate, the quantity of loans increases while the price of loans falls. These movements of the price and quantity of bank loans contradict the lending view that the supply schedule of loans shifts left in response to monetary contraction. Rather, the results imply that Australian banks accommodate the temporarily increased demand for loans.

Figures 3.4 and 3.5 are similar to each other. This might suggest that the U.S. variables have no power to improve forecasting movements in the Australian variables. Following the Toda and Yamamoto (1995) procedure, the null hypothesis that the coefficients of the U.S. variables are zero in the equations of the Australian variables and CP is tested. The Wald test statistic is 897.48 with 48 degrees of freedom. This is again suspiciously large.

After correcting for the small-sample bias, the Wald test statistic is reduced to 231.61. Nevertheless, the null hypothesis can be rejected at any conventional significance level.

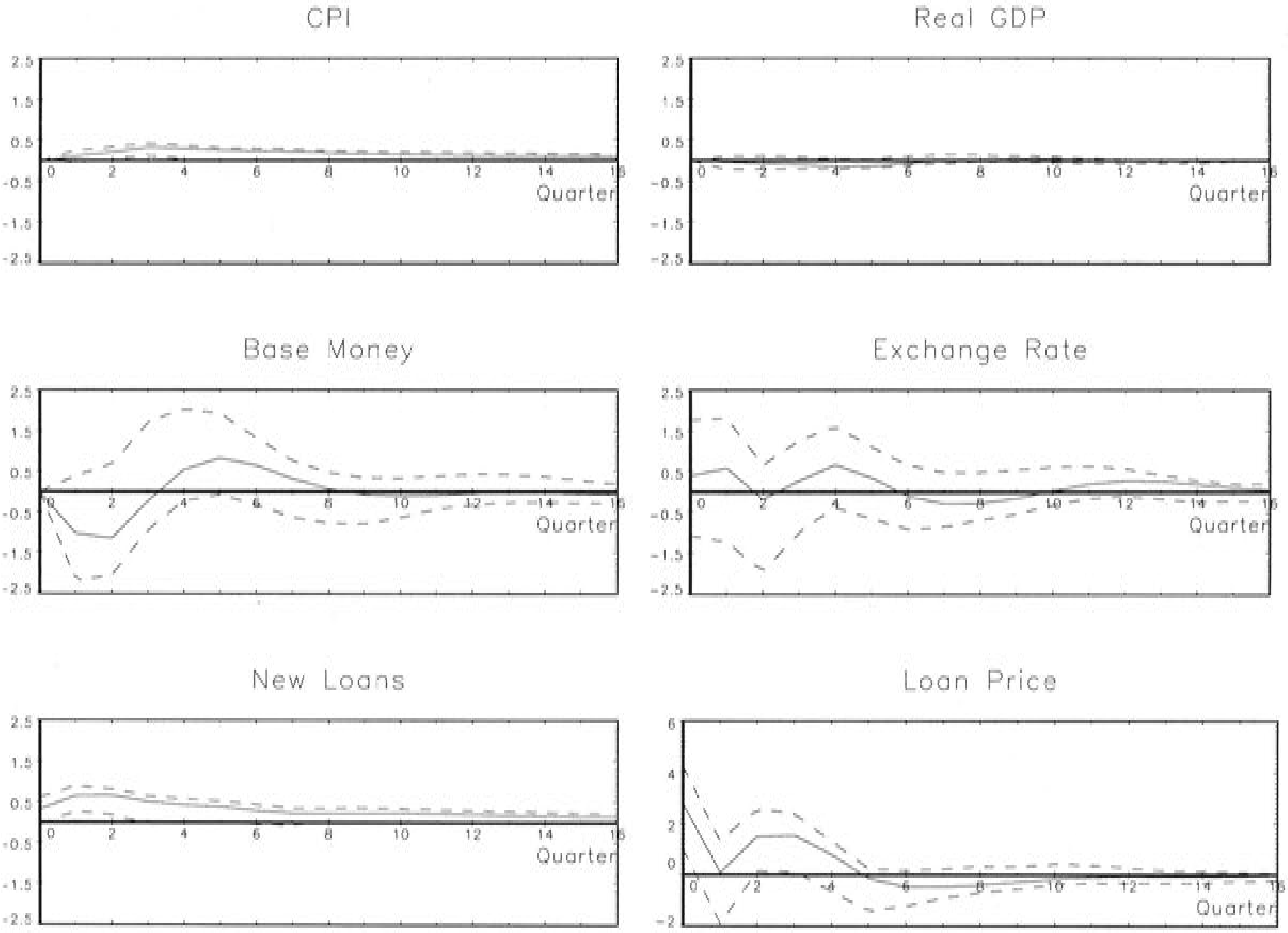

Figure 3.6: Responses to a cash rate shock (the restricted model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

Simulation results reported in Figure 3.5 are derived from the unrestricted model, which is chosen because the Wald test rejects the block exogeneity of the foreign variables. As is discussed, however, the test result may be unreliable in the finite sample. For the purpose of robustness check, the structural model (3.2) with the restriction of block exogeneity (3.3) is estimated over the same period with the same data. The calculated impulse response functions are reported in Figure 3.6. The initial positive response of loans is no longer significantly different from zero. It is significant at 10%, however.[17] The responses of the quantity and loans of bank loans are similar to those of the previous models. Therefore, the lending view is not again supported. The responses of the other variables are also consistent with those calculated from the restricted model.

3.3 Banking Behaviour

Various analyses of section 3.2 show that loans initially expand following a monetary tightening, and that the positive response of bank loans accompanies a rise of the marginal cost of bank loans to borrowers. Thus, the conclusion of section 3.2 is that the initial positive response of bank loans largely reflects a rightward shift of the demand schedule in the bank loan market. This is consistent with the argument of Gertler and Gilchrist (1993) that firms temporarily increase demand for bank loans to smooth reductions in their cash flows in the wake of tight money. Then, a question arises. How can Australian banks accommodate the change in the demand schedule for bank loans when the Reserve Bank of Australia tightens money?

In the U.S. context, Bernanke and Blinder (1992) emphasize the role of banks' security holdings in mitigating impacts of monetary contraction on their supply schedules of bank loans. Due to the contractual nature of bank loans, banks cannot immediately cut their supply of loans. Therefore, banks reduce their security holdings in the wake of tight money. This argument seems to apply to the Australian case. Figure 3.1 in section 3.1 shows that

[17] This means that a similarly calculated 80% confidence interval lies above zero at the initial three quarters.

deposits do not immediately fall in response to a hike in the cash rate. When loans begin to fall, deposits also begin to fall. In contrast, a fall of security holdings immediately follows a hike of the cash rate. The security holdings recover as deposits fall. These movements imply that Australian banks use their security holdings as a buffer stock.

By adjusting their liabilities, banks may be able to accommodate the temporarily increased demand for bank loans when money is tightened. Romer and Romer (1990) argue that U.S. banks raise funds by issuing the certificates of deposit (CDs) when the Federal Reserve Bank tightens money. To examine whether their argument holds for Australia or not, a VAR model is estimated over the period 1989:Q4 to 2000:Q2 including the cash rate, two components of bank liabilities (deposits and CDs) both deflated by the CPI, the unemployment rate, and the CPI itself. Deposits, CDs, and the CPI are in logs.[18] Two lags of each variable are included. Constant terms are also included. Figure 3.7 shows the impulse response functions of the unemployment rate and bank liabilities to a positive innovation in the cash rate. Clearly, CDs decrease in response to a monetary tightening. As a higher interest rate can make the issuance of CDs more costly to banks, the decrease of CDs is plausible. Thus, the Romers' argument does not hold for the Australian case.

Another feature of Australian bank behaviour which may insulate the supply schedule of bank loans from impacts of monetary contraction is their borrowing from overseas.[19]

[18] Data on CDs are available from 1989:Q2.

[19] The U.S. literature has not tested the hypothesis that U.S. banks make use of foreign currency liabilities to mitigate impacts of monetary contraction on their supply schedule of loans. This may be because many U.S. banks were too small to raise funds from overseas. The McFadden Act of 1929 required U.S. banks to obey state restrictions on branching, and interstate branching was prohibited by all the states. Individual states also restricted intrastate branching. In the most restrictive regime, each bank was limited to a single office. As a consequence, U.S. banks were generally small. In 1980, for instance, 9,900 of 12,290

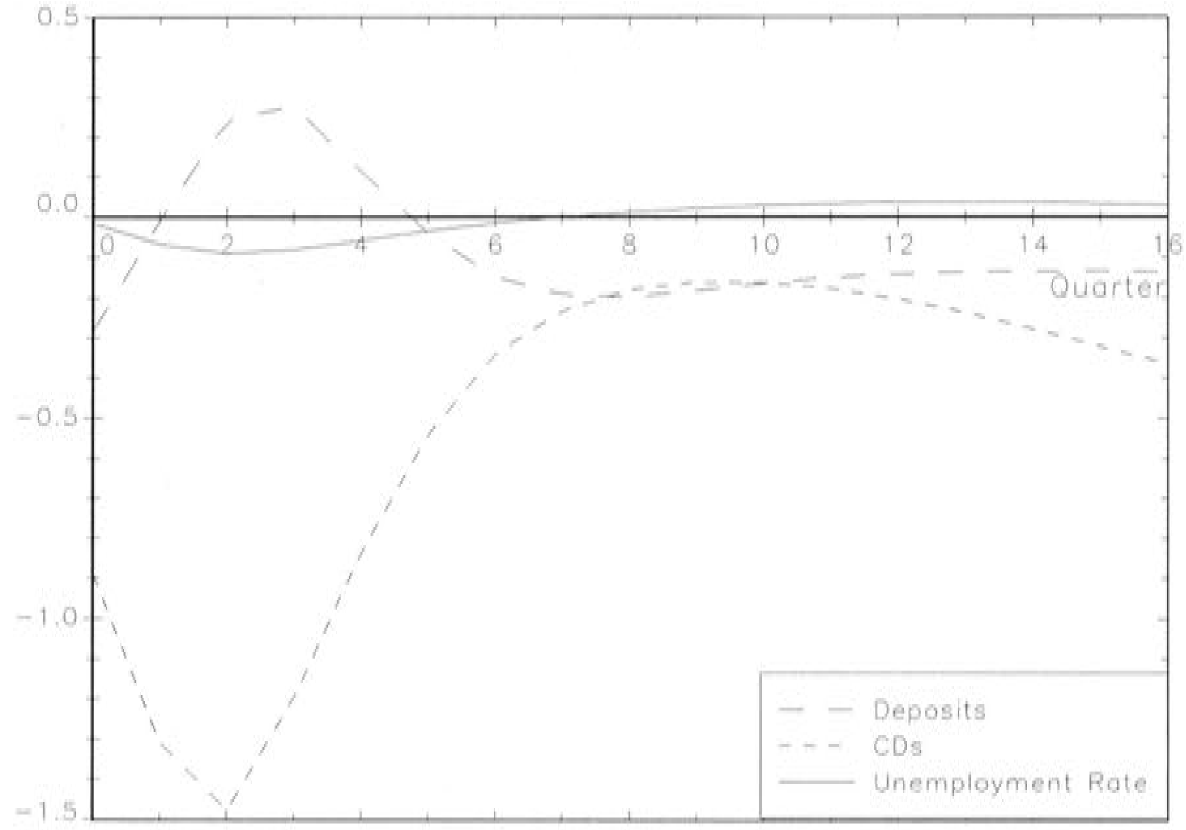

Figure 3.7: Responses to a Shock to the Cash Rate

Notes: Unemployment rate is measured in per cent.

CDs and Deposits are in logs and multiplied by 100.

The Australian banks have continuously increased borrowings from overseas over the past two decades. The ratio of Australian banks' foreign currency liabilities to their total liabilities grew from 3.39 % in October 1985 to 17.59 % in June 2000. As the data on the Australian banks' foreign currency liabilities are available from 1985:Q4, a second-order VAR is estimated over the period 1986:Q2 to 2000:Q2 including (in order) the cash rate, three bank balance-sheet variables (deposits, foreign currency liabilities, and loans) all deflated by the CPI, the unemployment rate, and the CPI itself. Constant terms are also

banks were with less than \$100 million in total assets, and domestic deposits (including CDs $\geq$ \$100,000) accounted for 96.8% of their total liabilities. It was not until the passage of the Riegle-Neal Act of 1994 that interstate branching was allowed. See, for instance, Berger, Kashyap, and Scalise (1995).

included. Except for the cash rate and the unemployment rate, all the variables are in logs and multiplied by 100. The calculated impulse response functions of the unemployment rate and bank balance-sheet variables to a positive innovation in the cash rate are shown in Figure 3.8. After an initial fall, foreign currency liabilities clearly increase in response to a hike of the cash rate. The increase of foreign currency liabilities coincides in timing with the expansion of loans, even though foreign currency liabilities continue to accumulate for two quarters after loans begin to decrease. Therefore, we may conclude that Australian banks accommodate a rightward shift of the demand schedule for bank loans by borrowing from overseas when the RBA tightens money.[20]

In summary, Australian banks can accommodate the temporarily increased demand for bank loans in the wake of tight money by decreasing their security holdings and borrowing from overseas. By adjusting their assets and liabilities, Australian banks can mitigate impacts of monetary contraction on their supply schedules of bank loans. These features of Australian bank behaviour make the lending channel of monetary policy transmission less important.

3.4 Conclusion

The lending view is not statistically supported for Australia by the results of various analyses in section 3.2. It does not imply the rejection of the lending view for other countries, however. As is shown in Chapter 2, the results are not inconsistent with the

[20] It is not clear why it is profitable for the Australian banks to raise funds from overseas in the wake of tight money. Answering this question will require a theoretical study on the banking behaviour in the international context. This will be a topic of my future study.

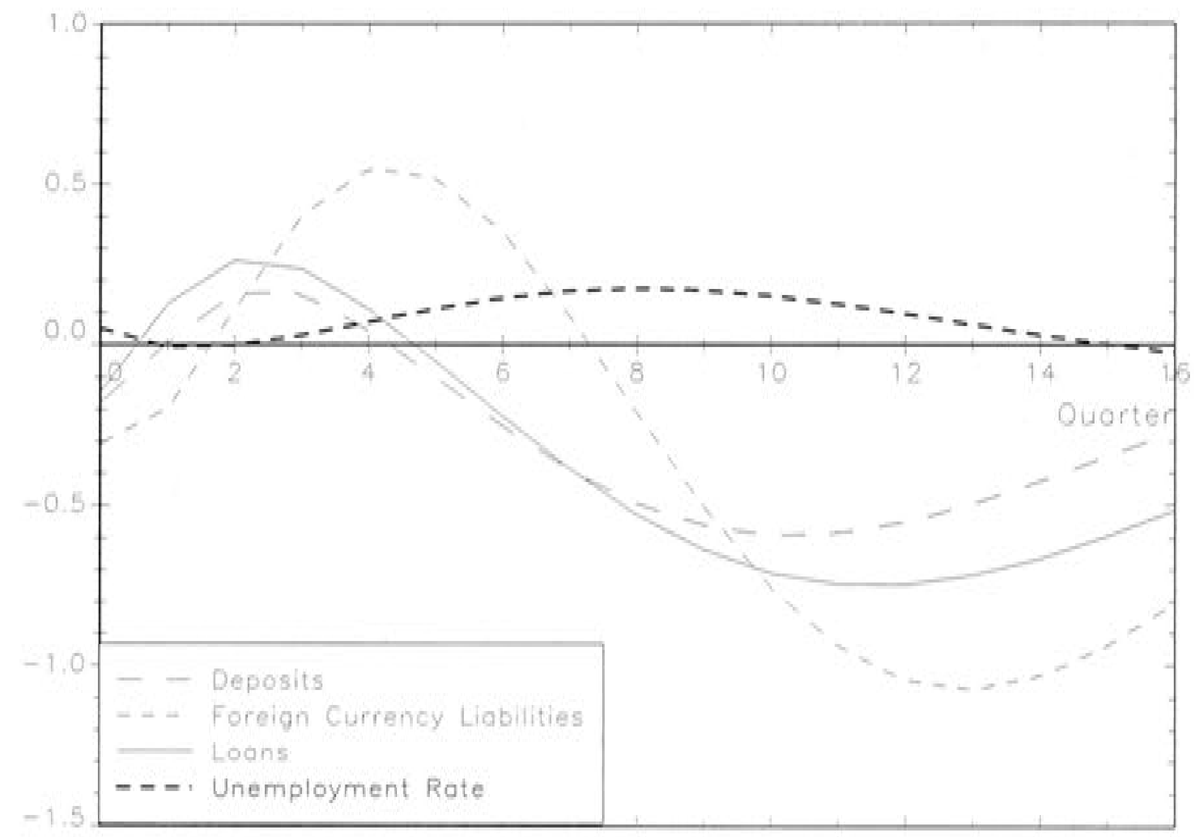

Figure 3.8: Responses to a Shock to the Cash Rate

Notes: Unemployment rate is measured in per cent.

The other variables are in logs and multiplied by 100.

lending view for Japan. In the U.S. literature, the lending view has also often been found significant. Employing a variety of approaches, for instance, Kashyap and Stein (1994) conclude that the evidence for the existence of the lending channel in the U.S. is quite strong. Thus, the results of this chapter are in contrast to those of similar studies for the U.S. and Japan.

The significance of the lending view may be sensitive to institutional characteristics of the financial markets. In section 3.3, it is shown that Australian banks borrow from overseas to mitigate impacts of monetary contraction on their supply schedules of bank loans. (Another finding of section 3.3 is that Australian banks use their holdings of public securities as a buffer stock.) In contrast, U.S. banks were generally too small to make use of foreign currency liabilities because of the McFadden Act. The Japanese banking industry was also heavily regulated. Frankel and Montgomery (1991), for instance, argue that banking regulations are heavier in Japan than in the U.S., the U.K., and Germany. Among the restrictions on the Japanese banking activities, the "window guidance", through which the Bank of Japan controlled the commercial bank lending, may be an important factor strengthening the lending channel (see Ueda 1992). As such, Australian banks are allowed to have more diversified portfolios and provide a wider range of services than were U.S. banks and Japanese banks. By further studying the lending view for different countries and/or different periods, we might be able to draw inferences about the consequences of the financial deregulation or innovation on the transmission mechanism of monetary policy.

Chapter 4

Credit View and Capital Adequacy Requirements

4.1 Introduction

The analyses of the preceding chapters suggest that the importance of credit in the transmission process of monetary policy may be sensitive to institutional characteristics of financial markets. In other words, the significance of the credit view may be dependent on the evolution of the financial system. Bernanke and Gertler (1995), for instance, argue that the importance of the credit channel is likely to diminish over time due to ongoing financial innovation and deregulation. There may be institutional changes that make the credit channel of monetary policy more important, however.

An example of such institutional changes may be the introduction of the risk-based capital standards. In July 1988, the bank supervisors of the G10 countries plus Luxembourg agreed to implement risk-based capital requirements, which took effect in 1989.

This is known as the Basle Accord. Under the Accord, the Bank for International Settlements (BIS) requires bank supervisors to impose minimum risk-weighted capital-to-asset ratios of eight per cent on all internationally operating banks of their countries.[1] The BIS gives positive weights and zero weights to risky components (e.g. commercial and industrial loans) and safe components (e.g. U.S. government securities) of banks' assets, respectively. This means that banks can raise their risk-weighted capital-to-asset ratios by substituting from loans to government bonds. If many banks shift their portfolios in this way at the same time, the aggregate supply schedule of bank loans will shift inward, and a credit crunch will ensue. In the U.S., banks representing more than one-fourth of total assets did not meet the risk-based capital standards of the BIS as of December 1989 (see Avery and Berger 1991). Consistent with the expectation, the implementation of the risk-based capital standards coincided in timing with the slowdown in bank lending. These events led economists to testing a hypothesis that the implementation of the risk-based capital standards caused a credit crunch.[2]

Although it can be of interest to test the hypothesis examined in the U.S. literature for other countries, it is not directly relevant with this thesis, whose focus is on the credit view. The U.S. literature regards the implementation of the risk-based capital standards, per se, as an exogenous shock, and examines its one-time impacts on bank lending. Consistent

[1] The BIS proposed to revise the Basle Accord of 1988 on its consultative paper on "A New Capital Adequacy Framework" issued in June 1999. This thesis focuses on the Accord of 1989, however. Santos (2001) provides a brief history of capital regulation since the Basle Accord of 1989. See, for instance, Altman and Saunders (2001) for further discussion on the BIS's new proposal of 1999.

[2] There is a relatively large empirical literature on the linkage between the Basle Accord and the U.S. credit crunch. See, for instance, Bernanke and Lown (1991), Haubrich and Wachtel (1993), Brian Hall (1993), Peek and Rosengren (1995), Berger and Udell (1994), and Brinkmann and Horvitz (1995).

with the objective of the thesis, however, this chapter examines how the implementation of the risk-based capital standards affects the channel through which an exogenous shock (e.g. monetary policy) has influences on bank lending. Importantly, allowable components of bank capital are dependent on national regulations of individual countries under the Basle Accord, which creates difference in the effects of the risk-based capital standards on the credit channel, for instance, between U.S. and Japan.

A notable difference in banking structures between U.S. and Japan is that Japanese banks hold corporate equities. They hold the stocks of their regular customers as part of long-term relationship, and hence these stocks are not traded for profit. Due to the long-run growth of stock prices during the post-war period, latent capital gains from the stock holdings were substantial to the Japanese banks in the latter half of 1980s. Under the Accord, the banks are allowed to count a certain proportion of latent capital gains from stock holdings toward capital, which makes the risk-weighted capital-to-asset ratios for the Japanese banks vulnerable to fluctuations in stock prices. If stock prices fall substantially, latent capital losses from stock holdings will lower the risk-based capital-to-asset ratios of the Japanese banks. In extreme cases, the banks may choose to reduce their assets (with positive risk weights) by cutting back on lending in order to meet the capital standards of the BIS. Thus, an exogenous shock that have influences on stock prices can affect lending activities of the Japanese banks under the Basle Accord. The following sections aim to formalise this idea.

This chapter is organised as follows. Section 4.2 reviews the risk-based capital standards of the BIS in the context of Japanese banks. Section 4.3 discusses a benchmark model for this chapter. In particular, the "costly-state-verification" model (Townsend

1979), which captures asymmetric information problems pertain to financial transactions, is employed.[3] With this model, we derive incentive-compatibility constraints for a bank to make loans. This section also examines how exogenous shocks affect these constraints and thereby bank lending. Section 4.4 introduces the essence of the risk-based capital standards of the BIS into the model, and shows how, in addition to the incentive compatibility constraints, a capital adequacy constraint must also be satisfied. Section 4.5 concludes by comparing the implications derived from the model in this chapter with the results of empirical works.

4.2 Summary of Risk-Based Capital Standards

Regulators have imposed high capital standards on banks in an attempt to protect depositors against bank failures. Prior to the Basle Accord, however, bank capital standards were stricter in some countries (e.g. the U.S.) than in other countries (e.g. Japan). As international banking activities increased due to the globalisation of finance, the regulatory discrepancy became a source of competitive inequality among international banks. Foreign banks, Japanese banks in particular, are argued to have increased their shares in the holdings of U.S. financial assets by taking advantage of lax capital regulations applied to them. While the U.S. regulators of banks were eager to tighten capital requirements in response to the S&L crisis, implementation of stricter capital standards was believed to put the U.S. banks at a greater disadvantage in competition with the foreign banks. This dilemma led the U.S. regulators to forging the consensus among the bank supervisors of

[3]More specifically, this chapter analyses the impact of the risk-based capital standards on the credit channel within a framework of the costly-state-verification model simplified by Romer (1996).

developed countries that international convergence of bank capital regulations is required. In 1987, the Basle Committee of the Bank for International Settlements (BIS) published guidelines for harmonizing the capital adequacy requirements in the international banking market. Following the guideline, the bank supervisors of the Group of 10 countries and Luxembourg arrived at the agreement, which is the Basle Accord, that all international banks should be subject to the same minimum level of the capital-to-asset ratios.[4]

As the adequate level of capital for an individual bank depends on the riskiness of its portfolio, the capital standards under the Basle Accord is risk-adjusted. Banks' assets are classified and assigned weights (0, 10, 20, 50, and 100 percent) depending on their risks. As summarised in Table 4.1, a heavier weight is assigned to a riskier asset. For instance, holdings of government bonds and commercial loans to the non-bank private sector are included in 0% risk category and 100% risk category, respectively. Due to the risk weights, a portfolio shift can clearly affect the denominator even when the total value of assets is held constant. Thus, a bank may have an incentive to substitute from risky assets to safe assets, at least temporarily, if it needs to meet the risk-based capital standards.

In the calculation of the numerator of the capital-to-asset ratio, two types of capital are defined, namely Tier 1 (Core) and Tier 2 (Supplementary) capital. Under the Basle Accord, an international bank is required to meet a capital standard:

$$\frac{\text{Tier 1} + \text{Tier 2} - \text{Deductible components}}{\sum w_i A_i} \geq 0.08. \tag{4.1}$$

where A_i and w_i denote the value of the bank's ith asset and its weight, respectively. Tier 1 capital is common to all the signatory countries, which essentially consists of stockholders' equity. On the other hand, allowable components of Tier 2 capital are dependent on

[4]See Kapstein (1989) for a more detailed history of forging the Basle Accord.

Table 4.1: Major Items of Risk-Based Assets

0% risk category
· Cash
· Claims fully guaranteed by OECD governments
· Fixed interest securities issued by OECD governments with a residual maturity of up to 1 year
20% risk category
· Claims on multilateral development banks, and claims fully guaranteed by these institutions
50% risk category
· Loans fully secured by mortgage on residential property
100% risk category
· Claims on the non-bank private sector

Source: Maximilian J. B. Hall (1993)

banking structures of individual countries (see Table 4.2). In contrast to the U.S. and U.K. banks, Japanese and West-German banks were allowed to hold corporate equities under the national regulations. Major Japanese banks, for instance, commonly held equities of their regular borrowers as part of long-term relationships, and these stocks were not traded for capital gains. Due to the steady rise of stock prices during the post-war period in Japan, latent capital gains from the long-term holdings of stocks were substantial as of the late 1980s. The regulators of Germany and Japan successfully negotiated with those of U.K. and U.S. for inclusion of latent capital gains from stock holdings in bank capital. The Basle framework allows banks to count 45% of latent capital gains from holdings of corporate equities toward Tier 2 capital.[5]

[5] Wagster (1996) estimates the risk-weighted capital-to-asset ratios for 10 Japanese banks, finding that the ratios with and without latent capital gains were, on average, 12.35% and 2.11% as of 1987, respectively. As such, it was crucial for Japanese banks and their regulators to obtain a permission, from regulators of

Table 4.2: Allowable Components of Capital for Banks of U.S., U.K., and Japan

Type of Capital	Countires
Tier 1 Capital	
1. Common shareholders' equity	All
2. Disclosed reserves	All
3. Some form of preferred stock	U.S.
Tier 2 Capital	
1. Undisclosed reserves that have been charged against income	Japan
2. Revaluation Reserves	
· Formal revaluation carried to the balance sheet	U.K.
· Market values of securities not already reflected on the balance sheet (45 percent)	Japan
3. Hybrid debt-capital instruments:	
· perpetual debt	U.K.
· mandatory convertible debt	U.S.

Source: Wagster (1996)

Equation (4.1) shows that the capital-to-asset ratio for a Japanese bank is vulnerable to a change in stock prices. Suppose that stock prices sharply fall. The fall of stock prices will reduce Tier 2 capital of the numerator without affecting any other component. At the same time, it will be difficult for a bank to issue new equities. The upshot will be contraction of bank loans, as Japanese banks will have to curtail risky assets (i.e., commercial and industrial loans) with positive weights in the calculation of the risk-weighted capital-to-asset ratio in an attempt to meet the capital standards of the BIS. In other words, any exogenous shock that can negatively affect stock prices may have impacts on the real

the other countries, to include latent capital gains from stock holdings into capital. See Kapstein (1989) for the negotiation between the signatory countries on the definition of bank capital. See also Maximilian Hall (1993) for cross-country difference in allowable components of Tier 2 capital.

economy of Japan by shifting the supply schedule of bank loans inward. In this way, the capital regulations of the BIS may strengthen the credit channel. The following two sections aim to formalise the credit channel for Japan in the presence of the risk-based capital standards. Section 4.3 sets up a benchmark model of the credit channel without the BIS's capital standards. From the model, two incentive compatibility constraints are derived, under which (1) a firm borrows from a bank, and (2) a bank makes loans to a firm. The section examines how exogenous shocks affect these incentive-compatibility constraints. Section 4.4 expands the model by introducing the risk-based capital standards. The objective is to examine how the capital standards affect the credit channel.

4.3 Benchmark Model

The basic structure of the model is as follows. Two types of agents are assumed, namely banks (lenders) and firms (borrowers). Each firm has a particular project whose expected return differs among the firms. A firm has two alternative options of investment, namely undertaking its risky project and holding a safe bond. Given the limited amount of internal funds, however, the firm has to borrow from a bank when it undertakes the project. If the project turns out unsuccessful, the firm will default. In such a case, the lender will have to audit the borrower. Auditing is costly, and the expected cost of auditing makes external funds more expensive to the borrower than internal funds. Taking into account the wedge between external funds and internal funds, the firm makes its investment decision. For the firm's project to be undertaken, a bank also must have an incentive to lend. Comparing the expected return from lending and the return from holding safe assets, the bank makes its decision. After discussing the assumptions in more detail, this section derives the incentive compatibility constraints for a firm and a bank to make the financial contract. Then, it examines how exogenous shocks affect these constraints.

4.3.1 Assumptions

Many risk-neutral firms are assumed to exist, each of which has a risky project. While these projects equally require one unit of input, their expected profits differ among the firms. In this sense, the firms are heterogenous. Each firm knows the expected profit of its project that is not observable to any other firms or banks. Given internal funds, each firm makes investment decision between undertaking its risky project and holding riskless assets (e.g. government bonds). The firms are endowed with internal funds. For simplicity, let us assume that the amount of internal funds, denoted by S^F, is same across the firms. S^F is assumed to be less than one: $0 < S^F < 1$. This assumption implies that a firm needs $1 - S^F$ units of external funds to undertake its project.

Firms are assumed to borrow from banks.[6] There is a number of risk-neutral banks. The banks are endowed with internal funds and deposits, and they are heterogeneous with respect to the amount of internal funds. Let S^B and D denote the amounts of internal funds and deposits, respectively. Given S^B and D, banks makes a portfolio choice between holding of safe assets (e.g. government bonds) and making loans. Since the focus is on the Japanese economy, a bank is assumed to hold equities of firms to which it makes loans. To simplify the relationship between a firm and a bank, the amount of an individual bank's

[6]This assumption is plausible when firms are small-to-medium size. There are prerequisites for a firm to raise funds in the bond markets of Japan, which are based on the firm size.

internal funds is assumed to meet the following condition:

$$S^F(i) \leq S^B < S^F(i) + S^F(j) \text{ for } i, j = 1, 2, \cdots, \text{ and } i \neq j, \tag{4.2}$$

where i and j are indices of firms. As will be discussed shortly, an individual bank has an incentive to borrow from one bank. Therefore, this assumption implies that an individual bank can make loans to one firm.

The debt contract between a firm and a bank is as follows. The amount of the repayment depends on the outcome of the project. If the project is successful, the firm fully repays the principal and interest. If the realised return of the project is insufficient for the full repayment, however, the firm only pays as much as it can.[7] Let X denote the amount that the firm promises to repay. Since the principal is $1 - S^F$ by assumption, the loan interest rate, r_L, is expressed as

$$r_L = \frac{X}{1 - S^F} - 1. \tag{4.3}$$

In the case of default, the amount that the firm actually repays is increasing, up to X, in the outcome of the project.

This financial contract, however, provides a firm with an incentive to underreport the outcome of its project. If a firm defaults, a bank will audit it. The auditing is costly, and the expected cost of auditing will be passed on to the borrower, which makes external funds more expensive than internal funds. Assume that information on the result of auditing is confidential. If a firm defaults, all the lenders will have to audit it separately. For simplicity, assume also that the cost of auditing is common to all banks. In such a case, a

[7] Ideally, the form of debt contract should be derived from optimization within a model. It is beyond the scope of this model, however. The modification will further this study.

firm has an incentive to minimise a wedge between external funds and internal funds by borrowing from one bank. Under these assumptions, financial relationship between a firm and a bank, if any, is simplified to be one-to-one.

For the debt contract between a firm and a bank to be made, (1) the firm must have an incentive to borrow in order to undertake its project, and (2) the bank must have an incentive to make loans. For instance, the firm will not undertake the project if its expected return is less than the return of an alternative investment opportunity. The same argument holds for the bank's decision about making loans. The following subsection derives the incentive compatibility constraints for these two events to occur.

4.3.2 Incentive-Compatibility Constraints

The above-mentioned financial contract between a firm and a bank makes the expected pay-off to the bank dependent on the outcome of the firm's project. The outcome of the project is a random variable, however. For simplicity, assume that the outcome of the project is uniformly distributed between 0 and 2γ. The bank will not lend, if $2\gamma < X$, where X is the amount of the principal and interest. If the outcome is equal to or greater than X, then the firm will make full repayment of X to the bank. This happens with the probability of $(2\gamma - X)/2\gamma$. If the outcome is less than X, however, the bank will receive the whole outcome, which is on average equal to $X/2$, from the firm and spend the cost of auditing. This happens with the probability of $X/2\gamma$. Let R and c denote the expected pay-off to the bank and the cost of auditing, respectively. Assume that c is constant. Then, R can be expressed as a function of X:

$$R(X) = \frac{2\gamma - X}{2\gamma}X + \frac{X}{2\gamma}(\frac{X}{2} - c) \text{ for } X \leq 2\gamma. \tag{4.4}$$

Let R^{MAX} denote the maximum value of R. Equation (4.4) implies that R is maximised at $X = 2\gamma - c$, and that the maximised value is given as

$$R^{MAX} = \frac{(2\gamma - c)^2}{4\gamma}.^{8} \tag{4.5}$$

If R^{MAX} is strictly smaller than the return from holding safe assets, the bank will not lend to the firm. In other words, the following condition must hold when the bank lends to the firm.

$$(1 + r_B)(1 - S^F) \leq R^{MAX},$$

where r_B is the riskless interest rate. With equation (4.5), this necessary condition for bank lending can be written as

$$(1 + r_B)(1 - S^F) \leq \frac{(2\gamma - c)^2}{4\gamma}. \tag{4.6}$$

Equation (4.6) shows that the lending activity of the bank is dependent on the four exogenous variables: r_B, S^F, γ, and c.

The equilibrium interest rate on loans is uniquely determined as follows. Competition among the homogeneous banks will exhaust positive profits of lending, thereby making its expected rate of return equal to the riskless interest rate. Since the bank lends $(1 - S^F)$ units of funds to the firm, it must hold in equilibrium that:

$$R = (1 + r_B)(1 - S^F). \tag{4.7}$$

[8] The first and second order conditions are

$$\frac{dR(X)}{dX} = 1 - \frac{X}{2\gamma} - \frac{c}{2\gamma} = 0, \text{ and } \frac{d^2R(X)}{dX^2} = -\frac{1}{2\gamma} < 0,$$

respectively. When c is zero, R^{MAX} is equal to the expected outcome of the project. As this is the costly-state-verification model, however, c is assumed to be strictly positive.

Given r_B and S^F, equation (4.7) uniquely determines the level of pay-off required for the bank to make loans. Substitute equation (4.7) into equation (4.4), and rearrange it:

$$X^2 - 2(2\gamma - c)X + 4\gamma(1 + r_B)(1 - S^F) = 0. \tag{4.8}$$

The solutions to equation (4.8) are

$$X = 2\gamma - c \pm \sqrt{(2\gamma - c)^2 - 4\gamma(1 + r_B)(1 - S^F)}.$$

If the necessary condition (4.6) is satisfied, equation (4.5) guarantees that the solutions are real numbers. It is also clear that the solutions are positive. Note, however, that X is defined as the sum of the principal and interest of loans. Since the principal is fixed at $1 - S^F$ by assumption, a larger X always means a higher interest on loans. The competition among the banks implies that the larger solution is implausible. Thus, the equilibrium level of X can be found as

$$X^* = 2\gamma - c - \sqrt{(2\gamma - c)^2 - 4\gamma(1 + r_B)(1 - S^F)}, \tag{4.9}$$

From equations (4.3) and (4.9), the interest rate on loans is uniquely determined in equilibrium:

$$r_L^* = \frac{X^*}{1 - S^F} - 1.$$

When a bank and a firm make the financial contract, the firm also has an incentive to borrow from the bank to undertake the project. The incentive compatibility constraint for the firm is derived as follows. Under the assumption of the uniform distribution, the expected outcome of the project is γ, from which the firm will make payment to the bank. The expected amount of the firm's payment to the bank consists of two components. One is what the bank expects to receive, which is denoted by R. As equation (4.7) shows, this is equal to $(1+r_B)(1-S^F)$ in equilibrium. The other is the expected cost of auditing (or monitoring). If the firm defaults, the bank will audit, which is costly, and the cost will be passed onto the firm. Let M denote the expected cost of auditing. Since the auditing is required only when the project's outcome is less than X, the value of M in equilibrium can be written as

$$M = c\frac{X^*}{2\gamma} = \frac{c}{2\gamma}[2\gamma - c - \sqrt{(2\gamma - c)^2 - 4\gamma(1+r_B)(1-S^F)}\ ]. \tag{4.10}$$

More compactly,

$$M = M(c, r_B, S^F, \gamma), \tag{4.11}$$

where

$$M_c > 0, \ M_{r_B} > 0, \ M_{S^F} < 0, \text{ and } M_\gamma < 0.$$

After the deduction of the expected payment to the bank, the firm expects to obtain the following amount in equilibrium by undertaking the project:

$$\gamma - [R(X^*) + M(c, r_B, S^F, \gamma)] = \gamma - (1+r_B)(1-S^F) - M(c, r_B, S^F, \gamma).$$

The firm compares this with the return from the alternative investment opportunity. If the firm does not undertake the project, it can obtain $(1+r_B)S^F$ by spending its internal funds on riskless assets. Thus, the incentive compatibility constraint for the firm can be written as

$$\gamma - (1+r_B)(1-S^F) - M(c, r_B, S^F, \gamma) \geq (1+r_B)S^F. \tag{4.12}$$

Equation (4.12) shows that the firm's investment decision is vulnerable to changes in r_B, S^F, c, and γ, which may be interpreted as exogenous shocks.

4.3.3 Effects of Exogenous Shocks on the Incentive Compatibility Constraint

As equations (4.6) and (4.12) show, the incentive compatibility constraints for the financial contract to hold between a firm and a bank depend on the four exogenous variables: r_B, S^F, c, and γ. This subsection examines how changes in these exogenous variables can affect the incentive compatibility constraints.[9] Changes in r_B represent exogenous shocks to the financial sector such as monetary policy. Changes in γ is exogenous shocks that affects the future profitability of the firm's project. One example is the firm's development of new technology, which is specific to the firm. Another example is real shocks that affect the economic outlook (such as the first oil embargo of 1973), which is common to all the agents in the economy. Changes in S^F represents exogenous shocks to the firm's internal funds. Under the assumption that the firm's internal funds can be approximated by its stock prices, a change in stock prices may be regarded as an example of such shocks.

Suppose that the necessary condition (4.6) holds for a bank with equality.

$$(1 + r_B)(1 - S^F) = \frac{(2\gamma - c)^2}{4\gamma}. \tag{4.13}$$

This bank may be called a "marginal bank". By taking total differentiation of equation (4.13), we obtain the following equation:

$$\underbrace{(1 - S^F)}_{+} dr_B - \underbrace{(1 + r_B)}_{+} dS^F = \underbrace{\frac{(2\gamma - c)(2\gamma + c)}{4\gamma^2}}_{+} d\gamma - \underbrace{\frac{(2\gamma - c)}{2\gamma}}_{+} dc.^{10} \tag{4.14}$$

[9] This chapter does not examine effects of changes in c, as these are hard to interpret in an economically sensible way.

[10] It is plausible to assume that $2\gamma - c > 0$. As equation (4.4) shows, $X = 2\gamma - c$. Since X is the sum of the principal and interest, X cannot be negative. If $X = 0$, no loans are made. Thus, the only case of interest is that $X = 2\gamma - c > 0$.

Equation (4.14) is used to examine how exogenous shocks affect the behaviour of the marginal bank.

Table 4.3 summarises the effects of exogenous changes on the incentive compatibility for a marginal bank. The impacts of a rise in r_B on the incentive compatibility constraint for the marginal bank, for instance, are calculated from equation (4.14) as follows:

$$\left.\frac{dS^F}{dr_B}\right|_{d\gamma=dc=0} = \frac{1-S^F}{1+r_B} > 0,$$

and

$$\left.\frac{d\gamma}{dr_B}\right|_{dS^F=dc=0} = \frac{4\gamma^2(1-S^F)}{(2\gamma-c)(2\gamma+c)} > 0.$$

In order for the marginal bank to have an incentive to lend to a firm, the firm must have a more profitable project or more internal funds (Proposition 1A). Its macroeconomic implication is that a monetary tightening may deprive banks of an incentive to lend to firms, thereby causing contraction of bank credit. This is consistent with the credit view. In a similar way, the impacts of a change in γ on the marginal bank's incentive compatibility constraint can be calculated from equation (4.14). For the constraint to be satisfied, a decrease in γ requires a fall of r_B or an increase of S^F when the other variables are held constant (Proposition 1B). As the deterioration of macroeconomic outlook can make the prospect of business gloomy, its consequences are that firms (with limited internal funds) will lose credit worthiness, but that expansionary monetary policy can counter the contraction of bank credit. With equation (4.14), the consequences of a change in S^F can be examined in a similar way. When S^F decreases, a fall of r_B or a rise of γ is necessary in order to provide the marginal bank with an incentive to lend (Proposition 1C). In what follows, assume that the firm's internal funds can be approximated by its stock price. Then, a fall of stock prices have macroeconomic implications similar to those of the deterioration of economic outlook.

Table 4.3: Propositions 1

Effects of exogenous shocks on the bank's incentive compatibility constraint	
1A.	An increase in r_B (e.g. a monetary tightening) requires
	(i) S^F to rise, for given γ and c.
	(ii) γ to rise, for given S^F and c.
1B.	A decrease in γ (e.g. the oil embargo) requires
	(i) r_B to fall, for given S^F and c.
	(ii) S^F to rise, for given r_B and c.
1C.	A decrease in S^F (e.g. a fall of stock prices) requires
	(i) r_B to fall, for given γ and c.
	(ii) γ to rise, for given r_B and c.

As equation (4.12) shows, exogenous shocks can similarly affect the incentive-compatibility constraint for a firm. Suppose that the necessary condition (4.12) holds with equality:

$$\gamma - 1 - r_B - M(c, r_B, S^F, \gamma) = 0 \tag{4.15}$$

This firm may be called a "marginal firm." By taking total differentiation of equation (4.15), we obtain the following equation

$$\underbrace{(1 - M_\gamma)}_{+} d\gamma - \underbrace{(1 + M_{r_B})}_{+} dr_B - \underbrace{M_{S^F}}_{-} dS^F - \underbrace{M_c}_{+} dc = 0, \tag{4.16}$$

Equation (4.16) is used to examine the impacts of exogenous shocks on the incentive compatibility constraint for a marginal firm.

Table 4.4 summarises the propositions derived from equation (4.16).[11] The impacts of a rise of r_B on the incentive compatibility constraint, for instance, can be calculated as

[11] Note that the effects of each exogenous shock on the incentive-compatibility constraint facing the firm are the same as those on the incentive-compatibility constraint facing the bank.

follows.

$$\left.\frac{dS^F}{dr_B}\right|_{d\gamma=dc=0} = -\frac{(1+M_{r_B})}{M_{S^F}} > 0,$$

and

$$\left.\frac{d\gamma}{dr_B}\right|_{dS^F=dc=0} = \frac{(1+M_{r_B})}{(1-M_\gamma)} > 0.$$

Without an increase of the project's expected return or the internal funds, a rise of r_B would deprive the marginal firm of an incentive to undertake the project (Proposition 2A). On the aggregate level, this implies that a monetary tightening will make the expected returns of the projects insufficient for the firms to undertake, which will result in a leftward shift of the demand schedule for bank loans. The effects of a change in γ on the incentive compatibility constraint for the marginal firm can be similarly derived from equation (4.16). If the profitability of the project falls for some reason, the marginal firm will lose an incentive to undertake the project, unless the riskless interest rate falls or internal funds increase (Proposition 2B). Macroeconomic implications of this proposition are that the deterioration of economic outlook decreases investment of firms, and that monetary easing may prevent investment demand from decreasing. Proposition 2C, which is derived in a similar way, is that a decrease of S^F requires either a fall of r_B or an increase of γ in order for the incentive compatibility constraint to hold. An implication of this proposition is that a fall of stock prices will lead to a decrease of business investment, which may be cancelled out by expansionary monetary policy. As Tables 4.3 and 4.4 show, these propositions and their implications derived from the firm's incentive compatibility constraint are the same as those derived from the bank's one.

Table 4.4: Propositions 2

Effects of exogenous shocks on the firm's incentive compatibility constraint	
2A.	An increase in r_B (e.g. a monetary tightening) requires
	(i) S^F to rise, for given γ and c.
	(ii) γ to rise, for given S^F and c.
2B.	A decrease in γ (e.g. the oil embargo) requires
	(i) r_B to fall, for given S^F and c.
	(ii) S^F to rise, for given r_B and c.
2C.	A decrease in S^F (e.g. a fall of stock prices) requires
	(i) r_B to fall, for given γ and c.
	(ii) γ to rise, for given r_B and c.

4.4 Effects of the Risk-Based Capital Standards on the Supply of Bank Loans

The preceding section derives the incentive compatibility constraints for the financial contract to hold between firms and banks, thereby examining their responses to exogenous shocks. These responses may be affected by intervention from the government, however. As section 2 discusses, the bank supervisor requires internationally operating banks to meet the risk-based capital standards under the Basle Accord. The implementation of the capital adequacy requirements imposes a new restriction on the banks. More specifically, international banks are required to keep their risk-weighted capital-to-asset ratios equal to or greater than eight per cent. Taking into account the new restriction, the banks will make portfolio choice, which will in turn affect the availability of bank credit to the firms. This section examines how the banks respond to exogenous shocks when they must meet the risk-based capital standards. It will be shown that even if the incentive-compatibility constraints (4.6) and (4.12) are satisfied, the project may not be undertaken. For this purpose, this section extends the benchmark model by introducing the risk-based capital standards as a new constraint for the banks.

4.4.1 Implementation of Risk-Based Capital Standards

In order to introduce the risk-based capital standards into the benchmark model, it is necessary to specify the components of a bank's balance sheet. The benchmark model assumes that a bank is endowed with internal funds (S^B) and deposits (D). The liability side of a bank's balance sheet is composed of these two items. Given S^B and D, a bank makes an investment choice between holding riskless bonds (B) and making risky loans (L). The benchmark model also assumes that a bank must hold its borrower's equities (S^F), which is established as an important constituent of relationship between Japanese banks and their regular customers. From these assumptions, the asset side of a bank's balance sheet is comprised of B, L, and S^F.

As the discussion 4.2 suggests, it will be shown that latent capital gains to a bank from the stock holdings play an important role in what follows. This means that the setting of the benchmark model needs to be modified with the introduction of time. Suppose that a bank is endowed with internal funds and has no liability at time 0. Let S^B denote the value of the internal funds. Then, the liability side of the bank's balance sheet is initially comprised of only S^B. Suppose that a firm issues equities at time 0. Let S_0^F denote the initial value of the equities. S_0^F is smaller than S^B. These assumptions are same as those of the benchmark model. Assume, however, that a bank purchases the equities of the potential borrower before making loans. This newly introduced assumption implies that the bank's assets are comprised of S_0^F and vault cash before making loans. Suppose that deposits (D) are given to the bank at time 1 after it purchases the firm's equities. With D and the vault cash, the bank makes loans to the firm. Any excess funds are spent on purchasing safe bonds. Let L and B denote the volumes of loans and bonds, respectively. Then, L and B appear on the asset sides of the bank's balance sheet at time 1. The market value of the firm's equities, which is the other component of the bank's assets, is likely to be different at time 1. Let S_1^F denote the market value of the firm's equities held by the bank at time 1. Then, the asset side of the bank's balance sheet is comprised of L, B, and S_1^F at time 1. On the other hand, the liability side is comprised of D, S^B, and $S_1^F - S_0^F$. The change in the bank's balance sheet is summarised in Table 4.5.[12] If the bank must meet the capital adequacy requirements at time 1, the bank will make investment decision at time 0 considering the expected composition of its balance sheet at time 1.

Table 4.5: Change on a Bank's Balance Sheet

Before lending		After lending	
Assets	Liabilities	Assets	Liabilities
S_0^F	S^B	L	D
Cash		B	S^B
		S_1^F	$S_1^F - S_0^F$

Under the Basle Accord, the capital standards are risk-based, which has two distinctive characteristics. One is that each component of a bank's assets is risk-weighted when its

[12] Latent capital gains from the stock holdings are defined as the difference between the market value and the acquisition value of the equities. Under the accounting rule of Japan, however, the book values of equities held by Japanese banks are based on the acquisition values. See, for instance, Kuroda, Kotani and Ogawa (1994) and Ogawa and Kubota (1995) for issues of bank accounting in Japan.

capital-to-asset ratio is calculated. As is discussed in section 4.2, riskless bonds and risky claims on the non-bank private sectors are given weights 0 and 1, respectively (see Table 4.1). This implies that B is excluded from the denominator of the risk-weighted capital-to-asset ratio. The other one is that allowable components of bank capital include a certain proportion of latent capital gains from the stock holdings. Suppose that the values of equities held by a bank increases from S_0^F to S_1^F. Then, latent capital gain, which is expressed as $S_1^F - S_0^F$, must be included in the numerator of the bank's capital-to-asset ratio. Thus, a bank is required to meet the following risk-based capital adequacy requirements at time 1:

$$\frac{S^B + \beta(S_1^F - S_0^F)}{B \times 0 + (L + S_0^F) \times 1} \geq \alpha, \tag{4.17}$$

where both α and β are positive constants. In practice, α and β are equal to 0.08 and 0.45, respectively.

Taking into account the capital standard (4.17), a bank decides at time 0 whether to lend to a firm. As a bank cannot know the future value of a firm's equities, however, S_1^F should be replaced with its expected value in the capital adequacy constraint for the bank.

$$\frac{S^B + \beta(E[S_1^F] - S_0^F)}{L + S_0^F} \geq \alpha.$$

where $E[S_1^F]$ denotes the value of S_0^F expected at time 0. This can be simplified by an assumption for the benchmark model that each firm's project requires one unit of input. This assumption implies that L is equal to $1 - S_0^F$.[13] By substituting $1 - S_0^F$ into L, we

[13] As is discussed in the preceding section, the expected cost of auditing makes external funds more expensive to the borrower than internal funds. For this reason, a firm has no incentive to borrow more than $1 - S_0^F$.

obtain the following condition.

$$S^B \geq \alpha + \beta S_0^F - \beta E[S_1^F]. \tag{4.18}$$

This is the new constraint introduced for the bank by the implementation of the risk-based capital standards.

4.4.2 Effects of Exogenous Shocks on the Capital Adequacy Constraint

The constraint (4.18) implies that there is a minimum level of S^B required for a bank to make business loans. To show this more clearly, it is necessary to express $E[S_1^F]$ as a function of the exogenous variables defined in the previous section. An important assumption is that the value of a firm's equities is equal to its net worth. If a firm undertakes the project, its net worth will be the expected outcome of the project less the expected payment to the bank at time 1. The expected outcome of the project is γ under the assumption of uniform distribution. The expected payment from the firm to the bank consists of the expected pay-off to the bank and the expected cost of auditing. Because of the competition among the banks, the expected pay-off to the bank must be equal to the return from the safe assets. Thus, the net worth of a firm that undertakes the project will be

$$E(S_1^F) = \gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma).^{14} \tag{4.19}$$

With equation (4.19), the capital adequacy constraint (4.18) can be written as

$$S^B \geq \alpha + \beta S_0^F - \beta[\gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma)]. \tag{4.20}$$

[14] This is equal to the left-hand-side of the necessary condition (4.12) for a firm to undertake its project in the benchmark model.

This shows that the minimum level of the bank's net worth required for it to make loans depends on the exogenous variables: γ, r_B, S_0^F, and c.

From the condition (4.20), we can derive the impacts of exogenous shocks on the banking behaviour under the risk-based capital standards. Let S_{MIN}^B denote the minimum level of S^B that satisfies the condition (4.20):

$$S_{MIN}^B = \alpha + \beta S_0^F - \beta[\gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma)]. \qquad (4.21)$$

The impacts of a rise in r_B, for instance, are calculated from partial differentiation of S_{MIN}^B with respect to r_B in equation (4.21).

$$\frac{\partial S_{MIN}^B}{\partial r_B} = \beta[(1 - S_0^F) + M_{r_B}] > 0.$$

If the riskless interest rate rises, a bank is required to have higher initial net worth in order to make loans when the other variables are held constant. In other words, a hike of the riskless interest rate will make banks with low net worth unable to meet the capital standards in future. If a substantial number of banks give up lending in response to a hike of the interest rate, aggregate bank credit will contract. The impacts of changes in γ and S_0^F on S_{MIN}^B can be derived in a similar way. Partial differentiation of S_{MIN}^B with respect to γ yields

$$\frac{\partial S_{MIN}^B}{\partial \gamma} = -\beta[1 - M_\gamma] < 0.$$

If the expected outcome of the project decreases, a bank is required to have a higher level of initial net worth when the other variables are held constant. A macroeconomic implication is that the deterioration of economic outlook will make banks with low net worth unable to make loans, thereby resulting in contraction of bank loans. Likewise,

$$\frac{\partial S_{MIN}^B}{\partial S_0^F} = \beta[M_{S_0^F} - r_B] < 0.$$

A decrease in the firm's net worth also requires a bank to have a higher level of internal funds when the other variables are held constant. The implication is that a fall of stock prices will deprive banks with lower net worth of ability to meet the capital standards, thereby reducing the availability of funds to bank-dependent firms. These results are summarised as propositions in Table 4.6.

Table 4.6: Propositions 3

Effects of exogenous shocks on the bank's capital adequacy constraint	
3A.	An increase in r_B (e.g. a monetary tightening) requires a higher S^B_{MIN}, for given γ, S^F_0 and c.
3B.	A decrease in γ (e.g. the oil embargo) requires a higher S^B_{MIN}, for given r_B, S^F_0, and c.
3C.	A decrease in S^F_0 (e.g. a fall of stock prices) requires a higher S^B_{MIN}, for given r_B, γ and c.

How does the introduction of the risk-based capital standard affect the transmission mechanism of monetary policy? In the benchmark model without the capital standard, the incentive compatibility constraints imply that a hike of r_B requires a higher level of S^F or γ in order for the financial contract to be made (see Tables 4.3 and 4.4). In other words, only *firms* with better balance sheets have incentive to undertake their projects, for which banks have incentive to provide funds at the same time. Thus, the benchmark model illustrates the balance-sheet channel of monetary policy. In contrast, however, the implementation of the capital standard affects the minimum level of S^B for the financial contract. As is summarised in Table 4.6, a hike of r_B requires a higher level of S^B_{MIN}. This means that only *banks* with larger amounts of loanable funds can make loans after monetary tightening, which is the bank-lending channel of monetary policy. Since the incentive compatibility constraints of the benchmark model must also hold, the implementation of the risk-based capital standard amplifies the impact of monetary policy by making room for the bank-lending channel to be operative.

4.5 Conclusion

Under the Basle Accord, the Bank for International Settlements requires bank supervisors of the signatory countries to impose capital adequacy requirements on international banks. As the implementation of the capital standards means a new constraint for the banks to satisfy, it can affect the banking behaviour. If exogenous shocks make the new constraint bind over a wider range of circumstances, for instance, these shocks will reinforce the credit channel. Thus, the implementation of the capital standards may have implications on the credit view.

Section 4.2 summarises the capital standards under the Basle Accord. The capital standards have two distinctive characteristics. One is that allowable components of bank capital include latent capital gains from the stock holdings. As the banks of Japan are allowed to hold common equities, the risk-based capital standards make the numerators of their capital-to-asset ratios vulnerable to changes in stock prices. The other characteristic is that assets are risk-weighted. Highly safe assets (such as sovereign bonds issued by any OECD country) are given zero weights and excluded from the denominator of the capital-to-asset ratio. Consequently, a bank may substitute from risky loans to holdings of safe bonds, at least temporarily, in an attempt to meet the capital standards. Thus, these two characteristics imply that banks will reduce loans in response to a fall of stock prices, reinforcing the balance sheet channel.

This chapter aims to formalise the impacts of the implementation of the risk-based capital standards on the credit view. Section 4.3 sets up a benchmark model within a framework model of the costly-state-verification model, from which the necessary condition for a firm to borrow from a bank and the necessary condition for a bank to lend to a firm are derived. These two necessary conditions must hold at the same time when a firm and a bank make the financial contract. These incentive compatibility constraints are used to examine how a bank and a firm respond to exogenous shocks. The implications are consistent with the credit view. Section 4.4 introduces the risk-based capital standards into the benchmark model. The risk-based capital standards are formalised as another constraint for a bank to satisfy. From this constraint, a minimum level of a bank's net worth required for it to make loans is derived. Then, the impacts of exogenous shocks on the required level of a bank's net worth are examined. The implication is consistent with the discussion in section 4.2: negative macroeconomic shocks increase the minimum levels of net worth required for banks, and banks with lower net worth reduce loans in an attempt to meet the capital standards.

Is this implication supported by empirical studies? Gibson (1997), for instance, finds that the deterioration of banks' health caused decline in investment in Japan during the early 1990s. Although this event coincided in timing with the implementation of the risk-based capital requirements, it is not clear whether this happened by making the capital standards more binding. Ito and Sasaki (1998) specify an increase of industrial loans as a linear function of the current and lagged risk-weighted capital-to-asset ratios, controlling for the effects of macroeconomic shocks and non-performing loans. With the micro data of 85 banks between 1990 and 1993, they estimate the linear functions for the city banks, the regional banks, and the trust banks. Consistent with the credit crunch hypothesis, they find that the coefficients of the capital-to-asset ratios are significantly positive for the city banks. They find, however, insignificant coefficients of the risk-weighted capital-to-asset ratios for the other two types of banks. Using a longer sample in a similar study, Woo (1999) also finds no evidence for the credit crunch hypothesis during most of the 1990s except for 1997.

Peek and Rosengren (1997) provide a possible explanation for the weak empirical support for the credit crunch hypothesis. They point out two important characteristics of the Japanese banking system in the early 1990s. One is the historically strong relationship between the Japanese banks and their regular customers. This implies that the Japanese banks were essentially reluctant to cut back on lending to the long-term domestic customers. The other characteristic is the active lending operations of the Japanese banks in foreign countries at that time. In the U.S., for instance, they accounted nearly one-fifth of commercial and industrial loans. This implies that the Japanese banks can reduce loans to the borrowers in the U.S. to meet the capital standards. Using the semi-annual panel data on the U.S. branches and subsidiaries of 29 Japanese banks, they estimate the relationship between an increase in lending of the branches and subsidiaries (adjusted by the size of total assets) and their parent banks' risk-weighted capital-to-asset ratios. They conclude that a shock to the Japanese stock market can be transmitted to the U.S. through the decline in bank lending through the U.S. branch of the Japanese banks. The simple model of this chapter does not take into account the overseas operations of the banks. Modelling the risk-based capital standards in the international portfolio choice will further the literature.

Chapter 5

Summary and Conclusion

5.1 Summary

This thesis focuses on the macroeconomic role of bank lending. After a monetary tightening, bank loans often contract at the outset of a recession. This sort of coincident events can be found in many countries (e.g. the U.S., Japan, and Australia). As is discussed in Chapter 1, however, the interpretation of the coincidence in timing between the credit contraction and the economic downturn is not unique. A standard interpretation is that a hike of the interest rate caused by a monetary tightening makes some investment projects unprofitable, thereby shifting the demand schedule for bank credit inward (i.e., the money view). The money view implies no impacts of the credit contraction on the real economy. Another interpretation is that tight money shifts the supply schedule of bank loans inward by draining the banking sector of loanable funds, thereby forcing bank-dependent borrowers to cut back on their investment expenditures. This is the bank-lending view, and is also called the credit view. Clearly, the bank-lending view implies that the cut back on lending has independent impacts on the real economy so long as there are good loans to be made. As such, the money view and the bank-lending view have different economic implications. For this reason, empirical distinction between the two views is of importance.

The distinction between the money view and the bank-lending view boils down to the identification of the supply and the demand schedules in the bank loan market. Chapter 2 shows that embedding the 'price' and quantity of loans in a VAR model reduces the difficulty in the identification to a problem like simultaneous equation bias. To reiterate, a shift of the supply schedule of bank loans can be identified by a negative correlation in responses to a monetary policy shock between the price and quantity of bank loans. The responses of the price and quantity of bank loans to a hike of the overnight interest rate are simulated from the VAR models including either the interest rate of bank loans or the diffusion index of banks' willingness to lend is included as a proxy for the price of bank loans. The simulation results of Chapter 2 show a leftward shift of the supply schedule of bank loans following a monetary tightening.

Although the supply schedule of bank loans is found to shift left after a monetary tightening, it does not necessarily imply the empirical support for the bank-lending view. Such a shift is also consistent with the other credit view, namely the balance sheet view. The balance sheet view is that a monetary tightening worsens borrowers' balance sheets, thereby depriving them of the credit-worthiness. This view implies a leftward shift of the supply schedule of credit following a monetary tightening, and hence this view and the bank-lending view are collectively called the credit view. In contrast to the bank-lending view, however, the balance sheet view implies that the credit contraction has no independent impacts on the real economy, as there are no good loans to be made. Thus, the balance sheet view should be distinguished from the bank-lending view.

In relation to the balance sheet view, Chapter 2 also tests the theory of credit cycle. This theory places emphasis on the role of durable assets (e.g. land) as collateral. Suppose that prices of durable assets fall following a temporary shock. Then, the fall of asset prices will weaken the balance sheets of borrowers, and the liquidity-constrained borrowers will have to cut back on their investment expenditures. A decrease of investment implies a leftward shift of the demand schedule for durable assets, which lowers the asset prices further. This process continues, thereby causing a persistent decline in output. To test this theory, the responses of macroeconomic variables to a fall of land prices are simulated from the structural VAR model for Japan. The simulation results are supportive of the theory: output, stock prices, and land prices significantly fall for a protracted period following a negative innovation to the land price index. The theory of credit cycle is clearly consistent with the balance sheet channel to the extent that an exogenous shock (e.g. monetary policy) can have impacts on asset prices. For this reason, the responses of land prices and stock prices to a hike of the short-term interest rate are also simulated from the same model. Although the indexes of stock prices and land prices fall following a hike of the interest rate, these falls are not significant. In this sense, the results of Chapter 2 are not inconsistent with the view that monetary policy operates through the balance sheet channel by affecting asset prices.

The importance of the bank-lending channel may be dependent on the characteristic of the financial system, however. To show this, Chapter 3 tests the bank-lending view for Australia. Due to the lack of the empirical studies on the bank-lending view in the

Australian context, this chapter applies an approach employed in the U.S. literature as well as the original approach in the preceding chapter. Although the non-financial corporate sector of Australia is highly dependent on bank loans, the results are not supportive of the credit view. The results imply that the contraction of loans following a hike of the cash rate is largely due to a leftward shift of the demand schedule for bank loans.

The question is what makes the credit channel less important in Australia. Chapter 3 examines how the banks of Australia change their portfolio in response to a hike of the cash rate. More specifically, the chapter estimates structural VAR models, simulating the responses of the variables on the banks' balance sheets to an innovation to the cash rate. There are two important findings. One is that a hike of the cash rate is followed by a decline in the holdings of public securities, which implies that the Australian banks use their holdings of securities as a buffer stock. The other is that the foreign currency liabilities increase in response to a hike of the cash rate, which means that the Australian banks can mitigate impacts of a monetary tightening on their loanable funds by borrowing from overseas. The latter finding has an important implication to the bank-lending view: the importance of the bank-lending channel is likely to diminish over time due to the ongoing financial innovation and/or deregulation as well as the globalisation of banking activities.

Despite the extensive deregulation in the financial market over the past decade, regulators of major industrial countries agreed to impose standardised capital requirements on the banks of their countries in 1988. This is known as the Basle Accord. Under the Accord, each international bank of the signatory countries is required to meet the standard that its risk-based capital-to-asset ratio must be eight per cent or above. In the U.S., the implementation of the risk-based capital standards coincided in timing with the contraction of bank credit. A standard interpretation is as follows. Since safe assets are excluded from the calculation of the denominator of the capital-to-asset ratio, the U.S. banks substituted from risky loans to safe government bonds in an attempt to meet the standards, which resulted in a credit crunch. As such, the implementation of the risk-based capital standards may be one of the factors that make a macroeconomic role of bank lending more important.

After the implementation of the risk-based capital standards, prolonged recessions and slowdowns in bank lending also characterised the recent experience of the Japanese economy. Nonetheless, there are few studies on the linkage between the risk-based capital standards and a credit crunch. In contrast to the U.S. banks, the banks of Japan commonly hold equities of their regular customers. Under the Basle Accord, latent capital gains from the stock holdings are included in allowable component of bank capital. Therefore, the risk-weighted capital-to-asset ratios of the Japanese banks are vulnerable to a change in stock prices. This implies that the implementation of the risk-based capital standards can affect the credit channel, and that these effects are different from those in the United States. Chapter 4 aims to formalise the effects of the risk-based capital standards on the credit view. For this purpose, the chapter utilises a simple theoretical model to count for the credit channel, and then expands it by including the risk-based capital standards. The model implies that there is a minimum level of internal funds for a bank to make loans to a firm, and that negative macroeconomic shocks require such a minimum level to be higher. In other words, the implementation of the risk-based capital standards makes the credit channel important.

5.2 Topics of Future Studies

The studies of this thesis can be expanded. Chapters 2 and 3, for instance, exclusively examine aggregate time series data. These methods may be subject to two criticisms. First, aggregate data can hardly capture heterogeneity, if any, among borrowers and/or lenders with respect to their responses to a monetary tightening. Second, a monetary structural VAR model implicitly assumes that the effects of tight money are a mirror image of those of expansionary monetary policy. If this assumption does not hold, the simulation results based on structural VAR models will be unreliable. By examining cross-sectional data on the behaviours of lenders and borrowers in response to a monetary tightening, however, we can complement the results of these two chapters. In fact, cross-section analysis has gained popularity in the recent literature on the credit view.

Another way to extend this study is related with the theoretical model of Chater 4. The model implies that negative macroeconomic shocks causes more severe slowdowns in bank lending in Japan under the risk-based capital standards. As is discussed in its concluding part of the chapter, however, the implication of the model is not supported by the empirical studies of other papers. This may be because the model does not incorporate the lending activities of the banks in foreign countries. Section 3.3 of Chapter 3 also suggests the importance of the international activities of banks. Modelling the risk-based capital standards in a bank's international portfolio will further the literature.

Dealing with related questions may also extend the thesis. An interesting empirical question is how important the credit channel is (compared to another channel such as the money channel). One might argue that we can estimate the relative importance of the credit channel to the money channel by calculating the impulse response functions of the macroeconomic variables to a supply shock and a demand shock to bank lending. It is not clear, however, whether an innovation to the quantity of loans, for instance, represents a supply shock or a demand shock in the loan market. Thus, examination of the relative importance of the credit channel will require a different approach.

Appendix A

Data Appendix

A.1 Data used in Chapter 2

Table A.1 summarises the data used for VAR analyses in Chatper 2. All the data except for the land price index are available from the Bank of Japan (BOJ) or the *International Financial Statistics* of the International Monetary Fund (IMF).[1]

The data on land price are downloaded from the web of the Japanese Real Estate Institute (JREI).[2] The JREI releases the land price indexes of city areas, which are classified by three purposes of use: commercial, industrial, and residential. This chapter utilizes the land price index for the commercial area. Since the JREI releases the land price indexes only twice a year, the data are interpolated when used for the VAR analyses in section 2.5. (An alternative official survey of land price is available from the web of the Ministry of Land, Infrastructure and Transport, but the frequency of the data is annual.)

[1] The address of the BOJ is "www.boj.or.jp/en/siryo/siryo_f.htm" from which the data are downloaded.

[2] The address of the English web of the Japanese Real Estate Institute is "www.reinet.or.jp/study/index-e.htm".

Table A.1: Sources of Data used in Chapter 2

Variable	Source	Code/Table	Abbreviation
Commodity Price Index (non-fuel)	IMF	00176AXD	CP
Exchange Rate	IMF	158RF	XR
Consumer Price Index	IMF	15864B	P
Industrial Production (seasonally adjusted)	IMF	15866C	Y
Base Money (reserve requirement change adjusted)	BOJ	ecdab015	M
Call Rate (overnight)	IMF	15860B	R
New Loans for Equipment Funds (manufacturing)	BOJ	cdab1260	LQ
Interest Rate on New Loans	BOJ	cdab0880	LP
Diffusion Index (actual results, manufacturing)	BOJ	cdbf0120	LP
Nikkei Stock Average (TSE225)	BOJ	ehstock	SP
Land Price (six major cities, commercial area)	JREI	11164	LD
U.S. Federal Funds Rate	IMF	11160B	R^{US}

Some mention has to be made of the construction of the diffusion index for the price for loans. The data on the diffusion index are available in the BOJ's quarterly economic survey of enterprises, TANKAN. The survey contains 38 questions, one of which is related with the financial institutions' lending attitude. Non-financial firms are asked whether the financial institutions' lending attitude is "accommodative," "not so severe," or "severe." The diffusion index is calculated for each industry by subtracting the percentage of firms answering "severe" from the percentage of those answering "accommodative." Suppose that the unobservable price of bank loans rose for some reason. (A rise of the loan price may take the form of a higher interest rate on loans or heavier collateral requirement.) Then, one would expect more firms to answer "severe" to the question. As such, the diffusion index may be negatively correlated with the unobservable price of loans. For consistency with the series for Y and L, the diffusion index for the manufacturing industry is chosen. In the analysis, the diffusion index is multiplied by -1, so that a higher value implies a higher price of loans.

As is usual, the quality of sampled data depends on how accurately the sample represents the population. This is particularly true of the analysis in chapter 2. While the data on the quantity of bank loans correspond to the population, the diffusion index is calculated from the sample in the economic survey. If the sampled firms are mainly large ones in the economic survey, for instance, the diffusion index may not successfully capture the price of loans since financial conditions are often tighter for small firms. This paper uses the diffusion index under the assumption that the sampled firms of the economic survey unbiasedly represent the population of Japanese firms.

A potential problem of the diffusion index of financial institutions' lending attitude arises from the fact that, while the firms are asked to choose one answer from "accommodative," "not so severe," and "severe", the index does not contain information provided by those answering "not so severe." Suppose that 45 % of the firms answer "accommodative" and 55 % answer "severe." In this case, the diffusion index is calculated as -10. The same value can be obtained, for example, if 10 % of the firms answer "severe" and no firm answers "accommodative." Despite the same value of the index, bank loan market conditions obviously differ from each other in these cases. In this way, any particular value of the diffusion index is consistent with an infinite number of different survey results. Fortunately, however, we do not have to worry about such a problem. As Figure A.1 shows, there are nearly one-to-one relationships from the diffusion index to the percentages of the firms choosing "accommodative" and "severe." Thus, it seems that the diffusion index of financial institutions' lending attitude unambiguously provides information about the bank loan market.

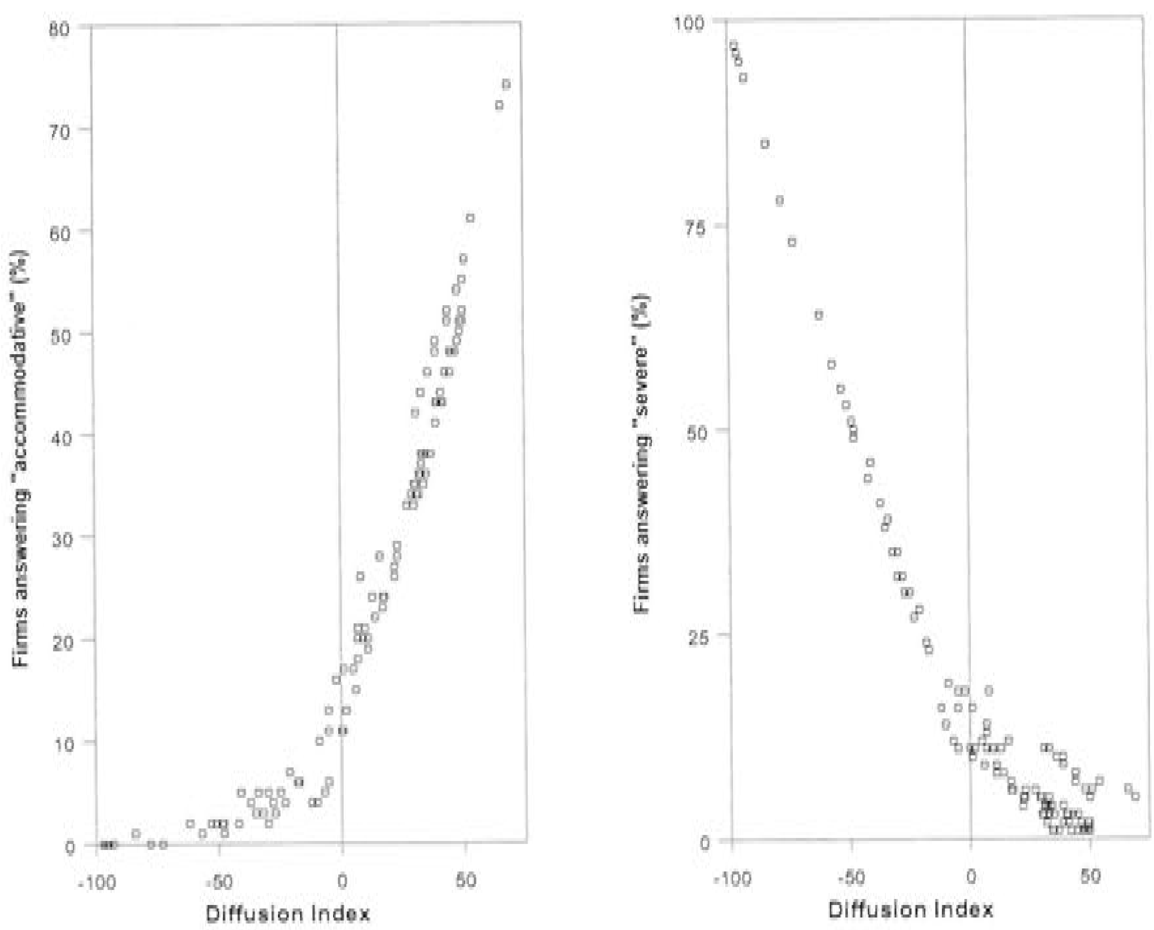

Figure A.1: Diffusion Index and its Components (Sample: 1970:Q2 - 2000:Q1)

A.2 Data used in Chapter 3

Table A.2 summarises the data used for the Bernanke and Blinder (1992) type models in sections 3.1 and 3.3. The data on the CPI and certificates of deposit are from the Australian Bureau of Statistics (ABS) catalogue No. 6401 and No. 5232, respectively. All the other data are taken from the *Bulletin* statistics of the Reserve Bank of Australia (RBA).

Some mention has to be made of the construction of the CPI. The ABS incorporated mortgage interest charges and consumer credit charges into the component of the CPI

Table A.2: Sources of Data used in Sections 3.1 and 3.3

Variable	Source	Table
Cash rate (11 am call)	RBA	F01
CPI excluding housing	ABS	6401-09
Unemployment rate	RBA	G06
Deposits repayable in Australia	RBA	B03
Public sector securities	RBA	B03
Loans, advances, and bills held	RBA	B03
Certificates of deposit	ABS	5232-6
Foreign currency liabilities	RBA	B03

(for all groups) between 1986:Q4 and 1998:Q2. The inclusion of interest charges makes the CPI unsuitable for evaluating monetary policy, as changes in the policy instrument mechanically result in movements in the CPI. For this reason, the "CPI excluding housing" is used.

The data used for the structural VAR models in section 3.2 are summarised in Table A.3. The CPI is the same as the one used in sections 3.1 and 3.3. Data sources are either the *International Financial Statistics* of the International Monetary Fund or the *Bulletin* statistics of the RBA, except for the data on the proxy for loan prices.

In order to capture the effects of a monetary tightening on the activity of the private non-financial corporate sector, one might suggest that real GDP should be replaced with the industrial production. Reading various issues of the *International Financial Statistics* of the IMF, however, one can notice that the data on the industrial production are frequently revised, and that these revisions are often substantial. This means that the recent data on the industrial production are likely to contain significant measurement errors.

Table A.3: Sources of Data used in Section 3.2

Variable	Source	Code/Table	Abbreviation
Commodity price index (non-fuel)	IMF	00176AXD	CP
Exchange rate (US$ per A$)	IMF	193AG	XR
CPI excluding housing	ABS	6401-09	P
Real GDP	IMF	19399BVR	Y
Money base	RBA	D03	M
Cash rate (11 am call)	RBA	F01	R
Loans and advances by banks	RBA	D02	LQ
Proxy for the loan price	ACCI & Westpac	Q. 4-b	LP
U.S. real GDP	IMF	11199BVR	Y^U
U.S. CPI	IMF	11164	P^U
U.S. federal funds rate	IMF	11160B	R^U

Given the small size of the sample, using the data with measurement errors seems undesirable. For this reason, this chapter uses real GDP rather than the index of industrial production.

Chapter 3 utilises the diffusion index in the "Survey of Industrial Trends" conducted by the Australian Chamber of Commerce and Industry (ACCI) and the Westpac Banking Corporation as a proxy for the marginal cost of loans to borrowers. A potential problem with the ACCI-Westpac diffusion index arises from the fact that it omits information provided by the firms answering "Same." Suppose that 55% of the firms answered "Harder" and 45% answered "Easier." Then, the diffusion index is calculated as 10. The same value of the diffusion index is obtained, for instance, if 10% of the firms answer "Harder" and no firm answers "Easier." As such, any particular value of the diffusion index is consistent with an infinite number of different survey results. To check if this problem is evident or not, Figure A.2 plots the percentages of the firms answering "Harder" and "Easier" against the resulting diffusion index. Roughly speaking, there are nearly one-to-one relationships from the percentages of the firms answering "Harder" and "Easier" to the diffusion index. In this sense, the diffusion index may correctly provide information about the loan market.

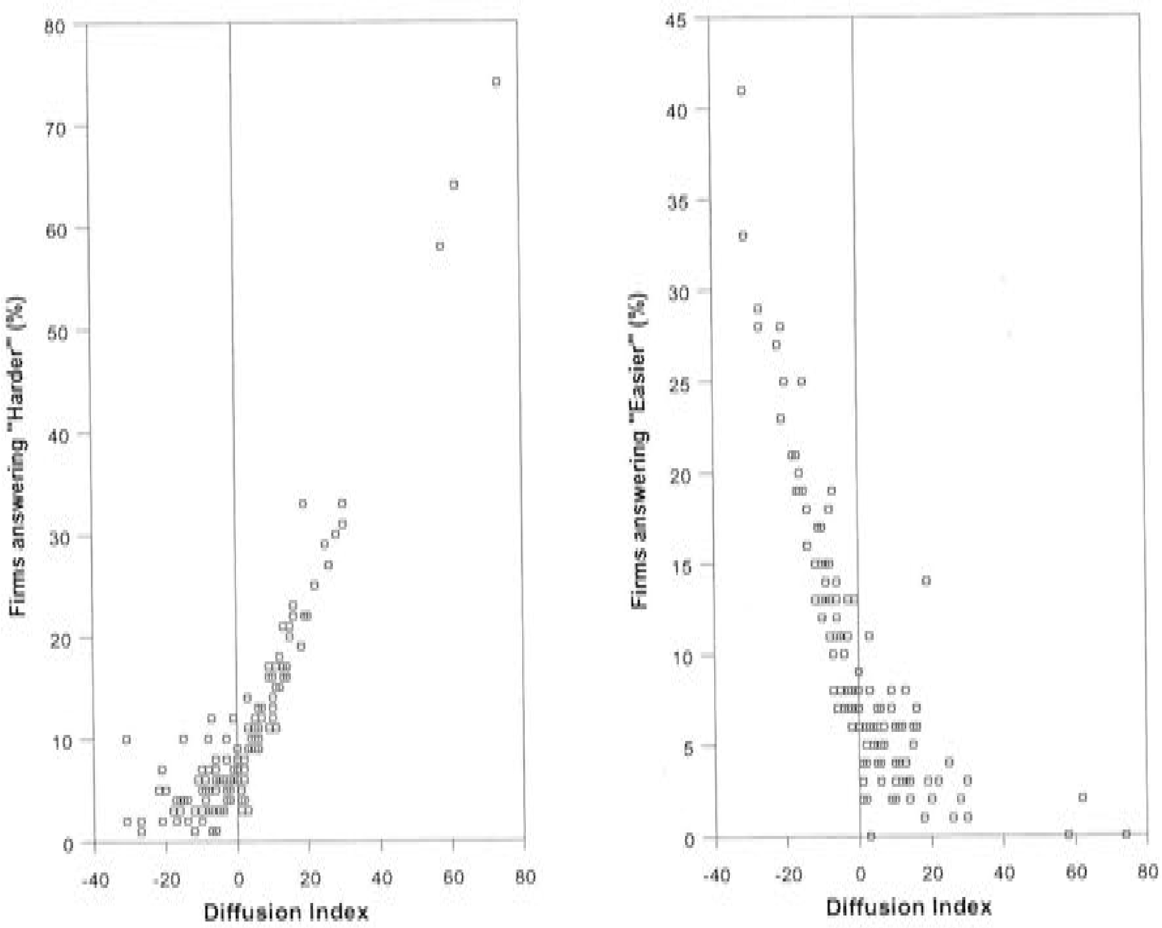

Figure A.2: Diffusion Index and its Components

Sample: 1966:Q2 - 2000:Q4

Appendix B

Impulse Response Analysis

Impulse response analysis is dynamic simulation based on an econometric model. This technique is useful for forecasting impacts of an exogenous shock on the economy. The empirical literature has sometimes displayed the estimates of the impulse response functions without confidence intervals (e.g. Bernanke and Blinder 1992 and Sims 1992). As an indicator of statistical reliability, however, confidence intervals for impulse responses are of importance. This appendix discusses the impulse responses and construction of their confidence intervals. For consistency with the econometric models of this thesis, the following discussion takes a VAR model as an example.[1]

[1]While impulse response analysis is often conducted within a framework of (structural) VAR models, it can be applied to a variety of dynamic econometric models. Gruen, Romalis, and Chandra (1998), for instance, conduct impulse response analysis based on a single-equation model.

B.1 Impulse Response Analysis

Before proceeding, it is worthwhile reviewing impulse response analysis within a framework of a structural VAR approach. Let $\mathbf{y}_t$ denote a vector containing the values that the variables of interest assume at date t. Then, a structural model is typically expressed in vector form:[2]

$$\mathbf{B}_0\mathbf{y}_t = \mathbf{B}_1\mathbf{y}_{t-1} + \cdots + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \tag{B.1}$$

where $\mathbf{u}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{D})$ and $\mathbf{D}$ is a diagonal matrix. This is a simultaneous equations model. By premultiplying each side of equation (B.1) by $\mathbf{B}_0^{-1}$, the structural model can be represented as vector autoregressive form:

$$\mathbf{y}_t = \mathbf{\Phi}_1\mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_p\mathbf{y}_{t-p} + \mathbf{e}_t, \tag{B.2}$$

with $\mathbf{e}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{\Omega})$ where

$$\mathbf{\Phi}_j = \mathbf{B}_0^{-1}\mathbf{B}_j \text{ for } j = 1, \cdots, p,$$

and

$$\mathbf{e} = \mathbf{B}_0^{-1}\mathbf{u}. \tag{B.3}$$

The VAR model (B.2) is a reduced form, and can be estimated consistently and efficiently equation by equation with the OLS. The estimated model is used for forecasting future values of variables in $\mathbf{y}$.

Suppose that the jth variable of $\mathbf{y}$, y_j, unexpectedly increased at date t. Then, how should we revise our forecast of future values of the variables of $\mathbf{y}$? By simple arrangement, the VAR model (B.2) can be written as

$$\mathbf{y}_{t+1} = \mathbf{\Phi}_1\mathbf{y}_t + \cdots + \mathbf{\Phi}_p\mathbf{y}_{t-p+1} + \mathbf{e}_{t+1},$$

[2] Inclusion of constants and/or time trends does not affect the following argument.

which implies

$$\Psi_1 \equiv \frac{\partial\ E(\mathbf{y}_{t+1}|I_t)}{\partial\ \mathbf{y'}_t} = \Phi_1,$$

where I_t is the set of information about the system as of date t. The row i, column j element of Ψ_1 measures an impact of a one-time impulse to y_j at date t on the expected value of y_i at date $t+1$. Similarly, the VAR model (B.2) can be arranged as

$$\mathbf{y}_{t+2} = \Phi_1\mathbf{y}_{t+1} + \Phi_2\mathbf{y}_t + \cdots + \Phi_p\mathbf{y}_{t-p+2} + \mathbf{e}_{t+2},$$

which implies

$$\Psi_2 \equiv \frac{\partial\ E(\mathbf{y}_{t+2}|I_t)}{\partial\ \mathbf{y'}_t} = \Phi_1\Psi_1 + \Phi_2.$$

By iteration, we have

$$\Psi_s \equiv \frac{\partial\ E(\mathbf{y}_{t+s}|I_t)}{\partial\ \mathbf{y'}_t} = \Phi_1\Psi_{s-1} + \Phi_2\Psi_{s-2}+, \cdots, +\Phi_p\Psi_{s-p} \text{ for } s = 0, 1, \cdots. \tag{B.4}$$

A plot of the row i, column j element in Ψ_s,

$$\frac{\partial\ E(y_{i,t+s}|I_t)}{\partial\ y_{j,t}},$$

as a function of time interval s is called the "impulse response function" of y_i to an innovation to y_j.

An innovation to y_j is equivalent to the jth element of $\mathbf{e}$, e_j, in the VAR model (B.2), which means

$$\frac{\partial\ E(\mathbf{y}_{t+s}|I_t)}{\partial\ \mathbf{y'}_t} = \frac{\partial\ E(\mathbf{y}_{t+s}|I_t)}{\partial\ \mathbf{e'}_t}. \tag{B.5}$$

As the VAR is a reduced form of the structural model (B.1), however, it is often exogenous shocks represented by $\mathbf{u}$ with which we are concerned. As equation (B.3) suggests, an element of $\mathbf{u}$ is a linear combination of elements in $\mathbf{e}$, and

$$\frac{\partial\ \mathbf{e}}{\partial\ \mathbf{u'}} = \mathbf{B}_0. \tag{B.6}$$

Equations (B.4) to (B.6) imply

$$\frac{\partial\ E(\mathbf{y}_{t+s}|I_t)}{\partial\ \mathbf{u'}_t} = \frac{\partial\ E(\mathbf{y}_{t+s}|I_t)}{\partial\ \mathbf{e'}_t}\frac{\partial\ \mathbf{e}_t}{\partial\ \mathbf{u'}_t} = \mathbf{\Psi}_s\mathbf{B}_0. \tag{B.7}$$

By plotting the row i, column j element of $\mathbf{\Psi}_s\mathbf{B}_0$ against time, we can simulate dynamic impacts of an exogenous shock associated with y_j, u_j, on the expected value of y_i. This is the technique used in this thesis.

The impulse response analysis is utilised mainly for forecasting. Since accuracy is of fundamental importance to forecasting, an indicator of its statistical reliability is required. Another usage of this technique is a statistical test of an economic hypothesis. Obviously, it makes little sense to draw statistical inferences without confidence intervals. For these reasons, it is essential to derive confidence intervals for impulse responses in the empirical studies. As the first step toward the derivation of the confidence intervals, the next section discusses the statistical distribution of impulse responses.

B.2 Distribution of Impulse Responses

How can we derive the distribution of the estimated impulse responses? To examine the statistical properties of the impulse responses, it is necessary to express the estimator of the impulse responses. For explanatory convenience, let us rewrite the VAR model (B.2) as

$$\mathbf{y}_t = (\mathbf{I} \otimes \mathbf{X}_t)\pi + \mathbf{e}_t, \tag{B.8}$$

where

$$\mathbf{X}_t \equiv [\mathbf{y}'_{t-1}, \mathbf{y}'_{t-2}, \cdots, \mathbf{y}'_{t-p}],$$

and

$$\pi \equiv \text{vec}([\mathbf{\Phi}_1, \mathbf{\Phi}_2, \cdots, \mathbf{\Phi}_p]').$$

Similarly, let ψ_s denote a column vector which stacks the columns of the matrix of impulse responses, $\mathbf{\Psi}_s$, on each other. That is,

$$\psi_s \equiv \text{vec}(\mathbf{\Psi}).$$

Equation (B.4) implies that an element of ψ_s can be expressed as a non-linear function of the elements of π:

$$\psi_s = g(\pi). \tag{B.9}$$

By replacing π with its OLS estimator $\hat{\pi}_T$, we can express the estimator of the impulse responses as

$$\hat{\psi}_{s,T} = g(\hat{\pi}_T). \tag{B.10}$$

where T is the number of observations used for the estimation.

Does the estimator of the impulse responses, $\hat{\psi}_{s,T}$, have any desirable statistical property? As is well known, parameters of a VAR model can be consistently estimated by applying OLS to each equation. In the context of this paper,

$$\text{plim } \hat{\pi}_T = \pi,$$

which reads that, as T goes to infinity, the OLS estimator $\hat{\pi}_T$ converges in probability to π, a vector containing the true parameters of the VAR. For this argument to hold, the lag structure of the VAR model should be carefully chosen. As the impulse responses are non-linear functions of the parameters in the underlying VAR model, the impulse analysis is usually sensitive to the choice of the number of the lags. If the lag structure is correctly specified, the consistency of $\hat{\pi}_T$ implies the consistency of $\hat{\psi}_{s,T}$ by virtue of the Slutsky theorem:[3]

$$\text{plim } \hat{\psi}_{s,T} = \psi_s.$$

Even though $\hat{\psi}_{s,T}$ is a consistent estimator of the impulse response function, statistical inference requires more detailed description of its distribution. Equation (B.10) implies that the asymptotic distribution of $\hat{\psi}_{s,T}$ depends on that of $\hat{\pi}_T$. Under certain conditions, the central limit theorem holds for the OLS estimator of parameters of a VAR model, and it establishes that, as T increases, $\sqrt{T}(\hat{\pi}_T - \pi)$ converges in law to a vector of Gaussian random variables (see, for instance, Proposition 11.1 of Hamilton 1994). More specifically,

$$\sqrt{T}(\hat{\pi}_T - \pi) \xrightarrow{L} N(\mathbf{0}, (\mathbf{\Omega} \otimes \mathbf{Q}^{-1})),$$

where

$$\mathbf{Q} = E(\mathbf{X}_t'\mathbf{X}_t).$$

The central limit theorem further establishes that, if $g(\cdot)$ in equation (B.9) is continous,

$$\sqrt{T}(\hat{\psi}_{s,T} - \psi_s) \xrightarrow{L} N(\mathbf{0}, \mathbf{G}_s(\mathbf{\Omega} \otimes \mathbf{Q}^{-1})\mathbf{G}_s'), \tag{B.11}$$

where

$$\mathbf{G}_s = \frac{\partial\, g(\pi)}{\partial\, \pi'}.$$

Equation (B.11) describes the asymptotic distribution of $\hat{\psi}_{s,T}$.

[3]The Slutsky theorem is as follows. For a continuous function $f(y_n)$ that is not a function of n,

$$\text{plim } f(y_n) = f(\text{plim } y_n).$$

See, for example, Theorem 4.7 of Greene (1997, pp.118-119). The Slutsky theorem holds for a vector function as well. See also Hamilton (1994, p.182).

While the estimator of $\mathbf{Q}$ is given by

$$\hat{\mathbf{Q}} = \frac{1}{T}\sum_{t=1}^{T}\mathbf{X}_t'\mathbf{X}_t,$$

the non-linearity of $g(\cdot)$ complicates the derivation of an explicit expression for $\mathbf{G}_s$. Runkle (1987), for instance, proposes to use numerical methods to compute the derivatives.[4]

The asymptotic distribution $\hat{\psi}_{s,T}$ is derived from its large-sample properties. Asymptotic theory may be inaccurate in a finite sample, and more often than not, a sample is small. One way to investigate the finite-sample properties of estimates is to refine asymptotic approximations. This approach is labour-intensive in a sense that it requires highly mathematical skills. An alternative way is to calculate numerical approximations. This approach is called the Monte Carlo approach, and it is capital-intensive in the sense that a great deal of computer time is required. Due to exponentially declining costs of computing, Monte Carlo methods have been popular in empirical research. This thesis also adopts the Monte Carlo approach. Among others, Monte Carlo integration and bootstrapping are major Monte Carlo methods used for impulse response analysis. The following section discusses these two methods.[5]

[4]An analytical expression for $\mathbf{G}_s$ is derived by Lütkepohl (1990). See also Evans and Wells (1986) for the asymptotic distribution of the impulse response function.

[5]Monte Carlo methods are widely utilised in the applied econometric literature. See, for example, Ch 21 of Davidson and MacKinnon (1993) and Ch 5 of Greene (1997) for Monte Carlo methods in a general context.

B.3 Monte Carlo Method

B.3.1 Monte Carlo Integration

Monte Carlo integration is a numerical method to approximate (posterior) moments of estimators. In the context of this paper, first and second order moments of elements in ψ_s are of interest. Monte Carlo integration is intrinsically a Bayesian approach in the sense that parameters are assumed to be random rather than fixed. As will be shown shortly, this technique works when the estimator of interest is a function of random parameters with known probability density function (pdf). Since every element of ψ_s is expressed as a non-linear function of those of π, Monte Carlo integration can be used to calculate the moments of ψ_s when the pdf for π is known.

Monte Carlo integration has been popular in the empirical VAR literature (e.g. Eichenbaum 1992 and Kim and Roubini 2000). This popularity comes mainly from computational convenience. An econometric computer package, RATS, utilises Monte Carlo integration as a default method to compute confidence intervals for impulse responses (see Doan 1992). With little modification to the pre-written program, a user of RATS can produce the estimated impulse response function with its confidence intervals. Even though the computer package does not necessarily require its user to understand Monte Carlo integration, ignoring the theoretical underpinnings may result in misuse of the technique.[6]

Monte Carlo integration is formalised by Kloek and van Dijk (1978).[7] Let $p(\pi|\text{data})$

[6] Misuse of the RATS program can occur when a structural model is over identified. Sims and Zha (1999) show that the RATS program for impulse response analysis is directly applicable only to just-identified models. They also show that an over-identified model requires substantial modification to the pre-written program.

[7] The following argument is a special case which simplifies analysis. This case holds when the posterior

denote a posterior pdf for π. Since $\psi_s = g(\pi)$, a kth order posterior moment of ψ_s is given by

$$E[h(\pi)|\text{data}] = \int_{-\infty}^{\infty} h(\pi) \cdot p(\pi|\text{data})\, d\pi \qquad \text{(B.12)}$$

where

$$h(\pi) = \begin{cases} \{g(\pi)\}^k & \text{for a uncentred moment} \\ \{g(\pi) - E[g(\pi)]\}^k & \text{for a centred moment.} \end{cases}$$

If the moment of interest is the posterior mean of ψ_s, for instance, $h(\pi) = g(\pi)$. Similarly, $h(\pi) = \{g(\pi) - E[g(\pi)]\}^2$ for the posterior variance of ψ_s. Monte Carlo integration is a numerical method to approximate the integral in equation (B.12) by computing the following sample value:

$$\hat{E}[h(\pi|\text{data})] = \frac{1}{N}\sum_{i=1}^{N} h(\pi^{(i)}) \cdot p(\pi^{(i)}|\text{data}), \qquad \text{(B.13)}$$

where $\pi^{(i)}$ denote a Monte Carlo draw from $p(\pi|\boldsymbol{\Omega})$. The consistency of this estimator is assured by the law of large numbers.

Monte Carlo integration requires more detailed description of the posterior pdf for π and $\boldsymbol{\Omega}$. Suppose that little is known, a priori, about parameter vectors π and $\boldsymbol{\Omega}$. Under the assumption that the elements of π and those of $\boldsymbol{\Omega}$ are independently distributed, a uninformative prior of its kind can be written in a simple form:

$$p(\boldsymbol{\Omega}) \propto |\boldsymbol{\Omega}|^{-(n+1)/2},$$

where $\propto$ and n denote proportionality and the number of variables in $\mathbf{y}_t$, respectively. Zellner (1971) shows that, given the uninformative prior, the posterior pdf for $\boldsymbol{\Omega}$ is the

pdf of π is used as the "importance function" in the notation of Kloek and van Dijk (1978). See their original paper for discussion on a more general case. This simplification is also adopted in RATS. See Doan (1992).

inverted Wishart form.[8] As will be shown shortly, it is straightforward to generate draws from this distribution. He further shows that, given $\mathbf{\Omega}$, the conditional posterior pdf for π is multivariate normal:

$$\pi \sim N(\hat{\pi}_T, \mathbf{\Omega} \otimes (\mathbf{X}'\mathbf{X})^{-1}). \tag{B.14}$$

where

$$\mathbf{X}'\mathbf{X} = \sum_{t=1}^{T} \mathbf{X}_t \mathbf{X}_t'.$$

It is this posterior pdf for π from which Monte Carlo draws are generated to calculate the integral in equation (B.12).

The above-cited theoretical works of Kloek and van Dijk (1978) and Zellner (1971) justify the following two-stage Monte Carlo method. First, parameter values $\mathbf{\Omega}$ are drawn from an inverted Wishart distribution of order T. This draw can be produced by computing

$$[\mathbf{Z}'(\mathbf{I} - \frac{1}{n}\mathbf{i}\mathbf{i}')\mathbf{Z}]^{-1}$$

where each row of $\mathbf{Z}$ is an independent draw from the T-variate standard normal distribution, and $\mathbf{i}$ denotes a n-column vector with every element equal to one.[9] By drawing N times, we will have N observations on $\mathbf{\Omega}$. Let $\mathbf{\Omega}^{(i)}$ denote a Monte Carlo draw. For each $\mathbf{\Omega}^{(i)}$, a parameter vector π is drawn from the distribution with density (B.14). This is the second stage Monte Carlo. For each $\pi^{(i)}$, the impulse response function $\psi_s(= g(\pi))$ is evaluated. Let $\psi_s^{(i)}$ denote the impulse response function evaluated by $\pi^{(i)}$. As equation (B.13) suggests, the posterior mean of ψ_s is approximated by the sample average of $\psi_s^{(i)}$:

$$\hat{\mu}_s = \frac{1}{N}\sum_{i=1}^{N} \psi_s^{(i)}.$$

[8] See Ch 8 of Zellner (1971) for the proof.

[9] See Greene (1997, p.179) for how to draw from a Wishart distribution.

Similarly, the posterior variance of the jth element in ψ_s is approximated by

$$\hat{\sigma}^2_{s,j} = \frac{1}{N}\sum_{i=1}^{N}(\psi^{(i)}_{s,j} - \hat{\mu}_{s,j})^2$$

where $\psi^{(i)}_{s,j}$ and $\mu_{s,j}$ denote the jth elements of $\psi^{(i)}_s$ and μ_s, respectively.

Figure B.1 shows the results of the estimation of the benchmark model for Australia.[10] All the variables except for the loan price are taken natural logs and multiplied by 100. The same scale is employed for all the graphs except for the graph of the loan price. In Figure B.1, the impulse responses to an innovation to the cash rate are displayed with their confidence intervals. The confidence intervals are constructed by Monte Carlo integration with uninformative prior being assumed. In each graph, the solid line is not the point estimate of the impulse response function, but its posterior mean. Dotted lines express the posterior two-standard deviations of the impulse response. By construction, the solid line lies in the middle of the dotted lines.

The above discussion makes it clear that the Monte Carlo integration is essentially a Bayesian approach. As the empirical analysis of this thesis is based on the sampling theory, however, Monte Carlo integration is not preferred. Another numerical method is employed to obtain confidence intervals for impulse responses. The next subsection discusses the other Monte Carlo method that is based on the sampling theory.

B.3.2 Bootstrap

There is another numerical method widely used in the empirical literature. This method, which was originally proposed by Efron (1979), is called "bootstrap" (see also Efron and Tibshirani 1986). In contrast to standard Monte Carlo experiments, random quantities

[10] Figure B.1 is produced by using RATS.

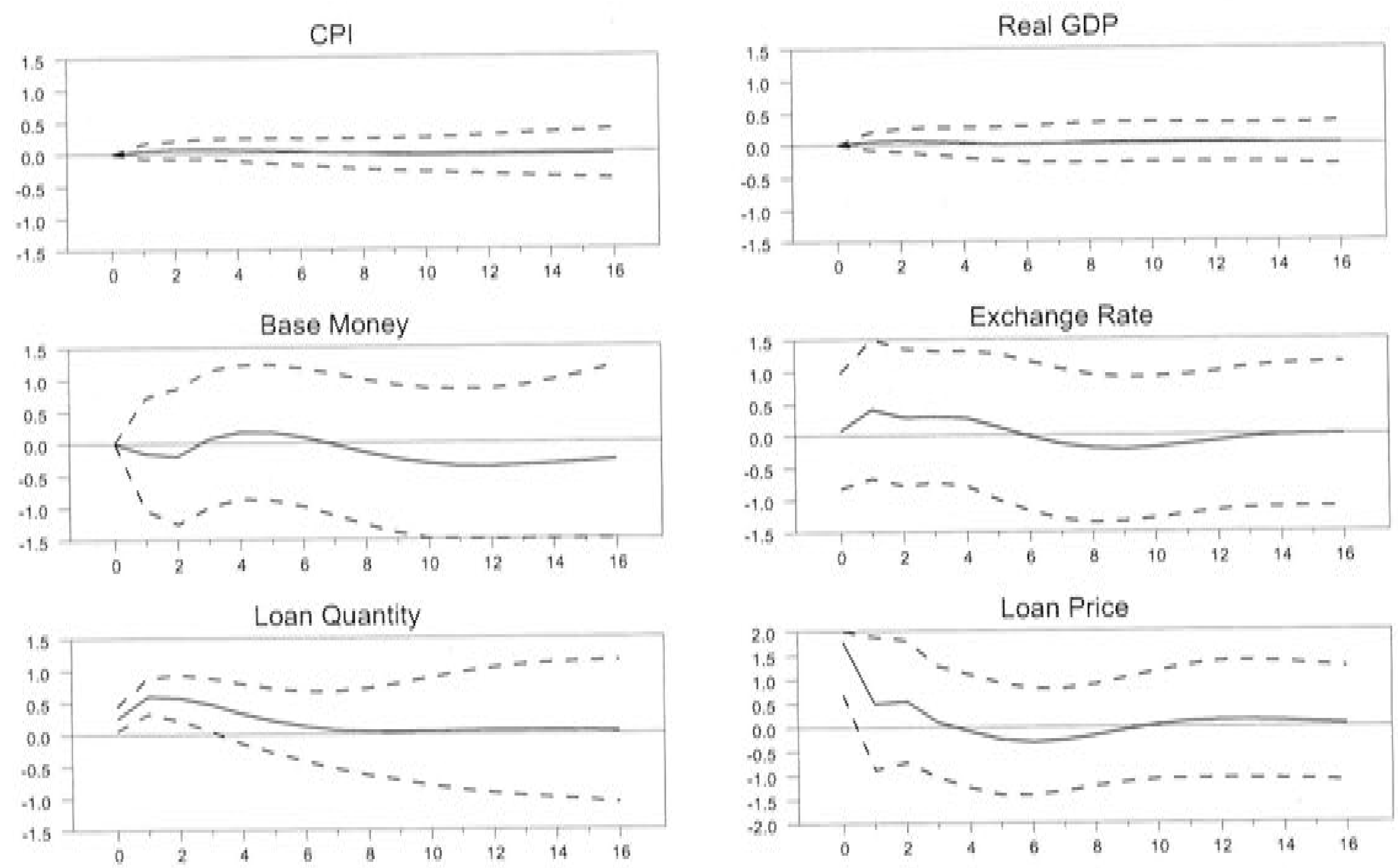

Figure B.1: Responses to a positive shock in the cash rate.

Notes: 90% confidence intervals are constructed by Monte Carlo integration.

of interest are not drawn from an assumed distribution. As will be shown, the bootstrap uses the sample data themselves to approximate the distribution of random quantities of interest. It is not necessary to assume any prior distributions for parameters. In this sense, the bootstrap is based on the classical theory of sampling.

While the bootstrap is utilised for a variety of statistical issues, it can be applied to the impulse response analysis. Runkle (1987) proposes the following procedure to obtain the distribution of the impulse responses π_s. First, the VAR model (B.2) is estimated. Let $\hat{\mathbf{\Phi}}$s and $\hat{e}_t$ are the estimates of $\mathbf{\Phi}$s and the associated vector error terms, respectively. In the bootstrap, $\hat{e}_t$ for $t = 1, \cdots, T$ are used to approximate the distribution of e_t under the assumption that e_t is independently and identically distributed.[11] Let Θ denote $\Theta =$

[11] In contrast to Monte Carlo integration (or other Monte Carlo methods), the bootstrap does not require

$(\hat{e}_1, \cdots, \hat{e}_T)$. The bootstrap begins with sampling T observations in a random way from Θ with "replacement". The artificial error terms, in turn, are used to generate the data set under the assumption that $\hat{\mathbf{\Phi}}$s are the true parameters of the data generating process. With the synthetic data set, the VAR model (B.2) is again estimated to calculate the impulse responses. This operation is repeated N times, at the end of which N observations on the impulse responses are available. Let $\hat{\pi}_s^i$ denote the estimated impulse response function in the ith operation where $i = 1, \cdots, N$. The distribution of π_s can be approximated by the sampling distribution of $\hat{\pi}_s^i$.

This thesis employs the "percentile method" to derive confidence intervals for π_s from the sampling distribution of $\hat{\pi}_s^i$. Let $\hat{\pi}_{s,j}^i$ denote the jth component of $\hat{\pi}_s^i$. N observations on $\hat{\pi}_{s,j}^i$ are sorted in ascending order such that $\hat{\pi}_{s,j}^i(1)$ and $\hat{\pi}_{s,j}^i(N)$ denote the smallest value and the largest value, respectively. Suppose that a 90% confidence interval for $\pi_{s,j}$ is of our interest. When $N = 1000$, for instance, the lower limit and the upper limit of the confidence interval are given by

$$\frac{1}{2}[\hat{\pi}_{s,j}^i(50) + \hat{\pi}_{s,j}^i(51)]$$

and

$$\frac{1}{2}[\hat{\pi}_{s,j}^i(950) + \hat{\pi}_{s,j}^i(951)],$$

respectively. This is the procedure that the thesis employs to derive confidence intervals for the estimated impulse response functions.

Figure B.2 shows the impulse responses calculated from the estimated benchmark model for Australia. In Figure B.2, the impulse responses to an innovation to the cash rate are again displayed with their 90% confidence intervals. The confidence intervals are

to assume the normality for the distribution of e_t.

numerically generated by the bootstrap. In each graph, the solid line and the dotted lines are the point estimate of the impulse response function and their 90% confidence intervals, respectively. As the confidence intervals are constructed by the percentile method, the solid line does not lie in the middle of the dotted lines.

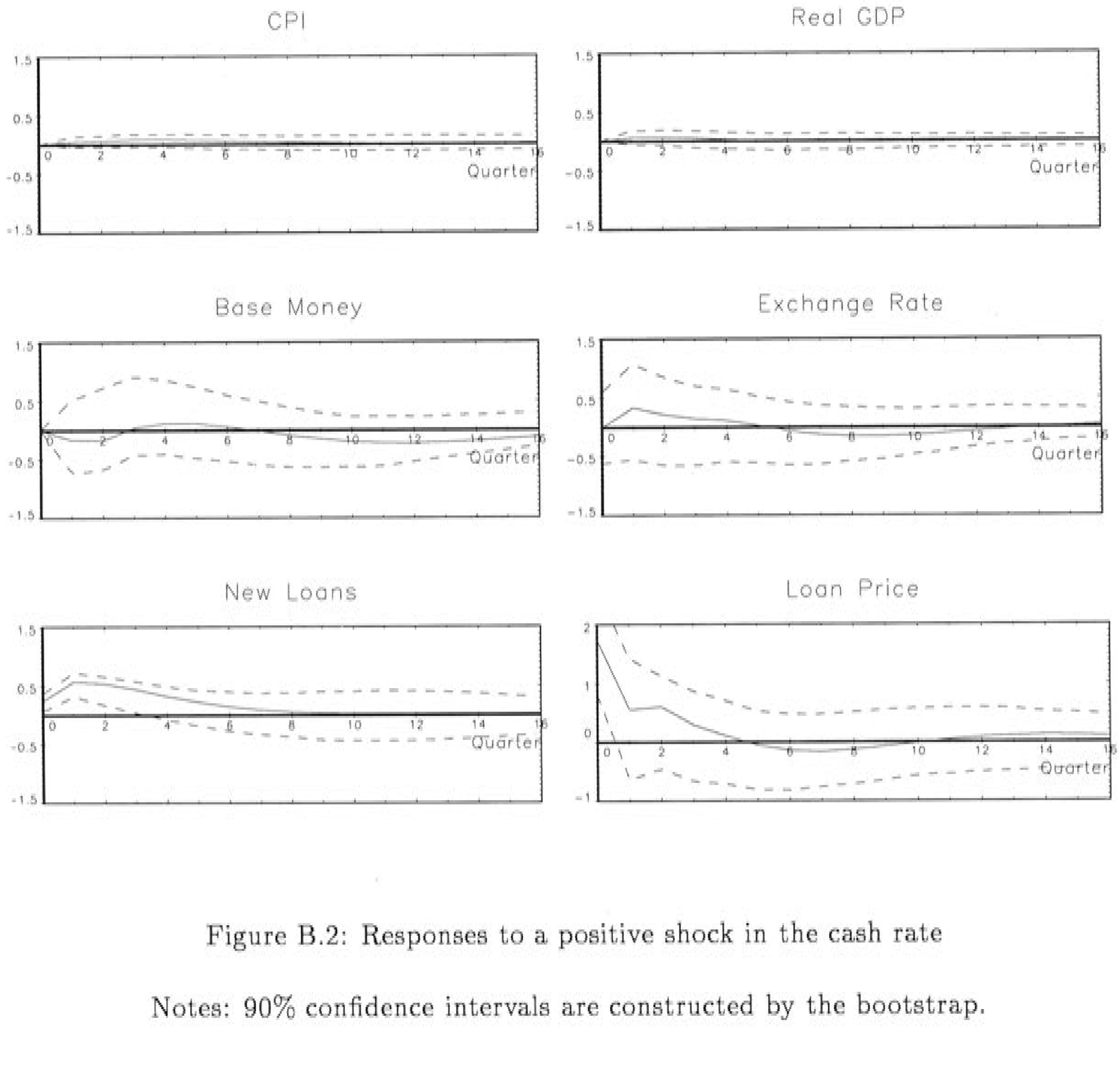

Figure B.2: Responses to a positive shock in the cash rate

Notes: 90% confidence intervals are constructed by the bootstrap.

B.4 Statistical Issues

This section discusses some issues in the impulse response analysis. As is discussed above, the impulse response function is calculated from the estimated parameters of the underlying econometric model (i.e., the VAR model (B.2) in the context of this thesis). This implies that two conditions must be met for the impulse analysis to be meaningful. First, the econometric model is a good approximate of the economy. Second, the parameters are accurately estimated. In practice, however, these two conditions are often violated.

The first condition may be violated by the linear structure of a VAR model. Whereas the structure of the economy is no doubt non-linear, the economy is approximated by a system of linear equations in a structural VAR approach. The linear structure of the model has been often criticised in the literature (e.g. Rudebusch 1998). In reality, however, the functional form of the economy is unknown *a priori*. Sims (1998), for instance, argues that it is misleading to introduce non-linearity of the wrong kinds into the model. Linear approximation of the economy (or a theoretical model of the economy) may be what we can do at best.

Even if the linearity is granted, the first condition is still vulnerable to the choice of the lag structure. The specification of the lag structure is particularly important for the impulse response analysis. Since an impulse response is expressed as a function of the VAR parameters, omitting significant lag(s) can be misleading. On the other hand, the overfitting can reduce the degrees of freedom, which may result in wide confidence intervals. As such, the lag order must be carefully chosen. In this thesis, the lag-orders of VAR models are based on the likelihood ratio test.[12]

In time series analysis, the second condition does not hold. Whereas parameters of a

[12]Different criteria choose different lag-orders, however. The Schwartz Information Criteria, for instance, usually chooses a shorter lag-order than the Akaike Information Criteria. Killian (2001) argues that the AIC is preferred to the more parsimonious SIC and Hannan-Quinn Criterion. See also the discussion in Sec 2.3 of Johansen (1995).

VAR model (and the impulse responses) are consistently estimated, their exact distribution is unknown in a small sample. Due to the lagged dependent variables, the estimates of VAR parameters are biased. Since impulse responses are calculated from the estimates of VAR parameters, the distribution of the estimated impulse responses is biased and skewed in a small sample. The bias of the estimated VAR parameters also has undesirable impacts on confidence intervals for impulse responses, because the estimated model is assumed to represent the "true" data generation process when confidence intervals for impulse responses are constructed by the bootstrap (and the Monte Carlo integration). As such, the impulse response analysis is not reliable when the bias is severe.

To deal with the small-sample bias in the impulse response analysis, Killian (1998) proposes "bootstrap after bootstrap." As its name suggests, this is the two-stage bootstrap. The first stage bootstrap is conducted to estimate the bias. Following the method mentioned above, the impulse responses are calculated N times. With these N observations are used to estimate how the bootstrapped impulse response function deviates, on average, from the point estimate of the impulse response. The average deviation is the estimate of the bias. In the second stage bootstrap, the estimated bias is subtracted from each of the bootstrapped impulse response. Confidence intervals for π are calculated from the impulse responses obtained from the bias-corrected bootstrap.[13]

Over-parameterisation is another factor which may violate the second condition. Consistent time series data are usually short due to the data availability and/or structural breaks of the economy. On the other hand, it is common to impose no restriction on the

[13]Theoretically, Killian's (1998) bias-correction method is attractive. In practice, however, this method is not often utilised in the empirical literature. Few examples, which utilise the "bootstrap after bootstrap", include Dungey and Pagan (2000).

dynamics of the system in a VAR model. As a consequence, the number of parameters to be estimated can be large compared to the available observations on the variables, which makes it difficult to secure meaningful degrees of freedom. The empirical literature has often reported too wide confidence intervals for impulse responses. Constructing the confidence intervals for impulse responses calculated by Sims (1980), for instance, Runkle (1987, p.437) argues that "unrestricted VARs often do not tell much about interesting macroeconomic questions". As such, the over-parameterisation can make the impulse response analysis unreliable. This is particularly true when the dimension of the system is high.

In fact, estimated parameters of a VAR model often have large standard errors and are hence insignificant. Nonetheless, it is not uncommon that they are jointly highly significant. This is the typical symptom of multicollinearity, which may be because of high correlation among variables, a small number of observations compared with the number of estimated parameters, or both.[14] One of the consequences of the mulitcollinearity is that confidence intervals are wide, which in turn makes the impulse response analysis inaccurate. As is well known, dropping a variable(s) is the simplest solution to the muulticollinearity problem. Dropping a variable(s) can lead to incorrect specification of the model used in the analysis, however.

A partial solution to the problem of over-parameterisation and/or mulitcollinearity is to impose zero restrictions on some coefficients which economic theory suggest are zero. In an open-economy structural VAR model, for instance, coefficients of the domestic

[14]The problem of a small sample is occasionally called "micronumerosity". Consequences of micronumerosity are essentially similar to those of mulitcollinearity, however. There is no point to distinguish microunmerosity and mulitcollinearity.

variables in the equations of the overseas variables may be restricted to be zero under the assumption of a small open economy (e.g. Cushman and Zha 1997 and Dungey and Pagan 2000). This set of zero restrictions implies that the overseas variables are block exogenous to the domestic variables, which can be statistically tested by a variant of the Granger-causality test. In order to reduce the number of estimated parameters in the model for Australia, this thesis tests the hypothesis that the U.S. variables are block exogenous to the Australian variables.

Economic theory does not always imply which variable(s) should be dropped from which equation(s), however. Even after dropping some variable(s) (e.g. the domestic variables) from an equation(s) of another variable(s) (e.g. the overseas variables), there can remain insignificant coefficients. Therefore, we might be able to improve the accuracy of the impulse response analysis by exploring the methods to deal with the mulitcollinearity. This can further the literature.

Appendix C

Measuring Monetary Policy Shock

A common critique of structural VAR models, or simultaneous equations models, is that any set of identifying assumptions is rarely convincing. This implies that monetary policy shocks are hard to identify in the monetary VAR models. As a robustness check, it may be worthwhile to calculate the impulse response functions of the variables of interest to monetary policy shocks identified in the existing literature. This section uses the monetary policy shocks estimated by Brischetto and Voss (1999).[1]

Brischetto and Voss (1999) estimate an open-economy VAR model, examining the monetary transmission mechanism in Australia. Their model consists of seven variables: an oil price index, the Federal Funds rate, domestic output, the domestic price level, a narrow monetary aggregate (M1), the cash rate, and the nominal exchange rate. The cash rate is assumed to represent the policy instrument of the Reserve Bank of Australia. The VAR model is estimated over the sample period 1980:Q1 to 1998:Q4. In addition, their

[1]This is the suggestion from one of the referees. I would like to thank Graham Voss for providing me with their data.

model differs from that of this paper in identifying assumptions, namely non-triangular restrictions are imposed for the purpose of identification. As is usual, the structural residuals of the cash rate equation are as monetary policy shocks.

As a robustness check, this section re-examines the responses of the quantity and price of loans to the monetary policy shocks identified by Brischetto and Voss (1999). Let BV denote their identified shock of monetary policy. Then, a simple model consisting of LQ, LP, and BV can be written as a system of equations:

$$\mathbf{y}_t = \mathbf{c}_0 + \mathbf{c}_1 t + \mathbf{\Phi}_1 \mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_{t-p} \mathbf{y}_{t-p} + \mathbf{e}_t, \tag{C.1}$$

with $\mathbf{e}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{\Omega})$ where

$$\mathbf{y}_t' = (BV_t, LQ_t, LP_t)'.$$

While the system of equations (C.1) is apparently a VAR model, BV that represents a monetary policy shock should be treated as an exogenous variable. This suggests that zero restrictions be imposed on the coefficient matrices $\mathbf{\Phi}$s as follows:

$$\mathbf{\Phi}_j = \begin{pmatrix} 0 & 0 & 0 \\ \phi_{21}^j & \phi_{22}^j & \phi_{23}^j \\ \phi_{31}^j & \phi_{32}^j & \phi_{33}^j \end{pmatrix} \quad \text{for } j = 1, \cdots, p, \tag{C.2}$$

The first elements of $\mathbf{c}_0$ and $\mathbf{c}_1$ should be also restricted to be zero. Consequently, the first element of $\mathbf{e}_t$ is equivalent to BV_t.

The system of equations (C.1) is estimated over the sample period of 1985:Q1 to 1998:Q4. The beginning of the sample is the same as that used in Chapter 3. The end of the sample period reflects the availability of the data on BV. The number of lags is two for consistency with the models in Chapter 3. LQ and LP are also measured in the same way. From the estimated model, the impulse response functions of LQ and LP to BV are calculated.

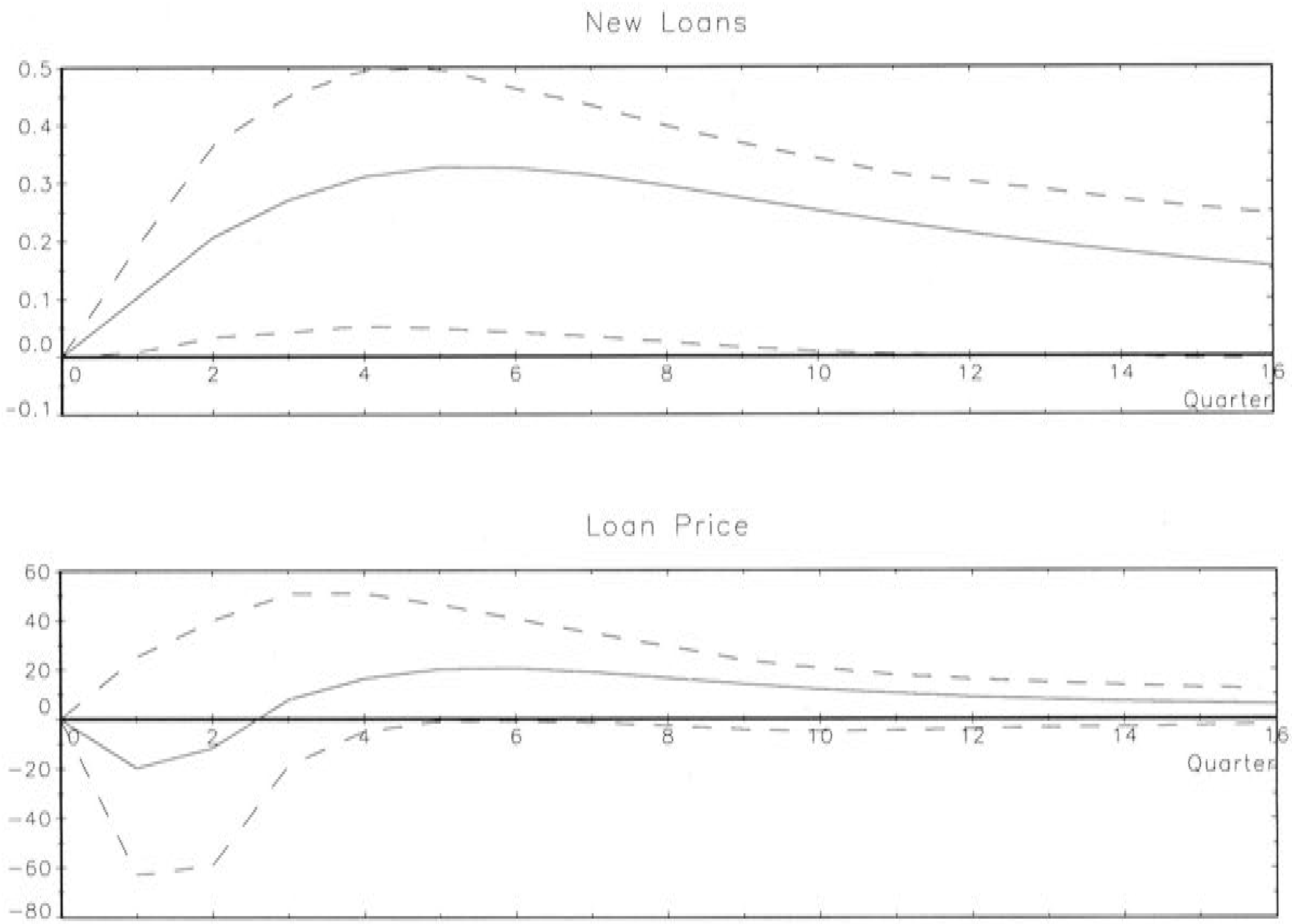

Figure C.1: Responses of Loan Variables to Monetary Policy

Monetary policy shocks are identified by Brischetto and Voss (1999).

Figure C.1 show the impulse responses of LQ and LP to an unexpected hike of the cash rate, which is identified by Brischetto and Voss (1999), with 90% confidence intervals. The quantity of new loans temporarily increases in response to a monetary policy shock. The temporal increase of new loans is significant. The price of new loans also temporarily increases. While the response of the loan price is initially insignificant, it is significantly positive in the fifth and sixth quarters after an unexpected hike of the cash rate. These responses of the loan price and quantity imply that the demand schedule for bank loans shifts outward in response to an unanticipated monetary tightening, and that Australian banks accommodate the temporarily increased demand for loans. Apart from the difference in lags, these implications are consistent with the results obtained in Chapter 3.

Appendix D

A 9-variable model in Ch 2

In an attempt to study the transmission process of monetary policy, chapter 2 calculates the impulse response functions to shocks in the short-term interest rates from the 9-variable structural VAR model. The other impulse responses might provide useful information, however. This section and the next one show all the impulse response functions calculated from the model in chapter 2.

The 9-variable model is estimated to test the credit view. The following nine figures are the impulse response functions calculated from the estimated model where the interest rate on loans measures the loan price.

The same model is estimated by replacing the interest rate on loans with the diffusion index. The impulse response functions calculated from the model are as follows.

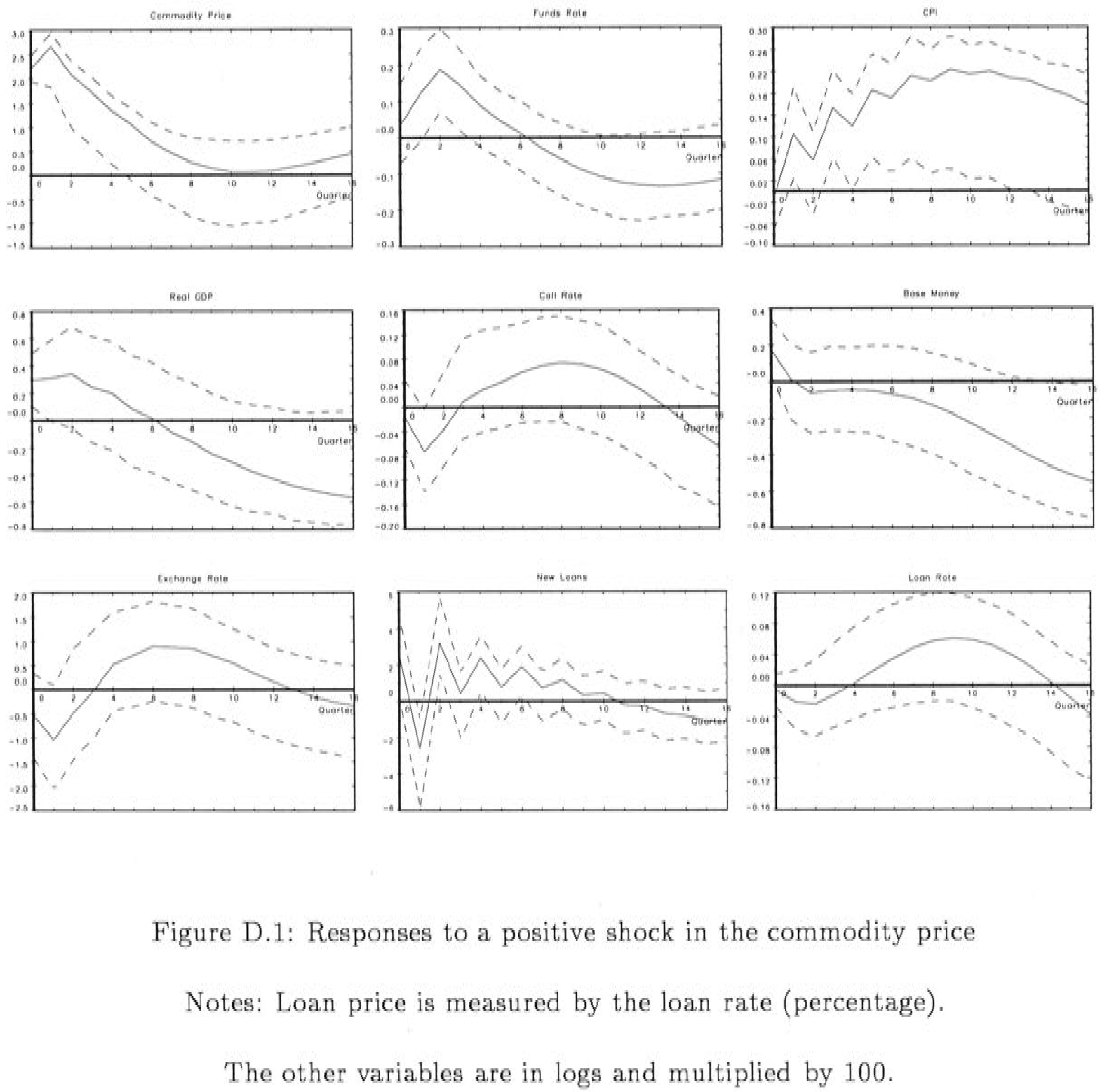

Figure D.1: Responses to a positive shock in the commodity price

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

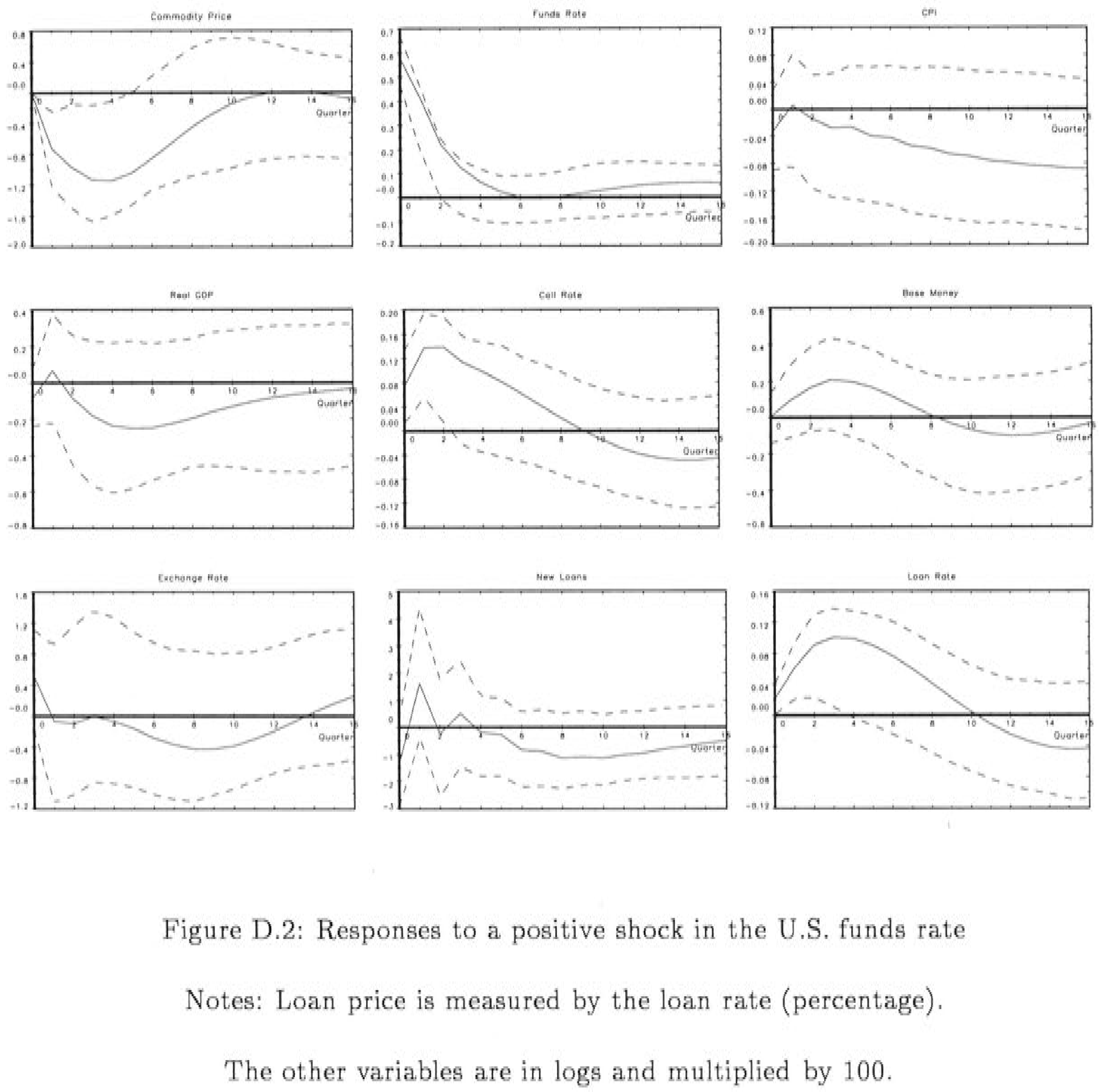

Figure D.2: Responses to a positive shock in the U.S. funds rate

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

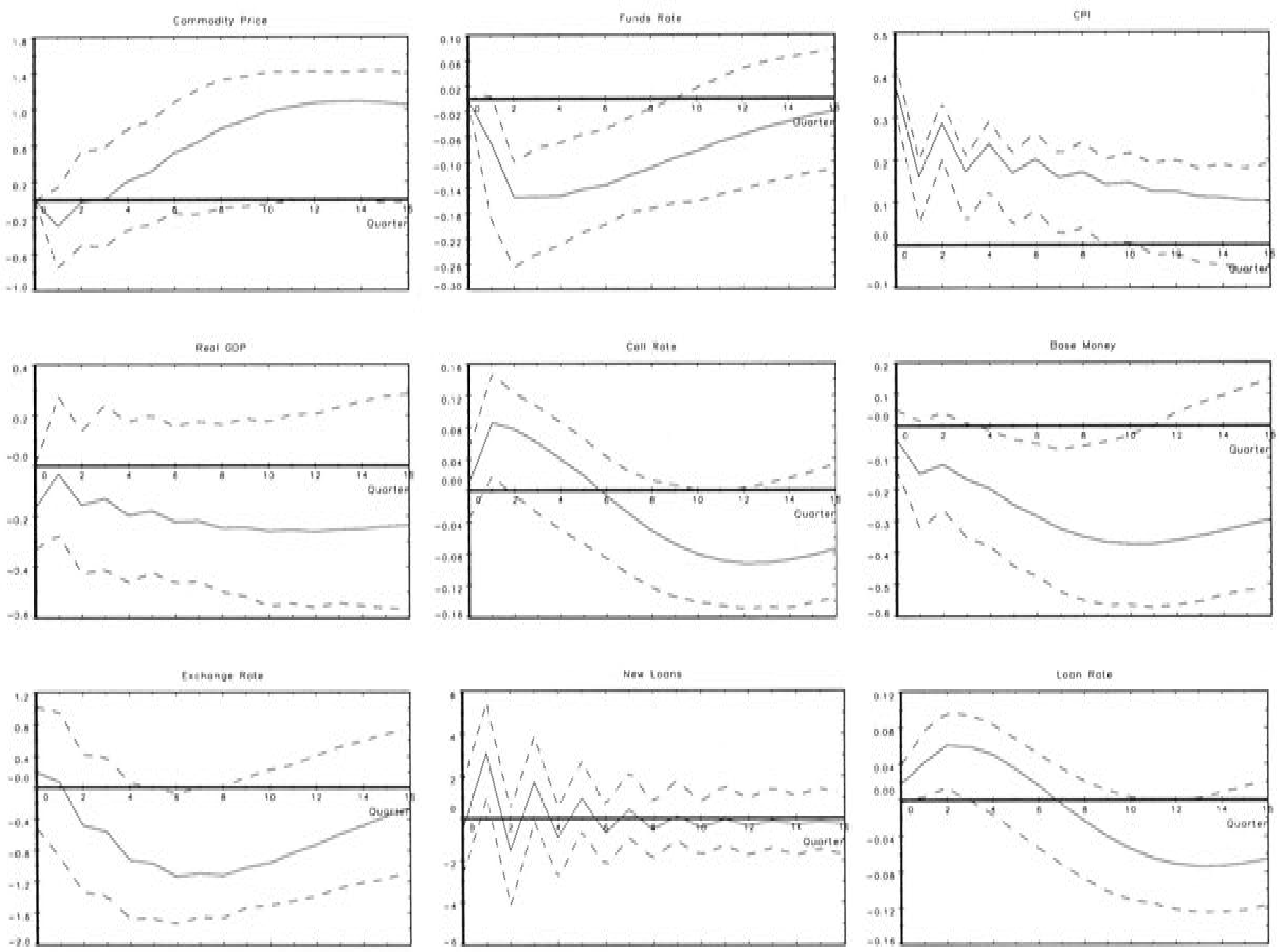

Figure D.3: Responses to a positive shock in the CPI

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

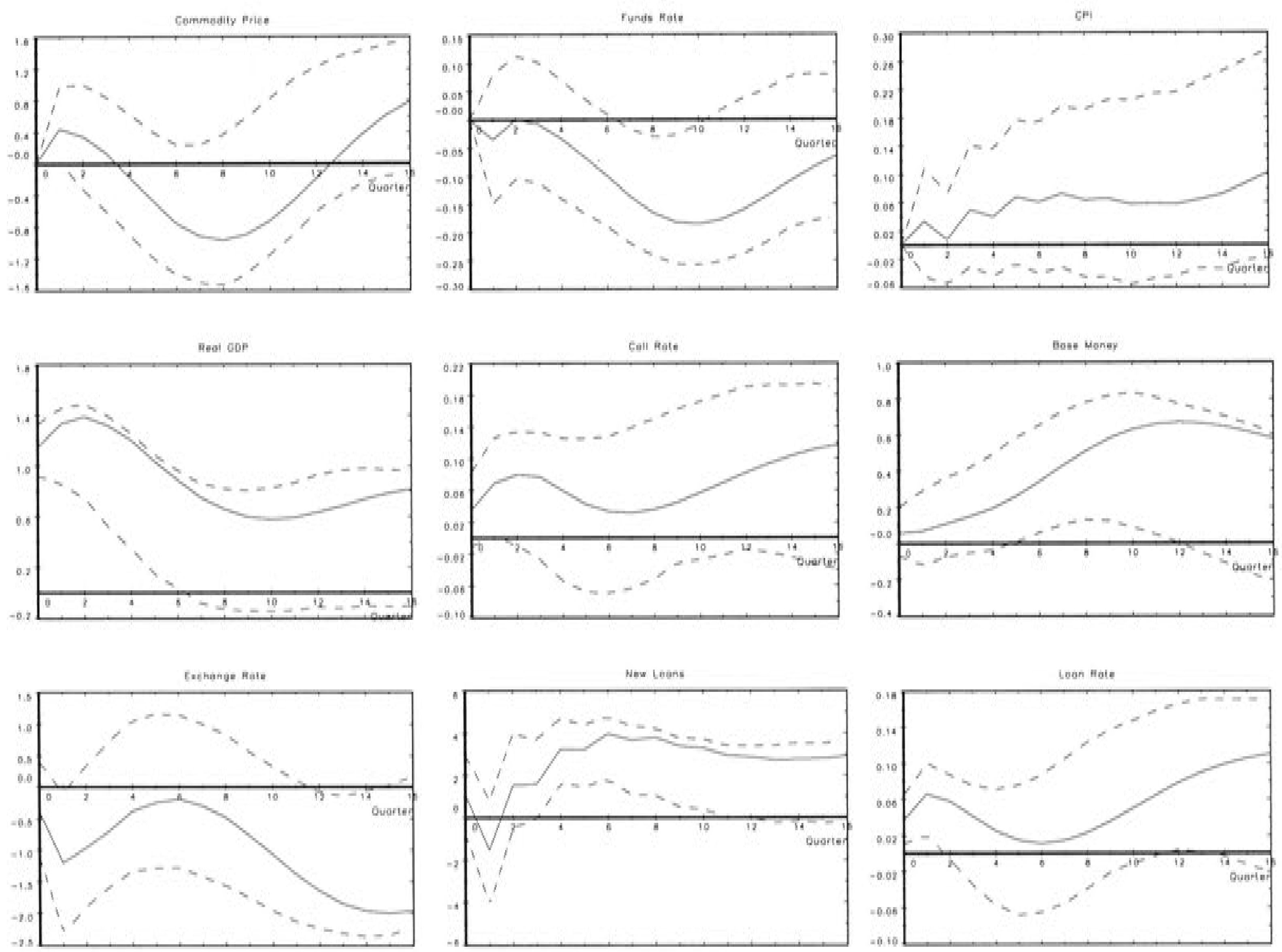

Figure D.4: Responses to a positive shock in the real GDP

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

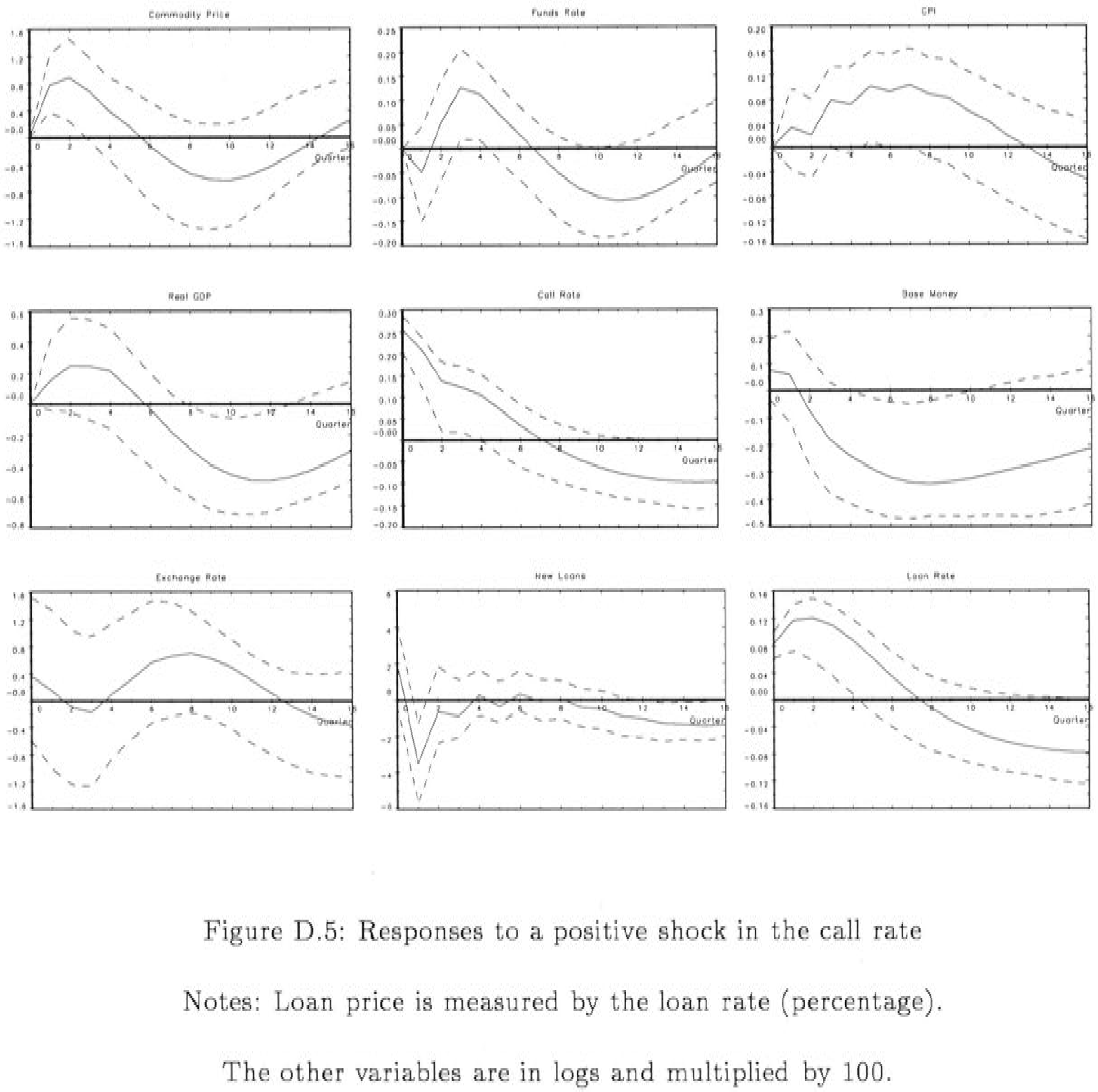

Figure D.5: Responses to a positive shock in the call rate

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

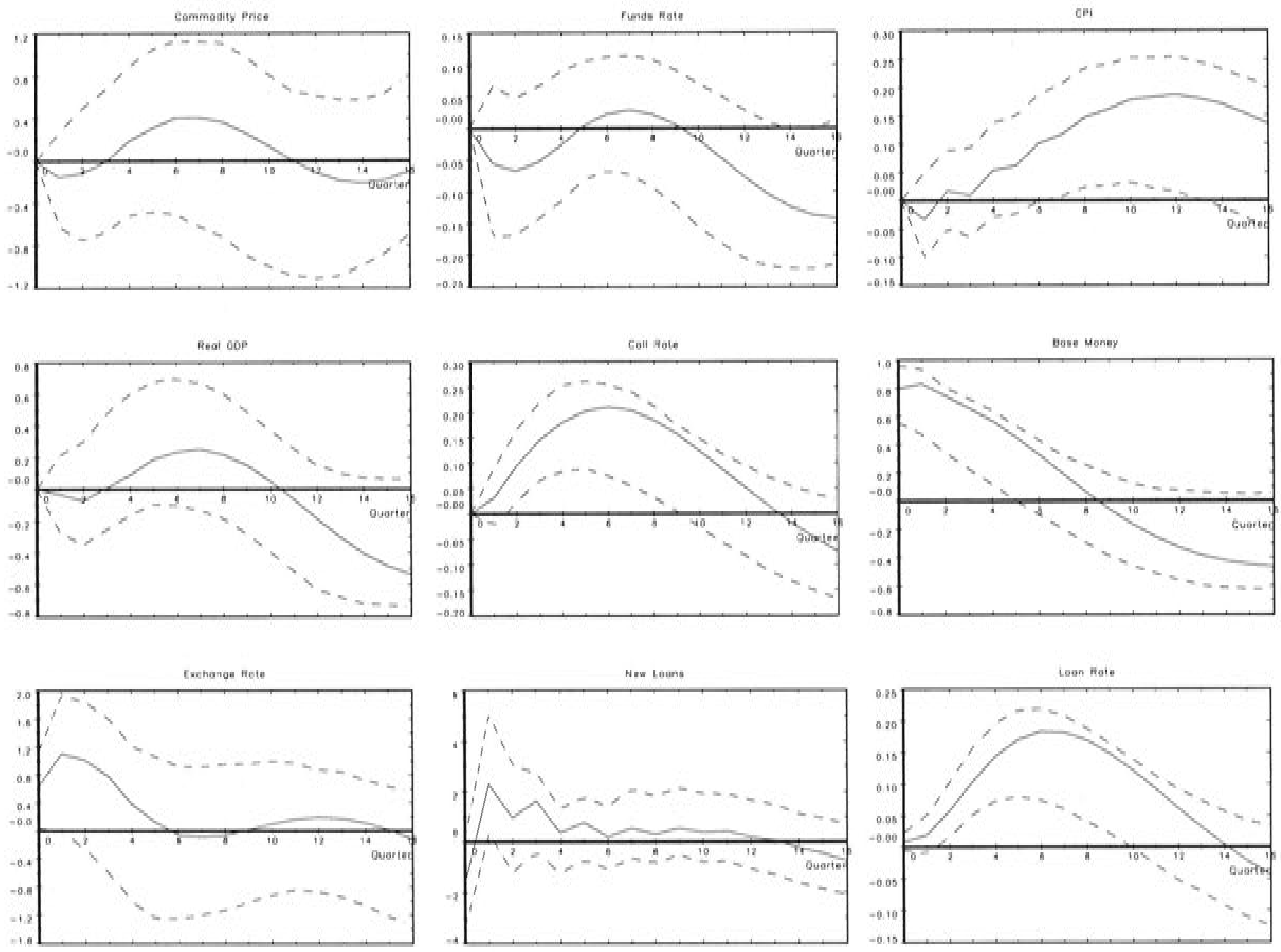

Figure D.6: Responses to a positive shock in the base money

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

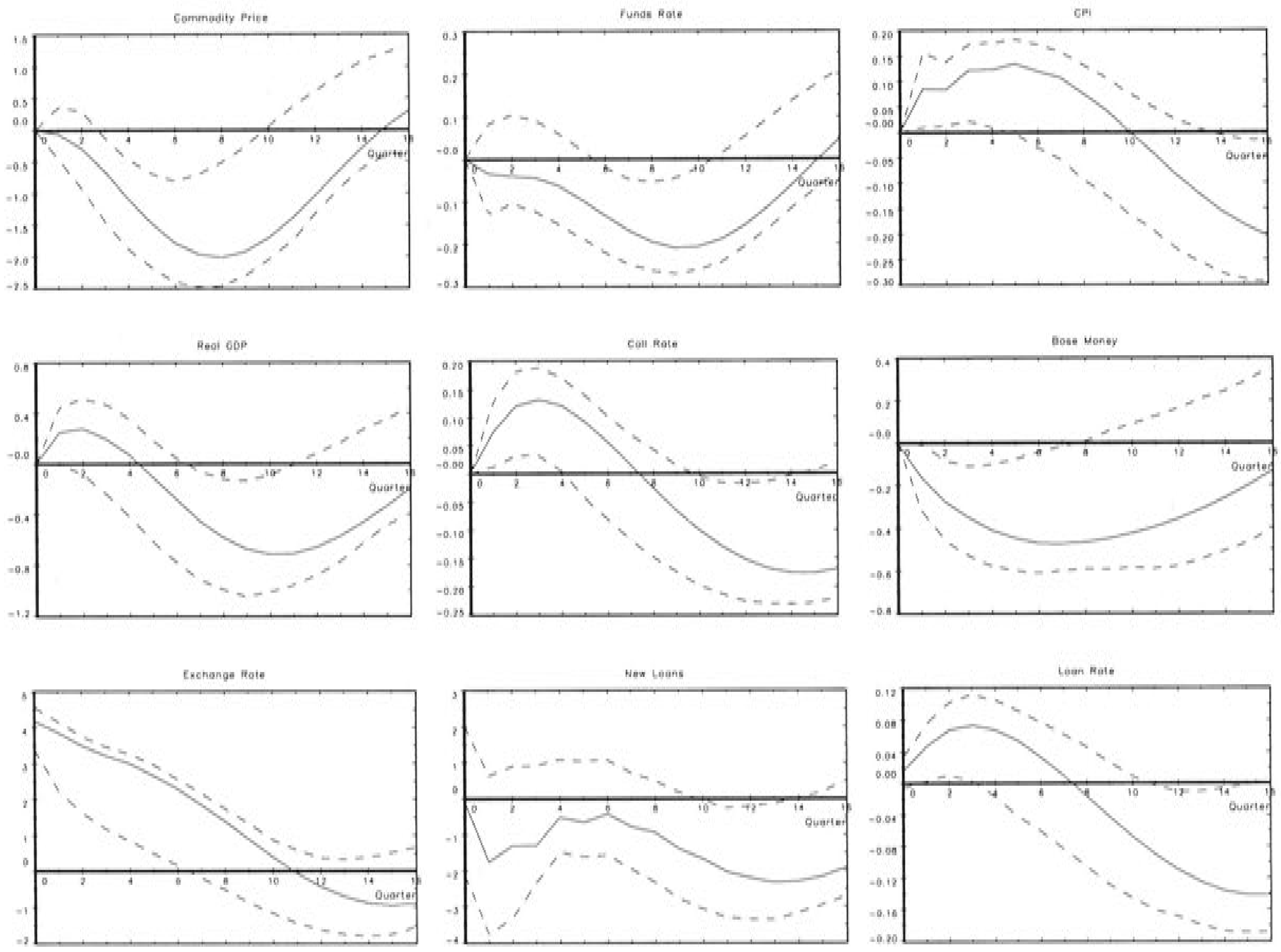

Figure D.7: Responses to a positive shock in the exchange rate

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

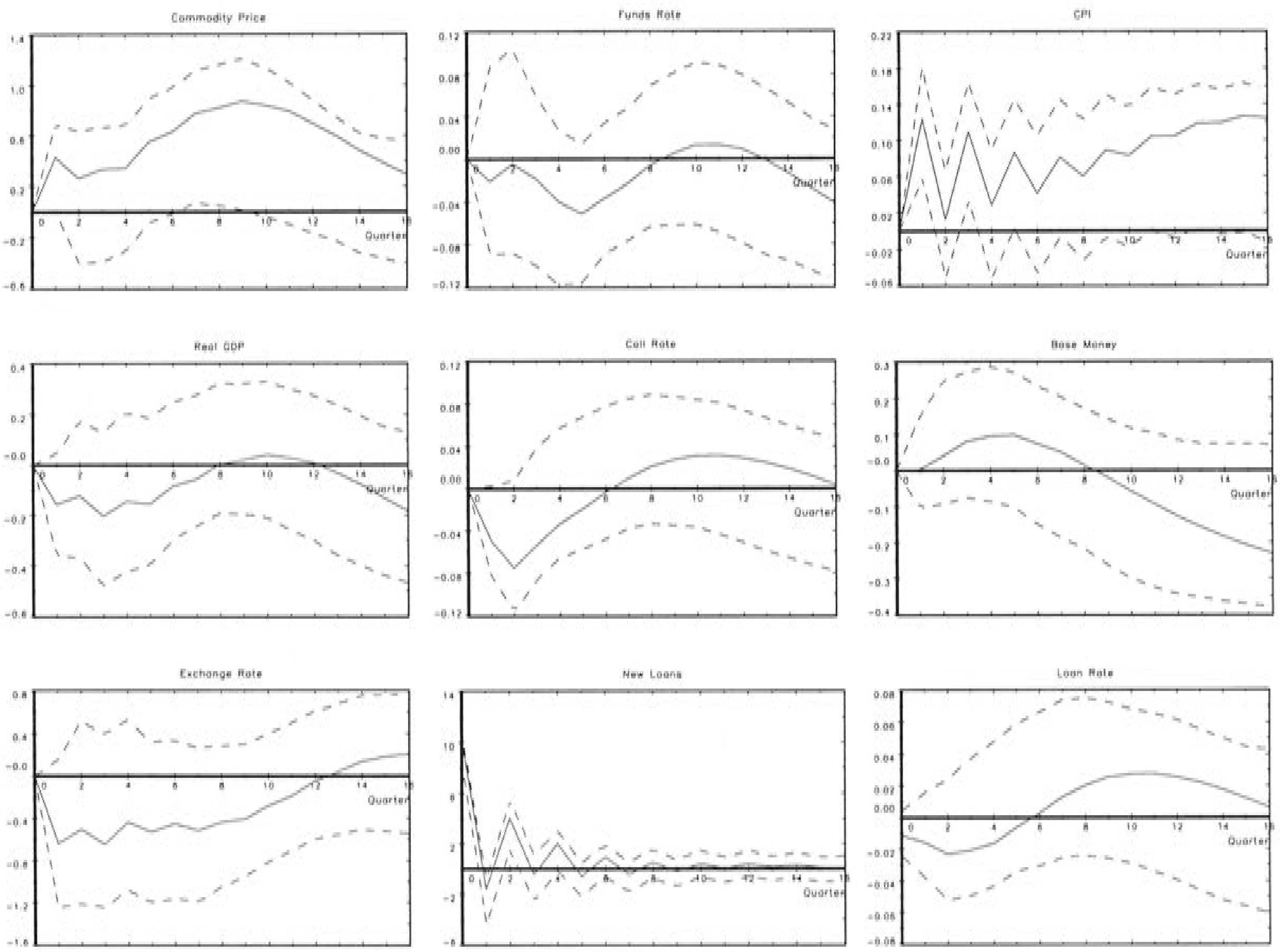

Figure D.8: Responses to a positive shock in the new loans

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

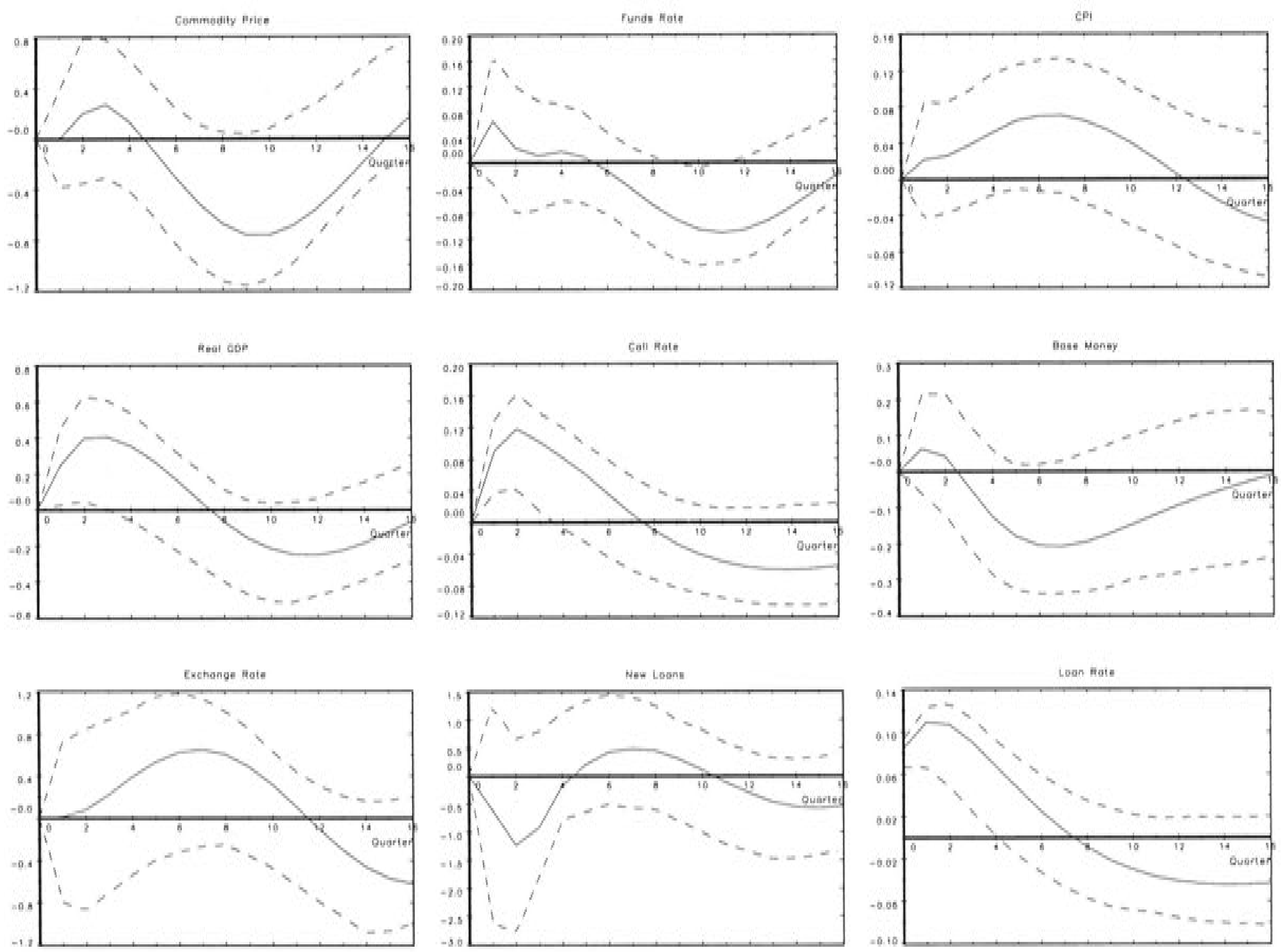

Figure D.9: Responses to a positive shock in the loan price

Notes: Loan price is measured by the loan rate (percentage).

The other variables are in logs and multiplied by 100.

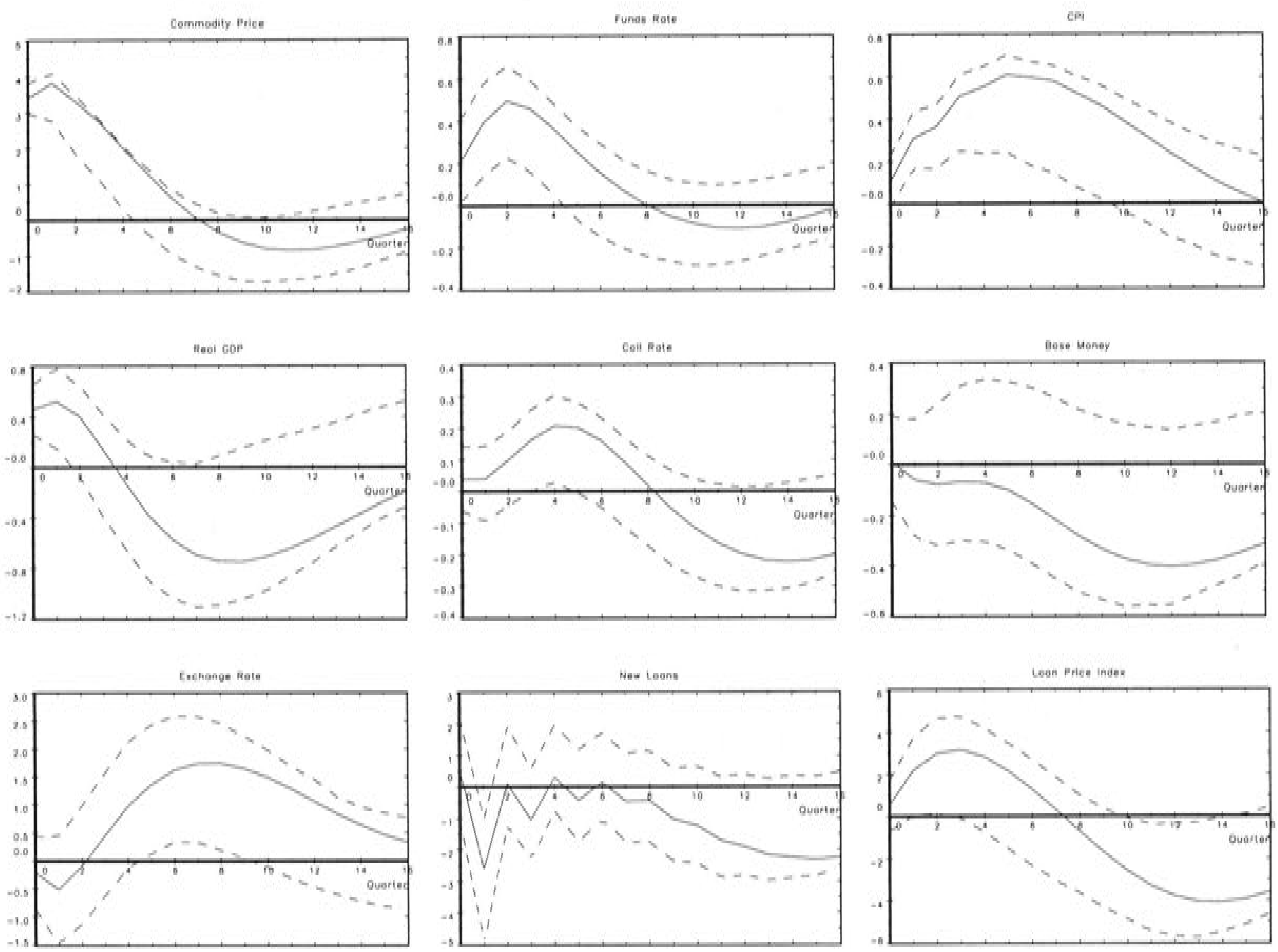

Figure D.10: Responses to a positive shock in the commodity price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

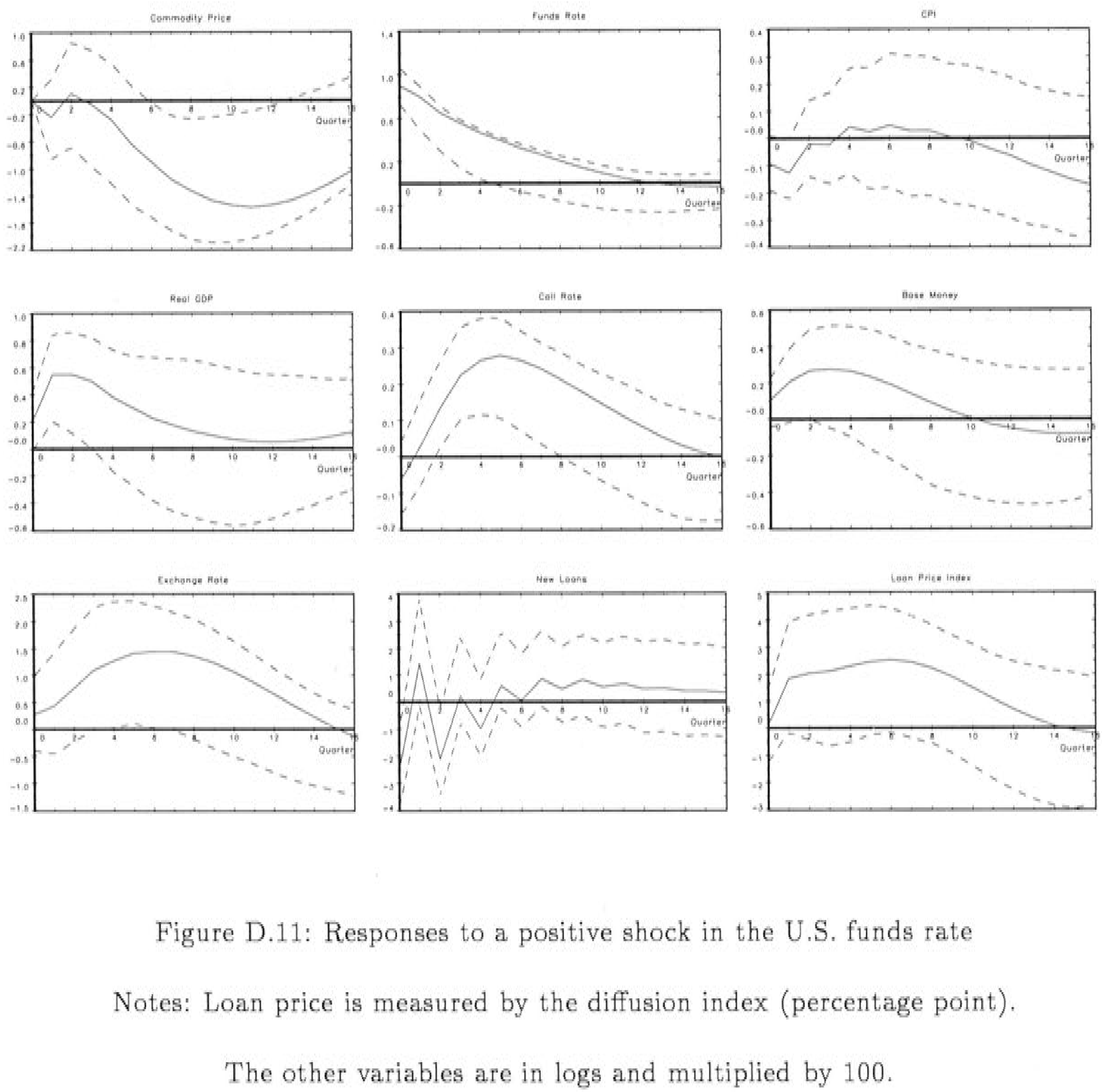

Figure D.11: Responses to a positive shock in the U.S. funds rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

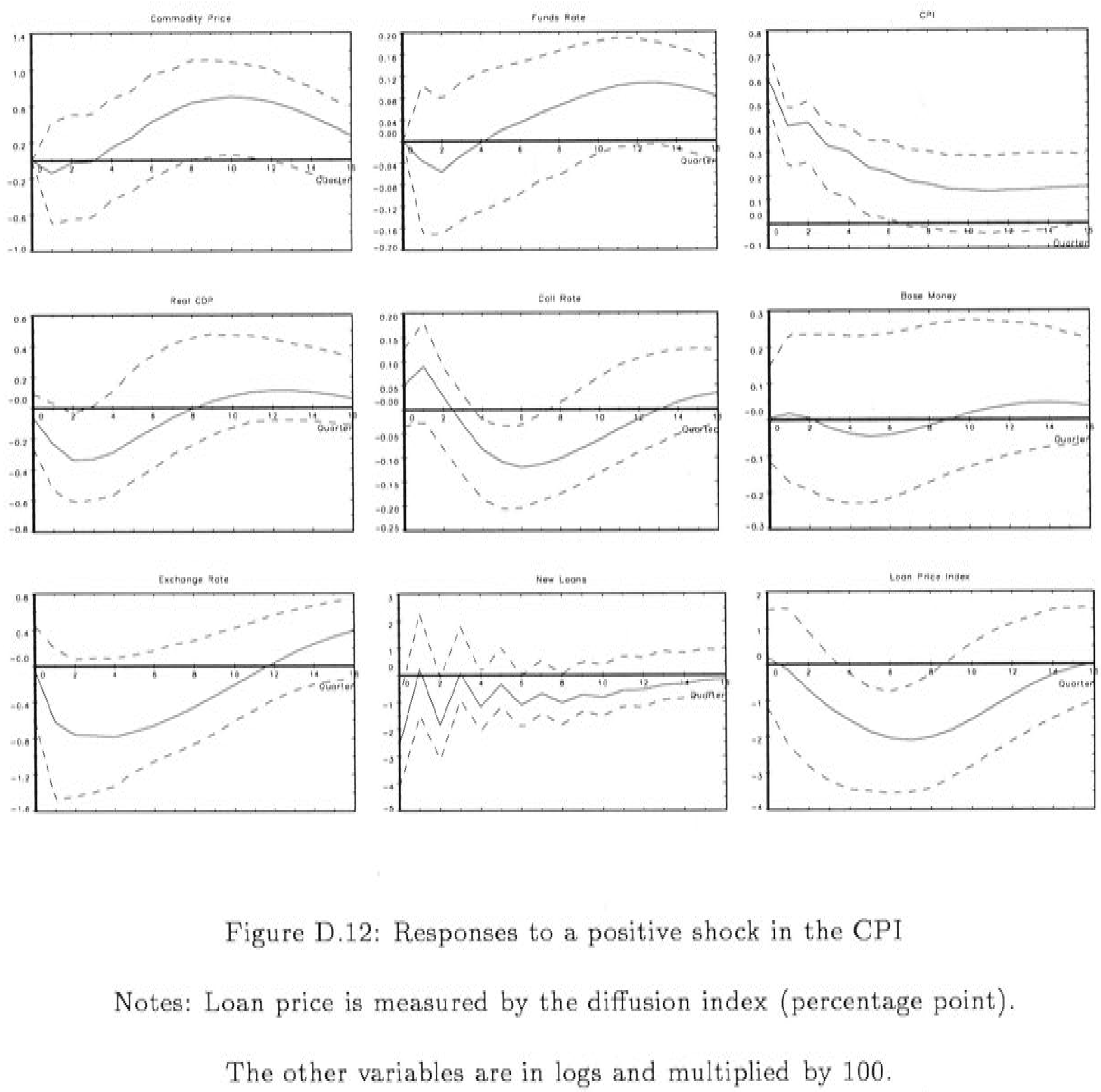

Figure D.12: Responses to a positive shock in the CPI

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

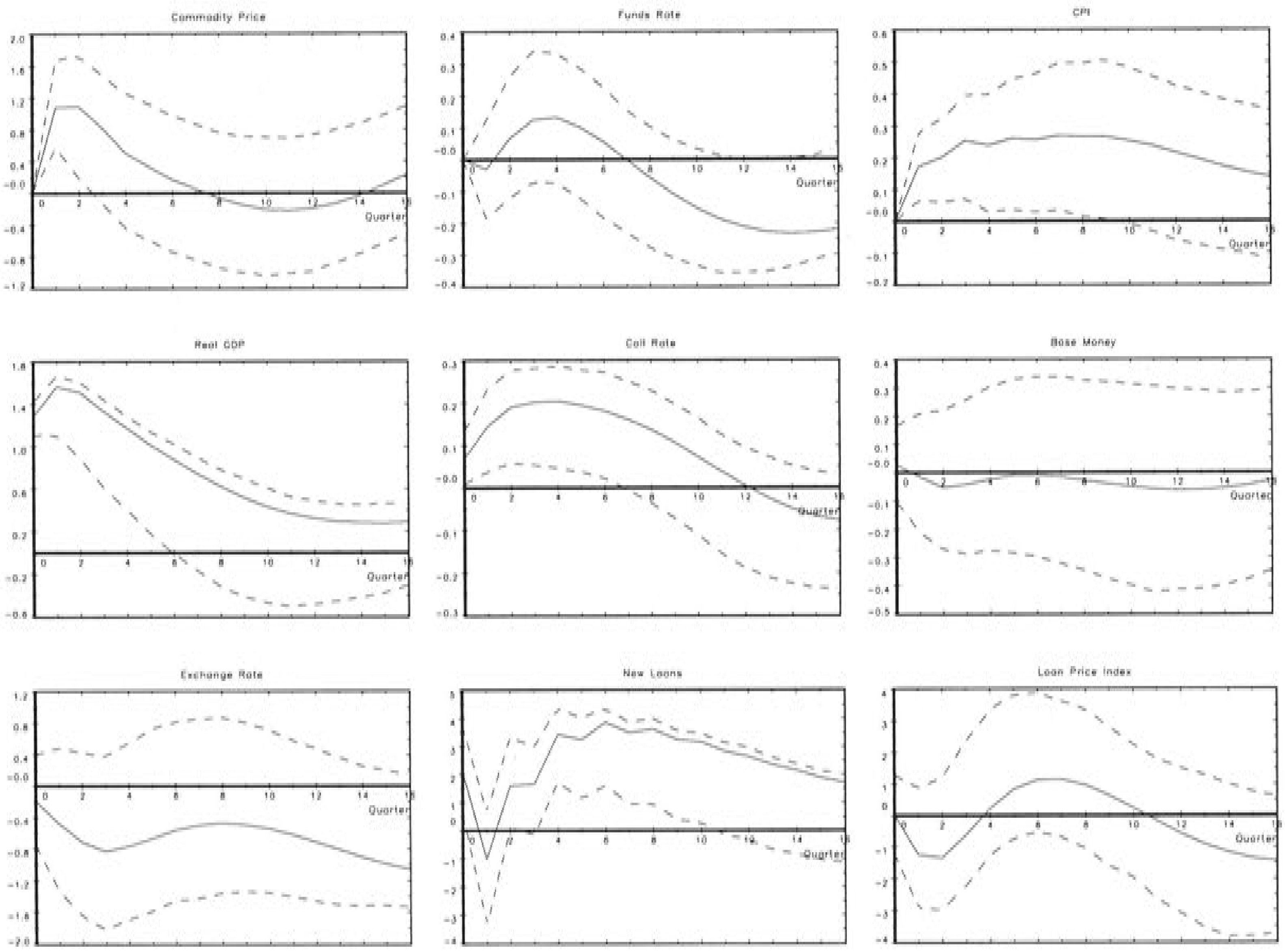

Figure D.13: Responses to a positive shock in the real GDP

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

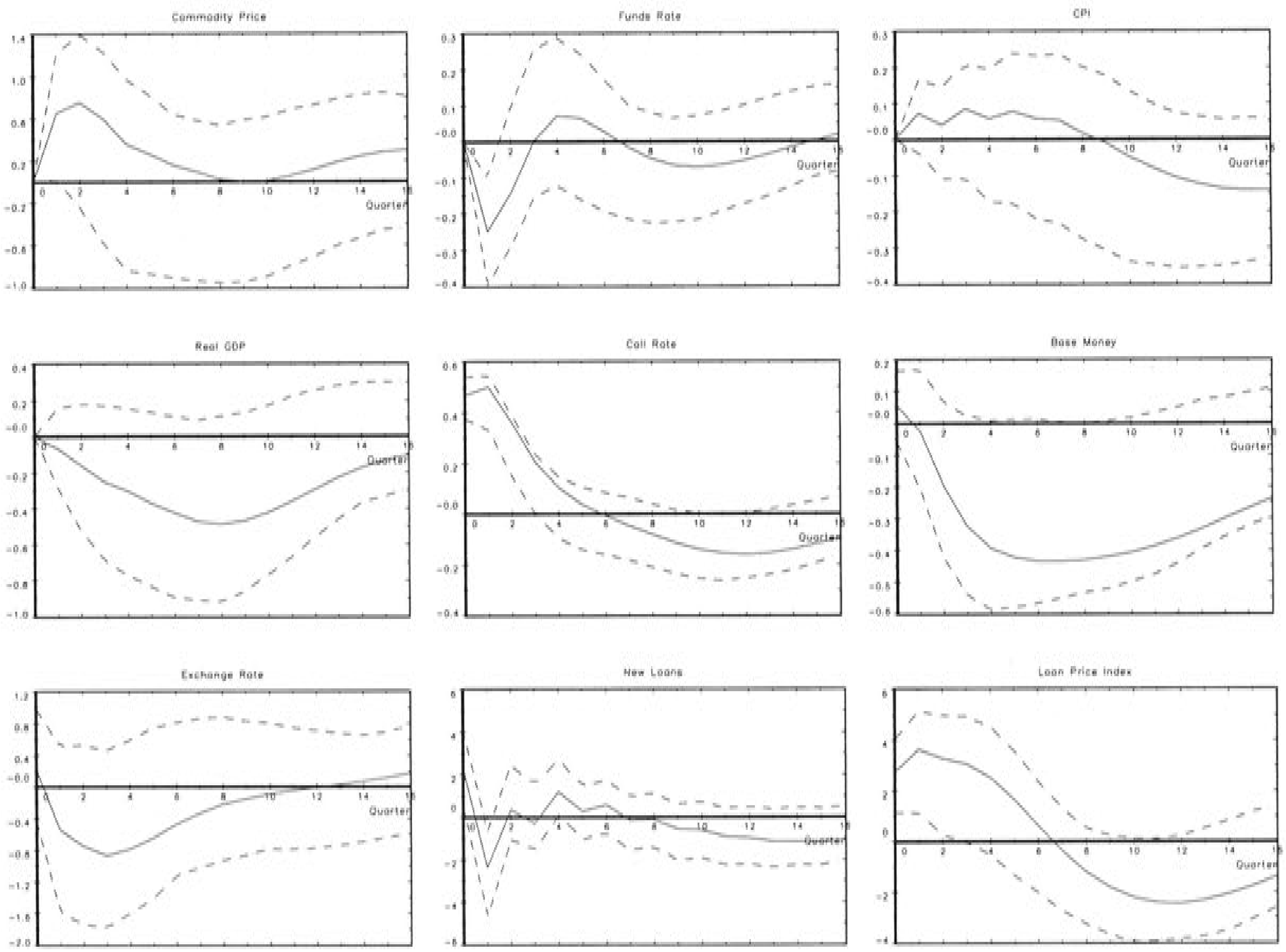

Figure D.14: Responses to a positive shock in the call rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

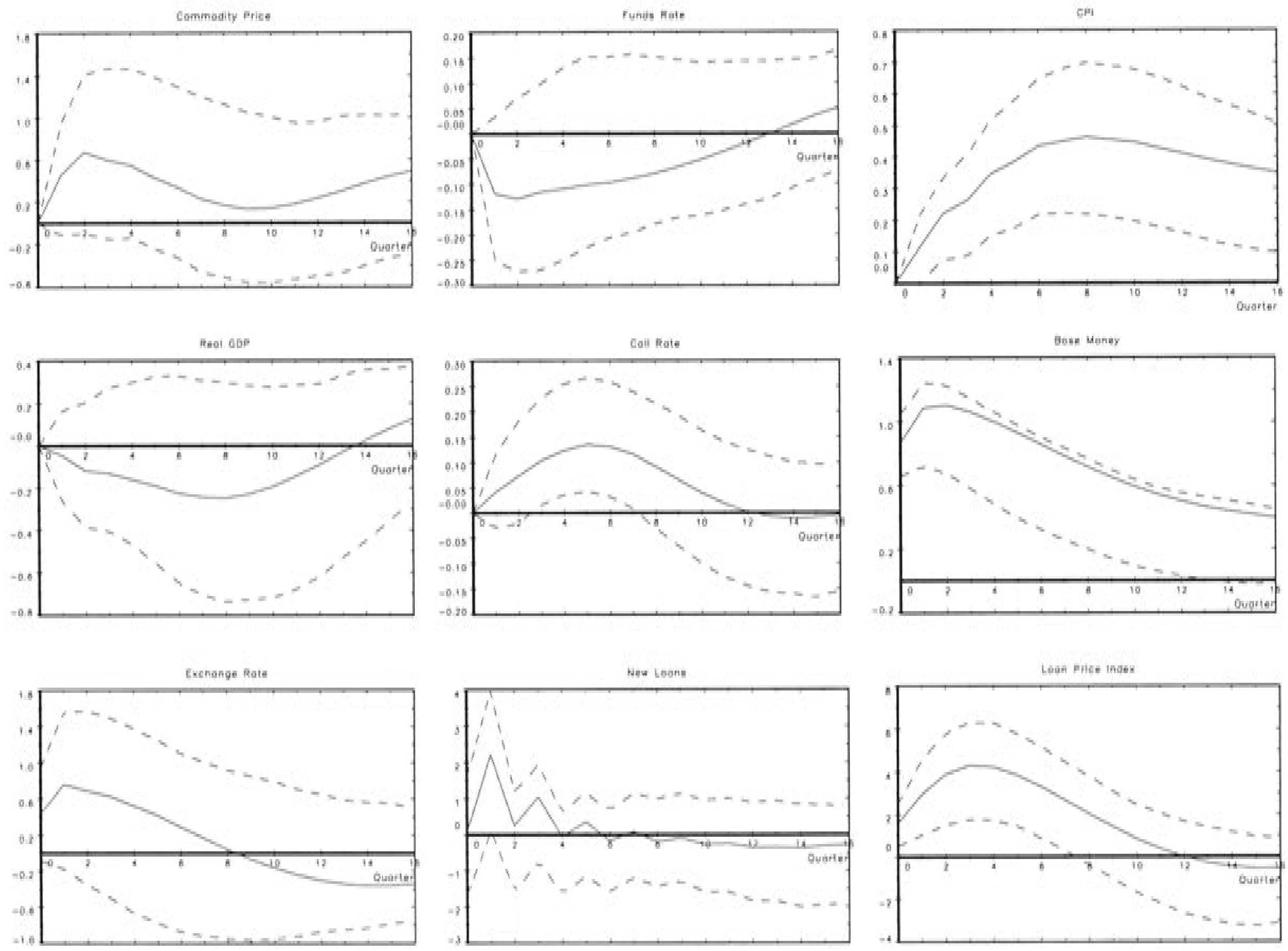

Figure D.15: Responses to a positive shock in the base money

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

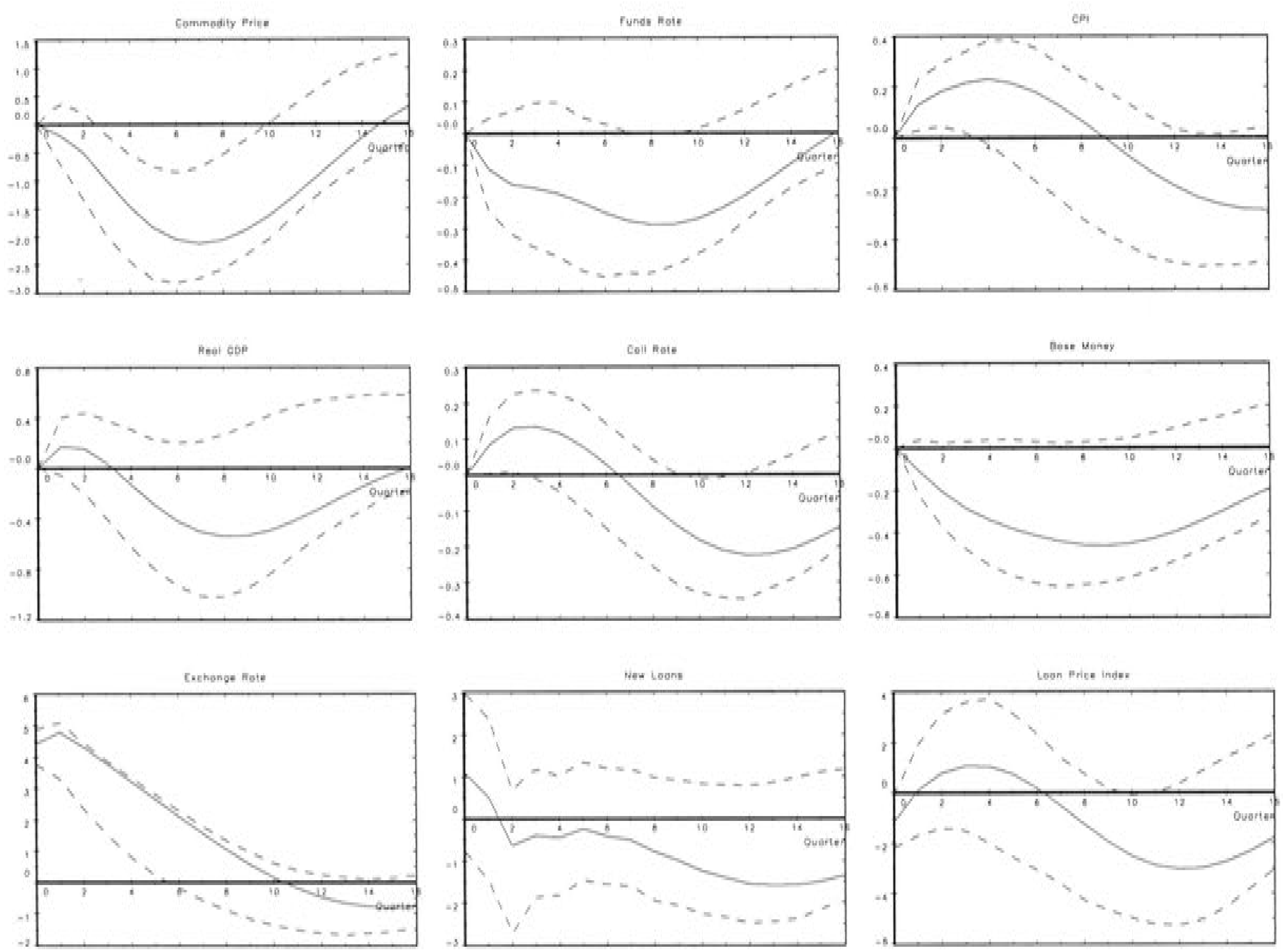

Figure D.16: Responses to a positive shock in the exchange rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

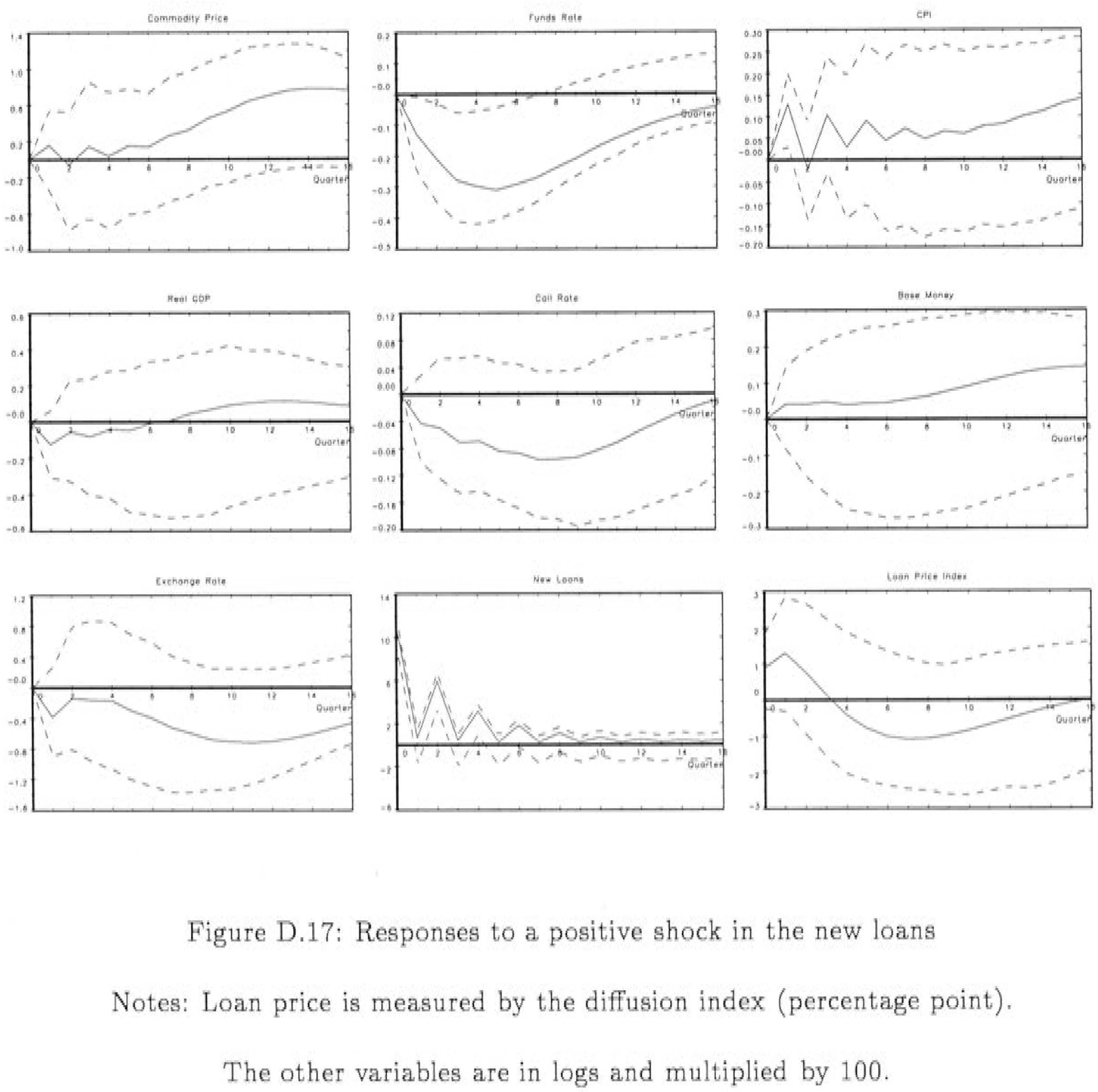

Figure D.17: Responses to a positive shock in the new loans

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

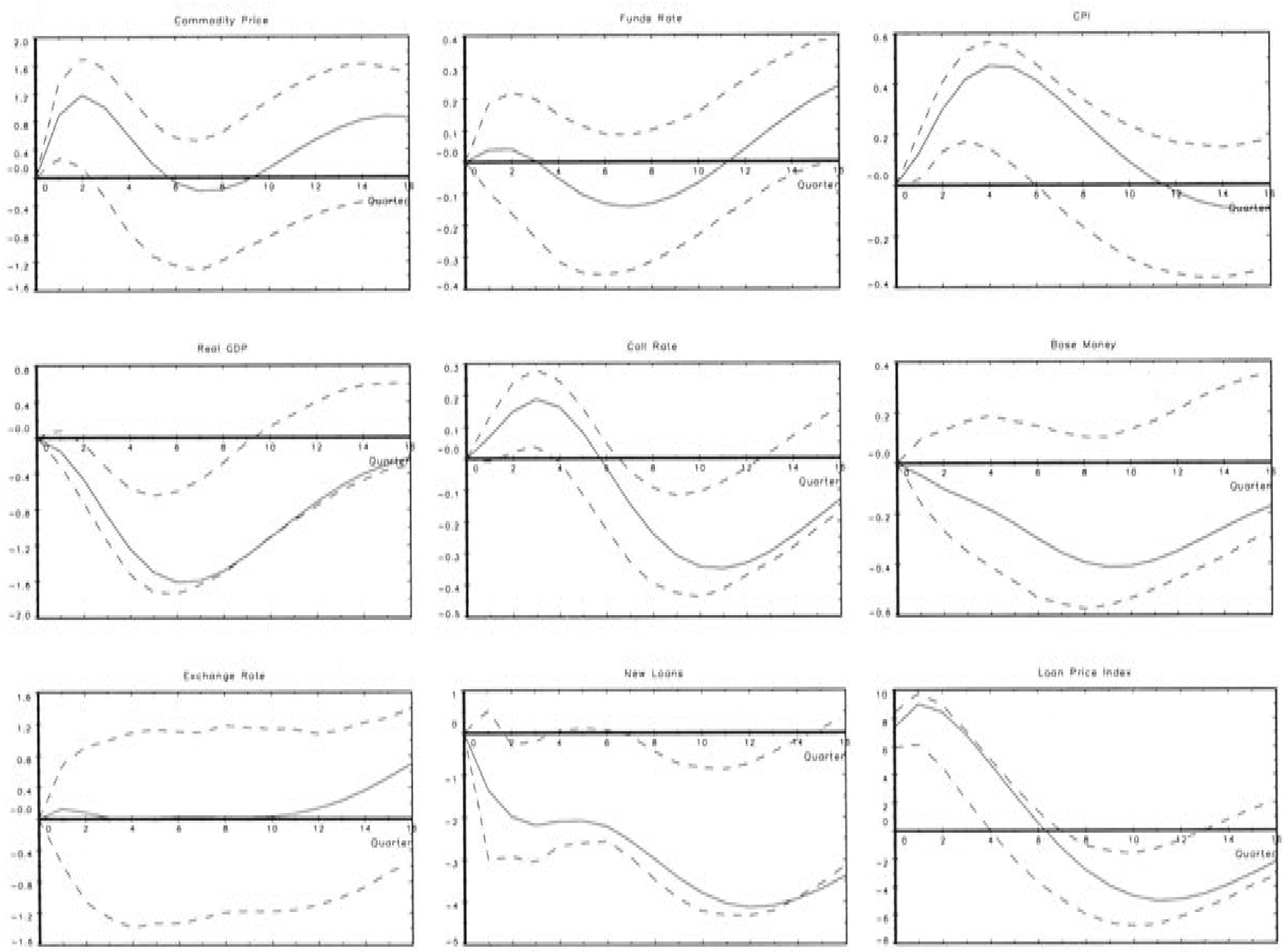

Figure D.18: Responses to a positive shock in the loan price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

Appendix E

An 11-variable model in Ch 2

Given the acceptance of the credit view, chapter 2 adds two asset prices to the set of the variables in an attempt to make distinction between two credit views, namely the balance-sheet view from the bank-lending view. The following eleven figures are all the impulse response functions calculated from the estimated model.

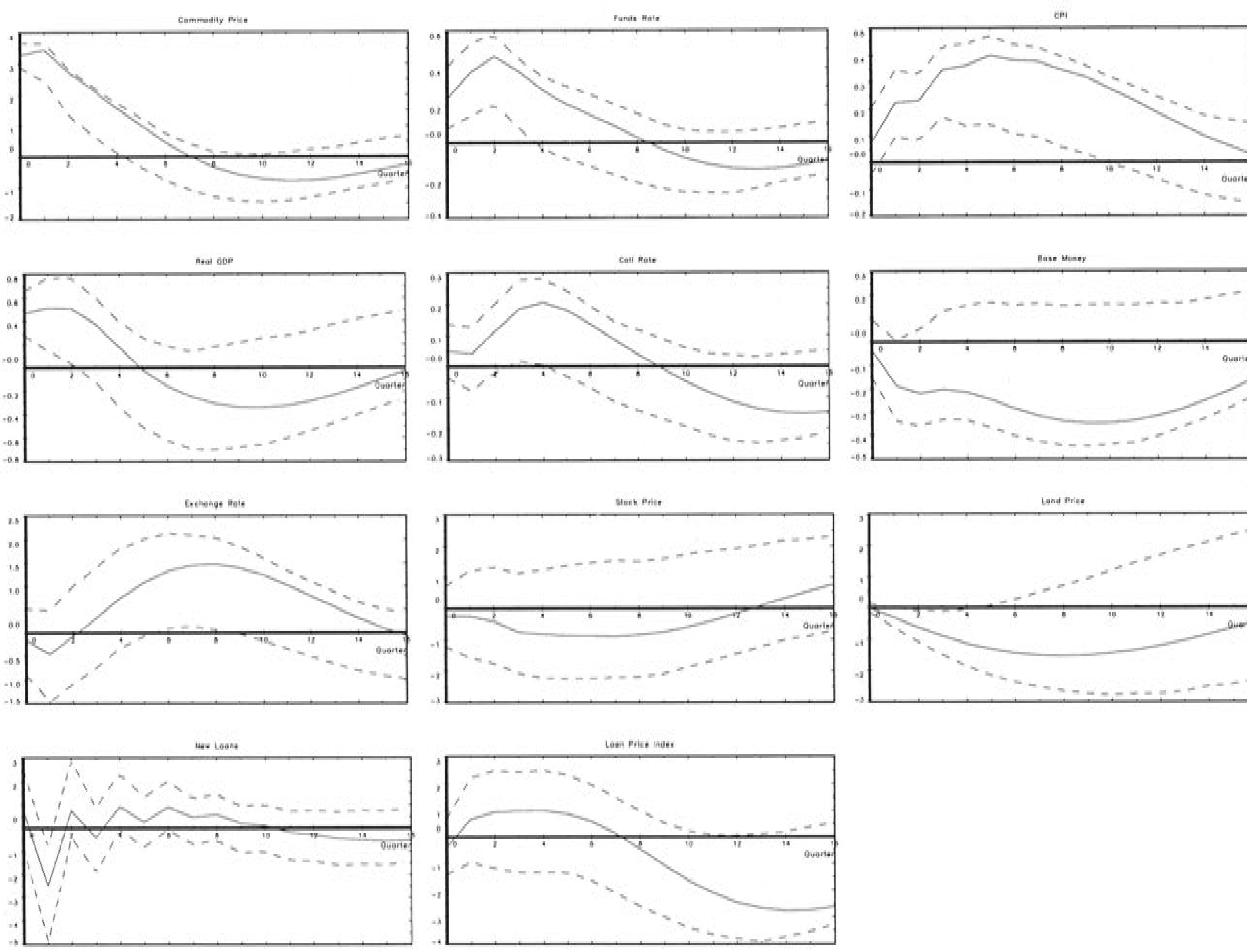

Figure E.1: Responses to a positive shock in the commodity price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

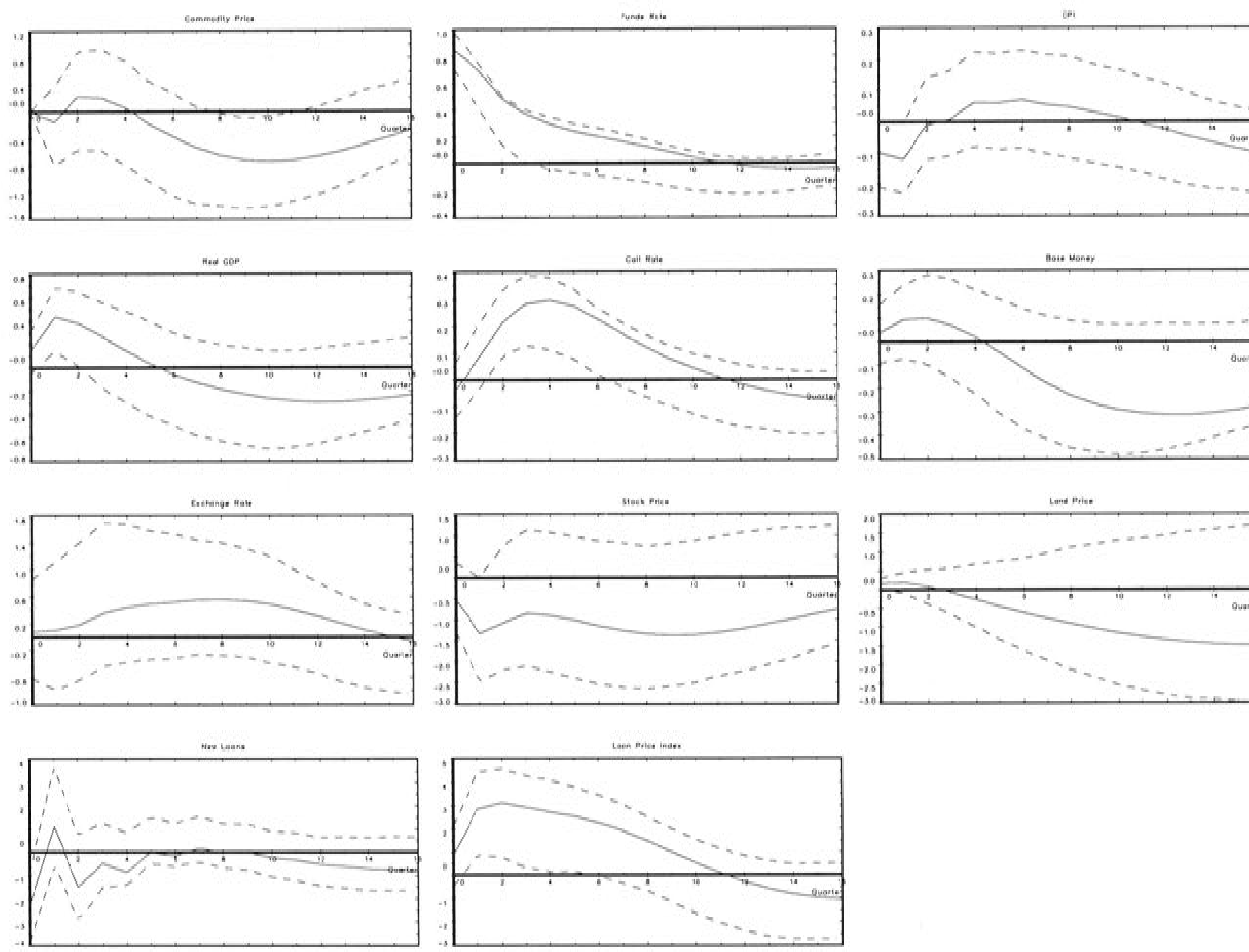

Figure E.2: Responses to a positive shock in the U.S. funds rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

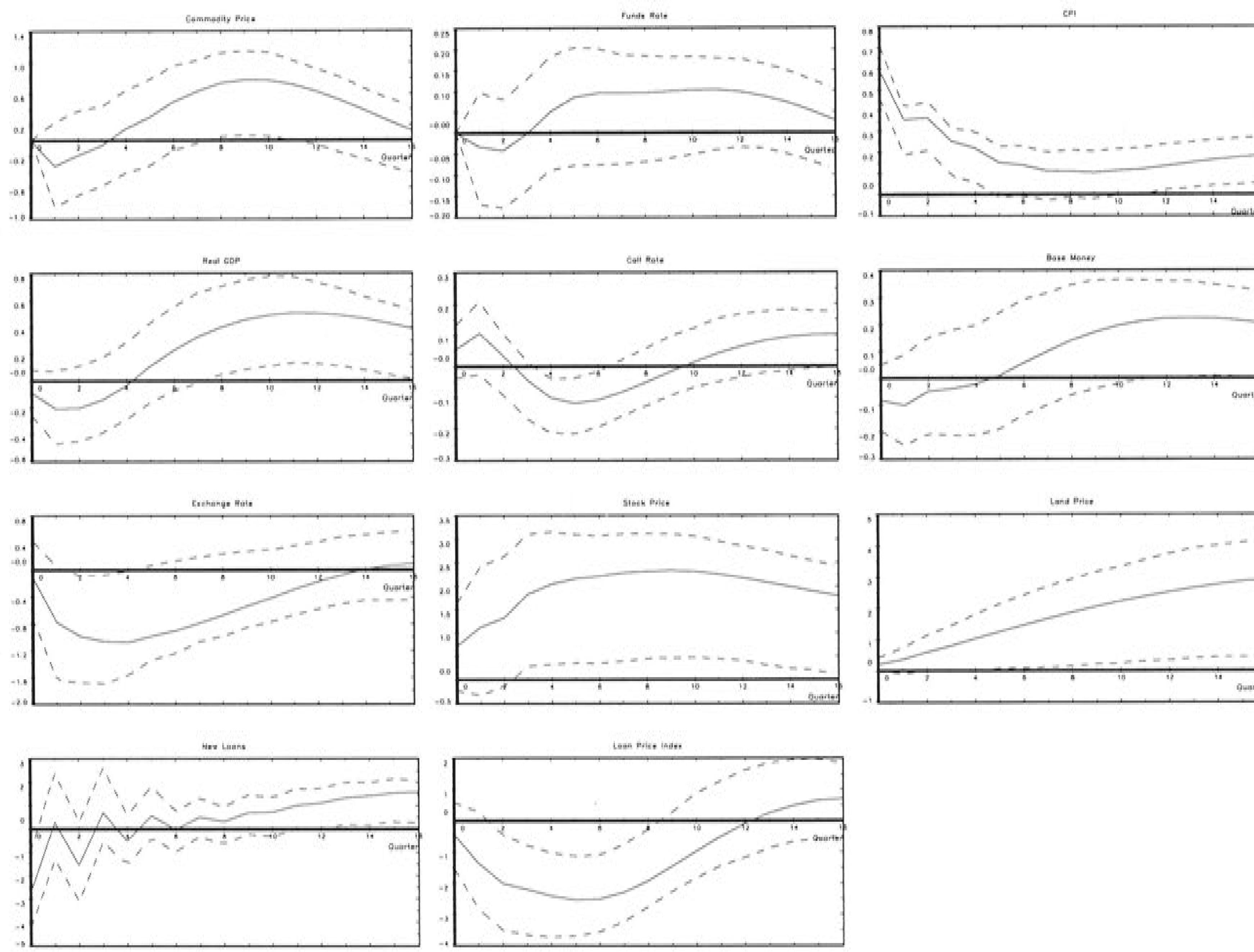

Figure E.3: Responses to a positive shock in the CPI

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

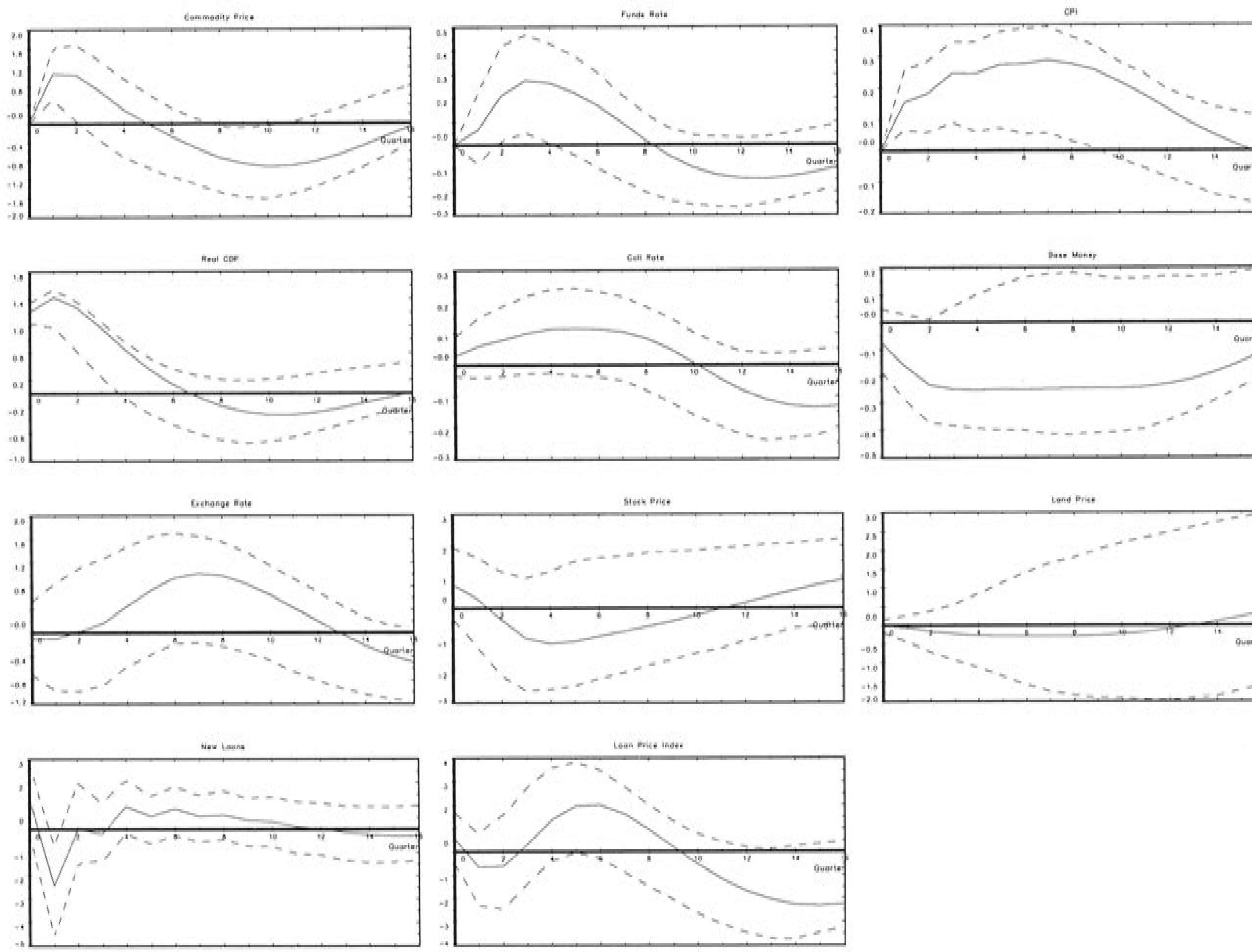

Figure E.4: Responses to a positive shock in the real GDP

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

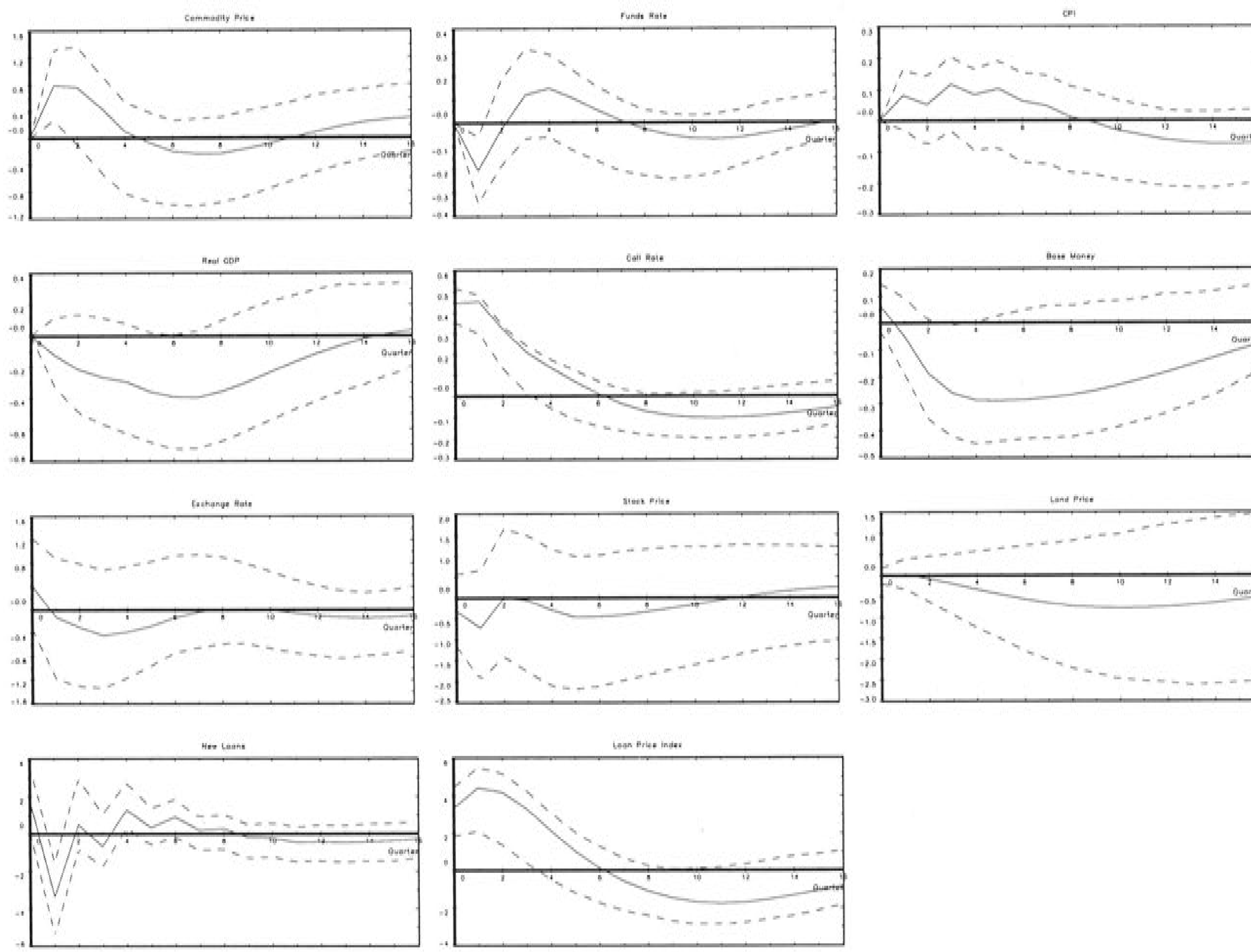

Figure E.5: Responses to a possitive shock in the call rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

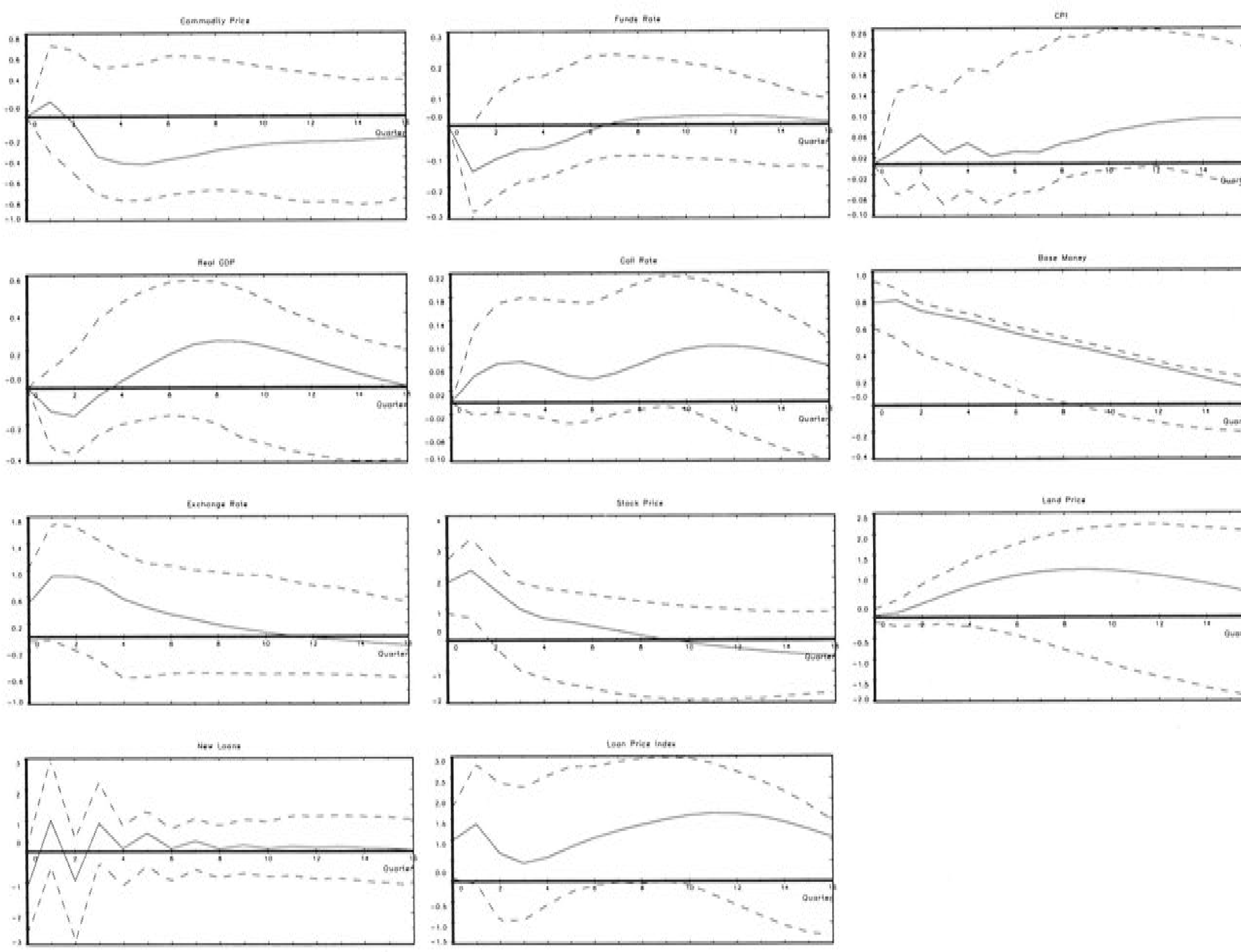

Figure E.6: Responses to a positive shock in the base money

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

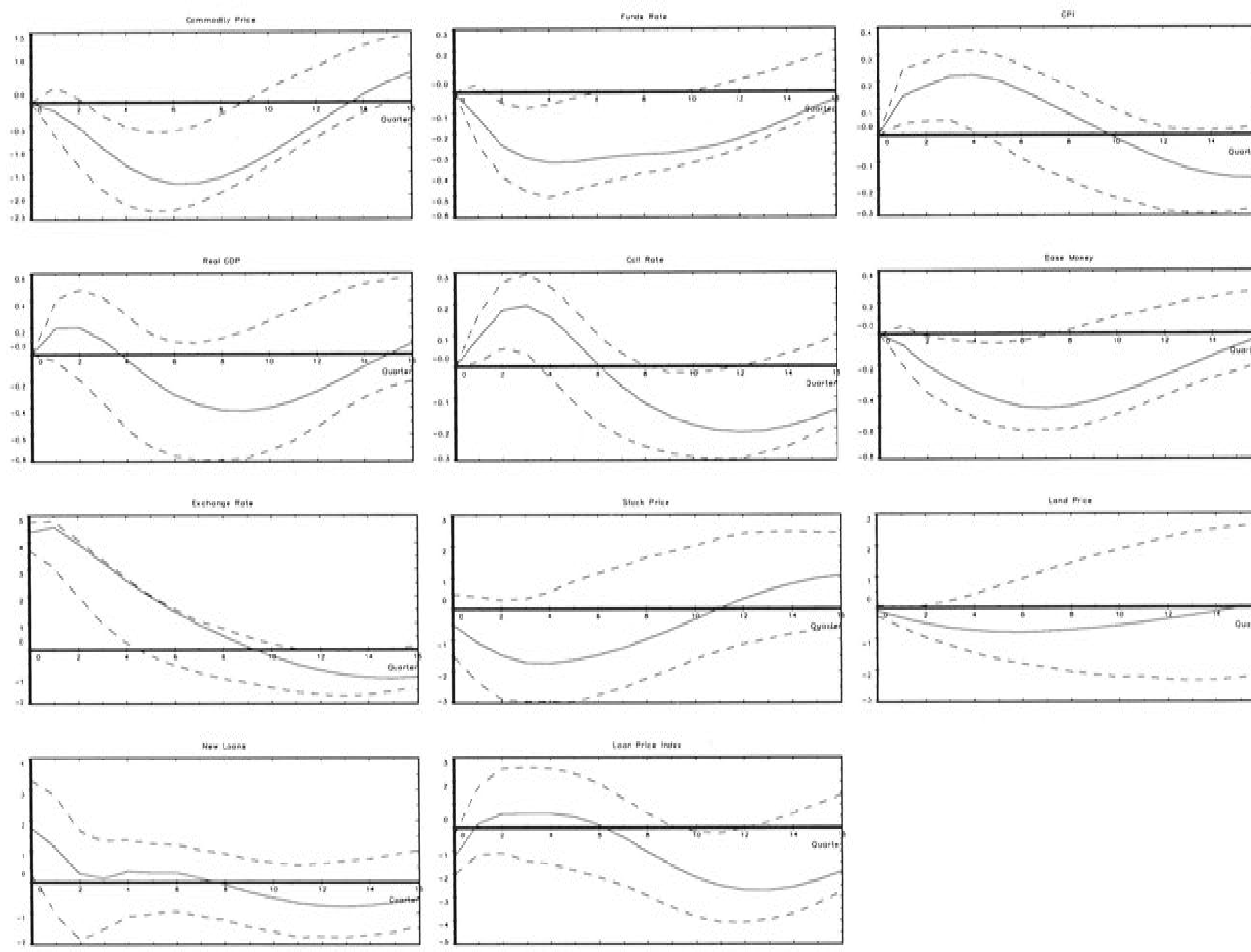

Figure E.7: Responses to a positive shock in the exchange rate

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

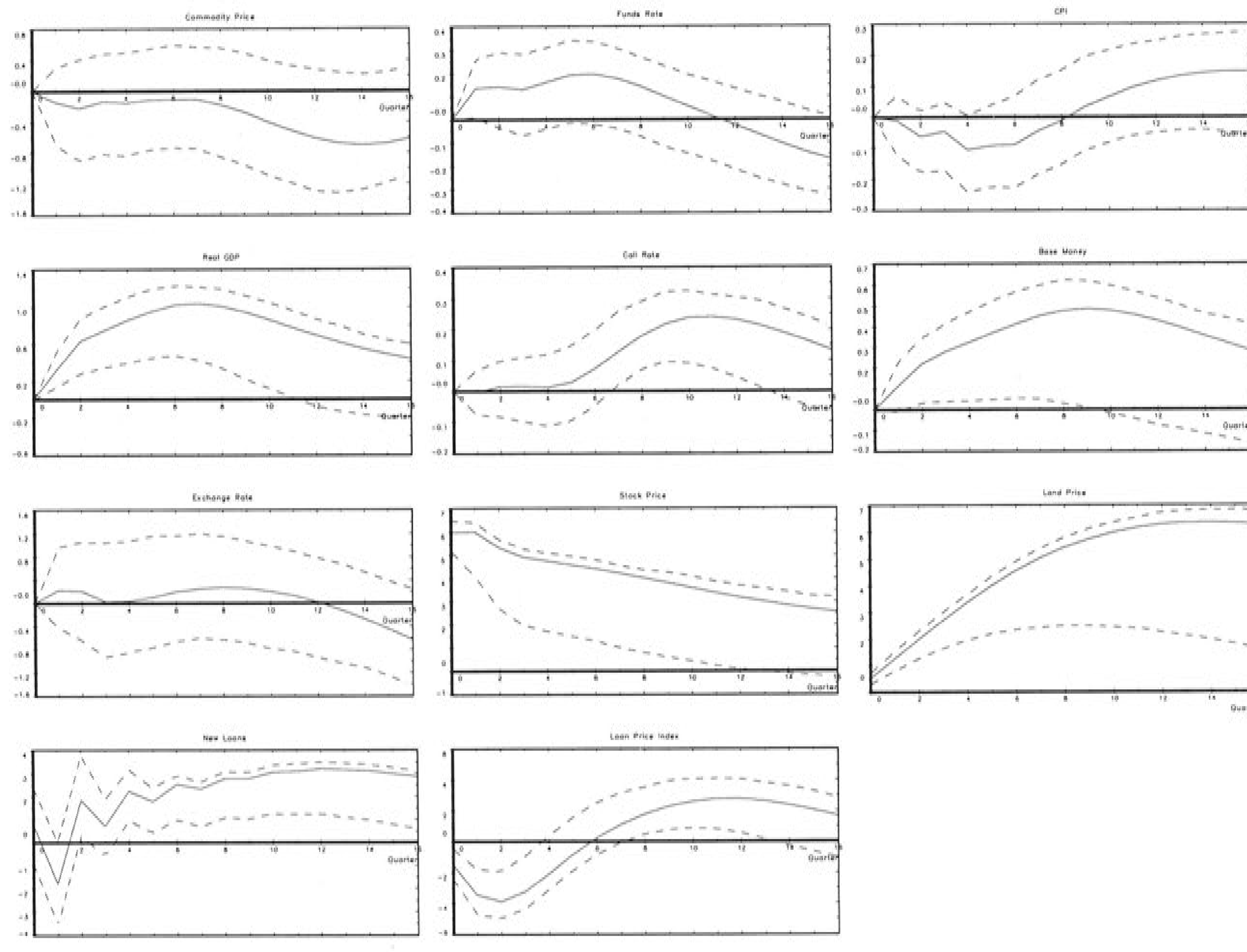

Figure E.8: Responses to a positive shock in the stock price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

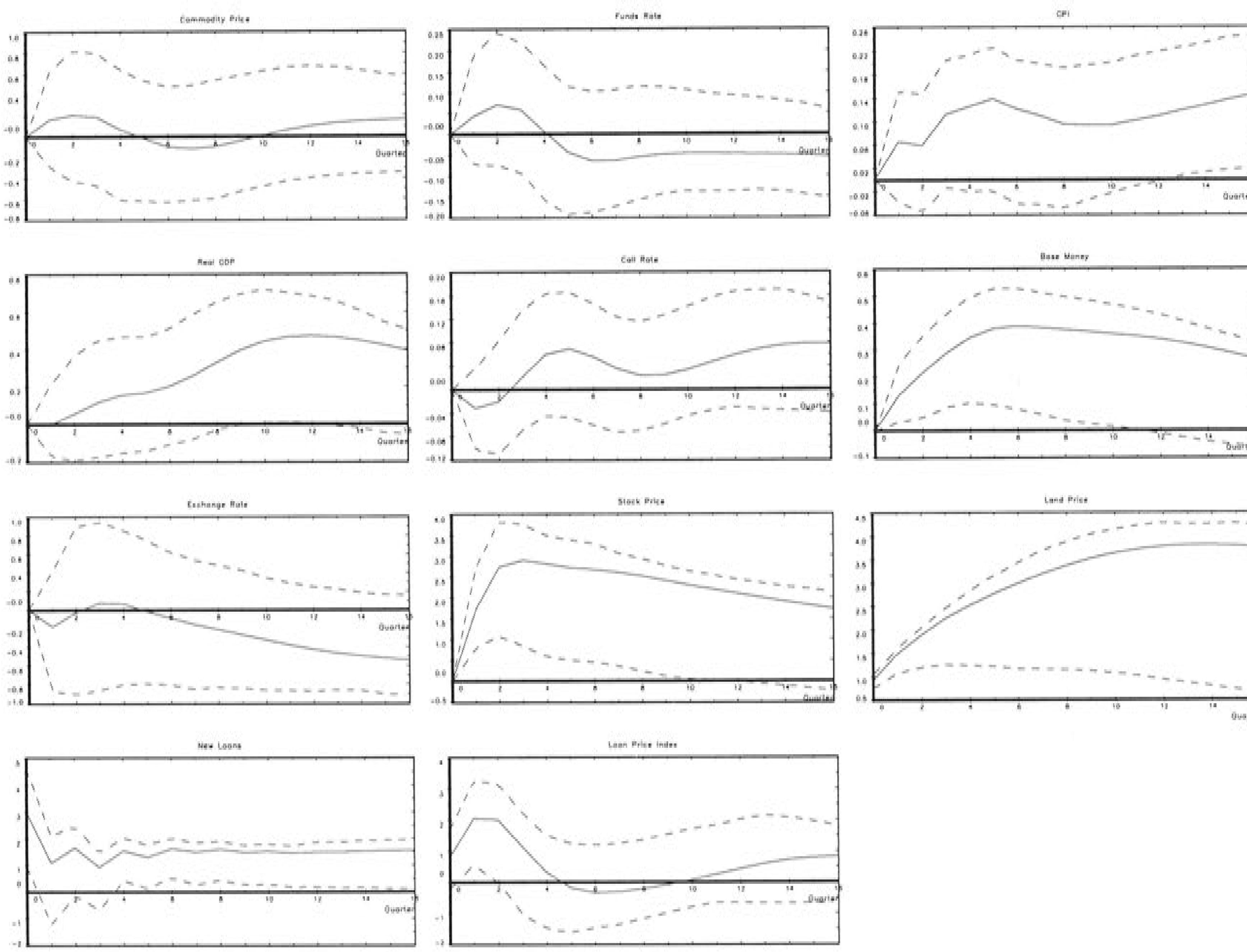

Figure E.9: Responses to a positive shock in the land price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

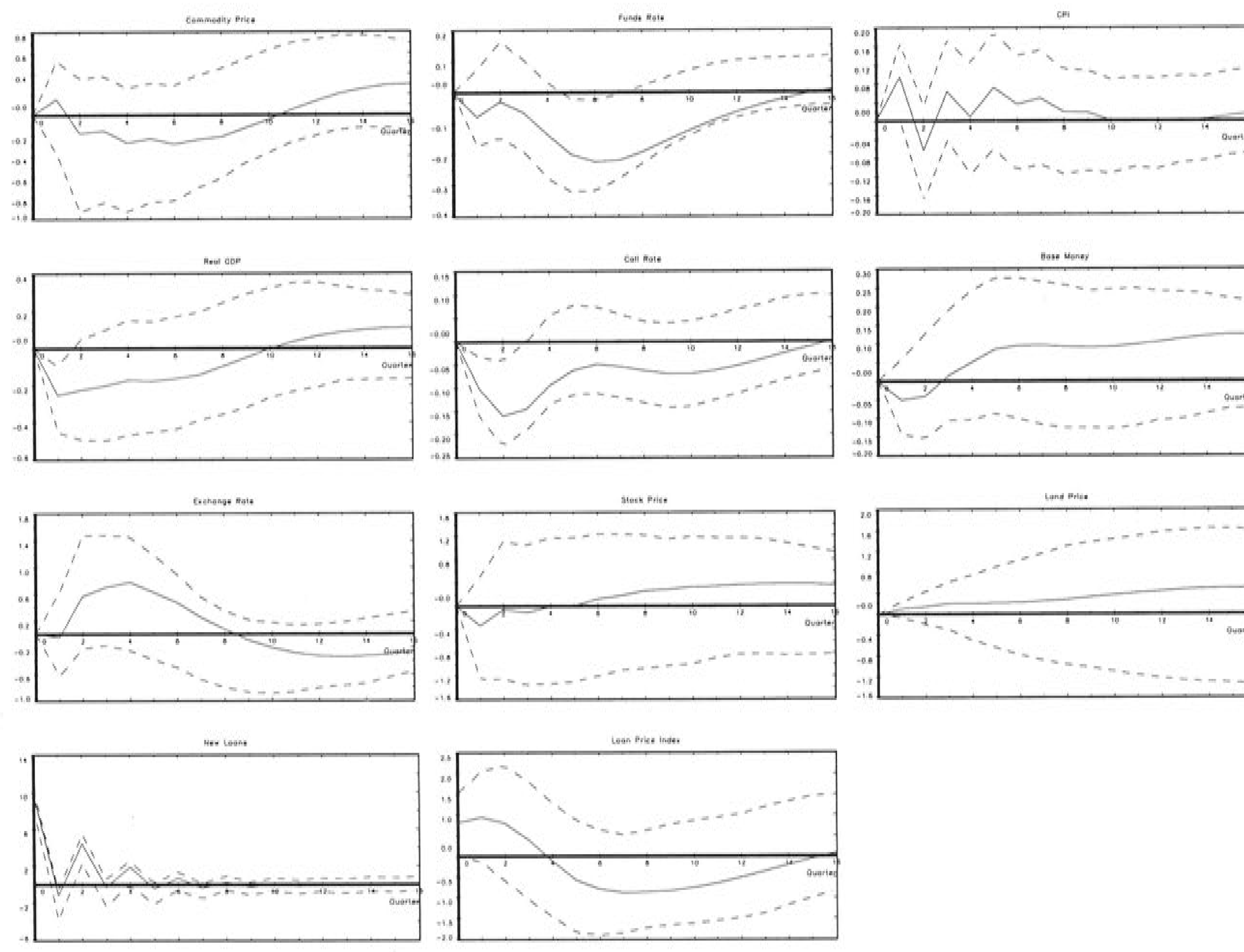

Figure E.10: Responses to a positive shock in the new loans

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

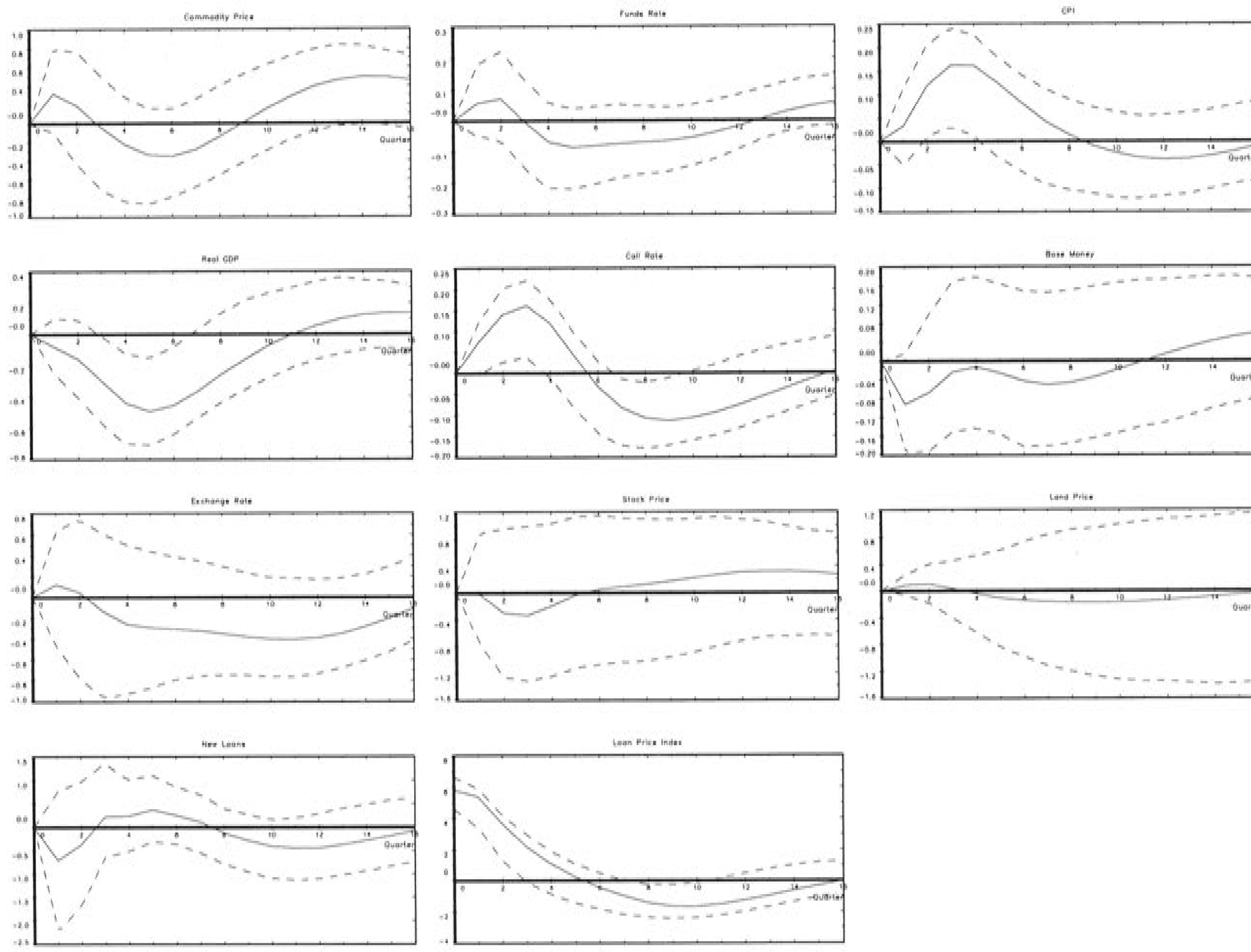

Figure E.11: Responses to a positive shock in the loan price

Notes: Loan price is measured by the diffusion index (percentage point).

The other variables are in logs and multiplied by 100.

Appendix F

A closed-economy model in Ch 3

Chapter 3 estimates the closed-economy model, calculating the impulse response functions to a shock in the call rate. The following eight diagrams are all the impulse response functions calculated from the estimated model.

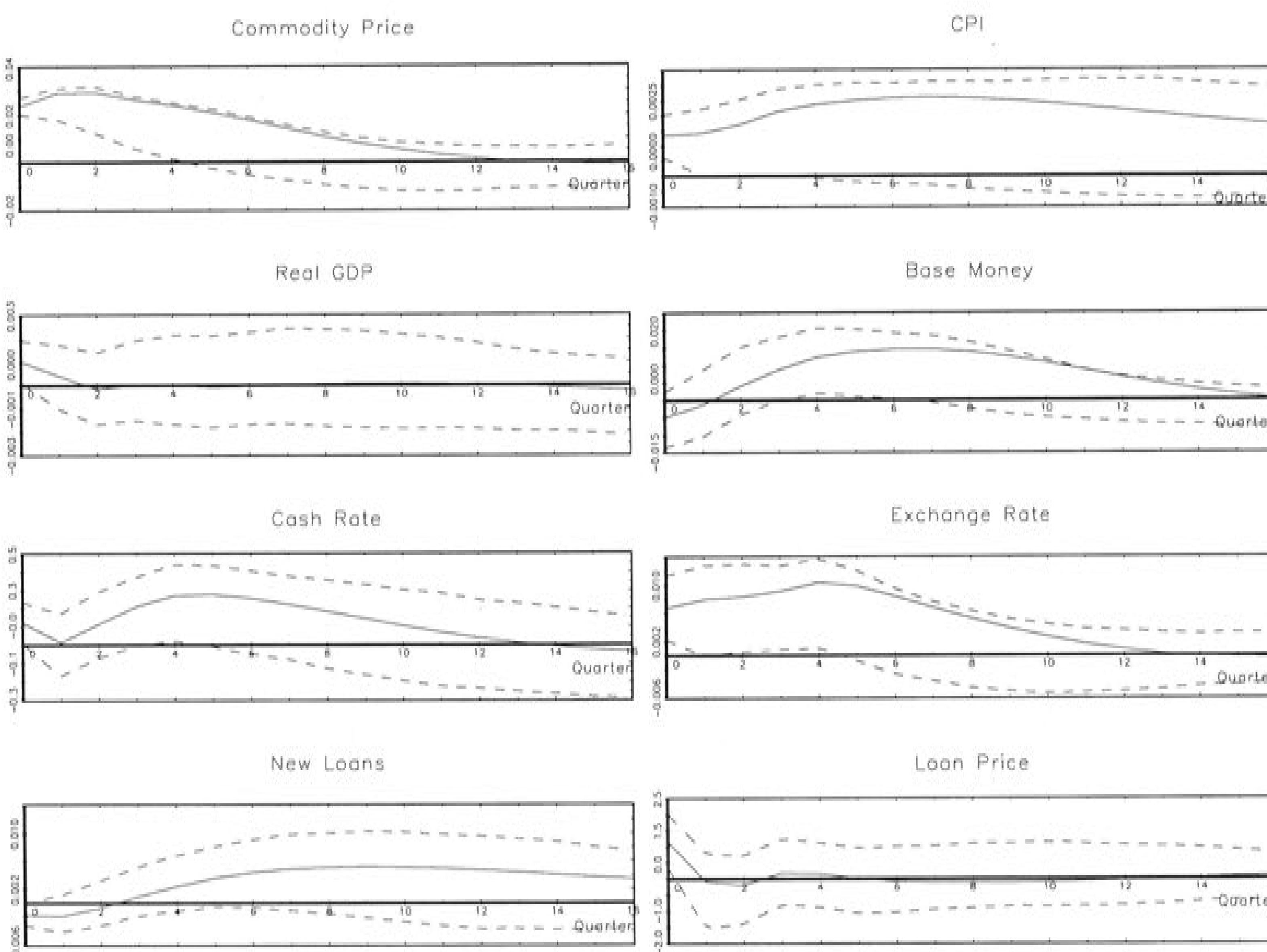

Figure F.1: Responses to a shock in the commodity price

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

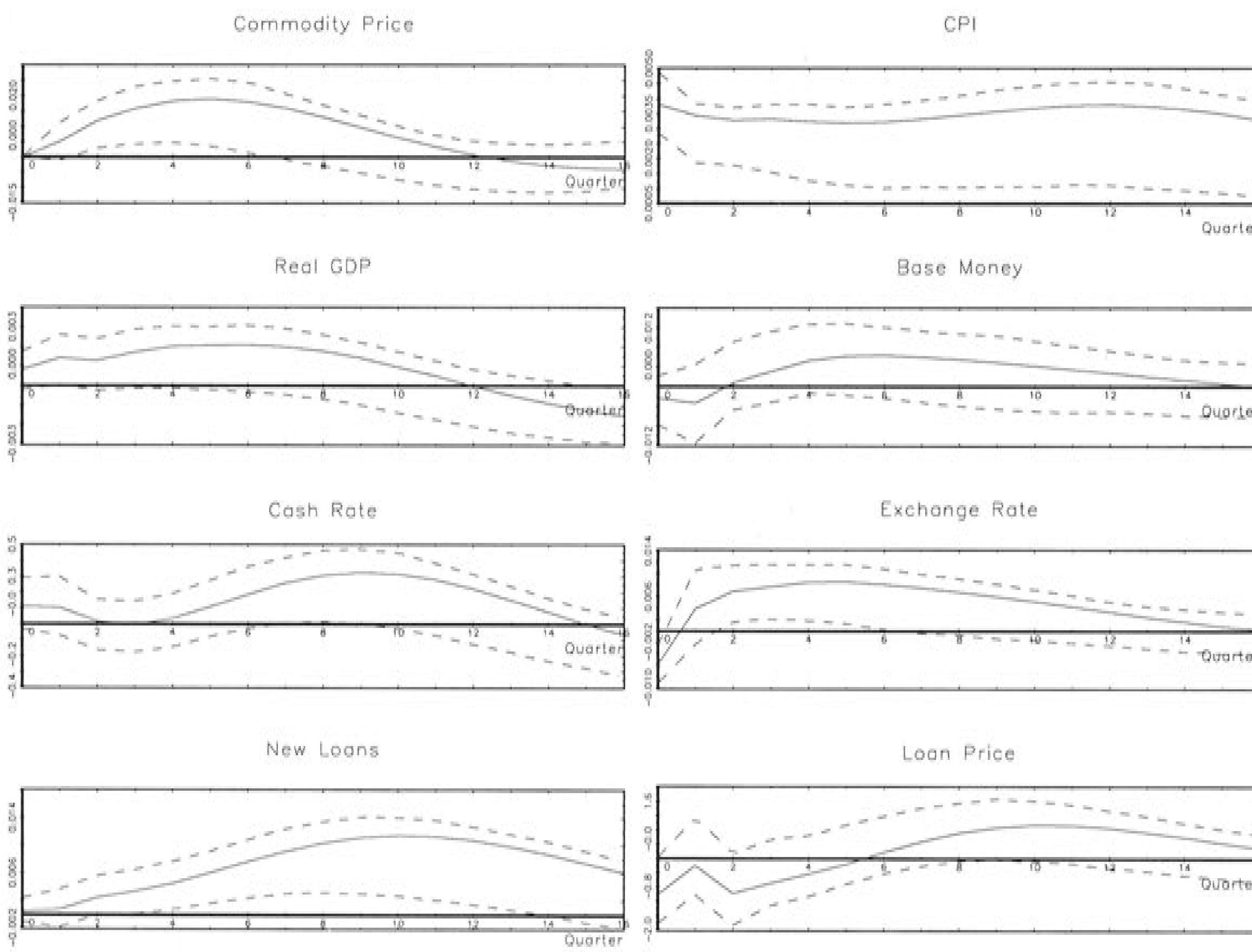

Figure F.2: Responses to a shock in the CPI

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

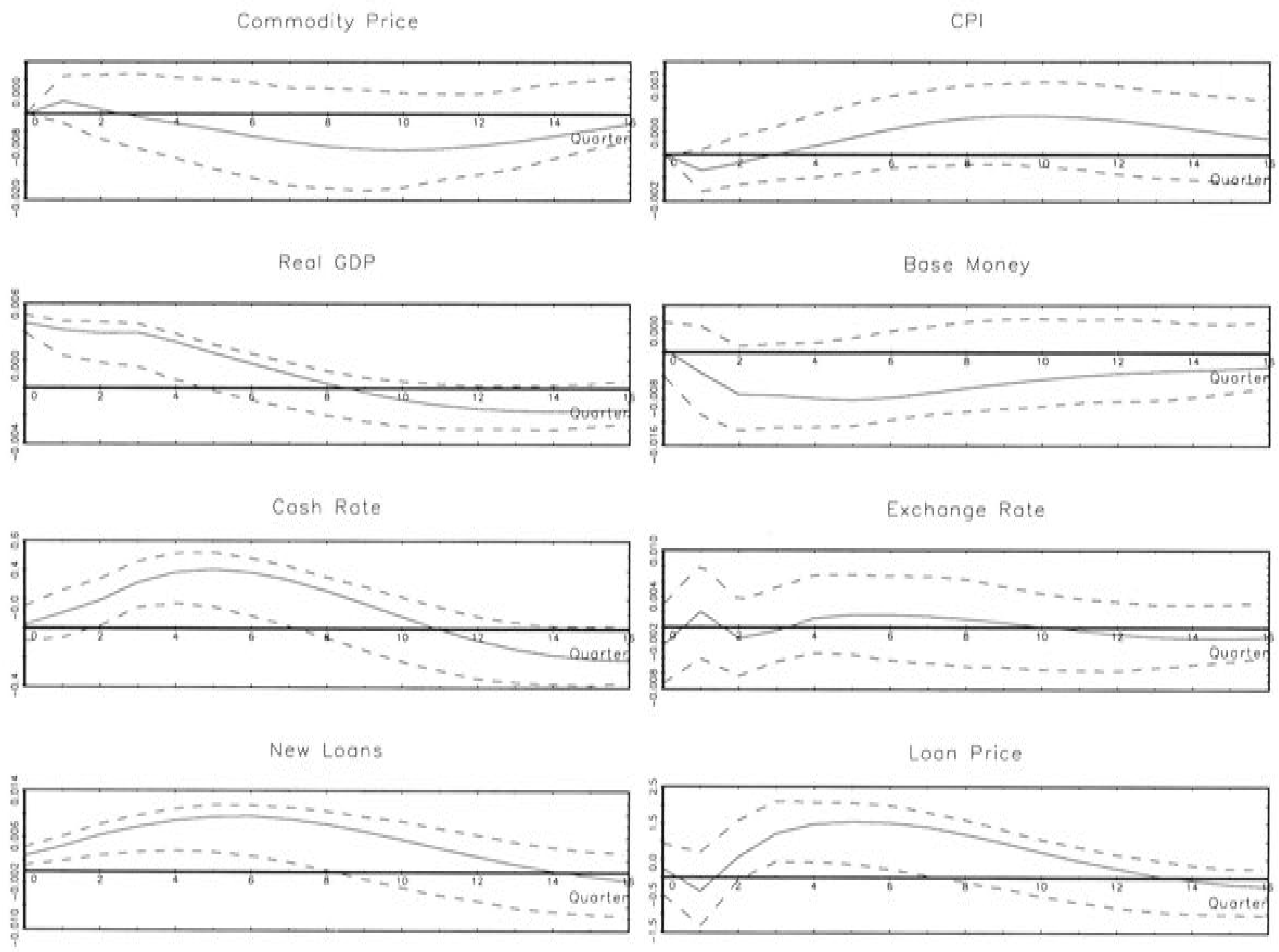

Figure F.3: Responses to a shock in the real GDP

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

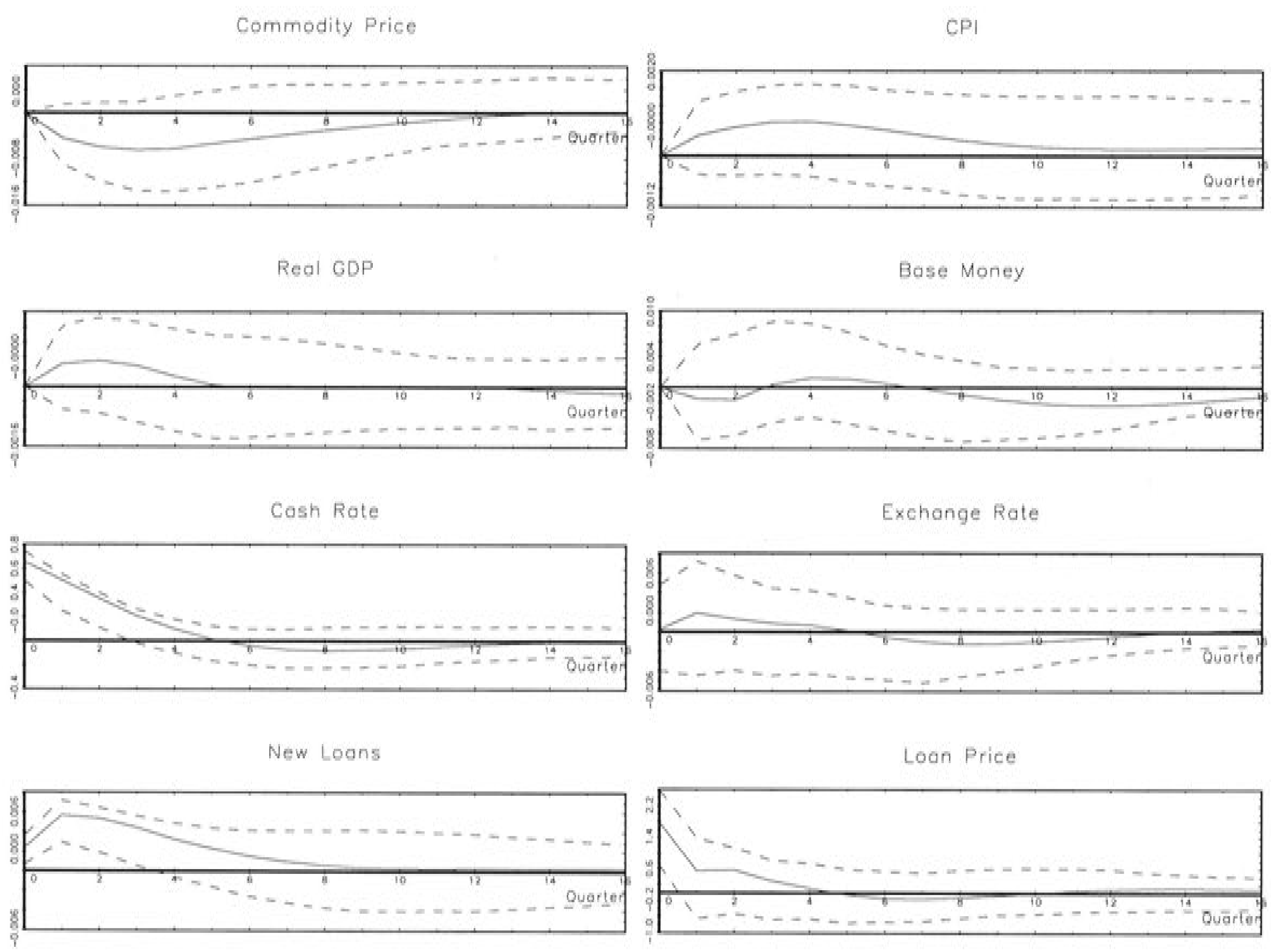

Figure F.4: Responses to a shock in the cash rate

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

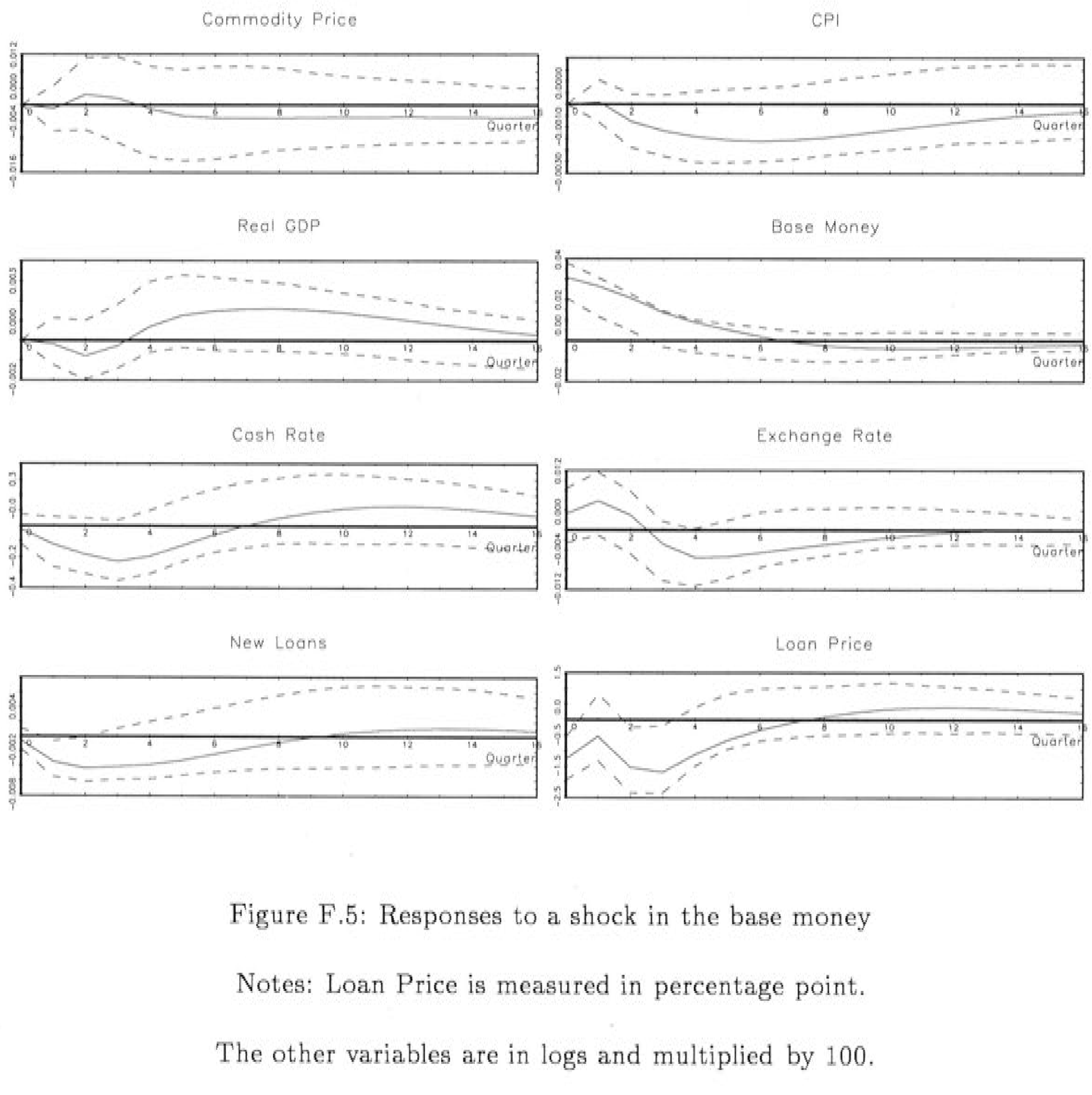

Figure F.5: Responses to a shock in the base money

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

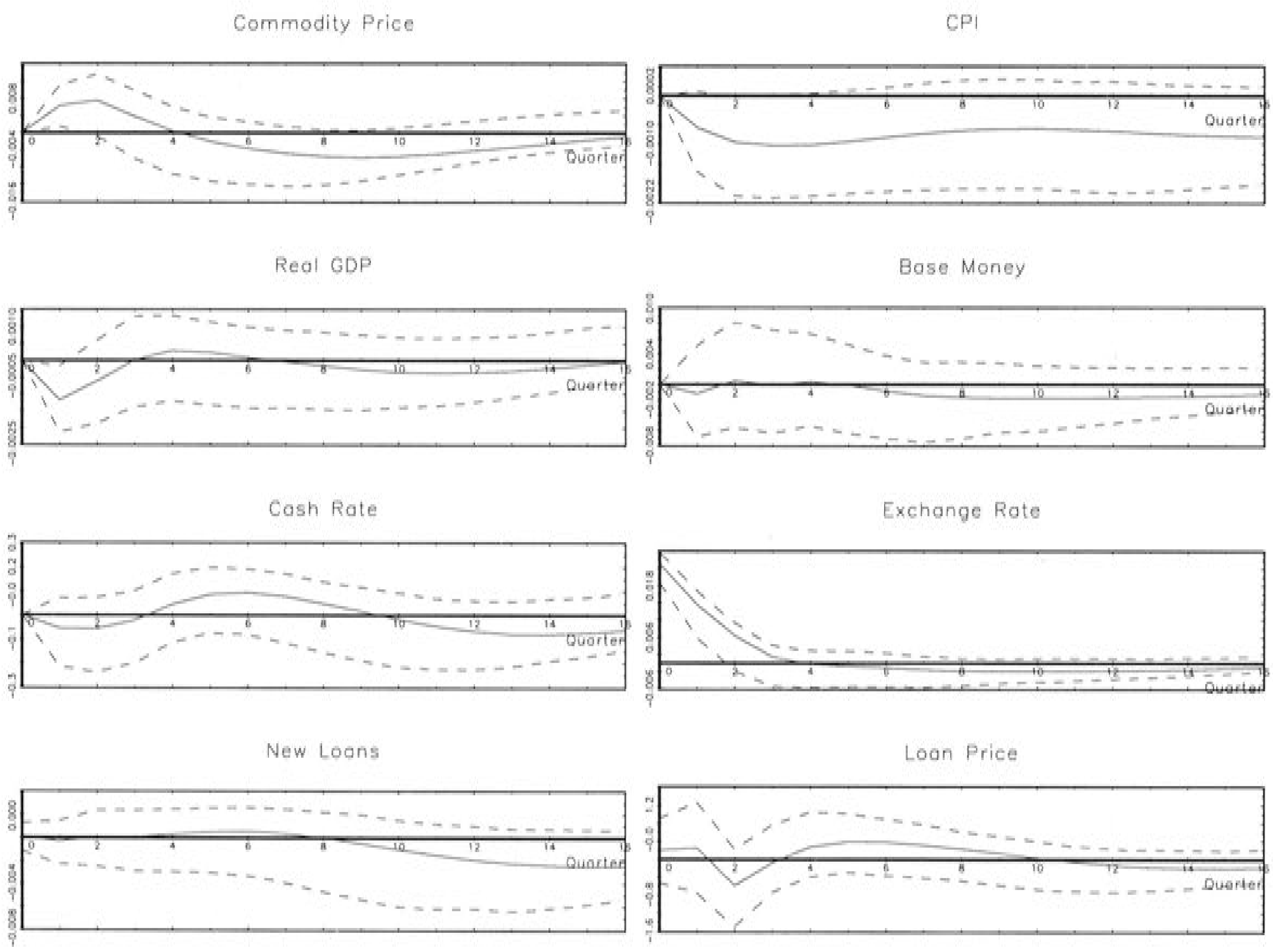

Figure F.6: Responses to a shock in the exchange rate

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

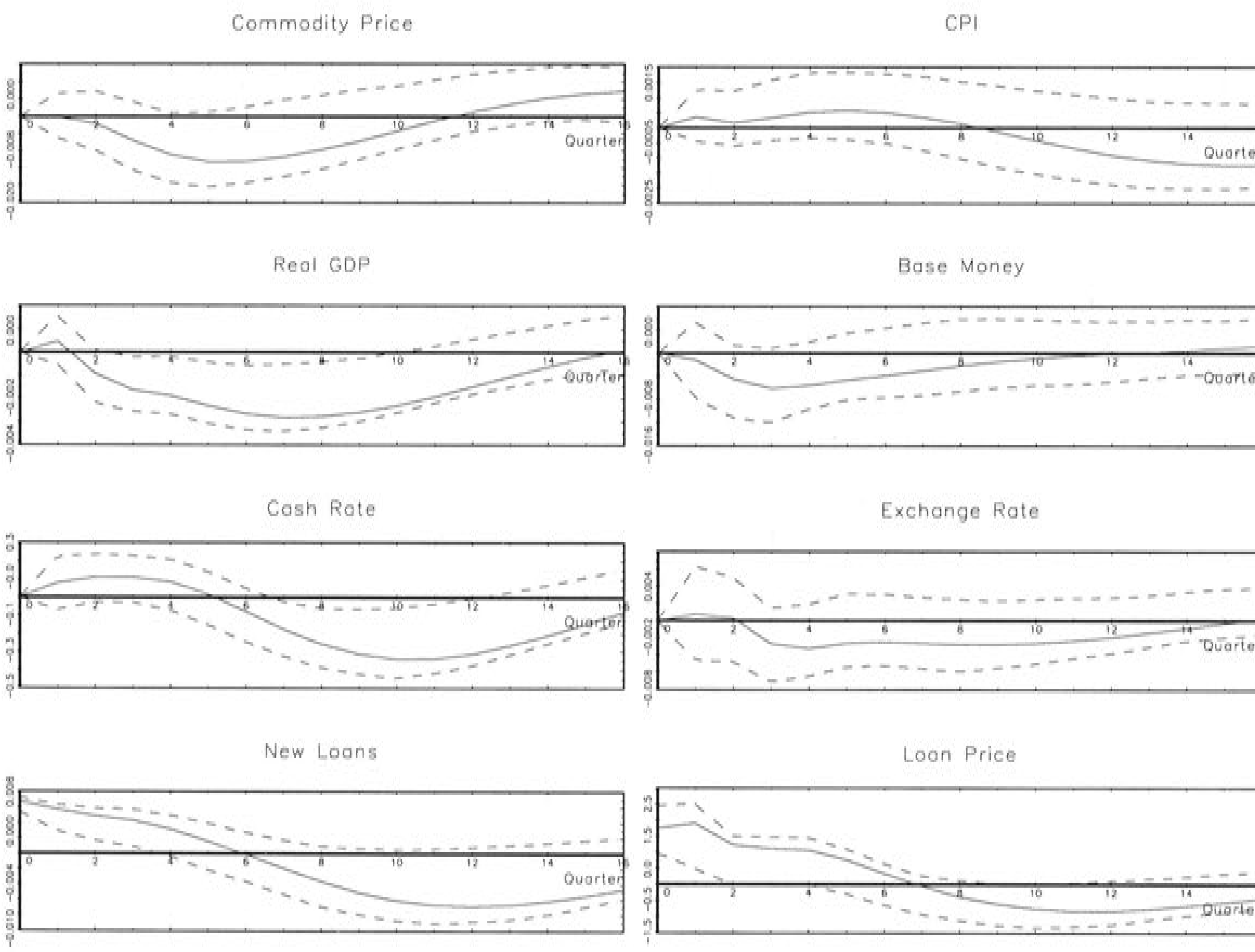

Figure F.7: Responses to a shock in the new loans

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

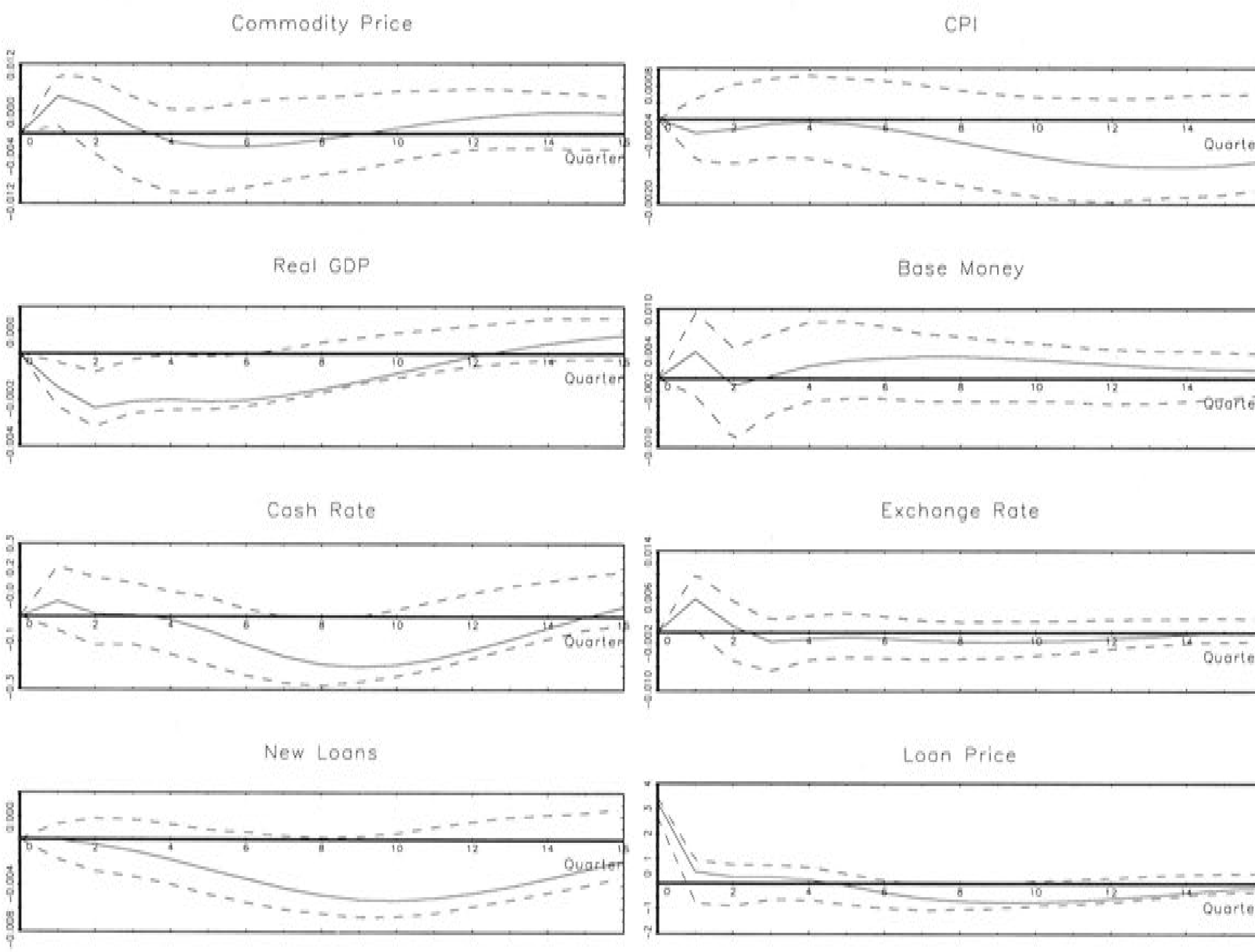

Figure F.8: Responses to a shock in the new loans

Notes: Loan Price is measured in percentage point.

The other variables are in logs and multiplied by 100.

Appendix G

An open economy model in Ch 3

Chapter 3 also takes into account the openness of the Australian economy, estimating an open-economy structural VAR model under the assumption that the U.S. represents the rest of the world. The following eleven diagrams are the impulse response functions calculated from the estimated model.

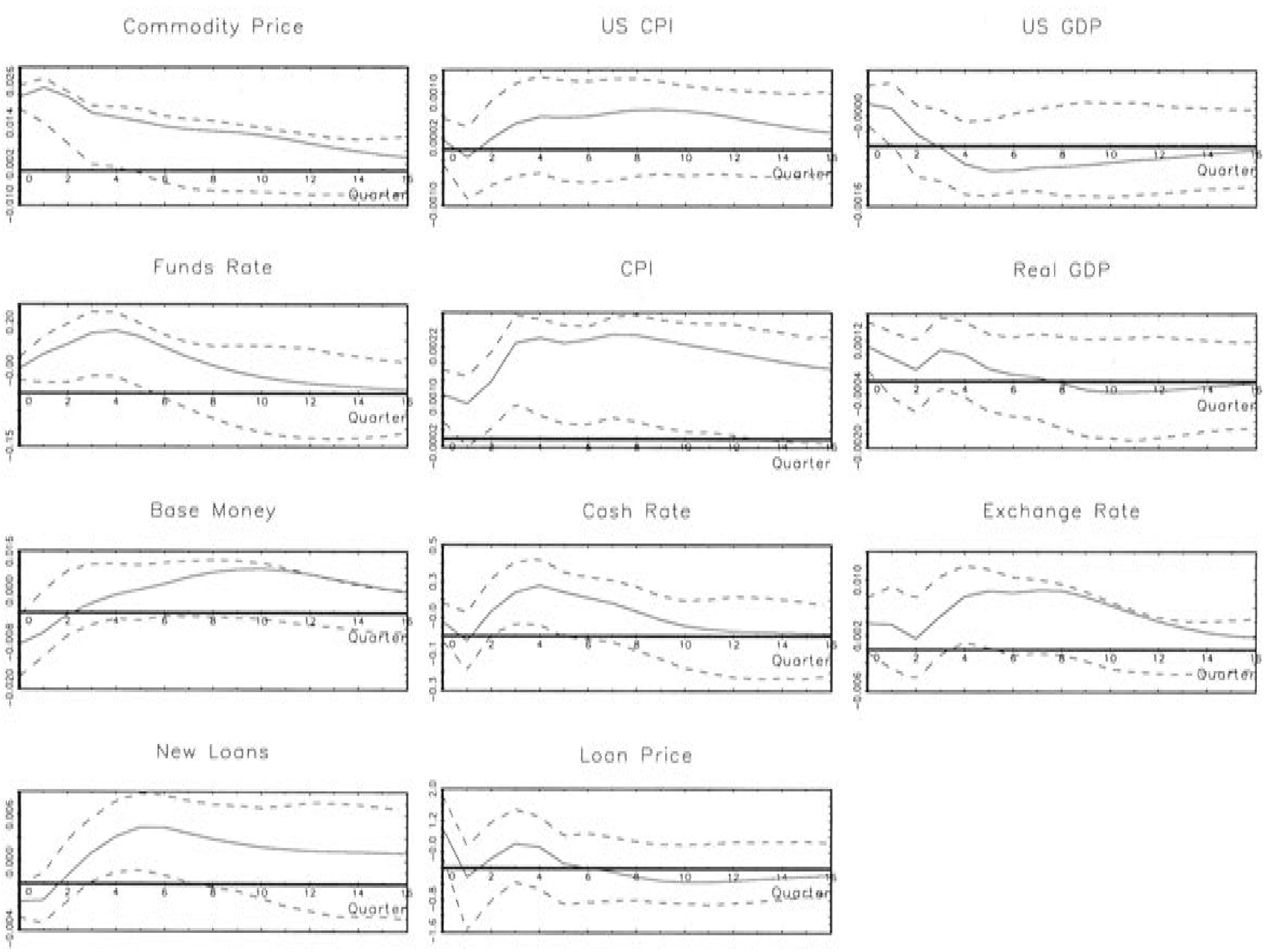

Figure G.1: Responses to a shock in the commodity price (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

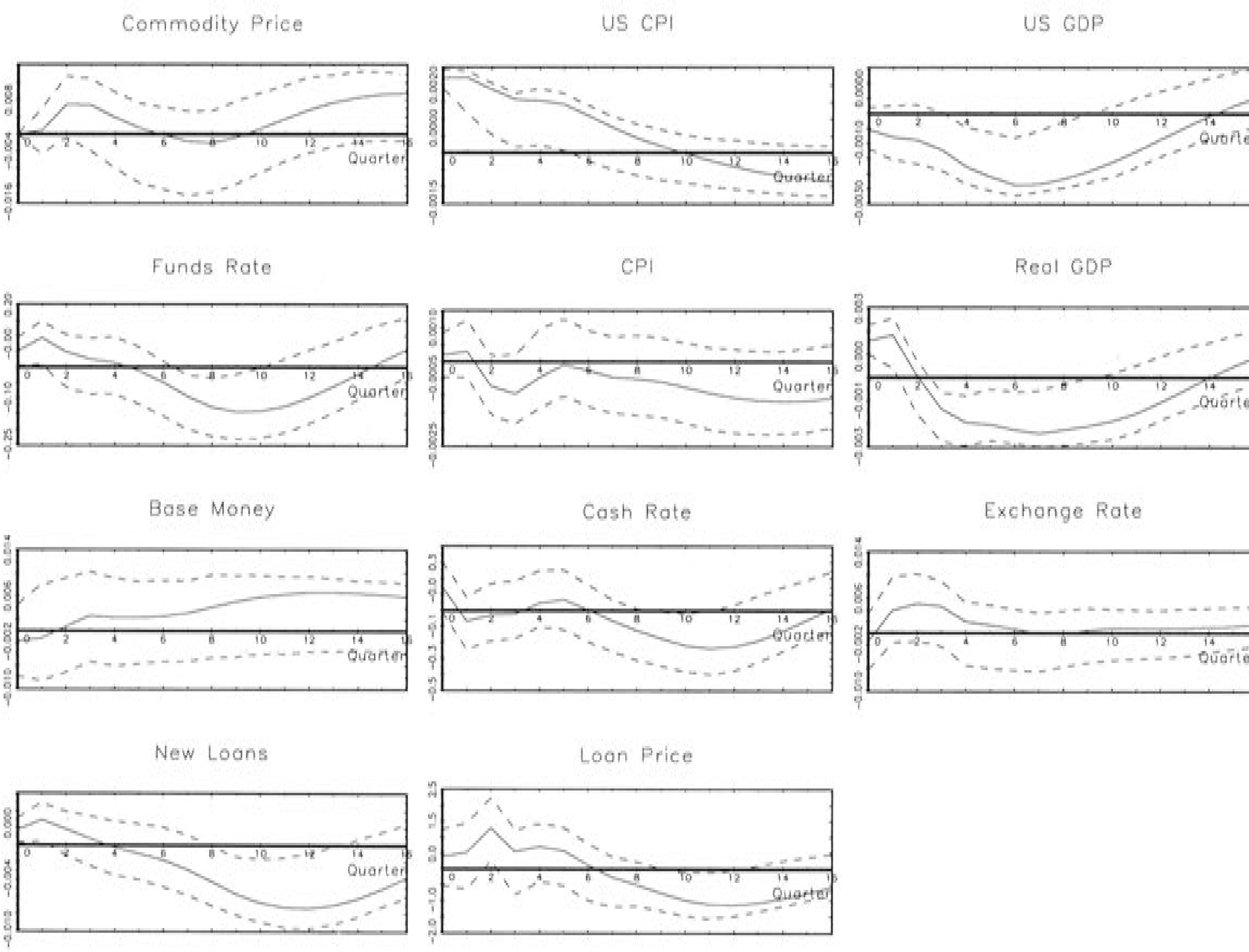

Figure G.2: Responses to a shock in the U.S. CPI (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

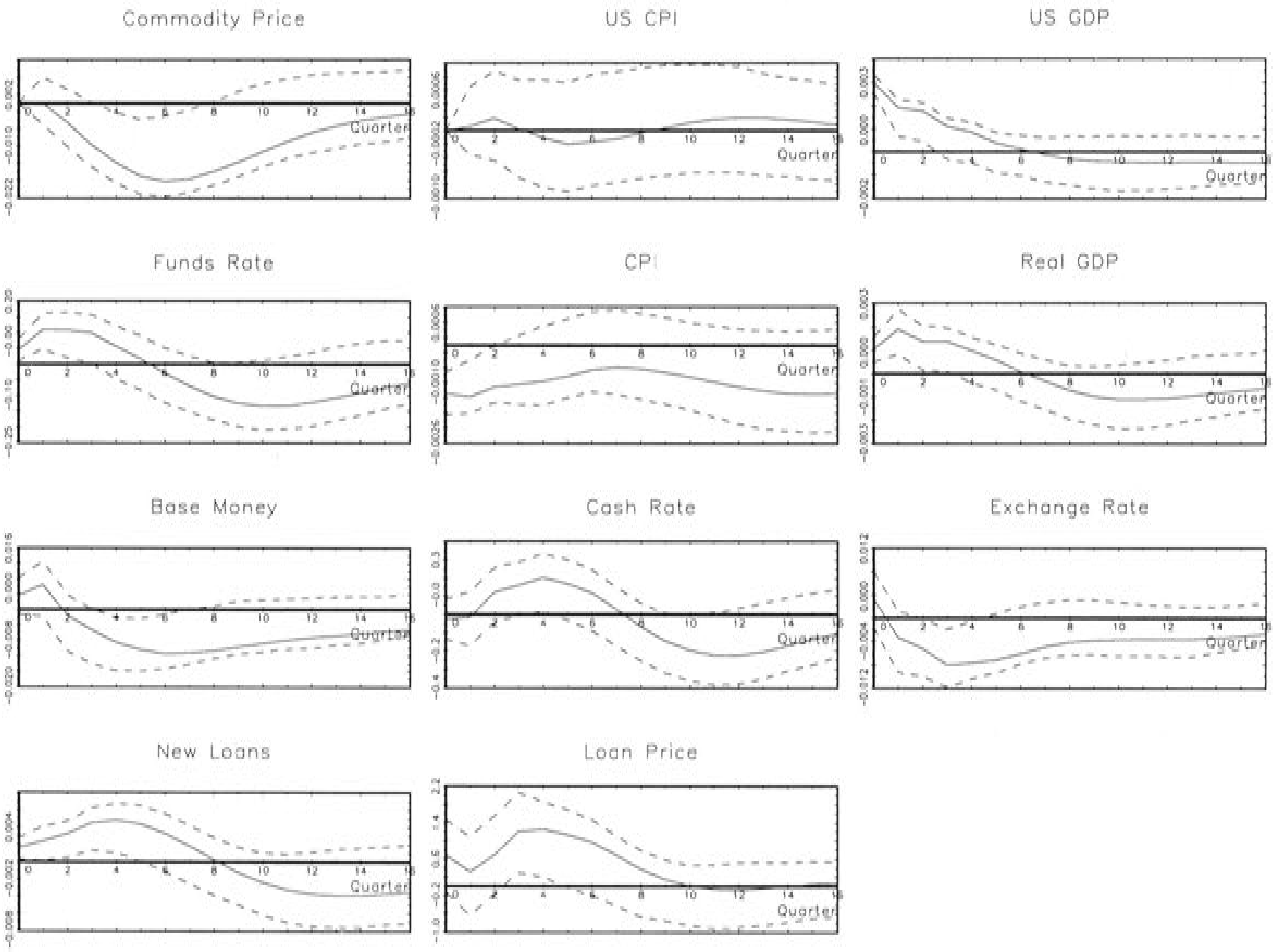

Figure G.3: Responses to a shock in the U.S. output (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

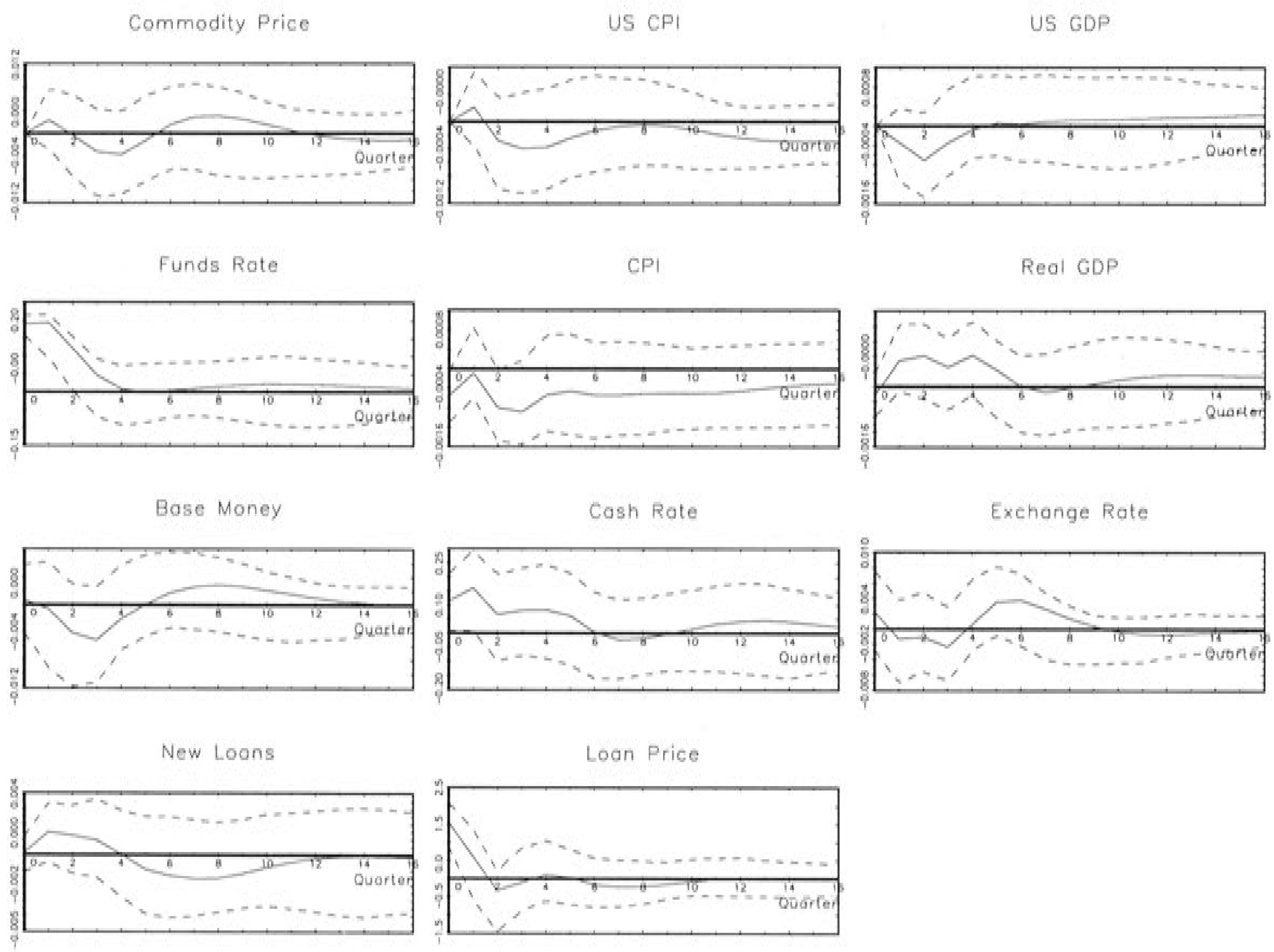

Figure G.4: Responses to a shock in the U.S. funds rate (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

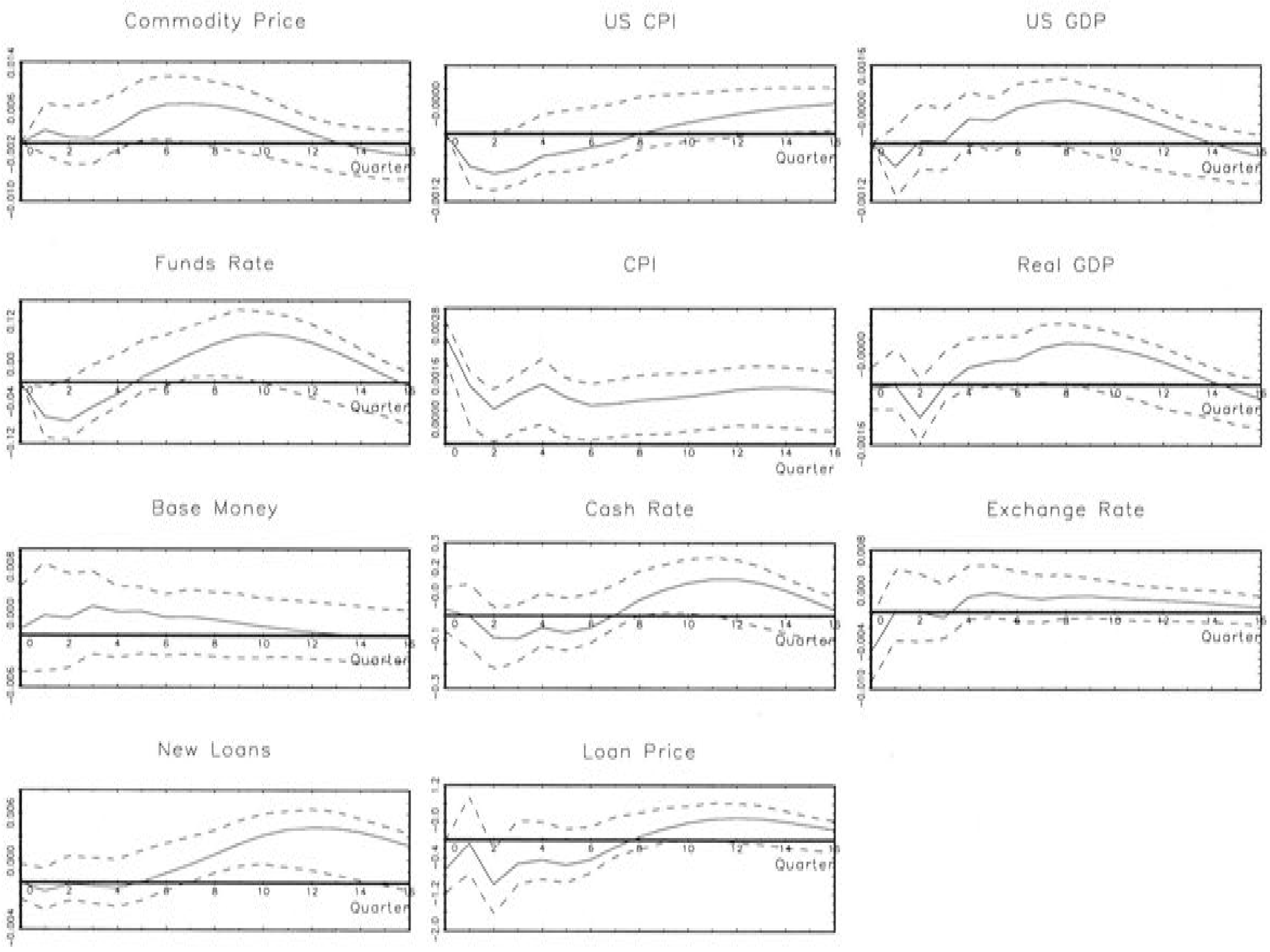

Figure G.5: Responses to a shock in the CPI (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

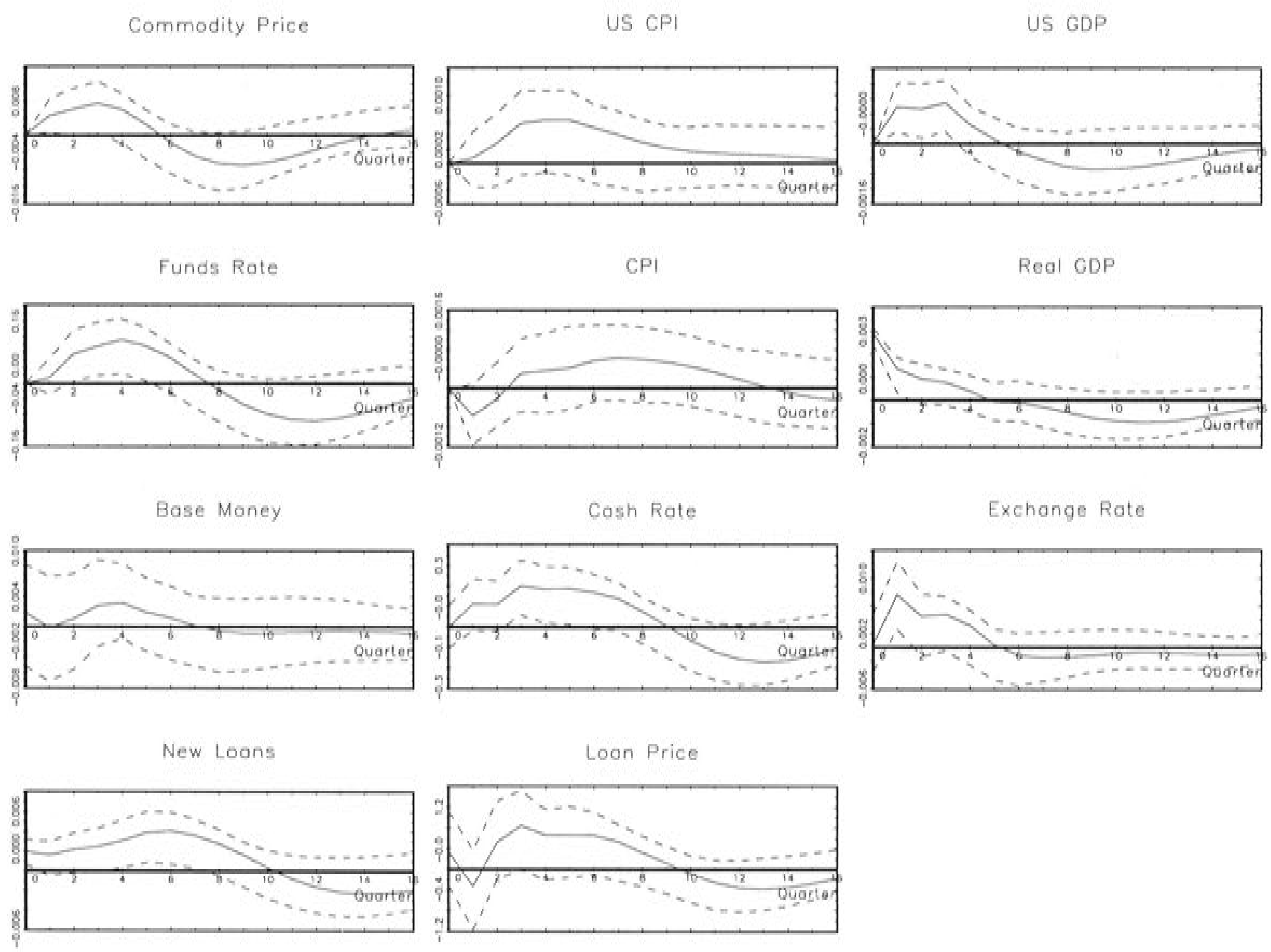

Figure G.6: Responses to a shock in the real GDP (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

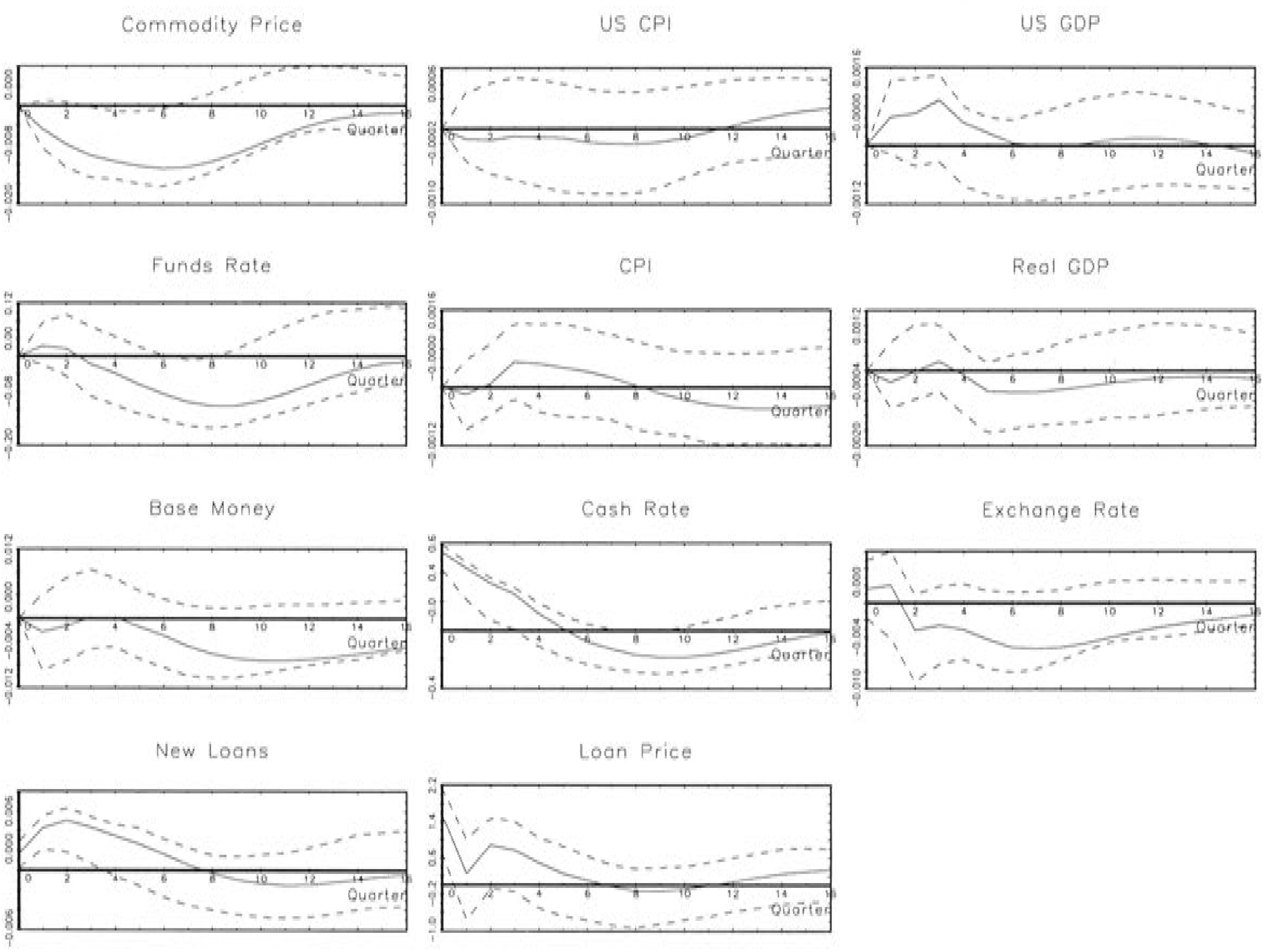

Figure G.7: Responses to a shock in the cash rate (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

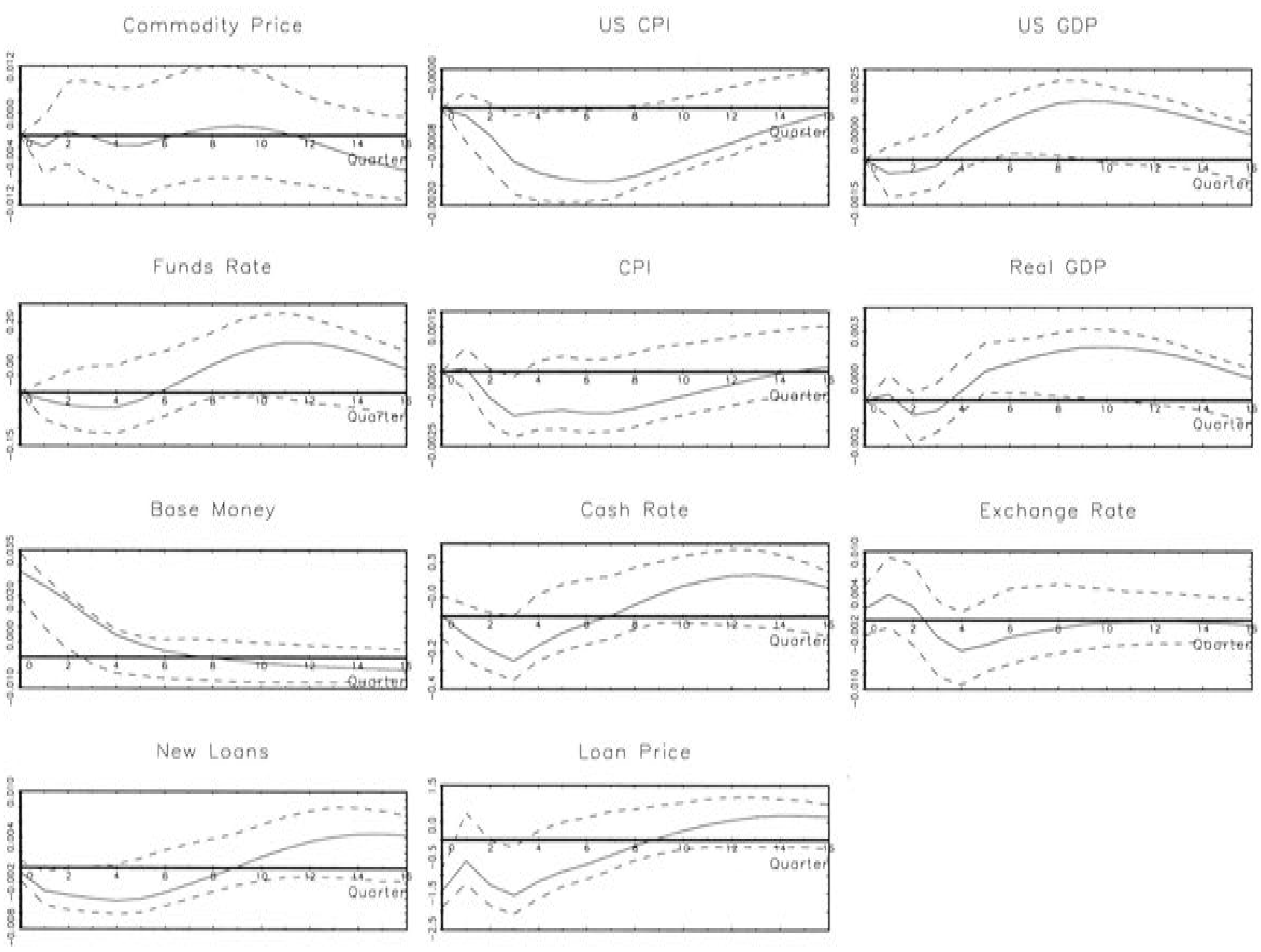

Figure G.8: Responses to a shock in the base money (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

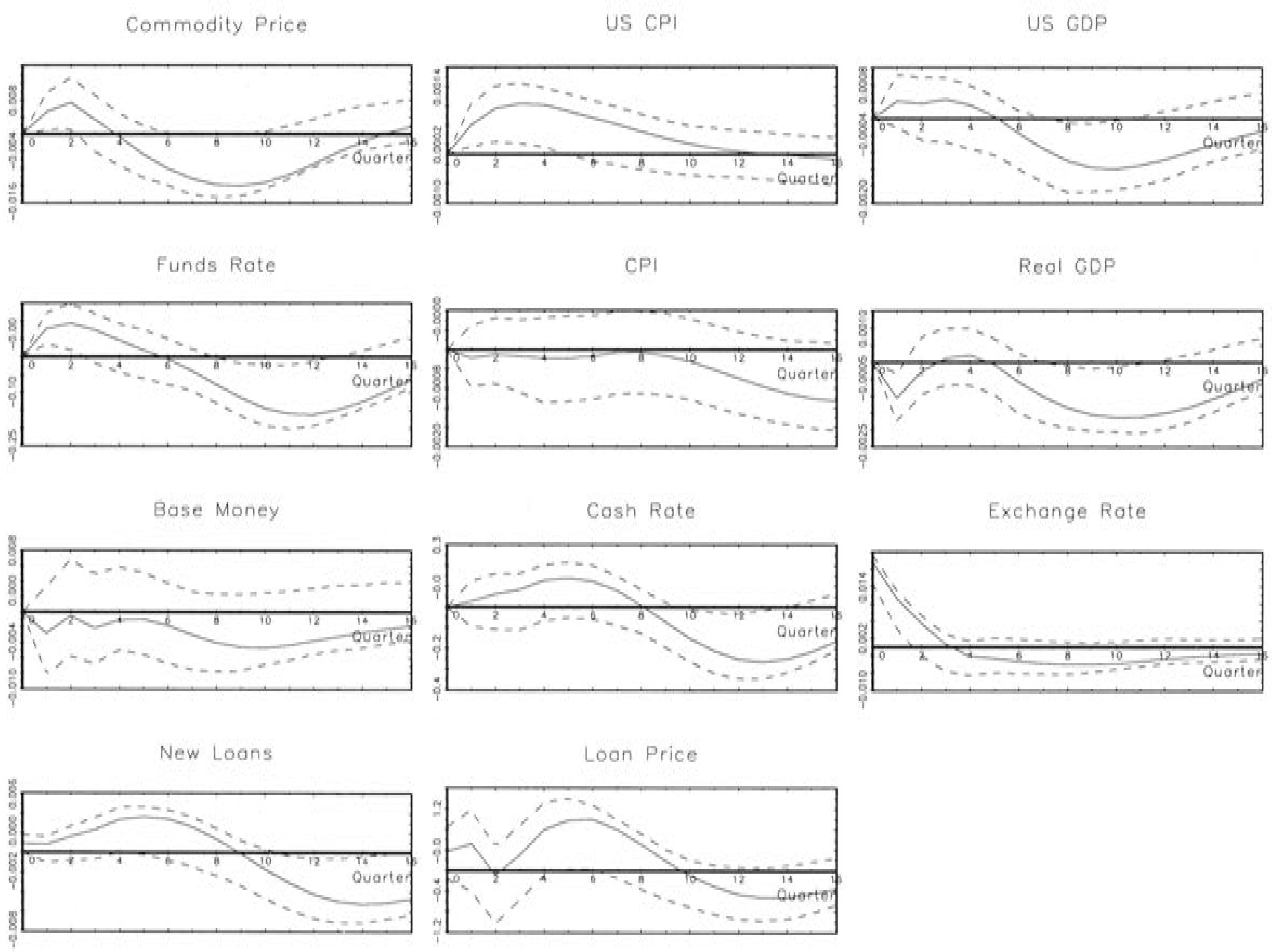

Figure G.9: Responses to a shock in the exchange rate (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

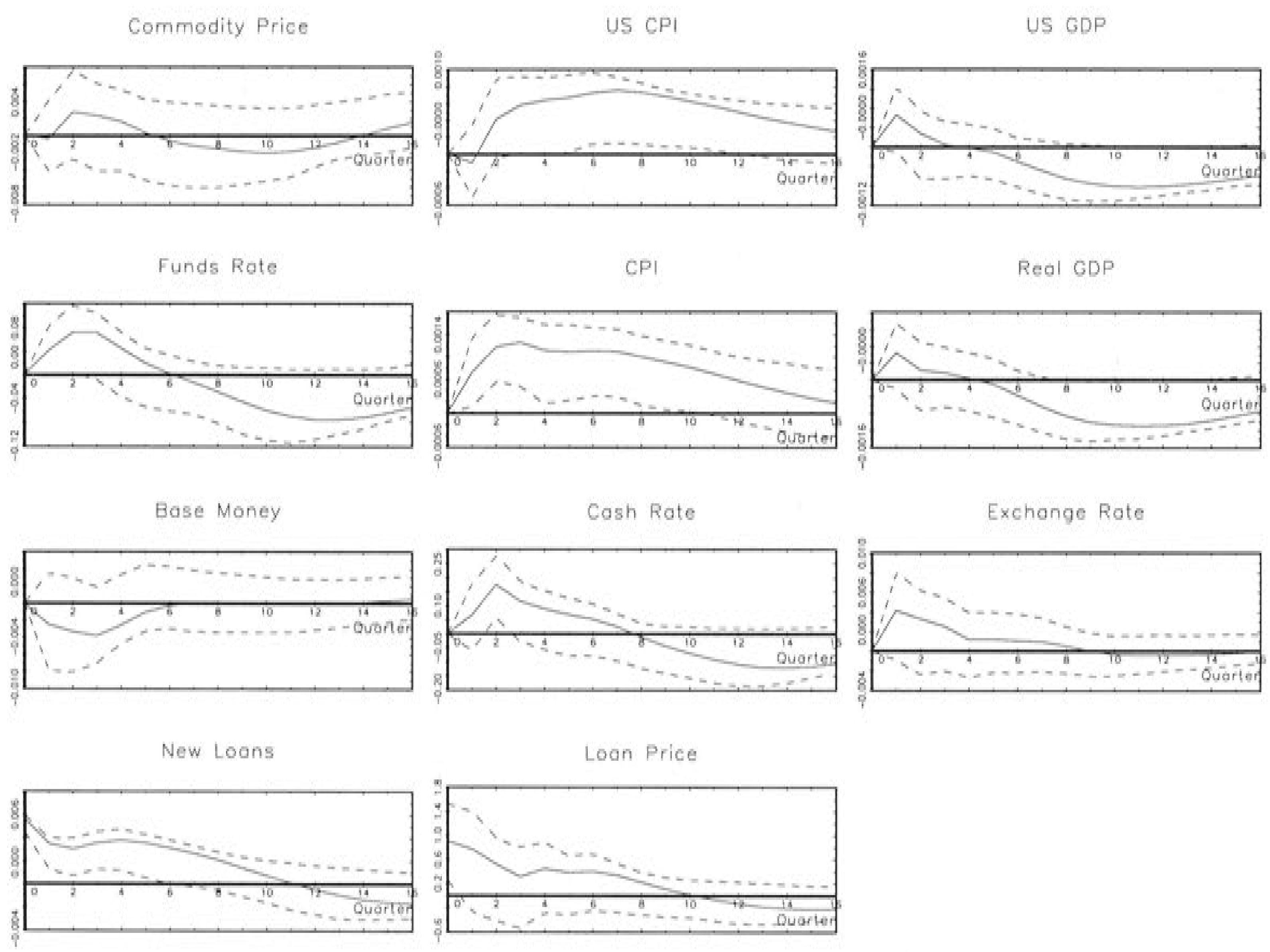

Figure G.10: Responses to a shock in the new loans (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

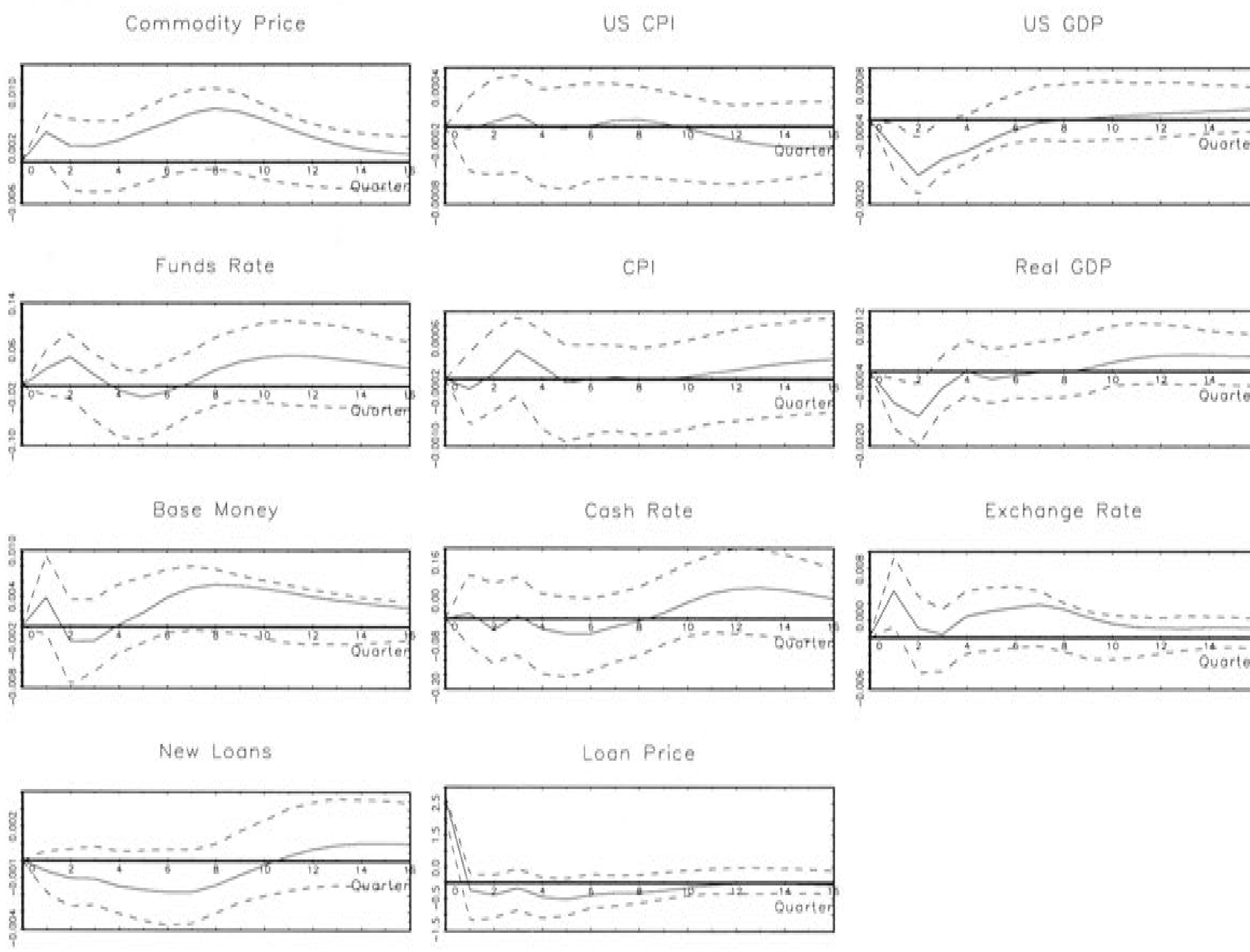

Figure G.11: Responses to a shock in the loan price (Unrestricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

Appendix H

A restricted model in Ch 3

Under the assumption of the small open-economy, Chapter 3 also estimates an open-economy structural VAR model by imposing zero restrictions on the coefficients of the domestic variables in the equations for the overseas variables. The following seven diagrams are all the impulse response functions to the domestic variables, which are calculated from the estimated model.

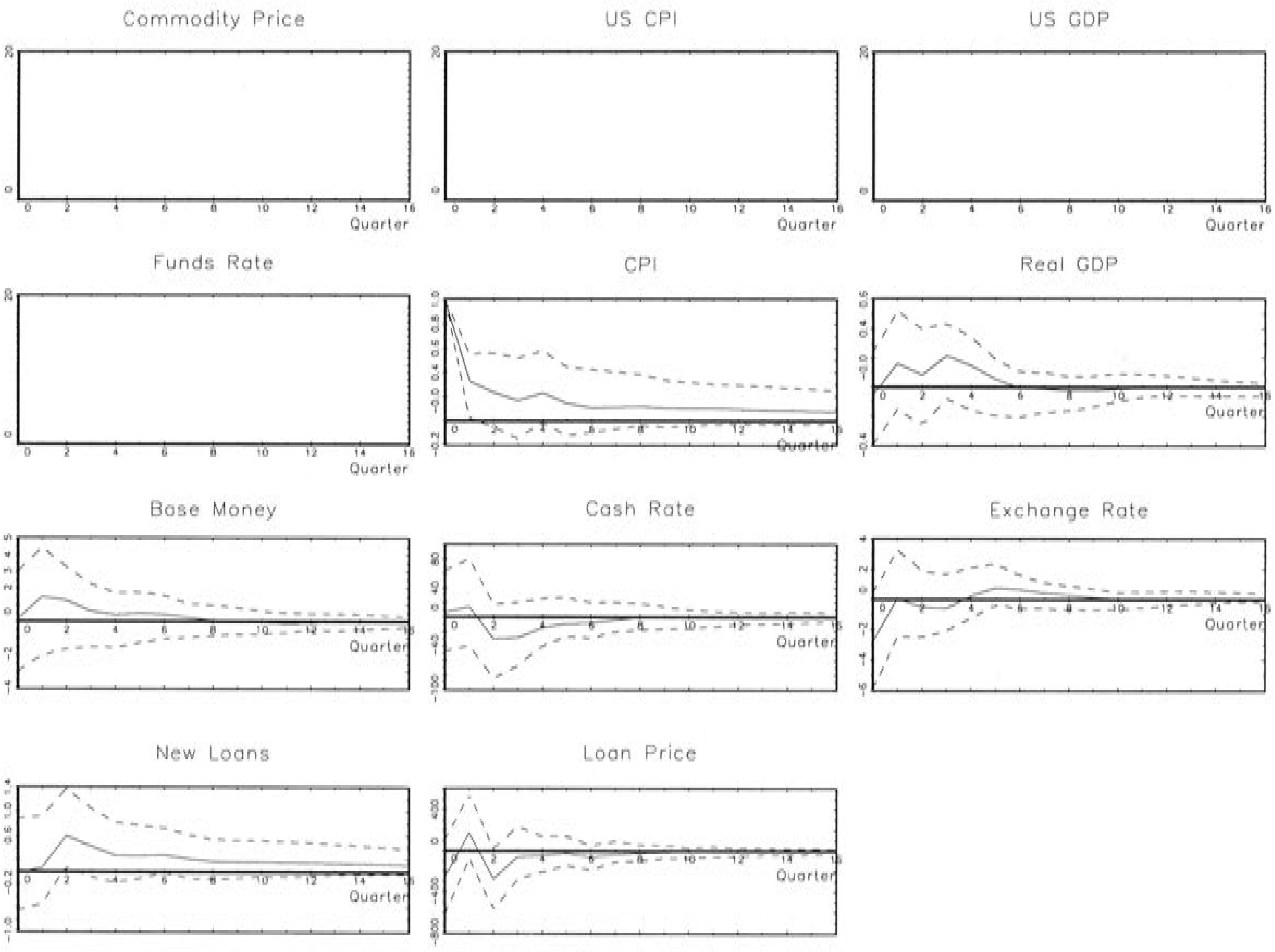

Figure H.1: Responses to a shock in the CPI (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

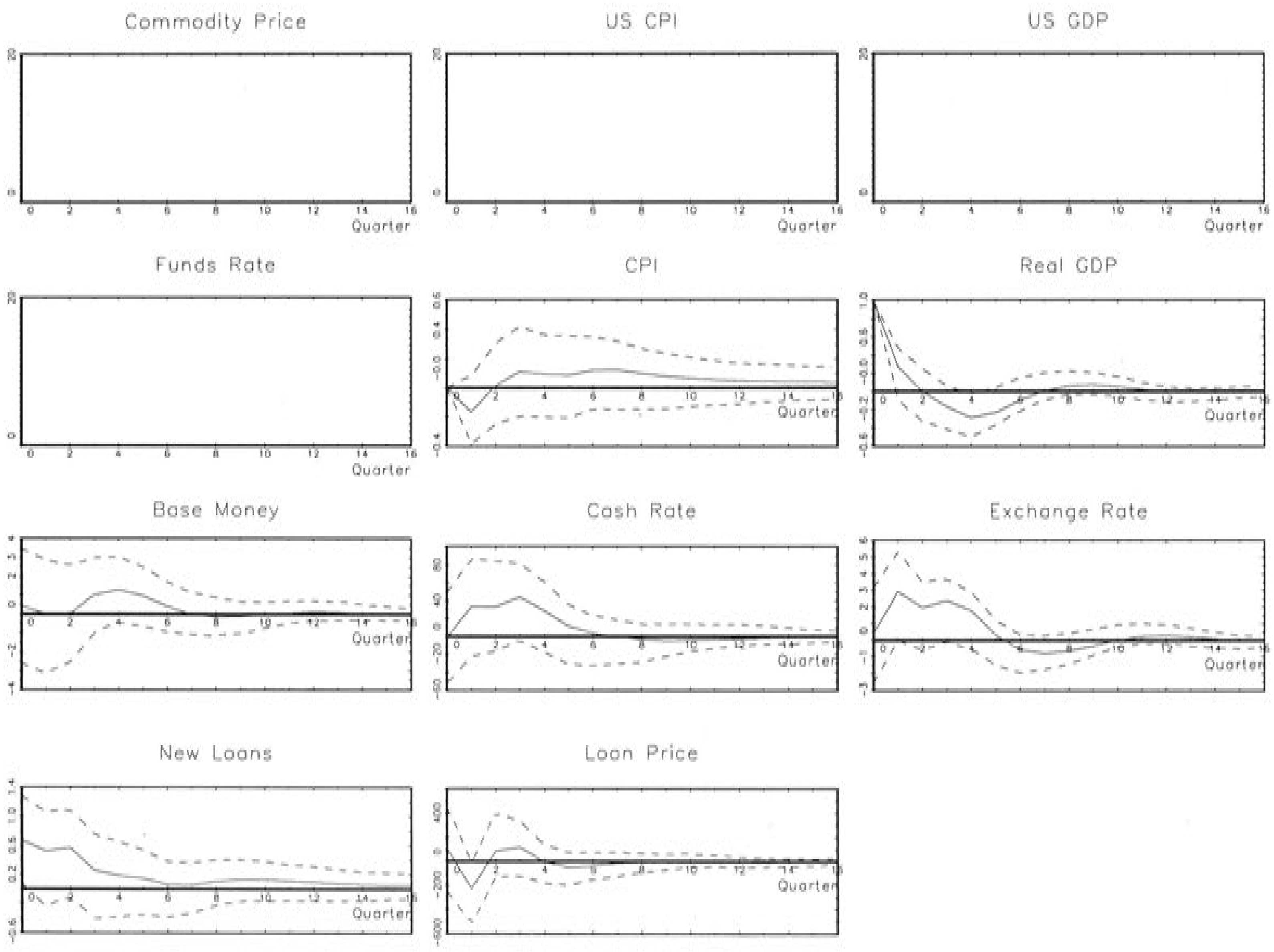

Figure H.2: Responses to a shock in the real GDP (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

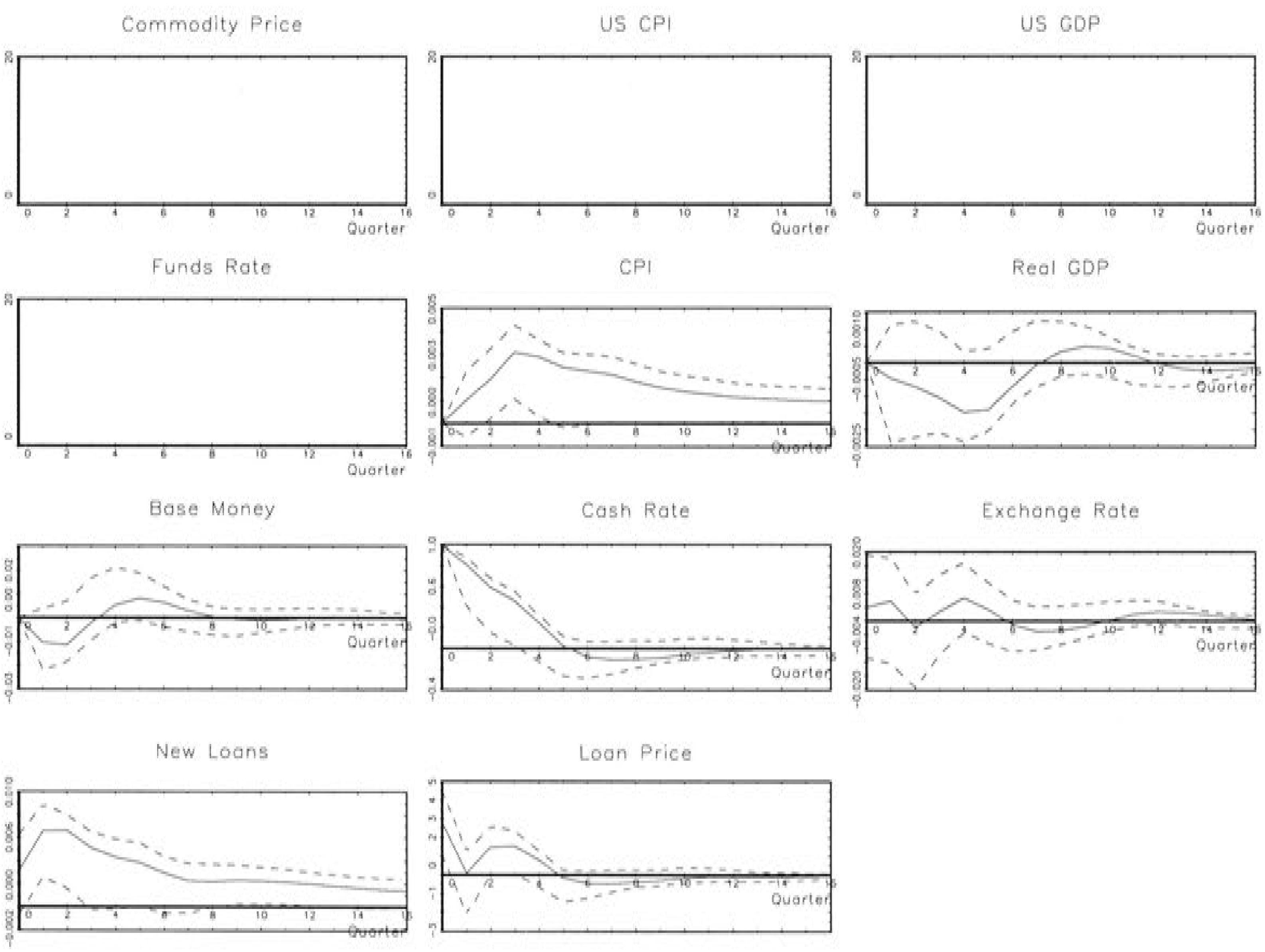

Figure H.3: Responses to a shock in the cash rate (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

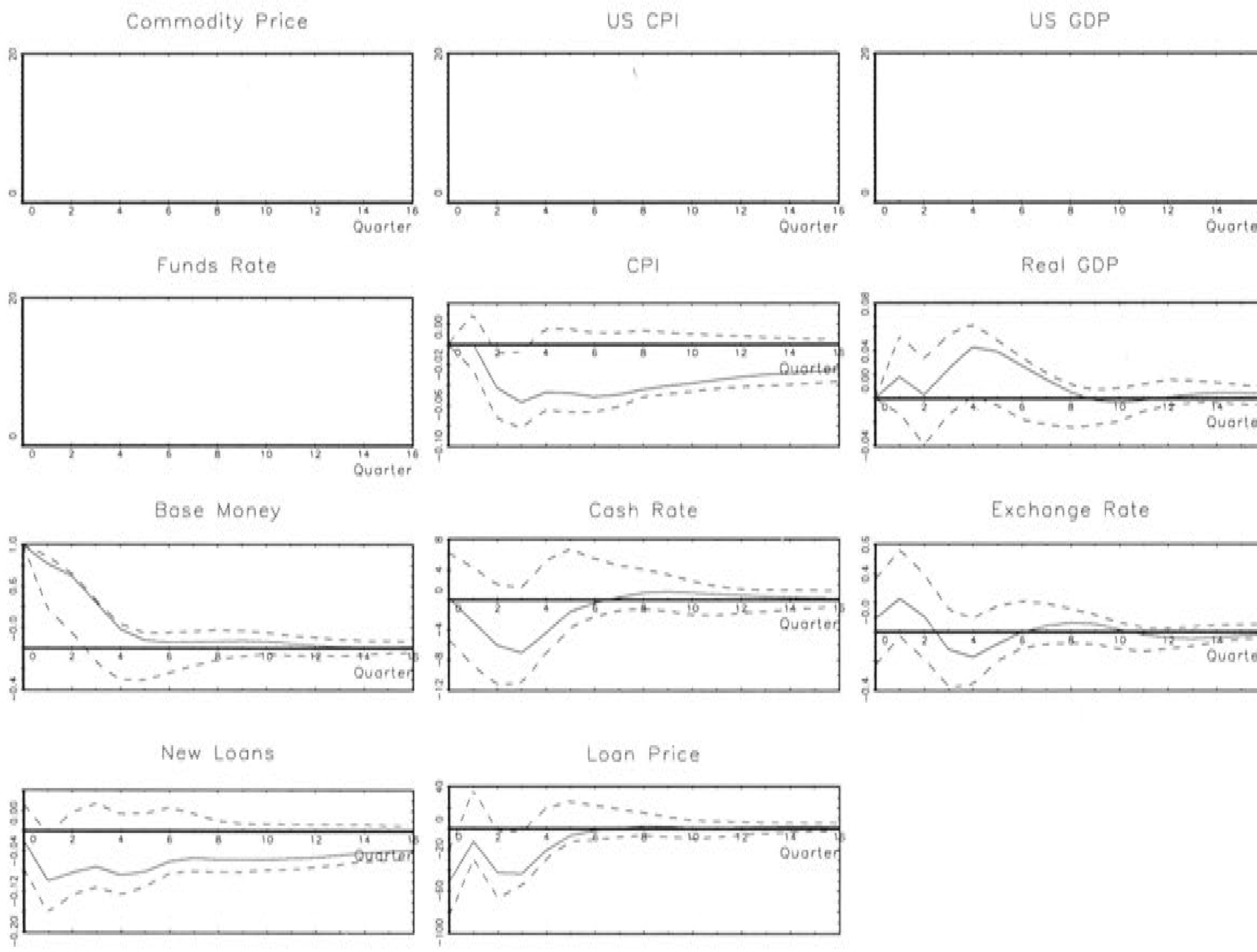

Figure H.4: Responses to a shock in the base money (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

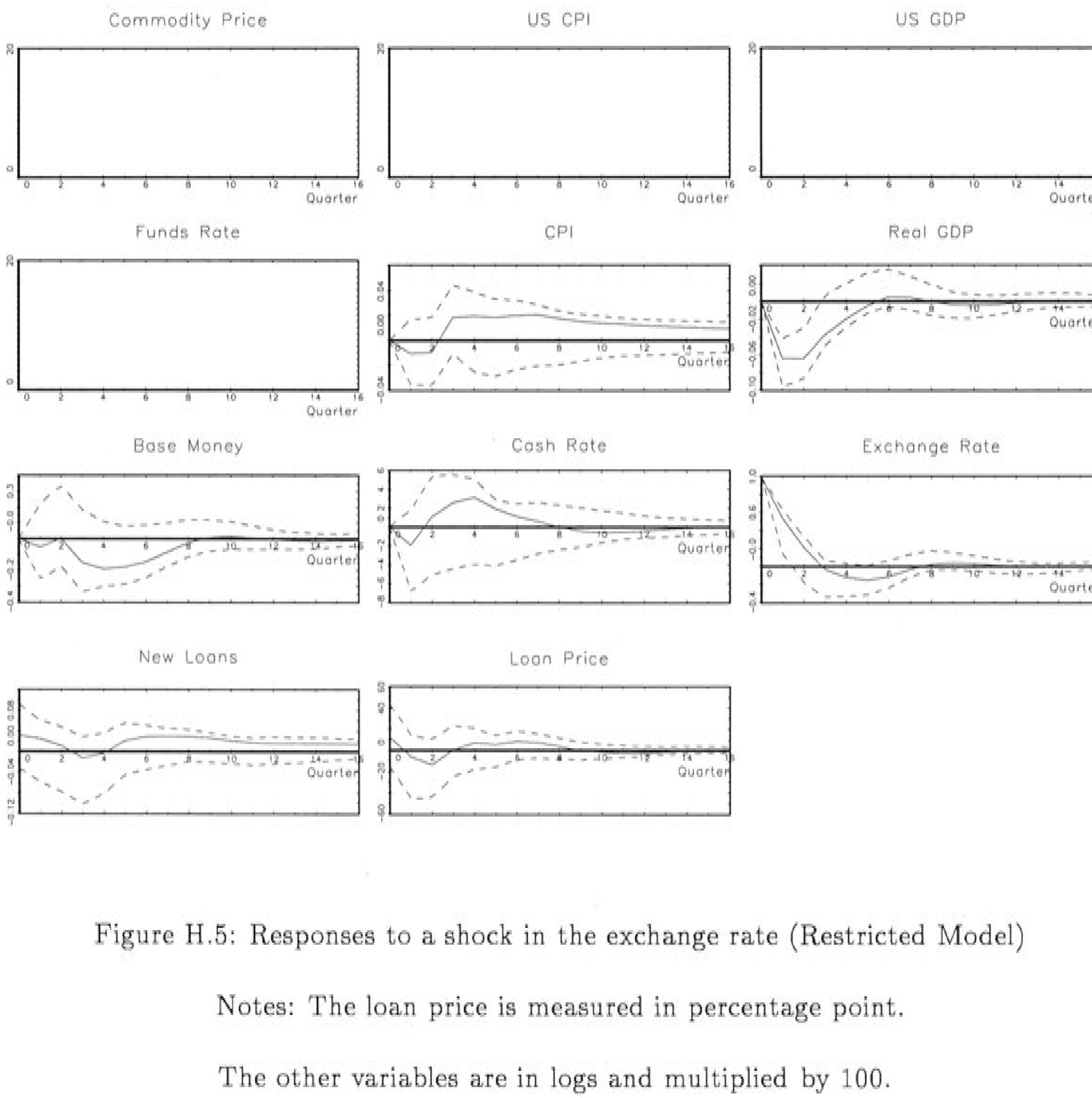

Figure H.5: Responses to a shock in the exchange rate (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

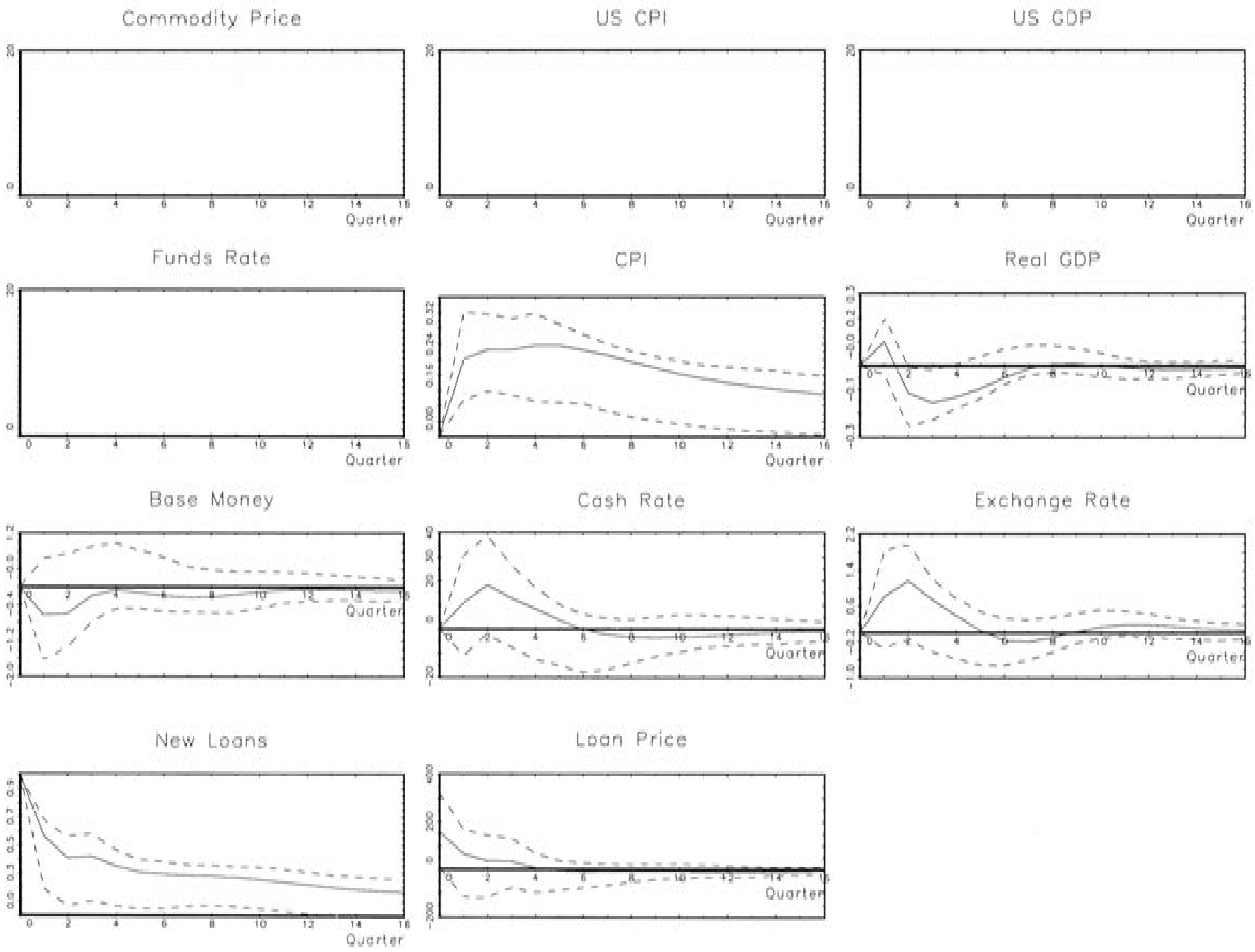

Figure H.6: Responses to a shock in the new loans (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

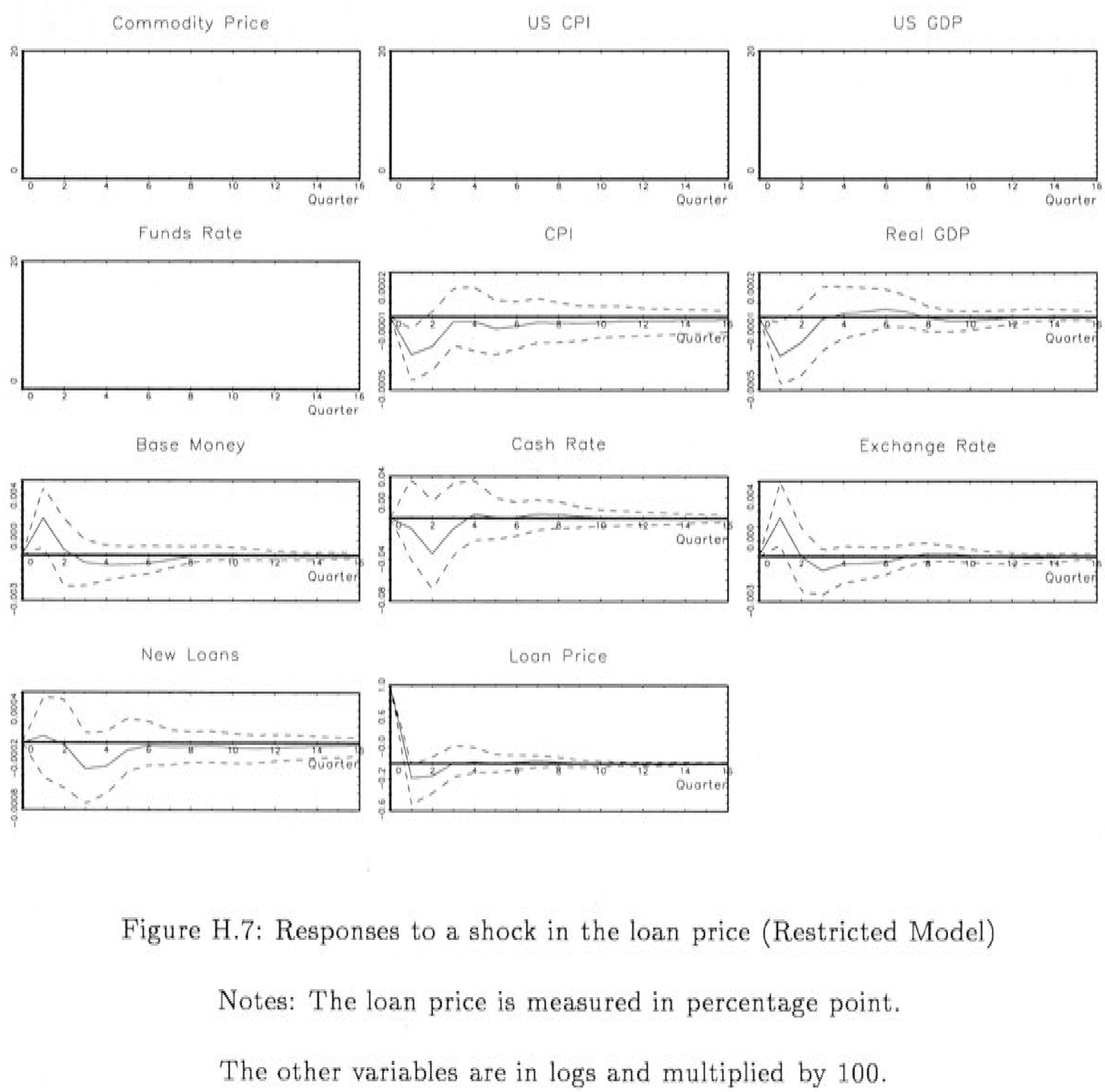

Figure H.7: Responses to a shock in the loan price (Restricted Model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

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THE AUSTRALIAN NATIONAL UNIVERSITY

WORKING PAPERS IN ECONOMICS AND ECONOMETRICS

THE CREDIT CHANNEL IN JAPAN: RESOLVING THE SUPPLY VERSUS DEMAND PUZZLE

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Working Paper No. 392

March 2001

ISBN: 08631 392 0

Abstract

A long-standing macroeconomic issue is how monetary policy affects the real economy. Previous VAR research has found that bank loans typically contracted following a monetary tightening. This is consistent with the credit view: a monetary tightening decreases aggregate demand by shifting the loan supply curve left. However, the finding is consistent with another interpretation: a monetary tightening operates through the conventional money channel and decreases the demand for loans. This observational equivalence is called the "supply-versus-demand puzzle." This paper shows that embedding the loan price in a macroeconomic VAR model reduces the puzzle to the simultaneous equation bias. As a proxy for the loan price, the survey-based data is utilised. The main finding is that the loan supply curve shifts left after a monetary tightening. The effectiveness of monetary policy is also confirmed. From these results, this paper concludes that monetary policy operates through the credit channel in Japan.

* This paper is based on my Ph.D. thesis at the Australian National University. I would like to thank Graeme Wells and Mardi Dungey for their helpful comments and discussions. I am also grateful to the Bank of Japan for providing the survey data on my request. Any errors are the sole responsibility of the author.

1 Introduction

Under the assumption that bank loans and bonds are imperfect substitutes for some borrowers, Bernanke and Blinder (1988) show that draining bank reserves reduces the amount of loanable funds and forces bank-dependent borrowers to cut their expenditures on investment. This transmission mechanism of monetary policy is called the "bank lending channel." Bernanke and Gertler (1989) show that a monetary tightening worsens enterprises' balance sheets and induces lenders to shift funds from risky loans to safe bonds, which decreases aggregate demand by forcing the enterprises to cut their investment plans. This transmission mechanism is called the "balance sheet channel," and these different channels of monetary policy are collectively called the "credit channel." This paper aims to show that the credit channel of monetary transmission is operative in Japan.

To study the monetary transmission mechanism, it is essential to investigate the dynamic interaction among macroeconomic variables, and this paper adopts a structural VAR approach. The main focus is on an empirical resolution of the "supply-versus-demand puzzle" (Bernanke 1993, p. 57) using Japanese data. The puzzle is as follows. Suppose that one estimates the impulse response function of bank loans to a negative innovation in monetary policy, finding that bank loans contract. Such a finding is consistent with the credit view that a monetary tightening shifts the loan supply curve left, but it is also possible that the fall of bank loans is due to a leftward shift of the demand curve for loans. The impulse response function of loans to an innovation in monetary policy does not, of itself, indicate whether the fall of bank loans is largely due to the leftward shift of the loan supply curve or the leftward shift of the loan demand curve.

This paper offers a way to identify shifts in supply and demand in the credit market by utilising survey-based data to proxy for the price of additional bank credit. As explained in the next section, embedding both the price and quantity of bank credit in a macroeconomic VAR reduces the supply-versus-demand puzzle to a standard identification problem. The third section of the paper provides a brief description of the VAR model that is used to investigate the credit channel of monetary transmission. This section also includes a discussion of the construction of our price of credit variable. Results are presented in the fourth section, and the main novelty of the paper is that we are able to establish that, in Japan, a monetary tightening is followed by a leftward shift of the loan supply curve. The fifth section concludes.

2 The Supply versus Demand Puzzle

2.1 Extant Studies

In search of evidence for the credit view, researchers have investigated the behaviour of credit aggregate following a monetary tightening. In an influential paper, Bernanke and Blinder (1992) estimate a VAR model for the U.S. economy from 1959 to 1978, which includes the federal funds rate, the unemployment rate, the consumer price index, and three bank balance-sheet variables (deposits, securities, and loans). They analyse the impulse response functions of these variables to an innovation to the funds rate, finding that an unanticipated hike in the funds rate is followed by a decline in loans and a rise of the unemployment rate. With a longer sample of 1959 to 1990, their findings are reproduced by Kashyap and Stein (1994). Using Japanese data, Ueda (1993) obtains similar results.

The finding that a decline in bank loans follows a monetary tightening is certainly consistent with the credit view: a monetary tightening has an impact on real economy by shifting the bank loan supply curve left. A problem is that similar results can be obtained even if the credit channel is not operative. Suppose that a monetary tightening depressed aggregate demand through the conventional money channel. Then, the consequent decrease of the demand for loans would lead to a decline in bank lending. The decline in bank lending, of itself, does not indicate whether the loan supply curve shifts left or the loan demand curve shifts left. This observational equivalence is the supply-versus-demand puzzle.

Kashyap, Stein, and Wilcox (1993) try to deal with the supply-versus-demand puzzle by looking at the behaviour of commercial paper and business bank loans in the wake of tight money. For this purpose, they define the "mix" as the ratio of business bank loans to the sum of business bank loans and commercial paper. Their intuition is as follows. A leftward shift of the supply curve of bank loans will force borrowers to substitute away from bank loans into commercial paper, so that the mix will drop. Using the U.S. data, they find that the mix drops following a monetary contraction. The fall of the mix does not necessarily mean a leftward shift of the supply curve of bank loans, however. It is possible, for instance, that the demand for commercial paper increased relative to the demand for bank loans.[1] If there are certain sorts of heterogeneities in credit demand, their approach is subject to the same identification problem as the bank loan market - the supply-versus-demand puzzle - which is the subject of this paper.

2.2 An Alternative Approach

This paper provides an alternative approach to resolve the supply-versus-demand puzzle. An important assumption is that an observable quantity of bank loans is the equilibrium value given by the intersection of the demand and supply curves in the bank loan market. Apart from errors in measurement, a change in the quantity may be associated with a shift of the demand curve, a shift of the supply curve, or both. A decline in the quantity, for example, is not necessarily caused by a leftward shift of the supply curve. Observing the price will, however, help us to identify the shifts of the supply and demand curves behind the change in the quantity.[2]

The approach can be well illustrated using a simple demand-supply model. Suppose that an exogenous shock occurred. Such a shock will shift the supply curve and/or the demand curve, so that the price (P) and/or the quantity (Q) will change.

[1] See Gertler and Gilchrist (1993) and Oliner and Rudebusch (1996) for the ambiguities concerning the interpretation of the Kashyap, Stein, and Wilcox (1993) results.

[2] A difficulty lies in measuring the price of bank loans. The construction of the price of bank loans will be discussed in section 3.2.

As depicted in Figure 1, there are four possible changes:

- Case I: Q increases, while P does not fall,
- Case II: P rises, while Q does not increase,
- Case III: Q decreases, while P does not rise,
- Case IV: P falls, while Q does not decrease.

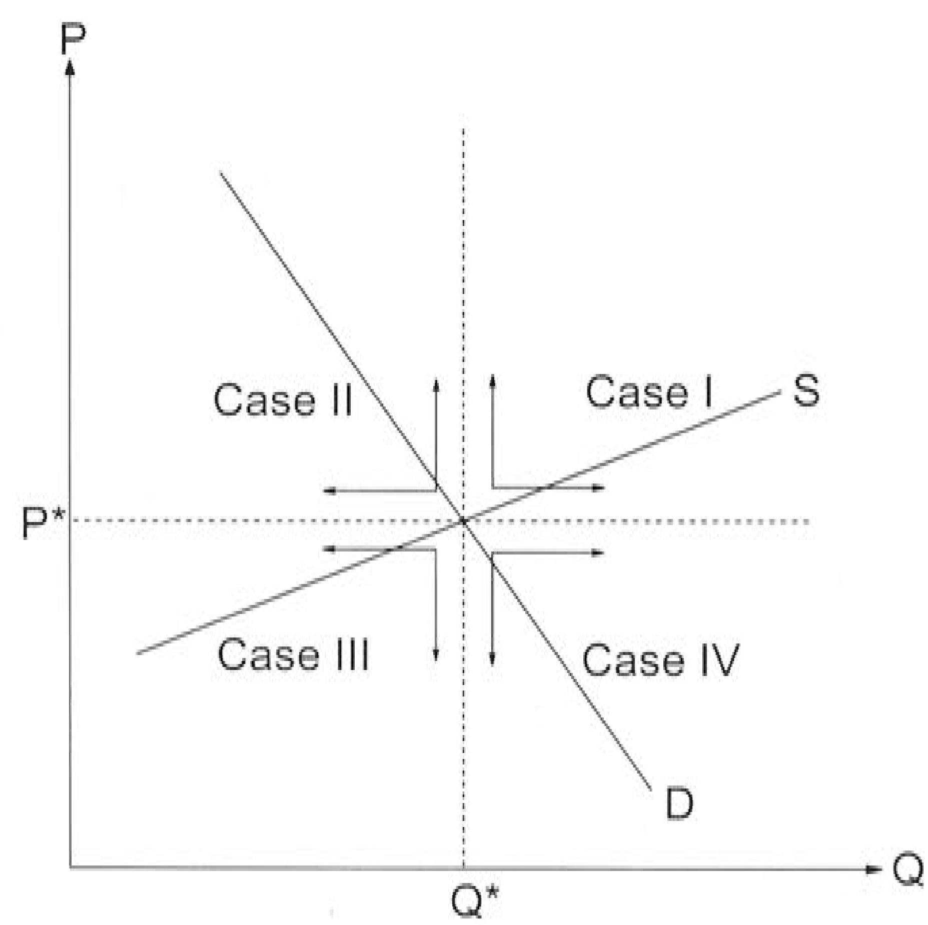

Figure 1: Possible changes in price and quantity of a commodity

Case I occurs only if the demand curve shifts right. It is not clear, however, whether the supply curve shifts right or left. Suppose that the demand curve shifts from D to D′ in Figure 2. As long as the supply curve shifts within a range between S′ and S″, both P and Q increase. If the supply curve shifts to S′, P does not change.

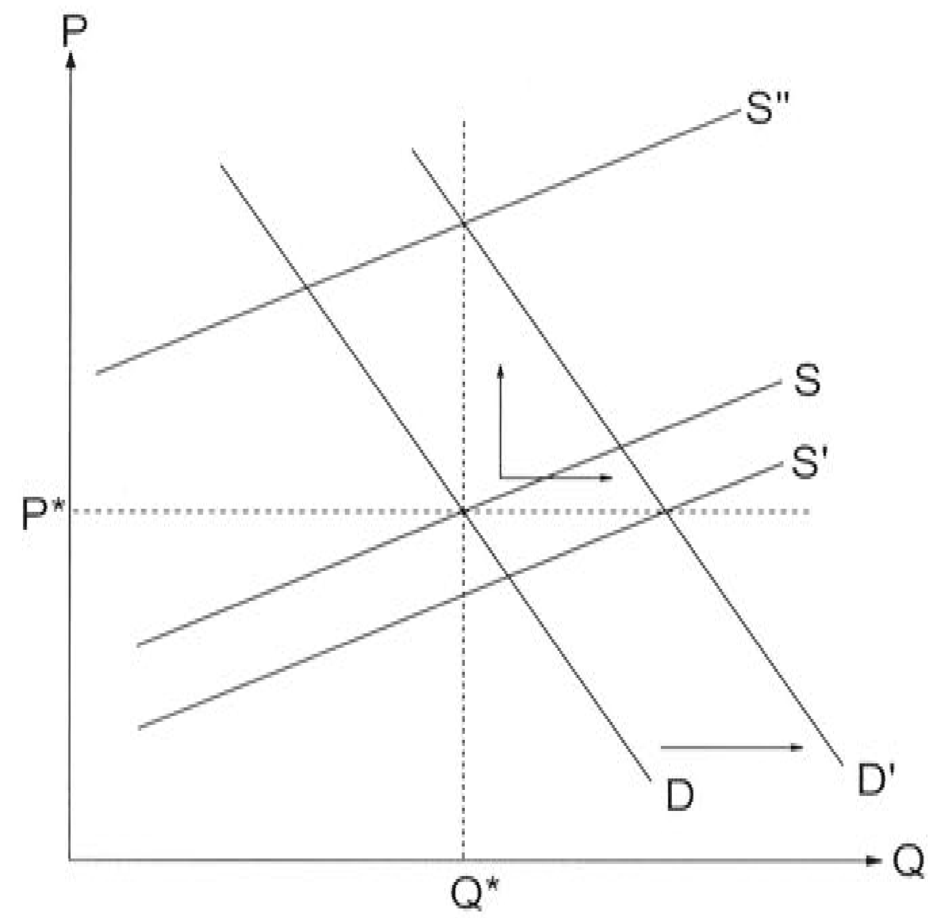

Figure 2: Case I: Q increases, while P does not fall.

Similarly, Case II occurs only if the supply curve shifts left. Suppose that the supply curve shifts to S′ in Figure 3. As long as the demand curve shifts to a range between D′ and D″, P rises and Q decreases. If the demand curve shifts to D′, Q does not change. In Case II, it is not clear how the demand curve shifts. Case III and IV can be depicted as mirror images of Figure 2 and 3, respectively. While Case III occurs if the demand curve shifts left, Case IV occurs if the supply curve shifts right.

In the context of testing the credit view, Case II is of prime interest. If we find Case II statistically significant in the bank loan market after a monetary tightening, we may conclude that the supply curve of loans shifts left, so that the credit view is supported. Similarly, we can reject the credit view if we find Case IV significant. In Case I and III, however, we cannot draw any conclusion about the position of the

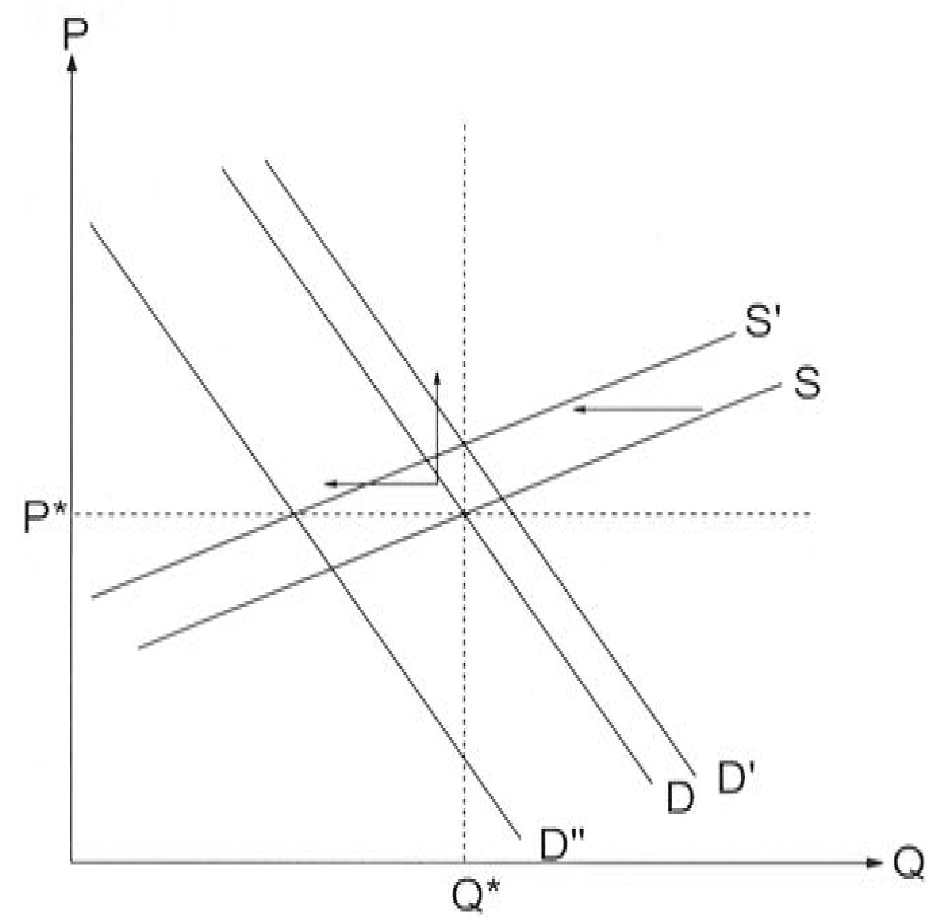

Figure 3: Case II: P rises, while Q does not increase.

supply curve.[3] Thus, the probability that we cannot accept the credit view when it is true may be high. Nevertheless, the approach identifies a shift of the supply curve of loans, depending on the results. Based on the above argument, the hypothesis will be formalised in a testable form in the fourth section.

[3]In Case I or III, a concrete conclusion about the money view can be drawn. One should note that the money view and the credit view are not exclusive each other. Rejection of the money view does not mean acceptance of the credit view, and acceptance of the money view does not mean rejection of the credit view.

3 Model and Estimation

3.1 Structural Model

This subsection describes the construction of our structural VAR model to test the credit view. When constructing a model, the first task is to decide which variables should be modelled. Taking into account the basic credit channel story, it is obvious that the dynamic interaction among three markets (goods, money, and loans) needs to be investigated.[4] Hence, the minimal set of variables to model are three quantities and three prices of these markets: aggregate real output (Y), the general price level (P), money (M), a short-term interest rate (R), bank loans (L), and a measure of the price of bank loans (LP).

In the structural VAR model, each of the six variables is linked. The model is typically written in vector form as

$$\mathbf{B}_0\mathbf{y}_t = -\boldsymbol{\Gamma}\mathbf{x}_t + \mathbf{u}_t, \tag{1}$$

where

$$\mathbf{y'}_t = (\mathrm{P}_t,\ \mathrm{Y}_t,\ \mathrm{M}_t,\ \mathrm{R}_t,\ \mathrm{L}_t,\ \mathrm{LP}_t), \tag{2}$$

$$-\boldsymbol{\Gamma} \equiv [\mathbf{k},\ \mathbf{B}_1,\ \mathbf{B}_2,\ \cdots,\ \mathbf{B}_p], \tag{3}$$

$$\mathbf{x'}_t \equiv [1,\ \mathbf{y'}_{t-1},\ \mathbf{y'}_{t-2},\ \cdots,\ \mathbf{y'}_{t-p}], \tag{4}$$

and $\mathbf{u}$ is a vector of structural shocks. We assume that these shocks are serially

[4]For instance, the theoretical model of Bernanke and Blinder (1988), which is the building block of the lending view, consists of the three markets: goods, money and credit.

uncorrelated and uncorrelatd with each other. That is,

$$E(\mathbf{u}_t \mathbf{u}_\tau) = \begin{cases} \mathbf{D} & \text{for } t = \tau \\ \mathbf{0} & \text{otherwise,} \end{cases} \tag{5}$$

where $\mathbf{D}$ is a diagonal matrix.

In the literature, the equation associated with the short-term interest rate, R, is usually interpreted as representing the response of the monetary authority to current and past developments in economy, and a shock to R is regarded as an innovation to monetary policy. This paper follows the convention. As the debate between Rudebusch (1998) and Sims (1998) shows, however, the common practice is contentious. For a shock in R to be a good indicator of monetary policy, it must be that the central bank supplies reserves elastically at the targeted level of R. Not until the late 1990s did the Bank of Japan (BOJ) disclose how it implemented monetary policy.[5] Nevertheless, there have been economists who have argued that the BOJ always attempted to control the overnight call rate (see, for example, Okina 1993, Ueda 1993, and Yoshikawa 1995). Okina (1993) emphasizes the institutional fact that the Japanese reserve accounting system is a lagged reserve system.[6] Under such a reserve system, the demand for reserves is predetermined each month. Since

[5]The Bank of Japan now officially announces that the overnight call rate is its operating target. See minutes of the Monetary Policy Meeting, which are available in English on the web of the Bank of Japan at http:\\www.boj.or.jp.

[6]In Japan, banks are required to maintain reserves, which are the product of the reserve ratio and average deposits outstanding in each calendar month, during the period from the 16th of that month to the 15th of the next month.

the Japanese banks hold almost no excess reserves, the BOJ faces a nearly vertical demand curve for reserves in the short-run. To avoid excessive fluctuations in the short-term interest rate, the BOJ must supply reserves passively at the targeted rate. Thus, it seems plausible to interpret a shock to R as an innovation to monetary policy.

3.2 Data Selection

The next task is to choose data to proxy the six variables in the model. The consumer price index and the seasonally adjusted index of industrial production are chosen for the price level (P) and real output (Y), respectively. For the short-term interest rate (R), the uncollateralised overnight call rate should be ideally chosen, since this is what the Bank of Japan (BOJ) now announces as its operating target. Not until July 1985, however, did the uncollateralised call market come into operation. To obtain a longer sample period, we use the collateralised overnight call rate, which the BOJ reputedly targeted before the money market reform of November 1988. For money (M), the monetary base is selected. As its quantity is directly affected by the BOJ's open market transactions, the monetary base seems more closely related with the call rate than are other monetary aggregates.[7] For the volume of bank loans (L), data series for "new loans for equipment funds" are found in TANKAN, the BOJ's quarterly economic survey of enterprises. For consistency with the output series,

[7]McCallum (1999) argues that the monetary base is an essential variable for evaluating the Japanese monetary policy.

which is the index of industrial production, the subset of the data, which refers to loans to manufacturing, is selected. Importantly, this series measures the flow of bank loans but not the stock.

Now turn to the data for the cost of bank credit. Data on "average contracted interest rates on new loans and discounts" are available from 1980, but there is a break in the series from October 1993 onwards when overdrafts are included.[8] An alternative series based on the diffusion index (DI) of "financial institutions' lending attitude" is available from 1970 onwards, and it is this series which is used here. The DI on lending attitude is released in the BOJ's TANKAN, in which firms are asked whether the financial institutions' lending attitude is "accommodative," "not so severe," or "severe." The BOJ calculates the DI by industry by subtracting the percentage of the firms answering "severe" from the percentage of those answering "accommodative." A lower value of the DI may be interpreted as indicating a tighter bank loan market. Suppose that an appropriate price of bank loans exists. If the price rises (due to a decrease of the supply of loans, an increase of the demand for loans, or both), more firms will perceive the loan market as tight. Therefore, it seems that the DI is correlated with the price of bank loans.

A potential problem of the DI arises from the fact that, while the firms are asked

[8]The change in the definition of loans and discounts also affects "new loans for equipment funds" by which we choose to measure the volume of bank loans (L). Consequently, the sample period of L is either from 1970:Q1 to 1993:Q1 or from 1993:Q4 onward. (The BOJ has released the figures of new loans for equipment funds since 1970.)

to choose one answer from "accommodative," "not so severe," and "severe", the DI does not contain information provided by those answering "not so severe." Suppose that 45 % of the firms answer "accommodative" and 55 % answer "severe." In this case, the DI is calculated as −10. The same value can be obtained, for example, if 10 % of the firms answer "severe" and no firm answers "accommodative." Despite the same value of the DI, bank loan market conditions obviously differ from each other in these cases. In this way, any particular value of the DI is consistent with an infinite number of different survey results. Fortunately, however, we do not have to worry about such a problem. As Figure 4 shows, there are nearly one-to-one relationships from the DI to the percentages of the firms choosing "accommodative" and "severe." Thus, it seems that the DI unambiguously provides information about the bank loan market.

As mentioned above, the full sample of the DI is longer by ten years than is that of the interest rate on new loans and discounts. In addition to providing a longer time series of consistent data, this series has the advantage of implicitly capturing non-price components of the cost of credit to borrowers (for example, collateral). Because of these advantages, this paper measures the price of bank loans by the DI rather than the interest rate on loans and discounts.[9] For consistency with the series for Y and L, the DI for manufacturing firms is chosen. In the following analysis, the DI is multiplied by −1 to measure the loan price (LP), so that a higher value

[9]As an alternative measure of the bank loan price, the interest rate on new loans and discounts will be used in section 4.3.

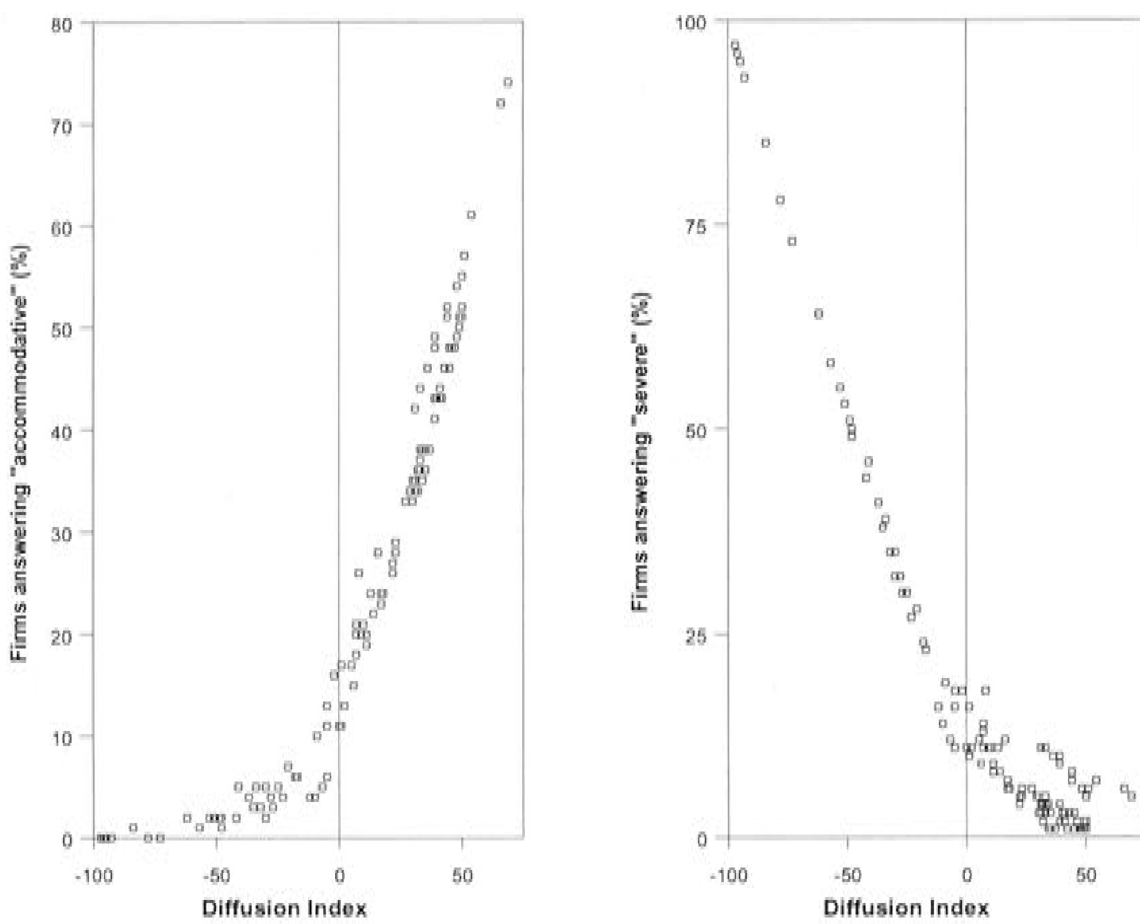

Figure 4: Diffusion Index and its Components (Sample: 1970:Q2 - 2000:Q1)

implies a higher price of loans.

3.3 Estimation

Estimating the structural model requires a set of identifying assumptions. For this purpose, a recursive structure is imposed upon the system. That is, $\mathbf{B}_0$ in (1) is restricted to be lower triangular. The causal ordering is given by (P, Y, M, R, L, LP).[10] Since a different ordering can have major consequences on the results, care must be taken (see, for example, Christiano, Eichenbaum, and Evans 1999). The rationale for the recursive structure is as follows. Since P is placed as the first variable, the other variables affect P only with a lag. This reflects the Keynesian

[10]For robustness checks, the model will be estimated under other causal orderings in section 4.3.

argument that prices slowly respond to economic developments. Y is placed before M and R under the assumption that money and the interest rate influence aggregate demand with a lag. This assumption is consistent with the monetarists' argument that monetary policy affects real economy only with a lag (so that fine-tuning is difficult). The position of M before R reflects the fact that the BOJ takes into account the current demand for the monetary base when it chooses the targeted level of the call rate. L and LP are placed after R because the BOJ obtains information about the bank loan market with a delay through its quarterly economic survey (TANKAN).

Imposing the recursive structure on the system, the parameters of (1) can be obtained by estimating the reduced form

$$\mathbf{y}_t = \mathbf{\Pi}'\mathbf{x}_t + \varepsilon_t, \tag{6}$$

where

$$\mathbf{\Pi}' = -\mathbf{B}_0^{-1}\mathbf{\Gamma}, \tag{7}$$

and

$$\varepsilon_t = \mathbf{B}_0^{-1}\mathbf{u}_t. \tag{8}$$

From the estimated parameters of (1), the impulse response functions of the variables to a shock in R will be calculated.

As the frequency of the data series for L and LP is quarterly, the other data series are converted from monthly to quarterly by taking the mean. All the variables except R and LP are measured as logarithms, while R is measured as a percent. Since only the index of industrial production for Y is seasonally adjusted, additive dummies are included to remove the seasonal variations. Constant terms are also included. The number of lags is set to four. As a benchmark analysis, the six variable VAR is estimated for the period 1973:Q1-1993:Q1. The selection of the starting period reflects a belief that the Japanese economy experienced a structural change around the first oil embargo. The ending period is chosen as above due to the series breaks in L and LP.

4 Results

First, this section formalizes the hypothesis in a testable form. A distinctive implication of the credit view is that a monetary tightening shifts the loan supply curve left. As depicted in Figure 3, a rise of the loan price detects a leftward shift of the loan supply curve unless the loan quantity increases. Consequently, our statistical work focuses on responses of the quantity and price of bank loans to a contractionary monetary shock. In addition, the effectiveness of monetary policy obviously needs to be tested. Following a monetary tightening, the credit view is accepted if:

- H1 The volume of bank loans (L) does not increase.
- H2 The price of bank loans (LP) rises.
- H3 Real output (Y) decreases.

Under the assumption that a short-term interest rate (R) is a good indicator of the

BOJ's monetary policy, H1 to H3 can be tested by the impulse response functions of L, LP, and Y to a shock in R.

4.1 Results of Benchmark Analysis

Figure 5 reports the results of our benchmark analysis. The solid lines display the estimated impulse response functions of the six variables to a one standard deviation shock to the call rate (R) representing an unexpected monetary tightening. Responses are shown over 16 quarters. The dashed lines denote two standard deviation bands of those impulse response functions. Assuming that ε_t in (6) is a Gaussian vector white noise, the standard deviation bands are calculated by a Monte Carlo method with an uninformative prior.

The impulse responses of Y and L show that there are co-movements between industrial production (Y) and bank loans (L). Y begins to decrease in the sixth quarter after a monetary tightening, and the decrease becomes significant in the eighth quarter. This timing roughly corresponds to the timing of the contraction of L: L begins to decrease continuously in the eighth quarter, although the decrease is insignificant. The timing pattern does not indicate whether the contraction of bank loans causes the decline in output or the latter induces the former. In other words, the question is whether the fall of L is due to a leftward shift of the supply curve of loans or a leftward shift of the demand curve for loans. This is the supply-versus-demand puzzle. Notice that the loan price (LP) falls below the initial level with the same timing as the decline in L. This corresponds to Case III in section 2.2.

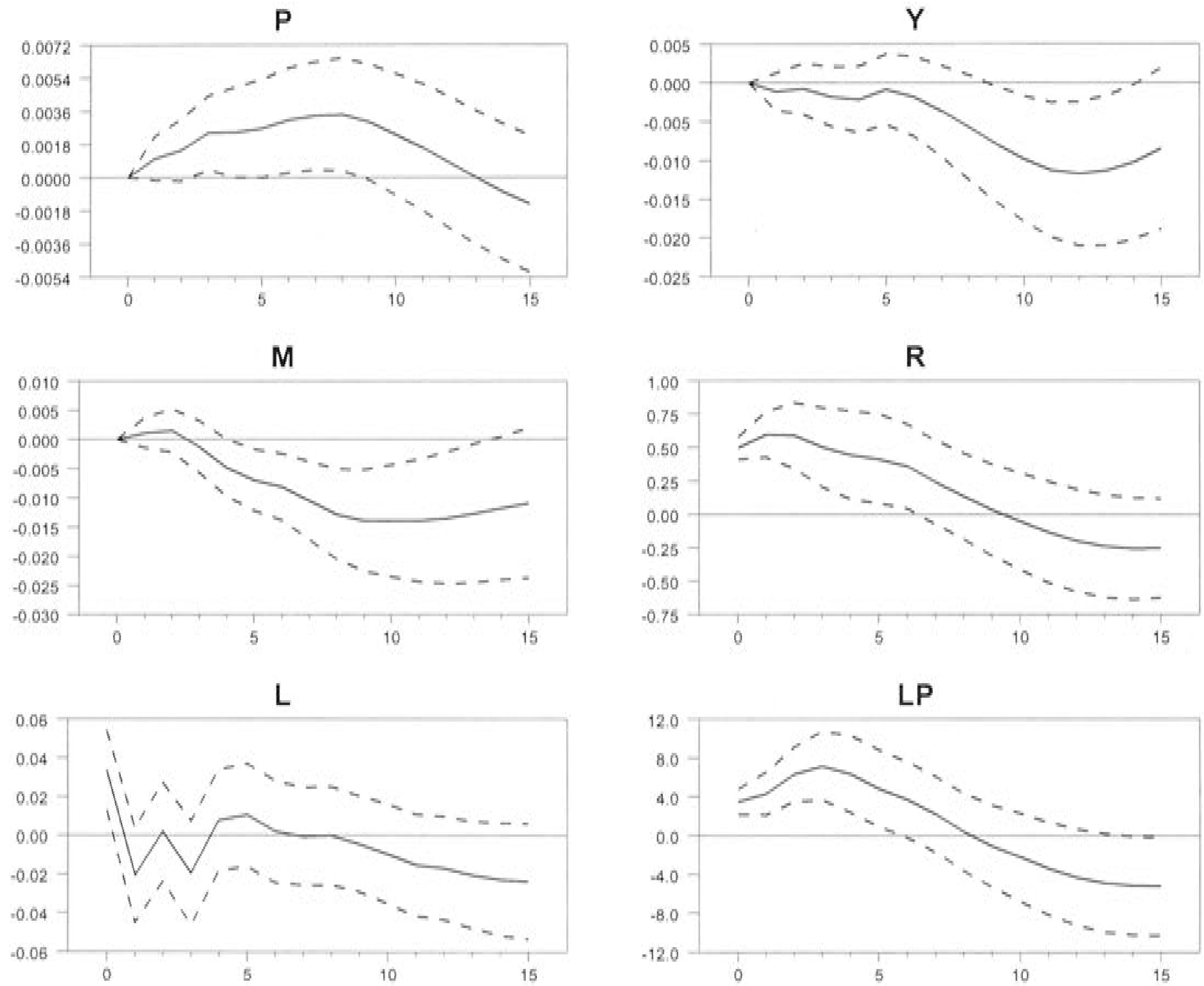

Figure 5: Impulse Responses to a Shock in R (Sample: 1973:Q1-1993:Q1)

(Benchmark Analysis)

Accordingly, we may conclude that the decline in bank lending, which occurs with the same timing as the decline in output, is due to a leftward shift of the loan demand curve.

Does the finding that the demand curve for bank loans eventually shifts right after a monetary tightening rule out the credit view? The answer is no. One must distinguish the short-run effects and the long-run effects of monetary policy on the bank loan markets. Not until the eighth quarter following a monetary contraction did bank loans clearly show a tendency to decline. Without information provided by the behaviour of the bank loan price, one would conclude that monetary policy had an impact on the bank loan market with a considerable lag. As explained shortly, the results show that the supply curve of bank loans quickly shifts left in response to a monetary tightening.

Let us test whether a monetary tightening is followed by a leftward shift of the loan supply curve or not. In response to a positive shock in the call rate (R), bank loans (L) immediately increase and then contract. Apart from the temporary jump, L does not significantly increase. Thus, H1 is accepted except for the initial quarter. On the other hand, the response of the loan price (LP) is significantly positive in the first six quarters, so that H2 is accepted over this period. Given the acceptance of H1 and H2, the conclusions are that the loan supply curve shifts left, at latest, in the next quarter of a monetary contraction, and that it takes more than four quarters for the loan supply curve to move back to its original position.[11] Importantly, our results are free from the supply-versus-demand puzzle.[12]

The next task is to test the effectiveness of monetary policy. As shown in Figure 5, industrial production (Y) begins to decrease slowly but significantly in response to a positive shock to the cash rate (R). Obviously, H3 is accepted, which is

[11]In the initial quarter, the loan supply curve may shift left or right as depicted in Figure 2.

[12]In fact, similar results can be obtained even if the loan supply curve does not shift. Suppose that the loan supply curve is vertical. Then, a rightward shift of the demand curve for bank loans will raise LP and have no effect on L, so that H1 and H2 will be accepted. In this paper, however, we assume that the supply curve of loans is not vertical.

consistent with the effectiveness of monetary policy. The effects of monetary policy on real output seem sizable. The impulse response function of Y suggests that industrial production declines by approximately 1.2 % in three years following an unexpected 0.5 % hike in the overnight call rate. Notice that the significant decline in real output is preceded by the leftward shift of the supply curve of bank loans. Therefore, this paper concludes that the credit channel is operative in Japan.

4.2 Interpretation of Anomalous Results

The initial positive response of bank loans (L) might seem to be evidence for misspecification of the model. A temporary positive response and a subsequent sluggishness of bank loans to a contractionary monetary shock are commonly found in the U.S. literature (see, for example, Bernanke and Blinder 1992, Gertler and Gilchrist 1993, and Kashyap and Stein 1994). Bernanke and Blinder (1992) and Kashyap and Stein (1994) attribute such behaviour of loans to the contractual nature of loan agreements.[13] Their argument might apply to loans for equipment funds to manufacturing firms, by which L is measured, in the sense that a financial contract setting the lending terms is usually written in advance. This implies that the volume of bank loans to an individual firm may not be responsive to a monetary tightening in the short-run. It is not clear, however, whether the contractual nature of loan

[13]This argument is particularly true of loans under commitment. Morgan (1998) contrasts movements in loans under commitment with movements in loans without commitment in the U.S.A., finding that only loans without commitment decrease after a monetary contraction.

agreements can cause the sluggishness of loans at an aggregate level. Suppose that a contract specifying the loan volume was written in advance. Then, the individual firm's demand curve for loans would look like the demand curve for a discrete commodity, namely a vertical demand curve with a reservation price. If there are many firms with dispersed reservation prices, the aggregate demand curve for loans will not be vertical. So, instead of a specific nature of loans, we emphasize the countercyclical demand for business loans. Gertler and Gilchrist (1993) argue that, in the wake of tight money, firms increase their needs for loans to smooth the impact of declining sales. Figure 5 of this paper shows that, while L significantly increases in the initial quarter, the price of loans (LP) significantly rises. This corresponds to Case I depicted in Figure 2, which is supportive of a rightward shift of the demand curve for bank loans.

Another result that might seem puzzling is the sluggish response of money (M). One might argue that a shock to the call rate (R) should be associated with an immediate fall of M. M does not have to fall in response to a monetary tightening, however. The base money, by which M is measured, consists of bank reserves and currency in circulation. The demand for currency depends largely on the current economic activity in the short-run. As long as it takes time for monetary policy to have effects on real economy, the demand for currency may not be responsive to a change in the interest rate. As explained earlier, each month's demanded volume of reserves is predetermined by the preceding month's volume of deposits under the Japanese reserve accounting system, so that the demand for bank reserves may be also insensitive to the interest rate in the short-run. Moreover, an interest rate hike will increase deposits, leading to an increase of the demand for reserves in future. Thus, the demand for the monetary base does not necessarily decrease or may even increase for a short time period after a monetary contraction. Such responses of the demand for the monetary base can explain the sluggishness of M in the wake of tight money.

The other anomalous result is the sustained positive responses of the price level (P) to a positive shock to the call rate (R). This is the well-known "price puzzle." Sims (1992) estimates VARs that include the interest rate, money, real output, and price level, finding that the price puzzle is evident in the U.S.A., the U.K., France, Germany, and Japan. He conjectures that the price puzzle appears when the VAR model omits the variable(s) from which the central bank attempts to anticipate inflationary pressures. It is known that including the commodity price index and/or the exchange rate sometimes resolves the price puzzle (see, for example, Sims 1992 and Christiano, Eichenbaum, and Evans 1996). With the commodity price index (CP) and the exchange rate (XR) added to the six variables, the VAR model is re-estimated.[14] The variables are ordered as (XR, CP, Y, P, M, R, L, LP). As Figure 6 shows, however, the price puzzle does not disappear. This is consistent with the Sims (1992) finding that including the commodity price and the exchange rate does not successfully change the results for Japan. Dungey and Fry (2000)

[14]The data series for CP and XR are the World export commodity price index and Yen per the U.S. dollar, respectively. Both are given by the IMF publication, *International Financial Statistics*.

estimate a three country VAR model (Australia, Japan, and the U.S.A.), obtaining similar results.

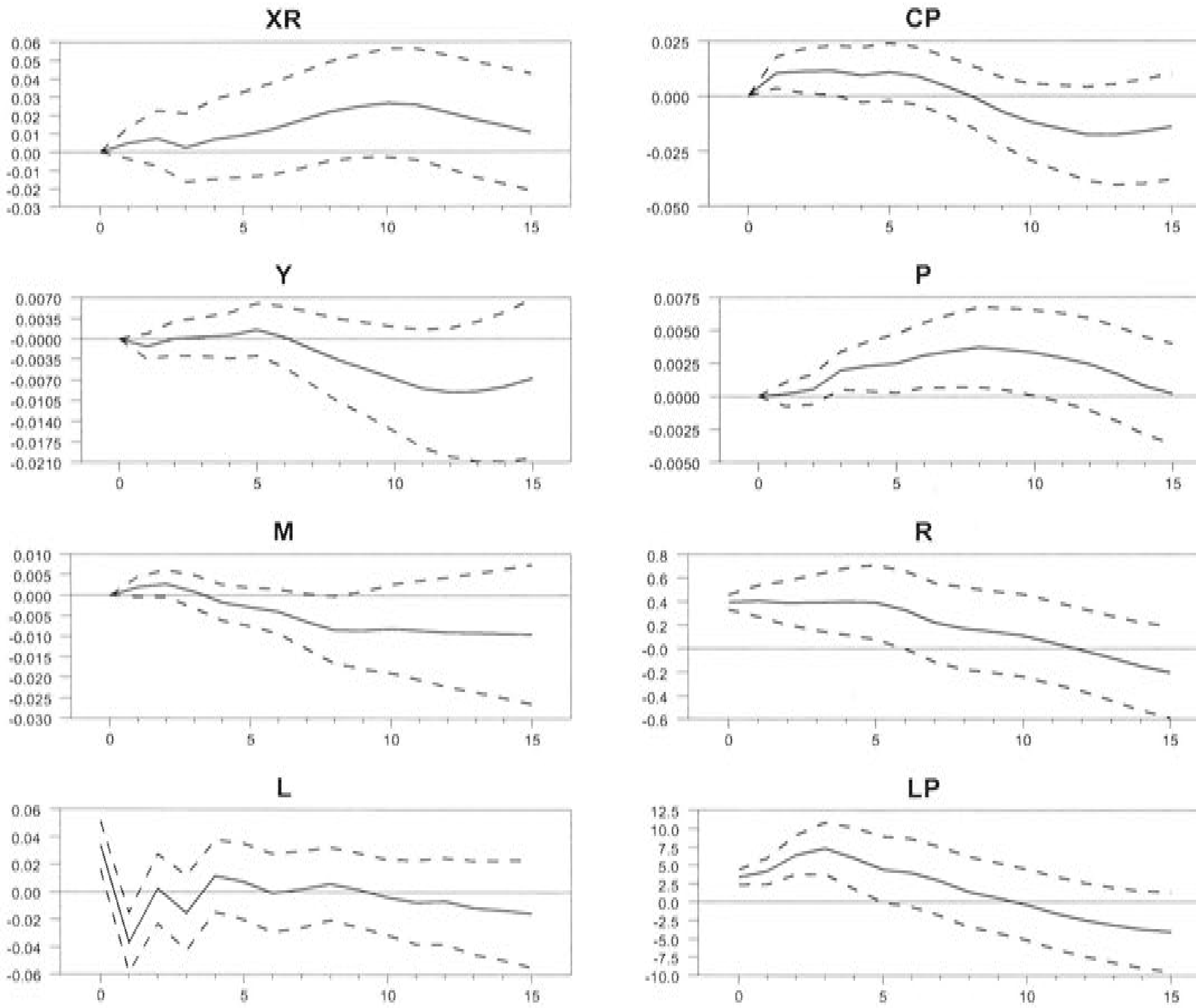

Figure 6: Impulse Responses to a Shock in R (Sample: 1973:Q1-1993:Q1)

(Including the Exchange Rate and the Commodity Price)

4.3 Robustness Checks

To assess the robustness of the benchmark results, the analyses were redone for an alternative measure of the price of bank loans, for different sample periods, and for other sets of identifying assumptions. This subsection briefly describes the results of the robustness checks.

First, the VAR model was re-estimated with the proxy for the loan price (LP) replaced with the "average contracted interest rate on new loans and discounts." As mentioned earlier, the data are available only from 1980:Q1. Results are shown in Figure 7 where LR denotes the interest rate on loans and discounts. Obviously,

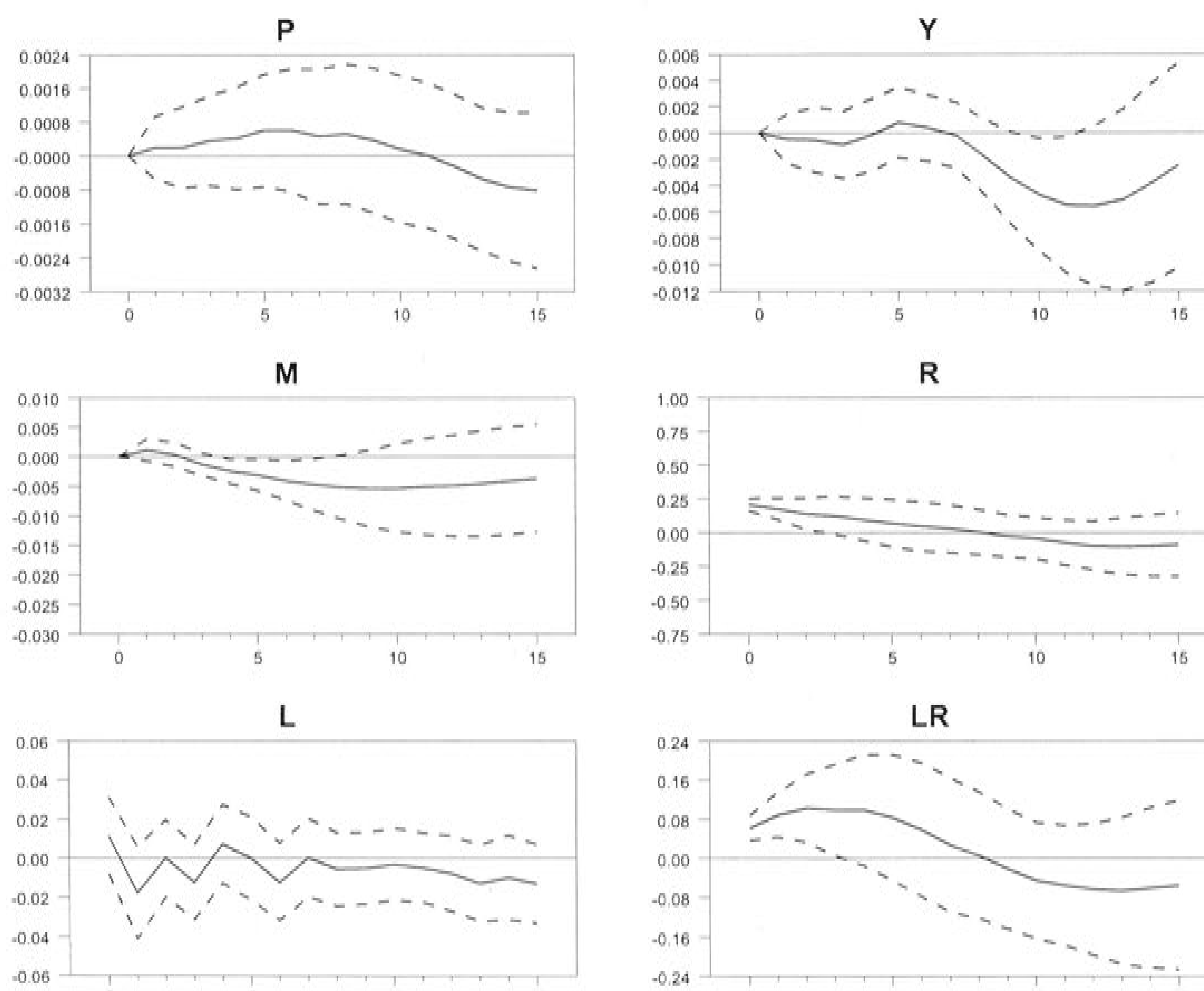

Figure 7: Impulse Responses to a Shock in R (Sample: 1980:Q1-1993:Q1)

(An Alternative Measure of the Loan Price)

H1 to H3 are again accepted. The alternative measure of the loan price does not markedly affect the benchmark results.[15] As the initial response of bank loans (L) is no longer significant, we may conclude that a leftward shift of the supply curve of bank loans immediately follows a monetary tightening.

Second, the sub-sample stability was analysed. With the sub-samples of 1974:Q1-1993:Q1, 1975:Q1-1993:Q1, 1976:Q1-1993:Q1, and 1977:Q1-1993:Q1, results were quite similar to those of our benchmark analysis. Each estimation confirmed that a sustained leftward shift of the loan supply curve occurred, at latest, in the next quarter of a monetary contraction, and that industrial production fell by approximately 1.2 % in three years after an unexpected 0.5 % hike in the call rate. With the sub-samples of 1978:Q1-1993:Q1, 1979:Q1-1993:Q1, 1980:Q1-1993:Q1, and 1981:Q1-1993:Q1, results changed with respect to a shift of the loan supply curve. Figure 8 shows the results with the sample 1981:Q1-1993:Q1.[16] While the initial positive response of bank loans (L) disappears, these results now show a relatively slow response of the loan price (LP). This implies that the loan supply curve shifts left, at latest, in the third quarter following a monetary tightening. Nevertheless, H1 to H3 are accepted.[17]

[15]It may be noteworthy that the error bands of the impulse response functions of the price level (P) become wider. The price puzzle is no longer significant, although the response of P is still positive.

[16]This starting period is selected based on the Kasa and Popper (1997) argument that the BOJ began to use modern money market operations in 1981.

[17]The VAR model was also re-estimated with longer samples. With the sample of 1972:Q1-1993:Q1, for example, it was confirmed that a leftward shift of the loan supply curve followed a monetary contraction. The effectiveness of monetary policy (H3) was not accepted, however. This

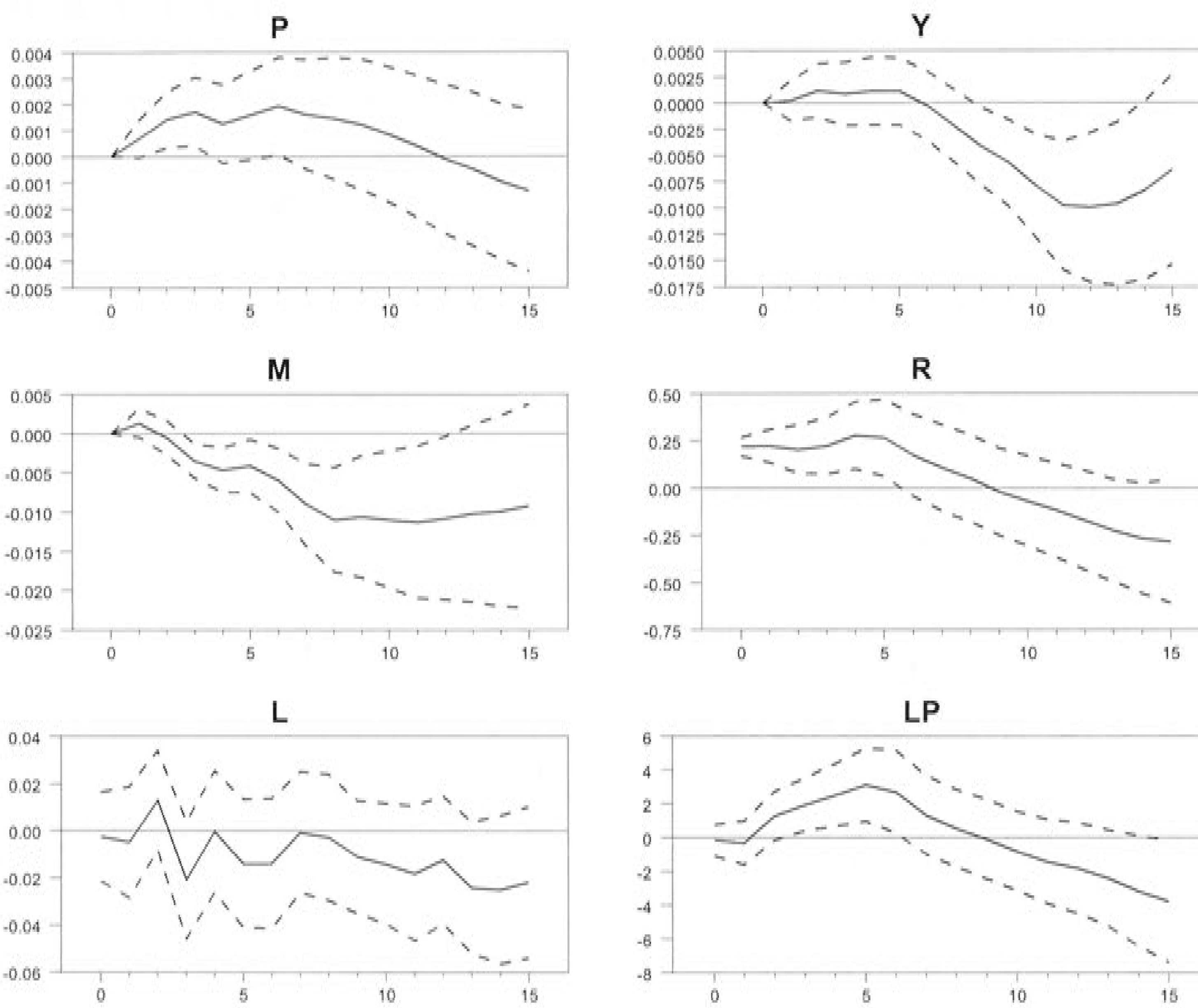

Figure 8: Impulse Responses to a Shock in R (Sample: 1981:Q1-1993:Q1)

(Sub-sample Analysis)

Finally, alternative recursive identifying assumptions were exmained. Sims (1998) suggests that the policy reaction function should exclude the current values of the variables that the authority observes with a delay. Assuming that the Bank of Japan (BOJ) observes the index of industrial production (Y) and the consumer price index (P) with a delay, the VAR model was re-estimated by ordering the variables

is presumably due to a structural break. Yoshikawa (1995), for example, argues that the Japanese economy experienced a structural change a few years before the oil embargo of 1973.

as (M, R, Y, P, L, LP).[18] As Figure 9 shows, ordering the variable in this way has almost no impact on the results of the benchmark analysis. The VAR model was

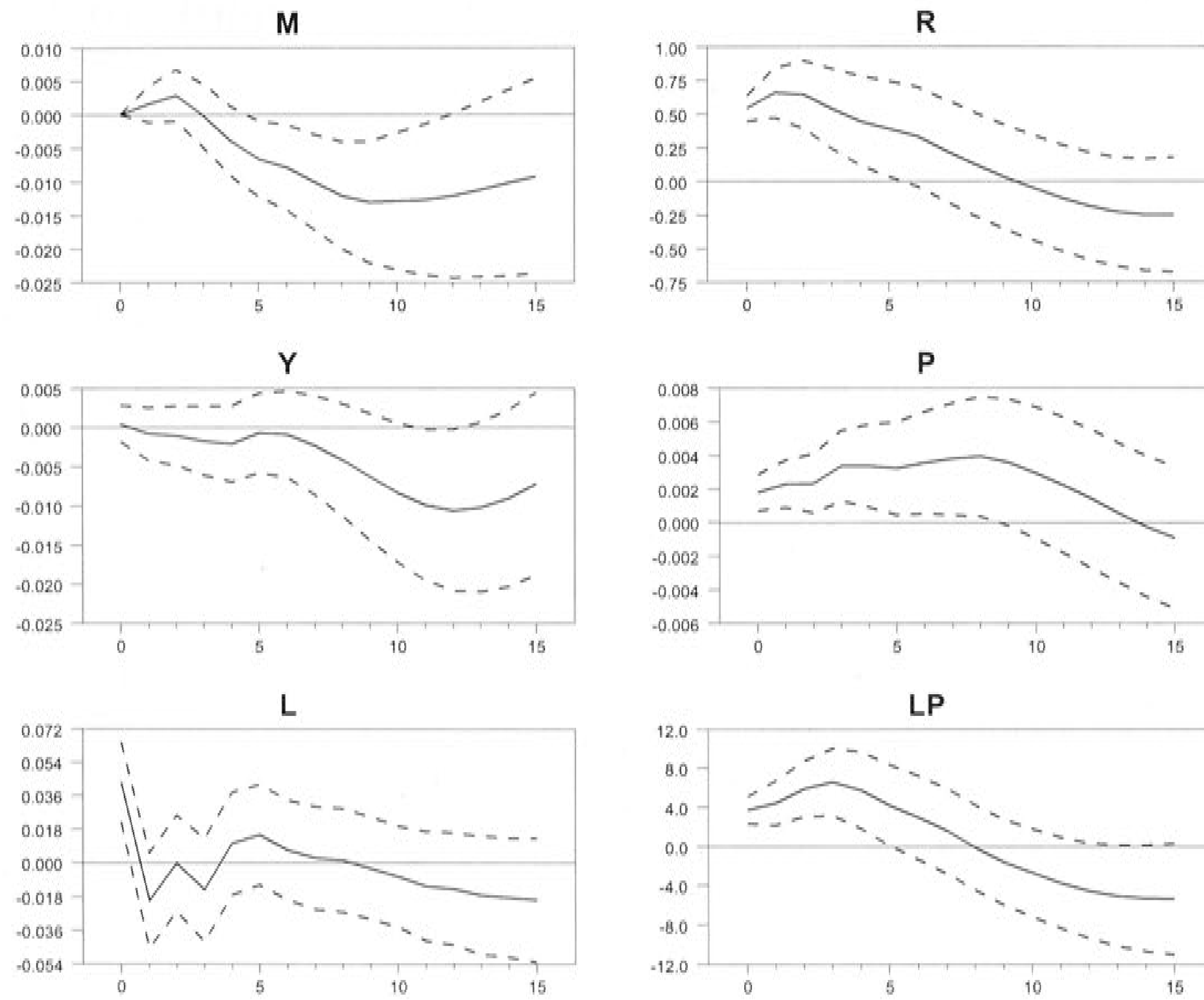

Figure 9: Impulse Responses to a Shock in R (Sample: 1973:Q1-1993:Q1)

(Reordering the Variables)

also re-estimated under a variety of orderings, and the results were quite robust to

[18]Neither the index of industrial production (IIP) nor the consumer price index (CPI) is published by the Bank of Japan. The Ministry of Economy, Trade and Industry and the Ministry of Public Management, Home Affairs, Posts and Telecommunications publish the IIP and the CPI, respectively.

the choice of the order.

5 Conclusion

Since the original work of Bernanke and Blinder (1992), the supply-versus-demand puzzle has been evident in similar empirical studies of the credit channel. A key to resolution of the puzzle lies in understanding its similarity to the simultaneous equation bias. An important assumption is that the quantity and price of bank loans are jointly determined and given by the intersection of the supply and demand curves. Using a simple demand-supply model, this paper showed how observing the behaviour of the quantity and price of bank loans could help to identify the shifts of the demand and supply curves in the bank loan market. As the price of loans, the diffusion index of "financial institutions' lending attitude" in the BOJ's quarterly economic survey of enterprises (TANKAN) was used.

To test the credit view, a six variable VAR model was estimated as a benchmark analysis. The six variables are prices and quantities in three markets: goods, money, and bank loans. One of the main results is that the loan supply curve shifts left, at latest, after one quarter following a monetary tightening. Importantly, our finding is free from the supply-versus-demand puzzle. Another significant finding is that a monetary tightening is followed by a sizable decrease of real output. In the estimation, industrial production decreases by approximately 1.2 % in three years following a 0.5 % hike in the call rate. These results clearly support the credit view for Japan.

The VAR model was re-estimated, using an alternative measure of the loan price, namely the "average contracted interest rate on new loans and discounts." The sample of the interest rate is shorter by seven years than is the sample of the diffusion index. Nevertheless, the results are similar to those of the benchmark analysis. For further robustness checks, the analysis was conducted for different sample periods and for different sets of identifying assumptions. The results were robust to these perturbations, and this paper concludes that the credit channel of monetary transmission is operative in Japan.

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THE AUSTRALIAN NATIONAL UNIVERSITY

WORKING PAPERS IN ECONOMICS AND ECONOMETRICS

Is the Lending Channel of Monetary Policy Dominant in Australia? (Revised)

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Working Paper No. 430

June 2003

ISBN: 086831 430 7

JEL Classification: E51, E52, G21

Abstract
A long-standing macroeconomic issue is how monetary policy affects the real economy. The lending view is that tight money affects aggregate demand by shifting the supply schedule left in the bank loan market. Previous studies have found that loans contract following tight money. It is not clear whether the financial contraction reflects a shift of the supply schedule or the demand schedule in the loan market, however. In an attempt to identify the shifts of the demand and supply schedules in the Australian loan market, this paper employs an original approach, which includes the quantity and the price of new loans. A variety of robustness check confirms that the lending view is not supported. The paper also examines features of Australian bank behaviour which make the lending view less plausible.

Acknowledgment:
I would like to thank Graeme Wells, Mardi Dungey, and two anonymous referees for their helpful comments and discussions. Also appreciated are comments and questions from the participants of seminars and conferences at Australian National University, Canterbury University, Curtin University of Technology, Hitotsubashi University, Griffith University, Monash University, University of Western Australia. I am grateful to the Australian Chamber of Commerce and Industry and the Westpac Banking Corporation for providing the survey data on my request. Any errors are the sole responsibility of the author.

1 Introduction

A long-standing and recurrent macroeconomic issue is how monetary policy affects the real economy. While standard macroeconomic models of aggregate demand have granted a significant role to money, there have always been economists who have stressed the importance of bank loans in the transmission process of monetary policy. Their views are collectively called the "lending view". In a nutshell, the lending view is that a monetary tightening shifts the supply schedule of bank loans left, thereby forcing bank-dependent borrowers to contract investments. This transmission mechanism of monetary policy is the "lending channel".

The lending view has an important implication. According to the lending view, the supply schedule of bank loans shifts left in the wake of tight money because banks have less money to lend. In other words, the banks will cut back on lending even though there are perfectly good loans to be made. In such a case, the supply-based contraction of bank loans has an independent impact on the real economy. (If the banks cut back on lending because firms are in bad shape or demand less money, the cutback will simply reflect the developments of the economy and hence have no independent impact on the economy.) It is this implication which distinguishes the lending channel from other channels of monetary policy.

There are reasons why it is important to study the lending channel of monetary policy. First, a credit aggregate may be a better indicator of monetary policy than an interest rate or a monetary aggregate. Second, a monetary tightening can have distributional consequences. While bank loans are a primary source of finance to small firms, large firms have a variety of financial sources. As a consequence, small firms will bear full brunt of the cutback of bank loans. Third, conventional prescriptions for a recession may not work. Suppose that the lending channel is usually operative. If the bank capital is depleted in recessions, the lending channel is likely to be weaker. In extreme cases, the injection of capital into the banking sector may be a better option than expansionary monetary policy and/or fiscal one. For these reasons, it is of fundamental importance, to policy makers in particular, to study the lending view.

The early literature typically tests the lending view with time series data, a common finding of which is contraction of bank loans in the wake of tight money. An influential work is that of Bernanke and Blinder (1992) who estimate a vector autoregression (VAR) model for the U.S. over the period 1959:8 to 1979:9, including the funds rate, the unemployment rate, the consumer price index (CPI), and bank balance-sheet variables (deposits, securities, and loans) all deflated by the CPI. They calculate impulse response functions to an innovation to the funds rate, finding that contraction of bank loans follows an unanticipated hike of the funds rate. Many researchers have employed this method for studies of different countries with different sample periods of data, reproducing essentially same results. With Australian data, for instance, Suzuki (2001) estimates a similar VAR model over the period 1985:Q1 to 2000:Q2, finding an unanticipated hike of the cash rate followed by contraction of bank loans. These findings are certainly *not inconsistent* with the hypothesis that monetary policy dominantly operates through the lending channel.

Unfortunately, however, contraction of bank loans in the wake of tight money cannot be an unambiguous evidence for the lending view. This is primarily due to high correlation between monetary and credit aggregates. When bank loans contract, deposits are also likely to contract. Therefore, one can argue that a monetary tightening depresses aggregate demand through the conventional money channel resulting in a decrease of demand for bank loans (i.e., the money view). In other words, it is necessary to identify the shifts of the supply and demand schedules in the bank loan market. Thus, the contraction of bank loans is consistent with the lending view as well as the money view. This observational equivalence is called the "supply-versus-demand puzzle" (Bernanke 1993). An empirical resolution of the puzzle is the main objective of this paper.

The supply-versus-demand puzzle has made it common to test the lending view, particularly in the U.S. literature, by examining the responses of banks to monetary policy with micro-data on banks' balance sheets (e.g., Kashyap and Stein 2000). In Australia, however, the banking sector is highly concentrated, which makes it of little use to analyse cross-sectional or panel data on banks' balance sheets.[1] Thus, testing the lending view for Australia requires an original approach with time series data. The next section discusses an original approach of this paper to resolve the supply-versus-demand puzzle with aggre-

[1] Four major banks have accounted for approximately 70% of total bank lending over the past decade in Australia. See, for instance, Tallman and Bharucha (2000).

gate time series data. As will be shown shortly, the results show that the lending channel of monetary policy is not dominantly operative in Australia. The third section examines features of Australian banks' behaviour which make the lending channel of monetary policy transmission less dominating. The fourth section concludes.

2 Empirical Resolution of the Puzzle

2.1 Model

This paper employs a vector autoregressions (VAR) approach, a main characteristic of which is a relatively small number of variables describing the dynamics of the economy. Let $\mathbf{x}_t$ denote a vector containing the values that the variables of interest assume at date t. Then, a VAR approach approximates the economy by a linear system of equations with constant terms and linear time trends being typically included:

$$\mathbf{B}_0\mathbf{x}_t = \mathbf{k}_0 + \mathbf{k}_1 t + \mathbf{B}_1\mathbf{x}_{t-1} + \cdots + \mathbf{B}_p\mathbf{x}_{t-p} + \mathbf{u}_t, \tag{1}$$

with $\mathbf{u}_t \sim$ i.i.d. $N(\mathbf{0}, \mathbf{D})$ where $\mathbf{D}$ is a diagonal matrix.

A macroeconomic VAR model commonly includes, at least, four variables: output (Y), price (P), money (M), and a short-term interest rate (R). These correspond to the variables of a standard IS-LM model. The four-variable VAR model, however, often results in the price puzzle, which is a finding of a sustained price rise following an unanticipated monetary tightening that is represented by a positive innovation to the interest rate. Sims (1992) conjectures that the price puzzle is a result of omitting variables which the monetary authority observes to obtain information on future inflationary pressures, suggesting that it should be resolved by including the exchange rate (XR) and the commodity price (CP) in a set of variables. Hence, six variables are considered fundamental in macroeconomic VAR modelling.

This paper expands the fundamental set of variables in order to study the lending channel of monetary policy. Bernanke and Blinder (1988) formalise the lending view by including the credit market in an IS-LM model, suggesting that the interaction among three markets (goods, money, and credit) be examined. Following their formalisation, the VAR model of this paper includes the loan price (LP) and the loan quantity (LQ) in a set of variables to model. As will be discussed shortly, the inclusion of the bank loan price enables the VAR model of the paper to test the lending view, distinguishing it from other similar models in the literature. As such, a minimal set of variables must consist of the prices and quantities of the three markets as well as the exchange rage and the commodity price.[2]

The openness of the Australian economy further suggests that the interaction between the Australian economy and the rest of the world should be modelled explicitly. No one would deny, for instance, that a change in the funds rate in the U.S. could affect the monetary policy in Australia. As Eichenbaum (1992) shows, a closed-economy VAR model for a non-U.S. country can lead to the price puzzle. Although the inclusion of the exchange rate may resolve the price puzzle, it often results in the exchange rate puzzle - that a depreciation of the domestic currency against the U.S. dollar follows a positive innovation in the short-term interest rate. Kim and Roubini (2000) estimate VAR models for non-U.S. G7 countries, finding that inclusion of the U.S. interest rate can eliminate those anomalous results. Brischetto and Voss (1999) confirm this finding by estimating a similar VAR model for Australia. Following their finding, the model of this paper includes the U.S. interest rate (R^U) in a set of variables.

The U.S. interest rate is not the only overseas variable which may affect a small open economy. In an attempt to model interdependence between economies, Cushman and Zha (1997) estimate an open-economy VAR model for Canada including the U.S. industrial production, the U.S. consumer price index, the federal funds rate, and the commodity price index in the U.S. dollar as the overseas variables. Dungey and Pagan (2000) also estimate an open-economy VAR model for Australia under the assumption that the rest of the world is represented by the U.S. economy, which is described by a group of U.S. variables: GDP, a real interest rate, the terms of trade, a measure of asset prices, and real exports. Dungey and Fry (2000) extend this modelling philosophy into a three country model. They estimate a three country VAR model treating the U.S. and Japan as the rest of the world to Australia. Following these works, this paper estimates an open-economy VAR model

[2]The earlier version of this paper analyses a VAR model consisting of the eight variables: output, the general price level, money, the short-term interest rate, bank loans, the price of bank loans, the exchange rate, and the commodity price. See Suzuki (2001) for the results.

where the U.S. is assumed to be the rest of the world to Australia. In particular, the set of variables includes the U.S. output (Y^U) and the U.S. price (P^U) as well as R^U. Thus, the VAR model of this paper consists of the eleven variables:

$$\mathrm{x}_t' = (P_t, Y_t, R_t, M_t, LP_t, LQ_t, XR_t, CP_t, P_t^U, Y_t^U, R_t^U)'. \tag{2}$$

2.2 Hypothesis

This section formalises the hypothesis, that monetary tightening dominantly operates through the lending channel, in a statistically testable form. (Note that the lending channel and the money channel are not exclusive to each other.) If the lending channel is operative, a monetary tightening will shift the supply schedule of bank loans. The early literature examines aggregate time series data, finding that contraction of bank loans follows a monetary tightening (e.g. Bernanke and Blinder 1991). As is mentioned in section 1, however, contraction of bank loans, of itself, is not necessarily a consequence of a leftward shift of the supply schedule (i.e., the supply versus demand puzzle). Thus, testing the lending view requires identifying the supply and demand schedule of bank loans.

For the purpose of identification, the set of variables includes the price and quantity of bank loans (see equation 2). A simple diagram of the demand and supply curves in the bank loan market can illustrate the idea. Suppose that a monetary tightening operated through the lending channel, shifting the supply curve of bank loans left from S to S′ in Figure 1. Then, one would expect to observe a rise of the price and a decrease of the quantity, so long as the demand schedule lies between D′ and D″. Similarly, a leftward shift of the demand schedule for loans, which the conventional money view predicts, would lead to decreases of the price and quantity of bank loans. As such, the inclusion of the price and quantity of bank loans reduces the puzzle to a problem like simultaneous equation bias, enabling us to test the lending view.

If the lending channel of monetary policy is dominant, a leftward shift of the supply schedule must be clearly observed following a monetary tightening. As Figure 1 depicts, a rise of the loan price detects a leftward shift of the supply schedule of bank loans unless the quantity of bank loans increases. For the study of the lending channel to be meaningful,

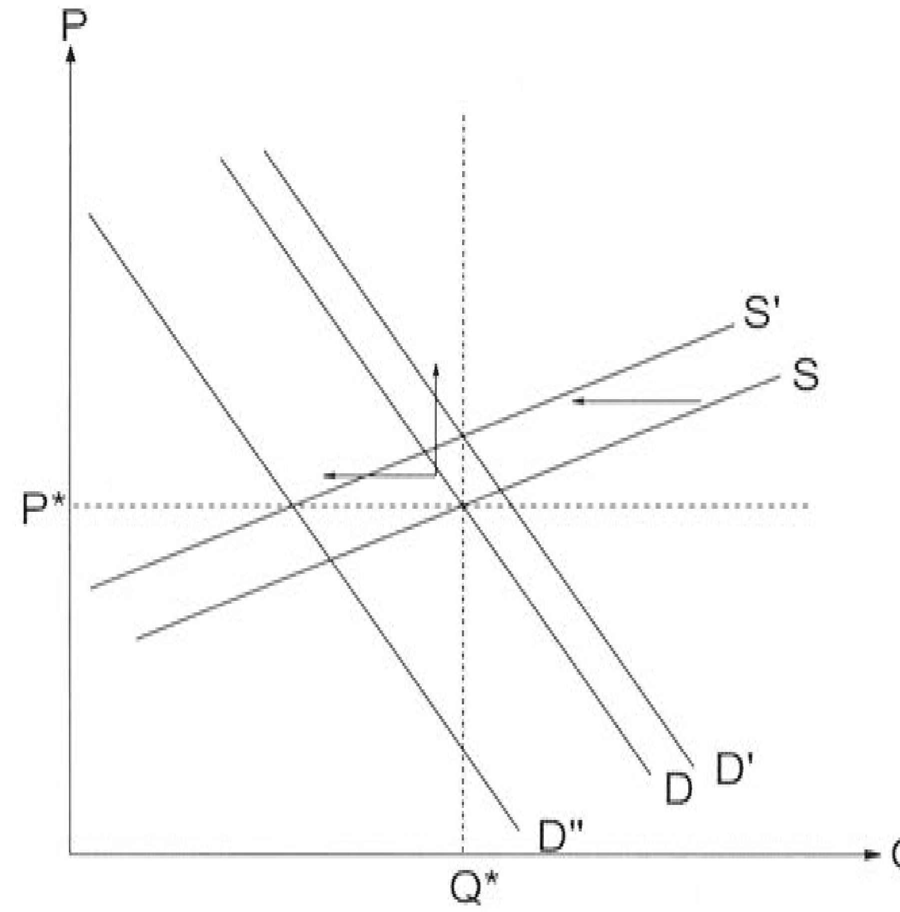

Figure 1: Consequences of a leftward shift of the supply curve.

it may be also worthwhile to test the effectiveness of monetary policy. Thus, the lending view will be accepted if:

H1 the quantity of bank loans (LQ) does not increase,

H2 the price of bank loans (LP) rises,

H3 and real output (Y) decreases,

following a monetary tightening. For the purpose of testing H1 to H3 statistically, the system of linear equations (1) is estimated to simulate impacts of monetary policy on the economy.

In macroeconomic modelling in general, however, it is always difficult to measure monetary policy in a convincing way. The early VAR literature in the U.S., for instance, often interprets an equation associated with the funds rate as the reaction function of the Fed, which implies that an innovation to the funds rate represents monetary policy. This practice has been subject to criticism, partly because of its anomalous results.[3] In contrast,

[3] See the debate between Rudebusch (1998) and Sims (1998). Rudebusch argues that an equation of

a similar practice produces no anomalous result in Australian VAR modelling. Consequently, it is now common to assume in the Australian literature that an innovation in the cash interest rate represents monetary policy (e.g., Brischetto and Voss 1999, Dungey and Fry 2000, and Dungey and Pagan 2000). Following the tradition, this paper assumes that a positive innovation to the interest rate (u^R) represents its unexpected hike by the RBA.

Simulating the dynamic responses of macroeconomic variables to monetary policy is equivalent to calculating the impulse response functions of those variables to an innovation to the interest rate. The impulse response function of LQ, for instance, is defined as

$$\frac{\partial\ E(LQ_{t+i}|I_t)}{\partial\ u_t^R} \text{ for } i = 0, 1, \cdots,$$

where the numerator denotes the expected value of LQ at time $t + i$ conditional on the information set available at time t. The impulse responses are calculated to test the hypotheses H1 to H3. H1 and H2 will hold if

$$\text{H1: } \frac{\partial\ E(LQ_{t+i}|I_t)}{\partial\ u_t^R} \leq 0 \text{ for } i = 0, 1, \cdots, \tag{3}$$

and

$$\text{H2: } \frac{\partial\ E(LP_{t+i}|I_t)}{\partial\ u_t^R} > 0 \text{ for } i = 0, 1, \cdots. \tag{4}$$

H3 will be similarly supported if

$$\text{H3: } \frac{\partial\ E(Y_{t+i}|I_t)}{\partial\ u_t^R} < 0 \text{ for } i = 0, 1, \cdots. \tag{5}$$

Thus, the impulse response functions of LQ, LP, and Y enables us to test the hypothesis that monetary policy dominantly operates through the lending channel.

2.3 Estimation

To calculate the impulse responses, the parameters of the system of linear equations (1) needs to be estimated with data. P and Y are conventionally measured by the log of CPI and the log of real GDP, respectively. The U.S. general price and output are similarly measured in logs. M is measured by the log of base money. Base money is chosen in an

the funds rate does not correctly model the reaction of the Fed. Regarding this sort of issues as universal in macroeconomic modelling, however, Sims criticises such critiques as unconstructive quibbles.

attempt to avoid possible problems caused by high correlation between money and bank credit. The cash rate is chosen for R, as it is the policy instrument of the Reserve Bank of Australia. R is measured in per cent. A positive innovation to R is interpreted as an unanticipated monetary tightening under the assumption that the equation associated with R is a reaction function of the RBA. R^U is similarly measured by the federal funds rate in per cent. XR is the log value of the Australian dollar measured in the U.S. dollars, which means that a rise in XR represents an appreciation of the Australian currency against the U.S. currency. CP is measured by the log of the world non-fuel commodity price index. LQ is the log of loans and advances by Australian banks. The sources of data are provided in the Appendix.

Measuring LP is not straightforward. A candidate for the loan price (i.e., the marginal cost of loans to borrowers) is an interest rate on new loans. Although data on the weighted average interest rate on total credit are available from 1993:Q4, there is no series available which gives the interest rate on new loans.[4] An alternative candidate is the diffusion index in the "Survey of Industrial Trends" conducted by the Australian Chamber of Commerce and Industry (ACCI) and the Westpac Banking Corporation. Question 4-b of the survey is "Do you find it is now harder, easier or the same as it was three months ago to get finance?" The diffusion index is calculated by subtracting the percentage of the firms answering "Easier" from the percentage of those answering "Harder." Suppose that the marginal cost of loans to borrowers rose due to a leftward shift of the supply curve of loans, a rightward shift of the demand curve for loans, or both. Then, firms would find it "Harder" to get finance. Consequently, one would observe a rise of the diffusion index. As such, the marginal cost of loans to borrowers and the ACCI-Westpac diffusion index may be positively correlated. Data on the diffusion index are available from 1966:Q2. In addition to providing a longer time series of data, the diffusion index is also expected to capture non-price components of the marginal cost of loans to borrowers such as collateral, or in extreme cases, the cost of being rationed out of the bank loan market. For these two advantages, the ACCI-Westpac diffusion index is utilized to measure LP (see Appendix A for further discussion on the ACCI-Westpac diffusion index).

[4] The weighted average interest rate is calculated from all the interest rates on outstanding loans. Consequently, it is too sticky to represent the current conditions of the loan market.

With those data, the system of linear equations (1) is estimated over the period 1985:Q1 to 2000:Q2. The beginning period reflects the abolition of monetary targeting in Australia (see MacFarlane 1999). The end of the period is chosen to avoid possible problems caused by the introduction of the goods and services tax (GST) in July 2000. The choice of this sample period means that we have 62 observations. A number of parameters in system equations (1) quickly consumes degrees of freedom, however.[5] In order to guarantee meaningful degrees of freedom, it may be worthwhile to restrict some of the parameters to be zero.

A less-disputable way to reduce the number of parameters may be to assume that Australian is a small open economy. For formalising this assumption, the eleven variables are divided into two groups: the overseas variables and the domestic variables. The group of the overseas variables consists of the three U.S. variables as well as the commodity price index. The other seven variables are the domestic variables. Then, $\mathbf{x}_t$ can be written as:

$$\mathbf{x}_t' = (\mathbf{x}_t^{o\prime}, \mathbf{x}_t^{d\prime})'.$$

where $\mathbf{x}^o$ and $\mathbf{x}^d$ denote the vector of the overseas variables and that of the domestic variables, respectively. If the coefficient matrices in the model (1) are partitioned conformably with $\mathbf{x}_t$ as

$$\mathbf{B}_j = \begin{pmatrix} \mathbf{B}_{11}^j & \mathbf{B}_{12}^j \\ \mathbf{B}_{21}^j & \mathbf{B}_{22}^j \end{pmatrix} \text{ for } j = 0, \cdots, p,$$

the restriction is equivalent to

$$\mathbf{B}_{12}^j = \mathbf{0} \text{ for } j = 0, \cdots, p. \tag{6}$$

In other words, the variables in $\mathbf{x}^o$ are assumed to be block-exogenous with respect to the variables in $\mathbf{x}^d$. Such a prior is often utilised in open-economy VAR modelling, but rarely tested. The earlier version of this paper tests the block exogeneity by employing the procedure of Toda and Yamamoto (1995). Unfortunately, however, the test statistics

[5] Degrees of freedom certainly depend on the number of lags, which can also affect the estimation results. The system of equations (1) are estimated with different numbers of lags, ranging from one to four. In what follows, the number of lags is set as two. The estimation results are qualitatively robust to the choice of the number of lags, however. See Appendix B.

are suspiciously large even after correcting small sample bias (see Suzuki 2001). In what follows, the simulation results are derived from both the unrestricted and restricted models.

Since the system of equations (1) is a simultaneous equation model, a set of identifying restrictions are required. Like most other VAR models, this paper assumes that $\mathbf{B}_0$ is lower triangular. The domestic variables are placed after the overseas variables (CP, P^U, Y^U, and R^U) under the assumption that the domestic variables cannot instantaneously affect the overseas variables. The domestic economic conditions can have influences on the rest of the world, if any, with certain time lags. The order of the domestic variables is P, Y, M, R, XR, LQ, and LP. Due to the prior that the price adjustment is sluggish, P is placed before all the other domestic variables, which means that the other domestic variables can affect P only with lags. Y is placed before M and R, which implies that M and R can affect Y with lags, under the assumption that "fine tuning" is a difficult task. The position of M before R reflects the prior that the RBA takes into account the current demand for money when it determines the targeted level of the cash rate. LQ and LP are placed after R because the RBA does not conduct survey of enterprises about the financial conditions, which means that the RBA can obtain information on the bank loan market with time lags.[6]

2.4 Results

First, the simulation results from the unrestricted eleven-variable VAR are examined. The impulse response functions of the variables to a positive shock in the cash rate calculated. In each graph of Figure 2, the solid line is the impulse response function of each variable to a positive shock in the cash rate. The size of the shock to the cash rate is one-standard-devation, which is calculated as an increase of approximately 0.55 percentage point in the cash rate. Figure 2 also displays the 90% confidence intervals for the estimated impulse responses by the dotted lines. Following Runkle (1987), this paper numerically generates the confidence intervals by "bootstrapping".[7] The 90% confidence intervals are

[6] As a different ordering of the variables can produce different results, robustness checks are conducted with different orderings. The qualitative results concerning the lending view are not sensitive to the ordering of the variables, however. See Appendix B.

[7] The procedure is as follows. First, the model (1) is estimated, and the estimated coefficients and the fitted residuals are saved. Then, the residuals are reshuffled with replacement, and the data set is artificially

used for one-tail tests at 5% significance level. In Figure 2, the loan price is measured in percentage point. The other variables are in logs and multiplied by 100, so that the impulse response functions approximate the percentage change of these variables in response to an unexpected 0.55 percentage point hike of cash rate. The same scale is used for all the variables except for the loan price.

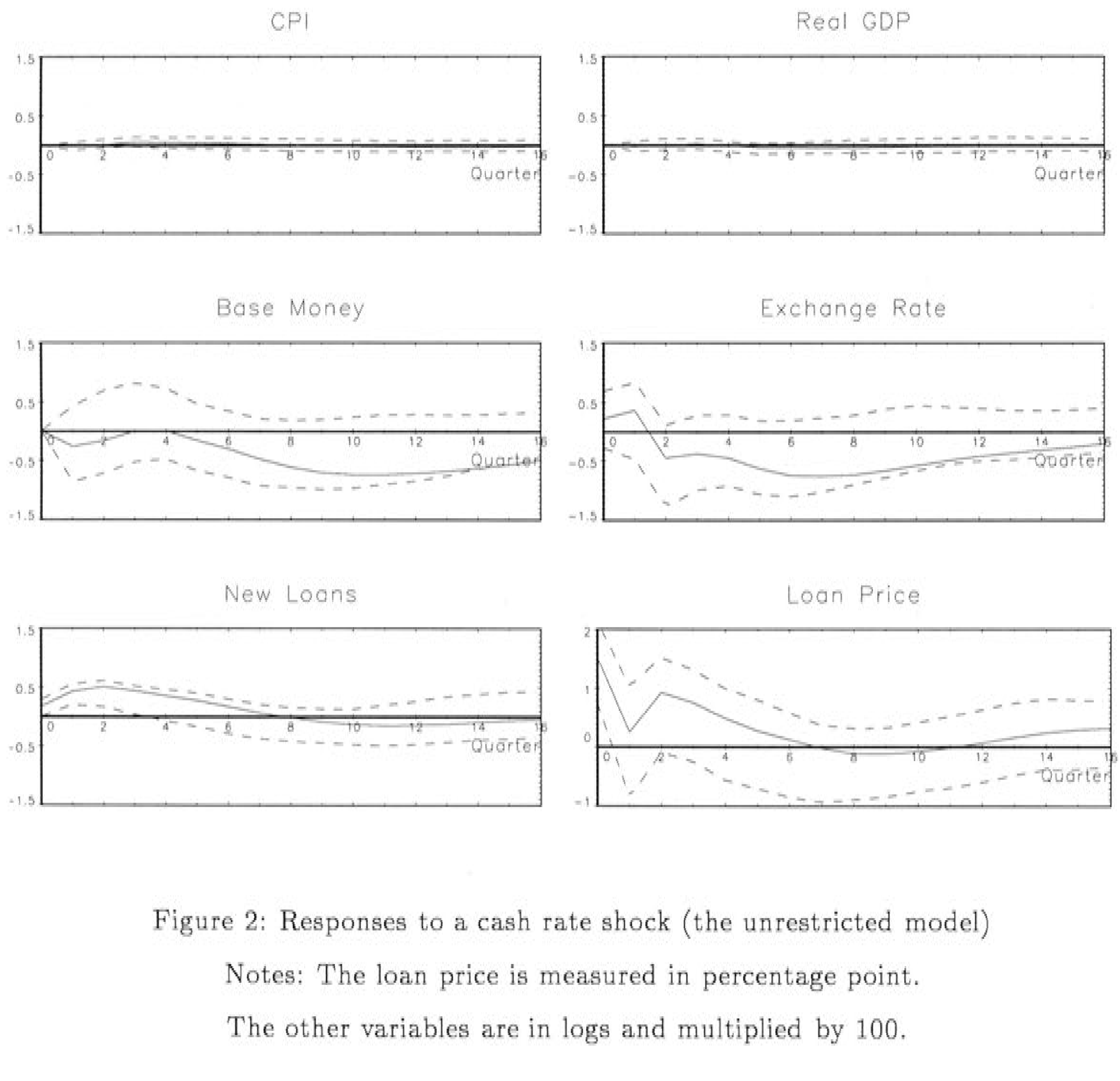

Figure 2: Responses to a cash rate shock (the unrestricted model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

The upper two graphs of Figure 2 indicate that impacts on the price and output

created using the estimated VAR as the true data-generation process. In this paper, a series of 1000 such simulations are undertaken. With each of the 1000 synthetic data sets, the model is re-estimated and the impulse response functions are calculated. The confidence intervals for the originally estimated impulse response functions are inferred from the ranges that include 90% of the values for the 1000 simulated impulse responses.

of a change in the cash rate are negligible. In particular, the left graph provides the statistical test for H3 (i.e., the effectiveness of monetary policy). The decline of real GDP is significantly different from zero only in the fifth quarter at 5% significance level:

$$\frac{\partial\ E(Y_{t+5}|I_t)}{\partial\ u_t^R} < 0.$$

While this seems to imply the effectiveness of monetary policy, its impact on the real GDP is negligible. The point estimate shows that the maximum effect is a decline of approximately 0.06% in real GDP in the seventh quarter following an unanticipated 0.55 percentage point rise of the cash rate. Are the results consistent with those of other Australian studies? Dungey and Pagan (2000), for instance, estimate an open-economy VAR model over the period 1980:Q1 to 1998:Q3. The maximum effect is a decline of nearly 0.3% in real GDP in the seventh quarter following an unanticipated 1.4 percentage point hike in the cash rate. Although the response of real GDP is significant at 5% significance level in their analysis, the size of the response is small. Brischetto and Voss (1999) similarly estimate a seven-variable VAR (real GDP, the CPI, M1, the cash rate, the exchange rate, the world oil prices, and the U.S. interest rate) over the period 1980:Q1 to 1998:Q4 finding that an unexpected 0.25 percentage point rise of the cash rate is followed by a decline of approximately 0.2% in real GDP in 12 quarters. The decline of real GDP is not significant at 5% significance level in their analysis, however. Thus, it seems reasonable to conclude that the effects of monetary policy are estimated to be small.

The centre graphs of Figure 2 show the impacts of an unanticipated hike of the cash rate on base money and the exchange rate, which can be displayed for the purpose of detecting, if any, misspecification(s) of the model. The point estimate of the left graph implies that base money initially falls by nearly 0.3% in response to the unexpected hike of the cash rate. The point estimate in the right graph is reasonable: the Australian dollar immediately appreciates by approximately 0.4% against the U.S. dollar following the same change in the cash rate. Although the responses of money and the exchange rate are not significantly different from zero, the point estimates are not anomalous.

As for testing the lending view, the lower two graphs in Figure 2 are of particular importance. The point estimates in these graphs show that the quantity and price of bank loans initially increase. While H2 is accepted, H1 is rejected at 5% significance level. Consequently, the hypothesis that the lending channel is dominant is rejected at 5% significance level. As can be inferred from Figure 1 in subsection 2.2, this pattern of co-movements between the price and the quantity implies that the demand schedule for bank loans shifts right in response to a monetary tightening. Such a temporary rightward shift of the demand schedule for bank loans is commonly found in the U.S. literature. Gertler and Gilchrist (1993), for instance, argue that U.S. firms temporarily increase the demand for bank loans in order to smooth reductions in their cash flows in the wake of tight money. Their argument may apply to the Australian case. After an initial increase, the quantity of bank loans begins to decrease. In the first quarter after a positive innovation in the cash rate, the quantity of loans increases while the price of loans falls. These movements of the price and quantity of bank loans contradict the hypothesis that the lending channel of monetary policy is dominant. Rather, the results imply that Australian banks accommodate the temporarily increased demand for bank loans.

For the purpose of robustness check, the structural model (1) with the restriction of block exogeneity (6) is also estimated over the same period using the same data. The calculated impulse response functions are shown in Figure 3. The initial positive response of loans is no longer significantly different from zero. It is significant at 10%, however.[8] The responses of the quantity and loans of bank loans are similar to those of the previous models. Therefore, the lending view is not again supported. The responses of the other variables are also consistent with those calculated from the restricted model.

3 Banking Behaviour

As is shown in the previous section, loans initially expand when money is tightened. It is also shown that the positive response of bank loans accompanies a rise of the marginal cost of bank loans to borrowers. Therefore, the previous section concludes that the initial positive response of bank loans is due to an rightward shift of the demand schedule in the bank loan market. This is consistent with the argument of Gertler and Gilchrist (1993) that firms temporarily increase demand for bank loans to smooth reductions in their cash

[8]This means that a similarly calculated 80% confidence interval lies above zero at the initial three quarters.

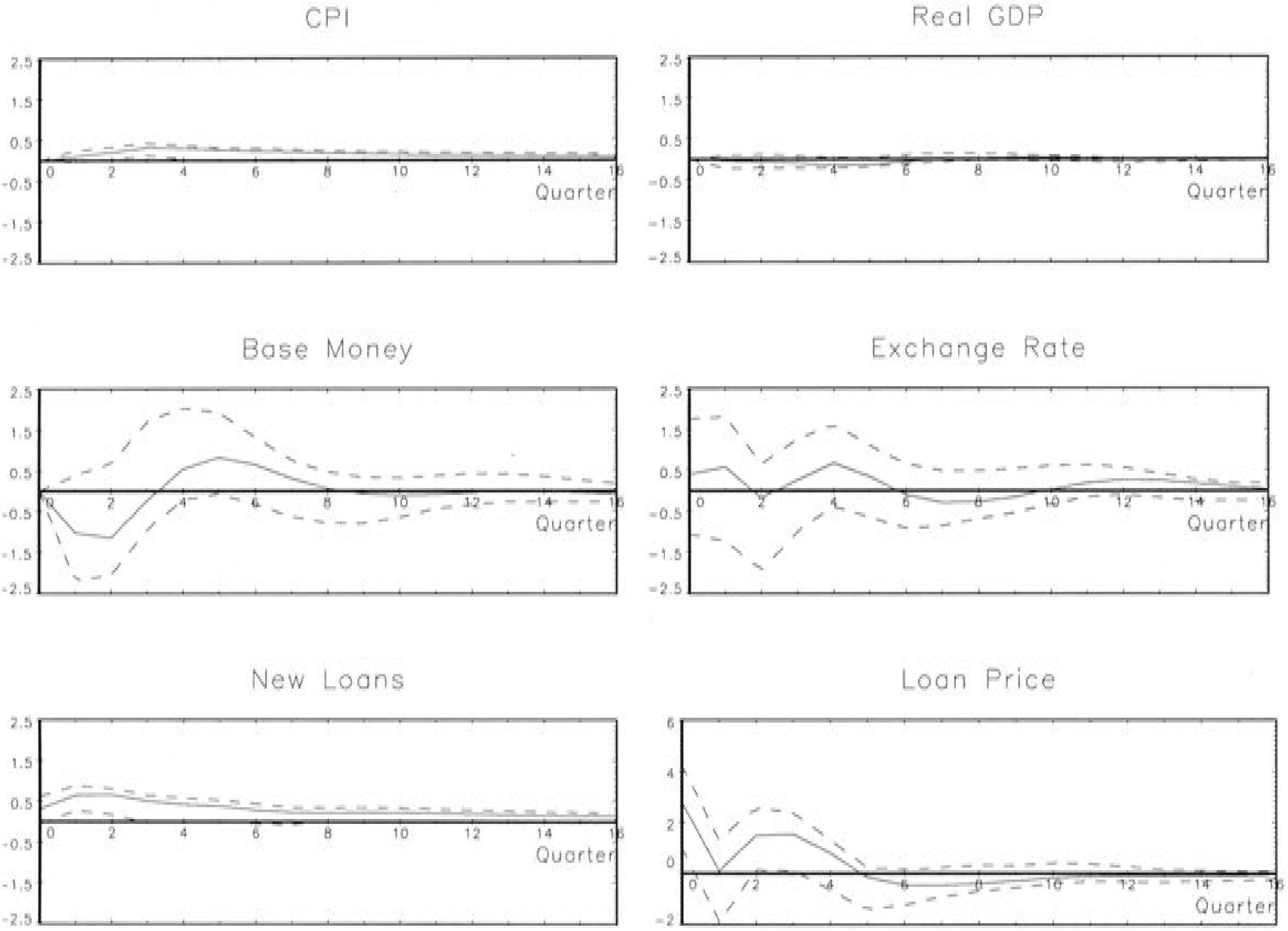

Figure 3: Responses to a cash rate shock (the restricted model)

Notes: The loan price is measured in percentage point.

The other variables are in logs and multiplied by 100.

flows in the wake of tight money. Then, a question arises. How can Australian banks accommodate the change in the demand schedule for bank loans when the Reserve Bank of Australia tightens money?

In the U.S. context, Bernanke and Blinder (1992) emphasize the role of banks' security holdings in mitigating impacts of monetary contraction on their supply schedules of bank loans. Due to the contractual nature of bank loans, banks cannot immediately cut their supply of loans. Therefore, banks reduce their security holdings in the wake of tight money. This argument seems to apply to the Australian case. Suzuki (2001) estimates a VAR model for Australia, finding that deposits do not immediately fall in response to a hike in the cash rate. An important finding is that when loans begin to fall, deposits also begin to fall. He also finds that a fall of security holdings immediately follows a hike of the cash rate, and that the security holdings recover as deposits fall. These findings imply that Australian banks use their security holdings as a buffer stock.

By adjusting their liabilities, banks may be able to accommodate the temporarily increased demand for bank loans when money is tightened. Romer and Romer (1990) argue that U.S. banks raise funds by issuing the certificates of deposit (CDs) when the Federal Reserve Bank tightens money. To examine whether their argument holds for Australia or not, a VAR model is estimated over the period 1989:Q4 to 2000:Q2 including the cash rate, two components of bank liabilities (deposits and CDs) both deflated by the CPI, the unemployment rate, and the CPI itself. Deposits, CDs, and the CPI are in logs.[9] Two lags of each variable are included. Constant terms are also included. Figure 4 shows the impulse response functions of the unemployment rate and bank liabilities to a positive innovation in the cash rate. Clearly, CDs decrease in response to a monetary tightening. As a higher interest rate can make the issuance of CDs more costly to banks, the decrease of CDs is plausible. Thus, the Romers' argument does not hold for the Australian case.

Another feature of Australian bank behaviour which may insulate the supply schedule of bank loans from impacts of monetary contraction is their borrowing from overseas.[10] Australian banks have continuously increased borrowings from overseas over the past two decades. The ratio of Australian banks' foreign currency liabilities to their total liabilities grew from 3.39 % in October 1985 to 17.59 % in June 2000. A VAR is estimated over the period 1986:Q2 to 2000:Q2 including (in order) the cash rate, three bank balance-sheet variables (deposits, foreign currency liabilities, and loans) all deflated by the CPI,

[9] Data on CDs are available from 1989:Q2.

[10] The U.S. literature has not tested the hypothesis that U.S. banks make use of foreign currency liabilities to mitigate impacts of monetary contraction on their supply schedule of loans. This may be because many U.S. banks were too small to raise funds from overseas. The McFadden Act of 1929 required U.S. banks to obey state restrictions on branching, and interstate branching was prohibited by all the states. Individual states also restricted intrastate branching. In the most restrictive regime, each bank was limited to a single office. As a consequence, U.S. banks were generally small. In 1980, for instance, 9,900 of 12,290 banks were with less than \$100 million in total assets, and domestic deposits (including CDs $\geq$ \$100,000) accounted for 96.8% of their total liabilities. It was not until the passage of the Riegle-Neal Act of 1994 that interstate branching was allowed. See Berger, Kashyap, and Scalise (1995).

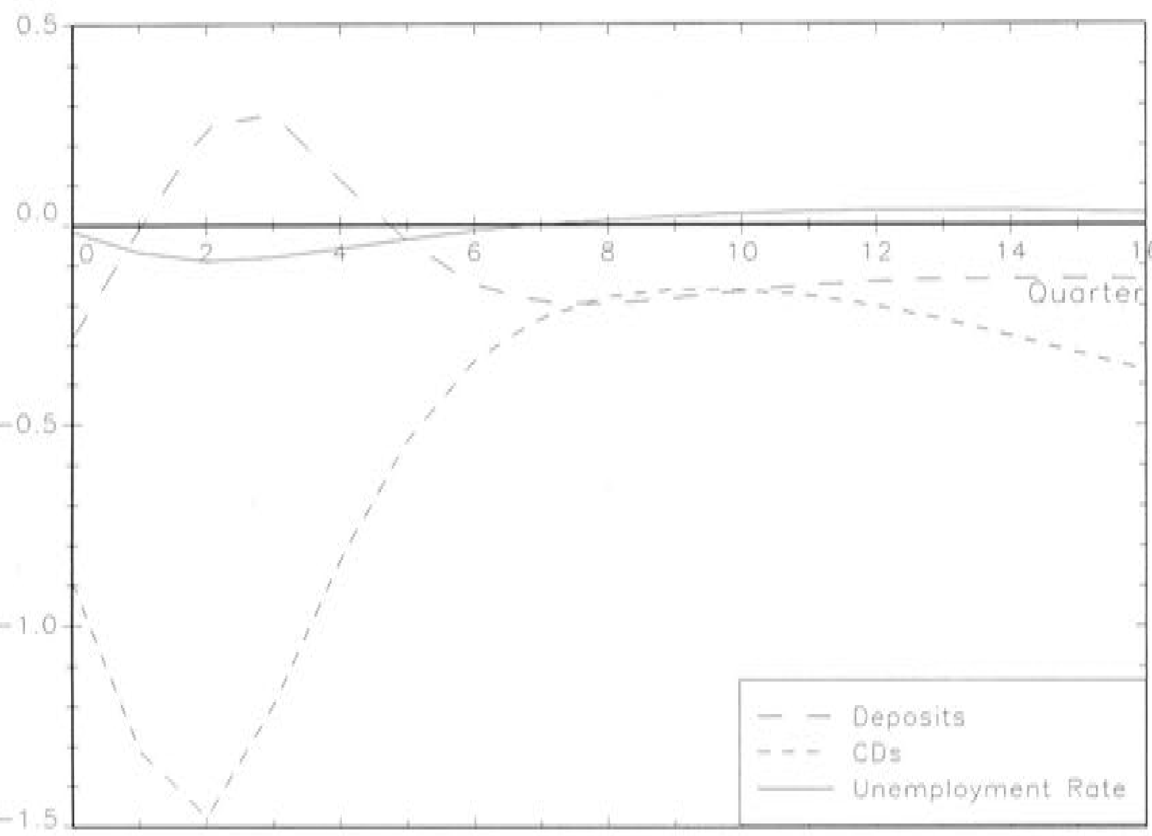

Figure 4: Responses to a Shock to the Cash Rate

Notes: Unemployment rate is measured in per cent.

CDs and Deposits are in logs and multiplied by 100.

the unemployment rate, and the CPI itself.[11] Two lags of each variables are included. Constant terms are also included. Except for the cash rate and the unemployment rate, all the variables are in logs and multiplied by 100. The calculated impulse response functions of the unemployment rate and bank balance-sheet variables to a positive innovation in the cash rate are shown in Figure 5. After an initial fall, foreign currency liabilities clearly increase in response to a hike of the cash rate. The timing of the increase of foreign currency liabilities coincides with the timing of the expansion of loans, even though foreign currency liabilities continue to accumulate for two quarters after loans begin to decrease. Therefore, we may conclude that Australian banks accommodate a rightward shift of the demand schedule for bank loans by borrowing from overseas when the RBA tightens money.

In summary, Australian banks can accommodate the temporarily increased demand for bank loans in the wake of tight money by decreasing their security holdings and borrowing

[11] Data on foreign currency liabilities are available from 1985:Q4.

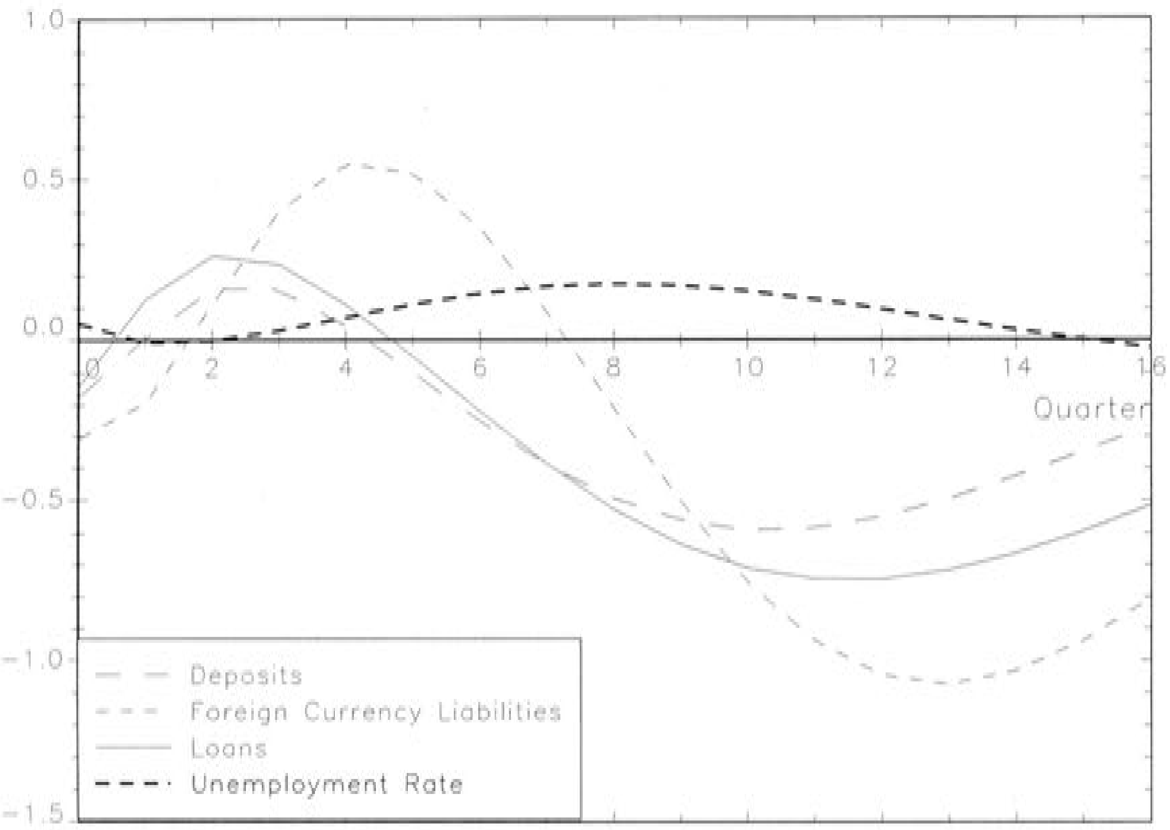

Figure 5: Responses to a Shock to the Cash Rate

Notes: Unemployment rate is measured in per cent.

The other variables are in logs and multiplied by 100.

from overseas. By adjusting their assets and liabilities, Australian banks can mitigate impacts of monetary contraction on their supply schedules of bank loans. These features of Australian bank behaviour make the lending channel of monetary policy transmission less important.

4 Conclusion

This paper tests the hypothesis that monetary policy dominantly operates through the lending channel in Australia. For this purpose, an original approach is proposed, which includes the variable for the quantity of new loans and the constructed variable measuring the "full price" of new loans. A central finding is that, even though bank loans contract following a monetary tightening, the contraction of bank loans is largely due to a left-ward shift of the demand schedule in the bank loan market. This finding is consistent with that of the earlier version of this paper employing the Kashyap, Stein, and Wilcox

(1993) approach that is commonly used in the U.S. literature. Thus, the hypothesis is not statistically supported.

The results of this paper do not reject the dominance of the lending channel of monetary policy in other countries, however. In the U.S. literature, the lending channel has been often found to be significantly operative. Employing a variety of approaches, for instance, Kashyap and Stein (1994) conclude that the evidence for the existence of the lending channel in the U.S. is quite strong. The hypothesis that the lending channel is operative is also supported for Japan. Using approaches similar to those of this paper with sample from 1975 to 1993, Suzuki (2001) argues that bank loans played a distinctive role in the transmission process of monetary policy in Japan. Thus, the results of this paper are in contrast to those of similar studies for the U.S. and Japan.

The significance of the lending view may be sensitive to institutional characteristics of the financial markets. An important finding of section 3 is that Australian banks borrow from overseas to mitigate impacts of monetary contraction on their supply schedules of bank loans. (Another finding of section 3 is that Australian banks use their holdings of public securities as a buffer stock.) In contrast, U.S. banks were generally too small to make use of foreign currency liabilities because of the McFadden Act which effectively prohibited their interstate and intrastate branching. The Japanese banking industry was also heavily regulated. For instance, it was not until May 1979 that the issuing of certificates of deposit was authorised in Japan. In addition, the Bank of Japan directly controlled the amount of commercial bank loans through "window guidance" (see Ueda 1993). As such, Australian banks are allowed to have more diversified portfolios and provide a wider range of services than were U.S. banks and Japanese banks. By further studying the lending view for different countries and/or different periods, we might be able to draw inferences about the consequences of the financial deregulation or innovation on the transmission mechanism of monetary policy.

A Data Appendix

Table 1 summarises the data used in section2. The data on the CPI are extracted from the dX data. Some mention has to be made of the construction of the CPI. The ABS incorporated mortgage interest charges and consumer credit charges into the component of the CPI (for all groups) between 1986:Q4 and 1998:Q2. The inclusion of interest charges makes the CPI unsuitable for evaluating monetary policy, as changes in the policy instrument mechanically result in movements in the CPI. For this reason, the "CPI excluding housing" is used.

Table 1:
Data for Sections 3.2 and 3.3

Variable	Source	Code/Table	Abbreviation
Commodity price index (non-fuel)	IMF	00176AXD	CP
Exchange rate (US$ per A$)	IMF	193AG	XR
CPI excluding housing	ABS	6401-09	P
Real GDP	IMF	19399BVR	Y
Money base	RBA	D03	M
Cash rate (11 am call)	RBA	F01	R
Loans and advances by banks	RBA	D02	LQ
Proxy for the loan price	ACCI & Westpac	Q. 4-b	LP
U.S. real GDP	IMF	11199BVR	Y^U
U.S. CPI	IMF	11164	P^U
U.S. federal funds rate	IMF	11160B	R^U

As is mentioned in the text, this paper utilises the diffusion index in the "Survey of Industrial Trends" conducted by the Australian Chamber of Commerce and Industry (ACCI) and the Westpac Banking Corporation as a proxy for the marginal cost of loans to borrowers. A potential problem with the ACCI-Westpac diffusion index arises from the fact that it omits information provided by the firms answering "Same." Suppose that 55% of the firms answered "Harder" and 45% answered "Easier." Then, the diffusion index is calculated as 10. The same value of the diffusion index is obtained, for instance, if 10% of the firms answer "Harder" and no firm answers "Easier." As such, any particular value of the diffusion index is consistent with an infinite number of different survey results. To check if this problem is evident or not, Figure 6 plots the percentages of the firms answering

"Harder" and "Easier" against the resulting diffusion index. Roughly speaking, there are nearly one-to-one relationships from the percentages of the firms answering "Harder" and "Easier" to the diffusion index. In this sense, the diffusion index may correctly provide information about the loan market.

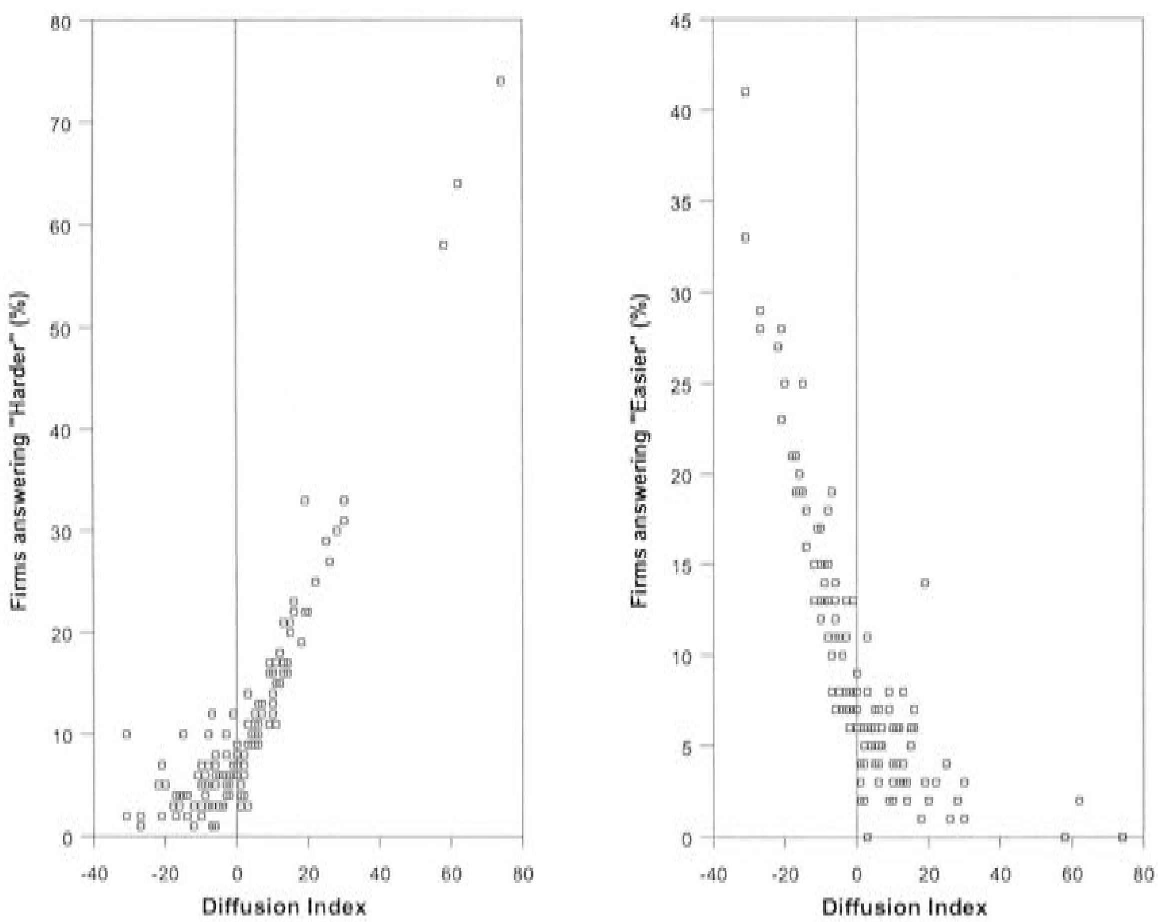

Figure 6: Diffusion Index and its Components
Sample: 1966:Q2 - 2000:Q4

B Robustness Check

For the purpose of checking robustness, the system of equations (1) is estimated by changing the ordering of the variables. Figures 7 to 14 show the simulation results from the unrestricted model estimated by reordering the variables. In estimation for Figure 7, the cash rate, which is the policy instrument of the RBA, is the first variable. This implies the assumption that the RBA determines the level of the cash rate without utilising any contemporaneous information from the variables in the system. Despite the unrealistic assumption, however, the simulation results are essentially same as those in Figure 2. The quantity and price of bank loans increase in response to an unanticipated hike of the cash

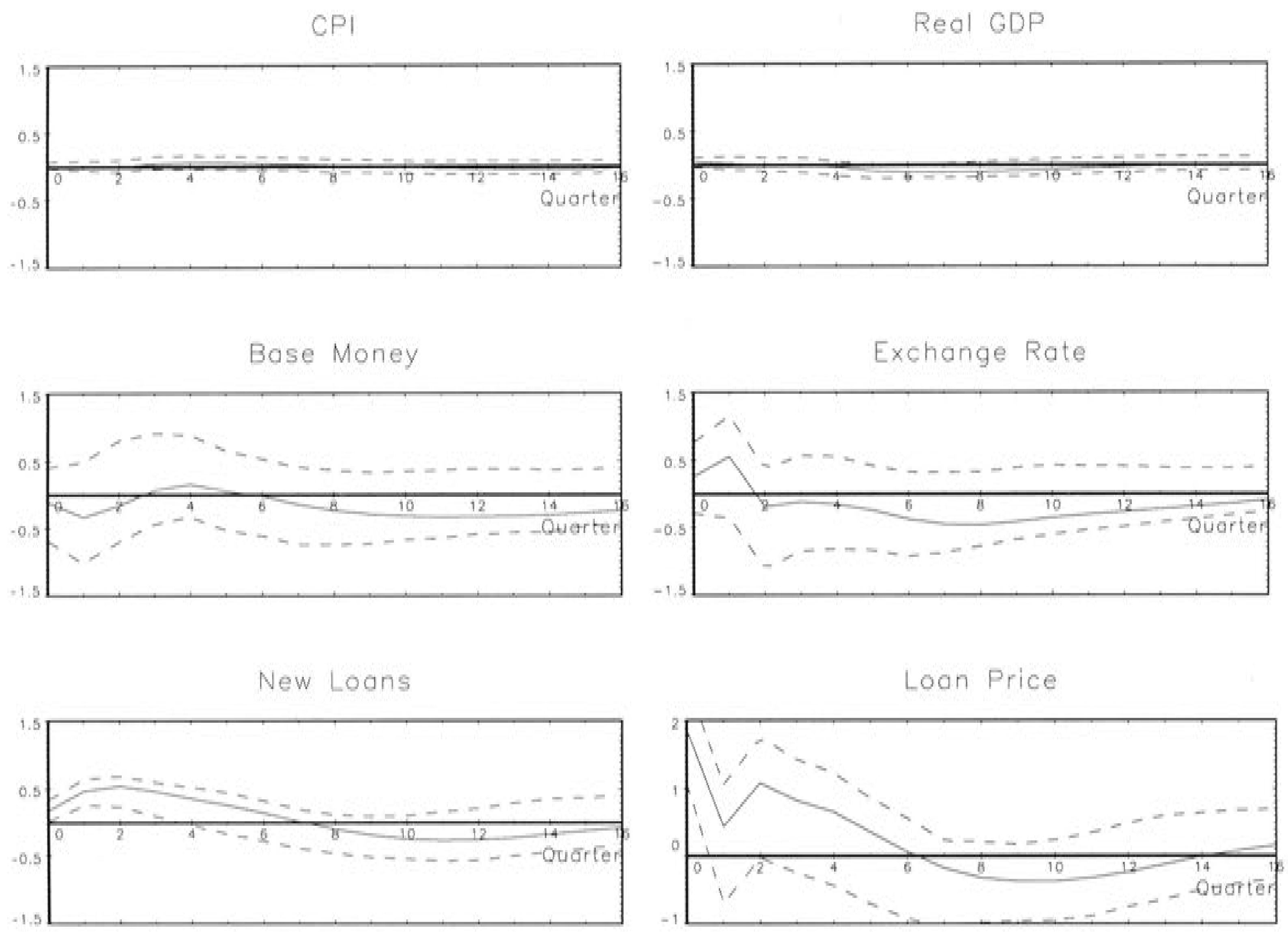

Figure 7: Robustness Check 1 (the Unrestricted Model).
R is the first variable.

rate.

In estimation for Figures 8 to 11, the short-term interest rate is similarly placed after a part or all of the overseas variables. This implies the assumption that the RBA utilises information from the variables placed before R when it determines the level of the short-term interest rate. As is clearly shown, the results are not sensitive to those change in the ordering of the variables.

In Figures 12 to 14, the short-term interest rate is placed after a part or all of the domestic variables except for those in the bank loan market. These changes do not qualitatively affect the simulation results, and hence the conclusion is robust.

For further robustness check, the same system of equations is re-estimated by changing the lag structure. In the estimation, the short-term interest rate is assumed to be the eighth

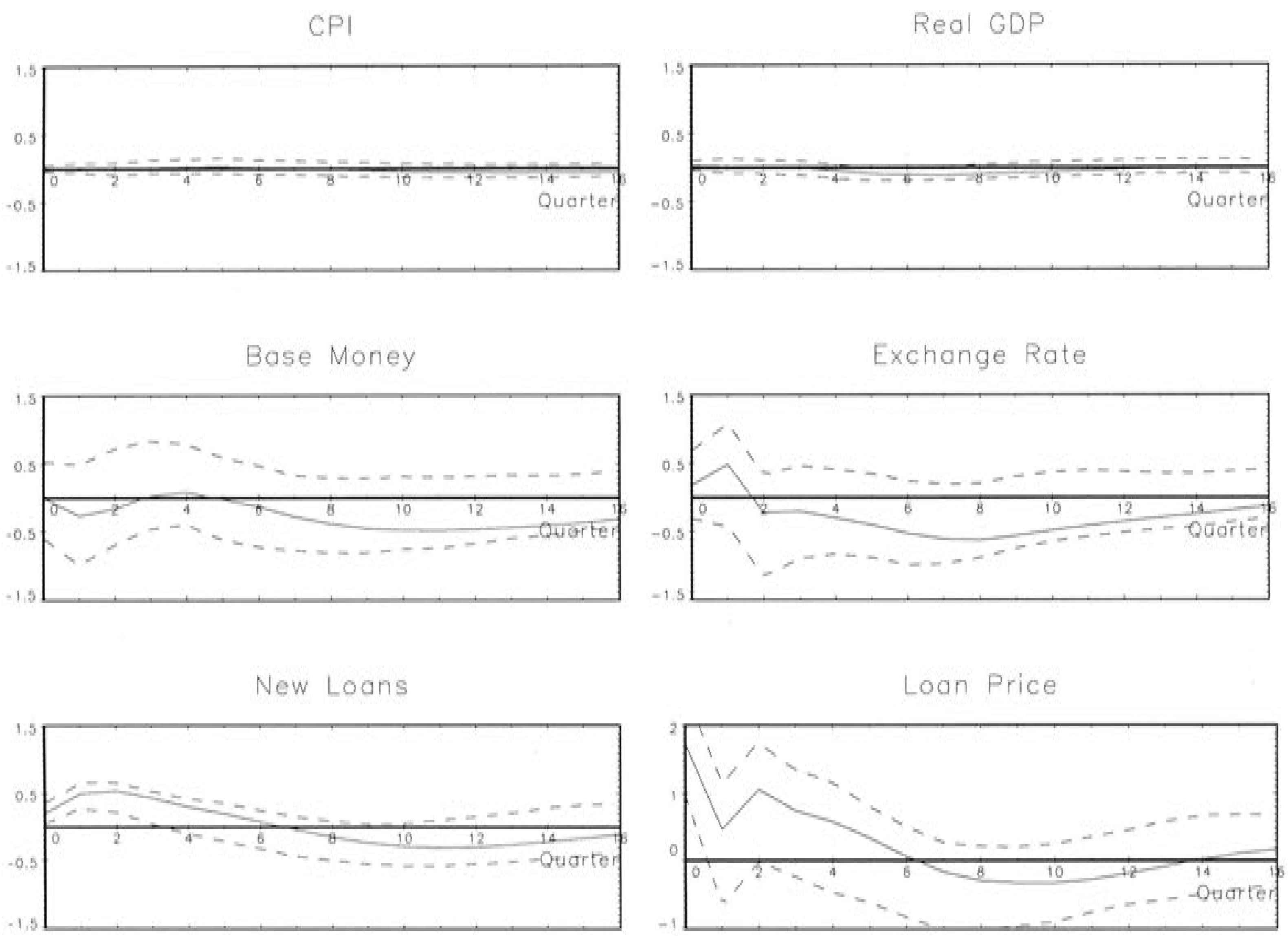

Figure 8: Robustness Check 2 (the Unrestricted Model)
R is the second variable.

variable. Figures 15 to 17 display the simulation results. As is clear from these figures, the results are essentially robust to the selection of the lag structure.

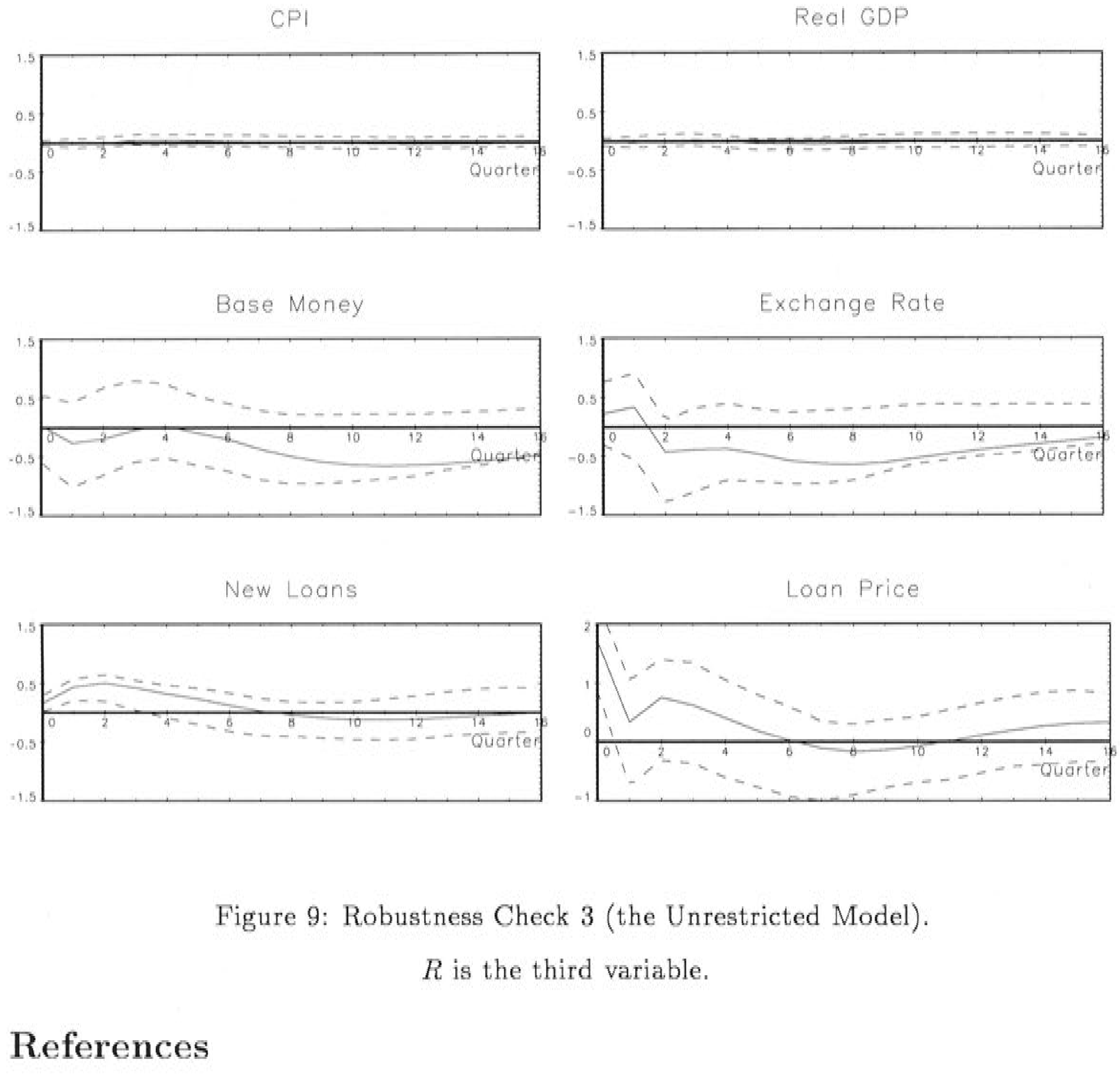

Figure 9: Robustness Check 3 (the Unrestricted Model).
R is the third variable.

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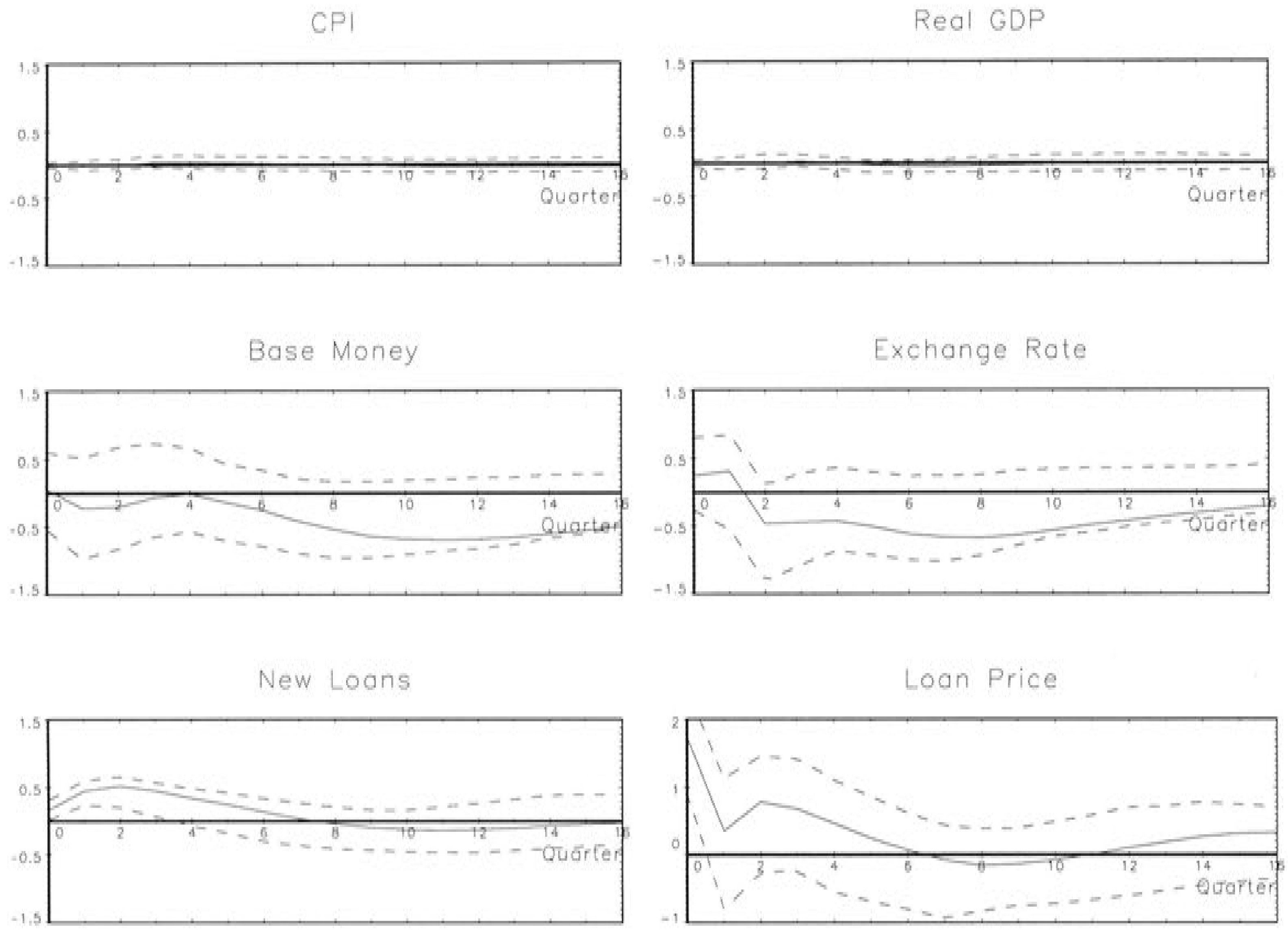

Figure 10: Robustness Check 4 (the Unrestricted Model).

R is the fourth variable.

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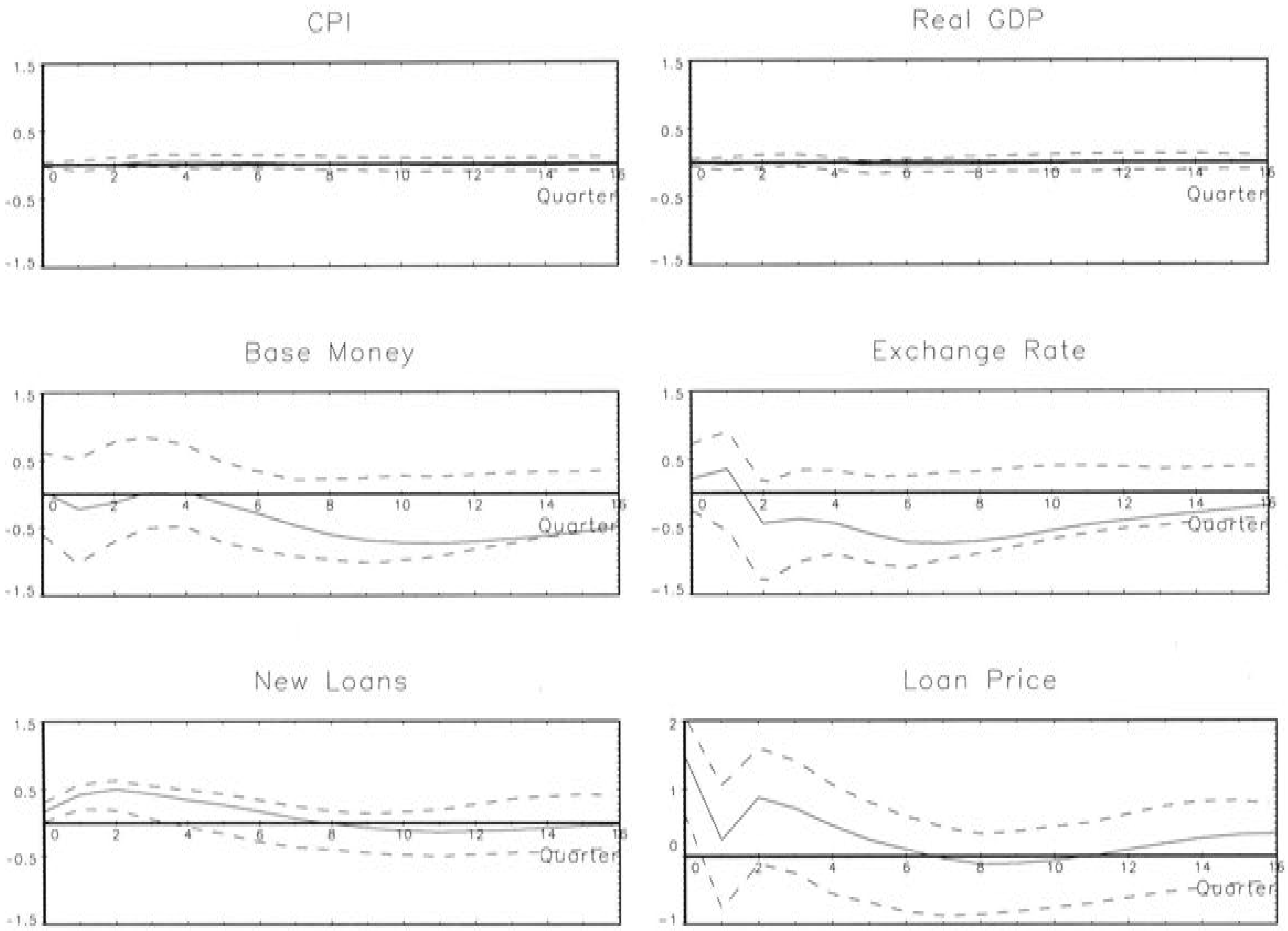

Figure 11: Robustness Check 5 (the Unrestricted Model).
R is the fifth variable.

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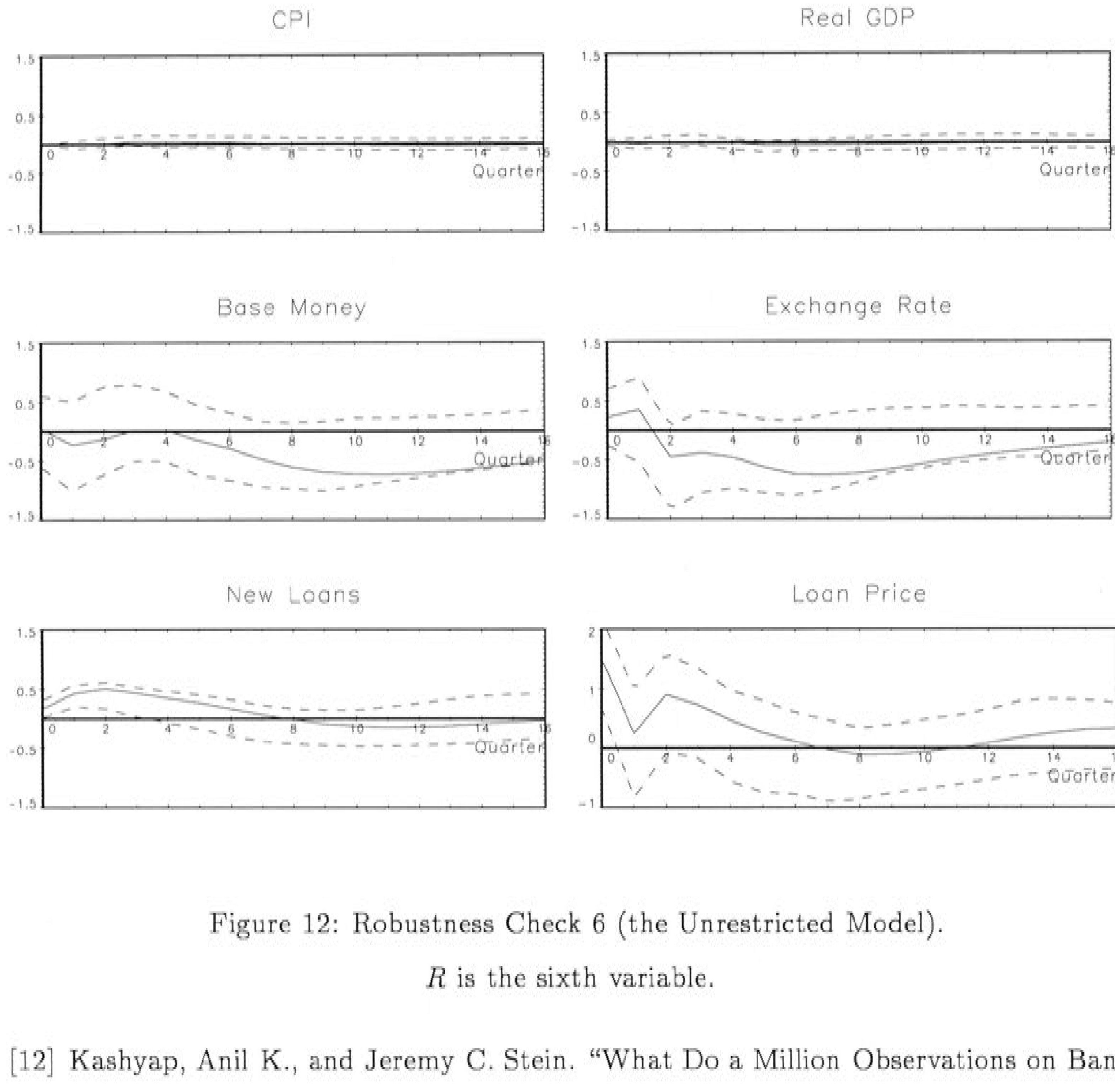

Figure 12: Robustness Check 6 (the Unrestricted Model).
R is the sixth variable.

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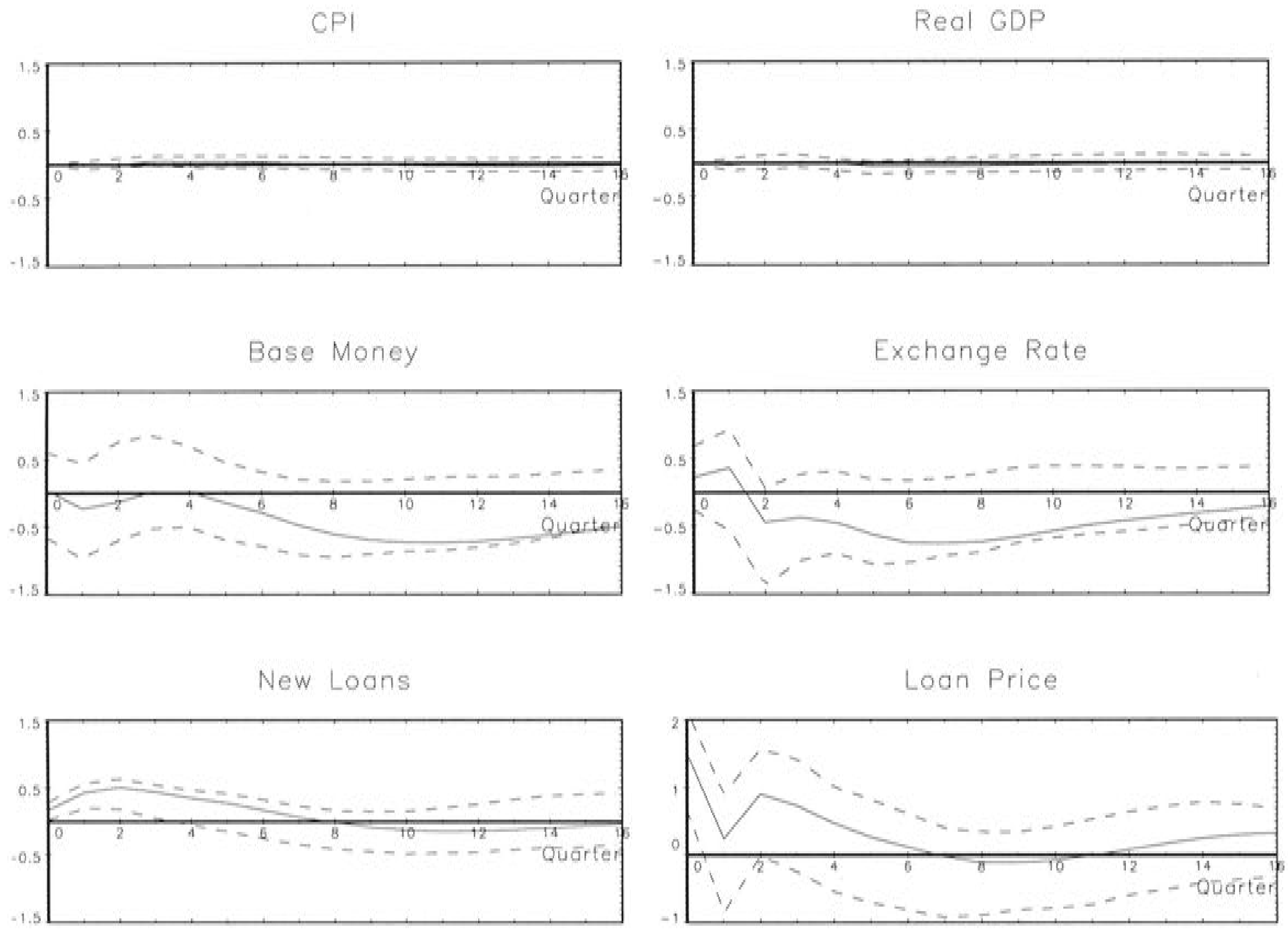

Figure 13: Robustness Check 7 (the Unrestricted Model).
R is the seventh variable.

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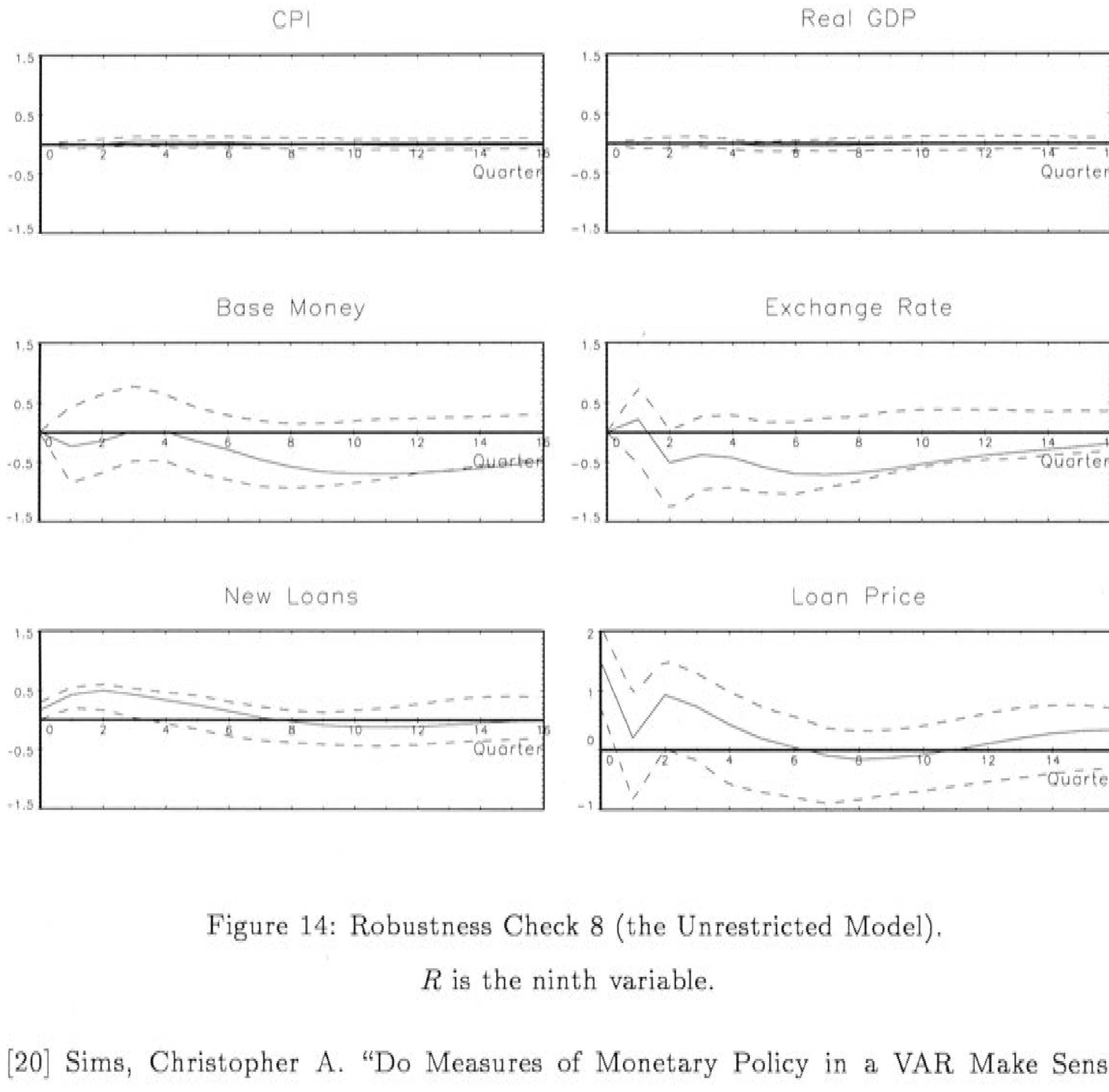

Figure 14: Robustness Check 8 (the Unrestricted Model).
R is the ninth variable.

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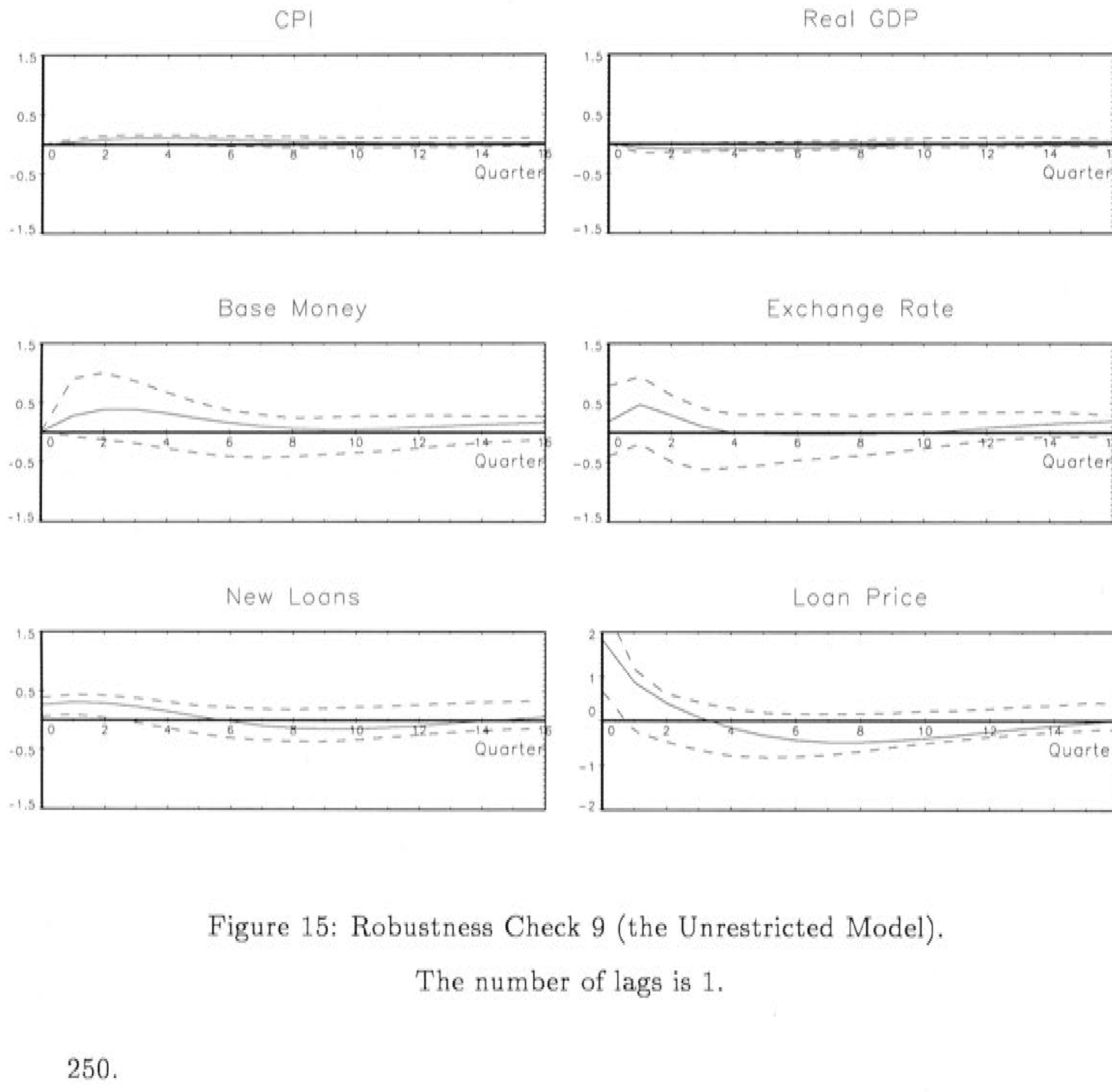

Figure 15: Robustness Check 9 (the Unrestricted Model).

The number of lags is 1.

250.

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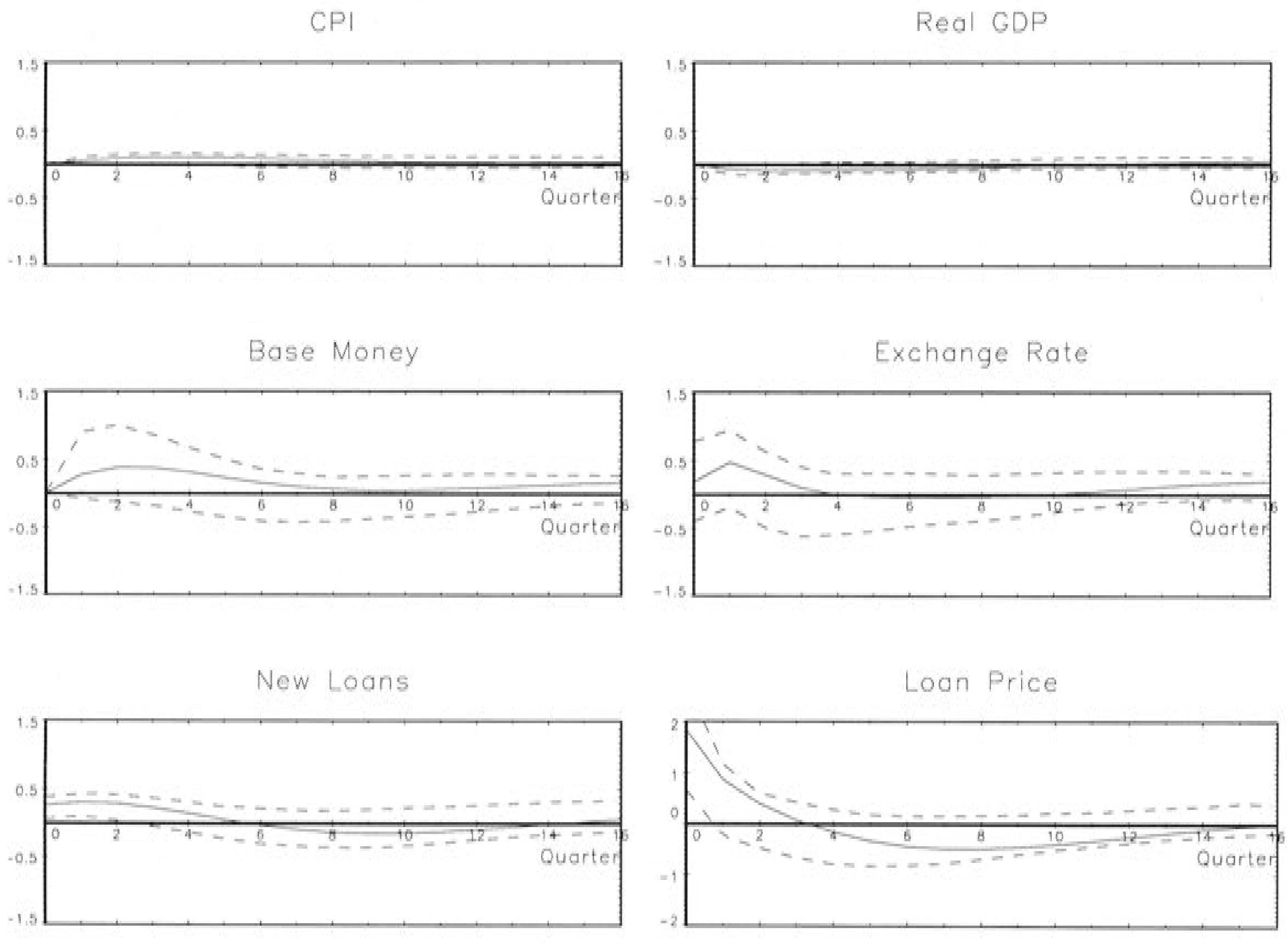

Figure 16: Robustness Check 10 (the Unrestricted Model).

The number of lags is 3.

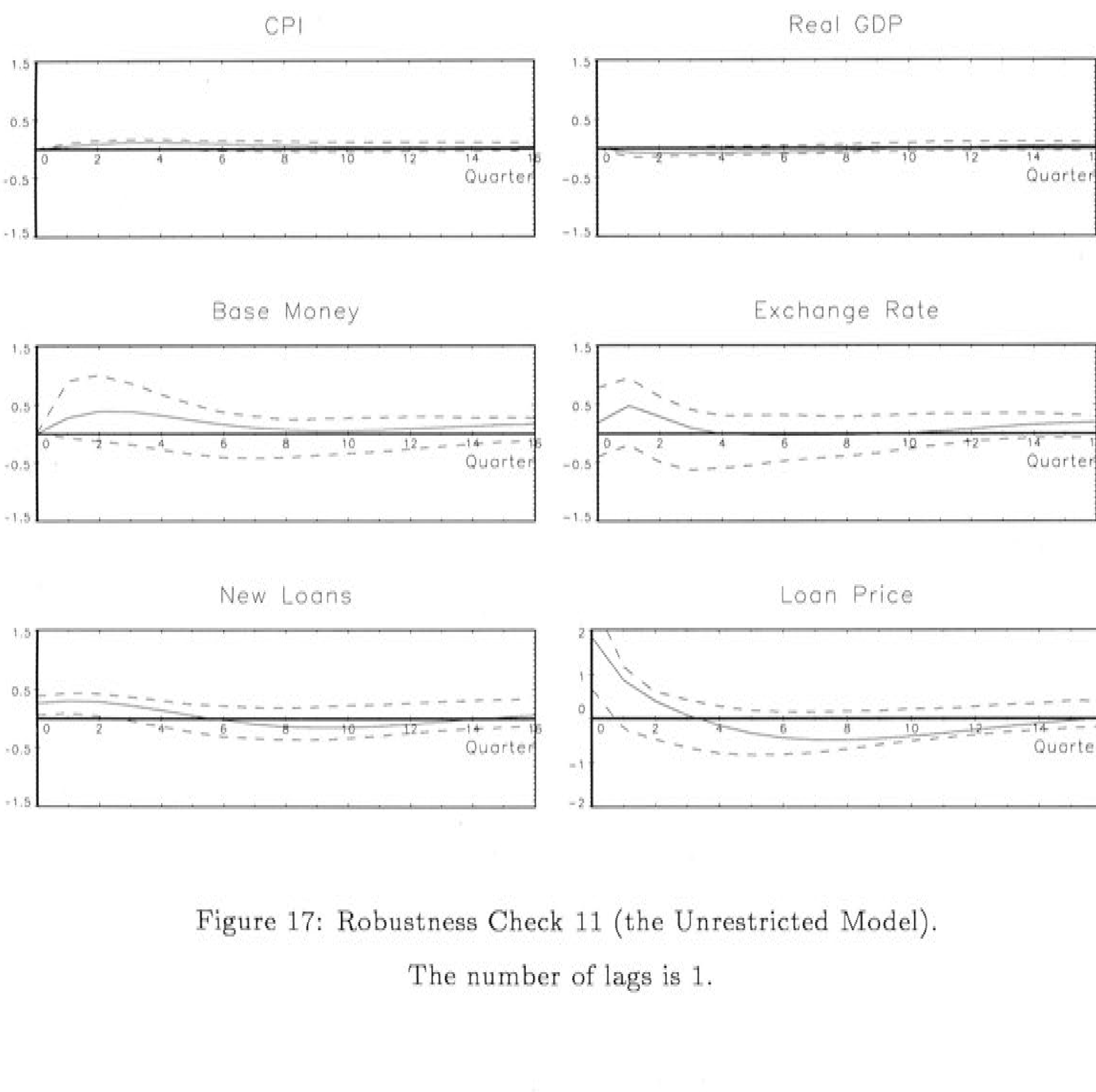

Figure 17: Robustness Check 11 (the Unrestricted Model).

The number of lags is 1.