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**Wouter Den Haan**, London Business School (LBS) and CEPR  
**Steven Sumner**, University of California, San Diego  
**Guy Yamashiro**, California State University, Long Beach

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Centre for Economic Policy Research  
90–98 Goswell Rd, London EC1V 7RR, UK  
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999  
Email: [cepr@cepr.org](mailto:cepr@cepr.org), Website: [www.cepr.org](http://www.cepr.org)

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## ABSTRACT

### Banks' Loan Portfolio and the Monetary Transmission Mechanism\*

This Paper compares the responses of bank loan components to a monetary tightening with the responses to negative output shocks. Real estate and consumer loans sharply decrease during a monetary tightening but not after a negative output shock. In contrast, commercial and industrial (C&I) loans (and commercial paper) sharply decrease in response to output shocks, but not in response to a monetary tightening. These results are difficult to reconcile with a bank-lending channel of monetary transmission, in which the supply of C&I loans is constrained. Hedging and bank capital regulation provide reasons why banks may want to substitute out of real estate and consumer loans, and into C&I loans during periods of high interest rates.

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Wouter Den Haan  
Department of Economics  
London Business School  
Regent's Park  
London  
NW1 4SA  
Tel: (44 20) 7262 5050 (x3362)  
Fax: (44 20) 7402 0718  
Email: wdenhaan@london.edu

Steven Sumner  
Department of Economics  
University of California  
San Diego, La Jolla  
CA 92093-0508  
USA  
Tel: (1 858) 534 3383  
Fax: (1 858) 534 7040  
Email: ssumner@weber.ucsd.edu

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Guy Yamashiro  
Department of Economics  
California State University, Long  
Beach  
1250 Bellflower Blvd  
Long Beach, CA 90840  
USA  
Email: [gyamashi@csulb.edu](mailto:gyamashi@csulb.edu)

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# 1 Introduction

The empirical properties of the monetary transmission mechanism are often characterized using impulse response functions of an estimated vector autoregressive system (VAR). The federal funds rate, a price index, and a measure for real activity are almost always included, but other variables have also been considered.<sup>1</sup> To estimate the parameters efficiently, however, one cannot include too many variables in the VAR. Empirical studies, therefore, typically only include comprehensive variables such as GDP and total loans and do not include all the separate micro components that comprise the comprehensive variable. However, if the micro components of a variable have different laws of motions, then the impulse response function of the aggregated variable may hide useful information about the role that these micro components play in the monetary transmission mechanism.<sup>2</sup> The following three exemplary papers point out that this is relevant for several key variables after a monetary tightening.

Gertler and Gilchrist (1994) show that small firms are responsible for a disproportionately large share of the response of total sales in the manufacturing sector. Kashyap and Stein (2000) show that the change in bank lending depends on the size of the bank and the strength of the bank's balance sheet. Finally, Barth and Ramey (2001) study the behavior of the price-wage ratio in different industry sectors and find both increases and decreases. These papers make clear that studying the behavior of the micro components can be very useful for increasing our understanding of the channels through which monetary policy shocks affect the economy.

This is especially true when the micro components move in different directions following the shock, since the sign of a variable's response is often useful in evaluating the relevance of alternative theories of the monetary transmission mechanism. Moreover, because substantial changes in the micro variables may be consistent with little change in the aggregate variable, one may not realize that these variables play an important role in the monetary transmission mechanism if one does not examine the micro variables.

We find this to be relevant in our analysis of the behavior of total bank loans and its components (commercial and industrial (C&I) loans, real estate loans, and consumer loans) after a monetary tightening. That is, the estimated responses for total loans are not robust and typically are not significant. Based on this a researcher may conclude that bank loans do not play an important role in the monetary transmission mechanism. This would be the wrong conclusion, however, because we find

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<sup>1</sup>See Christiano, Eichenbaum, and Evans (1999) for an excellent overview.

<sup>2</sup>Moreover, a structural VAR without the micro components could be misspecified, which would affect the corresponding impulse response functions for the aggregate variables.

an intriguing set of heterogeneous responses for the bank loan components that are both robust and significant.

It has already been recognized in the literature that determining what bank loans do after a monetary tightening is not as easy as one might think. Gertler and Gilchrist (1993b) summarize this as follows:

"Conventional wisdom holds that tightening of monetary policy should reduce bank lending. It is surprisingly difficult, however, to find convincing time series evidence to support this basic prediction of macroeconomic theory".

Several theories predict that bank lending should decline after a monetary tightening. According to the standard "interest-rate channel", a monetary tightening increases the user cost of capital and, thus, investment, and the amount borrowed to finance investment should decrease. According to the "bank-lending channel" a monetary tightening leads—in addition to a reduction in demand because of the increase in the interest rate—to a further reduction in consumer durable purchases and investment because bank-dependent borrowers face a reduction in the supply of bank loans.<sup>3</sup> The "balance-sheet channel" stresses the importance of frictions such as asymmetric information and limited enforcement for the availability of credit provided by both banks as well as other types of lenders. A reduction in real activity worsens the financial health of borrowers and adversely affects the price and availability of credit. This in turn magnifies and propagates the effects of a negative shock to economic activity.

This paper adds to the literature on the role of bank lending during the monetary transmission mechanism by doing the following. First, we analyze the behavior of the three main loan components following a monetary policy shock and establish robust responses. Second, we analyze the responses of commercial paper and bank equity. Third, we not only consider the behavior of financial variables after a monetary tightening, but also document the behavior of the loan components after negative output shocks. That is, we compare the behavior of the loan components during a monetary downturn—when interest rates display a sharp increase and output is low—with the behavior during a non-monetary downturn—when output is low and interest rates display a moderate decrease. By comparing the behavior of the different forms of lending and bank equity after the two types of shocks we can gain useful insights into the workings of the monetary transmission mechanism.

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<sup>3</sup>See Bernanke and Gertler (1995), Gertler, and Gilchrist (2000), and Mishkin (1995) for an overview.

The main results of this paper are the following.<sup>4</sup>

- After a monetary tightening, bank loan components behave quite differently from one another. In particular, real estate and consumer loans display significant declines, while the responses of C&I loans are either near zero or display significant positive responses.<sup>5</sup>
- In contrast, during a non-monetary downturn C&I loans display a sharp decrease, while real estate loans and consumer loans display either a moderate decrease or no decrease.
- Bank equity drops significantly during a monetary tightening but not during a non-monetary tightening.
- Commercial paper increases significantly in response to a monetary tightening, but decreases significantly in response to output shocks.
- The ratio of C&I loans to commercial paper decreases significantly in response to a monetary tightening but displays a large and significant increase in response to an output shock.

An important part of this paper is devoted to the interpretation of the results. Bernanke and Gertler (1995) point out that the "perverse" response of C&I loans could be consistent with a reduction in the supply of C&I loans, as predicted by the bank-lending channel theory, as long as the demand for C&I loans increases by more than the reduction in the supply. For example, firms might increase their demand for loans to finance an increase in inventories or a reduction in the utilization of their work force. We find that this explanation is difficult to reconcile with our empirical findings.

As an alternative we propose the hypothesis that after a monetary tightening—when interest rates are high and economic activity is low—banks prefer to invest in short-term assets, such as C&I loans, that earn a high return (because short-term interest rates are high) and are relatively safe, than invest in long-term and risky assets such as real estate loans. We show that the behavior of mortgage rates is consistent with such a shift in the supply of real estate loans. Moreover, the substitution out of long-term and risky assets and into C&I loans makes it possible that

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<sup>4</sup>Later in the paper we will be more precise about what we mean by a monetary and a non-monetary downturn and how comparable they are.

<sup>5</sup>This is consistent with the results in Gertler and Gilchrist (1993a) and Kashyap and Stein (1995) who document that C&I loans behave differently than total loans after a monetary tightening.

the supply of C&I loans increases even if deposits decrease. The reasons we discuss for the change in the desired loan portfolio are related to hedging and safe guarding the capital adequacy ratio. Portfolio behavior of banks has received very little attention in the literature on the monetary transmission mechanism and the results in this paper make clear that this omission may severely limit our understanding of the role of banks during a monetary tightening.

An additional contribution of this paper is to show that the results based on the Federal Reserve's H8 bank-loan data, which are typically used in the literature, are very similar to the results obtained using the more accurate bank loan data from the Consolidated Reports of Condition and Income (Call Reports).

The rest of this paper is organized as follows. Section 2 discusses the data used and the empirical methodology. Section 3 documents the behavior of total loans during both a monetary and a non-monetary downturn according to a VAR that does not disaggregate total loans into the loan components. Section 4 reports the results for the bank loan components. In Section 5 we interpret the results. The last section concludes.

## 2 Data sources and empirical methodology

In Section 2.1 we discuss the three data sets employed in our study. Section 2.2 contains a discussion of our empirical methods.

### 2.1 Data sources

Data for aggregate balance sheets are published by the Federal Reserve (H8 statistical release) for commercial banks in the United States and several subgroups of banks: "domestically chartered", "large domestic", "small domestic", and "foreign related". Data are available on a weekly and monthly basis. Our first data set is comprised of monthly (seasonally adjusted) bank loan data for all commercial banks from the H8 data set together with the federal funds rate, the consumer price index, and industrial production. The sample begins in January 1960 and ends in February 2003. A disadvantage of the H8 data is that they are based on *voluntary* bank credit reports submitted to the Federal Reserve.<sup>6</sup> Since the reports are voluntary the data

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<sup>6</sup>These are forms FR2416, FR2644, and FR2069. FR2416 is the most complete and is filed by participating large commercial banks. The size cutoff for filing form FR2416 (as of the first quarter of 1996) is 6 billion dollars in total assets. However, some banks with less than 6 billion in total assets are added to the sample to ensure adequate regional participation. FR2644 is less complete, collecting no deposit data, and is a random stratified sample of about 1,100 US commercial banks that do not report on the FR2416. Finally, US branches and agencies of foreign banks with 1.1



are based on only a sample of US banks, and are therefore, "blown up" to represent the entire universe. We refer to this data set as the "monthly H8".

Our second data set consists of the bank loan series from the Consolidated Reports of Condition and Income (Call Reports) together with the federal funds rate, the consumer price index, and personal income from the Bureau of Economic Analysis (BEA).<sup>7</sup> This sample starts in the first quarter of 1977 and ends in the last quarter of 2000 and will be referred to as the "quarterly Call".

Since all federally-insured banks<sup>8</sup> are required to submit these quarterly income-statement and balance-sheet data one can expect them to be of higher quality than the H8 data. In the Call Reports banks report on a "consolidated foreign and domestic" basis (RCFD) or on a "domestic only" basis (RCON). In general, the largest banks only provide data on a consolidated foreign and domestic basis so for several variables one would have to use the RCFD data. This is not true for all variables, however, and in particular it is not true for bank loans. We choose to use the RCON data for the following reasons. First, the RCON data are more appropriate for a study that looks at the relationship between bank loans and *domestic* real activity. Second, the RCON series are more comparable to the H8 data since the H8 data also do not include assets and liabilities outside the United States.<sup>9</sup> Third, the RCFD data display a break in December 1978.

A drawback of the Call Reports, however, is that constructing consistent time series is not trivial. The primary reason is that these reports are primarily designed for regulatory purposes. Consequently, as the banking sector evolves and regulations change, what is reported and how variables are measured also changes—posing a major challenge to the effort of constructing consistent time series. Den Haan, Sumner, and Yamashiro (2002) describe details on how this challenge can be overcome.

We find that the results for total loans and C&I loans differ across these two data sets. To investigate whether the differences in the results between the monthly-H8 data set and the quarterly-Call data set are due to the different loan data or different

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billions or more in assets (including IBSs) file the FR2069. Other large branches and agencies are added to the sample to ensure adequate world coverage. We are indebted to William Watkins for this information. More detailed information on the individual reporting forms may be found at <http://www.federalreserve.gov/boarddocs/reportforms/CategoryIndex.cfm>.

<sup>7</sup>We use the income measure from the BEA because it is also available at the state level and we consider regional models in our related work.

<sup>8</sup>The data cover banks regulated by the Federal Reserve System, the FDIC, and the Comptroller of the Currency.

<sup>9</sup>The universe of domestically-chartered commercial banks in the H8 is virtually identical to the set of commercial banks in the Call reports. The H8 series for domestically-chartered banks only starts in 1973, however, so we use the H8 series for all commercial and industrial banks. See Den Haan, Sumner, and Yamashiro (2002) and Appendix 7.1 for details.

sample periods, we use a third data set, which we refer to as the "quarterly H8", in which we replace the bank loan series from the Call reports with the quarterly H8 series.<sup>10</sup> We show that the differences are mainly due to the difference in sample periods. More details on the data sources and definitions of the series are given in the appendix (Section 7.1).

## 2.2 Empirical methodology

In Sections 2.2.1 and 2.2.2 we show how we estimate the behavior of the variables during a monetary downturn and a non-monetary downturn, respectively.

### 2.2.1 Monetary downturn

The standard procedure to study the impact of monetary policy on economic variables is to estimate a structural VAR using a limited set of variables. Consider the following VAR:<sup>11</sup>

$$Z_t = B_1 Z_{t-1} + \dots + B_q Z_{t-q} + u_t, \quad (1)$$

where  $Z_t' = [X_{1t}', r_t, X_{2t}']$ ,  $X_{1t}$  is a  $(k_1 \times 1)$  vector with elements whose contemporaneous values are in the information set of the central bank,  $r_t$  is the federal funds rate,  $X_{2t}$  is a  $(k_2 \times 1)$  vector with elements whose contemporaneous values are not in the information set of the central bank, and  $u_t$  is a  $(k \times 1)$  vector of residual terms with  $k = k_1 + 1 + k_2$ . We assume that all lagged values are in the information set of the central bank. In order to proceed one has to assume that there is a relationship between the reduced-form error terms,  $u_t$ , and the fundamental or structural shocks to the economy,  $\varepsilon_t$ . We assume that this relationship is given by:

$$u_t = \bar{A} \varepsilon_t, \quad (2)$$

where  $\bar{A}$  is a  $(k \times k)$  matrix of coefficients and  $\varepsilon_t$  is a  $(k \times 1)$  vector of fundamental uncorrelated shocks, each with a unit standard deviation. Thus,

$$E[u_t u_t'] = \bar{A} \bar{A}'. \quad (3)$$

When we replace  $E[u_t u_t']$  by its sample analogue, we obtain  $n(n+1)/2$  conditions on the coefficients in  $\bar{A}$ . Since  $\bar{A}$  has  $n^2$  elements,  $n(n-1)/2$  additional restrictions

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<sup>10</sup>The bank loan series are constructed by taking an average of the monthly observations in each quarter. The monthly H8 and the quarterly Call also differ in sampling frequency and income series used, but these differences are not important for explaining the differences in the results.

<sup>11</sup>To simplify the discussion we do not display constants, trend terms, or seasonal dummies that also may be included.

are needed to estimate all elements of  $\bar{A}$ . A standard practice is to obtain the additional  $n(n - 1)/2$  restrictions by assuming that  $\bar{A}$  is a lower-triangular matrix. Christiano, Eichenbaum, and Evans (1999), however, show that to determine the effects of a monetary policy shock one can work with the less-restrictive assumption that  $\bar{A}$  has the following *block*-triangular structure:

$$\bar{A} = \begin{bmatrix} \bar{A}_{11} & 0_{k_1 \times 1} & 0_{k_1 \times k_2} \\ \bar{A}_{21} & \bar{A}_{22} & 0_{1 \times k_2} \\ \bar{A}_{31} & \bar{A}_{32} & \bar{A}_{33} \end{bmatrix} \quad (4)$$

where  $\bar{A}_{11}$  is a  $(k_1 \times k_1)$  matrix,  $\bar{A}_{21}$  is a  $(1 \times k_1)$  matrix,  $\bar{A}_{31}$  is a  $(k_2 \times k_1)$  matrix,  $\bar{A}_{22}$  is a  $(1 \times 1)$  matrix,  $\bar{A}_{32}$  is a  $(k_2 \times 1)$  matrix,  $\bar{A}_{33}$  is a  $(k_2 \times k_2)$  matrix, and  $0_{i \times j}$  is a  $(i \times j)$  matrix with zero elements. Note that this structure is consistent with the assumption made above about the information set of the central bank.

We follow Bernanke and Blinder (1992) and many others by assuming that the federal funds rate is the relevant monetary instrument and that innovations in the federal funds rate represent innovations in monetary policy. Moreover, throughout this paper we assume that  $X_{1t}$  is empty and that all other elements are, thus, in  $X_{2t}$ . Intuitively,  $X_{1t}$  being empty means that the Board of Governors of the Federal Reserve (FED) does not respond to contemporaneous innovations in any of the variables of the system. While we do believe that the FED can respond quite quickly to new information one has to keep in mind that the data used here are revised data, which means that the value of a period  $t$  observation in our data set was not available to the FED in period  $t$ . Rudebusch (1998) points out that if the econometrician assumes that the FED responds to innovations in the contemporaneous values of the available original data but estimates the VAR with revised data, the estimated coefficients will be subject to bias and inconsistency. For these reasons, we believe it is better to assume that  $X_{1t}$  is empty.

### 2.2.2 Non-monetary downturn

In this paper we compare the behavior of variables during a monetary downturn to their behavior during a downturn of equal magnitude caused by real activity shocks. To be more precise, a non-monetary downturn is caused by a sequence of output shocks such that output follows the exact same path as it does during a monetary downturn. Our construction of a non-monetary downturn makes it convenient to quantitatively compare the responses, but one would obtain similar results by simply comparing the responses to a monetary policy shock with the responses to a *single* output shock.

Implementing this exercise requires us to make an additional assumption on  $\bar{A}$ . In particular, we assume that shocks to real activity have no contemporaneous effect on any of the other variables.<sup>12</sup> Under this assumption, there is a simple way to calculate the impulse response functions. In each period we simply set the value of aggregate real activity equal to the value observed during the monetary downturn, and then obtain values for the remaining variables by iterating on the VAR.<sup>13</sup> If the two downturns are comparable, then one can interpret the difference between the impulse response functions as the effect of the increase in the interest rate holding real activity constant.<sup>14</sup>

The motivation for looking at these impulse response functions is the following. The impulse response functions for the monetary downturn not only reflects the direct responses of the variables to an increase in the interest rate but also the indirect responses to changes in the other variables and in particular to the decline in real activity. This makes it difficult to understand what is going on, especially since a decline in real activity could increase or decrease the demand for bank loans.<sup>15</sup> For example, if one observes an increase in a loan component during a monetary downturn it could still be the case that there is a credit crunch, if a decline in real activity strongly increases the demand for that loan component. Without the credit crunch this loan component would have increased even more. By comparing the behavior of loan components during a monetary downturn with a non-monetary downturn of equal magnitude one can get an idea regarding the importance of the different effects of the higher interest rate. Obviously, there are some pitfalls to this comparison that we will discuss later. Nevertheless, we think the comparison does help in understanding the endogenous response of loan components to a reduction in real activity after a monetary tightening.

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<sup>12</sup>That is, the matrix  $\bar{A}_{33}$  also has a block-triangular structure. Note that the block-triangular structure imposed in Equation 4 already made the assumption that the innovation to output had no effect on the federal funds rate.

<sup>13</sup>The assumption that shocks to real activity do not affect the other variables contemporaneously implies that we do not have to explicitly calculate the values of the structural shocks during a monetary downturn. It is possible to make other assumptions on  $\bar{A}$  and still calculate the impulse response functions, but it would be slightly more cumbersome.

<sup>14</sup>In fact, the difference between these two impulse response functions is equal to the response to a shock in the federal funds rate when the response of the output variable is set equal to zero in every period.

<sup>15</sup>On the one hand the reduction in real activity would reduce investment and, thus, the need for loans, while on the other hand the reduction in sales would increase inventories, which could increase the demand for loans.

### 3 Response of total loans in a VAR with total loans

We begin with a system that includes total bank loans as the only loan variable. Specifically, the results discussed in this section are based on a VAR that includes the federal funds rate, a price index, a real activity measure, and total loans. All VARs include one year of lagged variables, a constant, and a linear trend. We also include quarterly dummies when we use the data from the Call reports since these are not adjusted for seasonality. The coefficients are estimated with ordinary least squares (OLS) and the significance levels are established using a Monte Carlo procedure with 5,000 replications in which data are generated by bootstrapping the estimated residuals. To avoid clutter we do not report confidence bands in the graphs but instead use open and solid squares to indicate that an estimate is significant at the 10% and 5% level, respectively.<sup>16</sup>

Panels A, B, and C of Figure 3.1 plot for the monthly-H8 data set the responses of output, the price level, and the federal funds rate, respectively, to a positive shock in the federal funds rate. The size of the shock is equal to one standard deviation of the federal funds rate's innovation. The results are similar to those found in the literature. In particular, the federal funds rate returns back to its original level in roughly two years and after a delay of two quarters output drops significantly. The price level first increases by a modest amount and then displays a substantial decrease, so this data set does not suffer from the price puzzle.

Panels B and C also plot the behavior of the price level and the interest rate during a non-monetary downturn in which the changes in output are identical to those observed during a monetary downturn, but are instead caused by a sequence of output shocks. The figure shows that interest rates (slightly) decrease in response to negative output shocks. These results are consistent with the Federal Reserve following a Taylor rule. Prices display a moderate drop during a non-monetary downturn. The results for the two quarterly data sets (not reported) are similar except that these data sets do suffer from the price puzzle.<sup>17</sup>

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<sup>16</sup>Significance levels are for a one-sided test.

<sup>17</sup>Christiano, Eichenbaum, Evans (1999) find that adding an index for sensitive commodity prices solves the price puzzle in their sample but we find that this doesn't resolve the puzzle for our more recent samples. We also tried the measure of monetary policy shocks proposed by Romer and Romer (2004) and reestimated the VAR over the period for which this measure is available (1977 - 1996). We find that the price level sharply increases during the first two quarters and after roughly one year has returned to its original level after which it hovers around zero. Although not a solution to the price puzzle it is an improvement, since when we use innovations in the federal funds rate as the monetary policy shock, the price level displays a persistent increase to a monetary tightening. More importantly, however, is that our other results are robust when the using this

In Figure 3.2 we plot the behavior of total loans during a monetary and a non-monetary downturn for the three data sets, and in Figure 3.3 we plot the difference between these two responses. The thing to notice is that the behavior of total loans in the sample starting in 1960 is consistent with the perceived wisdom about what happens during the monetary transmission mechanism. That is, total loans display a substantial and significant drop. Interestingly, while Bernanke and Blinder (1992) find that the total loan variable has a delayed response and goes down at the same time as output we find that it drops quite rapidly and before output. Moreover, while during a non-monetary downturn total loans also drop, the decline is smaller than what we observe during the monetary downturn. Therefore, the results are consistent with an interest-rate channel as well as a credit crunch in total bank loans during a monetary tightening.

For the two samples that starts in 1977, however, the results differ.<sup>18</sup> Although the behavior of total loans during a non-monetary downturn is very similar across all data sets, total loans actually *increase* during a monetary tightening according to the impulse response functions estimated with the data sets that start in 1977.<sup>19</sup> Consequently, when we look at the difference between the behavior of total loans during a monetary and a non-monetary downturn in Figure 3.3 we see that the difference is negative for the monthly-H8 data that starts in 1960 and positive for the two data sets that start in 1977. The results for the samples that start in 1977, however, are not significant and not robust. For example, if one estimates the VAR with only two lags instead of four then the response of total loans during a monetary downturn and a non-monetary downturn are more similar to the one found for the longer data set, although none of the responses are significant.<sup>20</sup>

Given that the results are neither robust nor significant one might conclude that after 1977 loans do not respond to a monetary tightening or—more precisely—that the data do not have the information necessary to reveal a convincing pattern. In the next section, however, we show that although this may be true for the aggregate it is definitely not true for the loan components. For the samples that begin in 1977, the loan components display robust and significant responses after a monetary tightening. Moreover, we will see that the differences between the results for the different data sets are not as striking as the results for total loans would suggest.

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alternative measure.

<sup>18</sup>The differences between the results for the monthly-H8 data set, starting in 1960, and the results for the two quarterly data sets, both starting in 1977, are due to the difference in the time period covered and not, for example, to differences in sampling frequency. If we estimate the VAR using data from the monthly-H8 that begins in 1977, then the results are similar to those obtained with the two quarterly data sets.

<sup>19</sup>Note, however, that only the first response is significant.

<sup>20</sup>See Figure A.1 in the appendix.

## 4 Loan component responses

The results discussed in this section are based on a VAR that includes the three loan components, the federal funds rate, a price index, and a real activity measure. The benchmark specifications for the VARs include one year of lagged variables, a constant, and a linear trend. We include quarterly dummies when we use the data from the Call reports since these are not adjusted for seasonality.

In addition, we estimate VARs for which the specification is chosen using the Bayes Information Criterion (BIC). We search for the best model among a set of models that allows as regressors the variables mentioned above and a quadratic deterministic trend. BIC chooses a specification that is much more concise than our benchmark specification. In the appendix (Section 7.2), we document that the results are similar to those that are based on our benchmark specification. Because of the similarity we will only report the results for the benchmark specification in the main text of the paper.

### 4.1 Time series behavior of loan components

In Figure 4.1 we plot the monthly loan components after a trend has been removed using the HP filter.<sup>21</sup> Several observations can be made. First, we see that before 1980 the series are highly correlated and have fluctuations of similar amplitude. After 1980, however, there is obviously less comovement and the amplitudes of the series are quite different. In particular, after 1980, consumer loans display large fluctuations similar to those observed in the seventies, whereas C&I loans and real estate loans seem to go through cycles with a smaller amplitude and shorter period. In particular, for the period from January 1960 to December 1979 the standard deviation of the HP-filtered series are equal to 0.040, 0.042, and 0.049 for C&I loans, real estate loans, and consumer loans, respectively. For the period from January 1980 to February 2003 these numbers are equal to 0.034, 0.024, and 0.050

### 4.2 Results

Figure 4.2 plots the output response for the three data sets. The figure shows that the output response is similar for the three data sets and similar to those based on the VAR that includes total loans instead of the three loan components. The price level and the federal funds rate responses are also not affected by the disaggregation of total loans into the loan components and are, therefore, not reported.

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<sup>21</sup>We follow Ravn and Uhlig (2002) and set the smoothing parameter for monthly data equal to 129,600.

Figure 4.3 reports the behavior of the three loan components during a monetary and a non-monetary downturn based on the results of the monthly-H8 sample, which runs from January 1960 to February 2003. In Section 3 we showed that, for this sample, total loans fell substantially during a monetary downturn, and displayed a moderate decline during a non-monetary downturn. Figure 4.3 clearly shows that the drop in total loans during a monetary downturn is due to a drop in real estate loans and consumer loans as these two series display a substantial and significant drop, while C&I loans fluctuate around zero, with the only significant estimates being some positive responses at the beginning of the monetary tightening. During a non-monetary downturn, however, the drop in total loans is due to the fall in C&I loans.

Figures 4.4 and 4.5 plot the results for the two quarterly data sets. The results are fairly similar to those observed for the monthly data set except that, in response to an unexpected increase in the federal funds rate, C&I loans do not fluctuate around zero, but, in fact, displays a substantial and frequently significant positive response. There are even less differences between the three data sets when we look at the behavior of the loan components during a monetary downturn *relative* to that of a non-monetary downturn. In all three data sets we see that C&I loans fall substantially more during a non-monetary downturn than during a monetary downturn. This is documented in Panel A of Figure 4.6. The other two panels of Figure 4.6 show that the reverse is true for real estate and consumer loans. The results are significant for all three loan components.

### 4.3 Robustness

In the last subsection we mentioned that the responses of total loans estimated with the two samples that start in 1977 were not only insignificant, but also not robust, since the impulses depended on the specification of the VAR used.<sup>22</sup> In fact, even the sign of the response of total loans during a monetary downturn relative to the response during a non-monetary downturn changed. In contrast to the results for total loans, the significant increase in C&I loans during a monetary downturn relative to a non-monetary downturn as well as the opposite finding for real estate and consumer loans are quite robust. Since the loan components move in opposite directions it is not too surprising that the results for total loans do not display a robust positive or negative response. These results clearly demonstrate the potential

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<sup>22</sup>The finding that none of the loan components increases in response to a monetary tightening in the sample that starts in 1960, coupled with the finding that the responses differ in sign for the shorter samples explain why the observed fall in the response for total loans is a robust finding when estimated with the longer sample but not when estimated with the shorter sample.



shortfall of using aggregate data. That is, the analysis for the VAR with the loan components reveals an intriguing set of significant and robust results, while the analysis for the VAR with total loans does not. The results for the loan components are not only robust for different VAR specifications, they are also fairly robust across data sets. The main difference for the various data sets being that the response of C&I loans during a monetary downturn is significantly positive in the data sets that begin in 1977 while it fluctuates around zero in the data set that starts in 1960.

In Den Haan, Sumner, and Yamashiro (2004) we investigate whether the results are different for small banks and we find the results to be remarkably similar although there are some quantitative differences. In particular, we find the total loan response to a monetary tightening is more negative for small banks, although the adjustment of small banks' loan portfolios, during both a monetary and a non-monetary downturn, is very similar to what we find for large banks.

#### **4.4 H8 versus Call data**

The quarterly-Call data set produces a stronger response in C&I loans than the quarterly-H8 data set. There are three differences between the data from the Call Reports and the H8. First, since all banks are required to file Call reports this data is likely to be of better quality. Second, the Call reports provide a snapshot of end-of-quarter loans, while the H8 data are averages of weekly data. Third, the H8 universe consists of all commercial banks while the Call reports only include commercial banks that are domestically chartered. Since there actually is an H8 data set for domestically-chartered banks for the shorter data set we can determine which of those three factors can explain the differences in our results. We find the difference is mainly due to the difference in the universe of banks included.<sup>23</sup> This is interesting because it means that the lower increase in C&I loans after a monetary tightening, for the quarterly-H8 data set (both in absolute terms and relative to the response during a non-monetary downturn), is due to the inclusion of branches and agencies of foreign banks (and/or other banks without a domestic charter) in the H8 data set.

#### **4.5 Commercial paper**

In the recent literature, the comparison between the behavior of C&I bank loans and commercial paper during a monetary downturn has played an important role in the interpretation of the empirical findings. In particular, Kashyap, Stein, and Wilcox (1993) point out that if there is a bank-lending channel the ratio of C&I bank loans

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<sup>23</sup>In the appendix (Section 7), we describe the universe of banks in detail.

to commercial paper should decrease in response to a monetary tightening. We therefore examine the behavior of commercial paper during a monetary and a non-monetary downturn. The results are given in Figure 4.7.<sup>24</sup> The figure shows that during a monetary downturn, commercial paper sharply increases and, consistent with the results in the literature, we find that after a monetary tightening the "mix variable", i.e., the ratio of C&I bank loans to commercial paper, decreases. Interestingly, we find that during a non-monetary downturn commercial paper not only drops, but drops by much more than C&I bank loans. In section 5.2.2 we discuss these results in more detail.

## 4.6 Responses to a single output shock

We end this section by looking at the responses of the bank loan components and commercial paper to a one-time output shock. This exercise will be useful in interpreting the results, but is also meant to convince the reader that the behavior of each of the responses during a non-monetary downturn, which relies on a sequence of output shocks, are not that different from the responses observed after a single unexpected disturbance to output. The results are shown in Figure 4.8. The results for the bank loan components and commercial paper are given in panels A and B, respectively. The responses of all variables except output are restricted to be zero in the period the output shock occurs. The figure shows that C&I loans decrease rapidly in the periods following the shock. Consistent with the results found above for the non-monetary downturn we find much smaller declines for consumer loans and no significant declines for real estate loans. Panel B shows that commercial paper displays a decline that, while similar to the one observed for C&I loans, is much bigger. Whereas the largest drop in C&I loans is 0.79%, the largest drop in commercial paper is 3.7%.<sup>25</sup>

## 5 Interpretation of the results

The results of the last section are helpful in understanding how the monetary transmission mechanism operates. Useful in interpreting the results is knowing whether or not the non-monetary downturn is comparable to the monetary downturn. The

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<sup>24</sup>The results for commercial paper are from a VAR identical to the benchmark specification for total loans but with total loans replaced by commercial paper.

<sup>25</sup>The responses in Panels A and B are from different VARs and the output responses are slightly different but the differences are too small to matter for the large quantitative difference in the response of C&I loans and the response of commercial paper. Similar differences are found when C&I loans and commercial paper are included in the same VAR.

idea of the comparison is to correct the responses of the loan components during a monetary downturn for a change in real activity. Any differences in the responses would then not be due to changes in real activity, but to factors such as the direct effect of higher interest rates on the cost of borrowing, or to an increase in credit market frictions not due to the reduction in real activity. Admittedly, this correction is an ambitious task, and below we discuss possible problems. Furthermore, we provide an interpretation of the results under both the assumption that the two downturns are comparable and that they are not. In both cases we conclude that the "perverse" response of C&I loans is unlikely to be consistent with a reduction in the supply of C&I loans.

In Section 5.1, we give an interpretation of the results under the assumption that these two downturns are not comparable, and consider the circumstances under which the results are consistent with a reduction in the supply of C&I loans during a monetary tightening. In Section 5.2, we interpret the results under the assumption that the downturns are comparable.

## 5.1 Downturns not comparable

One possible reason why the two downturns would not be comparable is a difference in the perceived persistence of the decline in real activity.<sup>26</sup> Recall that the monetary downturn is caused by *one* unexpected positive shock to the federal funds rate. In contrast, to ensure the exact same pattern of real activity, we require *a sequence* of output shocks. For example, if the private sector expects structural output shocks to be more persistent than monetary policy shocks, then the exact same observed change in real activity would affect C&I loans differently. In particular, it may very well be possible that the demand for C&I loans would increase after a temporary (monetary) shock to finance inventories, while a more persistent (output) shock leads to cancellation of investment plans and a reduction in the demand for C&I loans.

In our VAR, which includes a linear trend, output actually reverts back to its pre-shock value faster after an output shock than after a monetary shock.<sup>27</sup> More-

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<sup>26</sup> Another possibility is a difference in the behavior of prices, but we are less concerned with this case. Although there are some minor differences, changes in inflation are very small relative to the change in interest rates. That is, the behavior of real interest rates is similar to the behavior of nominal interest rates in both the monetary and the non-monetary downturn.

<sup>27</sup> Consistent with this observation is the pattern of output shocks that generate the monetary downturn. To generate the output decline observed during a monetary downturn, a series of negative shocks is needed, although they very quickly decline. If output shocks were more persistent than monetary shocks the negative output shock(s) would have to be followed by positive output shocks.

over, Sumner (2003) finds that, after an oil price shock, the behavior of the loan components as well as interest rates and output, is very similar to the responses observed after an output shock.

But it is true that in VAR specifications without a linear trend, output shocks have more persistent effects on output than interest rate shocks. Since the idea that output shocks have more persistent effects on output is plausible, we continue the discussion in this subsection without the assumption that the two downturns are comparable. The main question we want to address is whether the "perverse" effect on C&I loans could be consistent with a bank-lending channel.

The increase in C&I loans could still be consistent with the presence of a bank-lending channel for C&I loans if the demand for C&I loans increases. This increased demand could be to finance, for example, an increase in inventories. As long as the increase in the demand for C&I loans is big enough then the observed increase in C&I loans could be consistent with a reduction in the supply of C&I loans as predicted by the bank-lending channel.<sup>28</sup> The reason why no such increase in the demand for C&I loans is observed after an output shock could be that output shocks have more persistent effects on output and firms only want to increase borrowing to smooth out temporary shocks. For the same reason, there can be an increase in commercial paper in response to a monetary policy shock and a decrease in response to an output shock.

In the next two subsections we look at the empirical results more closely and discuss whether it is possible to reconcile the bank-lending channel with the perverse effect on C&I loans. We point out that in order to generate these results you would need (i) an elastic supply and demand for loans, and (ii) an explanation for why C&I loans increase before real activity declines in response to a negative monetary policy shock.

### 5.1.1 Elastic supply and demand of C&I loans

In this section we address the question of whether a credit crunch during a monetary tightening is consistent with an increase in C&I loans *and* the observed behavior of not only the federal funds rate but also the rate on C&I loans. After discussing the observed behavior of interest rates we argue that the presence of a credit crunch in C&I loans during a monetary tightening requires an elastic supply and demand of C&I loans.

**Behavior of interest rates** In Figure 5.1 we plot the impact of a monetary tightening on the federal funds rate, the rate on C&I loans, the rate on 3-month

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<sup>28</sup>The balance-sheet channel would also lead to a reduction in the supply of loans.

commercial paper, and the rate on conventional 30-year fixed-rate mortgages. The figure also plots the hypothetical value of a 10-year and 30-year bond calculated using the expectations-hypothesis value implied by the impulse response function of the federal funds rate. We will come back to this figure later, but the key observation is that the response of the rate on C&I loans is very similar to the response of the federal funds rate.

**An intuitive graphical argument** If during a monetary tightening the demand for C&I loans increases and the supply of C&I loans decreases one would expect a substantial increase in the spread between the C&I loan rate and the federal funds rate unless both the demand and the supply of C&I loans are very elastic. This point is made clear in Figure 5.2. The curve  $r_{C\&I}^D(L_{C\&I}; r)$  is the demand curve and specifies the loan rate,  $r_{C\&I}$ , firms are willing to pay as a decreasing function of the amount they borrow  $L_{C\&I}$  when the market rate of return is equal to  $r$ . At a given level of  $L_{C\&I}$  an increase in  $r$  leads to an increase in  $r_{C\&I}^D$ . The curve labeled  $r_{C\&I}^S(L_{C\&I}; r)$  is the rate that banks will charge when they lend  $L_{C\&I}$  and the market rate is equal to  $r$ . A monetary tightening corresponds to an increase in the market interest rate  $r$ . In panel A we plot the standard interpretation of the effects of a monetary tightening according to the interest-rate channel. The increase in the market rate,  $r$ , shifts the supply curve and the demand curve up, which leads to an increase in the rate on C&I loans and a reduction of the quantity. The shift in the supply curve is not caused by a credit crunch but simply reflects the fact that banks will charge higher interest rates if their own cost of borrowing increases.

The question we want to address is under what conditions a monetary tightening can lead to (i) a credit crunch, that is, a further upward shift of the  $r_{C\&I}^S(L_{C\&I}; r)$  curve, (ii) an increase in the total amount of loans,  $L_{C\&I}$ , and (iii) an increase in  $r_{C\&I}$  that is similar to the increase in  $r$ .<sup>29</sup> Panel B adds to the effects of the interest-rate channel of panel A (labelled 1<sup>A</sup> and 1<sup>B</sup>) a credit crunch or reduction in the supply of bank loans (labelled 2<sup>B</sup>) and an increase in the demand for bank loans (labelled 2<sup>A</sup>). The figure clearly shows that C&I loans can increase even when there is a reduction in bank loans, as predicted by the bank-lending channel, as long as the increase in demand is big enough. But the point of this picture is to point out that the increase in demand raises  $r_{C\&I}$ , unless the supply curve is elastic, and that the increase in supply raises  $r_{C\&I}$  as well, unless the demand curve is very elastic. There are two

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<sup>29</sup>Of course, it is much more natural to think of the bank-lending channel as causing an increase in the spread. In fact, Kashyap and Stein (1995) in their discussion of the bank-lending channel point at the theoretical possibility that a contraction in policy "can in some circumstances have a very significant effect on the spread between loans and bonds, and therefore on the investment of those firms that rely on banks for financing." But such an increase in the spread is not observed.

ways to reconcile the perverse increase of C&I loans with the bank-lending channel. The first possibility is that both supply and demand curves are very elastic.<sup>30</sup> The second possibility is that the interest-rate channel by itself (the effects labelled 1<sup>A</sup> and 1<sup>B</sup>) does not increase  $r_{C\&I}$  by much.

**A model for the market of C&I loans** The data show that the spread between the rate on C&I loans and the federal funds rate remains basically unchanged during a monetary tightening. This empirical finding could be reconciled with a credit crunch, and an increase in the demand for C&I loans if the effect of a monetary tightening itself (the effects labelled 1<sup>A</sup> and 1<sup>B</sup> in Figure 5.2) would imply a reduction in the spread. Here we build a simple model about the effect of a monetary tightening on the spread and argue that this possibility is unlikely.

We start by discussing the demand for C&I loans. Suppose that firms can use internal funds,  $F$ , and external funds,  $L_{C\&I}$  to finance investment. The monetary opportunity cost of internal funds is equal to  $r$ . But by using internal funds firms also reduce their liquidity positions and ability to respond quickly/cheaply to opportunities or setbacks. This additional cost of using internal funds is assumed to be equal to  $0.5\gamma F^2$  with  $\gamma > 0$ . The maximization problem for the firm is given by

$$\max_{F, L_{C\&I}} (F + L_{C\&I})^\alpha - rF - r_{C\&I}L_{C\&I} - 0.5\gamma F^2. \quad (5)$$

The first-order conditions are

$$\alpha(F + L_{C\&I})^{\alpha-1} = r_{C\&I}, \text{ and} \quad (6)$$

$$\alpha(F + L_{C\&I})^{\alpha-1} = r + \gamma F. \quad (7)$$

This leads to the following demand for bank loans:

$$L_{C\&I} = \frac{r - r_{C\&I}}{\gamma} + \left(\frac{r_{C\&I}}{\alpha}\right)^{\frac{1}{\alpha-1}}. \quad (8)$$

Banks finance one-period loans with checkable deposits,  $D$ , that earn no interest, and time deposits,  $T$ , that earn interest rate  $r^T$ . Here we make the standard assumption that  $r^T = r$ . Checkable deposits are subject to a constant reserve requirement. Since banks would not want to hold excess reserves in this environment, the amount of reserves satisfies the following equation:

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<sup>30</sup>One possible reason for an elastic supply curve is that a significant part of C&I loans are credit lines. If firms have guaranteed access to credit at prearranged rates then the banks supply to the increased use of the credit line would be infinitely elastic. A reduction in the supply of (new) C&I loans would still have an upward effect on loan rates unless the demand was elastic.

$$R = \theta D. \quad (9)$$

The demand for checkable deposits is given by

$$D = \delta_0 + \delta_1 r. \quad (10)$$

The central bank chooses  $r$ , which it can influence directly by choosing  $R$ . We assume that banks have monopolistic power<sup>31</sup> and that the demand function they face is given by 8. Time deposits are equal to

$$T = L_{C\&I} - (1 - \theta)D. \quad (11)$$

The banks' maximization problem is given by

$$\max_{L_{C\&I}} r_{C\&I} L_{C\&I} - r(L_{C\&I} - (1 - \theta)D). \quad (12)$$

The first-order condition is equal to

$$r_{C\&I} + \frac{\partial r_{C\&I}}{\partial L_{C\&I}} L_{C\&I} = r \quad (13)$$

and states that the marginal cost of an increase in loans,  $r$ , equals the marginal revenue of an increase in loans.

To understand what happens with the spread  $r_{C\&I} - r$  in response to an increase in  $r$  we have to know what happens to  $\frac{\partial r_{C\&I}}{\partial L_{C\&I}} L_{C\&I}$ . The response of this variable depends crucially on the amount of monopoly power that banks have. If  $\gamma$  is close to zero then internal funds and external funds are close to being perfect substitutes for firms, banks have little monopoly power, and  $r_{C\&I}$  is close to  $r$ . If  $\gamma$  is large, however, then banks push  $r_{C\&I}$  substantially above  $r$ . To see this consider the case where  $\gamma$  is infinite and firms do not want to use internal funds. After some simple algebraic manipulations it can be shown that the first-order condition 13 leads to

$$r_{C\&I} = \frac{r}{\alpha} \text{ and} \quad (14)$$

$$dr_{C\&I} = \frac{1}{\alpha} dr > dr. \quad (15)$$

Thus, an increase in  $r$  leads to a bigger increase in  $r_{C\&I}$  and an increase in the spread. At the other extreme, when  $\gamma$  is equal to zero, we have that  $r_{C\&I} = r$ , and,

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<sup>31</sup>As pointed out by Kashyap and Stein (1995) this could be due to informational "lock-in" effects and is consistent with several theoretical and empirical papers.

thus, changes in  $r_{C\&I}$  are equal to changes in  $r$ . Therefore, there is no increase in the spread.

So far we have just considered a standard monetary tightening without a credit crunch, or an increase in the demand for loans to finance things like an increase in inventories. These are likely to have a positive effect on the spread. So unless the effect of a monetary tightening itself actually reduces the spread one cannot expect the total effect on the spread to remain unchanged. For some intermediate values of  $\gamma$  it is indeed possible that in response to an increase in  $r$  the value of  $\frac{\partial r_{C\&I}}{\partial L_{C\&I}} L_{C\&I}$  decreases in absolute terms, which means that the increase in  $r_{C\&I}$  is less than the increase in  $r$ . Quantitatively the effect is small, however. This is documented in Figure 5.3 that plots the increase in  $r_{C\&I}$  divided by the increase in  $r$  when  $r$  increases from 1% to 2% as well as the value of  $r_{C\&I}$  when  $r$  is equal to 1%.

This model, therefore, predicts that the change in  $r_{C\&I}$  is roughly similar to the change in  $r$  when banks do not have much monopoly power and substantially bigger when they do.<sup>32</sup> If in addition to the increase in  $r$  there is an autonomous increase in demand and a credit crunch one would, thus, not expect the increase in  $r_{C\&I}$  to be similar to the increase in  $r$ .

To conclude, the analysis here shows that it would be hard to reconcile a monetary tightening with (i) a credit crunch, (ii) an increase in the total amount of loans, and (iii) an increase in  $r_{C\&I}$  that is similar to the increase in  $r$ . Therefore, we conclude that one would need a non-trivial model to obtain these three characteristics. One possibility may be that firms increase their demand for C&I loans, not to finance an increase in inventories, but to finance the increase in interest payments. The hypothesis that an increase in the interest rate leads to an increase in the demand for loans is fairly unorthodox. Consequently, it is not clear what the effect of an increase in  $r$  on  $\frac{\partial r_{C\&I}}{\partial L_{C\&I}} L_{C\&I}$  would be, and whether it would be a reason why there would be less upward pressure on  $r_{C\&I}$ . In the next subsection we discuss that this reason for an increase in the demand for C&I loans actually fits the timing of the response better than an increase in the demand to finance the increase in inventories.

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<sup>32</sup>In this model, bank dependence (i.e.,  $\gamma > 0$ ) affects the level of output but actually does not amplify the effect of changes in  $r$  on output. To be precise, the percentage decrease in output following an increase in  $r$  when  $\gamma = 0$  is equal to the percentage change when  $\gamma$  is infinite. For intermediate values of  $\gamma$  the percentage decrease is less. In fact, for the value of  $\gamma$  for which the percentage change in  $r_{C\&I}$  is the smallest the percentage change in output is the smallest as well. This follows directly from 6.



### 5.1.2 Timing of the increase in C&I loans

In this section we continue to address the question as to whether the empirical findings are consistent with the existence of a bank-lending channel. Above we pointed out that this would require an increase in the demand for C&I loans. When the downturn in economic activity in response to a monetary tightening is different from the downturn in response to output shocks then it is possible that the increase in demand during a monetary tightening is due to the (temporary) reduction in real activity. But, as is documented in Figures 4.3, 4.4, & 4.5, C&I loans actually increase immediately, while real activity only begins its decline after two quarters, and the decline does not become substantial until after at least a year (See Figure 4.2).

Another relevant finding is that in response to an output shock, output immediately plummets and both C&I loans and commercial paper rapidly<sup>33</sup> follow, implying that firms do not try to buffer the immediate decline of output by increased borrowing.

But as pointed out above, there is another possibility as to why the demand for C&I loans might increase during a monetary tightening, and that is, the increase in the interest rate itself. Although it may sound strange that the demand for loans actually increases in response to an increase in interest rates it would be possible if firms are strapped for cash and can only finance the increase in borrowing costs by borrowing more. One would expect this effect to be stronger for constrained firms, and, thus, stronger for small firms. Gertler and Gilchrist (1993b), however, show that bank lending to small firms decline while bank lending to large firms increase.

## 5.2 Comparable downturns

If the monetary and the non-monetary downturn are comparable then one can interpret the difference in the responses during the two downturns as the effect of a monetary tightening after a correction for changes in real activity.<sup>34</sup> The results found here then imply that a monetary tightening—after a correction for the decline in real activity—has a strong negative effect on real estate lending and consumer loans but actually has a positive effect on C&I loans.

Under this interpretation it cannot be the case that after a monetary tightening firms increase the demand for C&I loans in response to the reduction in real activity because they want to finance the increase in inventories or underutilization of production factors. This leaves us with two possibilities. The first possibility is that

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<sup>33</sup>See Figure 4.8.

<sup>34</sup>Note that this change in real activity could affect both the demand and supply of loans.

firms increase the demand for C&I loans not because of the decline in real activity, but to finance the increased cost of borrowing, which was discussed in Section 5.1. The second possibility is that there is an increase in the *supply* of C&I loans, which is discussed in Section 5.2.1. In Section 5.2.2 we give reasons why the supply of commercial paper could increase in response to a monetary tightening and also why it could increase by more than C&I loans.

### 5.2.1 Why would the supply of C&I loans increase?

The question arises as to why there would be an increase in the amount of C&I bank loans. Under the assumption that monetary and non-monetary downturns are comparable it cannot be due to a reduction in real activity. In this section we discuss four reasons why banks may prefer C&I loans over the other two loan components during a monetary downturn. The first reason is related to differences in risk, the second to differences in the market structure, the third reason refers to hedging, and the fourth is related to bank capital regulation and the effect that the short-term interest rate has on the current-period profit margins of the different loan components.

**Reason I: Stronger balance-sheet channel for consumers** In the recent literature the balance-sheet channel has received a lot of attention. This channel, like the bank-lending channel, stresses credit market frictions but instead of focusing on the balance sheet of the bank this channel focuses on the balance sheet of the borrower. The idea is that healthy balance sheets lessen the impact of frictions, such as information asymmetries and limited enforcement, and make it possible for the borrower to receive more funds from the lender. Suppose that the "balance-sheet effect" is quantitatively more important for consumers than for firms. Banks respond by reducing the supply of loans to consumers (both real estate and consumer), which would make it easier for banks to supply funds to firms. Since we look at the responses for a monetary downturn relative to the responses for a non-monetary downturn, the "balance-sheet effect" does not refer to a worsening of the balance sheet because of a change in real activity, but only because of an increase in interest rates. Why would an increase in interest rates be more harmful for consumers, and, thus, have a bigger effect on consumer loans and real estate loans?<sup>35</sup> One possibility is that interest payments are a bigger fraction of the expenditures for consumers than for firms. Another possibility is that the increase in interest

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<sup>35</sup>Our real estate loan series also includes mortgages to firms and in none of our data sets can we separately identify residential mortgages.

rates leads to a decrease in property prices<sup>36</sup>, which is more harmful for the credit worthiness of consumers than firms.

The available data on delinquency and charge-off rates for the three loan components is unfortunately not long enough to estimate impulse response functions. In Figures 5.4 and 5.5 we plot the delinquency and charge-off rates for the loan components, but the graph itself does not seem to provide evidence for the hypothesis that C&I loans become relatively less risky during periods of high interest rates.

**Reason II: Stickiness of rates on consumer loans** It has been pointed out in the literature that rates on consumer loans are sticky. For example, Calem and Mester (1995) point out that between May 1989 and November 1991 the prime rate dropped from 11.5 percent to 7.5 percent, but during this period credit-card rates of the largest issuers were held fixed at 18-20 percent. Brito and Hartley (1995) provide theoretical arguments why credit-card interest rates are not likely to be responsive to changes in the cost of funds<sup>37</sup>. Similarly, Calem and Mester (1995) argue that credit-card rates are sticky because (i) consumers face search and switching costs and (ii) banks face an adverse-selection problem if they unilaterally reduce interest rates. In Figure 5.6 we plot the federal funds rate, the rate on 24-month personal loans, and the rate on credit cards. The figure clearly shows that both the interest rate on credit card loans and the interest rate on personal bank loans are not very responsive to changes in the federal funds rate. That is, during periods of monetary tightening the spread on consumer loans decreases.<sup>38</sup> This reduction in the spread is likely to be accompanied by a reduction in the supply of consumer loans, which would make it possible for banks to increase C&I loans.

**Reason III: Changes in interest rates and hedging** Financial institutions tend to mismatch their balance sheet maturities to some degree.<sup>39</sup> This makes them vulnerable to changes in interest rates. Through hedging they try to limit this risk. What is important for our paper is that hedging affects the banks' loan portfolio as well as the yields earned on the various loans. Perli and Sack (2003) point out that *"It is indeed a common view among fixed-income market participants that mortgage hedging activity has frequently amplified movements in long-term interest rates"*. Although there are several ways in which banks try to hedge against un-

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<sup>36</sup>See McCarthy and Peach (2002).

<sup>37</sup>They point out that an increase in the cost of funds for banks also increases the opportunity costs of using money, and that the demand for credit card loans is more sensitive to this opportunity cost.

<sup>38</sup>More thorough empirical evidence can be found in Calem and Mester (1995).

<sup>39</sup>See, for example, Saunders (1994, p. 84).

foreseen changes in interest rates one important way to hedge is by adjusting the portfolio in order to align the maturities of assets and liabilities. When interest rates increase, the expected maturity of mortgage loans increase because lenders are less likely to refinance. To compensate for the increase in the maturity of their assets banks will sell long-term assets, which increases long-term rates. So this type of hedging behavior not only could explain a substitution out of mortgage loans, but can also explain why long-term rates increase by much more than is predicted by the expectations hypothesis. The tightening of monetary policy in 1994 is a good example to illustrate this effect. From February through May of 1994 the federal funds rate increased by 125 basis points. Interestingly, long rates began to rise in October 1993 several months before the tightening actually took place. Moreover, during the same period of time the 125 basis point increase in the federal funds rate was accompanied by a 133 basis point increase in the ten-year Treasury rate. One argument that hedging was important for this movement in long rates is that the yield curve did flatten for maturities over ten years and that the maximum maturity of the bonds used for hedging is ten years.<sup>40</sup>

**Reason IV: Current-period profitability and the Basel Accord** The effect of changes in interest rates on banks' profitability has received a lot of attention in the literature.<sup>41</sup> The literature shows that the effect is ambiguous and depends on how profitability is measured. The discussion below will make clear why the effects are ambiguous, but the focus in this section is more limited. We are mainly interested in the consequences of changes in the interest rate on *recorded* current-period earnings. Recorded current-period earnings are important because they affect the book value of a bank's equity and, thus—because of bank capital regulation—the amount of risky assets a bank can have on its balance sheets. The Basel Committee on Banking Supervision is aware that banks can be "*vulnerable to fluctuations in recorded profits, irrespective of whether any losses incurred may be offset, under the economic approach, by larger earnings which, because of accounting conventions, will only emerge gradually over the years.*"<sup>42</sup> Also, Berger, Herring, and Szegö (1995) point out that calculating the market value of bank equity is not only really difficult, but is also not appropriate for regulatory purposes since it contains the value of the bank's limited liability, and the regulator bears most of the cost of this option. Finally, in BIS (2004) it is pointed out that even traditional sources of non-interest income, such as transaction processing fees, are becoming more interest rate sensitive.

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<sup>40</sup>See Fernald, Keane, and Mosser (1994).

<sup>41</sup>For references see Hasan and Sarkar (2002).

<sup>42</sup>See BIS (1993, page 10).

In particular, with the adoption of the 1988 Basel Capital Accord in the United States under the 1991 Federal Deposit Insurance Corporation Improvement Act (FDICIA) regulation banks are required to hold minimum bank equity levels, which are stated as a percentage of risk-weighted assets. But even before the adoption of the Basel Capital Accord, commercial banks had reasons to be concerned about their bank equity position. The first nationwide capital requirement for commercial banks was mandated by the International Banking Act of 1978. Prior to 1978 the only federal capital standards were for newly chartered banks and other capital standards were ad hoc, usually implemented as an incident to a Bank Holding Company application.<sup>43</sup> Several empirical studies find indeed that there is a robust link between loan growth and bank profitability.<sup>44</sup> As pointed out by Sharpe (1995), it is typically difficult, if not impossible, to determine whether a reduction in bank capital leads to a reduction in lending because of regulation, or whether low bank profitability is correlated with other variables important for the amount of bank loans issued.<sup>45</sup>

Because banks finance long-term assets with short-term liabilities and rates on long-term assets change by less than short-term interest rates one can expect current-period earnings to be negatively affected by an increase in short-term interest rates. To determine, quantitatively, how important the response of bank equity is to an increase in the interest rate we look at the changes in the book value of bank equity during a monetary and a non-monetary downturn.<sup>46</sup> The results are reported in Figure 5.7. The figure shows that in response to a monetary tightening there is a substantial and significant reduction in bank equity. Moreover, in response to output shocks there is no such decline. These two striking findings regarding the behavior of bank equity suggest that the recorded value of current-period profits could indeed play an important role during the monetary transmission mechanism.

To make the basic idea clear we develop a very simple model with the following characteristics.

- The total amount of loans,  $\bar{L}$ , is fixed so we only focus on the portfolio effects of changes in the interest rate.
- Banks can invest in short-term (one-period) loans,  $L_{C\&I,t}$ , and long-term (two-period) loans,  $L_{RE,t}$ , that are financed by one-period liabilities.

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<sup>43</sup>See Greenbaum and Thakor (1994).

<sup>44</sup>See Sharpe (1995) for an overview.

<sup>45</sup>That the market value of bank equity is important is shown in Peek and Rosengren (1997). They show that bank lending of Japanese banks in the United States was negatively affected in the early nineties when reductions in Japanese stock prices reduced the market value of bank equity.

<sup>46</sup>See the appendix for some more information.

- There are costs associated with deteriorations of the capital adequacy ratio.
- There is no risk. The rate on one-period loans,  $r_{C\&I,t}$ , is equal to the market interest rate,  $r_t$ , and the rate on two-period loans satisfies the expectations hypothesis. So changes in returns only matter in so far as they affect the capital adequacy ratio.
- There are no changes in real activity.

With this model we want to make two points. First, in response to an increase in the market interest rate  $r_t$  banks would like to substitute out of long-term loans, and into short-term loans. Second, this result does not depend on the particular capital requirements for the two loans, and in particular, holds when capital requirements are higher for short-term loans (as they are when short-term loans are C&I loans and long-term loans are mortgages).

The capital adequacy ratio is equal to

$$\frac{E_t}{R_t},$$

where  $R_t$  is the amount of credit risk and  $E_t$  is the beginning-of-period bank equity. The amount of credit risk is given by

$$R_t = \phi_{C\&I}(L_{C\&I,t}) + \phi_{RE}(L_{RE,t}) + \phi_{RE}(L_{RE,t-1}),$$

where the functions  $\phi_{C\&I}(L_{C\&I,t})$  and  $\phi_{RE}(L_{RE,t})$  are increasing and strictly convex.<sup>47</sup> There are disadvantages of having low capital adequacy ratios even when banks have a capital adequacy ratio above the legal limit. At low capital adequacy ratios banks have a higher probability of being below the legal limit in the future and an increased chance of interference from the regulator. In addition, the capital adequacy ratio affects a bank's credit rating. Here we assume that banks face a cost that is proportional to the inverse of the capital adequacy ratio, but our results do not depend on the functional form as long as there is a cost to a decline in the capital adequacy ratio.

The bank's portfolio problem is given by

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<sup>47</sup>Moreover, we assume that the functions  $\phi_{C\&I}$  and  $\phi_{RE}$ , and the value of  $\bar{L}$  are such that internal solutions for both loans are chosen.

$$\begin{aligned}
& \min_{\{L_{RE,t}, L_{C\&I,t}, E_{t+1}\}_{t=1}^{\infty}} \sum_{t=1}^{\infty} \beta_t \frac{\phi_{C\&I}(L_{C\&I,t}) + \phi_{RE}(L_{RE,t}) + \phi_{RE}(L_{RE,t-1})}{E_t} \\
& \text{s.t.} \\
& L_{C\&I,t} + L_{RE,t} + L_{RE,t-1} = \bar{L} \\
& E_{t+1} = (1 + r_t)E_t + (r_{C\&I,t} - r_t)L_{C\&I,t} + (r_{RE,t} - r_t)L_{RE,t} + (r_{RE,t-1} - r_t)L_{RE,t-1} \\
& E_1 \text{ and } L_{RE,0} \text{ given}
\end{aligned}$$

The discount factor  $\beta_t$  is given by

$$\beta_t = \prod_{\tau=1}^t \frac{1}{1 + r_{\tau}}. \quad (16)$$

The expectations hypothesis implies that

$$r_{C\&I,t} = r_t \quad (17)$$

and

$$(r_{C\&I,t} - r_t)(1 + r_{t+1}) + (r_{RE,t} - r_{t+1}) = 0. \quad (18)$$

Using 17 and 18 the first-order conditions can be written as

$$\frac{\phi'_{C\&I}(L_{C\&I,t})}{E_t} = \eta_t \quad (19)$$

and

$$\begin{aligned}
\frac{\phi'_{RE}(L_{RE,t})}{E_t} + \frac{\phi'_{RE}(L_{RE,t})}{(1 + r_t)E_{t+1}} &= \eta_t + \frac{\eta_{t+1}}{(1 + r_t)} \\
+ \frac{1}{(1 + r_t)}(r_{RE,t} - r_t) \frac{R_{t+1}}{E_{t+1}^2} &
\end{aligned} \quad (20)$$

The intuition for these equations is fairly straightforward. The marginal cost of holding a one-period loan is equal to  $\phi'_{C\&I}(L_{C\&I,t})/E_t$ . Since C&I loans do not affect recorded profits the only benefit is satisfying the constraint that a certain amount of loans be held. The four terms on the first line of 20 capture the properties that two-period loans affect the capital adequacy ratio for two periods, and help to fulfill the loan requirement for two periods. Since the expectations hypothesis holds, holding

a two-period bond does not affect the bank's equity position at the time the loans expire. But, if the current interest rate is not equal to the following period's interest rate then the bank's equity position will be temporarily affected because  $r_{RE,t} \neq r_t$ . For example, when  $r_t > r_{t+1}$  then  $r_{RE,t} - r_t < 0$ . Consequently, recorded profits and bank equity decline. In the next period  $r_{RE,t} - r_{t+1} > 0$ , recorded profits increase, and bank equity returns to its original level.

Consider the case when the market interest rate is constant. In this case the two first-order conditions can be written as

$$\frac{\phi'_{C\&I}(L_{C\&I})}{E} = \eta \quad (21)$$

and

$$\frac{\phi'_{RE}(L_{RE})}{E} + \frac{\phi'_{RE}(L_{RE})}{(1+r)E} = \eta + \frac{\eta}{(1+r)}. \quad (22)$$

Note that variables without a time subscript indicate the steady-state value. If  $\phi_{C\&I}(L) = \phi_{RE}(L)$  then we would have that  $L_{C\&I} = L_{RE}$  but if  $\phi_{C\&I}(L) > \phi_{RE}(L)$  for all  $L$ , then we would have that  $L_{C\&I} < L_{RE}$ . The latter is the relevant case under current legislation since mortgage loans have a smaller risk weight than C&I loans.

We want to consider the effect of a one-time increase in the interest rate  $r_t$ . In particular we set  $r_t = r$  for all  $t$  except for  $t = 1$  where  $r_t = r' > r$ . Because the expectations hypothesis holds, the increase in the rate on two-period loans is less than the increase in  $r$ . Consequently, the current-period profit margin on two-period loans decreases in period one, but increases in period two. Moreover, no matter how the bank adjusts its portfolio, its equity position will be back to its original value in period three.

The increase in  $r$  lowers the amount of bank equity at the beginning of period two. Since in period two all interest rates are back to normal it is not hard to see, from the first-order conditions, that the bank's optimal choice for C&I and real estate loans return to normal as well. Note that this does not depend on the particular choice of  $\phi_{C\&I}(L)$  and  $\phi_{RE}(L)$ . So even if holding C&I loans requires more bank capital, then a reduction in bank equity does not affect the optimal ratio of the two loan categories in the bank's portfolio.

When we substitute  $\eta_t$  out of the first-order conditions then we get for period one<sup>48</sup>

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<sup>48</sup>Variables without a subscript are equal to the steady state value.



$$\begin{aligned}
& \frac{\phi'_{C\&I}(L_{C\&I,1})}{E} + \frac{\phi'_{C\&I}(L_{C\&I})}{(1+r_1)E_2} = \\
& \frac{\phi'_{RE}(L_{RE,1})}{E} + \frac{\phi'_{RE}(L_{RE})}{(1+r_1)E_2} \\
& - \frac{(r_{RE,1} - r_1)}{(1+r_1)} \frac{R_2}{(E_2)^2}.
\end{aligned} \tag{23}$$

When short-term interest rates increase two-period bonds are less attractive, since the (temporary) decrease in equity increases the cost of holding these bonds. Consequently  $L_{RE}$  has to decrease.

This model predicts that banks would like to substitute out of long-term loans, such as mortgages, and into short-term loans, such as C&I loans. Moreover, if it really is hard to change interest rates on credit card loans, then the analysis given here provides an additional argument as to why consumer loans are not attractive. The model is a partial equilibrium model in that it takes interest rates as given. The desire to substitute out of real estate loans is likely to increase the rates on long-term assets, which is indeed what we see in the data. An increase in the mortgage rate over the expectations hypothesis value offers, of course, a great opportunity for those banks that have sufficient bank capital, and thus are less affected by a temporary reduction in bank capital. This prediction is consistent with the empirical evidence of Hasan and Sarkar (2002) who show that "high-slack" banks, that is, banks far from their lending limits imposed by capital requirements, have lower levels of interest rate risk than banks with little lending slack.

### 5.2.2 Why does commercial paper increase?

A similar reason could cause the supply of commercial paper to increase. During any downturn it is hard to find profitable investments, but during monetary downturns short-term bonds earn high returns. During a monetary downturn, mutual funds may, therefore, switch from long-term investments, such as equity, to commercial paper, which is a relatively safe investment and earns a high return. Recall that in Kashyap, Stein, and Wilcox (1993) it is argued that the observed decrease in the ratio of C&I loans to commercial paper after a monetary tightening is due to a bank-lending channel and a *decrease* in the supply of C&I bank loans. We argue that the observed decrease in the mix variable is also consistent with an *increase* in the supply of C&I loans as long as the supply of commercial paper increases by more. But note that the increase in the supply of C&I loans is due to a substitution effect. In addition to this substitution effect there also is the decline in deposits

that reduces the amount funds available for any type of loan. If other lenders do not face a similar drain on their financing then C&I loans should increase by less than commercial paper.<sup>49</sup>

### 5.3 Summary of the interpretation

Understanding what happens during the monetary transmission mechanism is a difficult question. But we think that some important lessons can be learned from the results presented here, and, in particular, the results shed light on whether there is a reduction in the supply of bank loans. The results are consistent with the hypothesis that the supply of consumer and real estate loans decreases during a monetary tightening. To reconcile the observed increase of C&I loans with a credit crunch is more difficult. Bernanke and Gertler (1995) argue that the observed increase can still be consistent with a reduction in supply if the observed build up of inventories leads to an increase in the demand for C&I loans. This explanation, however, raises the following three questions. First, since rates on C&I loans do not increase by much more than the federal funds rate one would need that both the demand and the supply of C&I loans are elastic. Second, if the increase in the demand for C&I loans is due to the reduction in real activity (for example, to finance inventories) then one would have to provide a reason why C&I loans increase before real activity declines. The same timing issue arises if one wants to explain the increase in commercial paper by the reduction in real activity. Third, if firms increase the demand for C&I loans during a (temporary) monetary downturn, and reduce the demand in response to a persistent output shock then why do consumers not increase the demand for bank loans during a monetary downturn?

Another possibility is that firms borrow more to finance the increase in interest payments. This explanation would fit the timing of the response better. A drawback of this explanation is that one would only expect the demand for C&I loans to *increase* with the interest rate for firms that are financially constrained. But Gertler and Gilchrist (1993a) actually show that bank lending to small firms declines during a monetary tightening while it increases to large firms, and typically large firms are thought to be less likely to be constrained.

This raises the question as to whether one should seriously consider the possibility that the supply of C&I loans actually increases during a monetary tightening, a view that is enforced when one compares the positive response of C&I loans during a monetary downturn with the strong negative response during a non-monetary downturn. The reasons given in this section suggest that there may indeed be important reasons why banks may want to change the composition of their loan

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<sup>49</sup> And large firms who can issue commercial paper would benefit more than small firms.

portfolio during a monetary tightening, and if the substitution effects are strong enough the supply of C&I loans could actually increase.

## 6 Concluding Comments

Bernanke and Gertler (1995) point out that the most rapid and (in percentage terms, by far the strongest) effect of a monetary policy shock is on residential investment whereas business structure investment, also a long-lived investment, does not seem to be much affected. If portfolio considerations like the ones discussed in this paper are important then the strong reduction in the supply of consumer and real estate loans could explain the strong decline in residential investment and it also can explain why C&I loans increase.

An important lesson that can be learned from the results of this paper is that if banks amplify the economic downturn during a monetary tightening it is more likely to be through a reduction in the supply of consumer and real estate loans than through C&I loans. In contrast, the literature typically focuses on the role of firms,<sup>50</sup> although some authors have pointed out that a monetary tightening may be important for real estate and consumer bank loans. For example, Ludvigson (1998) shows that automobile loans issued by banks decrease more during a monetary downturn than other automobile loans. Also, the recent reduction in the federal funds rate mainly seemed to have stimulated consumption spending and residential investment, and not business investment.

Recently, several papers have argued that the risk-based bank capital requirements of the new Basel accord could increase the procyclicality of the minimum capital requirements and thus limit the role of the bank as intermediary during recessions.<sup>51</sup> Most of the literature doesn't distinguish between recessions following a monetary tightening—when interest rates are high—and other economic downturns—when interest rates are not high. This paper makes clear that the behavior of interest rates is key to understand what happens with bank equity. A related issue is that the Basel Committee has given a lot more attention to credit risk than interest rate risk and some authors argue that banks have substituted priced credit risk for unpriced interest rate risk to take advantage of the implicit subsidy for interest rate risk under the Basle Accord.<sup>52</sup> But this means of course that banks are sensitive to unexpected changes in interest rates and this paper demonstrates

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<sup>50</sup>See, for example, Fisher (1999), Gertler and Gilchrist (1993a,1994), Kashyap and Stein (1995), Kashyap, Stein, and Wilcox (1993), Repullo and Suarez (2000), and Warner and Georges (2001).

<sup>51</sup>See, for example, Catarineu-Raball, Jacson, Tsomocos (2003) and Kashyap and Stein (2003).

<sup>52</sup>See Allen, Jatinai, and Landskroner (1996).

how this sensitivity shows up in changes in the banks' loan portfolio.

This paper also raises several interesting questions that we leave for future research. An important empirical question is whether the reduction in real estate loans held by commercial banks mean that the overall amount of real estate loans decrease or whether other financial sectors increase their holdings of real estate loans. On the theoretical side it would be interesting to delve more deeply into the portfolio behavior of banks during a monetary tightening. Such theoretical work is especially important since financial markets and in particular hedging possibilities undergo important changes over time. Developments in financial institutions and available financial instruments are likely to affect how banks adjust their portfolio following a monetary tightening and, thus, how monetary policy affect the real economy.

## 7 Appendix

### 7.1 Data sources and definitions

In this section we give the data sources and provide more detailed information about the variables used. As discussed in section 2.1, we used three data sets in our analysis of the behavior of U.S. loans. The names we use for the data sets are related to the source for the loan variables but note that each data set also includes other variables.

#### 7.1.1 Monthly H8 data set

<b>Variable</b>	<b>Source</b>
Consumer price index (SA)	<a href="http://research.stlouisfed.org/">http://research.stlouisfed.org/</a>
Industrial production (SA)	<a href="http://www.federalreserve.gov/">http://www.federalreserve.gov/</a>
Federal funds rate	<a href="http://www.federalreserve.gov/">http://www.federalreserve.gov/</a>
C&I loans (SA)	<a href="http://www.federalreserve.gov/">http://www.federalreserve.gov/</a>
Real estate loans (SA)	<a href="http://www.federalreserve.gov/">http://www.federalreserve.gov/</a>
Consumer loans (SA)	<a href="http://www.federalreserve.gov/">http://www.federalreserve.gov/</a>

All series start in January 1960 and end in February 2003. We use the bank universe that includes all commercial banks. Total loans is always defined as the sum of the three loan components we are interested in, which are C&I, real estate, and consumer loans.<sup>53</sup> These three loan components don't cover all bank loans but most of them. In particular, their sum roughly equals 85% of all bank loans.

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<sup>53</sup>The main reason is that in related work we are especially interested in empirical analysis that uses aggregate variables.

Not surprisingly, the sum of the three components and all bank loans are highly correlated.<sup>54</sup> Results that use the actual total loan series are very similar.

### 7.1.2 Quarterly Call data set

Bank balance-sheet data are available at <http://faculty.london.edu/wdenhaan> and a description on how they are constructed can be found in Den Haan, Sumner, and Yamashiro (2002). In this paper we use the index series that correct for mergers. The universe of commercial banks for the Call Reports is almost identical to the one used to construct the H8 series for domestically-chartered banks.<sup>55</sup> Besides domestically-chartered banks the H8 series for all commercial banks includes: branches and agencies of foreign banks, state-licensed agencies acting as a bank, Edge-Act corporations, New York investment companies, and the American Express International Banking Corporation.<sup>56</sup> Savings and loan banks are not included in any of the data sets. The Call Reports allow us to include savings and loan banks but in the beginning of the sample they report infrequently. See Den Haan, Sumner, and Yamashiro (2002) for a further discussion.

Quarterly observations for the CPI and federal funds rate are constructed by taking an average of the monthly observations. The income variable used is personal income (by place of work) from the Bureau of Economic Analysis. It was downloaded from <http://www.bea.doc.gov/>. In related work we examine the effect of regional responses to monetary policy shocks and the advantage of this real activity measure is that it is available at the regional level. The results are very similar, however, if we use GDP and its deflator, which we document for some key results in the next section of this appendix.

### 7.1.3 Quarterly H8 data set

The quarterly observations for the H8 bank loan series are constructed by taking an average of the monthly observations. Since we compare this data set with the quarterly Call data set, it starts in the first quarter of 1977 and ends in the last

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<sup>54</sup>The correlation between the log change of the sum of the three loan components and the log change of all bank loans is equal to 0.84.

<sup>55</sup>The difference is that the H8 universe also includes non-deposit trust companies (rssi9048=250). We did not include them because these institutions report irregularly in the beginning of the Call report sample and the size of their loan portfolio is very small relative to the total loan portfolio of commercial banks.

<sup>56</sup>This information was provided to us by William Watkins of the Board of Governors of the Federal Reserve System.

quarter of 2000. The other series are identical to those of the Quarterly Call data set.

#### 7.1.4 Additional data

We used the variable FL103169700.Q from the flow of funds data set for our commercial paper series. The delinquency and charge-off rates are on loans and leases at commercial banks. The rate on C&I loans is a weighted average effective loan rate on all C&I Loans made by domestic commercial banks. The mortgage rate is the contract rate on 30-year, fixed-rate conventional home mortgages. The commercial-paper rate is the rate on three-month commercial paper. Starting September 1997, the rate on commercial paper is reported separately for financial and non-financial firms. The two series are virtually identical, however. We use the rate for non-financial firms. Both the credit card rate and the rate on 24 month personal loans are on loans by commercial banks. All these series were downloaded from <http://www.federalreserve.gov>.

From <http://research.stlouisfed.org/fred2/> we downloaded GDP and real GDP (chained 2000\$). The bank equity data used are described in Den Haan, Sumner, Yamashiro (2002). It consists of the sum of common equity and its surplus, undivided profits, and capital reserves less the net unrealized loss on marketable equity securities.<sup>57</sup>

## 7.2 Robustness

In this appendix we report the results to support the claims made about the robustness of the results. The first subsection discusses the (lack of) robustness of the results for the VARs that include total loans as the only loan variable. The second subsection documents that the results for VARs, which include the three loan components, when BIC is used to choose the specification of the VAR are very similar to the results for our benchmark specification. It is also shown that the results are robust when we use GDP and its deflator and use domestically-chartered domestic banks instead of all banks for the H8 series.

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<sup>57</sup>There are two reasons to include loan reserves. First, without it there is a dramatic drop in bank equity in the second quarter of 1987 when banks responded to Brazil's announcement that it would cease paying on its debts by allocating large amounts to their loan reserves. Second, loan loss reserves are included in the measure of Tier 2 regulatory capital, which is used in calculating a bank's required capital adequacy ratio.

### 7.2.1 VAR with total loans

In Section 3 we mentioned that the sign of the impulse response function for total loans based on the VAR with total loans and the data sets that started in 1977 is not robust to changes in the specification of the VAR. In our benchmark specification that uses one year of lags and a linear trend we found the response of total loans to be positive. We now look at what happens to the results if we use two lags instead of four to estimate impulse response functions for the quarterly-Call data set.<sup>58</sup> If we use two lags instead of four then the impulse response functions for the interest rate, prices, and output are very similar and are not reported. Some of the results for total loans are different, however. Figure A.1 plots the impulse response functions for total loans during a monetary and a non-monetary downturn. The graph shows that the impulse response function for total loans during a non-monetary downturn is similar to the one based on a VAR with one year worth of lags. But the impulse response function for total loans during a monetary downturn is now not only negative, it is also below the impulse response function for the non-monetary downturn. Of course one shouldn't exaggerate this non-robustness result because for both VAR specifications the results are not significantly different from zero.

### 7.2.2 VAR with loan components

In this section we check whether the results are robust if we use alternative variables and different VAR specifications.

**GDP and its deflator** To be consistent with our work on the regional effects of monetary policy shocks, we used the personal income series available from the BEA and the consumer price index. The results are very similar, however, when GDP and its deflator are used with a couple of minor exceptions. For example, if we use GDP and its deflator with the quarterly-Call data set then we find that in response to a negative monetary policy shock the initial positive response of GDP is larger. Moreover, the response is positive for two quarters, while using the BEA measure the response is positive for only one quarter. This more positive response of output makes the initial response of C&I loans during a non-monetary downturn somewhat more positive too.<sup>59</sup> In Figure A.2 we document the similarity for differential responses of the loan components.

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<sup>58</sup>Similar results were found for the quarterly-H8 data set.

<sup>59</sup>The reason is that when we use GDP we also find that C&I loans follow the real activity measure in response to an output shock.

**Domestically-chartered commercial banks** In Figure A.3 we compare the responses to C&I loans using quarterly-Call (same as in panel A of Figure 4.4) and the H8 data for domestically chartered series. The figure shows that the results are fairly similar so that a big part of the difference between the Call and the H8 data is due to the fact that H8 also includes branches of international banks.

**Using BIC to choose the VAR specification** The benchmark specification includes one year of lags, a constant, a linear trend, and in the case of the Call data, quarterly dummies. We tried several other specifications and found that—in contrast to the results for total loans—the results for loan components are robust to changes in the specification of the VAR, even for the shorter data sets that start in 1977. Here we report the results based on a VAR specification that is selected by BIC. We choose the model with the lowest value for BIC in a class of models that allows for a linear trend, a quadratic trend, and up to one year worth of lags.<sup>60</sup> For the Call data we also allow for quarterly dummies. The chosen specifications are reported in Table A.1. Since BIC imposes quite a strong penalty for additional parameters it chooses a specification that is much more concise than our VAR specification.

To save space we only report the results for the loan variables. In particular, Figures A.4, A.5, and A.6 plot the impulse response functions for the loan components for a monetary and a non-monetary downturn. We see that the results are very similar to those reported in Section 4. That is, the response for C&I loans during a monetary downturn is above the response during a non-monetary downturn, and for the data sets that start in 1977 the response during a monetary downturn is clearly positive.<sup>61</sup> For real estate loans and consumer loans the response during a monetary downturn is negative and below the response during a non-monetary downturn. One difference with the results reported in the text is that the impulse response for real estate loans for a monetary downturn for the quarterly-Call data has no significant coefficients.

## References

- [1] Allen, Linda, Julapa Jatiani, Yoram Landskroner, 1996, Interest Rate Risk Subsidization in International Capital Standards, *Journal of Economics and*

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<sup>60</sup>For the monthly data we set the minimum number of lags equal to three months and for the quarterly data sets we set the minimum number of lags equal to two quarters.

<sup>61</sup>One exception is that for the sample from 1960 to 2003 C&I loans actually do decrease substantially following a monetary tightening. When we add more lags of the interest rate and output to the equation for C&I loans, however, then the results are again very similar to those reported in the main text.



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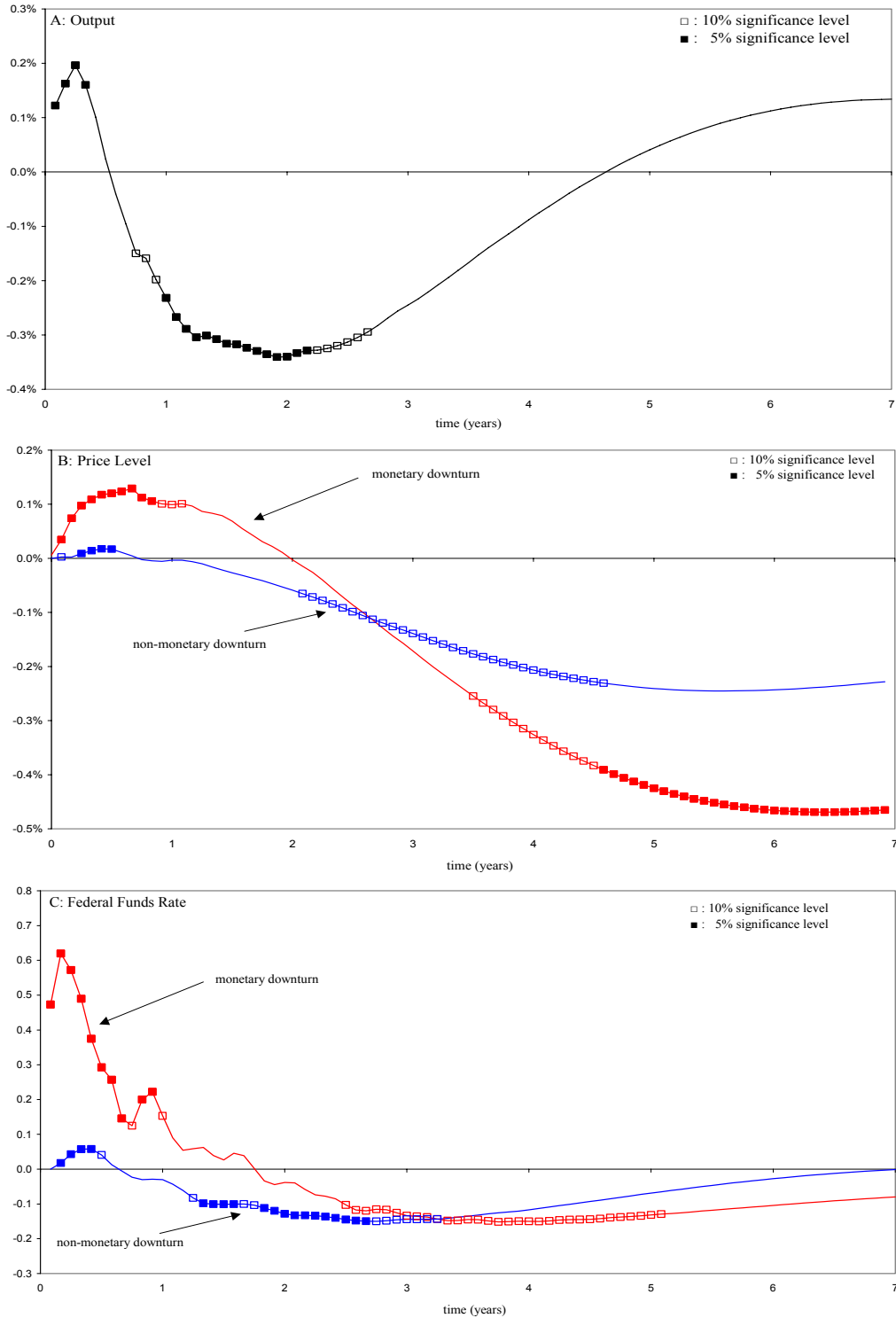
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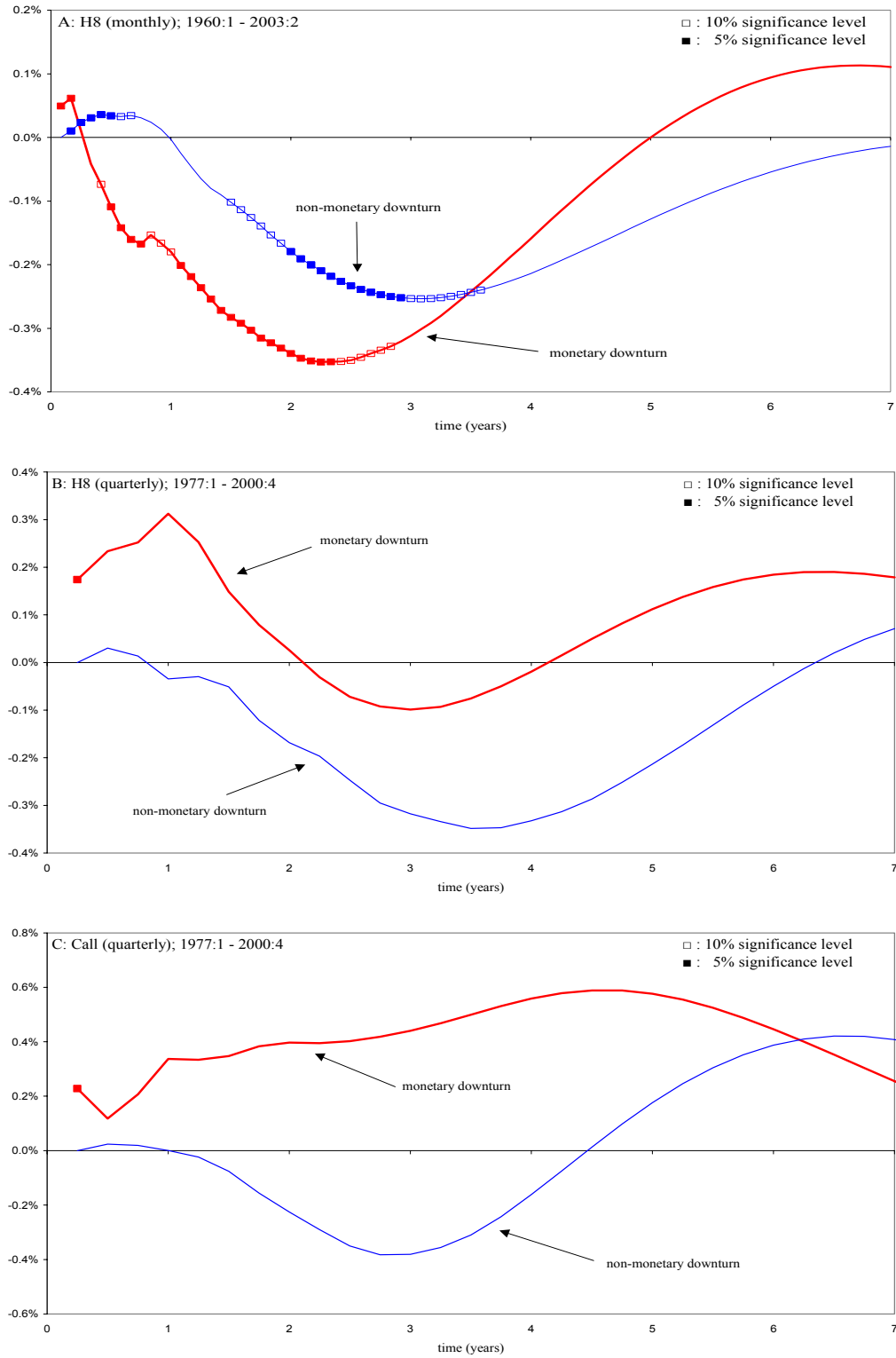
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Figure 3.1: Impulse responses for VAR with no disaggregation into loan components (monthly H8; 1960:1 – 2003:2)



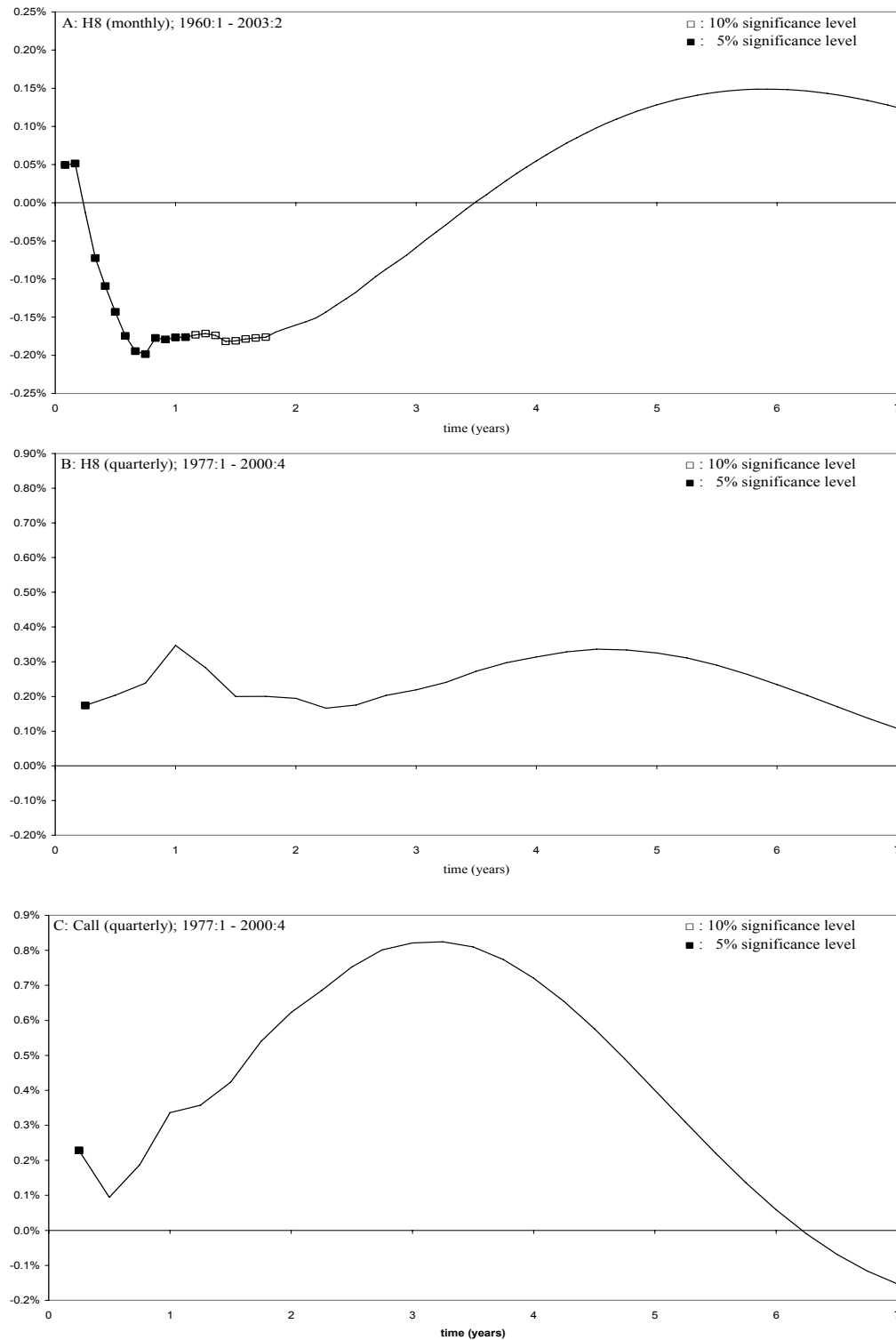
Note: These graphs plot the response of the indicated variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. In Panels B and C the curve labelled “non-monetary downturn” plots the time path of the price level and the federal funds rate respectively, following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn plotted in panel A. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure 3.2: Total loans impulses for VAR with no disaggregation into loan components



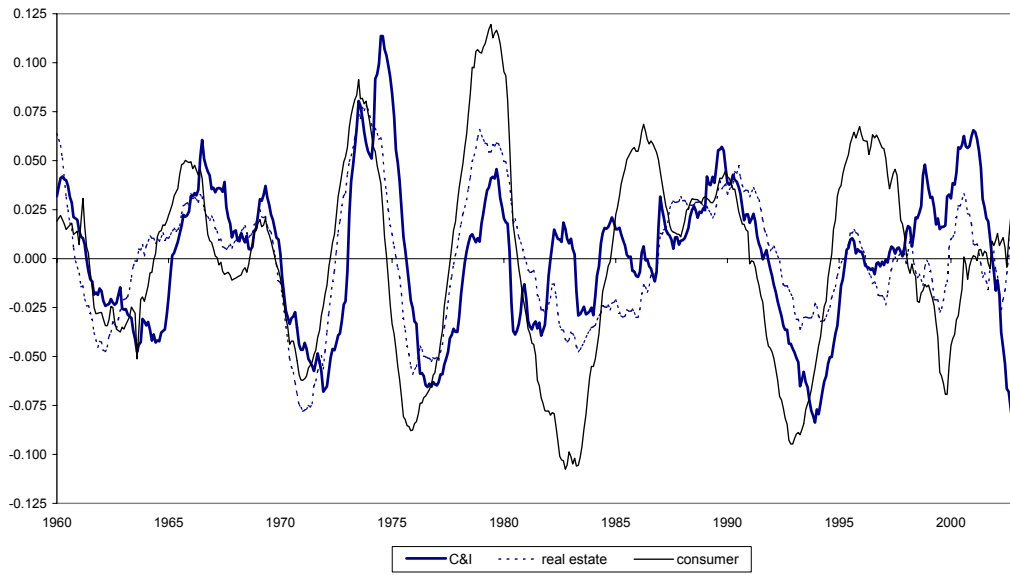
Note: These graphs plot the response of total loans to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn and the response to a sequence of output shocks that generates the same movements in output, i.e. a non-monetary downturn, for the indicated data set. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure 3.3: Total loans during monetary downturn relative to non-monetary downturn (no disaggregation into loan components)**



Note: These graphs plot the difference between the response of total bank loans during a monetary downturn and a non-monetary downturn of equal magnitude for the indicated data set. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

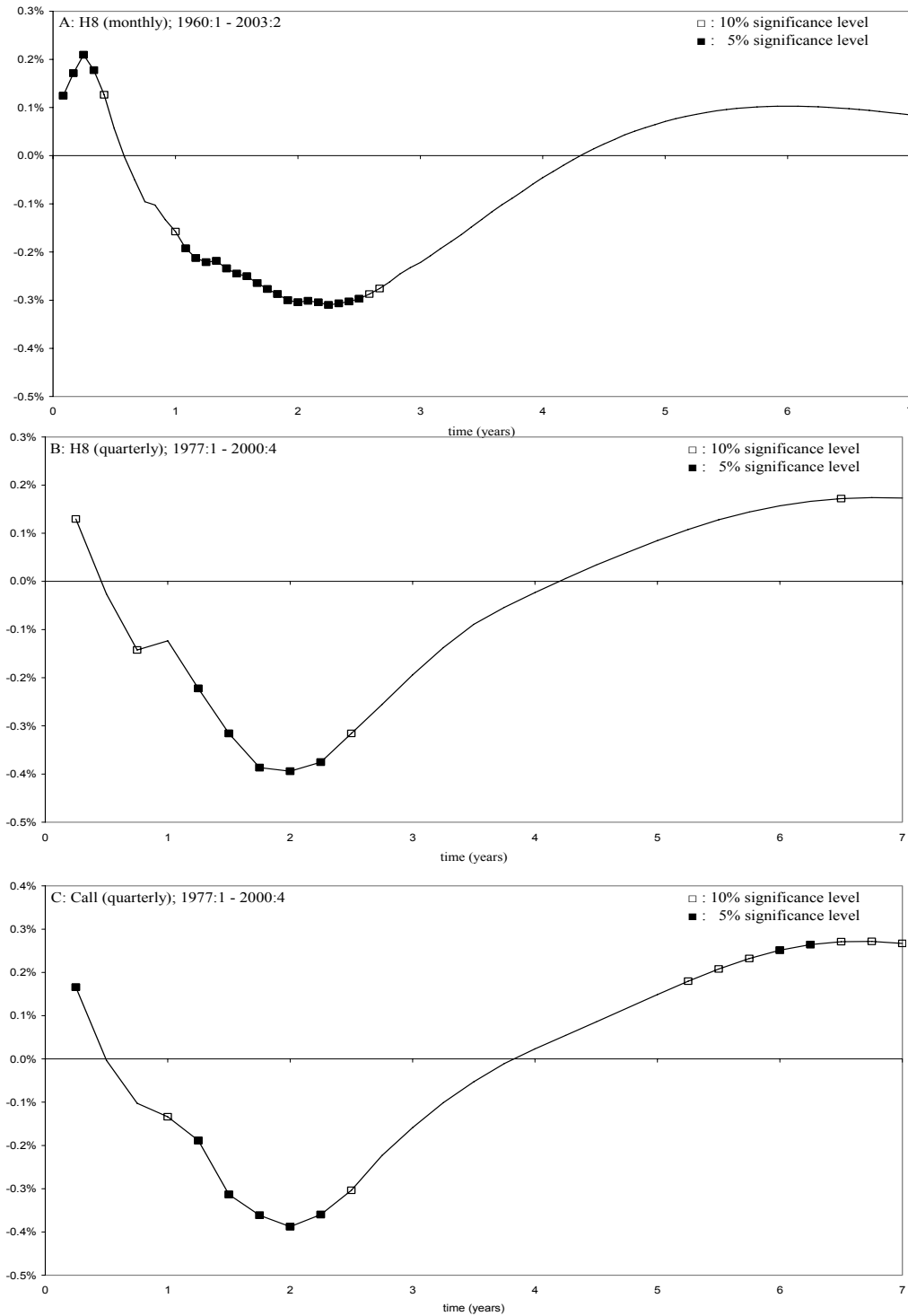
Figure 4.1: Detrended loan components



Note: This graph plots the loan components after a trend has been taken out using the HP filter.

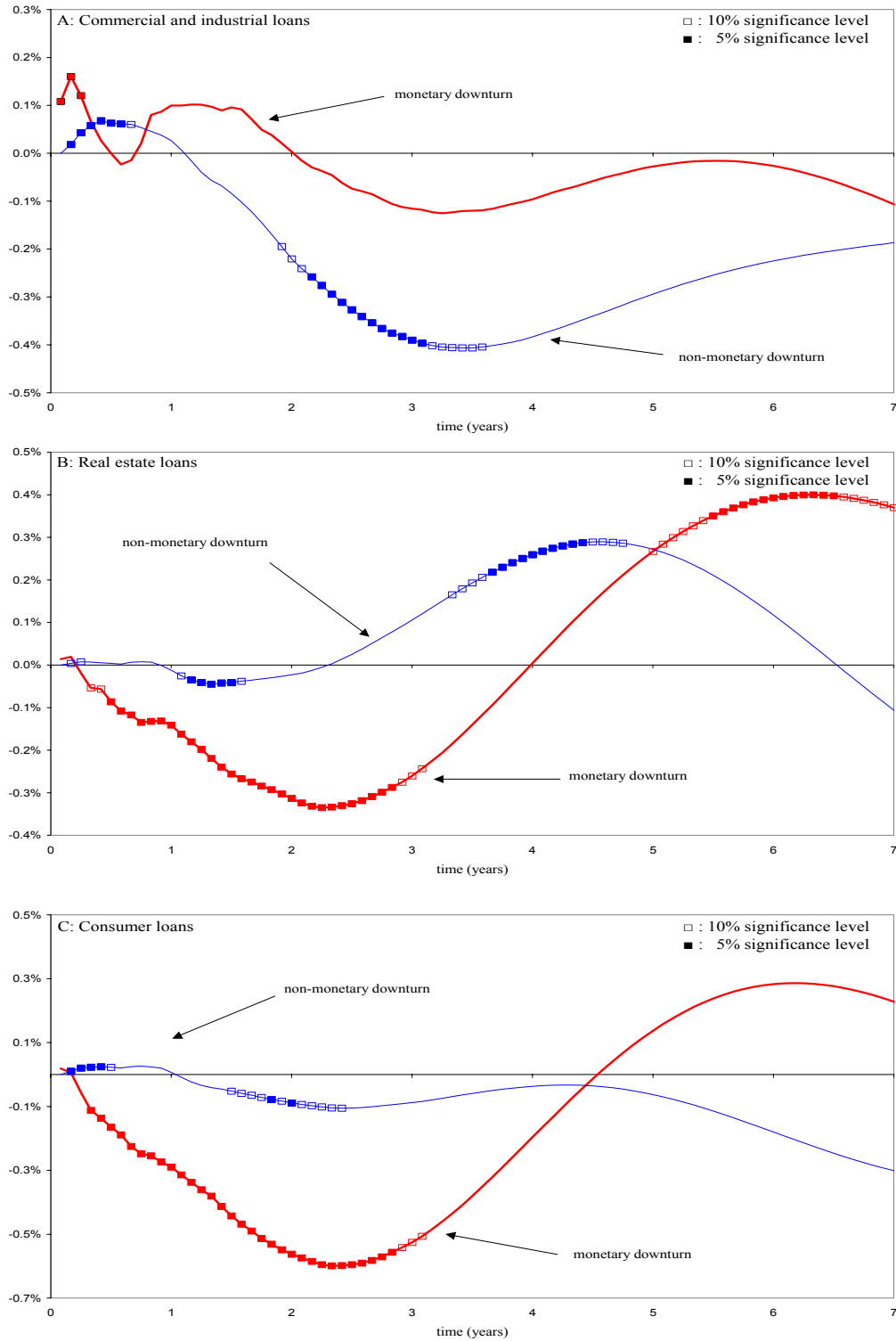


Figure 4.2: Output responses for VAR with disaggregation into loan components



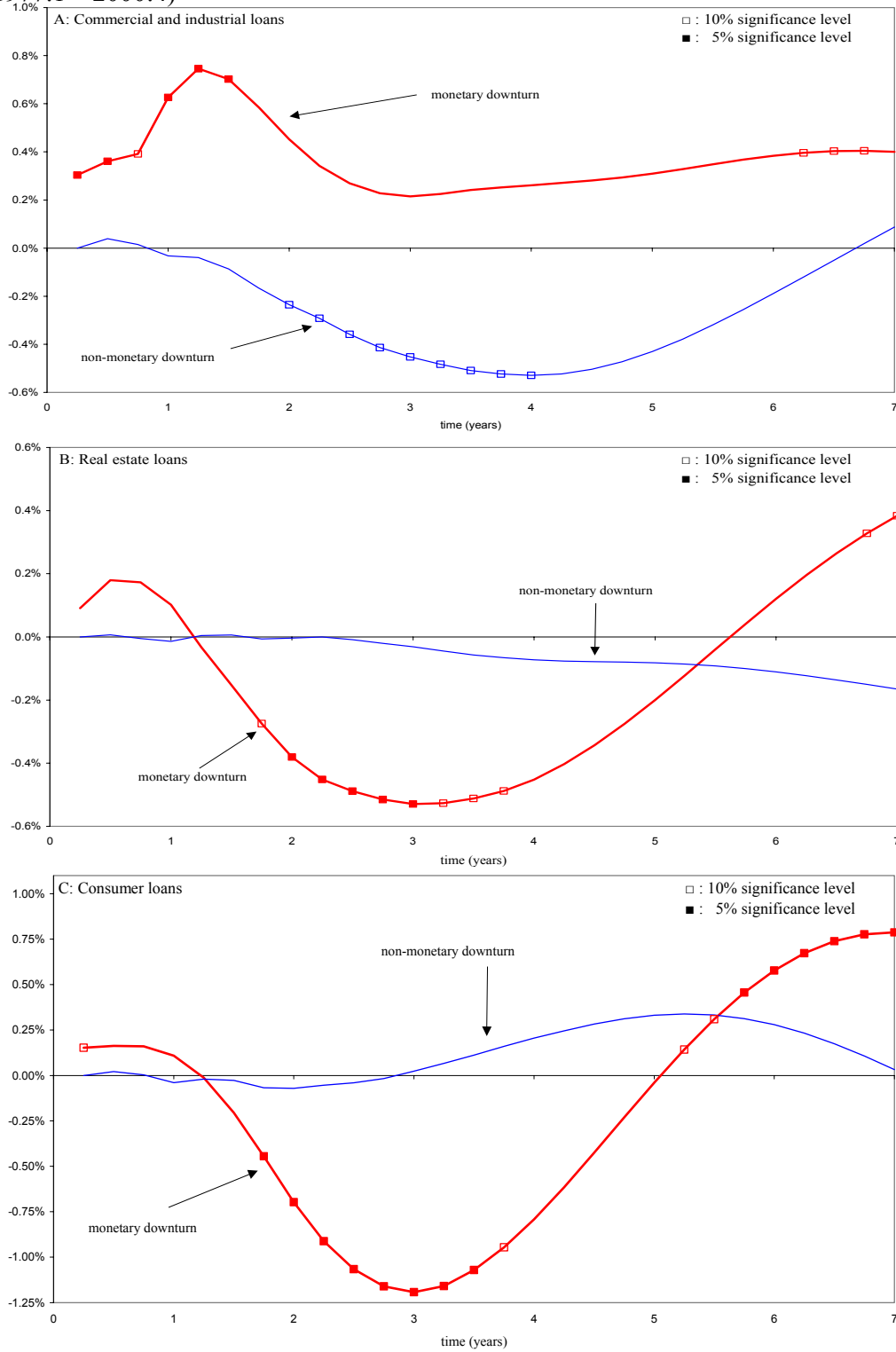
Note: These graphs plot the response of output to a one-standard deviation shock to the federal funds rate. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure 4.3: Loan impulse responses for VAR with loan components; Monthly H8 (January 1960 – February 2003)



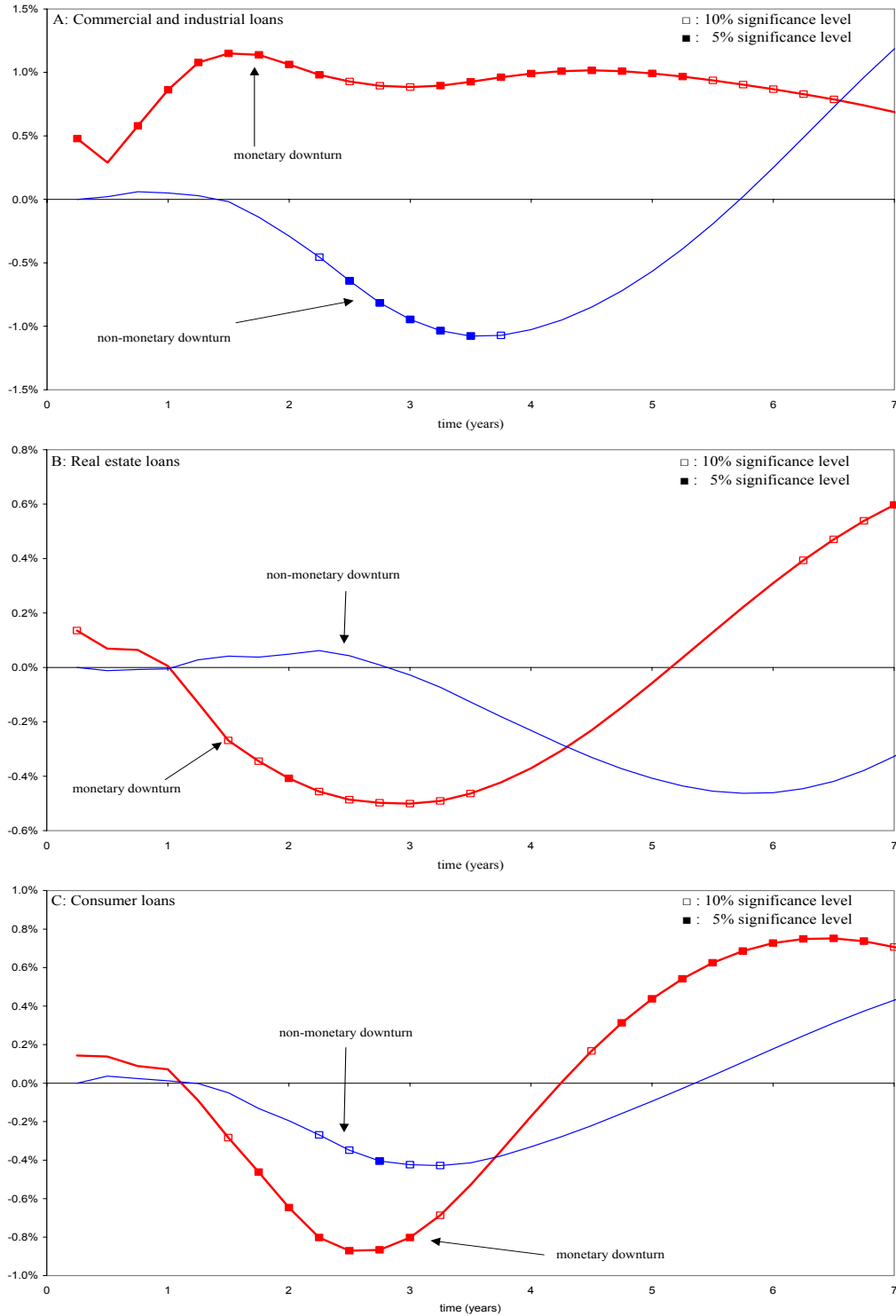
Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled “non-monetary downturn” plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure 4.4: Loan impulse responses for VAR with loan components; Quarterly H8 (1977:1 – 2000:4)



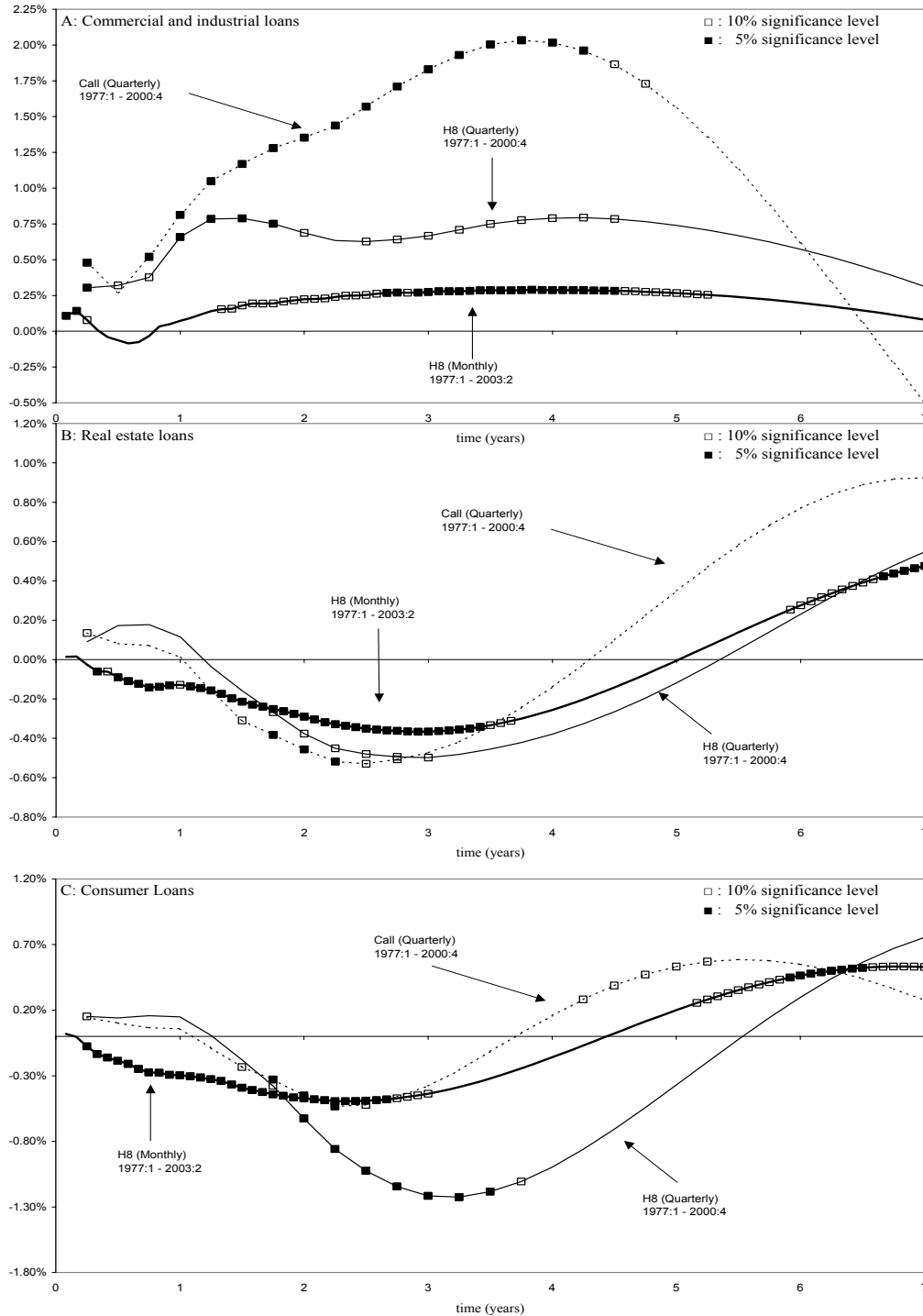
Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled “non-monetary downturn” plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure 4.5: Loan impulse responses for VAR with loan components; Quarterly CALL (1977:1 – 2000:4)**



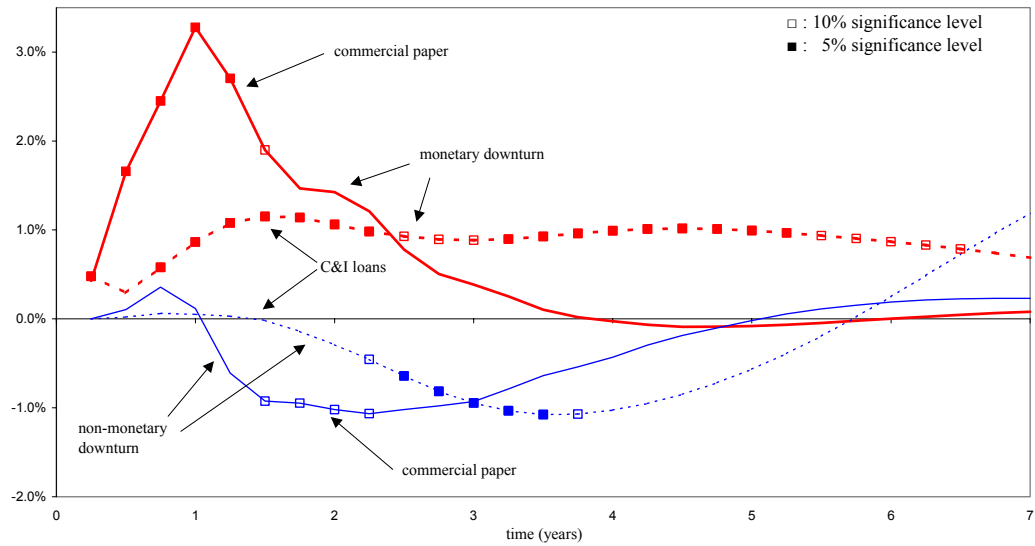
Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled "non-monetary downturn" plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure 4.6: Loans during monetary downturn relative to non-monetary downturn



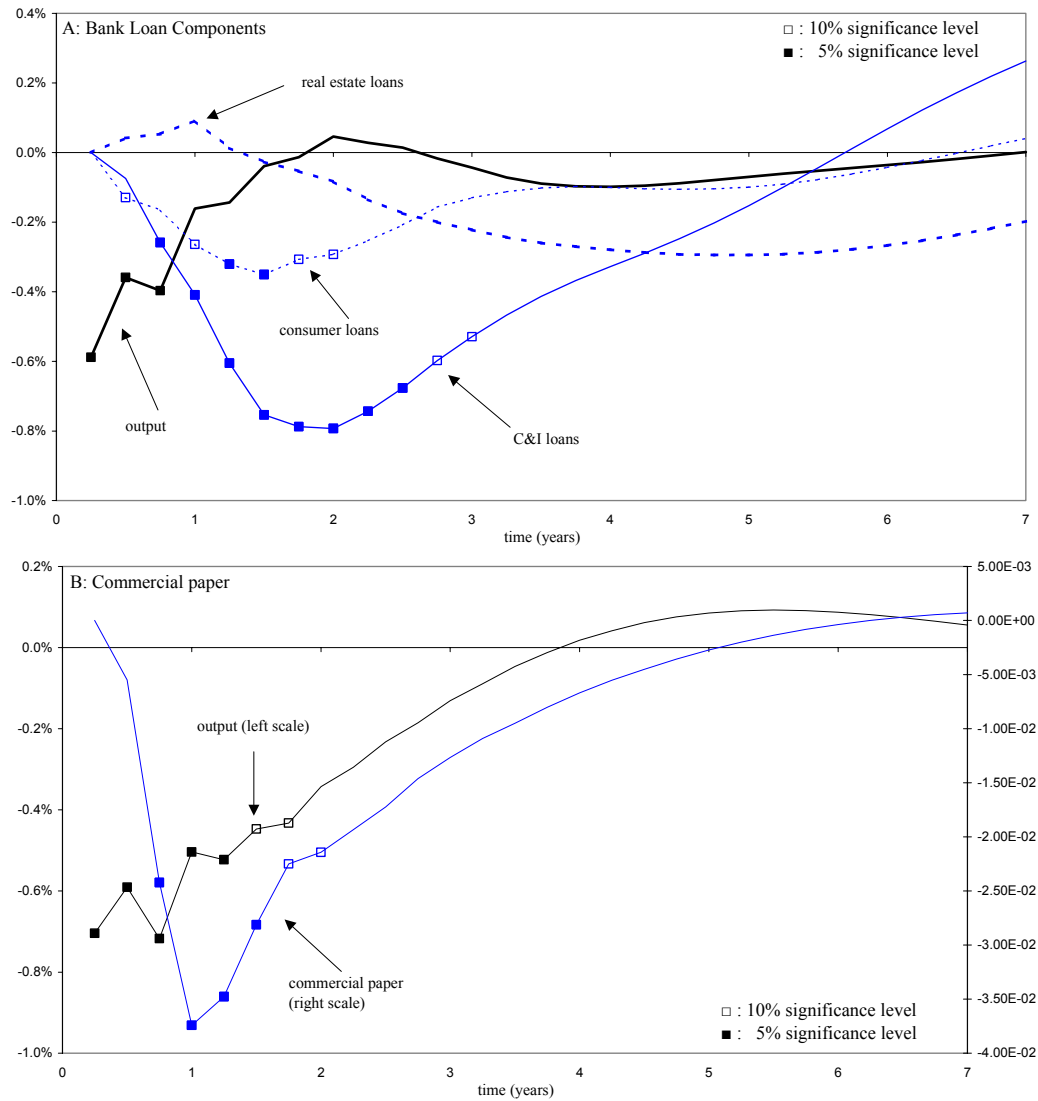
Note: These graphs plot the difference between the response of the indicated loan component during a monetary downturn and a non-monetary downturn of equal magnitude for the indicated variable and data set. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure 4.7: Commercial paper and C&I loan impulse responses (1977:1 – 2000:4)**



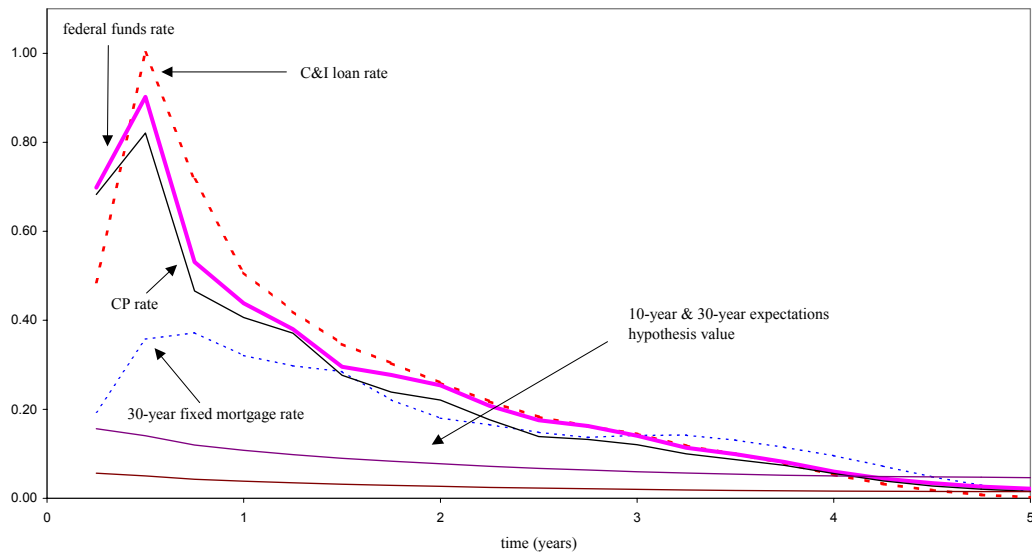
Note: This graph plots the response of the indicated variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled “non-monetary downturn” plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn. The results are based on the benchmark specification and the quarterly-CALL data set. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure 4.8: Responses to an output shock**  
(1977:1 – 2000:4)



Note: These graphs plot the response of the indicated variable to a single, one-standard deviation output shock. The results are based on the benchmark specification and the quarterly-CALL data set. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

## 5.1: Responses of interest rates to a monetary policy shock

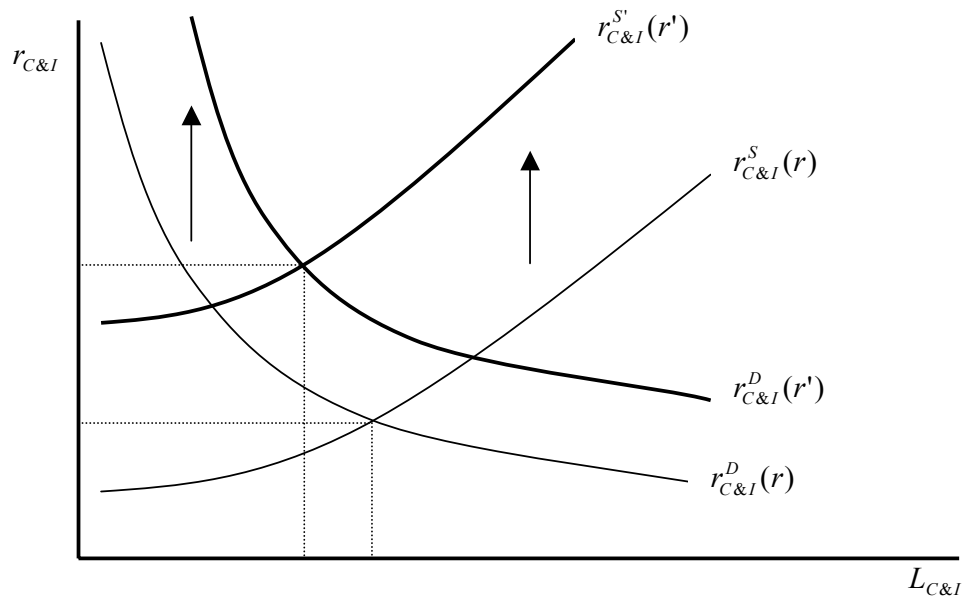


Note: This graph plots the response of the indicated variable to a one-standard deviation innovation to the federal funds rate. The response to the federal funds rate is used to calculate the expectations-hypothesis value. The variables included in the VAR are the federal funds rate, the rate on C&I loans, the rate on 30-year fixed-rate mortgages, the rate on commercial paper, real income, and the CPI. The data is estimated over the period from 1977 to 2000.



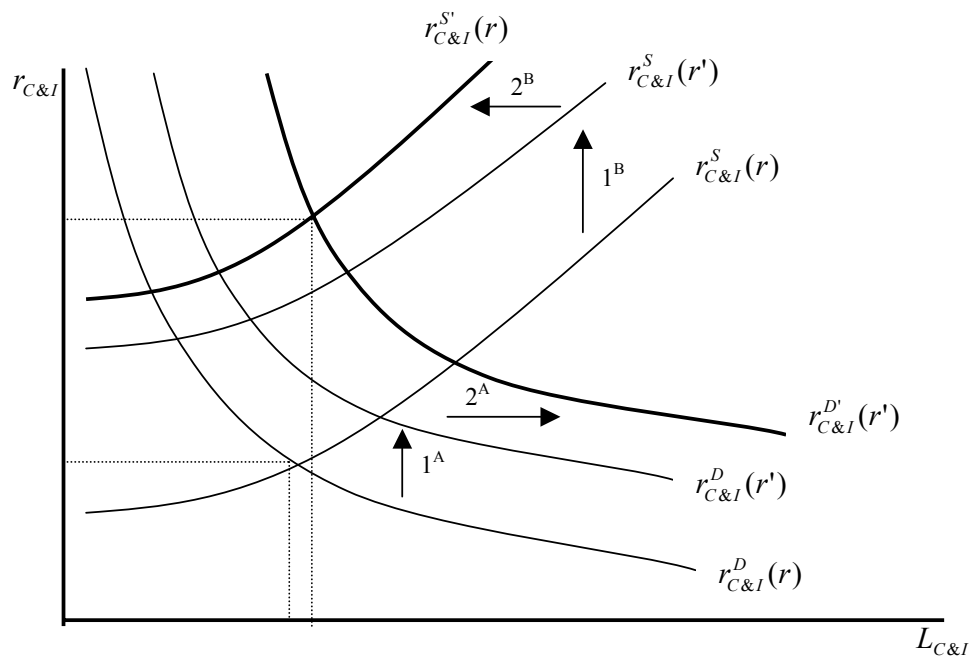
Figure 5.2: Effect of monetary tightening on bank-loan rates

Panel A: Interest rate channel;  $r' > r$



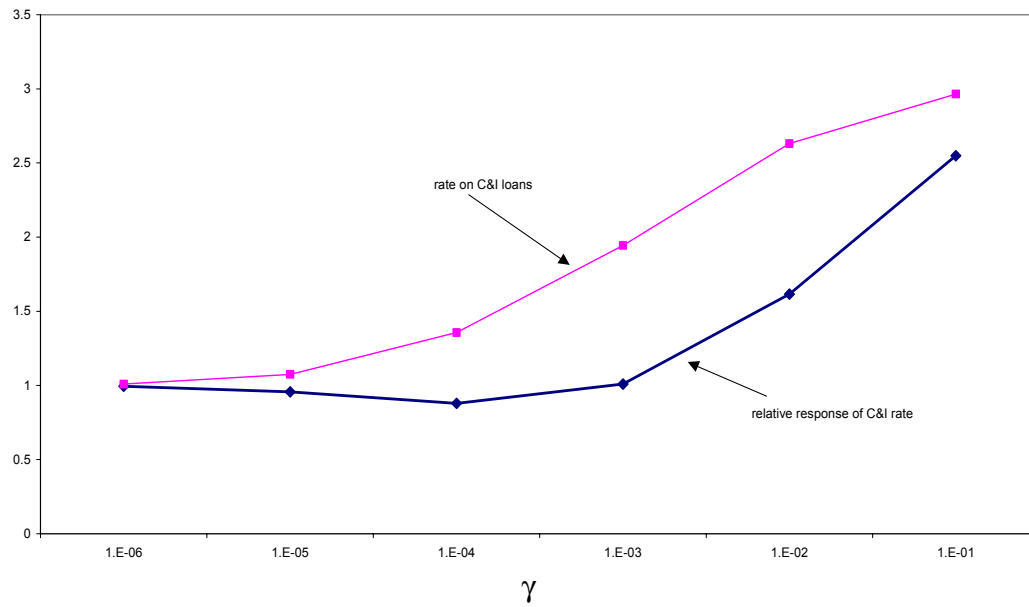
Note: The shift of  $r_{C&I}^D(r)$  to  $r_{C&I}^{D'}(r')$  and the shift of  $r_{C&I}^S(r)$  to  $r_{C&I}^{S'}(r')$  represent the standard interest-rate channel.

Panel B: Bank-lending channel and perverse loan effect;  $r' > r$



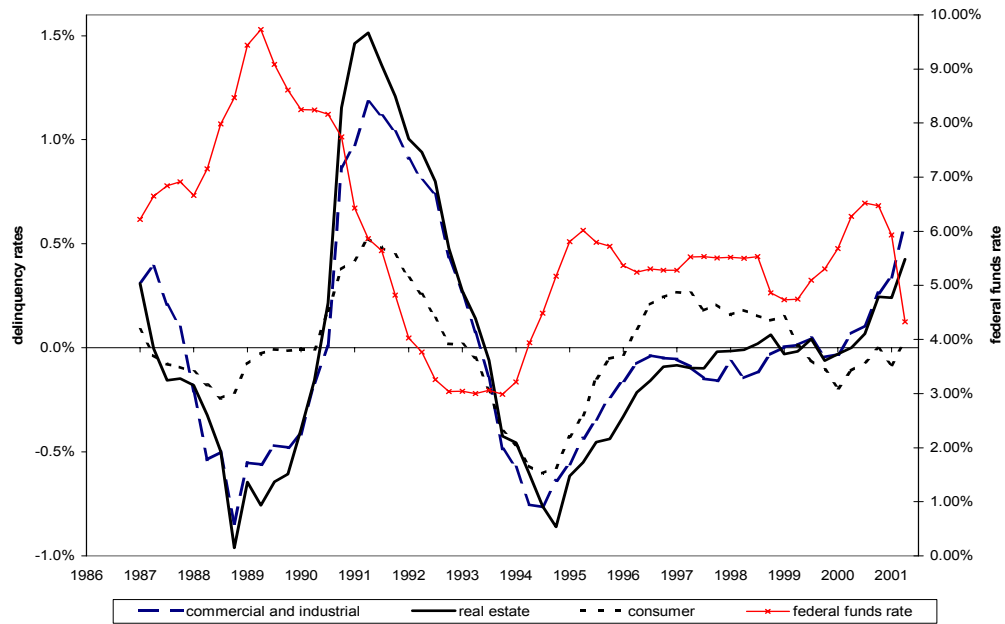
Note: The shift of  $r_{C&I}^D(r)$  to  $r_{C&I}^{D'}(r')$ , labelled  $1^A$ , and the shift of  $r_{C&I}^S(r)$  to  $r_{C&I}^{S'}(r')$ , labelled  $1^B$ , represent the standard interest-rate channel. The shift from  $r_{C&I}^{D'}(r')$  to  $r_{C&I}^{D''}(r')$ , labelled  $2^A$ , represent the autonomous increase in demand. The shift from  $r_{C&I}^{S'}(r')$  to  $r_{C&I}^{S''}(r')$ , labelled  $2^B$ , represent the decrease in supply according to the bank-lending channel.

Figure 5.3: Response of rate on bank loans;  $\Delta r_{C\&I} / \Delta r$



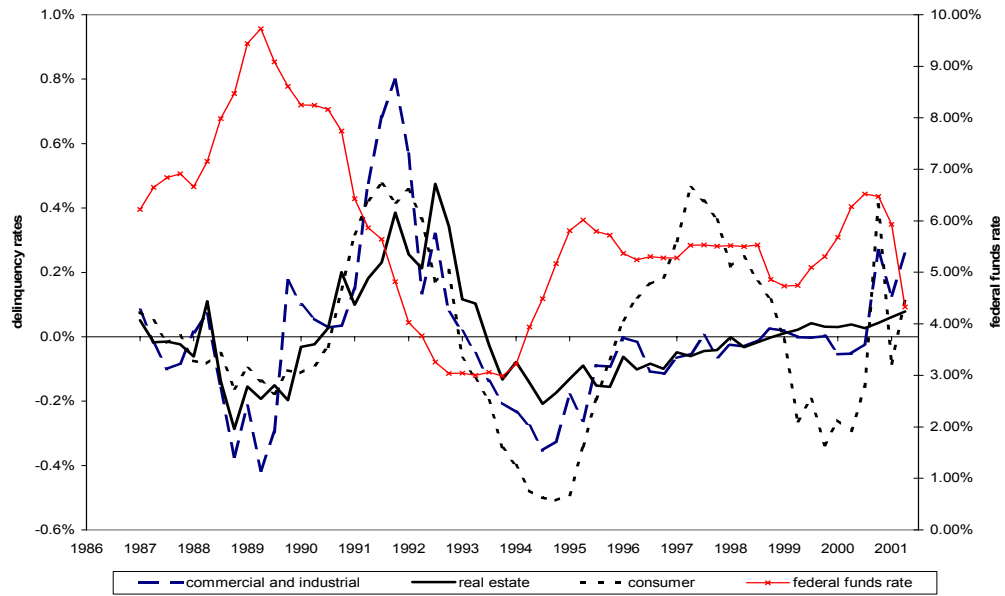
Note: This graph plots the increase in  $r_{C\&I}$  when the interest rate  $r$  increases from 1% to 2% (divided by the increase in the interest rate) and the value of  $r_{C\&I}$  when the interest rate is equal to 1%. The value of  $\alpha$  is equal to 0.33.

Figure 5.4: Delinquency rates



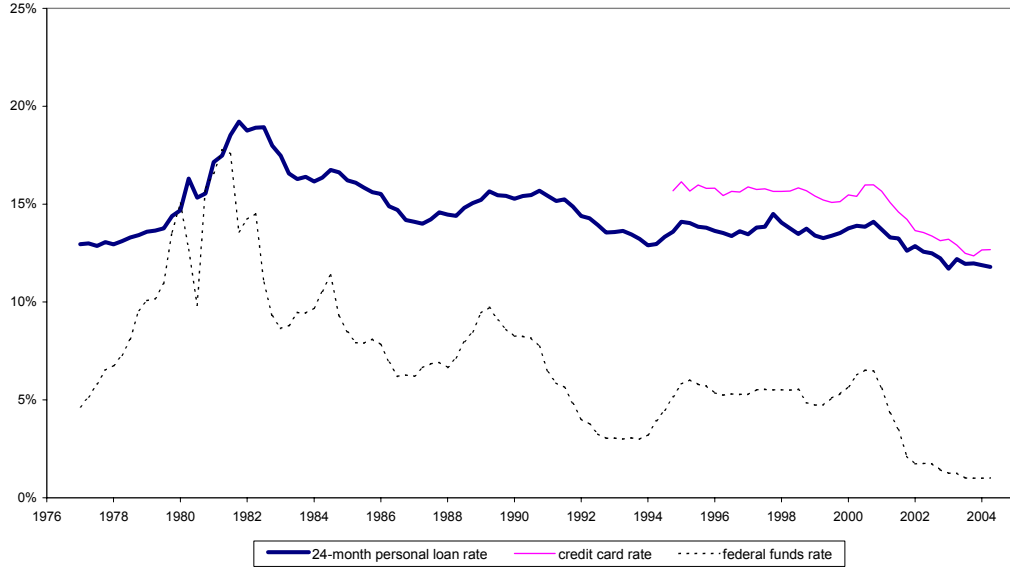
Note: This graph plots the federal funds rate and the HP-filtered delinquency rates for aggregate commercial and industrial loans, real estate loans and consumer loans for the period 1987:1-2001:2.

Figure 5.5: Charge-off rates

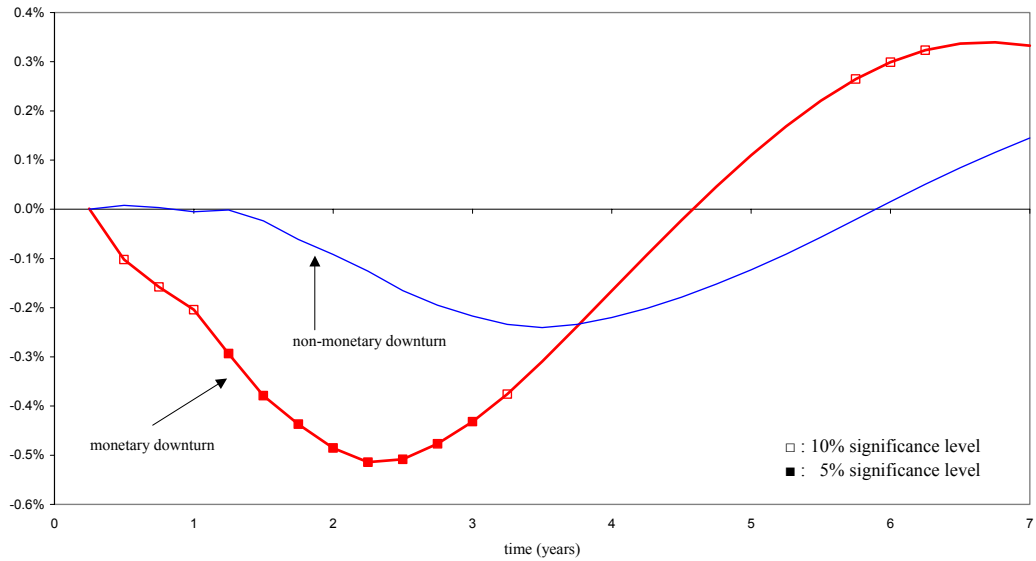


Note: This graph plots the federal funds rate and the HP-filtered charge-off rates for aggregate commercial and industrial loans, real estate loans and consumer loans for the period 1987:1-2001:2.

**Figure 5.6: Rates on consumer loans**

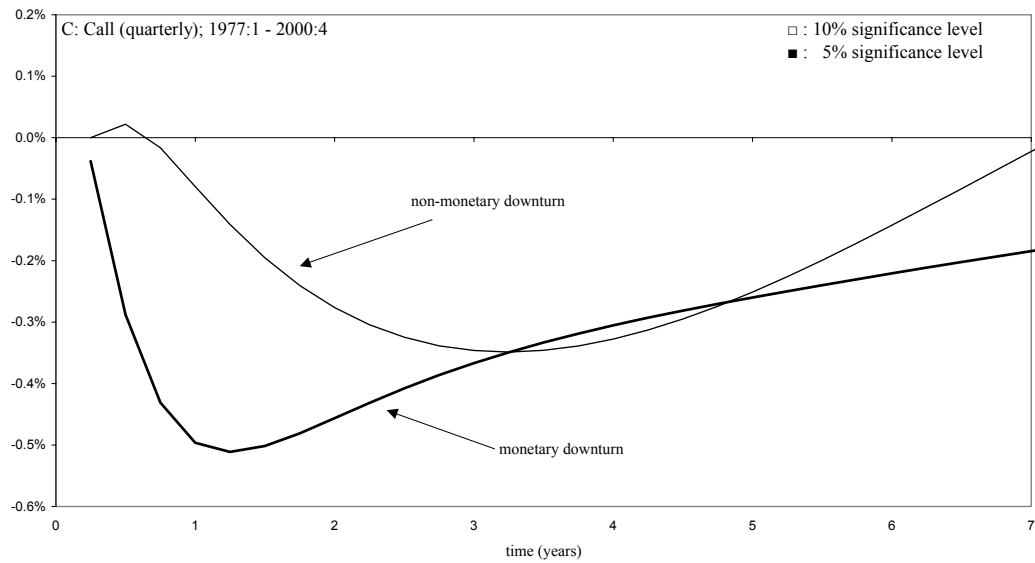


**Figure 5.7: Response of bank equity (1977:1 – 2000:4)**



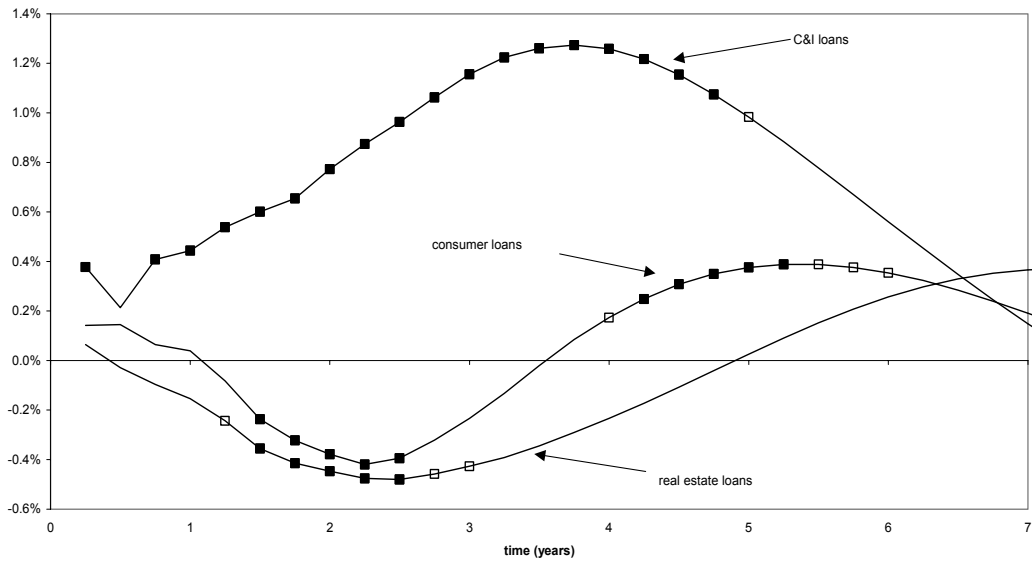
Note: This graph plots the response of bank equity to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled “non-monetary downturn” plot the time path of bank equity following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn. The results are based on the benchmark specification and the quarterly-CALL data set. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure A.1: Total loans impulses for VAR with no disaggregation into loan components  
 (VAR with two quarters worth of lags, constant, linear trend, and seasonal dummies)



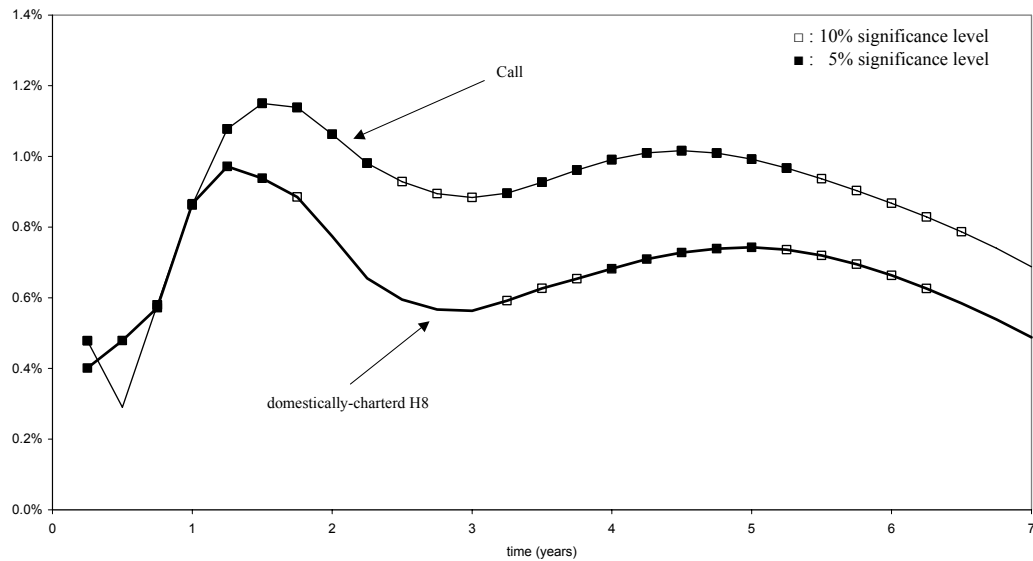
Note: These graphs plot the response of total loans to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn and the response to a sequence of output shocks that generates the same movements in output, i.e. a non-monetary downturn, for the indicated data set. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure A.2: Loan impulse responses for VAR with loan components; Quarterly Call (1977:1 – 2000:4; GDP and its deflator)**



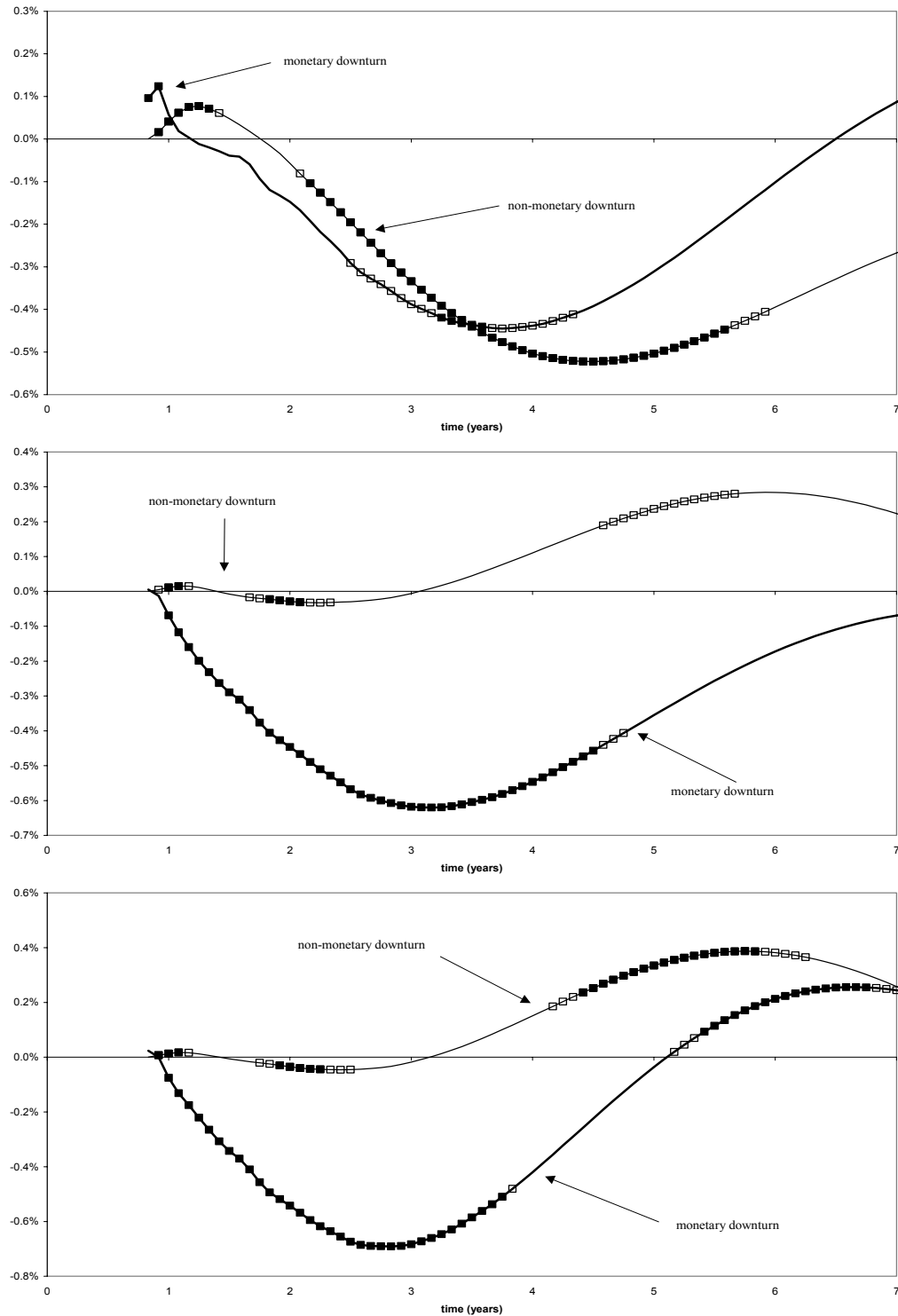
Note: This graph plots the difference between the response of total monetary loans during a monetary downturn and a non-monetary downturn of equal magnitude for the indicated loan component. The results are based on the benchmark specification. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

**Figure A.3: C&I loan impulse responses; CALL & H8 (1977:1 – 2003:2)**



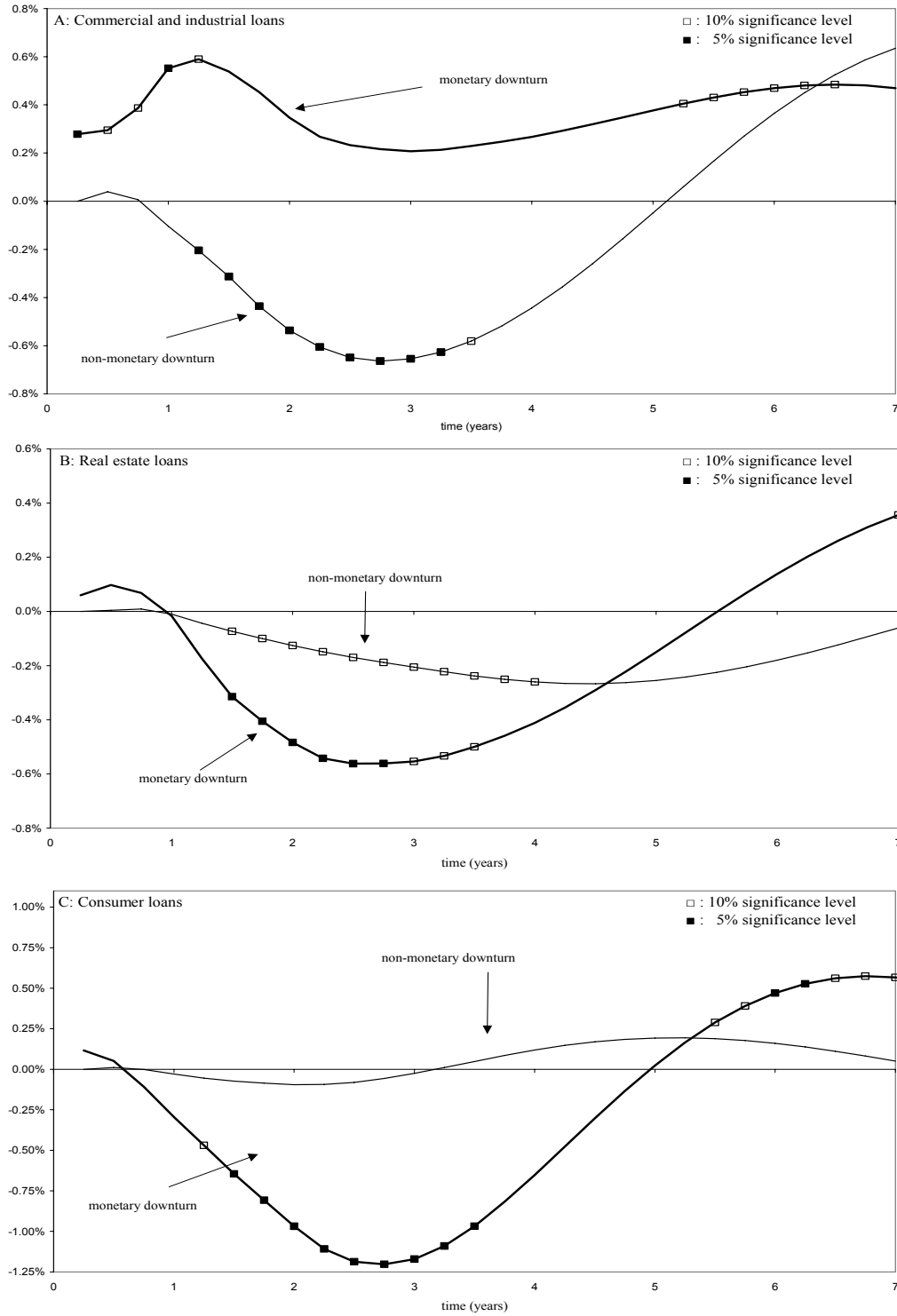
Note: This graph plots the response of C&I loans using the quarterly-Call and the domestically-chartered series from the H8. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Figure A.4: Loan impulse responses for VAR with loan components; Monthly H8 (January 1960 – February 2003; VAR specification based on BIC)



Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled "non-monetary downturn" plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn plotted in panel A. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

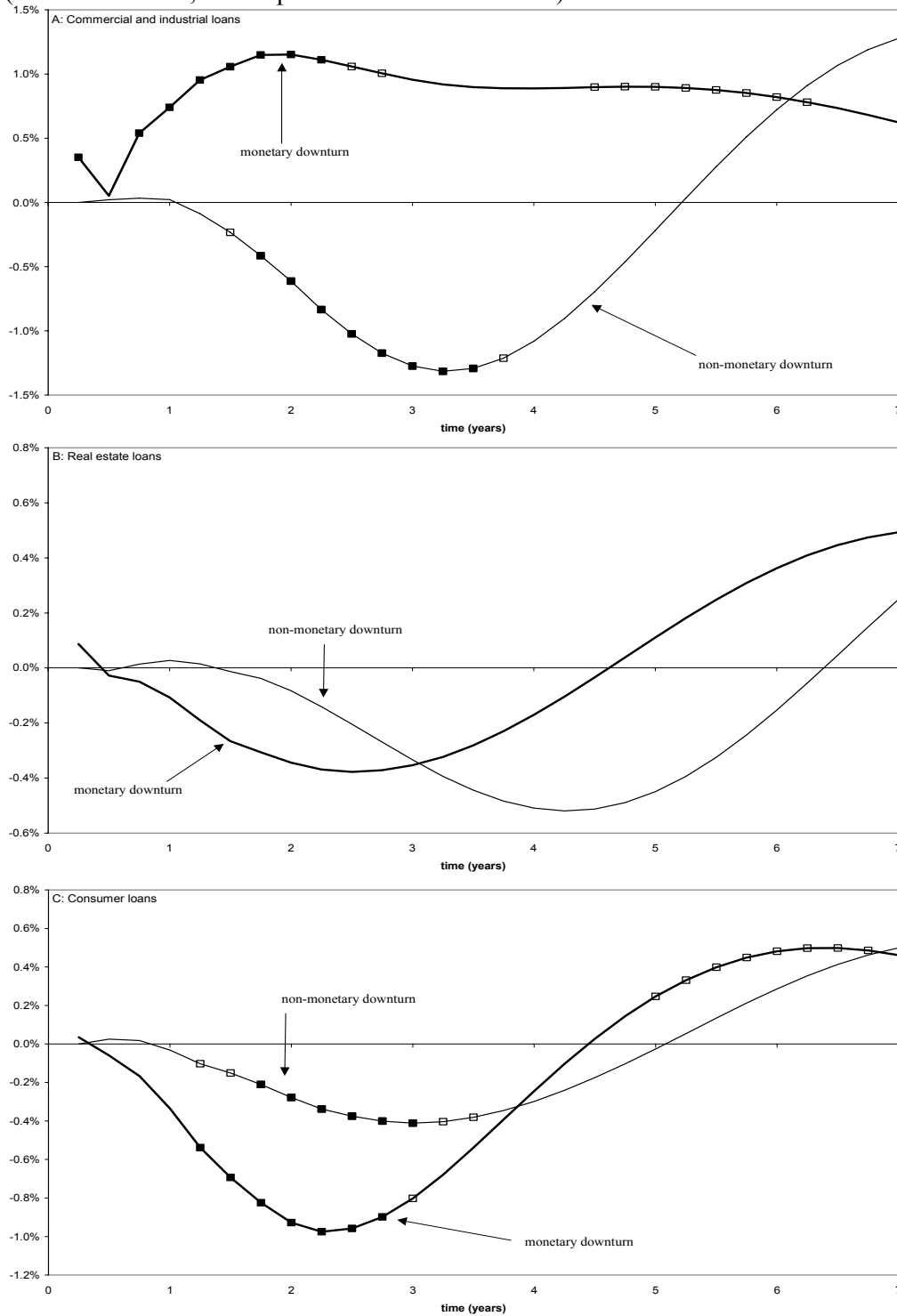
Figure A.5: Loan impulse responses for VAR with loan components; Quarterly H8 (1977:1 – 2003:2; VAR specification based on BIC)



Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled "non-monetary downturn" plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn plotted in panel A. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).



Figure A.6: Loan impulse responses for VAR with loan components; Quarterly CALL (1977:1 – 2003:2; VAR specification based on BIC)



Note: These graphs plot the response of the indicated loan variable to a one-standard deviation shock to the federal funds rate, i.e., a monetary downturn. The curves labelled "non-monetary downturn" plot the time path of the loan variable following a sequence of output shocks that generates a time path for output that is identical to that of the monetary downturn plotted in panel A. Open squares indicate a significant response at the 10% level and a solid square indicates a significant response at the 5% level (both one-sided tests).

Table A.1: VAR specifications chosen by BIC

<b>Monthly H8</b>	number of lags for						trend	dummies
	R	P	C&I	RE	CON	Y		
Federal funds rate (R)	12	3	3	3	3	3	L	-
Price level (P)	3	3	4	3	3	3	none	-
C&I loans (C&I)	3	3	4	3	3	3	L	-
Real estate loans (RE)	3	3	3	4	3	3	none	-
Consumer loans (CON)	3	3	3	3	5	3	L&Q	-
Real activity (Y)	3	3	3	3	3	3	none	-
<b>Quarterly H8</b>								
Federal funds rate (R)	2	3	2	2	3	2	none	-
Price level (P)	2	4	2	2	2	2	none	-
C&I loans (C&I)	2	4	3	3	2	2	none	-
Real estate loans (RE)	2	4	3	2	2	2	none	-
Consumer loans (CON)	2	2	2	4	2	2	none	-
Real activity (Y)	2	2	3	2	2	2	L	-
<b>Quarterly Call</b>								
Federal funds rate (R)	2	3	2	2	2	2	none	0
Price level (P)	2	2	2	2	3	2	none	2 <sup>nd</sup>
C&I loans (C&I)	2	2	3	2	2	2	none	3 <sup>rd</sup>
Real estate loans (RE)	2	2	2	2	2	2	L&Q	1 <sup>st</sup>
Consumer loans (CON)	2	2	2	4	2	2	none	1 <sup>st</sup>
Real activity (Y)	2	2	4	2	2	2	L	0

Note: In the trend column, "L" indicates a linear trend is chosen and "L&Q" indicates both a linear and a quadratic trend are chosen. In the dummies column, the quarter of the chosen dummy is indicated. Note that the procedure allows for multiple dummies but at most one is chosen. The H8 data is adjusted for seasonality so we do not allow for dummies to enter the specification