

The (Lack of a) Role for Financial Innovation  
in Explaining Changes in Business Cycle Properties

**VERY PRELIMINARY**

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**Abstract**

In this paper, we analyze the time series behavior of home mortgages and consumer credit and investigate *(i)* whether the business cycle behavior and their responses to different shocks had changed before the recent financial crisis as a consequence of financial innovation and *(ii)* whether there were warnings signs in the data for the upcoming financial turmoil. A new framework to analyze financial innovation is proposed.

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# 1 Introduction

The recent financial crisis has highlighted the importance of understanding the effects of financial innovation on economic trends and business cycles. Even before the crisis hit, there were several papers that argued that financial innovation had an impact on business cycle behavior. For example, Campbell and Hercowitz (2006) and Jermann and Quadrini (2006) argue that financial innovation may have played a role in the observed reduction in the volatility of output. This reduction in output volatility goes together with a reduction in the volatility in financial variables in Campbell and Hercowitz (2006), but with an increase in Jermann and Quadrini (2006). There also have been papers that have warned that particular institutional changes in financial markets could be destabilizing.<sup>1</sup>

In the empirical part of this paper, we analyze the time series properties of key real activity variables as well as household loan variables and try to detect evidence for the hypothesis that financial innovation had changed the properties of the US business cycle before the financial crisis hit and if so in what way. That is, we are interested in the question what the data before the crisis had to tell about financial innovation. In particular, we are interested in the question whether there is evidence that responsiveness had become weaker or stronger because of financial innovation. A clear message comes out of our empirical work and that is that there is much more convincing evidence that financial innovation had changed the cyclical behavior of consumer credit and durable expenditures, than that it had changed the cyclical behavior of home mortgages and residential investment. Given that the financial crisis started in the market for a particular type of home mortgages, this is a striking result.

In the theoretical part of this paper, we propose a very simple framework to think about financial innovation. The standard model to analyze financial frictions and financial innovation is a model in which permanent differences in discount factors lead to the existence of borrowers and lenders; financial frictions are introduced by borrowing constraints that are typically assumed to be always binding. Financial innovation is modelled as a change in the borrowing constraint, e.g. in the amount that can be borrowed as a

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<sup>1</sup>See, for example, Danielsson, Embrechts, Goodhart, Keating, Muennich, Renault, and Shin (2001).

fraction of income or the value of durables owned. But the constraint is always assumed to be present and binding in every period. With this never disappearing borrowing constraint it is difficult to think about financial innovation. It is also not clear that one can think sensibly about financial innovation in a model in which the desire to borrow or save is imposed in such an exogenous manner through imposing different discount rates. We build a simple life-cycle model in which reasons for borrowing arise more naturally, namely agents borrow when young when they expect their income still to grow. We replace the borrowing constraint by a smooth penalty function, which allows us to solve the model using simple numerical techniques such as low-order perturbation procedures. More importantly, it frees the model from the restrictions of the borrowing constraint. Using some simple examples, we will show that the model with the borrowing constraint has some implausible predictions that would not occur in the model with a penalty function. There are important advantages of not having different discount factors. For example, the proposed model is also well defined if there are no frictions, i.e. no penalty functions or constraints, and no idiosyncratic income shocks. This makes it much more natural to think about financial innovation. Finally, the use of penalty function makes it possible to introduce nonlinearities such that changes in the penalty function can reduce the sensitivities to small shocks but increase the sensitivities to large shocks.<sup>2</sup>

In the empirical part of the paper, we compare the time series properties over the period from the third quarter of 1953 to the last quarter of 1978 with the properties over the period from the first quarter of 1984 to the first quarter of 2008. We exclude the volatile period around 1980 when Paul Volcker became chairman of the FED and stable inflation became a lot more important part of monetary policy. Across these two subperiods, there are some important differences in the variability of cyclical components and in the correlation between the different variables. There also have been some changes in the impulse response functions (IRFs) of structural VARs.

Several of these changes could have been caused by financial innovation, but could

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<sup>2</sup>Obviously, if one does introduce stronger non-linearities then one has to use a numerical solution procedure that can handle them and lower-order perturbation solutions may not work anymore.

equally well be have been caused by other changes. For example, if the responses of loans and real activity to a particular shock in the second subsample is a scaled down version of the responses in the first subsample, then it could be that financial innovation lowered the impact of the shock, but it is also possible that the impact of the shock is reduced for other reasons. Moreover, it is also possible that the variability of the shock has been reduced, because for most shocks we cannot distinguish between the variability of the shock and the instantaneous impact on economic variables. An observed change that fits the "classic" story of financial innovation would consist of a response of loans that switches from negative in the first subsample to positive in the second subsample, while at the same time the response of output would be less negative in the second subsample. The story would then be that financial innovation made it possible to lend more during bad times (or at least cut lending by less) which dampened the downturn. When we look at monetary policy shocks then we find that both the consumer credit responses changes as well as the responses of GDP and durable expenditures change from significantly negative to roughly zero. In contrast, we still find significantly negative responses for home mortgages and residential investment. Although the responses of consumer credit did not switch sign, the observed pattern is consistent with the classical financial innovation story, that is financial innovation made it easier for consumers to keep on receiving consumer credit during a monetary downturn, which in turn reduced the severity of the economic downturn.

Several papers in the literature that analyze the consequences of financial innovation focus attention on the observed sharp drop in the correlation between GDP and both consumer credit and home mortgages.<sup>3</sup> It seems plausible that financial innovation leads to a reduction in these correlation coefficients or—as discussed in the last paragraph—even to a change from a positive to a negative correlation. We argue, however, that changes in the correlation coefficients of loans and real activity are by themselves unreliable evidence for financial innovation. As mentioned above, financial innovation could simply scale down the responses of all variables, leaving the correlation unchanged. An even stronger argument against using the drop in the correlation as evidence of financial innovation is

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<sup>3</sup>See, for example, Campbell and Hercowitz (2006) and Iacoviello and Pavan (2008).

provided by the responses of home mortgages following a monetary policy shock. We find that the strong positive correlation between home mortgages and GDP in the first subsample is mainly due to monetary policy and "real activity" shocks. Monetary policy shocks are not only less important in the second subsample, but the negative response of output has basically disappeared. At the same time the negative response of home mortgages (and residential investment) has not. It seems not very plausible that financial innovation had the effect of causing a much smaller drop in output but not in home mortgages. The comovement of home mortgages and real activity following a real activity shock has also sharply dropped. Looking at the impulse response functions, however, there is only a small shift in the responses and in particular the turning points that turn out to have a substantial effect on the covariance.

## 2 Data & Methodology

### 2.1 Data

Our data for home mortgages and consumer credit are from the Flow of Funds data set and cover the sample from 1953Q3 to 2008Q1. For the household sector, home mortgages and consumer credit are the two largest liabilities.<sup>4</sup> In 2005, home mortgages were 72% of total liabilities and consumer credit was 18%. Home mortgages not only include first and second mortgages on one-to-four-family properties but also loans taken out under home equity lines of credit. There are many different types of consumer credit. Two particularly important categories are revolving credit (credit cards) and automobile loans.<sup>5</sup>

In this paper, we focus on household liabilities independent of ownership. The fraction of loans owned by banks has become smaller overtime; even when loans are initiated by banks they often end up on the balance sheet of other (financial) institutions. Important for the increased incidence of ownership transition (both between sectors and within the banking sector) has been the emergence of "special-purpose vehicles". In 2005, \$614 billion

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<sup>4</sup>In the Flow of Funds data set, the household sector is combined with the non-profit sector.

<sup>5</sup>According to the documentation published on the FED website, of the \$1.3 trillion in consumer credit outstanding at the end of 1997, \$417 billion was in the form of automobile loans.

of the \$2.1 trillion in consumer credit was held in pools of securitized assets. The securities issued to finance the purchase of these pools may be held by banks or other institutions, but for the analysis performed here we do not distinguish between the ownership of the liability. In Den Haan and Sterk (2008) we investigate whether the cyclical properties of the loans owned by different entities differ and whether this plays a role in the changing time series behavior of the total. Here, however, we are interested in how the business cycle behavior of total aggregates has changed.

## 2.2 Identifying monetary shocks

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>6</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  $k = k_1 + 1 + k_2$ . All lagged values are assumed to be 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,  $\varepsilon_t$ . This relationship is assumed to be 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,

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

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<sup>6</sup>To simplify the discussion we do not display the constant and the trend term that are also included.

When  $E[u_t u_t']$  is replaced by its sample analogue, one obtains  $k(k+1)/2$  conditions on the coefficients in  $\bar{A}$ . Since  $\bar{A}$  has  $k^2$  elements,  $k(k-1)/2$  additional restrictions are needed to estimate all elements of  $\bar{A}$ . A standard practice is to obtain the additional  $k(k-1)/2$  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. Our benchmark specification is based on the assumption that  $X_{2t}$  is empty and that all other elements are, thus, in  $X_{1t}$ . Intuitively,  $X_{2t}$  being empty means that the Board of Governors of the Federal Reserve (FED) can respond to contemporaneous innovations in any of the variables of the system. For quarterly data, an identification based on the exclusion of contemporaneous effects seems plausible. For quarterly data this seems a sensible identification assumption.

### 2.3 Comovement decomposition

In this paper, we also use the comovement statistics of den Haan (2000) to characterize the correlation of different variables. Advantages of this procedure is that it captures a possible dynamic aspect of the correlation and that it can be easily decomposed into the different shocks.

den Haan (2000) shows that the covariance between the  $K^{\text{th}}$ -period ahead forecast errors of  $x_t$  and  $y_t$ ,  $COV(x, y; K)$ , is equal to

$$COV(x, y; K) = \sum_{m=1}^M COV(x, y; K, m) \text{ with } COV(x, y; K, m) = \sum_{k=1}^K x_k^{imp,m}, y_k^{imp,m}, \quad (5)$$

where  $x_k^{imp,m}$  ( $y_k^{imp,m}$ ) is the  $k^{\text{th}}$ -period responses of variable  $x$  ( $y$ ) to a one-standard-deviation innovation of the  $m^{\text{th}}$  shock. The cross product  $x_k^{imp,m}, y_k^{imp,m}$  indicates whether variables  $x$  and  $y$  move in the same or in opposite direction after an innovation in the  $m^{\text{th}}$  shock.<sup>7</sup> The total covariance is simply the accumulated sum of the cross products for all possible shocks. There are six variables in our VAR, so there are also six shocks, that is,  $M = 6$ . To decompose the correlation coefficient, we use

$$\begin{aligned} COR(x, y; K) &= \sum_{m=1}^M COR(x, y; K, m) \\ &\text{with} \\ COR(x, y; K, m) &= \frac{\sum_{k=1}^K x_k^{imp,m}, y_k^{imp,m}}{SD(x; K), SD(y; K)}, \\ SD(z; K) &= \left( \sum_{m=1}^M COV(z, z; K, m) \right)^{1/2} \text{ for } z = x, y \end{aligned} \quad (6)$$

When calculating the part of the correlation that is due to a particular shock, we use the total standard deviations in the denominator to ensure that the sum of all the scaled covariances adds up to the total correlation coefficient.

### 3 Summary statistics

In this section, we discuss general properties of the behavior of consumer credit and home mortgages over the period from 1953Q3 to 2008Q1. We start with a description of the trends.

**Trends.** Panel A of figure 1 documents how the two loan components have changed as a fraction of GDP. Both liabilities have increased as a fraction of GDP but home mortgages have increased at a much sharper rate. Consumer credit increased from 9.3% of GDP

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<sup>7</sup>Identification assumptions affect the impulse response functions, and thus, the decomposition of the covariance, but not that total magnitude.

in 1955Q1 to 18.2% of GDP in 2007Q4, whereas over the same period home mortgages increased from 19.5% of GDP to 75.0%. The observed increases do not necessarily mean that consumers borrow more relative to the value of their house or stock of durables. It also may be the case that the prices of durables and real estate have increased faster than GDP. Another possibility is that the demand for durables and housing relative to GDP has increased. Panel B of figure 1 plots the two liabilities scaled by the value of the associated asset. Now we see for both loan components a similar increase; not as sharp as the increase of mortgages relative to GDP, but still quite impressive. Scaled by the value of real estate, home mortgages increased from 20.4% in 1955Q1 to 47.1% in 2007Q4. As a fraction of durables, consumer credit increased from 28.9% to 63.4%.

The increases in home mortgages and consumer credit have not been uniform over the sample period. Let's first consider consumer credit. As a fraction of GDP, consumer credit has steadily increased.<sup>8</sup> As a fraction of durables a different picture emerges. A large part of the growth is located in the beginning of the sample. Consumer credit increased to 41.9% of durables in 1970 and was then remarkably stable for over two decades. Starting in the early nineties the ratio started to increase again.

Now consider home mortgages. As a fraction of GDP, home mortgages have displayed quite an intriguing growth process. There are several periods in which the growth rate of home mortgages as a fraction of GDP sharply increases, but the sustained increase in the growth rate of home mortgages relative to GDP that started around the beginning of the new millennium is without precedent. As a fraction of real estate, however, the growth pattern is a bit simpler and very similar to the pattern observed for consumer credit. That is, a sharp increase in the fifties and early sixties followed by a period of no growth, and finally a renewed steady increase. Interestingly, using real estate as the scalings factor there is no sharp acceleration at the end of the sample. The recent acceleration of home mortgages relative to GDP can, thus, for a large part be attributed to an acceleration of the value of real estate relative to GDP.

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<sup>8</sup>In particular, in the four decades starting in 1955Q1, the change in consumer credit as a fraction of GDP was equal to 3.67%, -0.09%, 0.49%, and 1.11%.

**Cyclical behavior.** In figure 2 we plot the cyclical components of the two loan components, residential investment, and durable purchases. It also plots the nominal interest rate and the cyclical component of GDP. Summary statistics regarding the cyclical behavior are reported in tables 1 and 2. In particular, table 1 reports the standard deviations of the cyclical components and table 2 the cross correlations.

In addition, we report the comovement statistics proposed in den Haan (2000). These provide an alternative way to describe the comovement between two series. This procedure uses an estimated VAR to calculate the implied correlation between the forecast errors of two series at different forecast horizons. By looking at different forecast horizons one obtains a more complete picture of the comovement including the dynamic aspects of the comovement. The dynamic aspects are also a feature of impulse response functions (IRFs), but the disadvantage of impulse response functions is that they require identifying assumptions.

Figures 3 and 4 plot the statistics for home mortgages and consumer credit, respectively. Panel A of each figure plots the correlation with GDP and panel B the correlation with the associated spending component.

The following observations can be made.

- **Volatility reduction in real activity.** Table 1 confirms the well-known result that the volatility of cyclical movements in GDP in the second subsample is much less than the volatility in the first subsample. The volatility of residential investment and durable expenditures display a drop of almost the same size. Figure 2 indicates that for GDP both the incidence of large swings in the cyclical component has been reduced in the later sample (fewer recessions) and the magnitude of swings has become smaller. This is also true for residential investment and durables, although both spending components decreased sharply during the recession of the early nineties. Moreover, residential investment also seems to have started a sharp decrease during the recent financial crisis.
- **Smaller reduction in volatility of loan components.** The reduction in the volatility of the cyclical component of home mortgages and durable expenditures

is much smaller. The standard deviation of home mortgages in the 1984:1-2008:1 sample is only 19% below the standard deviation in the 1954:3-1978:4 sample for home mortgages and for consumer credit the reduction is 21%. The figure suggests that the use of the HP filter to construct the cyclical components may have underestimated the reduction in volatility for home mortgages. In the later sample, the cyclical component of home mortgages starts out being positive and then gradually decreases until it becomes negative. If this gradual reduction would have been filtered out, then the standard deviation of home mortgages would have fallen much more.

- **Changing comovement GDP and loan components.** Figure 2 and table 2 document another difference between the earlier and the later sample that is at least as striking as the reduction in volatilities. That is, the sharp reduction in the correlation between the cyclical components of the two loan categories and the cyclical component of GDP. The correlation between home mortgages with GDP drops drastically from 0.81 to 0.05 and the correlation between consumer credit and GDP drops from 0.74 to 0.18. The change in the pattern of comovement is also clearly visible in figure 2. In the beginning of the sample there is a very close connection between the movements of the cyclical component of GDP and the two loan categories, a link that seems to have virtually disappeared in the later half of the sample. In particular, home mortgages do not drop during the recession of the early nineties whereas residential investment as well as consumer credit and durables do display substantial decline. Most interestingly, consumer credit seems to move in an opposite direction to both GDP and durable expenditures since the mid nineties. Figures 3 and 4, that plot the correlation coefficients of forecast errors, also document a substantial drop in comovement. The drop in the positive correlation between consumer loans and GDP is—as argued by Campbell and Hercowitz (2006)—consistent with the hypothesis that financial innovations make it easier for consumers to keep on lending even when times are difficult. Of course, it is also possible that the correlation has changed for reasons that are not related to financial innovation. An alternative

explanation is that the comovement differs for different underlying shocks and that shocks that cause a positive comovement have become relatively less important.

- **Changing comovement expenditure components and loan components?**

We also find a drop in the comovement between the cyclical components of durable expenditures and consumer credit, although the drop is not as large as the drop for the correlation with GDP. When we look at the correlation of home mortgages and residential investment then we basically find no drop in the correlation coefficients when they are constructed using VAR forecast errors and only a relatively small drop when we look at the correlation of HP-filtered series.

- **Changing comovement loan components.** The correlation between the two loan components has decreased drastically. As documented in table 2, it was equal to 0.92 in the early subsample, while it was only 0.11 in the later subsample. Figure 2.B documents that since the mid nineties consumer loans have displayed large irregular swings not seemingly related with either GDP, the federal funds rate, or mortgages.

The reduction in the correlation between the two loan components and GDP has received attention in several papers and we will delve deeper into the reasons behind the drop as well throughout this paper. The results in table 2 suggest that there are two reasons for the drop in this correlation between the loan components and GDP. First, there is a drop in the correlation between the loan components and the associated spending component. This drop is clearly not as spectacular as the drop in the correlation with GDP. For example, the correlation between consumer credit and durable expenditures drops from 0.64 to 0.31 and the correlation between home mortgages and residential investment drops from 0.48 to 0.32. So although there is a considerable drop, there also still is a substantial correlation left. The other part of the story seems to be that the correlation between GDP and the spending components has dropped. The correlation of residential investment and GDP has dropped from 0.59 to 0.48 and the correlation between durable expenditures and GDP has dropped from 0.87 to 0.63.

## 4 Impulse response functions

We divide the discussion of the IRFs into two parts. In section 4.1, we discuss the IRFs of a monetary shock. In section 4.2, we discuss the IRFs of the remaining shocks. The key difference is that the monetary policy shocks have a (more) structural interpretation and there is a measure for the size of the underlying shock, namely the change in the federal funds rate.

### 4.1 Monetary shocks

#### Findings:

1. The negative output response has disappeared and even has become slightly positive. It is still possible to get a negative response with some VAR specifications, but responses around zero are found much more often. In the appendix, we provide more information on this using sign restrictions.
2. The same is true for the response of durable expenditures.
3. The response of consumer credit has turned zero in the later sample and this is robust across different VAR specifications. Below we will investigate whether this could simply be due to the smaller response in the real activity variables.
4. The response of residential investment has become smaller, but is still significantly negative. The response has become much more delayed and more persistent. This pattern for the response of residential investment is also found by McCarthy and Peach (2002). The maximum drop in residential investment (during the first five years) is equal to 2.7% in the early sample and only 1.1% in the later sample. But the maximum increase in the federal funds rate has also dropped from 76.8 to 32.2 basis points.
5. Similarly, the response of home mortgages has become smaller. The maximum decrease (during the first five years) dropped from 0.71% to 0.29%, but relative to the size of the federal funds rate response this is only a minor reduction.

6. In the early sample, the IRF of prices suffers from the price puzzle in that there is a significant increase during the first two years. In the second subsample there is a small reduction in the price level, but note that prices drop quite quickly. Over the whole sample there is virtually no price puzzle and prices almost follow the textbook response, that is, flat initially and then a reduction.

## 4.2 Other shocks

There are six more variables and one could in principle identify six more shocks. We use the Cholesky decomposition and ordered the remaining variables so that those variables that are likely to have the slowest response are ordered first. Although this is not an implausible assumption, one could clearly question whether the identified shocks are truly structural. For our purpose this is not strictly necessary. We show that several aspects of the driving process, as represented by the structural IRFs of the VAR, have remained remarkably stable over time. Whether the shocks have a structural interpretation or not is then not that important for us.

**Real activity shock** The three real activity variables are GDP, durable expenditures, and residential investment. The IRFs of the three corresponding shocks have several similarities. For example, all three lead to a reduction in GDP and lead to—as predicted by the Taylor rule—a reduction of the federal funds rate. Residential investment and durable expenditures, however, do not always move in the same direction, which means that part of these shocks are related to shocks that cause some reallocation. To simplify the discussion we focus on the sum of the three IRFs corresponding to these three real activity variables. This corresponds to the responses when the innovations of each of the three variables are equal to 1 standard deviation. In the appendix, we give the IRFs of the three separate shock and show that the main conclusion of this subsection does not depend on looking at the joint shocks. Using sign restrictions we also show that the IRFs of this combination shock is robust for different identifying assumptions.

In both subsamples, the initial downturn is followed by a subsequent upturn which is

quite substantial in residential investment. The federal funds rate drops and more so in the second subsample even though the economic downturn is less. Prices drop in both subsamples. Home mortgages have the same IRF as residential investment, but the initial downturn is very small. If there is a difference in the IRF of home mortgages across the two samples, then it is that the response becomes positive sooner.

For consumer credit we find that the qualitative shape of the IRFs is similar in the two subsamples, but that the magnitude of the drop and the significance levels has become less. The drop in magnitude resembles the drop in magnitude of the responses of the real activity variables. When we look at the IRFs of the three individual shocks then we also find that the responses of consumer credit to a "GDP shock" and a "durable expenditure" shock have not changed but that the response of consumer credit to a "residential investment shock" has disappeared.

**Consumer credit shock.** Almost none of the responses except consumer credit are significant. Interestingly, the IRFs of both durables expenditures and GDP have the same shape in both subsamples, namely initially negative, then positive, and then negative. The difference between the two subsamples is that the second set of negative IRF values occurs earlier in the first subsample and is larger even though the credit response is less negative.

**Home mortgage shock.** Like consumer credit shocks, home mortgage shocks are not associated with many significant real activity responses except in the second subsample when home mortgage shocks lead to a significant and more persistent (but not larger) decline in residential investment. The response of home mortgages themselves has become larger in the second period.

**Prices.** The price shock does not generate many significant values for the IRFs; the reduction in durable expenditures in the second subsample is the only IRF for which there are several significant responses in the two subsamples. If anything, a positive increase in prices is associated with a reduction in real activity. When we ignore that most responses

are not significant and when we compare the two subsamples, then we can make the following observations. First, the federal funds rate displays a (marginally significant) positive response to the increase in prices in the second subsample, but not in the first. Second, the response of GDP has become smaller whereas the loan response have become more negative and for home mortgages the insignificant positive responses beyond the 6<sup>th</sup> period have all turned negative, some of them even significantly so. Third, the responses for residential investment and durable expenditures have become more negative.

## **5 Financial innovation**

The IRFs of VAR are often not very robust in the sense that minor changes in the specification lead to different outcomes. We find it therefore surprising that there are in fact quite a few patterns that have remained stable over time. But there also have been several changes. The question we address here is whether these changes could be the result of financial innovation. In section 5.1, we discuss what kind of patterns are consistent with standard views of financial innovation, what kind of patterns are strongly suggestive to financial innovation, and what kind of patterns are not very likely the result of financial innovation. In section 5.2, we then discuss what types of changes are observed for our data set.

### **5.1 When are changes in business cycle behavior due to financial innovation?**

That financial innovation has taken place is beyond dispute. It is not clear however, whether financial innovation has changed the business cycle properties of the US economy. Theory does not provide us with an unambiguous prediction about the effects of financial innovation on business cycle properties. One possibility is that because of financial innovation the volatility of economic variables has become smaller, for example, because better diversification of financial institutions makes it easier for them to keep on lending during economic downturns, which in turn dampens the reduction in loans and the corresponding spending components. But it is also possible that financial innovation increases the

responses to (some) shocks. Financial innovation has clearly increased the total amount of household debt relative to income and asset value. But if financial institutions lend out more and even lend out more to borrowers that before were not eligible for any credit then it may very well be the case that this additional debt puts a higher burden on the borrower during economic downturns, which leads to sharper reductions in the supply of debt during economic downturns.

Thus, both an increase and a reduction in the response to a shock could be consistent with financial innovation. Financial innovation has not been the only important structural change that took place in the post-war period. For example monetary policy has changed a lot, but there also have been changes in product market competition, inventory control, and services have grown sharply relative to manufacturing. Often one could give more than one explanation for an observed change in the business cycle behavior of a set of variables.

The question arises whether there are particular changes that are typical for financial innovation and are hard to reconcile with other important changes and whether there are particular changes are difficult to reconcile with financial innovation. We think that the following changes would be quite convincing. If the response of loans to a particular shock is significantly negative in the first subsample and significantly positive in the second subsample and if at the same time the response of output has become smaller then this seems to us very suggestive of financial innovation.<sup>9</sup> On the other hand, if the response of a loans becomes more negative and the response of output less negative then this suggests quite strongly that financial innovation cannot have been a major factor or is at least dominated by other changes.

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<sup>9</sup>There probably is for every pattern more than one story to tell. For example, this pattern would be consistent with a world in which there is no financial innovation but in which (i) loan supply increases following a monetary tightening and (ii) loan demand decreases if real activity decreases, (iii) real activity decreases by less in the second subsample because of a reason not related to financial innovation, e.g., more flexible prices. If the demand effect is less in the second subsample then it could be dominated by the (unchanged) supply effect and we would observe a change in the sign of the loan response and a smaller real activity response.

In the remainder of the section we will go through the differences between the two subsamples discussed above and try to tell stories. That is we will see whether the observed changes can easily or perhaps exclusively be explained with financial innovation. The results can be summarized as follows. First, although there clearly are changes in business cycle behavior that are consistent with financial innovation, none cleanly fit the pattern described above that is difficult to explain with something else than financial innovation. Second, when we compare the results for consumer credit and home mortgages then the changes observed for consumer credit are consistently more in line with financial innovation than the changes observed for home mortgages.

## **5.2 Are changes in business cycle behavior due to financial innovation?**

In sections 3 and 4 we reported several changes in standard deviations, correlation coefficients, and IRFs. We now ask ourselves whether these are (most) consistent with financial innovation or whether the observed changes in the business cycle behavior of home mortgages, consumer credit, GDP, residential investment, and consumer credit are hard to reconcile with financial innovation. In particular, is financial innovation behind the reduction in the volatility of real activity and the reduction in the covariance between loan components and GDP.

We start with a discussion of the IRFs. The IRFs give a complete description of the time series behavior and also capture changes in standard deviations and correlation coefficients.

### **5.2.1 Financial innovation and changing monetary IRFs**

The IRF corresponding to a monetary policy shock have an important advantage that the other IRFs do not have and that is that the instantaneous response of the federal funds rate can be taken as a reasonable measure of the size of the shock. That is, a larger unexpected change in the federal funds rate corresponds with a larger underlying structural shock. For the other shocks this is not so clear cut and the first-period response provides a measure not only of the size of the underlying structural shock but also of the

size of the instantaneous response.

A key finding is that the responses of GDP and durable expenditures following a monetary tightening have clearly changed. In particular, from significantly negative they have become basically zero. Do the changes in these IRFs together with the results found for loans support the hypothesis that financial innovation has caused the economy to become resilient to unexpected monetary policy shocks?

1. **Home mortgages:** Monetary policy shocks are definitely smaller in the second subsample, but they have become somewhat more persistent, that is, the federal funds rate takes longer to return to its preshock value. To facilitate the comparison of the responses in the face of these different time paths of the federal funds rate, we plot in figure 10 the IRF of home mortgages and residential investment for the VAR of the second subsample when we feed the VAR a series of monetary policy shocks that result in an IRF for the federal funds rate identical to the one observed in the first subsample. The figure also plots the IRFs of these two variables for the first subsample. The figure documents that the responses of residential investment are not smaller in the later subsample, only more delayed. The responses of home mortgages have become smaller. One possible story would be that financial innovation has made it possible that home mortgages drop by less and that because of this real activity is less sensitive to the monetary tightening. There are a couple reasons, however, to doubt this interpretation.

- (a) The reduction in the response of home mortgages is not that robust. In fact, for several VAR specifications we find virtually no change but we never encountered a VAR specification in which the drop in home mortgages in the later sample was substantially smaller than the one reported.
- (b) If financial innovation—through a smaller reduction in home mortgages—is behind the smaller responses of durable expenditures and GDP, then it is somewhat surprising that the drop in residential investment did not become smaller. It is not impossible of course. For example, financial innovation may have made

it possible for households to face a smaller decrease in their home equity loans and that this made it possible to have lower reduction in durable expenditures, but that their access to home mortgages to finance residential investment was unchanged.

- (c) It is not clear whether the percentage change in home mortgages is the right measure given that home mortgages have increased sharply relative to GDP and relative to the level of residential investment. Scaled for the size and persistence of the shock, we find that the largest reductions for home mortgages are equal to 0.71% and 0.43% in the first and second subsample, respectively. But the ratio of average mortgages relative to average GDP is in the second subsample 442% higher than in the first subsample. Consequently, the maximum reduction in home mortgage relative to GDP is equal to 0.06% in the first subsample and 0.22% in the second subsample. If we calculate the drop in mortgages relative to the level of residential investment then we find that the maximum reduction in home mortgage is equal to 0.93% in the first subsample and 4.61% in the second subsample.
- (d) There is one more reason that financial innovation in the market for home mortgages is behind the smaller responses of durable expenditures and GDP and that is that there is a plausible alternative explanation. The alternative is that home mortgages do not drop by that much because real activity is reduced by less (GDP and durable expenditures drop by less and residential investment drop is delayed). To check the validity of this story we plot in figure 11 the IRF of home mortgages for the second subsample when the economy faces a series of monetary policy and real activity shocks such that the IRF for the federal funds rate and the three real activity variables are identical to the one observed in the first subsample. The figure also plots the original IRF of home mortgages during a monetary tightening in the second subsample. The figure shows that the drop of home mortgages in the second subsample is a lot stronger. That is, given the response of the real activity variables and the federal funds rate the

observed response of home mortgages is actually quite low relative to what was observed during the first subsample.

2. **Consumer credit:** In contrast to the results for home mortgages, we find that the negative response of consumer credit that is observed in the first subsample has disappeared in the second subsample. Moreover, this is a robust result.

(a) The changes in the result for consumer credit clearly fit the standard financial innovation story a lot better than the (lack of changes) for home mortgages and residential investment. That is, financial innovation in the market for consumer credit has made it easier to keep on extending credit when interest rates increase and this is behind the disappearance of the economic downturn (except for residential investment) following a monetary tightening. To see whether there is some support for the hypothesis that the vanishing reduction in loans are important for the disappearance in the reduction of durable expenditures and GDP, we recalculate the IRFs in the first subsample by resetting the loan responses equal to zero in each period. The results are reported in figure 12. One can only obtain very limited information from these exercises. The reason is that the coefficients of other variables in the GDP and durable expenditure equation, like the coefficient on the federal funds rate, may also capture the effect from the loan market on output. These are not structural equations. But if the direct effect of consumer credit in these equations contains at least some information about the responses, then the reduction in consumer credit did contribute to the fall in GDP and durable expenditures in the first subsample. So at least for consumer credit there are some changes in the IRFs that are consistent with financial innovation.

(b) An alternative story to tell is that the responses of several expenditure components to a monetary policy shock have become smaller, for example, because prices have become less sticky and that this is the reason behind the smaller response of consumer credit. Support for this claim is given in figure 13 that

plots the IRF of consumer credit when the economy faced a sequence of real activity shocks such that the IRFs of residential investment, durable expenditures, and GDP in the second subsample are identical to those observed in the first subsample. Similar to the results found for home mortgages when we look at the case where the federal funds rate and the three real activity variables responds in a way that is identical to the way they respond during a monetary downturn in the first subsample, then the predicted response of consumer credit in the second subsample is only stronger than the response observed in the second subsample.

In this paper, we argue that if financial innovation has had a major impact on the business cycle behavior then it should show up in the estimated dynamic system characterized by IRFs. One aspect that did change is that the variance of monetary policy shocks has become smaller. Above we compared the results in the two subsamples for equal change in the federal funds rate. But the question arises why monetary policy shocks and whether the increased stability could be related to financial innovation. For example, if financial innovation leads to a healthier financial sector (for example because of better diversification) then there is less reason for the central bank to change the interest rate solely because of reasons related to the health of the financial sector, which would show up as a monetary policy shock in a structural VAR. The recent subprime mortgage crisis makes clear that if it ever was true it no longer is the case. Moreover, given that there are other plausible reasons, like the increased understanding on the importance of rules instead of discretion, this seems not the most convincing evidence that financial innovation has changed business cycle properties.

### **5.2.2 Financial innovation and changes in other IRFs**

In this section, we discuss the changes in the other IRFs and see whether the changes are consistent with the hypothesis that financial innovation has changed business cycle properties.

**Results based on real activity shocks.** The general shape of the IRFs following a real activity shock seems quite similar across the two subsamples except that the magnitudes are smaller in the second subsample. When we take a closer look, however, then there do seem to have been some changes. In the first subsample the three real activity variables as well as the two loan components display an initial decrease followed by a quite substantial increase. During the initial economic downturn, the federal funds rate drops by 50 basis points and this monetary easing could be the reason for the subsequent expansion. In the second subsample, the observed pattern is very similar except that the sign switch for the responses of home mortgages occurs much faster (in fact there barely is an initial negative response) and the responses of the three real activity variables also turn positive earlier (although all three are still significantly negative for several periods).

Although the shortening of the economic downturn, i.e., the leftward shift of the IRFs, seems relatively small it does fit the standard story of financial innovation dampening the impact of shocks. The idea would be that because of financial innovation home mortgages only display a minor initial response and in fact quickly increase in response to this negative real activity shock. This upward shift of the response in home mortgages shortens and possibly dampens the economic downturn. In terms of statistical significance the shifts are not substantial and we do not think of this as strong evidence of financial evidence. But it would be consistent with it. There is another reason why this shift in the IRFs is important. Although the magnitude of the shift does not look substantial, it is in fact important for the change in the covariance between the loan components and the real activity components, a statistic that has received attention by papers that focus on financial innovation and changing business cycle behavior. We will discuss this in more detail below but note that the range of forecast horizons at which the home mortgage and the GDP responses have the opposite sign is larger in the second than in the first subsample.

**Prices.** The changes in the IRFs after a price shock are close to the opposite of what one would expect if financial innovation had affect business cycle properties. Recall that there were very few significant responses but if anything loan response had become more

negative and GDP response less negative. The responses of residential investment and durable expenditures even have become more negative (and those of durable expenditures significantly so). A much more straightforward explanation for this change is that the FED has become more responsive to inflationary pressure, which explains the upward shift of the response of the federal funds rate, which in turn explains the downward shift of the responses of the two loan components and the associated spending categories.

**Consumer credit shock.** Similar to the results for prices, the IRFs are mainly not significant and if anything are not consistent with standard theories about the impact of financial innovation. In particular, although the drop in consumer credit has become larger and more persistent the IRFs of the three real activity variables have if anything only become more muted.

**Home mortgage shock.** There are some aspect to the changes in the IRFs of a home mortgage shock that resemble the discussion above for the changes in the IRFs of a price and a consumer credit shock. That is, the reduction in home mortgages has clearly increased, the response of residential investment is significantly negative in the second subsample compared to significantly positive in the first subsample, and the responses of durable expenditures and GDP have become less negative. The reduction in the decreases of durable expenditures and GDP are very minor, however, so it is difficult to argue that financial innovation has made it possible to better deal with large negative shocks in home mortgages, for example, by letting mortgages decrease for those customers for whom they are less consequential.

If we take into account the response of consumer credit, however, the case for financial innovation becomes stronger. In the first subsample, the reduction in home mortgages goes together with a reduction in consumer credit (although not significant). In contrast, in the second subsample, the reduction in home mortgages goes together with a sharp and significant increase in consumer credit. One possible story would be that because of financial innovation the financial sector has been much better capable of reallocating resources between its different assets if, for one reason or another, one particular asset

became less attractive. One could then say that this increased reallocation into consumer credit is the reason for the vanishing negative responses of durable expenditures and GDP.

### 5.2.3 Financial innovation and changing covariances

Papers that focus on the effects of financial innovation on business cycle behavior also pay attention to the sharp drop in the covariance between consumer loans and GDP. In this section, we use the IRFs to understand why this covariance has dropped and whether the underlying reason is consistent with financial innovation.

Here we focus mainly on the comovement statistics of den Haan (2000), because there is a direct connection between the correlation coefficients at the different forecast horizons and the IRFs. The analysis turns out to be remarkably simple because there are only two shocks that turn out to matter: the monetary policy shock and the real activity shock. Figure 14 plots the correlation coefficient between home mortgages and GDP (top panel) and the correlation coefficient between home mortgages and residential investment (bottom panel). It plots the results for the first and the second subsample. It also plots the contribution of the monetary policy shock and the real activity shock. When we add up the two corresponding curves then we are very close to the total, so the other shocks contribute very little to the comovement between home mortgages and these two real activity variables. First consider the correlation with GDP which is plotted in the top panel. In the first subsample, the positive correlation between home mortgages and GDP is mainly due to monetary policy shocks, but a significant part is due to real activity shock. At higher forecast horizons the real activity shocks explain roughly one third of the total correlation, but at shorter forecast horizons it is more. In the second subsample, the correlation has turned negative and this is due both to a change in the sign of the comovement due to monetary policy shocks and to a change in the sign of the comovement due to real activity shocks. This change in the sign could very well be consistent with financial innovation. If financial innovation makes it possible to increase mortgages following a monetary downturn and this in turn leads to a lower reduction in real activity, then this would make the correlation between the two variables positive. But from the discussion above we know

that this is not what is behind the sign change for the comovement due to monetary policy shocks. This comovement has not become negative because the responses of mortgages have become positive, but because the response of GDP has turned slightly positive. The responses of mortgages are still significantly negative and as argued the magnitudes in the second subsample are compared to those observed in the first subsample still substantial.

The drop in the correlation due to real activity shocks is due to the earlier sign switch in the response of home mortgages. As explained above this could be consistent with financial innovation but the shifts are not substantial, just like the change in the comovement due to real activity shocks is much smaller than the change in the comovement due to monetary policy shocks. This is even more true when we look at the correlation between home mortgages and residential investment. Here the drop in correlation is at higher forecast horizons only due to a drop in the comovement due to monetary policy shocks.

A drop in the correlation is not a necessary, that is, financial innovation can very well dampen business cycle fluctuations and leave correlation coefficients unchanged. This would for example be the case if all IRFs are scaled down because of financial innovation. We analyze the covariances because they have received attention in papers in the literature that focus on the effects of financial innovation on business cycle properties. After looking at the reasons behind the drop in the correlation, it seems doubtful to us that financial innovation is an important factor for home mortgages. We now turn to consumer credit.

Figure 15 gives the results for the correlation between consumer credit and GDP (top panel) and between consumer credit and durable expenditures. Again only monetary policy and real activity shocks matter. But there are several differences with the results for home mortgages. First, compared to the results for home mortgages, real activity shocks play a relatively more important role for the comovement. This is true both for the correlation with GDP and for the correlation with durable expenditures. Second, in contrast to the correlation between home mortgages and residential investment, the correlation between consumer credit and durable expenditures does drop substantially.

As argued above, the changes in the IRFs following a monetary policy shock could be interpreted as the result of financial innovation (although we also discussed an alternative

explanation). When we look at real activity shock and the IRFs of consumer credit and the two considered real activity variables, then it is difficult to see these changes and, thus, the drop in the correlation coefficient it causes, as the consequence of financial innovation. Comparing the results in the second subsample with the results in the first subsample, we see that for consumer credit it takes longer before the response turns positive, for durable expenditures it happens quicker, and for GDP it takes roughly the same amount of time. This results in the loan component and the real activity variables having the same sign for a shorter time period, which implies a lower correlation. But the more persistently negative response of consumer credit is not the one would expect if financial innovation would play a role in dampening the shocks. Thus, the part of the drop in the comovement between consumer credit and real activity that is due to real activity shocks does not seem to be related to financial innovation.

#### **5.2.4 Summary**

There are obvious limitations to an informal discussion like the one given here and one should be careful drawing hard conclusions. Nevertheless, we believe that there are some important lessons to be learned about the role of financial innovation in the changing business cycle behavior. The most important one is without doubt that—up to the crisis in the market for subprime mortgage markets—there is much more support for the view that changes in the market for consumer credit had been instrumental in affecting the business cycle behavior of key macroeconomic variables than for the view that changes in the market for home mortgages had done so.

## **6 Financial innovation and frictions**

### **6.1 Motivation and key elements**

Following classic articles like Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) there are now many articles that study the role of financial frictions for business cycles and the impact of financial innovation. A popular framework is the one in which impatient

agents borrow from patient agents. Whether an agent is patient or impatient is simply imposed by having differences in discount factors.<sup>10</sup> A borrowing constraint ensures that the differences in discount factors do not cause the total wealth of the patient agents to dominate the wealth of the impatient guys. The parameters are chosen such that the constraint is always binding which facilitates finding a numerical solution.<sup>11</sup>

Although this framework has delivered some key insights, we feel it is not the most appropriate framework to think about financial innovation. Financial innovation is modelled in this framework as a change in the parameters of the borrowing constraint, for example, financial innovation could increase the fraction the agent can borrow as a fraction of his income or the value of the durables owned. But the constraint remains binding in every period for every borrower. It would be more natural to study financial innovation in a model in which the constraint would eventually become irrelevant. If the constraint is not always binding, then one cannot use simple linearization (or low-order perturbation techniques) anymore. Moreover, it is tricky not to have a constraint in a model in which agents have different discount factors.<sup>12</sup>

In developing this framework we had the following objectives in mind.

1. Whether agents borrow or save should not be imposed exogenously but be the result of a fundamental economic problem. In our problem the reason why agents borrow or save is the consequence of a standard life-cycle problem.
2. Financial frictions have to be incorporated in a way that is less restrictive than the use of always binding borrowing constraint. We will give examples documenting that borrowing constraints can lead to unlikely predictions of the model. Much flexibility can be achieved by replacing the borrowing constraint with a smooth

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<sup>10</sup>This framework is used in ?, XXX and is used to study financial innovation in Campbell and Hercowitz (2006).

<sup>11</sup>Actually, parameters are such that the constraint is binding in the steady state. We are not aware of papers that actually check whether the constraint is indeed always binding along the simulated time paths.

<sup>12</sup>It is not impossible. If the average consumption level of the impatient guys is sufficiently below the level of the patient guys then idiosyncratic shocks are costlier to them. This generates differences in the expected value of the marginal rate of substitution that compensates for the different discount factors.

penalty function. One can think of the borrowing constraint as an extreme penalty function, namely one that imposes no penalty when the constraint is satisfied and an infinite penalty when it is not. Such extreme penalty function not only severely restrict the models predictions, they also do not seem realistic, that is, typically there are no fully inflexible constraints on the amount borrowed and absolutely no consequences until that constraint is hit. More sensible is to let the interest rate being paid increase (possibly sharply) with the amount borrowed.

3. The framework of the model should have as a special case a model without any financial frictions and this model should be easy to analyze and sensible. Moreover, studying the transition from the version of the model with frictions to the version of the model without any frictions should also be straightforward. In the standard model with patient and impatient agents, loosening the borrowing constraint will at some point lead to a version of the model in which the assumption that the constraint always bind is incorrect and one has to rely on numerical solution techniques that can deal with the non-differentiability of the policy function implied by this property. Moreover, the difference in discount factors leads to a strong divergence in the wealth levels of the patient and impatient agents when borrowing constraints are loosened.<sup>13</sup>
4. There should be a sensible version of the model that is as simple to solve and analyze as the popular framework with one type of patient and one type of impatient agent. Our framework is an extension of the perpetual youth model in which *young* agents become *"old"* with a fixed probability and old agents die with a fixed hazard. We use "old" as a relative indicator. For now we do not consider retirement and the empirical counterpart of our old agents are middle-age agents that earn on average more than young agents.

This framework captures the basic life-cycle aspects but limits the number of age

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<sup>13</sup>The presence of idiosyncratic risk will slow down the desire of the impatient agent to increase borrowing. Thus, if idiosyncratic risk is high enough and the difference between the discount factors not too high then the wealth levels of the two types of agents would not diverge too much. Of course, if the discount factors are close then one can no longer rely on the assumption that the borrowing constraint is always binding.

groups to only two. Since some agents stay young or alive longer than others there is also wealth heterogeneity and the cross-sectional wealth distribution would be a state variable in the presence of aggregate risk. Although there are algorithms to solve these models, it does complicate the numerical analysis. The introduction of a simple transfer makes it possible to construct a simpler version in which there is only type young and one type. The simplification basically boils down to not modelling the transition from new born to typical young (or from new middle age to typical middle age).

5. We want that simple numerical techniques, such as low-order perturbation, are capable to solve accurately at least the relatively simple versions of our framework. Numerical convenience is achieved in the standard framework by the assumption that the constraint is always binding.<sup>14</sup> As long as the non-linearities in the penalty function are limited, then our framework can be solved using low-order perturbation techniques.
6. Ideally the model is flexible enough to (i) generate the prediction that financial innovation can lead to a reduction in volatility, which seemed—according to many—to have been the case before the financial crisis hit and (ii) generate an increase in volatility when either larger shocks hit the system or when leverage ratios reach critical values. By having sufficient non-linearities in the penalty functions this is a possibility although to solve the model accurately one should, most likely, rely on numerical solution techniques that are appropriate for these types of nonlinearities.

## 6.2 Description of the model

There are two types of agents in the model that differ in age. The "young" earn labor income  $e_{y,t}$  each period and the "old" earn  $e_{o,t}$ , with  $e_{o,t} > e_{y,t}$ .<sup>15</sup> A young agent ages

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<sup>14</sup>It is a sad state of affairs that authors do not check whether this is indeed the case on a typical simulated time path. One exception is the paper by ?.

<sup>15</sup>For now we simply consider an endowment economy and do not yet consider the effect of financial innovation on output produced.

with fixed probability,  $\rho_{age}$ , and an old agent dies with fixed probability  $\rho_d$ . Agents can borrow or lend. Because  $e_{o,t} > e_{y,t}$  and because we abstract (for now) from idiosyncratic income shocks, the young will be the borrowers and the old will be the savers. Let  $d_{y,t}$  be the amount borrowed by a young agent in period  $t$  and let  $s_{o,t}$  be the amount saved by an old agent in period  $t$ . The old save at rate  $r_t$  and the young borrow at rate  $r_t + q(d_{y,t})$ . To simplify the exposition we assume that the spread,  $q$ , only depends on the amount borrowed, but the spread could also depend on other factors, such as the lending rate or the borrower's income level. In this model we take the specification of the spread between borrowing and lending rates,  $q(d_{y,t})$ , as given. In this sense we do not differ from models that impose an exogenous borrowing constraint, although we have more flexibility and argue that this specification is more realistic than a borrowing constraint.<sup>16</sup> It obviously would be a worthwhile exercise to model the behavior of the intermediary and to endogenize the specification of  $q(d_{y,t})$ .

The maximization problem of the old is equal to

$$\begin{aligned} v_o(s_{o,-1}) &= \max_{c_o, s_o} \frac{c_o^{1-\gamma}-1}{1-\gamma} + \beta(1 - \rho_d)v_o(s_o) \\ \text{s.t. } c_o + s_o &= e_o + r_{-1}s_{o,-1} \end{aligned} \quad (7)$$

The maximization problem of the young is equal to

$$\begin{aligned} v_y(d_{y,-1}) &= \max_{c_y, d_y} \frac{c_y^{1-\gamma}-1}{1-\gamma} + \beta(1 - \rho_{age})v_y(d_y) + \beta\rho_{age}v_o(-d_y) \\ \text{s.t. } c_y + d_{y,-1}(1 + r + q(d_{y,-1})) &= e_o + d_y \end{aligned} \quad (8)$$

The Euler equations are given by

$$c_o^{-\gamma} = \beta(1 - \rho_d)\mathbf{E}_t c_{o,+1}^{-\gamma} [1 + r] \quad (9)$$

and

$$\begin{aligned} c_y^{-\gamma} &= \beta(1 - \rho_{age})\mathbf{E}_t \left[ c_{y,+1}^{-\gamma}(1 + r + q(d_y) + q'(d_y)d_y) \right] \\ &\quad + \beta\rho_{age}\mathbf{E}_t \left[ c_{o,+1}^{-\gamma}(1 + r + q(d_y) + q'(d_y)d_y) \right] \end{aligned} \quad (10)$$

Our notation ignores the heterogeneity among the agents of the same type. For example, a new born would start with a debt level equal to zero whereas a young agent that has been

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<sup>16</sup>A borrowing constraint would correspond to a penalty term that is infinite when the constraint is violated and zero when it is not.

a young agent for several periods will have build up a positive debt level. Similarly, the consumption level of an agent that has just become an old agent will be different from the consumption of an old agent that has been an old agent for some time. This heterogeneity complicates the numerical analysis but can be reduced by a simple transfer scheme that we discuss next.

**Transfers and reducing heterogeneity** The idea of the transfer scheme is to make newborns identical to the other young and the youngest cohort of old agents identical to the other old agents. To accomplish this we tax the newborns so that their wealth position is equal to that of the other young, that is, equal to  $e_y - d_{y,-1}(1 + r + q(d_{y,-1}))$  and we subsidize the youngest cohort of old agents so that their wealth position is equal to  $e_o + s_o$ . The tax of the newborns is redistributed to the other young agents and the subsidy to the young cohort of old agents is paid out of the savings of the deceased and the old. There are, thus, no transfers across age groups and the transfers transform the framework into one in which transitions (from newborn to typical young and from newly old to typical old) are immediate. We feel that the richer life cycle transitions are less important for the issues we address here, but we intend to investigate this issue more carefully.

**Equilibrium** In equilibrium, the total savings of the old is equal to the total demand for debt of the young, that is,

$$N_y d_y = N_o s_o. \quad (11)$$

The number of young and old agents are given by the following two equations.

$$\rho_{age} N_y = \rho_d N_o \quad (12)$$

and

$$N_y + N_o = 1.$$

**Reducing the heterogeneity** Even though the hazard rates are constant there is a lot of heterogeneity in this model. In particular, for each type of agent there is a cross-sectional distribution of wealth levels. In the presence of aggregate uncertainty this would

imply that the set of state variables is infinite dimensional. This aspect clearly makes the model more complex than the popular framework with a representative borrower and a representative saver. It is not clear whether this additional heterogeneity is needed for all questions. We now show that this model can simply be reduced to one with a representative young and a representative old through the use of transfers and taxes. All transfers are among members within the same age group. By focusing on this case with a representative young and a representative old one basically does not model the transitions from newborn to typical young and from newly old to typical old.

To understand the idea of the transfers scheme suppose that we start in a situation in which all young and all old agents have identical wealth levels. The question is whether there is a transfer scheme such that this remains the case. It is not hard to see that if there is initial dispersion in wealth levels that implementing the transfer scheme implies that the wealth dispersion will gradually disappear and eventually the economy will be in the situation considered here.

Without transfers a newborn will be richer than the other young agents since he starts out with zero debt. To make him equal we tax the newborns with an amount equal to the current debt of the other young. The revenues of this tax is redistributed among the other young. By redistributing the tax within the group of young agents, the group of young agents, i.e., the representative young agent, still has the benefit of starting with zero debt as a new born. To make the most recent cohort of old agents identical to the other old they have to be subsidized so that their wealth level is equal to that of the other old. This tax is financed out of the estates of the deceased and the amount that remains to be financed is paid out of a tax on the other old.<sup>17</sup>

### 6.3 Richness of the new framework

Using some very simple examples, we document how restrictive the standard framework is and how much richer the alternative framework. We start by looking at the responses

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<sup>17</sup>The estate tax raises enough revenue to give the aged young an amount equal to the amount of savings of the current old but not enough to wipe out their debt levels.

of the borrowers, i.e., either the young or the impatient agents, following an increase in the income levels of the old and the young. Next, we look at the predictions of the model following financial innovation. For simplicity we look at permanent changes, that is, we look at changes in the steady state, but at least for persistent changes the results reported here will be relevant for those as well.

**Increase in income levels.** Consider the standard framework in which parameters are chosen such that the borrower, i.e., the impatient agent, is always at the constraint. Consider two different borrowing constraints. In the first case, the borrowing constraint specifies a fixed maximum and in the second case the borrowing constraint specifies a maximum for the amount borrowed relative to the borrower's income.

Suppose that the income of the old agents increase. For both specifications of the borrowing constraint the prediction of the borrowing constraint model would be that nothing will happen with any financial variables: the patient agents will simply consume the extra income. When the income of the impatient agents increases the predictions of the model are also straightforward. In the first case again nothing happens except that the impatient agents will consume the extra income. In the second case, debt of the impatient increases proportionally.

The latter case is the most interesting. Note that this prediction is very robust. For example, even if the income of the borrowers increases enormously, they will increase their debt level. In fact, the same prediction would occur when the increase in the income level is temporary. The borrowers will not save any of the temporary income increase no matter how high. Obviously, there is an increase in the income level so that the assumption that the borrowing constraint remains binding is no longer valid. But this means that one has to rely on more sophisticated numerical solution procedures.

In our framework, there are two forces that determine the outcome. The first force is the one that an increase in income will lead to an increase in savings. This channel is missing if the debt levels are fully determined by the borrowing constraint. The second force is the penalty term. This force is similar to the effects of the borrowing constraint. In particular, if the penalty term is very steep then the predictions of the model will be

like the predictions of the model with an always binding constraint. Consider again an increase in the income levels of the savers, i.e., the old. If the penalty term only depends on the debt level, then an increase in income of the old will lead to a *reduction* in debt levels. How large the change will be depends on the specification of the penalty term. If it is very steep then there will be only a small reduction, similar to the prediction of the model with the constraint. Now consider the case in which the income of the young increases. The most interesting case is the one in which the penalty term depends on debt levels relative to income. In the model with an always binding borrowing constraint, an increase in income leads to a proportional increase in debt. In our framework, debt could decrease as well as increase. The standard consumption smoothing argument pushes debt levels down, but the increase in income also pushes the lending spread down for given debt levels. If the penalty term increases sharply with debt relative to income then the second argument dominates and debt levels would increase like they do in the model with an always binding borrowing constraint.

**Financial innovation.** We now analyze the effects of financial innovation in the standard framework, with patient and impatient agents and an always binding borrowing constraint, and in the new framework, with young and old agents and a varying lending spread. We will analyze how financial innovation affects the responsiveness of debt to (permanent) changes in the income levels of the borrowers. In the model with borrowing constraints, financial innovation is modelled as a relaxation of the constraint. In the new framework, financial innovation is modelled as a reduction in the spread between borrowing and lending rates.

The fact that production is exogenous makes it trivial to predict how financial innovation will affect the volatility of debt (and the consumption levels). If the borrowing constraint simply restricts the amount borrowed then financial innovation will only have an effect on steady state levels but will not affect sensitivities. The same is true if the borrowing constraint restricts debt relative to income, that is, both before and after financial innovation debt moves proportional to income. In the new framework, the predictions of the model on volatility is not that restrictive. In fact, volatility can increase as well as

decrease. In figure 16 we plot the spread as a function of debt before and after financial innovation. We consider two types of financial innovation. In both cases the spread drops at each amount of debt. In the first case the spread reduces proportionally and in the second the spread become lower but at some point the spread becomes steeper. This is not that implausible. The lowering of the spread may increase the number of riskier borrowers and this leads banks to increase the spread by relatively more when debt levels increase. The two types of financial innovation are calibrated to result in the same equilibrium, that is, after financial innovation there is more debt and a lower spread between borrowing and lending rates.

Now consider the effect financial innovation on the responsiveness of debt to changes in income levels. Before financial innovation a 1% decrease (increase) in income leads to a 3.1% increase (3.5% decrease) in debt levels. For a 10% increase these numbers are 21.7% and 92.8%.<sup>18</sup> Note how the asymmetry increases with the size of the shock. How the responsiveness of debt changes depends a lot on how financial innovation takes place. First consider the case in which the spread curve simply is scaled down. For a 1% decrease (increase) in income we now observe a 3.5% increase (4.0% decrease) in debt levels, so volatility has increased somewhat. For a 10% change these numbers are 22.5% and 120.8%. Thus, financial innovation leads to somewhat larger responses in debt levels. The moderate increase in volatility is due to the flattening of the penalty term at the equilibrium debt level.

Now consider the effect of financial innovation when the penalty term not only drops but also becomes steeper. Now a 1% decrease (increase) in income leads to a 0.06% increase (0.095% decrease) in debt levels. That is, there is a drastic reduction in volatility. For a 10% change in income, these numbers are equal to 0.23% and 117%. That is, there still is a drastic reduction in volatility for shocks that increase the demand for debt but not for shocks that decrease the demand for debt.

This numerical example is based on quite arbitrary parameter values. But it illustrates clearly that the effects of financial innovation on volatility are not clear cut even in this

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<sup>18</sup>Percentage changes are calculated as the change in the log levels.

extremely simple model. That is, not if the friction is modelled with a penalty term. If the friction are modelled with a borrowing constraint then the predictions of financial innovation are clear cut and follow basically directly from how one specifies the borrowing constraint.

The key question that remains is how financial innovation has affected the penalty term. It may be possible to gain insight in this question by obtaining explicit information on the lending spread before and after financial innovation. An alternative approach would be to enter to model the intermediation in more detail and endogenize the lending spread. The life-cycle framework adopted here is because of its simplicity still be useful for this richer model with an explicit model of the financial intermediary as well.

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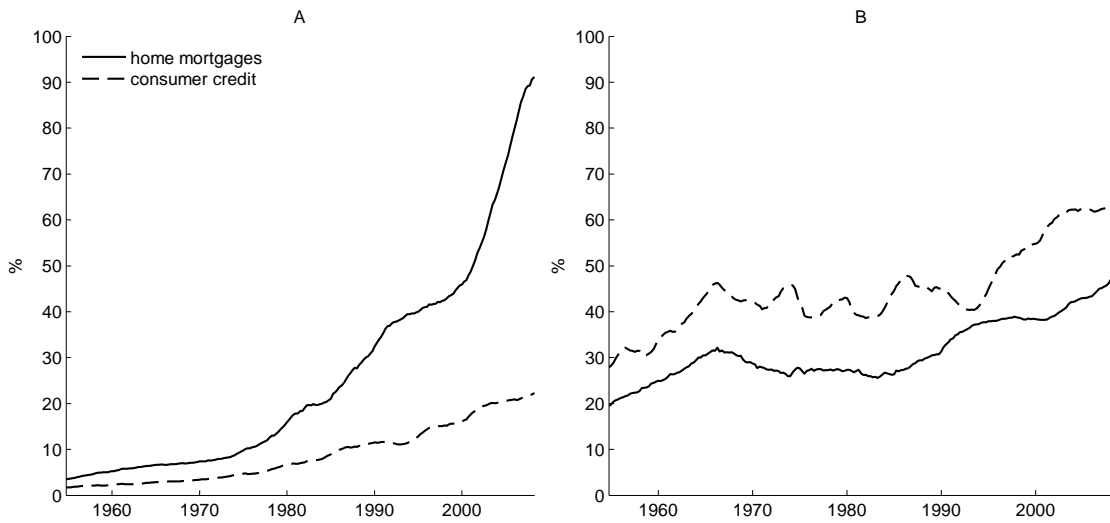
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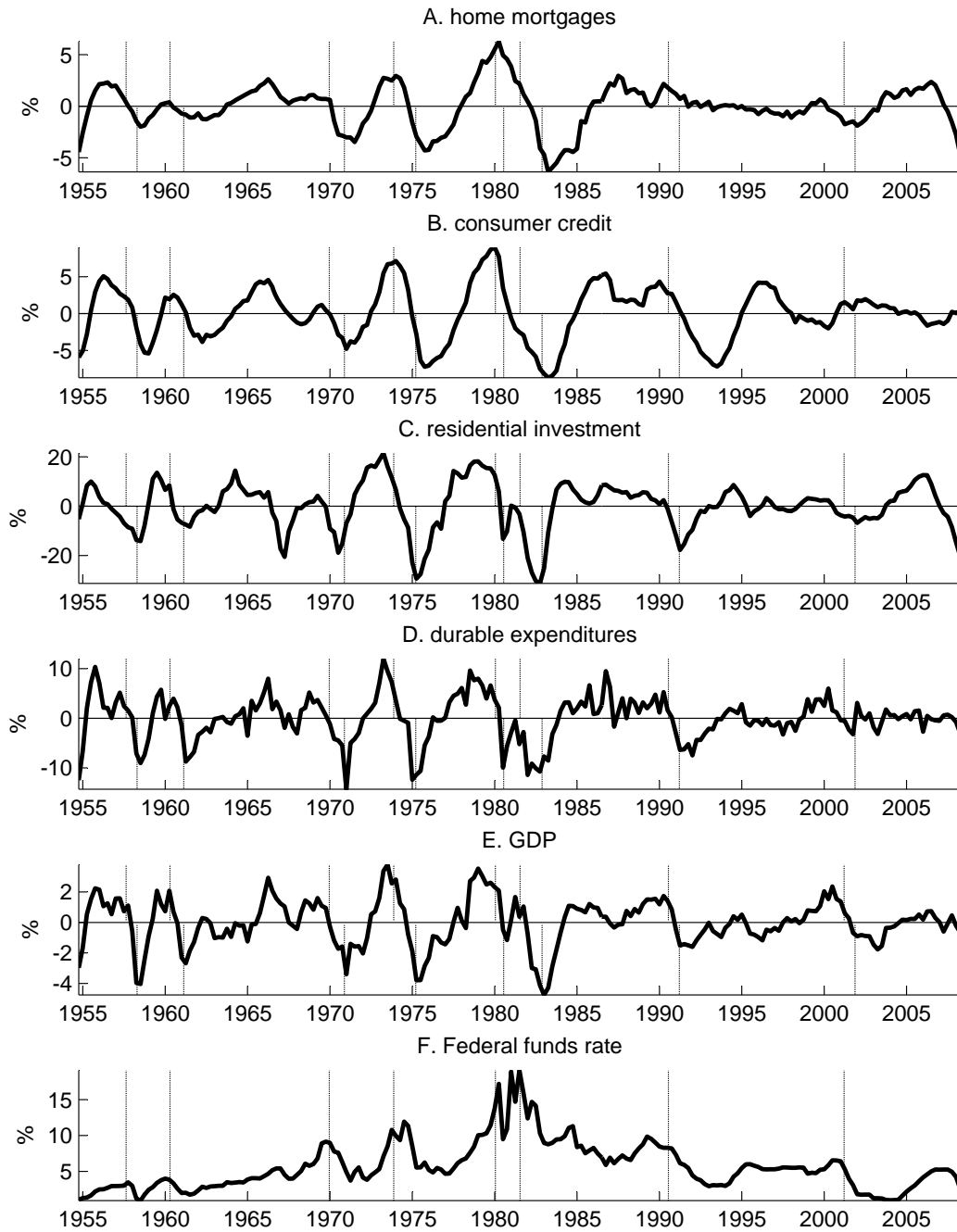
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Figure 1: Household loans



Notes: Panel A of this figure plots the loan variables as a percentage of GDP. Panel B plots home mortgages and consumer credit as percentages of respectively the value of real estate and the value of durables owned by households and nonprofit organizations.

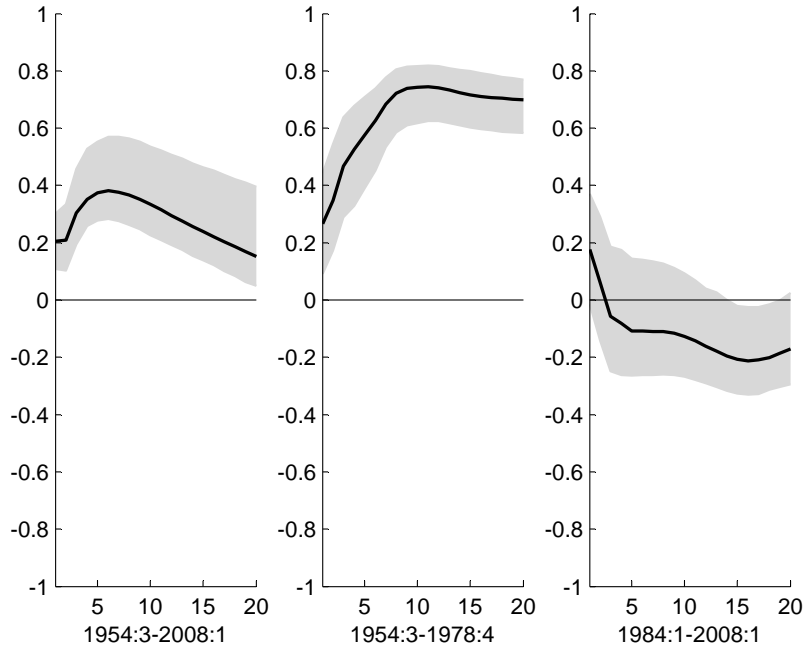
Figure 2: Cyclical components



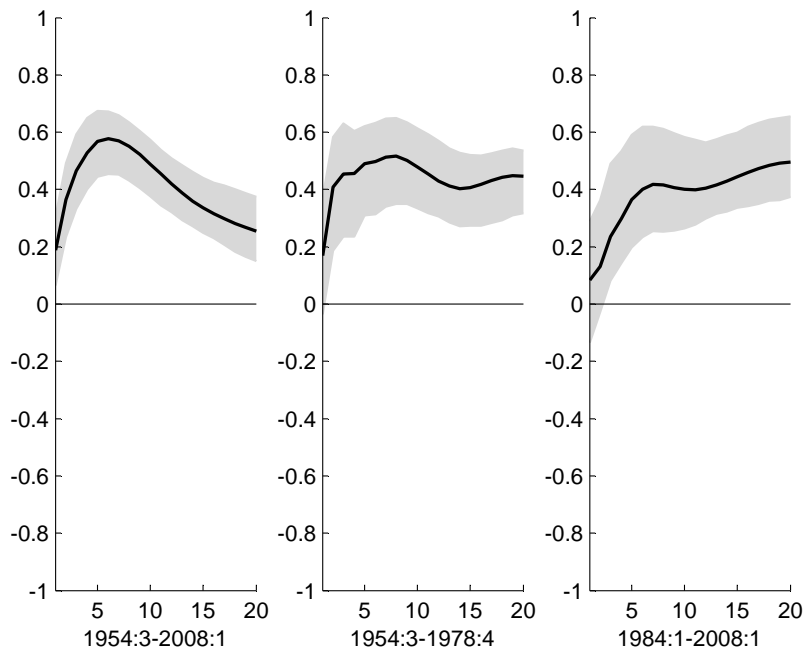
Notes: These graphs plot the cyclical components of home mortgages, consumer credit, residential investment and durable expenditures (blue lines). Each panel also plots the cyclical component of GDP (dashed line) and the Federal funds rate. Cyclical components are calculated using the HP filter with  $\lambda = 1600$ .

Figure 3: Comovement between home mortgages and real activity.

A. Correlation between home mortgages and GDP



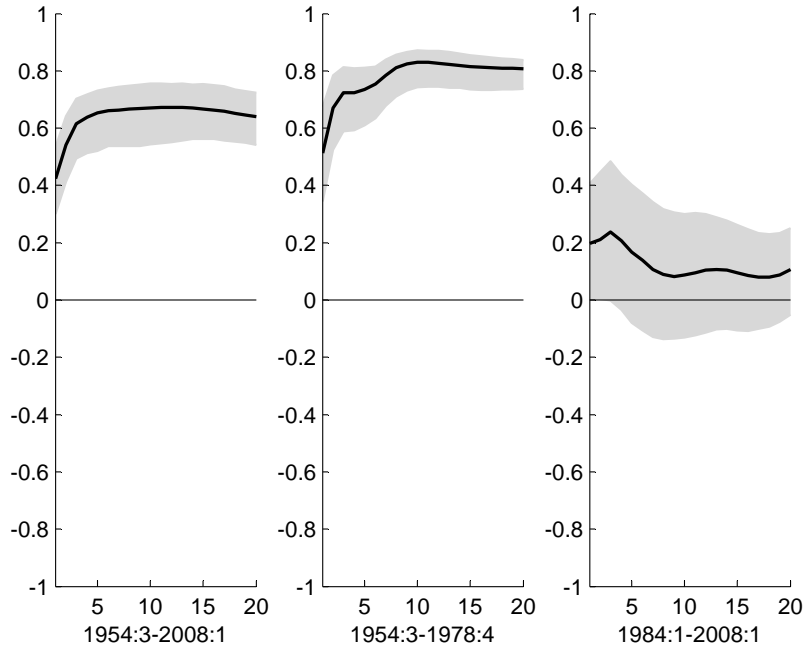
B. Correlation between home mortgages and residential investment



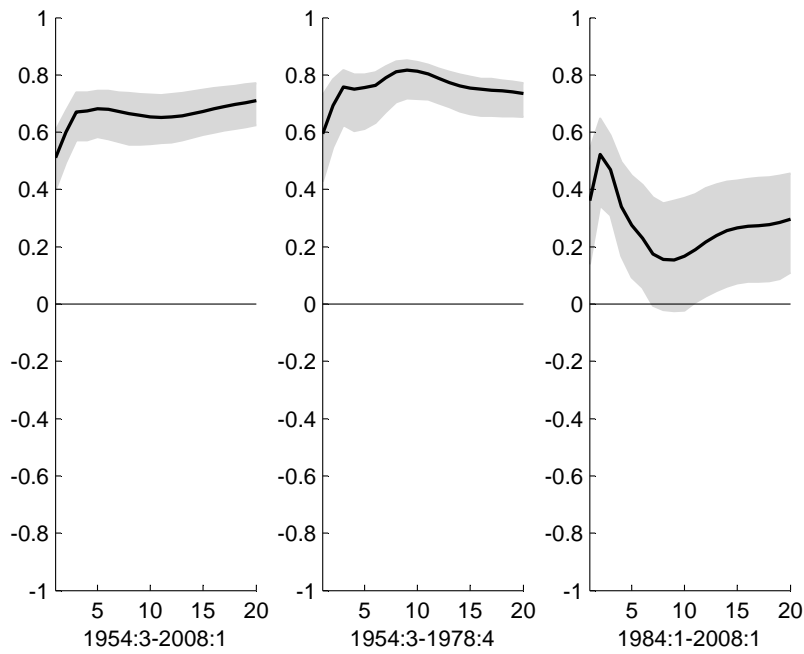
Notes: Correlation and covariance of forecast errors of home mortgages and GDP in the benchmark VAR.

Figure 4: Comovement between consumer credit and real activity.

A. Correlation between consumer credit and GDP

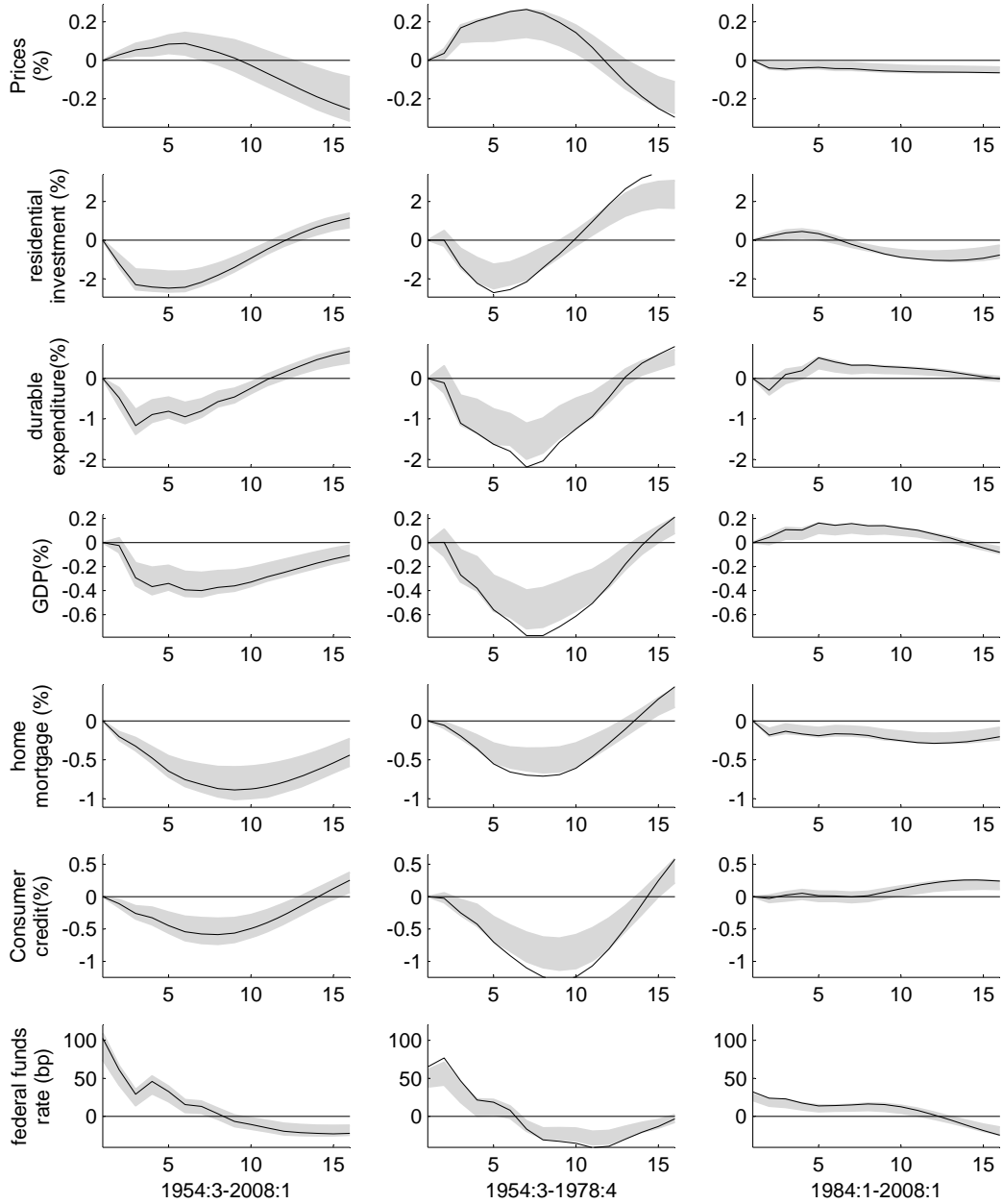


B. Correlation between consumer credit and durable expenditures



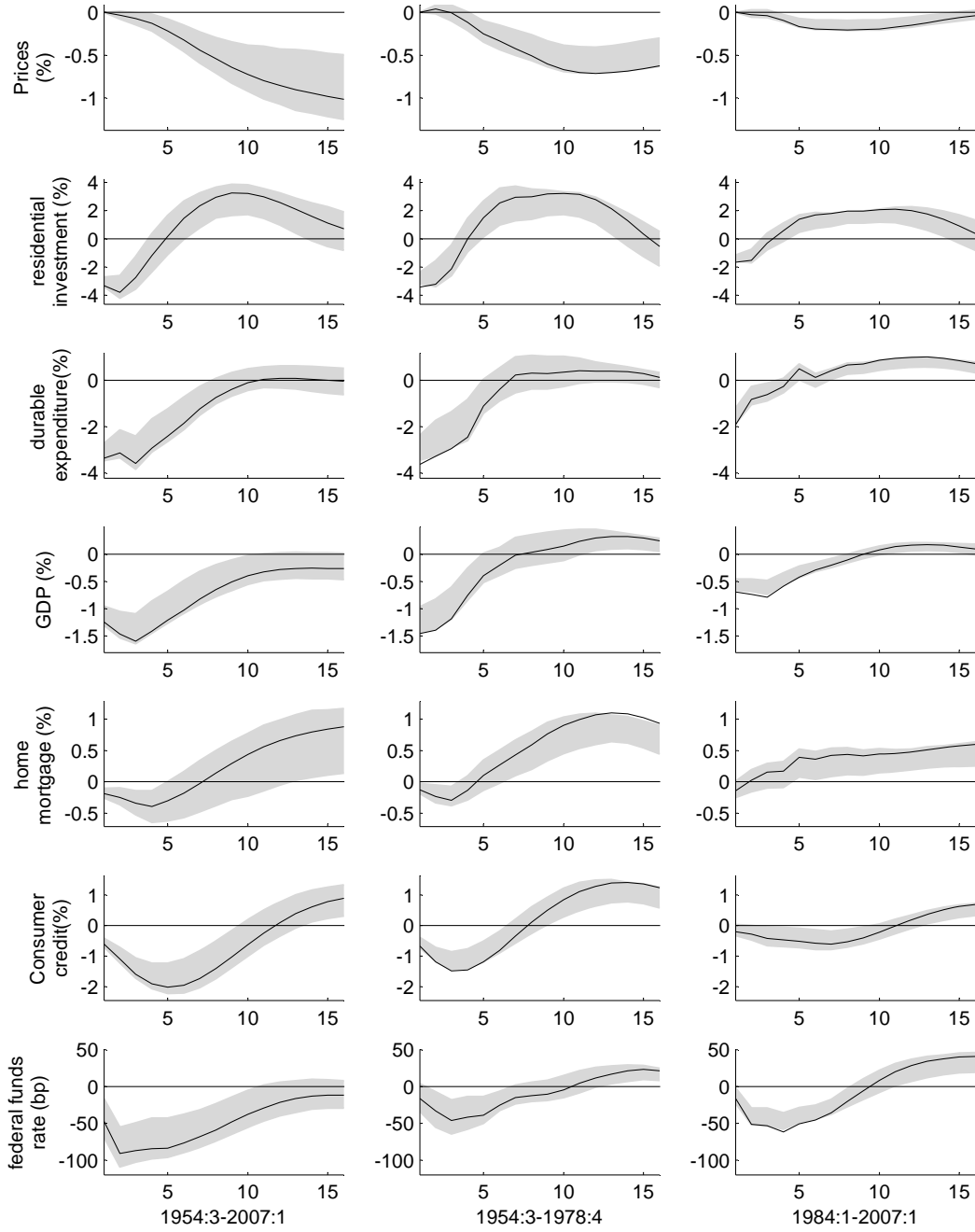
Notes: Correlation and covariance of forecast errors of consumer credit and GDP in the benchmark VAR.

Figure 5: IRFs following a monetary tightening



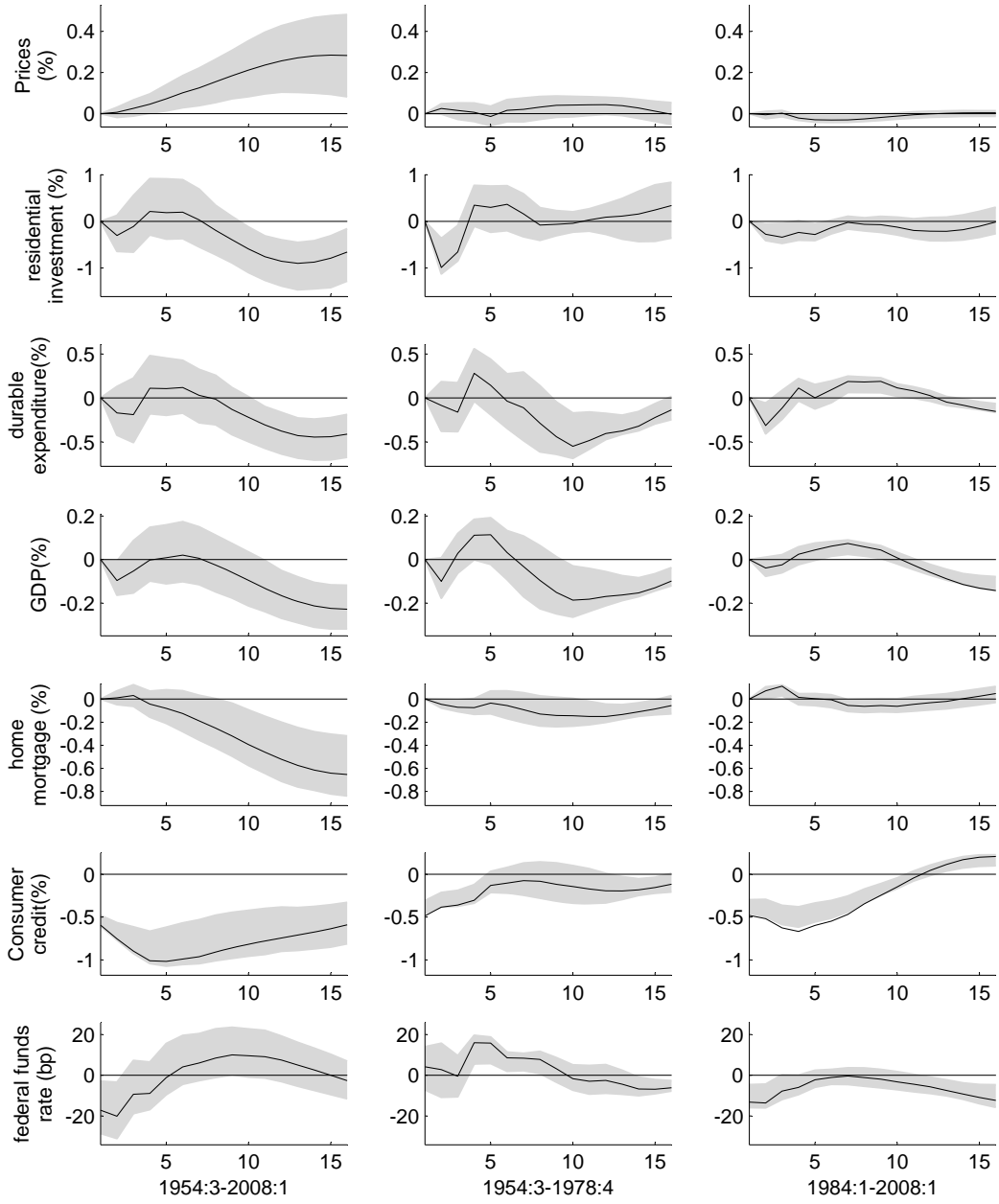
Notes: Responses to a one standard deviation shock in the federal funds rate.

Figure 6: IRFs following a real activity shock



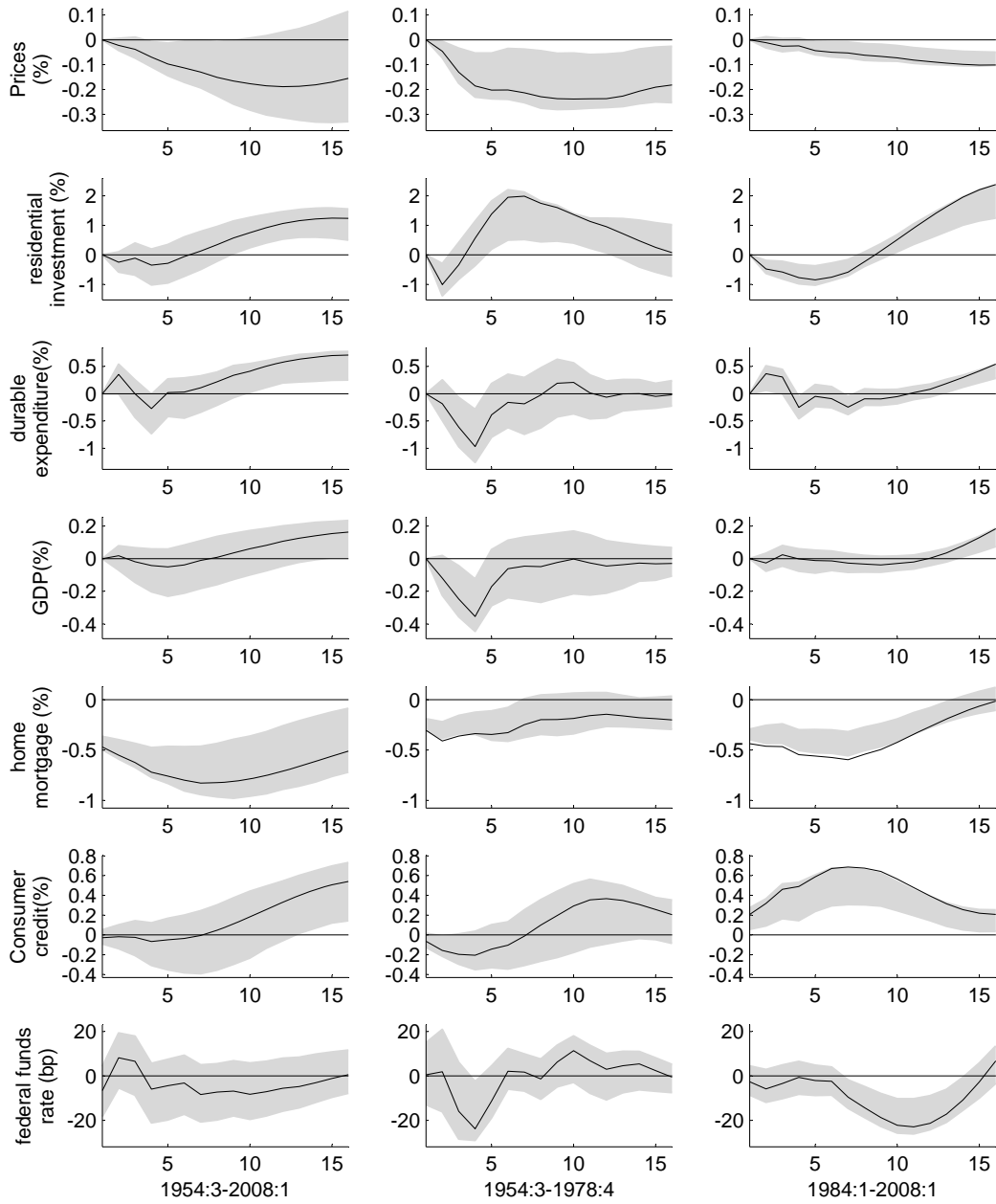
Notes: Responses to a simultaneous one standard deviation shock in residential investment, durable expenditures and GDP.

Figure 7: IRFs following a consumer credit shock



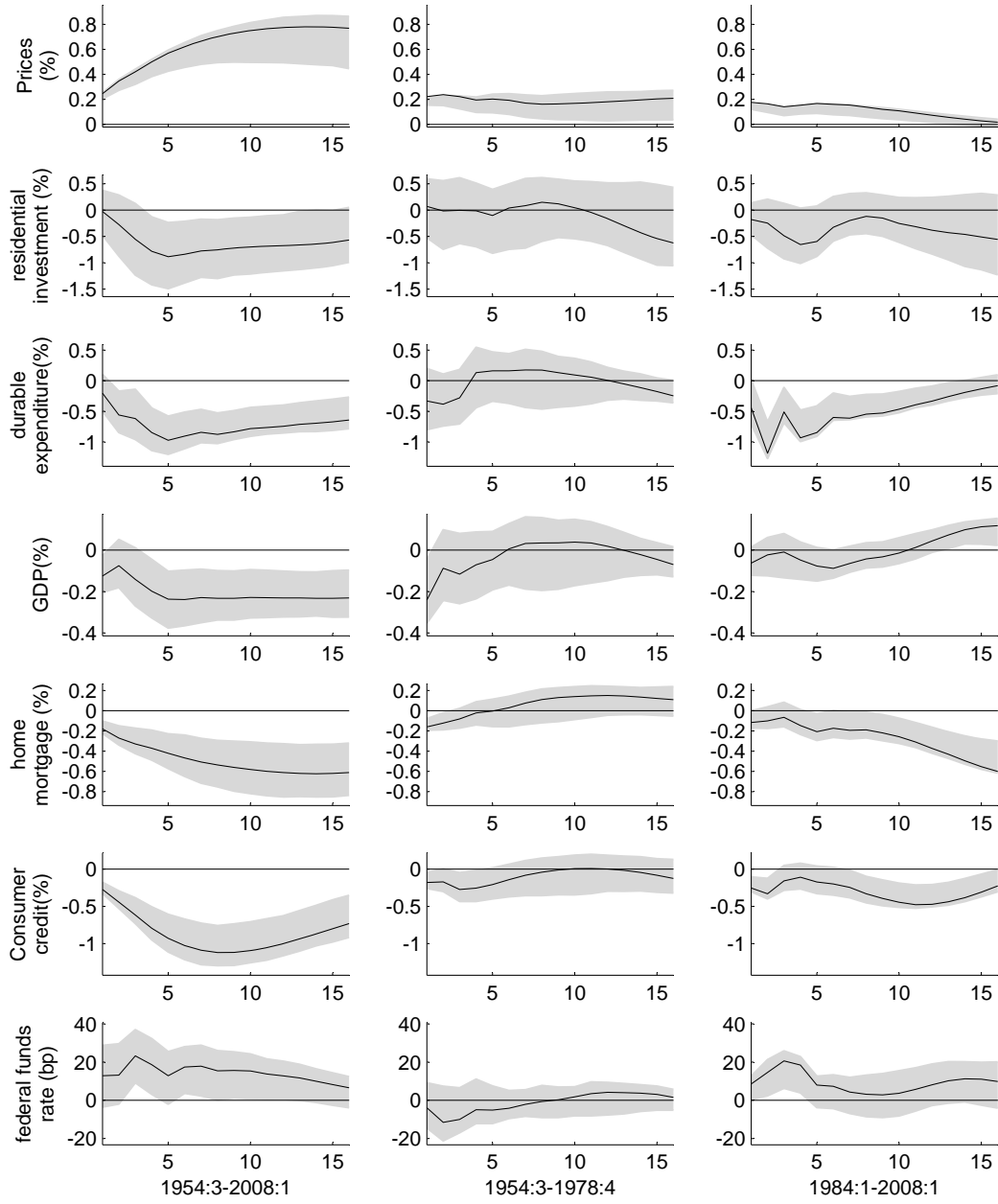
Notes: Responses to a one standard deviation shock in home mortgages.

Figure 8: IRFs following a home mortgage shock



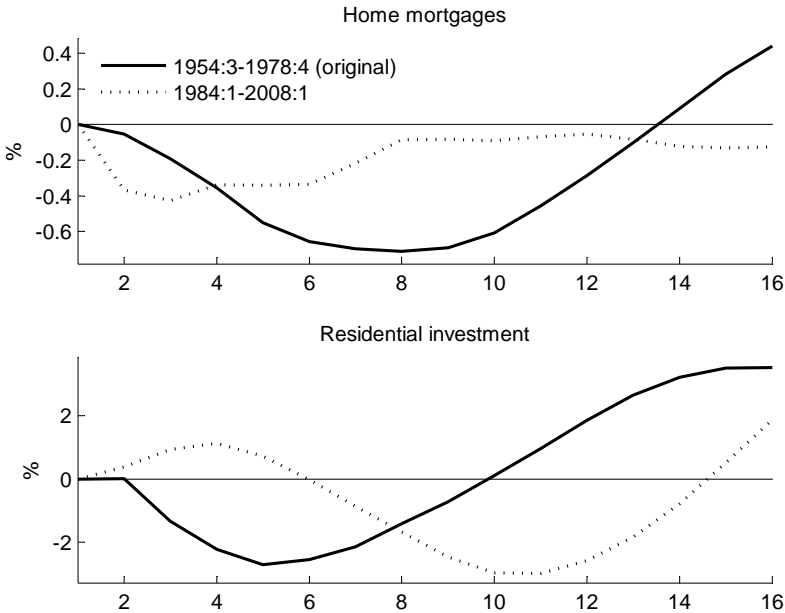
Notes: Responses to a one standard deviation shock in consumer credit.

Figure 9: IRFs following a price level shock



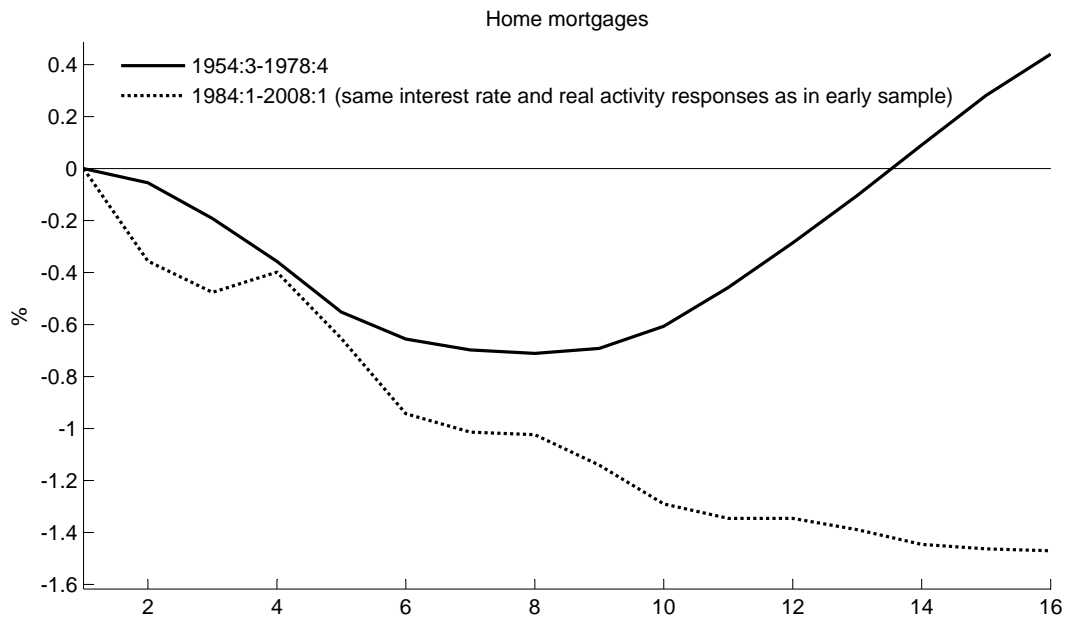
Notes: Responses to a one standard deviation shock in the price level.

Figure 10: IRFs of home mortgages and residential investment (with same interest rate response as in early sample)



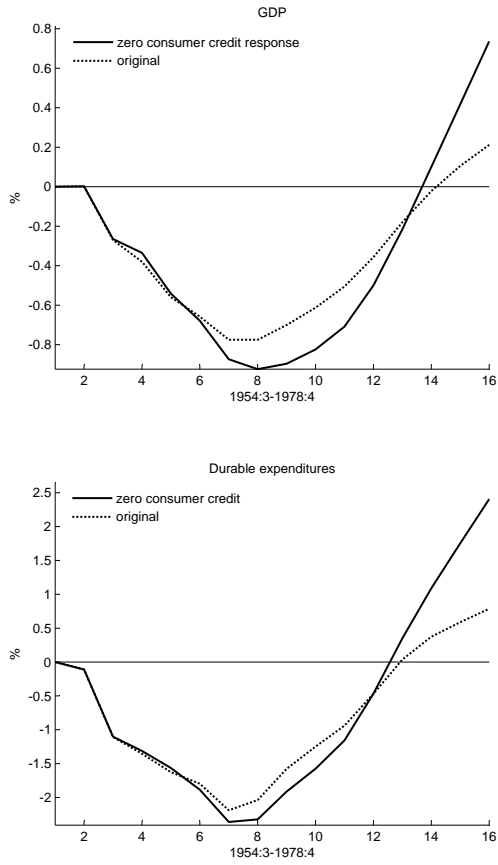
Notes: This figure plots the IRF of consumer credit in the first sample following a monetary tightening and the IRF of consumer credit in the second sample when the economy faces a sequence of monetary policy shocks such that the IRF of the federal funds rate is identical to the one observed in the first subsample.

Figure 11: IRFs of home mortgages  
(with same interest rate and real activity responses as in early sample)



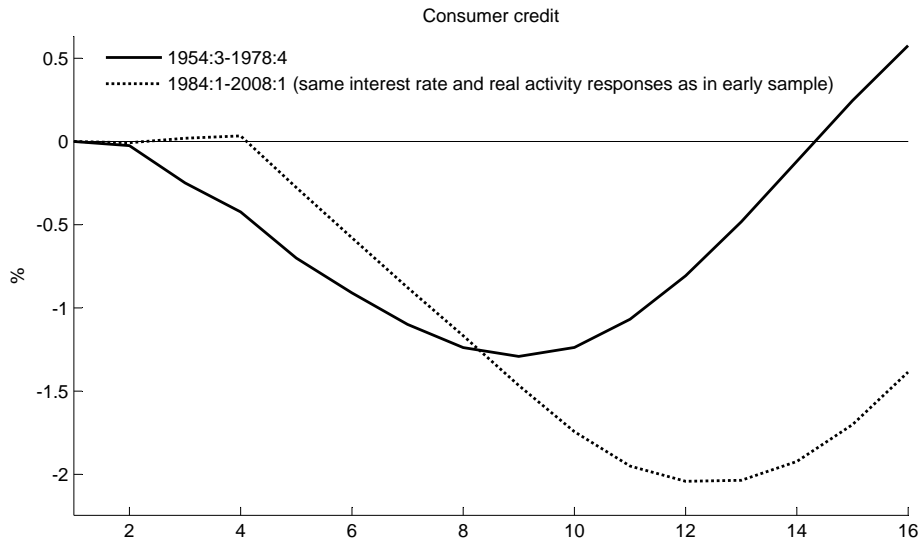
Notes: This figure plots the IRF of home mortgages in the first subsample following a monetary tightening and the IRF of home mortgages in the second subsample when the economy faces a sequence of monetary and real activity shocks such that the response of the federal funds rate and real activity variables are identical to those observed in the first sample.

Figure 12: IRFs of durable expenditures and GDP  
(consumer credit remains constant)



Notes: These IRFs are constructed by simply setting the response of consumer credit equal to zero each period.

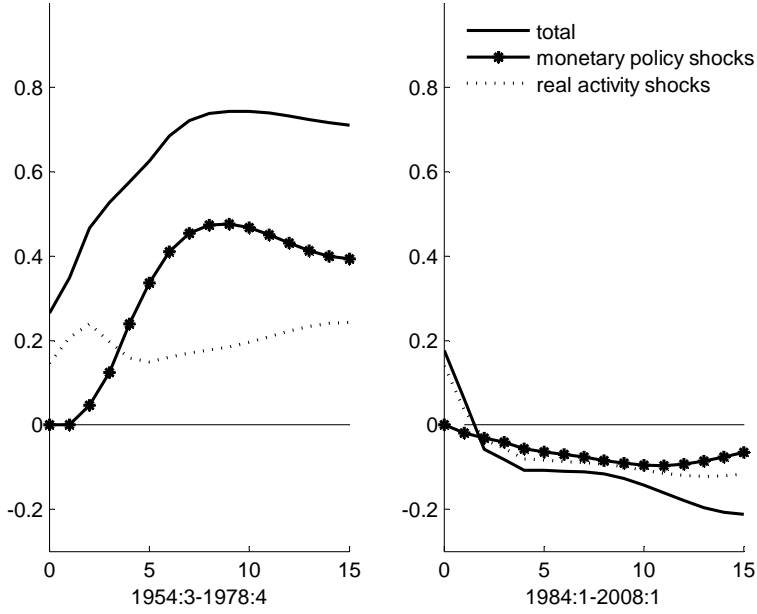
Figure 13: IRFs of consumer credit  
(with same interest rate and real activity responses as in early sample)



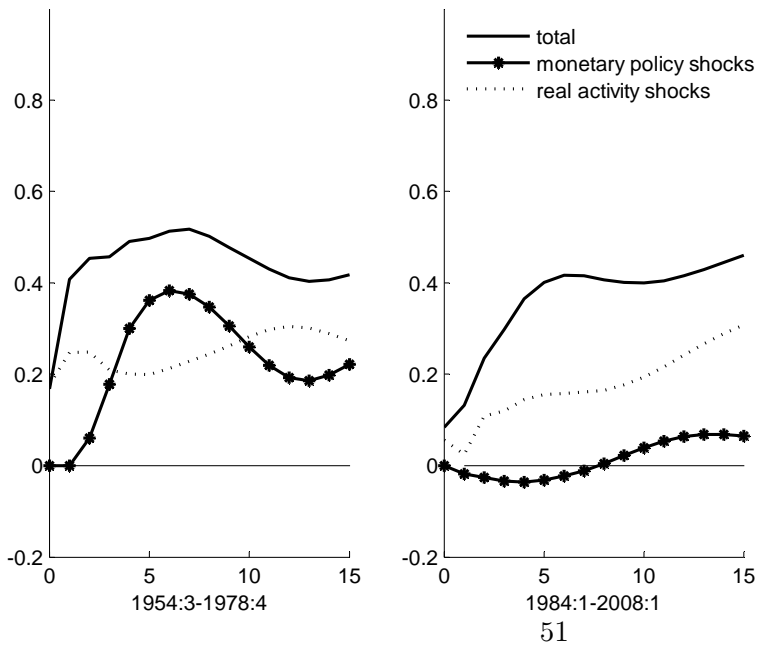
Notes: This figure plots the IRF of consumer credit in the first subsample following a monetary tightening and the IRF of consumer credit in the second subsample when the economy faces a sequence of monetary and real activity shocks such that the response of the federal funds rate and real activity variables are identical to those observed in the first sample.

Figure 14: Comovement between home mortgages and real activity.

A. Correlation home mortgages and GDP



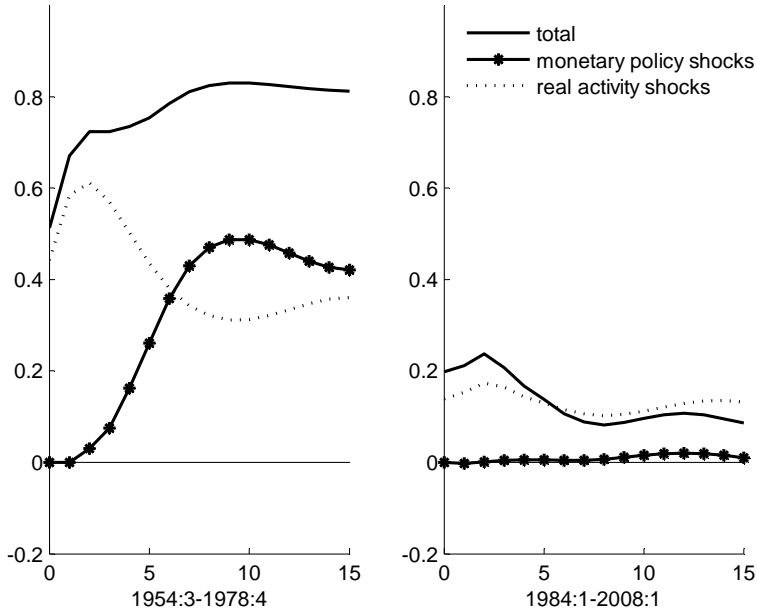
B. Correlation home mortgages and residential investment



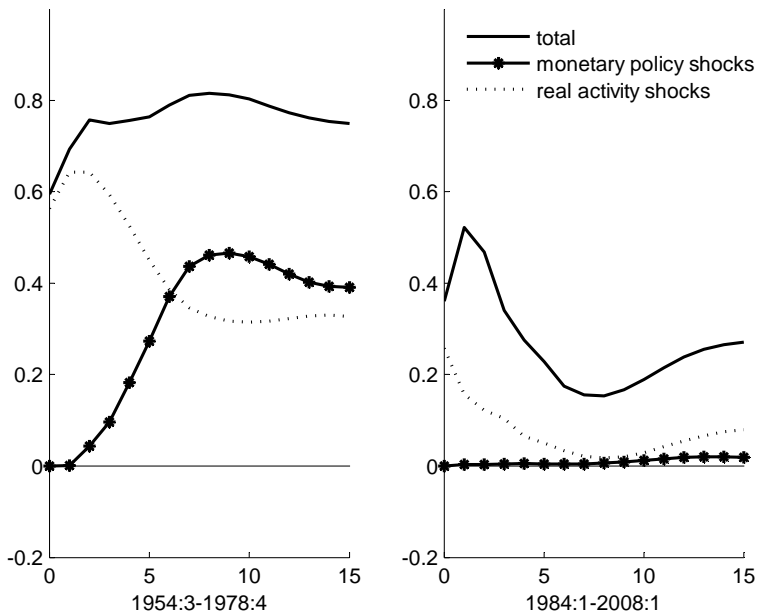
Notes: Correlation of forecast errors according to the benchmark VAR. The graph also indicates the role of the two shocks that contribute the most to the correlation coefficient.

Figure 15: Comovement between consumer credit and GDP.

A. Correlation consumer credit and GDP

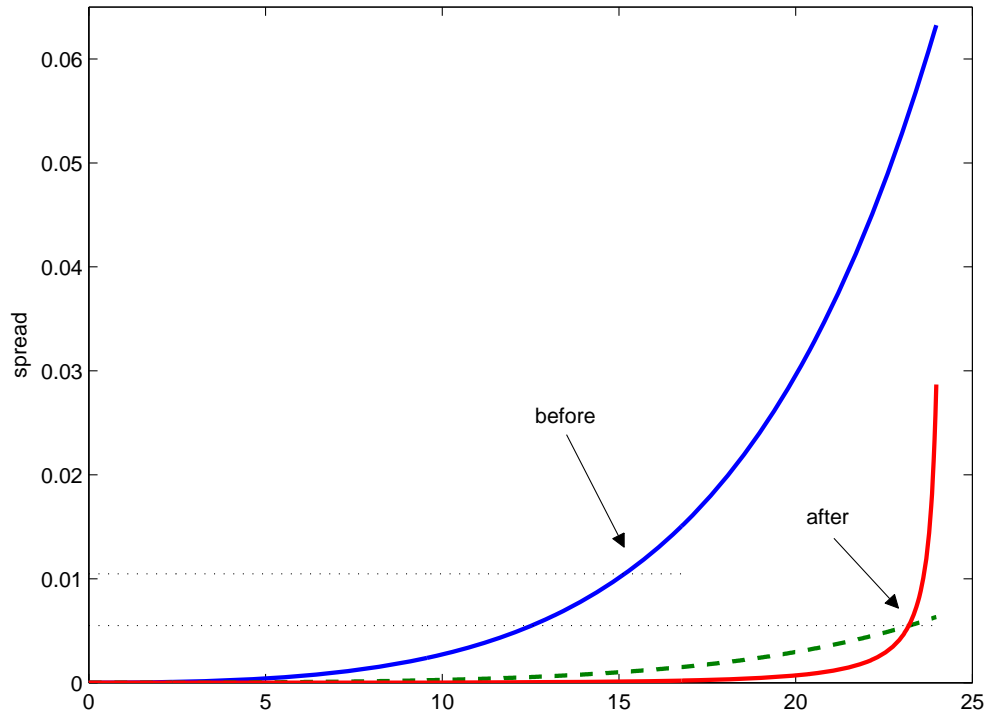


B. Correlation consumer credit and durable expenditures



Notes: Correlation of forecast errors according to the benchmark VAR. The graph also indicates the role of the two shocks that contribute the most to the correlation coefficient.

Figure 16: Equilibrium before and after financial innovation



Notes: This graph plots the lending spread as a function of debt and the equilibrium spread before financial innovation and after financial innovation for two different types of financial innovation.

Table 1: Standard Deviations (in %)

	'54:3-'08:1	'54:3-'78:4	'84:1-'08:1	change
Home mortgages	2.10	1.89	1.53	19%
Consumer credit	3.64	3.60	2.83	21%
GDP	1.53	1.75	0.89	49%
Residential investment	9.75	10.73	6.33	41%
Durable expenditures	4.48	5.21	2.83	46%

Notes: The table reports the standard deviation of the cyclical component of the indicated variable. In each sample, the trend used to construct the cyclical component is obtained by applying the HP filter over the whole sample.

Table 2: Correlation coefficients

	GDP	R.I.	D.E.	H.M.	C.C.
'54:3 - '08:1					
GDP	1				
Residential Investment	0.62	1			
Durable Expenditures	0.81	0.72	1		
Home Mortgages	0.63	0.39	0.44	1	
Consumer Credit	0.65	0.39	0.57	0.68	1
'54:3 - '78:4					
GDP	1				
Residential Investment	0.59	1			
Durable Expenditures	0.87	0.69	1		
Home Mortgages	0.81	0.48	0.70	1	
Consumer Credit	0.74	0.41	0.64	0.92	1
'84:1 - '08:1					
GDP	1				
Residential Investment	0.48	1			
Durable Expenditures	0.63	0.57	1		
Home Mortgages	0.05	0.32	0.10	1	
Consumer Credit	0.18	0.01	0.31	0.12	1

Notes: The tables reports the correlation between the cyclical component of the indicated variable and the cyclical component of GDP. In each sample, the trend used to construct the cyclical component is obtained by applying the HP filter over the whole sample.