Tax Shocks, Financial Channels, and Changes in Output

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Abstract In this paper, I revise prior explanations for the differing response of the U.S. economy to tax shocks in the 1952-1980 and 1980-2007 sub-periods. I find the Fed is more likely to accommodate tax shocks after 1980. Also, consumption smoothing likely does not explain the change between sub-periods; rather, the shifting effect of tax shocks is driven by the fact that tax policy targets low and middle income households before 1980 and high income households after 1980. This suggests the change between sub-periods reflects different fiscal policy choices, not a change in the response of the economy to revenue shocks.

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1 Introduction

In this paper I examine the ways in which the components of output, monetary policy variables and financial variables respond to tax shocks. Following the work on the response of sector balance sheets to monetary policy shocks by Christiano, Eichenbaum, and Evans (CEE, 1996) and using the identification procedure outlined in Perotti (2012) I investigate the response of various Flow of Funds series to tax shocks. In addition to exploring the response of the balance sheets of households, businesses, the financial sector, and the government to tax shocks I examine the response of consumption and investment to fiscal policy shocks. lastly, I also use the Flow of Funds as well as interest rate data to explore the response of the Federal Reserve to tax shocks. Of particular concern in this paper is establishing possible explanations for the changing response of the economy to fiscal policy shocks after 1980. This change has been a strain of investigation in the literature since Roberto Perotti (2005) established a structural break in the response of the economy to fiscal policy shocks in first quarter of 1980.

In line with Perotti (2005) and Romer and Romer (RR, 2010) I find that there is a weaker response of output to tax shocks after 1980. The weaker response is reinforced by my finding that components of GDP also respond more weakly to tax shocks after 1980. Before 1980 a positive tax revenue shock produces a multiplier of about -4[1]. After 1980 the multiplier is reduced to a little more than -1.5[2]. RR suggest the hypothesis that the change in the output response is driven by a change in monetary policy regime. They suggest that monetary policy responds more strongly to counteract fiscal policy shocks after 1980. Both Perotti and RR also pose an alternative hypothesis that the weaker response to fiscal policy shocks after 1980 is driven by the fact that households have a greater ability to consumption smooth in response to a tax shock because they have better access to financial services after 1980.

My results show that monetary policy is not the source of the smaller re-

[1]RR find a multiplier of -4.29 for this earlier period and Perotti finds a response of -1.01

[2]RR find that after 1980 the multiplier is -3.08 and Perotti finds that output actually increases with a multiplier of .69

sponse of output to fiscal policy shocks. Contrary to conventional wisdom about the evolution of monetary policy, the federal funds rate (both nominal and real) falls before 1980 in response to a positive tax shock. After 1980 the federal funds rate increases in response to positive tax shocks. The response of the Fed's balance sheet across the subperiods corroborates these findings. These changes in the federal funds rate suggest that the Federal Reserve was more likely to counteract fiscal policy shocks—that is, to pursue monetary policy that contradicted fiscal policy changes—before 1980 and to accommodate fiscal policy shocks after 1980. This shift in the relationship between fiscal and monetary policy from a regime in which monetary authorities were hostile to tax shock before 1980 to one in which policy was coordinated to move in the same direction is a new finding in the literature.

The second explanation that has previously been offered for the decline in the response of output tax shocks is that households after 1980 had greater access to the financial system and so had a greater ability to consumption smooth when faced with income changes induced by a tax shock. If this is true and households are smoothing consumption in response to a tax shock, then one would expect tax changes to primarily manifest themselves in changes in savings behavior. On balance, I argue that there is some weak evidence to support this theory. There is certainly more churn on household balance sheets after 1980, particularly on the asset side. However, the effect of tax shocks on net assets held by households is smaller in the period 1980-2007 than in the period from 1952-1980. This is the opposite of what one would expect if the consumption smoothing argument holds. One component of the balance sheet that changes strongly after 1980 are liquid bank assets (M2) held by households. However, there is also a strong response of holdings of M2 by households, though smaller, before 1980. It is unclear that the decline in M2 holdings across sectors after 1980 is the result of consumption smoothing. Rather, there is evidence to support the idea that that change in M2 is a reflection of changes in mortgage lending on the other side of the financial sector's balance sheet after 1980. One other piece of evidence not in favor of the consumption smoothing hypothesis is that there is also evidence to suggest the

decline in M2 is driven by a change in sector balance sheets towards less liquid assets in response to a tax shock. One would expect balance sheet holdings to change in favor of shorter term and more liquid assets and liabilities.

I propose an alternative explanation—related but more general than the consumption smoothing hypothesis—for why the economy responds less to tax shocks after 1980. The emphasis of tax policy shifts significantly towards adjusting marginal tax rates as the main federal tax policy instrument after 1980. Before 1980 the RR tax shocks are largely comprised of adjustments to social security and excise taxes. After 1980 the RR tax shocks are mostly adjustments to marginal tax rates. This is related to the consumption smoothing hypothesis, particularly if one thinks of the change between subperiods as reflecting a shift in the *types* of households impacted by the exogenous tax policy changes. In the discussion section of this paper I offer some evidence that tax policy after 1980, particularly that caught by the RR series, more heavily targets high earnings households. These households are more likely to have access to financial resources that allow them to smooth economic activity in response to tax shocks. This added nuance to the "increased liquidity" explanation for the diminished effect of tax shocks has important policy implications. It is important to point out, that the "regime shift" explanation is not dependent on consumption smoothing, for which the evidence is weak. However, if, as argued by Perotti and RR, the diminished effect can be explained by an across the board shift in access to financial resources, that implies a structural change in the efficacy of tax policy after 1980 towards a more "Ricardian" world. However, if tax policy is less effective simply because policy makers have chosen policies that have a smaller impact on the economy, then the two subperiods reflect different policy regimes and the responses of output to tax shocks are the result of different choices from a menu of tax policy options.

The VAR model utilized here also allows me to establish a number of other empirical facts. This VAR model combines the RR narratively identified exogenous tax shocks series—tax shocks identified by culling the historical record—and a control, developed in Perotti (2012) to eliminate bias in the estimates of response to tax shocks from the noise of revenue changes that

cannot be attributed to the exogenous shocks or changes in output.

First, there is some evidence that tax increases cause federal deficits to increase before 1980. This is likely due to the strong decline in private economic activity in response to the tax shocks. This "business cycle" effect of tax revenue changes on output probably has the unintended second order effects of lowering tax revenue collected. After 1980 tax increases have the expected effect of shrinking Treasury bonds outstanding. To be clear, these impulse response shocks are symmetric with respect to the sign of the shock so this also means that before 1980 tax cuts cause Treasury bonds outstanding to decline and after 1980 tax cuts cause the Federal government to borrow more. Federal tax revenue shocks also cause changes in sector holdings of other government liabilities, namely GSE liabilities and municipal bonds. After 1980 a positive tax shock increases the amount of GSE securities outstanding. In the pre-1980 period households respond to positive tax shocks by primarily liquidating GSE securities. After 1980 households respond to revenue increases by selling off municipal bonds. The response of household holdings of government liabilities is stronger in general after 1980.

Second, the change in household mortgage borrowing follows roughly the same pattern as the change in residential investment before 1980. After 1980 there is a large disconnect between the response of mortgage borrowing and changes in residential investment in response to a tax shock. Before 1980, a positive tax shock causes both residential investment and mortgage borrowing to fall initially, but then increase after twelve quarters. However, after 1980 a positive tax shock causes a decline in residential investment, though the response is of a smaller magnitude than before 1980. Also of note, after 1980 the response of mortgage borrowing is about 4.5 times larger after 12 quarters than the response in residential investment, but the response of mortgage borrowing is not significant. Much of the change in household mortgage liabilities due to tax shocks after 1980 can be explained by the housing boom of the mid 2000s.

2 Methodology

The recent literature on the effects of fiscal policy shocks has for the most part been concerned with the credible identification of shocks. Researchers that study fiscal policy shocks are approaching a consensus that narrative identification—the establishment of exogenous shocks by a close examination of the historical record—is a key identification strategy. The seminal paper by RR (2010) establishes a series of narratively identified shocks—culled from the historical record—that have become the baseline series for testing the impact of tax revenue shocks on output.

Perotti (2012) has called attention to the problem of identifying the response of output to tax shocks when there is idiosyncratic noise in the tax revenue series that is distinct from the "discretionary" tax shocks of RR and the response of tax revenue to changes in output. Equation 1 breaks down the response of tax revenue changes into three components: exogenous shocks, the response of revenue to output, and the idiosyncratic "noise" that cannot be accounted for by the other two variables

$$s_t = d_t + \eta y_t + \mu \tag{1}$$

Where s_t is the log change in tax revenues, y_t is the log change in output, d_t denotes discretionary tax changes [3] and μ is a random error term, assumed to be i.i.d. with a zero mean and uncorrelated with d_t. The η term, is the elasticity of tax revenue to changes in output. RR propose a "narrative" procedure for identifying d_t. Their d_t series comes from an examination of the historical record to establish moments in which discretionary tax changes can be considered exogenous to changes in the overall economy. The empirical issue Perotti highlights is that empirical models that incorporate these RR revenue shocks have not done an adequate job of controlling for μ, which can bias results. He proposes a simple adjustment to the vector autoregressive model to

[3] To be exact, d_t is an unexpected discretionary tax changes at time t. I assume for this paper—following Perotti—that the discretionary tax changes (detailed bellow) are unanticipated.

control for the idiosyncratic shocks. With the combination of RR narratively identified shocks and the Perotti adjustment there is now a compelling procedure for identifying the effect of fiscal policy shocks on the economy. This paper employs this hybrid identification strategy in Perroti to identify exogenous revenue shocks. As Perotti explains, the identification problem can be articulated as such:

Take a simple AR(1) regression of tax revenue on output:

$$y_t = \alpha y_{t-1} + \gamma_1 d_t + \gamma_1'(s_t - d_t) + \gamma_2 d_{t-1} + \gamma_2'(s_{t-1} - d_{t-1}) + \epsilon_t \tag{2}$$

Where I remind the reader that $s_t - d_t = \eta y + \mu$. If one assumes that $\gamma_i = \gamma_i'$ then

$$y_t = \alpha y_{t-1} + \gamma_1 s_t + \gamma_2 s_{t-1} + \epsilon_t \tag{3}$$

Here, changes in output only depends on changes in total revenues as all components of revenue effect output the same. Similarly if $\gamma_1' = \gamma_2' = 0$ then equation 2 reduces to

$$y_t = \alpha y_{t-1} + \gamma_1 d_t + \gamma_2 d_{t-1} + \epsilon_t \tag{4}$$

In equation 4 changes in output only depends on exogenous shocks as measured by the narrative series. However, the more general case, in which $\gamma_i \neq \gamma_i'$ or $\gamma_1' \neq \gamma_2' \neq 0$ we get:

$$y_t = \Theta(\alpha + \gamma_2'\eta) y_{t-1} + \Theta\gamma_1 d_t + \Theta\gamma_2 d_{t-1} + \Theta\gamma_1'\mu_t + \Theta\gamma_2'\mu_{t-1} + \Theta\epsilon \tag{5}$$

Where $\Theta = \frac{1}{1-\gamma_1'\eta}$. Here, an empirical specification that does not account for μ will suffer from omitted variable bias.

Perotti's proposed solution is to simply correct the omitted variable bias by adding an estimate of the μ series, what he calls an "instrument" for μ. To do this he uses an IV estimation of the following equation, which includes more relevant variables and more lags than in the simple illustrative Eq.1:

$$s_t = \alpha_0 + \eta y_t + \alpha_1 d_t + \alpha_2 \Delta i_t + \alpha_3 g_t + \alpha_4 \Delta \pi_t + \nu_t \tag{6}$$

Where d_t is the RR narrative series. The RR shocks are as a percent of output. The log change of output per capita is denoted by y_t, Δi_t is the one period change in the interest rate (discussed below), g_t is the log change of government spending per capita, and $\Delta\pi$ is the one quarter change in the inflation rate. The instruments used are lags 0 to -4 of d_t and lags -1 to -4 of the other independent variables. Estimating Equation 6 produces a series we can use to control for changes in tax revenue not accounted for by the variables included in the VAR estimates below. A four lag (-1 to -4) moving average of ν is used to construct the μ variable.

Peortti is agnostic on the appropriate VAR model to use, though he finds estimates across specifications produce similar results with the inclusion of μ. I take a similar approach, though for ease of exposition I use a simple model averaging technique following Buckland et al (1997) to produce a single estimate for each set of variables.

The procedure for testing the response of the menu of variables of interest—both for the components of GDP and the various Flow of Funds variables—is a simple one. Following CEE, I simply add the variable of interest to the baseline specifications described below. For purposes of the Choleski decomposition necessary for extracting shocks from the VAR specification, I order the variable of interest last. The these variables of interest are all the log difference of constant dollar variables.

There are four different VAR models used by Perotti. The first is what he calls the "augmented" RR VAR.

$$X_t = A(L)d_t + B(L)X_{t-12} + \mu_{t-12} + e_t \tag{7}$$

Where A(L) is of order 13 and B(L) is of order 4. As in all the model specifications, X contains all of the variables in equation 6 as well as a constant when testing the response of output, the federal funds rate, inflation and government spending. Elements of the flow of funds and the components of

GDP are appended to X individually when estimating their impulse response functions.

The second comes from Mertens and Ravn (MR 2012):

$$X_t = A(L)d_t + B(L)X_{t-1} + \mu_t + e_t \tag{8}$$

Where A(L) here is of order 5 and B(L) is of order 4.

The third is a simple VAR specification

$$X_t = B(L)X_{t-1} + \mu_t + e_t \tag{9}$$

Where d_t is included in the list of endogenous variables. Impulse responses are generated using a Choleski decomposition that orders d_t first. In VAR specifications that contain the components of GDP and Flow of Funds variables, those variables are ordered last.

Finally, a specification from Favero and Giavazzi (FG, 2011)

$$X_t = \alpha d_t + B(L)X_{t-1} + \mu_t + e_t \tag{10}$$

Where B(L) is of order 4. The FG specification also includes total government revenue in the list of endogenous variables. As well, the IV estimate of μ for the FG specification additionally includes lags 1 to 4 of total government revenue.

Table 1 shows impulse response estimates for the above four specifications—with the baseline variables discussed above—to a positive shock to tax revenue of 1% of GDP. The table show the results as reported by Perotti and my results[4].

Perotti follows FG in utilizing a measure of the cost of debt serving as the interest for Δi[5]. It is not obvious that this is the correct interest rate to use in

[4]My results are obviously slightly different than those reported in Perotti. It is not clear what data exactly was being used and I received no response from several attempts to contact the author. The difference are minor, and primarily seem to be in the timing of the peak response of output

[5]Interest payments by the federal government divided by the previous quarter's federal public debt level.

this context, in particular because, as FG show, debt servicing does not seem to factor into the impulse responses of output to revenue shocks very strongly. In Table 1 I also show the impulse response of output to revenue shocks when the federal funds rate is used as the interest rate. As is clear from the table, the federal funds rate reduces the response of output fairly significantly, from an average peak response of -2.44% to an average peak response of -1.86%.

The use of the federal funds rate instead of a debt servicing interest rate is justified for a number of reasons. First, there is no clear reason to believe that policy makers consider the cost of debt servicing when making policy decisions. This certainly does not seem to be the case starting in the 1980s, when both deficits and the cost of debt service increased in parallel. Second, of no small interest is the relationship between monetary and fiscal policy. New Keynesian models take the policy rate to be the central factor in determining the ability of fiscal policy to influence output(Woodford, 2010). Third, and relatedly, since much of the focus of this paper is on sector balance sheets it make sense to include the federal funds rate, since the federal funds rate has a more clear connection to borrowing and lending behavior in the private sector than the cost of Federal debt service.

The final two columns of Table 1 are relevant for the model averaging procedure by which I condense the four specifications to a single impulse response function. Following Buckland et al, I used the Akaike information criteria (AIC) form the underlying VARs of the impulse response functions to establish simple weights for each specification[6]. As the the final column of table 1 shows, the RR and MR specifications dominate the averaged response. This is a testament to good model design, as the two "uglier" models are better specifications according to the AIC[7] than the simpler, more elegant FG and VAR specifications. However, I include all four models because the cost of doing so is low relative even to the small amount of added information. The relative weights of the different specifications fluctuates depending on the additional

[6]Each model averaging bootstrap consists of 1000 repetitions.

[7]Neither the relative ranking or the weights changed very much when other information criteria are used.

variable added to the regressions, but there is a pattern of dominance of the RR and MR specification in the model averaging estimates.

3 Results

3.1 The Response of Output

Figure 1 shows the model averaged response of GDP and selected components of output to a tax revenue shock equal to 1% of output. The figure shows the response for the total postwar period as well as the before and after 1980 subperiods.

The response across subsamples varies significantly. First, as RR find, there is a much stronger response of output to tax changes before 1980 than after 1980. The magnitude of the different responses is also similar. Before 1980 an exogenous revenue cut would result in a peak multiplier of 4, while after 1980 an exogenous revenue cut would result in a multiplier of only 1.57.

Both Perotti (2005) and RR speculate that the multiplier effect after 1980 is smaller because of a reduced response of consumption to revenue changed. Figures 1b and 1c corroborate this though other components of GDP also show large differences in response to output shocks. Both residential and nonresidential investment show dramatic differences across periods. Nonresidential investment shows a very strong response to revenue changes before 1980, but shows essentially no response after 1980. Residential investment also shows significant differences between periods. Most striking is the change in signs across period. Before 1980, a 1% increase in tax revenue actually *increases* residential investment by about 1% of GDP three years after the initial shock. After 1980 residential investment shows the expected, negative, sign. The magnitude of the change to nonresidential investment is smaller after 1980 but its effect on the decline in output in response to a tax revenue shock is about as large as the contribution of personal consumption, which is also much smaller than the pre-1980 response. The response of net exports is not economically

significantly different[8] between periods.

3.2 The Response of Policy Variables

Table 2 shows the response of inflation, government spending, and the federal funds rate to a tax shock under the same baseline VAR specification in table 1. The inflation and federal funds rate values are responses in cumulative levels while the government spending variable is the accumulated response of government spending variables as a percent of GDP.

There are two striking things from Table 2. First, the response of inflation to tax shocks does not change across periods. Secondly, and relatedly, the results show that the federal funds rate is more likely to change much more significantly in the pre-1980 period than in the post-1980 period in response to a fiscal policy shock.

It is not obvious how to interpret the response of the nominal federal funds rate, so it is useful to also look at the ex post real federal funds rate. Table 3 shows estimates of the ex post real federal funds rate. I have adjusted the nominal rate in two different ways. First, I make an adjustment to the federal funds rate using the the annualized quarterly inflation rate. Since the fed funds rate tracks the interest rate on three month treasury bill very closely the within quarter inflation rate seems to be the appropriate adjustment. This also minimizes the span of time for which one has to make the implicit assumption that ex post inflation rates are the same as the ex ante inflation rate policy makers would be anticipating. Secondly, since it is conventional to adjust the fed funds rate by an annual (four quarters ahead) inflation rate, I have also included impulse response results for the real fed funds rate based on that adjustment.

The results for the real federal funds rate are in line with the movement of the nominal rate for the pre and post 1980 periods, though the response of

[8]The table shows estimates of both the response of export and imports. The "net export" response in the accompanying graph is the response of exports minus the response of imports. It is not possible to estimate a separate response of net exports due to the presence of negative values.

the real federal funds rate is weaker than the nominal rate before 1980 and stronger after 1980. For the full 1948-2007 period the sign of the respose is reversed for the real rate, most likely owing to the weaker negative response of the pre-1980 period and the strengthened positive response post-1980.

In terms of the real rate, the Federal Reserve is counteractive to tax revenue shocks before 1980 and accommodating to tax revenue shocks after 1980. The evidence for changes in both the nominal and real federal funds rate is somewhat weak, since the nominal response is only weakly statistically significant before 1980 and the real rate response is only weakly significant after 1980. This leaves open the possibility that the Fed remained neutral in the face of tax shocks in either or both periods. The findings here are counter intuitive given that the consensus narrative of monetary policy in the two subperiods. The traditional narrative of the pre-1980 era is one in which monetary authorities exacerbated the inflationary impacts of fiscal policy shocks—particularly during the 1970s. In the Volker period and afterwards the Fed was seen as strongly disciplining inflationary impulses. The evidence in Tables 2 and 3 to the extent that they show a response of the Federal Reserve to tax shocks at all, show the opposite to be true.

These results also contradict the findings of RR. RR find that—with the nominal federal funds rate as their policy instrument of interest—monetary policy is weakly counteractive after 1980. However, their result comes from a 3 variable VAR that includes only output, their measure of tax shocks, and the federal funds rate.

The results above have implications for the thesis that monetary policy plays a role in the smaller response of output to tax shocks after 1980. The results can be read as the Fed either accommodating exogenous revenue changes or—given the weak statistical significance of the result—as the Fed remaining essentially neutral. Either way, the Fed is not pursing counteractive monetary policy in the face of tax shocks after 1980.

It is useful to expand the analysis another degree deeper by looking at the balance sheet response of the Fed. Changes in the assets of the Federal Reserve are directly related to increases in the monetary base on the liabilities

sides. The directional response of Federal Reserve assets then is an indication of whether the fed intends on contracting (decreasing assets) or expanding (increasing assets) the monetary base in response to a tax shock. Figure 2 shows the response of selected assets held by the Federal Reserve to a tax shock, scaled to be a percentage of GDP. This adds corroborating evidence that the response of the Fed's balance sheet to fiscal policy shocks is stronger before 1980 than after 1980. The direction of the acquired assets for the most part also suggests accommodating (or neutral) monetary policy.

The response of total government spending in Table 2 is also of interest. It fits the general pattern of a strong pre-1980 response. One question that arises is "what are the budget financing implications of the RR shocks?" Many of these shocks were specifically targeted at changing debt levels. Figure 3 shows the response of net total government liabilities in response to tax shocks across the three periods. The effect on total government liabilities is clearly much stronger after 1980, in which a positive tax shock lowers total government net liabilities by 3.108% of GDP after 15 quarters. The reverse is also obviously true: while tax cuts did not have a statistically significant effect on government liabilities before 1980, tax cuts clearly caused deficits—when looking at government borrowing as a whole—after 1980. It is useful to break total government spending into its constituent parts: federal, state and local and GSE borrowing. Figures 4 to 6 show the response of each level of government liabilities. As well as the expected strong response of treasury bonds to the federal revenue shocks of the RR series these tax shocks also cause strong changes in government sponsored enterprise (GSE) liabilities issued, and changes in state and municipal securities outstanding.

Table 4 shows the response of total treasury bonds outstanding and the acquisition of treasury bonds by the private sector. There are not many patterns across subperiods that emerge from these impulse response functions. It would appear that before 1980 a positive tax shock has the counter intuitive effect of increasing treasury issues, which can obviously be thought of increasing federal liabilities. After 1980, tax increases have the expected effect of reducing federal debt. Households sell off treasury bonds in response to a revenue shock

before 1980 while firms purchase them. This pattern is reversed after 1980, but it is difficult to draw any strong conclusions about sector behavior since the averaged impulse responses are not even marginally statistically significant.

The flow of funds approach of this paper also makes it possible to explore the response of other government sectors to tax shocks. While there has been minimal treatment of treasury debt response to fiscal policy shocks[9], there has been no attempt at exploring the impact of federal tax changes on other government sectors.

As Table 5 shows, household holdings of GSE liabilities show a consistently strong response across subperiods. Households liquidate their GSE holdings across subperiods, though the response before 1980 is almost three times as strong as it is after 1980. It is not, however, clear where these GSE securities unloaded by households before 1980 are being absorbed. GSE's themselves show a small contraction in GSE liabilities outstanding before 1980. After 1980 GSE's actually increase their liabilities outstanding in response to a tax increases. As well, after 1980 the changes in GSE liabilities issued and the holdings of GSE debt by households show a more clear balance with the other sectors. For the most part household's liquidated GSE holdings are absorbed into the financial sector (which includes the GSEs).

Municipal liabilities also show changes in response to a federal government revenue shock. Figure 6 shows that a positive revenue shock causes a small increase in state and local borrowing before 1980. After 1980 a positive shock to federal revenue causes a decline in debt outstanding by state and local government with a corresponding decline in the holding of municipal debt by households.

[9]To be more accurate, papers that consider debt effects of fiscal policy shocks tend to use debt as a constraint on fiscal policy changes. Mountford and Ulilgh (2008) for instance allow for balanced budget constraints to be relaxed in their VAR model. FG, on the other hand treat debt as a long run constraint on output. Neither paper explores the effect of fiscal policy shocks on changes in debt levels.

3.3 The Response of Sector Balance Sheets

This section looks at private sector balance sheets. First, I present a more general picture of the changes in net liabilities of nonfinancial business and the change in net assets of households and financial business in response to tax policy shocks. This approach most closely follows CEE's approach to gauge the response of sector balance sheet to monetary policy shocks. However, this does not provide very much information. It is instructive to look at the change in the composition of sector balance sheets more closely for clues to the behavioral response of sectors—particularly households—to revenue shocks. The first subsection explores the changes in net assets and liabilities of households, non-financial business and financial business while the subsequent subsections explore the balance sheet changes of each sector individually in more detail.

3.3.1 Net Assets and Liabilities

Figures 7 to 9 show the response of net assets and liabilities for net lenders (households and financial business) and net borrowers (nonfinancial business) The impulse responses, as with all the impulse responses in this paper, are the accumulated response—as a percent of GDP—of the variable of interest to a revenue shock of 1% of GDP.

Figure 7 shows the response of household asset holdings to a tax revenue shock of 1% of GDP, both with and without equity assets included. This is done because the equity response in the pre-1980 period is very strong. At its peak response household assets, including equity value, fall by almost 14% of GDP in response to a positive revenue shock. With no corresponding acquisition of equities in other sectors, this is most likely due to a "business cycle" response of household assets to tax changes that is stronger in the pre-1980 period. This decline parallels the more clear decline in GDP and its components (Figure 1. The evidence suggests that equity market values are falling in response to the effect of tax shocks on the economy over all, and not as a direct response to tax shocks driven by household decision making regarding those assets. For other household financial assets, the behavioral versus market

value response is less obvious. Put another way, in evaluating the impulse response functions it is not clear what is driving the response of output to tax shocks. There is a "first order" direct effect of tax changes on assets. This may be thought of as the "Ricardian" or "behavioral" effect, as households see their tax bill change and so adjust the composition of their assets and liabilities to consumption smooth, minimize their tax bills, or for other reasons directly related to changes in policy. There is also a "second order" indirect effect of tax changes on the composition of liabilities and assets from the effects of the output response to tax changes on sector balance sheets. If, say, a tax increases lowers output then one assumes consumption and investment will fall and households and businesses will adjust their balance sheets in response to the change in output. As well, the market value of assets will also fluctuate in response to the change in output as the unexpected shock to output/income causes a revision of the present value of those assets. This "business cycle" effect, I argue, is the dominant effect on household balance sheets before 1980 and this effect largely manifest itself in change in household equity holdings. There is more evidence of the "business cycle" effect on household balance sheets presented below.

Even excluding equity values, households experience a decline in net assets in response to a positive tax shock before 1980. After 1980 the response is not statistically significant—even by the low bar of a 68% significance level—with the exception of a single period when equities are excluded.

Figure 8 shows the response of nonfinancial business net liabilities (ignoring equity liabilities). Business liabilities show a significant and positive response to tax shocks after 1980 in the medium to long run (after 4 quarters). However, the response is not even marginally statistically significant before 1980 or for the full period.

Financial business responses to tax shocks, shown in Figure 9, show a very weak response relative to other sectors in both subperiods. However, of some interest is that the sign of response changes across subperiods. A positive tax shock causes financial net assets to increase before 1980 and causes net assets to fall after 1980.

Figures 7 to 9 can be thought of as a preliminary look at the data. A closer and more detailed look at sector balance sheets is warranted, both to explain why net liabilities and assets respond as they do and to get a better sense of where economic activity is shifting in response to tax shocks. The next three subsections explore both the asset and liabilities response to tax policy changes to households, nonfinancial business and the financial sector respectively

3.3.2 Households

Looking at Figure 10, across the entire postwar period and in both subperiods there evidence to suggest that tax shocks affect the composition of assets held by households, moving households out of more liquid assets—M2 and government assets—and into less liquid private assets. "M2 Assets" is a measure of household holding of money assets, which includes currency, deposits and money market funds. As Figure 10 shows, the reaction of household "liquid" assets is much stronger after 1980. Correspondingly, there is some evidence to suggest that a tax revenue increase causes, in part, a shift of assets from liquid to less liquid assets after 1980. However, one should bear in mind that the effect on household net assets is stronger before 1980 (again, even excluding the large equity shock, discussed below) than after 1980, even if there is stronger "churn" among the elements of household balance sheets.

Most striking from Figure 10b is the reaction of equity held by households, which shows an almost 12% decline in response to a tax increase before 1980. As discussed above, this equity decline is an aspect of the "business cycle" response evident in the NIPA impulse response functions before 1980 (Figure 1). There is a large decline in equity values with a trough at four quarters. This fall in equities held by housheolds then dissipates towards—statistically speaking—no net effect after 12 quarters. The response of equities changes sign after 1980, but is not statistically significant. Tax increases also cause households to increase their holdings of corporate and foreign bonds in both subperiods with the effect being both economically and statistically more significant after 1980.

Turning to household liabilities, Figure 11 provides evidence of a "business cycle" response before 1980 on the household liabilities side. Here the response of mortgages before 1980 show a clear cyclical response in which, for the first 10 quarters accumulated mortgage borrowing by households is negative—with a trough at six quarters of -.48% of GDP—in response to a increase in taxes, but then mortgage borrowing climbs steadily more positive during the next 10 quarters.

Figure 11 also makes it clear that it is not consumer credit per se that is driving the lack of response to tax shocks after 1980. It is not, however, crucial to the thesis of consumption smoothing that consumer credit specifically plays a large role. A case can be made, looking back at Figure 10, that households are significantly more prone toward "dipping into" liquid assets after 1980 than before 1980. However, the evidence suggests households are not dipping into their liquid savings to consumption smooth. Rather, there is a shift towards other—less liquid—assets in response to a tax shock. For instance, the increase in household holding of corporate and foreign bonds—while perhaps also a market driven change akin to changes in equities—does hint at households shifting assets between "liquid" assets such as money and government securities and less liquid/private sector assets.

The fact that household mortgage liabilities also show a larger response after 1980 (Figure 11), though the response of residential investment is smaller in the post-1980 period (Figure 1), suggests a wider disconnect between the response of household balance sheets and economic activity[10]. It is also plausible that if the decline in mortgage borrowing during this period in response to a positive tax shock is largely in the form of mortgage refinancing, the decline in mortgage lending—again, not statistically significant—would also be reflected in a decline of cash on hand for households as households paid off their mortgage borrowing.

While there does seem to be more balance sheet activity after 1980, the net effect on household balance sheets is greater before 1980. At its trough,

[10]This increased response of mortgages after 1980 is largely driven by the post 2001 portion of the sample, discussed below.

the change in net assets before 1980 is over -13% of GDP after four quarters, and is significant at the 95% level. This response is obviously largely driven by the decline in equity assets. After 1980, net assets peak at at a statistically insignificant 3.511% of GDP after 19 quarters. The difference between subperiods in net asset changes is also apparent even when equities are excluded. Referring again to Figure 7, even with equities excluded, the peak effect of a tax shock on net assets of households is larger before 1980. With equities excluded there is a peak decline of 4.42% at 19 quarters after a steadily accumulated decrease before 1980 vs a marginally significant decline of 2.81% which holds steady after 6 quarters post 1980.

3.3.3 Nonfinancial Business

Nonfinancial business asset holdings do not change that dramatically between subperiods in response to tax revenue shocks. As Figure 12 shows, the full sample period shows a very statistically weak response. While the individual periods show a response over 2% of GDP in each period, there is a minimal difference between subperiods. Of note is that the change in total assets has a clearer underlying cause in the pre-1980 period. Trade receivables before 1980 show a cyclical pattern similar to that of output, equity assets and mortgage liabilities held by households. However, after 1980 there is no clear asset class driving the decline in total assets held by nonfinancial businesses.

Figure 13 shows the response of business liabilities to a tax shock of 1%, excluding equities[11]. The magnitude of the change in liabilities is not very different between periods, but what is driving the response of liabilities does change. Before 1980, non-mortgage loans and trade payables are driving the decline in liabilities. After 1980, it is mortgage borrowing that is driving the decline in liabilities in response to a positive tax shock. The response of business liabilities, assets and net liabilities after 1980 is the least consistent across the corresponding variables of all the sectors. Net liabilities in Figure 13 shows

[11]The dynamics of nonfinancial equity liabilities are captured adequately by equity holdings of households discussed above. Financial businesses are both an issuer and purchaser of equity and the response of equity assets and liabilities of the financial sector are discussed below.

a peak *increase* response of 2.043% after 12 quarters. However, both liabilities and assets decline in response to a tax shock when looked at separately. The relative responses of assets and liabilities imply a *decline* of net liabilities of .97% of GDP after 12 quarters. As well, the small cumulative responses of the selected components of business assets suggest a smaller response than show by total assets, this implies a stronger decline in business liabilities than .97% of GDP. With this in mind, one should approach the post-1980 response of business liabilities with more caution than other results.

The decline in mortgage liabilities by businesses correlates with both the decline in household mortgage liabilities after 1980 in Figure 11c and the decline in residential investment shown in Table 1c. However, the decline in business mortgage liabilities is more strongly statistically significant than the decline in household mortgage liabilities (which is not statistically significant at conventional significance levels). The response of business mortgage liabilities to tax changes is driven by the changes in mortgage borrowing by noncorporate business [12]. It is important to reiterate that this mortgage borrowing by small firms does not show up in business or residential investment in the same way there is a clear connection between household mortgage borrowing and the cyclical response of mortgages to a tax shock before 1980. The mortgage/investment spending disconnect is somewhat more clear when looking at changes in total mortgage lending by financial firms in Figure 14. Lending by the financial sector can be thought of as an aggregate measure of mortgage lending. Financial business mortgage lending is discussed in more detail below, but it is useful to point out here that Figure 14 shows a decline in mortgage lending of 4%-5%, in the post 1980 period. This is several times the peak decline in residential (-0.79%) and nonresidential investment (-0.29%).

[12]This is not shown in the accompanying figures but noncorporate business mortgage liabilities explain -1.537 percentage points of the -2.033% (of GDP) change in nonfinancial business mortgage borrowing in response to a positive tax shock. The result is significantly different than zero with a confidence interval of 95%

3.3.4 Financial Business

Figure 14 shows the response of assets held by financial businesses for the three subperiods. Before 1980, assets held by the financial sector fall more dramatically than they do after 1980. This is in line with the general pattern of a stronger response of the economy to tax shocks in the earlier period. However, the reader is reminded that net assets of the financial sector (Figure 9) show a small increase in net assets before 1980 and a small decline in net assets after 1980, though these net changes are of marginal significance. The small response of net as opposed to total assets is of course consistent with the financial sector functioning as a financial intermediary for households and nonfinancial business. This function implies that any changes in assets must be offset by a change in liabilities.

Mutual funds do not play a significant role in financial firms asset holdings before 1980, primarily because they did not exist for much of the earlier period. They have been included because they are one of the few asset categories held by financial business to show a strongly significant response to tax shocks after 1980. There is some evidence to suggest that in both periods tax increases cause financial business firms to acquire government assets (this is discussed in more detail above). Mortgage holding by financial business—which includes the GSEs—responds much more strongly after 1980. There is also some evidence that there is some substitution between assets after 1980. Equity and mutual fund assets increase, while mortgage assets decrease in response to a positive tax shock. However, it is not clear how much of the increase is driven by the price of these assets as opposed to decisions by financial businesses to remove these assets from their balance sheet. The lack of response of equity assets by the financial sector before 1980 suggests that equity asset holdings by the financial sector are driven less by market value than equity holdings of households.

Figure 15 shows the change in liabilities of the financial sector. As mentioned above, the response of total financial sector liabilities is stronger before 1980. Of particular interest is the stronger response of "retirement" liabilities, which include pension fund and life insurance company obligations to house-

holds. The stronger response of financial sector liabilities before 1980 provides more evidence that the business cycle impact of tax shocks is stronger before 1980. Retirement obligations are long terms savings and likely to be illiquid. Changes in their value must be primarily driven by their market value. The change in retirement liabilities can be seen as corroborating evidence for the thesis of a more pronounced business cycle effect of tax shocks on the economy before 1980. Also of note in Figure 15 is that in both periods there is evidence that tax increases cause equity outstanding by financial firms to increase. This increase, is more persistent after 1980.

Finally, the change in M2 liabilities can be thought of as the total change in banking liabilities in response to a tax increase. There is a stronger decrease in M2 liabilities after 1980 (a fall of 4% of GDP) than before 1980 (a fall of 2.8% of GDP). It is not clear how to read this, however. The bulk of the evidence suggests that before 1980 the change in M2 is driven by the business cycle effect of tax shocks and is a response to output changes rather than the tax shock directly. After 1980, it is plausible that this decline in M2 is a mirror of the decline in mortgages outstanding. That is, M2 seems to be filling in the gap between the small output response (of both consumption and residential investment) and the large decrease in mortgages outstanding. To think about it as a tax increase, mortgage liabilities—which are falling—are being paid back with liquid assets. To think about it as a tax cut, the induced increase in mortgage lending is being "hoarded" on bank balance sheets as deposits instead of being spent on residential investment. Another way to think of this is not as "hoard" per se but as a "Wicksellian" increase in liabilities (deposits) to match the increase in assets (mortgages) created. Anderson (1993) points out that mortgage refinancing which leads to prepayment of securitized mortgages is a drawn out process. Repaying a sercuritized mortgage early necessitates an increase in M2 for any extra dollar of securitized mortgage lending. Regulations requires that prepayment of securitized mortgages be held in demand deposits until the funds are dispersed to the ultimate holders of the mortgage backed security. This process can take anywhere from four to six weeks. The increased prominence of mortgage securitization is characteristic of the entire

post-1980 period, not simply the post 2001 housing bubble.

It should be admitted that the tax-mortgage lending-M2 connection is fairly speculative. While it is my view that this is a credible explanation, it deserves further study as there are a few clear problems with the hypothesis. First, while mortgage borrowing is large in absolute terms after 1980, it is not statistically significant, though the response of M2 is strongly significant. However, a more detailed look at the mortgage borrowing response to tax shocks is outside the scope of this paper. The most cautious reading of the results from this paper to say there the tax-policy-mortgage connection is not established credibly. Second, it is not obvious that the finding here is not spurious. The interpretation of these impulse shocks is that the tax changes *caused* the increase in mortgage borrowing. If one accepts that the change in M2 is a mechanical response to mortgage refinancing then whatever causality applies to mortgages also applies to M2. Tax policy is not among the conventional explanations for the housing bubble of the mid 2000s. Truncating the sample at 2001q1 [13] causes the response of home mortgage borrowing to tax changes to shrink dramatically. However, the strong response of nonfinancial business mortgage borrowing remains essentially invariant to inclusion of the housing bubble. Unpacking the separate effects of tax shocks on the different types of mortgages borrowing and the effect of different types of mortgage borrowing on M2 is beyond the scope of this paper. Finally, after 1980 the bulk of the change in total M2 liabilities is taking place as a decline in household holding of M2. It is not at all clear how the legal requirements to hold the proceeds of prepaid mortgages in demand deposits manifest itself on the asset side of household balance sheets as opposed to the liabilities side of financial business balance sheets.

Looked at from another perspective, the response of M2 liabilities is the most convincing piece of evidence in favor of the "consumption smoothing" explanation put forth by both Perotti and RR for why the economy is less responsive to fiscal policy shocks after 1980. However, the pattern of the impulse response suggests that M2 liabilities decline steadily over time. For

[13] Not shown

the smoothing hypothesis to make sense, there should be a large initial impact response of M2 to the tax increase. As it is, the peak effect of the tax increase on M2 does not come for 4 years after the initial shock, suggesting that M2 is responding to changes in the economy—or to other balance sheet changes—over this period of time.

4 Discussion

Using the identification technique of Perotti (2012) this paper has expanded the analysis of the effect of exogenous tax revenue shocks beyond measuring simply the response of GDP. I have looked at the response of the components of GDP, the interest rate and balance sheet response of the Federal Reserve, and the response of private sector balance sheets. This analysis has in particular focused on establishing the difference in the response of output to tax changes identified by Perotti (2005) around a structural break in 1980. To that end, I have established the Federal Reserve weakly counteracts tax shocks before 1980 but weakly accommodates tax shocks after 1980. That is, before 1980 a positive tax shock caused the nominal federal funds rate to fall. The real fed funds rate also falls, but by a smaller magnitude. The response after 1980 is the opposite. In response to a positive tax shock the nominal and real federal fund rate both increase. After 1980 the response of the real federal funds rate is stronger than the response of the nominal rate. One important caveat to note is that the inconsistent and marginal statistical significance of the response of both the real and nominal federal funds rate does not preclude the possibility that the Federal Reserve does not respond to tax shocks in either period.

I have also found that households' balance sheets respond more strongly to tax shocks before 1980 than after 1980. There are two layers to this response. Household holdings of equities respond much more strongly to tax shocks before 1980, which explain much of the difference in responses. However, even ignoring the equity response, net household assets respond more strongly before 1980. I take the pattern of equity response, as well as the much stronger response of the components of GDP before 1980 and the behavior of illiquid

pension assets as further evidence establishing that before 1980 tax shocks had a much more pronounced "business cycle" effect on output than after 1980. The response of equity holdings by households is primarily a passive change in the market value of equities consistent with the large decline in output in response to a positive tax shock before 1980.

The comparison across periods for the nonfinancial business sector's balance sheet is complicated by the fact that the results are inconsistent across the different ways of measuring business assets after 1980. However, the both economically and statistically significant response of business mortgage liabilities after 1980 stands out. In general the response of mortgage liabilities to tax shocks is strong across sectors, though not always statistically significant.

Finally, I have shown that federal tax shocks have implications for borrowing not only for the Federal government but also state and local governments and the GSEs. Before 1980 tax increases actually increase the amount of Treasury liabilities outstanding as well as state and local liabilities, though the effect on state and local government liabilities is very small. After 1980 Treasury and state and local liabilities have the sign one would expect. Federal revenue increases lower government debt at both levels of government, though it probably make more sense after 1980 to think about this pattern as deficit generating tax cuts driving an increase in borrowing. GSE liabilities outstanding fall slightly before 1980 in response to a positive tax shock, though the decline in household holdings of GSE liabilities is both economically and statistically significant (1.28% of GDP in response to a 1% tax shock). After 1980, tax increases cause an increase in GSE liabilities outstanding.

The results of this paper should be taken in the context of previous empirical findings. Perroti and RR have speculated that the reduced effect of tax changes on output after 1980—first established by Perotti (2005)—is due either to the ability of households to consumption smooth because of greater access to finance after 1980, a more active Federal Reserve that is more intolerant of potentially inflationary fiscal policy, or some combination of the two. As explained above, I do not find any evidence to support the theory that the Federal Reserve became more hostile to fiscal policy shocks after 1980. To

the extent that one can claim that the Fed was responding to tax shocks at all, the evidence presented in this paper is largely not in favor of the thesis that that monetary policy served as an external brake on the impact of tax revenue shocks after 1980. The reaction of both the nominal and real interest rate and the Fed's balance sheet indicate that the Fed was not pursing counteractive monetary policy after 1980. Quite the contrary, Fed policy is more counteractive before 1980 than after 1980. After 1980 the Fed is either mildly accommodating or passive in the face of tax policy shocks.

Instead, it would appear that tax shocks are more likely to induce a cyclical response from the economy before 1980 which induces a counteractive monetary policy response. The evidence from the Fed's balance sheet response to tax shocks is more consistent with the argument the Federal Reserve responds to changes in the economy after a tax shock before 1980, than the Fed responding to the tax shocks themselves. There is essentially a one year lag before the Fed pursues open market sales in response to a increase in federal taxes, as shown in Figure 2b. In contrast, after 1980 tax changes produce a much smaller response in the economy, primarily as a relatively weak response in household consumption and residential investment. Correspondingly the Fed's balance sheet shows no clear pattern of response.

The household consumption smoothing story is more difficult to unpack from the data presented here. While the response of sector balance sheets are different across periods, it is not possible to pinpoint the cause of the differences across periods. While a convincing case can be made that sector balance sheets are responding to output changes before 1980, it is not clear what is driving them afterward. One thing one can say with certainty is that there is *more* (equity changes before 1980 notwithstanding) sector balance sheet activity after 1980 even if, on net, balance sheets respond less strongly before 1980 that after 1980.

The perspective here on the consumption smoothing hypothesis is different than other authors. Previous authors have taken the nature of the RR tax shocks to have remained invariant across the two subperiods and have treated the change in the impact of tax shocks as a structural break in the response

of the economy to tax shocks[14]. However, it is plausible that the difference between the two periods is a difference in the types of fiscal policy being pursued while the response of the economy remained invariant to any given specific type of tax shock. It is important to point out that this is not a problem that is unique to the "narrative" identification scheme but it is a problem across all attempts to identify exogenous shocks. If a hypothetical government raises taxes strictly through value added taxes for, say, 30 years and then switches in one year to a system of exclusively raising taxes through income taxes for the next 30 years there would be the problem of heterogeneity of responses for all types of identifications schemes. The difference in the effect of the shocks would show up in both in narratively identified shocks that can be traced to specific historical events and in any shocks extracted from the aggregate data—for example a correctly identified SVAR model—which at first blush tend to be regarded as more "generic" though they are based on the same historical series. It should be noted that if there is heterogeneity of types of tax shocks then the narrative identification scheme is extremely useful because it is so transparent. It is a much more difficult project to trace shocks identified by, say, an SVAR back to specific tax changes.

The policy implications of this perspective are also important to point out. If the change after 1980 is driven by a change in the response of the economy to an invariant type of tax shock then one can expect those changes to be persistent going forward[15]. In this case it is the change in the nature of the economy neutering the ability of fiscal policy to influence the economy. This way of thinking about the time series by Perotti and RR is at the heart of both the consumption smoothing hypothesis and the "hostile" monetary policy hypothesis. However, if the change after 1980 represents a change in the kind of tax policy pursued, then each of the two subperiods represent

[14]It is important to point out that the evidence for a structural break presented by Perotti (2005) is that there were structural breaks in individual time series use to compose the VAR. The idea that there is a structural break in the relationship between the variables is reasoned out from the breaks in the individual time series.

[15]It is likely that there is a second major structural break—akin to the one in the early 1980s—in the economy around 2008q3. However, this new subperiod we are living in is likely to share more in common with the 1980-2008 subperiod than the earlier one

choices made from a menu of policy choices. Some of these choices are more likely to change output and/or shift sector balance sheets than other policies.

Table 4 shows a tally of the different types of tax changes found in the RR narrative series detailed in Romer and Romer (2009). Table 4 shows a clear shift in the object of tax policy before and after 1980. Most striking is the shift towards marginal tax policy after 1980. There is also a corresponding shift from low and middle income households (mostly in the form of payroll tax changes) as the dominant targets of the RR shocks to a focus on tax changes that affect all income levels and/or a greater proportion of tax cuts for high income households. There is also a tendency for tax bills after 1980 to be less focused and to include multiple kinds of tax changes all in a single bill[16]

The evidence here suggests that if the hypothesis of consumption smoothing holds—that is, if the shift in the impact of shocks on the economy is driven by a greater ability to smooth economic activity in response to tax shocks—here is an important subtlety to the consumption smoothing mechanism. There is a shift in the *types* of households on the receiving end of these tax changes. A simple way to think about this is that tax shocks before 1980 predominantly affect liquidity constrained households (low and medium income households) who do not smooth consumption in response to a tax change. After 1980, as high income households are the target of an increased proportion of tax changes, their ability to smooth consumption dissipates the effect of tax changes. Stated another way, it is not that a single representative household has greater access to liquidity after 1980 and can consequently smooth consumption more effectively. Rather, tax shocks after 1980 target households that have historically had a greater ability to consumption smooth. This is consistent with the Mankiw and Campbell (1989) finding that the evidence for consumption smoothing behavior in the US is consistent with a proportion of households (they argue 50%) who are liquidity constrained. The idea that the change in the economy's response is a shift from tax policy from low income

[16]There is some ambiguity here, as the evolution towards the types of tax changes that dominate after 1980 are evident by the 1970s. There are two income tax shocks before 1971 and four income tax shocks between 1971 and 1980.

(illiquid) to high income (liquid) households is also consistent with the Zidar (2015) who finds that tax cuts for lower income groups are more likely to spur employment growth.

This, of course, suggests the need for further research. This paper has shown that there is much to be gained from trying to assess the transmission mechanisms for fiscal policy shocks. While I have presented strong evidence that monetary policy has not played a critical role in the response of the economy to tax shocks after 1980, there is still an open question about why there is such a significant disconnect between the real economy and balance sheet activity after 1980.

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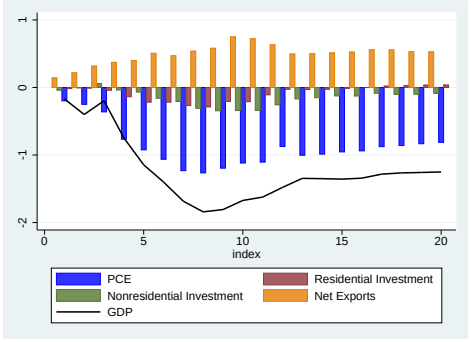
Figures and Tables

Full Sample

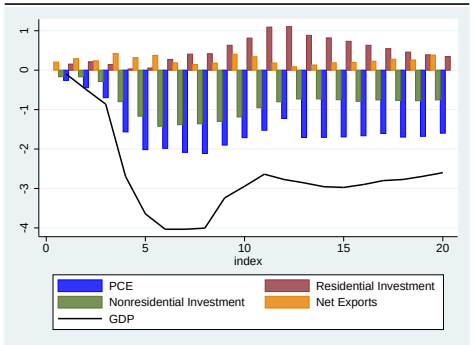
	6 Qrt	12 Qrt	Peak (Qrt)
GDP	-1.400	-1.479	**-1.841 (8)**
Consumption	**-1.063**	**-0.874**	**-1.264 (8)**
Nonresidential Inv.	-0.159	-0.257	-0.345 (9)
Residential Inv.	-0.218	-0.027	-0.288 (8)
Exports	0.024	-0.128	0.136 (4)
Imports	-0.484	**-0.762**	**-0.844 (10)**



(a) 1948q1-2007q4

Pre-1980

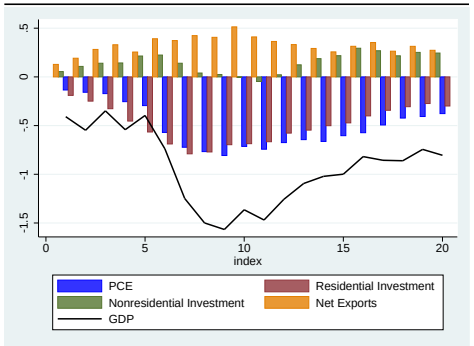
	6 Qrt	12 Qrt	Peak (Qrt)
GDP	**-4.035**	-2.773	**-4.035 (6)**
Consumption	**-1.982**	-1.225	**-2.113 (8)**
Nonresidential Inv.	**-1.422**	-0.802	**-1.422 (6)**
Residential Inv.	0.273	**1.104**	**1.104 (12)**
Exports	-0.050	-0.212	0.303 (2)
Imports	-0.426	-0.395	-0.489 (11)



(b) 1948q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
GDP	-0.738	-1.257	-1.567 (9)
Consumption	-0.570	-0.675	-0.807 (9)
Nonresidential Inv.	0.224	0.022	0.294 (16)
Residential Inv.	**-0.689**	**-0.577**	**-0.790 (7)**
Exports	-0.141	-0.315	-0.403 (18)
Imports	-0.533	-0.679	-0.805 (10)



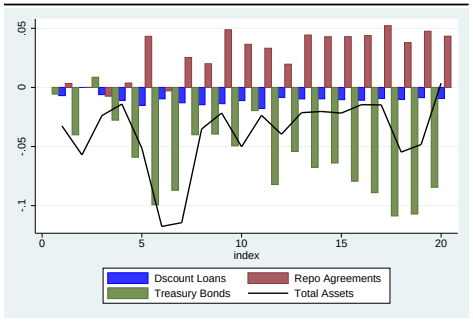
(c) 1980q1-2007q1

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 1: The response of GDP and its components to a revenue shock equal to 1% of GDP.

Full Sample

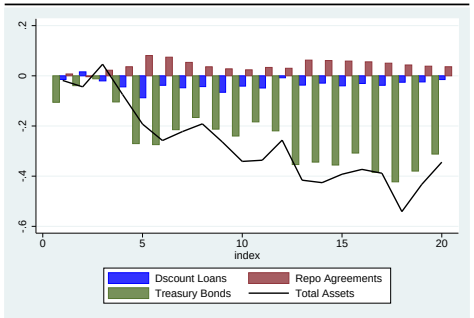
	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-0.118	-0.04	-0.118 (6)
Discount Loans	-0.01	-0.008	-0.018 (11)
Repos	-0.003	0.020	0.052 (17)
Treasury Bonds	-0.099	-0.082	-0.109 (18)



(a) 1952q1-2007q4

Pre-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-0.258	-0.256	-0.541 (18)
Discount Loans	-0.038	-0.008	-0.087 (5)
Repos	0.074	0.030	**0.081 (5)**
Treasury Bonds	-0.274	-0.219	-0.423 (18)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	0.056	0.084	0.149 (16)
Discount Loans	-0.002	-0.001	-0.003 (11)
Repos	0.009	0.088	0.140 (9)
Treasury Bonds	0.051	0.016	0.087 (5)
GSE Securities	-0.052	**-0.081**	**-0.106 (19)**

(c) 1980q1-2007q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 2: The response of selected Federal Reserve assets to a positive revenue shock of 1% of GDP.

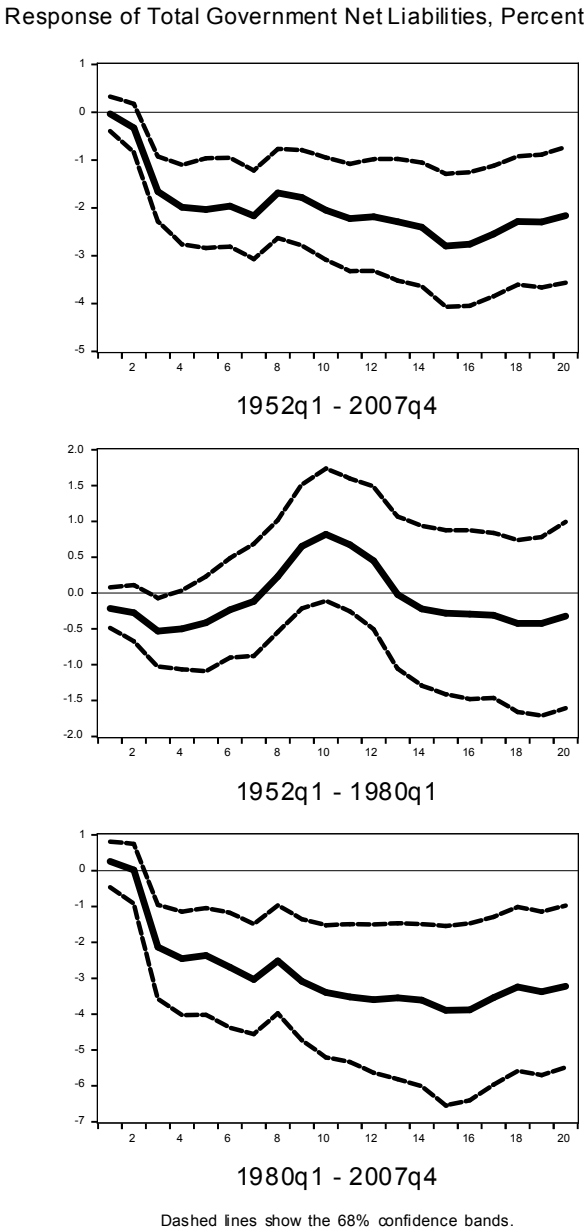
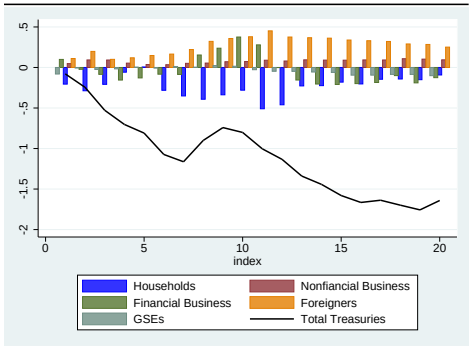


Figure 3: The response of total government net liabilities to a tax shock of 1% of GDP

Full Sample

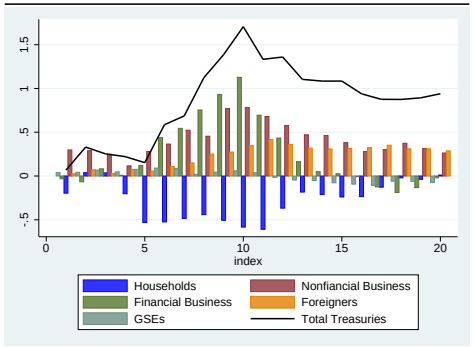
	6 Qrt	12 Qrt	Peak (Qrt)
Total Treasury Bonds	-1.073	-1.133	-1.757 (19)
Households	-0.282	-0.46	-0.510 (11)
Nonfin Business	0.034	0.080	0.108 (18)
Financial Business	-0.083	-0.001	0.376 (10)
GSE	-0.008	-0.047	-0.101 (20)
Foreigners	0.165	0.376	0.452 (11)



(a) 1952q1-2007q4

Pre-1980

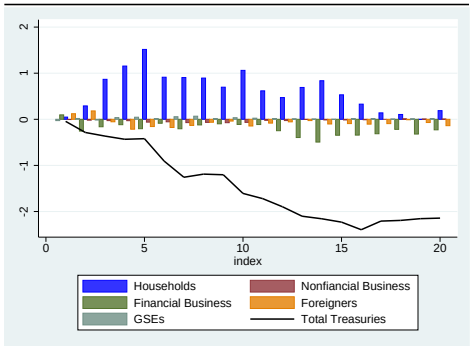
	6 Qrt	12 Qrt	Peak (Qrt)
Total Treasury Bonds	0.586	1.359	1.706 (10)
Households	-0.525	-0.367	-0.609 (11)
Nonfin Business	0.365	0.577	0.783 (10)
Financial Business	0.438	0.434	1.128 (10)
GSE	0.091	-0.015	-0.108 (17)
Foreigners	0.110	0.361	0.415 (11)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Treasury Bonds	-0.906	-1.896	-2.394 (16)
Households	0.913	0.471	1.515 (5)
Nonfin Business	-0.054	-0.028	-0.074 (9)
Financial Business	-0.086	-0.248	-0.494 (14)
GSE	0.016	0.015	0.068 (8)
Foreigners	-0.178	-0.056	-0.215 (4)



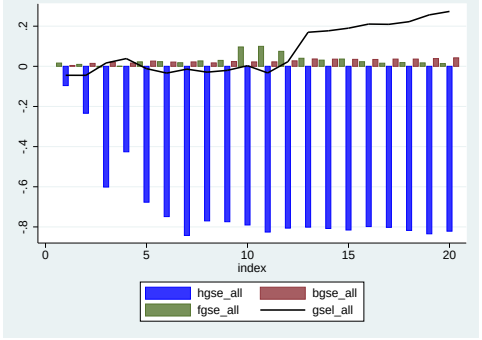
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 4: The response of Treasury holdings to a positive revenue shock of 1% of GDP.

Full Sample

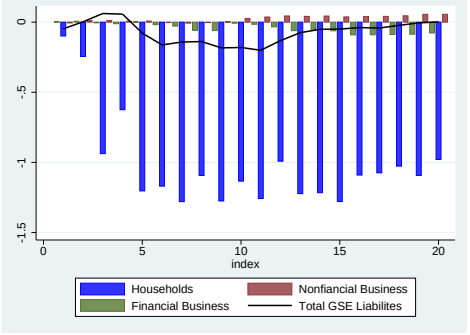
	6 Qrt	12 Qrt	Peak (Qrt)
Total GSE Liabilities	-0.034	0.023	0.273 (20)
Households	**-0.749**	**-0.806**	**-0.842 (7)**
Nonfin Business	0.021	0.027	0.042 (20)
Financial Business	0.023	0.075	0.100 (11)



(a) 1952q1-2007q4

Pre-1980

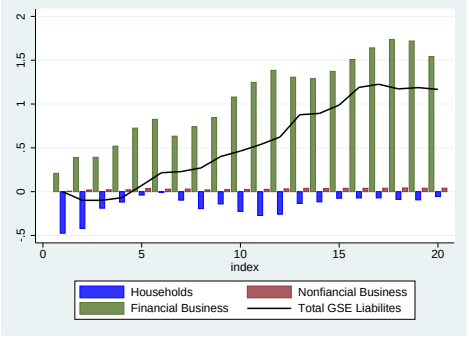
	6 Qrt	12 Qrt	Peak (Qrt)
Total GSE Liabilities	-0.162	-0.132	-0.200 (11)
Households	**-1.169**	**-0.991**	**-1.280 (7)**
Nonfin Business	-0.003	0.044	0.056 (20)
Financial Business	-0.018	-0.034	-0.091 (16)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total GSE Liabilities	0.216	0.623	1.226 (17)
Households	-0.009	-0.258	**-0.474 (1)**
Nonfin Business	0.029	0.032	0.042 (18)
Financial Business	0.825	1.384	1.736 (18)



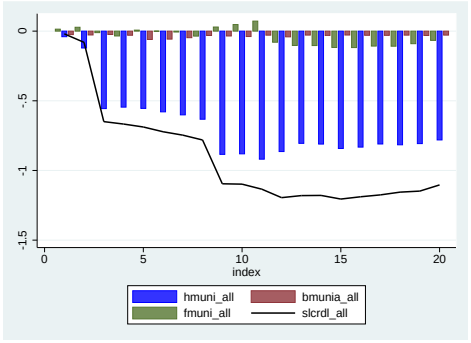
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 5: The response of GSE liabilities holdings to a positive revenue shock of 1% of GDP.

Full Sample

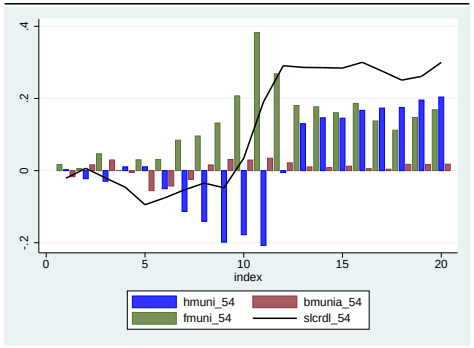
	6 Qrt	12 Qrt	Peak (Qrt)
State and Local Bonds	**-0.722**	**-1.195**	**-1.205 (15)**
Households	**-0.579**	**-0.864**	**-0.919 (11)**
Nonfin Business	-0.057	-0.041	-0.060 (5)
Financial Business	-0.001	-0.08	-0.118 (16)



(a) 1952q1-2007q4

Pre-1980

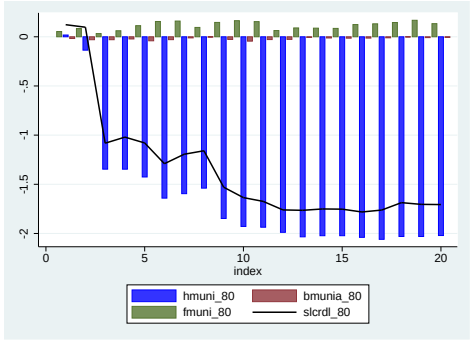
	6 Qrt	12 Qrt	Peak (Qrt)
State and Local Bonds	-0.076	0.291	0.300 (16)
Households	-0.05	-0.005	-0.207 (11)
Nonfin Business	-0.043	0.021	-0.056 (5)
Financial Business	0.031	0.268	0.383 (11)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
State and Local Bonds	-1.29	-1.76	-1.781 (16)
Households	**-1.641**	**-1.988**	**-2.059 (17)**
Nonfin Business	-0.029	-0.026	-0.044 (10)
Financial Business	0.156	0.063	0.168 (19)



(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 6: The response of state and local bond holdings to a positive revenue shock of 1% of GDP.

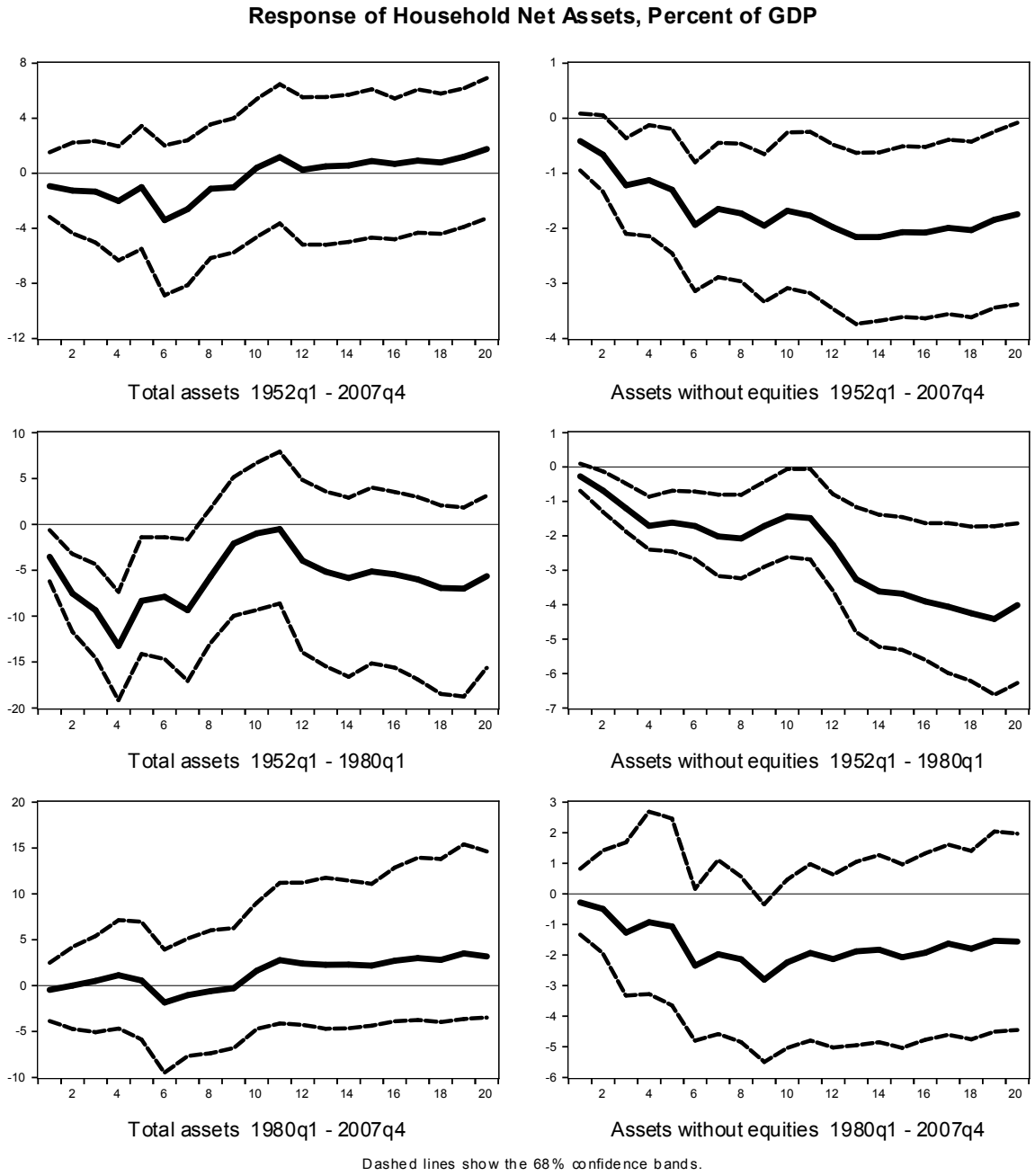


Figure 7: The response of household net assets to a tax shock of 1% of GDP

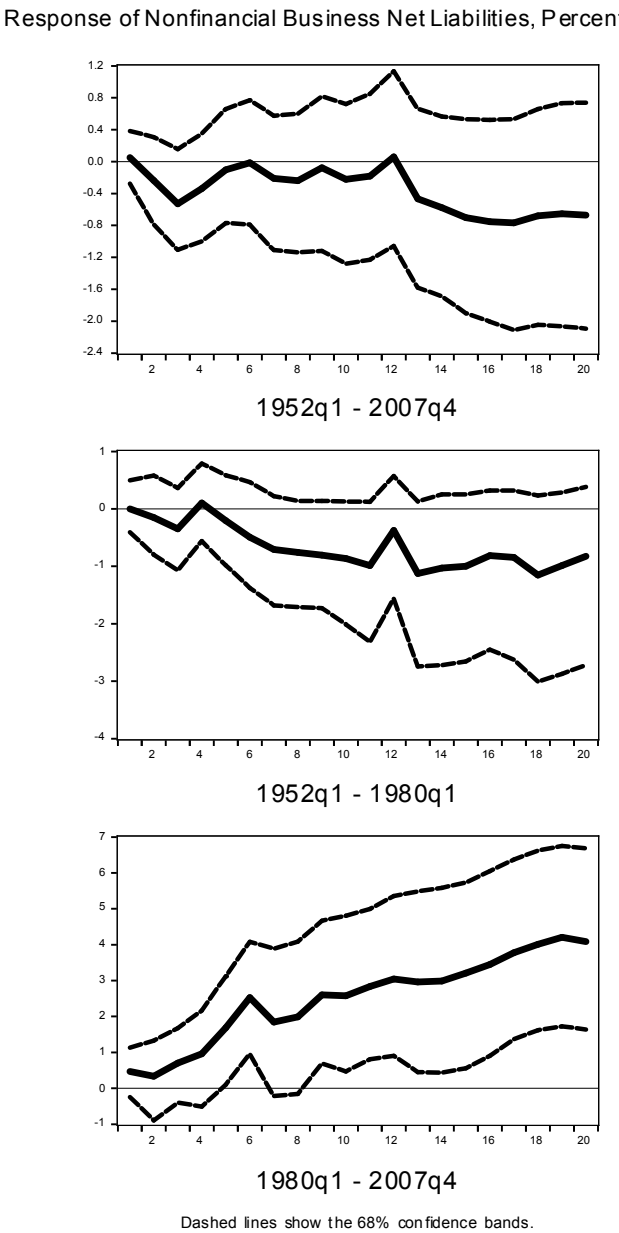


Figure 8: The response of nonfinancial business net liablities to a tax shock of 1% of GDP

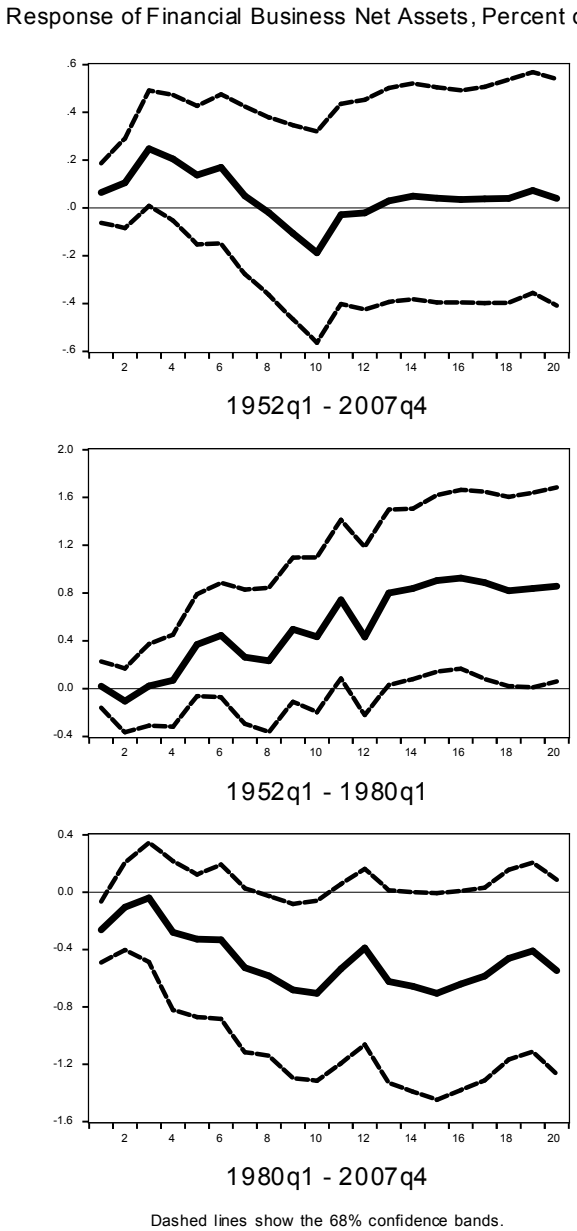


Figure 9: The response of financial business net assets to a tax shock of 1% of GDP

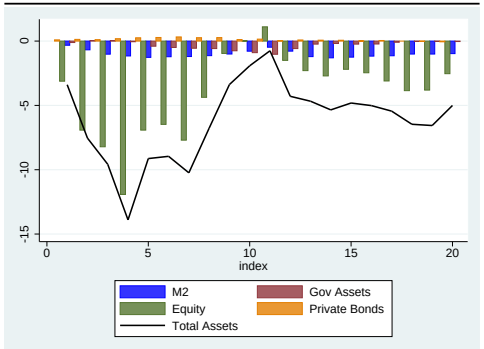
Full Sample

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-3.734	-0.676	-3.734 (6)
M2 Assets	-1.037	-1.805	-2.207 (17)
Gov Assets	**-1.519**	**-2.313**	**-2.655 (11)**
Equity	-1.256	2.058	2.741 (11)
Private Bonds	**0.482**	0.364	**0.482 (6)**

(a) 1952q1-2007q4

Pre-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-8.957	-4.291	**-13.900 (4)**
M2 Assets	-1.216	-0.781	-1.302 (14)
Gov Assets	-0.495	-0.583	-1.024 (11)
Equity	-6.475	-1.499	**-11.923 (4)**
Private Bonds	0.281	0.026	0.324 (7)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-1.994	1.248	2.890 (19)
M2 Assets	-1.735	**-3.18**	**-3.777 (15)**
Gov Assets	-1.761	**-2.833**	**-2.833 (12)**
Equity	-0.072	3.575	4.256 (19)
Private Bonds	**1.329**	1.402	**1.753 (20)**

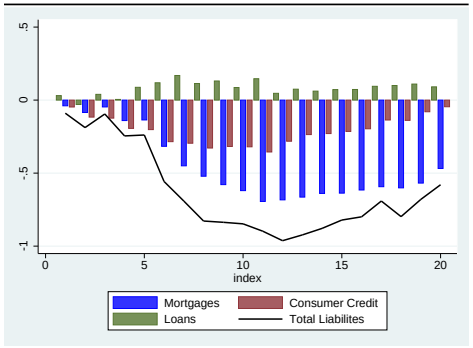
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 10: The response of selected housheold financial assets to a positive revenue shock of 1% of GDP.

Full Sample)

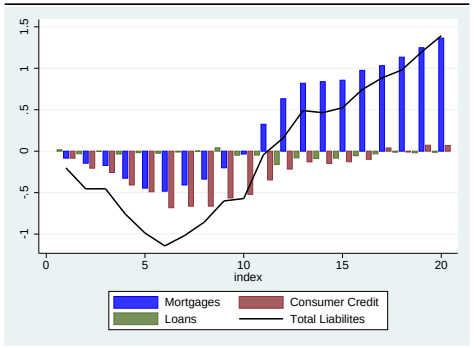
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	-0.557	-0.963	-0.963 (12)
Mortgages	-0.316	-0.683	-0.694 (11)
Consumer Credit	-0.285	-0.282	-0.355 (11)
Loans	0.119	0.046	0.169 (7)



(a) 1952q1-2007q4

Pre-1980

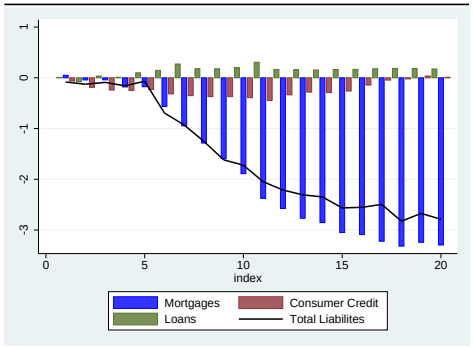
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	-1.142	0.160	1.392 (20)
Mortgages	-0.483	0.633	**1.364 (20)**
Consumer Credit	-0.682	-0.216	-0.682 (6)
Loans	-0.025	-0.161	-0.161 (12)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	-0.692	-2.211	-2.826 (18)
Mortgages	-0.564	-2.577	-3.318 (18)
Consumer Credit	-0.317	-0.336	-0.446 (11)
Loans	0.147	0.165	0.306 (11)



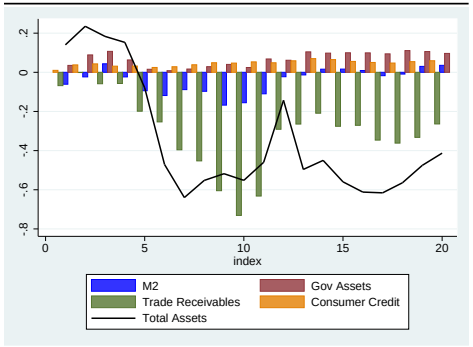
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 11: The response of selected household liabilities to a positive revenue shock of 1% of GDP.

Full Sample

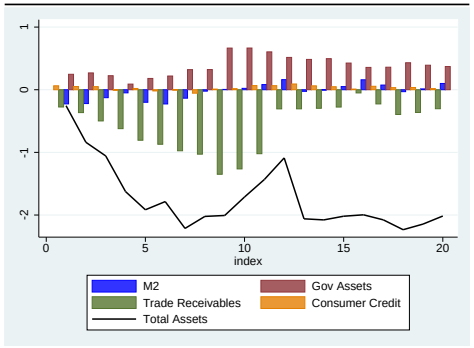
	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-0.471	-0.143	-0.640 (7)
M2 Assets	-0.119	-0.023	-0.168 (9)
Gov Assets	0.008	0.062	0.111 (18)
Consumer Credit	0.025	0.049	0.070 (14)
Trade Rec.	-0.253	-0.291	-0.731 (10)



(a) 1952q1-2007q4

Pre-1980

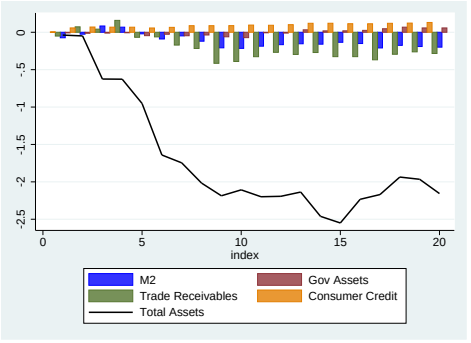
	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	**-1.785**	-1.088	-2.234 (18)
M2 Assets	-0.227	0.161	-0.227 (6)
Gov Assets	0.219	0.516	0.666 (10)
Consumer Credit	-0.019	0.065	0.092 (13)
Trade Rec.	-0.871	-0.306	-1.350 (9)



(b) 1952q1-1980q1

Post-1980)

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-1.641	-2.193	-2.550 (15)
M2 Assets	-0.09	-0.166	-0.215 (10)
Gov Assets	-0.026	-0.011	-0.072 (10)
Consumer Credit	0.058	**0.094**	**0.131 (20)**
Trade Rec.	-0.062	-0.268	-0.415 (9)



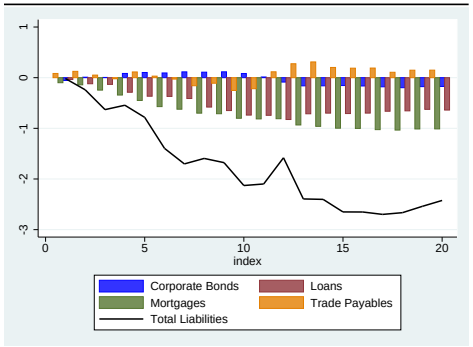
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 12: The response of selected business financial assets to a positive revenue shock of 1% of GDP.

Full Sample

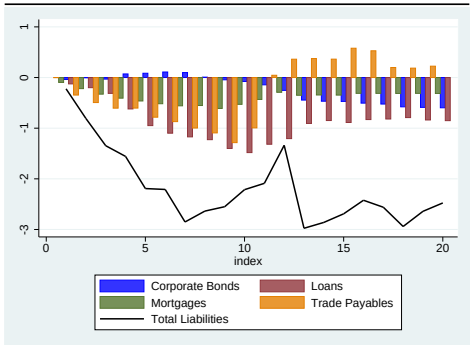
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilities	-1.396	-1.581	-2.699 (17)
Corp Bonds	0.093	-0.087	-0.198 (18)
Loans	-0.37	**-0.826**	**-0.826 (12)**
Mortgages	**-0.571**	-0.81	-1.035 (18)
Trade Pay.	0.030	0.116	0.311 (14)



(a) 1952q1-2007q4

Pre-1980

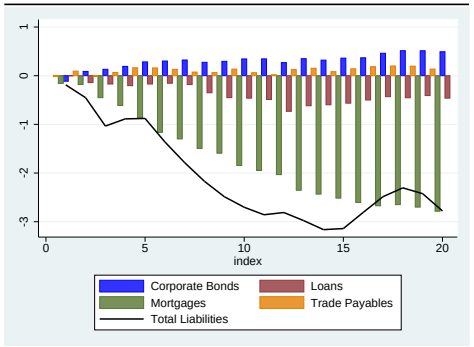
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilities	-2.21	-1.338	-2.976 (13)
Corp Bonds	0.109	-0.254	-0.597 (20)
Loans	**-1.099**	**-1.206**	**-1.482 (10)**
Mortgages	**-0.517**	-0.292	-0.611 (9)
Trade Pay.	-0.783	0.045	-1.285 (10)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilities	-1.361	-2.811	-3.163 (14)
Corp Bonds	0.301	0.269	0.513 (18)
Loans	-0.155	-0.732	-0.732 (12)
Mortgages	**-1.165**	**-2.033**	**-2.784 (20)**
Trade Pay.	0.160	0.019	0.199 (18)



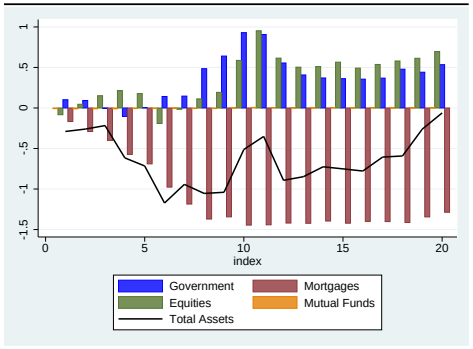
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 13: The response of selected business liabilities to a positive revenue shock of 1% of GDP.

Full Sample

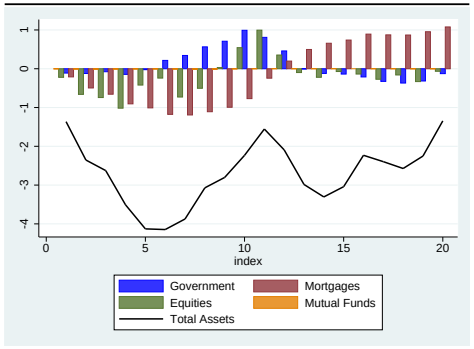
	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-1.172	-0.892	-1.172 (6)
Government	0.142	0.555	0.929 (10)
Mortgages	-0.977	-1.42	-1.445 (10)
Equities	-0.191	0.615	0.952 (11)
Mutual Funds	-0.006	0.004	-0.011 (2)



(a) 1952q1-2007q4

Pre-1980

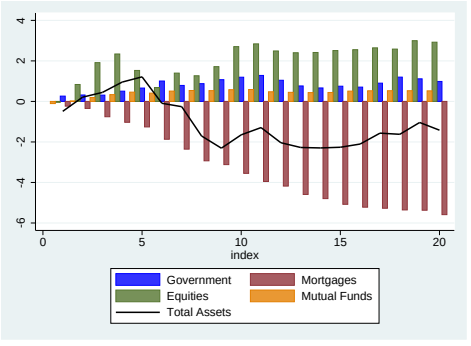
	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-4.146	-2.092	-4.146 (6)
Government	0.215	0.459	0.992 (10)
Mortgages	-1.176	0.198	-1.192 (7)
Equity	-0.241	0.354	-1.017 (4)
Mutual Funds	-0.008	0.001	-0.014 (8)



(b) 1952q1-1980q1

Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Assets	-0.092	-2.038	-2.307 (9)
Government	1.007	1.045	1.283 (11)
Mortgages	-1.867	-4.179	-5.588 (20)
Equity	0.685	2.490	2.997 (19)
Mutual Funds	0.410	0.476	**0.587 (11)**



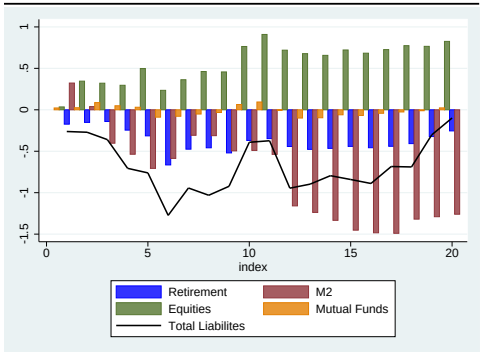
(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 14: The response of selected financial business assets to a positive revenue shock of 1% of GDP.

Financial Business Liabilites; Full Sample

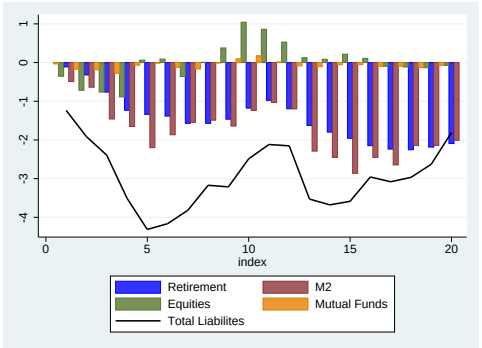
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	-1.274	-0.945	-1.274 (6)
Retirement	-0.665	-0.443	-0.665 (6)
Mutual Funds	-0.089	-0.005	-0.100 (13)
M2	-0.586	-1.159	-1.490 (17)
Equities	0.235	0.719	0.909 (11)



(a) 1952q1-2007q4

Financial Business Liabilites; Pre-1980

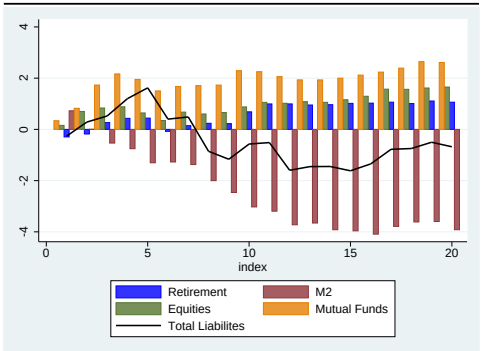
	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	**-4.165**	-2.153	**-4.315 (5)**
Retirement	-1.383	-1.193	-2.253 (18)
Mutual Funds	-0.017	0.018	-0.276 (4)
M2	-1.867	-1.198	-2.863 (15)
Equities	0.090	0.529	1.042 (10)



(b) 1952q1-1980q1

Financial Business Liabilites; Post-1980

	6 Qrt	12 Qrt	Peak (Qrt)
Total Liabilites	0.401	-1.596	1.622 (5)
Retirement	-0.076	0.994	1.108 (19)
Mutual Funds	1.502	2.060	2.645 (19)
M2	-1.273	-3.726	-4.090 (16)
Equities	0.346	1.019	1.653 (20)



(c) 1980Q1-2007Q4

Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Figure 15: The response of selected financial business liabilities to a positive revenue shock of 1% of GDP.

Table 1: Baseline GDP impulse response estimates and model weights in model averaging procedure.

	Perotti Results		My Results (i=FG debt service)			My Results (i=fed funds)			AIC (i=fed funds)	Averaging Weights*
	6 qrt	12 qrt	6qrt	12 qrt	Peak (qrt)	6qrt	12 qrt	Peak (qrt)		
RR	-1.22	-1.50	**-1.623**	**-1.888**	**-2.598 (8)**	**-1.605**	**-1.941**	**-2.552 (8)**	-28.02	0.384
VAR	**-1.88**	**-2.46**	**-2.184**	**-1.946**	**-2.184 (6)**	-1.469	-1.407	**-1.641 (8)**	-36.72	0.005
MR	**-1.83**	**-2.32**	**-2.243**	**-1.948**	**-2.245 (7)**	-1.458	-1.355	**-1.656 (7)**	-27.22	0.573
FG	**-1.85**	**-2.29**	**-2.481**	**-2.713**	**-2.744 (9)**	-1.281	-1.568	-1.592 (11)	-32.66	0.038

*Weighting calculation follows Buckland et al (1997): $exp(AIC_i/2)/\Sigma exp(AIC/2)$
Yellow cells indicate that the impulse response is significant at the 68% level.
Orange cells indicate that the impulse response is significant at the 95% level.
All responses are accumulated % of GDP

Table 2 The response of "policy" variables to a revenue shock equal to 1% of GDP.

	Inflation			Government Spending			Nominal Federal Funds Rate		
	6 qrt	12 qrt	Peak (qrt)	6 qrt	12 qrt	Peak (qrt)	6 qrt	12 qrt	Peak (qrt)
1948-2007	-0.099	-0.125	-0.155 (9)	-0.954	-1.925	-2.120 (16)	0.031	-0.395	-0.649 (11)
1948-1980	-0.209	-0.104	-0.209 (6)	-2.026	-4.86	-5.041 (14)	-1.711	-1.391	-2.117 (11)
1980-2007	-0.107	-0.163	-0.209 (5)	-0.098	-0.658	-1.078 (16)	0.119	-0.225	0.469 (5)

Table 3: The response of the real federal funds rate to a tax revenue shock of 1% of GDP.

	1 Quarter Inflation Rate			4 Quarter Inflation Rate		
	6 qrt	12 qrt	Peak (Qrt)	6 qrt	12 qrt	Peak (Qrt)
48-07	1.114	0.286	1.114 (6)	0.758	0.448	0.900 (4)
48-80	-0.336	-0.169	-0.755 (11)	-0.827	-0.855	-1.087 (7)
80-07	0.788	0.441	0.905 (5)	1.127	0.612	1.353 (4)

Table 4: Romer and Romer tax revenue shocks, by type and target income group.

	Pre-1980		Post-1980	
Tax Type				
	Total	% of all	Total	% of all
All Exogenous Tax Changes	24	100%	12	100%
Payroll Taxes	7	29.17%	3	25.00%
Excise (Production and Consumer Goods)	5	20.83%	4	33.33%
Investment or Depreciation	7	29.17%	4	33.33%
Corporate Income Tax and other Business Taxes	3	12.50%	4	33.33%
Income tax	6	25.00%	7	58.33%
Income Target				
	Total	% of all	Total	% of all
Low	11	45.83%	2	16.67%
Medium	8	33.33%	3	25.00%
High	2	8.33%	3	25.00%
All Income Level	6	25.00%	6	50.00%

Source: Romer and Romer (2008).
Percentages do not add up to 100% because the individual tax bills detailed in Romer and Romer 2009 often include multiple types of tax changes. As well, only income and payroll tax changes target particular income groups.