Fiscal Adjustment to Monetary Shocks

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Abstract

How does the fiscal side of the US government react to monetary policy? I estimate the response of several fiscal variables to monetary shocks. Following an interest rate hike, tax receipts fall, outlays excluding interest payments are constant, and interest payments and debt increase. The fall in output that follows a monetary tightening — not legislated changes in marginal tax rates — drives the response of receipts. The fiscal authority therefore responds passively to monetary shocks, keeping spending constant and letting debt adjust to satisfy its budget constraint. In heterogeneous agent models, this scenario dampens output's response to monetary policy.

Keywords: fiscal policy, monetary policy, heterogeneous agent models

JEL codes: E52, E63

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1 Introduction

In heterogeneous agent new Keynesian (HANK) models, the effect of a monetary policy shock on the economy sharply depends on how the fiscal side of the government reacts (Kaplan et al., 2018). An interest rate hike increases payments on public debt, thus deteriorating the budget balance. Whether the fiscal authority clears its budget constraint by changing income taxes, transfers, spending or issuing more debt, shapes the response of output because it shifts the burden of adjustment to different households. Yet little empirical evidence exists on how Congress responds to the Federal Open Market Committee's (FOMC) decisions.

To answer that question, I estimate the response of several fiscal variables to monetary policy shocks constructed in the spirit of Romer and Romer (2004). These shocks are interest rate changes purged from forecasts of output, inflation and unemployment prepared by the staff of the Federal Reserve System. Since the FOMC might react to news about future fiscal policy, I purge rate changes from forecasts of government receipts, expenditures and surpluses as well. Then, I estimate the effect of those shocks on tax receipts, outlays, debt and surpluses at the federal level. The data on fiscal variables was manually collected from the *Treasury Bulletin*.

I find that, following an exogenous monetary policy tightening, receipts decrease, outlays excluding interest payments are constant, and interest payments and debt increase — all of these variables being expressed in real terms. For a hundred basis point increase in the federal funds rate (FFR) target, tax receipts fall by about 2% within two years and bounce back after two more years. Using a database on legislated tax changes (Romer and Romer, 2010), I show that this response is not driven by legislated changes in the tax schedule, but by the endogenous reaction of tax receipts to the fall in output. With receipts falling, roughly constant spending, and increased interest rate payments, the budget balance deteriorates and feeds an increase in federal debt.

Finally, I show that a simple model of government behavior and debt dynamics can generate these impulse response functions. An ingredient of the model is important to match the response of interest payments: long-term debt. Indeed, a model with only short-term debt would imply that interest payments react in proportion to the interest rate. With an initial interest rate of 6% — the average FFR from 1969 to 2007 —, interest rate payments would jump, in such a model, by 17% following a 100 basis points increase in the nominal interest rate. My empirical findings suggest a much milder response, 5% at the most. Thus, incorporating a realistic maturity structure of government debt into HANK models may also matter to their predictions, because said structure determines the size of the required fiscal adjustment.

Related literature: Kaplan et al. (2018) lament that "there is no empirical evidence that reveals what type of fiscal adjustment is the most likely to occur in practice, following a monetary shock". Still, some papers have touched this question *en passant*. Using vector autoregression (VAR) shocks, Cochrane (1999) finds "not a shred of statistical evidence that federal-funds shocks forecast surpluses". Using a VAR with high-frequency shocks, Sterk and Tenreyro (2018) estimate a response of real debt that is roughly consistent with mine. Also using a VAR with high-frequency shocks, Caramp and Silva (2018) find that fiscal revenues over GDP fall after a monetary shock, government purchases are constant and transfers slightly increase. In spirit, my paper also draws on Coibion et al. (2017), who estimate the response of consumption inequality to Romer and Romer-style shocks, and seek to provide stylized facts for heterogeneous agents models.

2 Methodology

2.1 Estimation Strategy

To identify monetary shocks, I use a variation on the measure developed by Romer and Romer (2004), henceforth RR. RR purge rate changes from forecasts of output, inflation and unemployment to remove the component of monetary policy that is endogenous to economic conditions. The forecasts they use, known as the Greenbook forecasts, are prepared before each Federal Open Market Committee (FOMC) meeting by the staff of the Federal Reserve.

It is plausible, however, that the monetary side of the US government should systematically react to the stance of its fiscal side, above and beyond the latter's effect on output, inflation and unemployment. For instance, the FOMC may monetize fiscal deficits, or tighten in the face of those deficits as a show of independence. To mitigate this concern, I add Greenbook forecasts for receipts, expenditures and surplus of the federal government to the list of controls. Thus, I estimate:

$$\begin{aligned}
\Delta i_m =& \alpha + \beta i_{m-1} + \sum_{q=-1}^{2} \gamma^q \Delta \tilde{y}_m^q + \sum_{q=-1}^{2} \zeta^q \left(\Delta \tilde{y}_m^q - \Delta \tilde{y}_{m-1}^q\right) \\
&+ \sum_{q=-1}^{2} \eta^q \tilde{\pi}_m^q + \sum_{q=-1}^{2} \theta^q \left(\tilde{\pi}_m^q - \tilde{\pi}_{m-1}^q\right) + \iota \tilde{u}_m^0 \\
&+ \sum_{q=-1}^{2} \kappa^q \Delta r\tilde{e}c_m^q + \sum_{q=-1}^{2} \lambda^q \left(\Delta r\tilde{e}c_m^q - \Delta r\tilde{e}c_{m-1}^q\right) \\
&+ \sum_{q=-1}^{2} \mu^q \Delta e\tilde{x}p_m^q + \sum_{q=-1}^{2} \nu^q \left(\Delta e\tilde{x}p_m^q - \Delta e\tilde{x}p_{m-1}^q\right) \\
&+ \sum_{q=-1}^{2} \pi^q s\tilde{r}pl_m^q + \sum_{q=-1}^{2} \rho^q \left(s\tilde{r}pl_m^q - s\tilde{r}pl_{m-1}^q\right) + \epsilon_m
\end{aligned} \tag{1}$$

where i_m is the intended federal funds rate in month m, and $\Delta \tilde{y}_m^q$, $\tilde{\pi}_m^q$, $\tilde{u}_m^q$, $\Delta r\tilde{e}c_m^q$, $\Delta e\tilde{x}p_m^q$ and $s\tilde{r}pl_m^q$ are the forecasts for real output growth, inflation, unemployment, receipts growth, expenditures growth and total budget surplus as a share of output in the previous ($q = -1$), current ($q = 0$) and subsequent ($q = 1, 2$) quarters. The residuals obtained after running this regression, $\hat{\epsilon}_m$, are my measure of monetary shocks.

Following Jordà (2005), my main empirical specification is:

$$y_{m+k} - y_{m-1} = \omega^k + \psi^k \hat{\epsilon}_m + X'_{m-1}\chi^k + \xi^k_m \tag{2}$$

where y_t is the logarithm of the fiscal variable of interest, $\hat{\epsilon}_m$ is the residual obtained in equation (1), and X_{m-1} is a vector of controls. The controls are a quarter of lagged changes in industrial production and the consumer price index (CPI), as well as a quarter of lagged values of the unemployment rate, the FFR and the shocks. The impulse response function at horizon k is given by the various ψ^k for $0 \leq k \leq K$. For each k, I estimate equation (2) as a univariate regression. Standard errors are hetoroskedasticity and autocorrelation robust (HAC).

2.2 Variables of Interest

The variables of interest are receipts, outlays excluding interest payments, interest payments and debt of the federal government. Receipts are mainly composed of income and social insurance taxes. Outlays are all payments made to liquidate an obligation other than the repayment of debt principal. Since that definition includes interest payments, I break them into outlays excluding interest payments and interest payments. Interest payments are defined as interest paid by the Treasury minus interest paid to government accounts. Debt is federal debt held by the public. I deflate each variable by the CPI, and express it in natural logarithm.

Theoretical models usually distinguish government spending from transfers. Alas, the *Treasury Bulletin* isn't as detailed: these two categories are lumped together under outlays. Since, as we shall see, I find no response of outlays (excluding interest payments), it is a safe assumption that neither reacts. The other possibility, which is unlikely, is that they react in opposite directions and exactly offset each other.

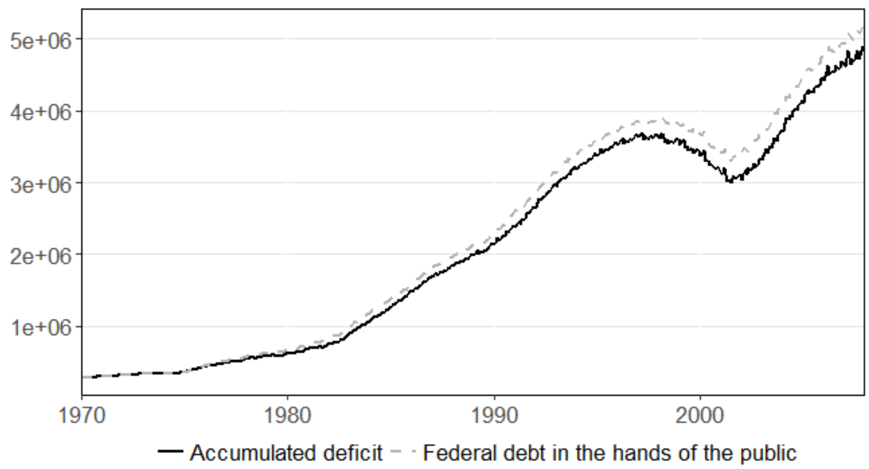
Up to accounting reconciliations, the following identity holds (in nominal terms):

$$\text{outlays} - \text{receipts} = \Delta \text{ federal debt held by the public} - \Delta \text{ monetary assets} - \Delta \text{ other balances} \tag{3}$$

Monetary assets are mainly Treasury operating cash, other balances include various accounts.[1] While these two items are sometimes non negligible, I focus on the evolution of debt as it closely matches accumulated deficit over time (figure 1).

[1]See White House - Office of Management and Budget (2018) for more details.

Figure 1: Deficit and debt over the long run



Note: expressed in million dollars. Both series are equal in January 1970 by construction.

Finally, I shall be interested in surpluses. Since a surplus can switch sign, I express it as a share of receipts instead of taking its logarithm:

$$\text{surplus} = \frac{\text{receipts} - \text{outlays}}{\text{receipts}}$$

This formula corresponds to the primary surplus if interest payments are excluded from outlays, to the total surplus otherwise.

2.3 Data

Especially before 1980, monthly fiscal data is not readily available in digital format. With the help of a research assistant, I hand-collected data from the *Treasury Bulletin* and the *Monthly Treasury Statement of Receipts and Outlays*.[2] Since this data displays extreme seasonal variations, I tame it with the Census Bureau's X-13ARIMA-SEATS — this is implemented in R thanks to the `seasonal` package. To avoid data mining suspicions, I did not seek to adjust the default configuration and let the software choose the specification.

I obtained the Greenbook forecasts from Coibion et al.'s (2017) and Croushore and van Norden's (2018) online appendices. The shock series start in March 1969, when the Greenbooks begin forecasting two quarters ahead, and ends in 2007, since the zero-lower bound became binding in 2008.

Industrial production, CPI and unemployment rate are standard series, downloaded from FRED.

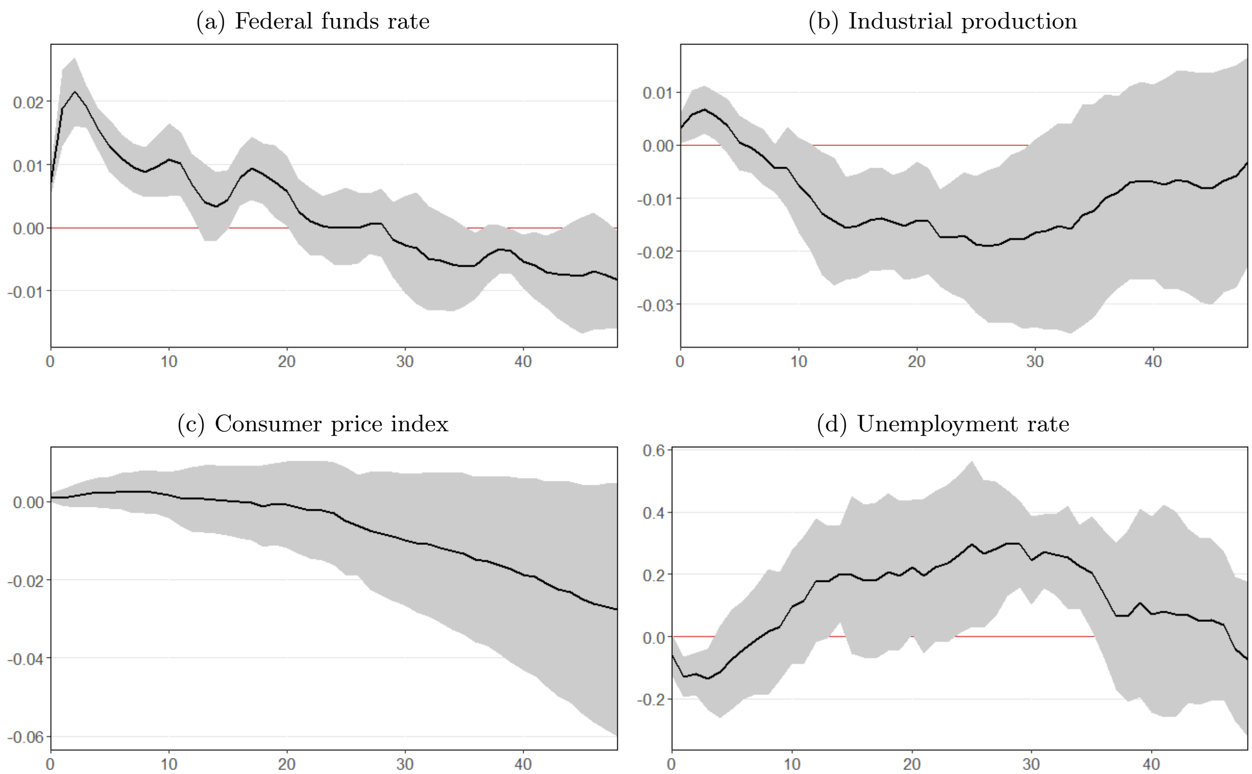
[2] Section B in the appendix contains precise references to the series used.

3 Results

3.1 Baseline

To give context, I first reproduce the well-known responses of the FFR, industrial production, the CPI and the unemployment rate after a RR-style shock (Ramey, 2016, Nakamura and Steinsson, 2018). These are shown in figure 2. The FFR increases by 100 basis points on impact, keeps increasing for a few months, and reverts to its initial value 20 months after the shock. Industrial production falls by about 2% within two years and bounces back within two additional years. The CPI falls by 3% in 4 years. The unemployment rate increases by up to 30 basis points.

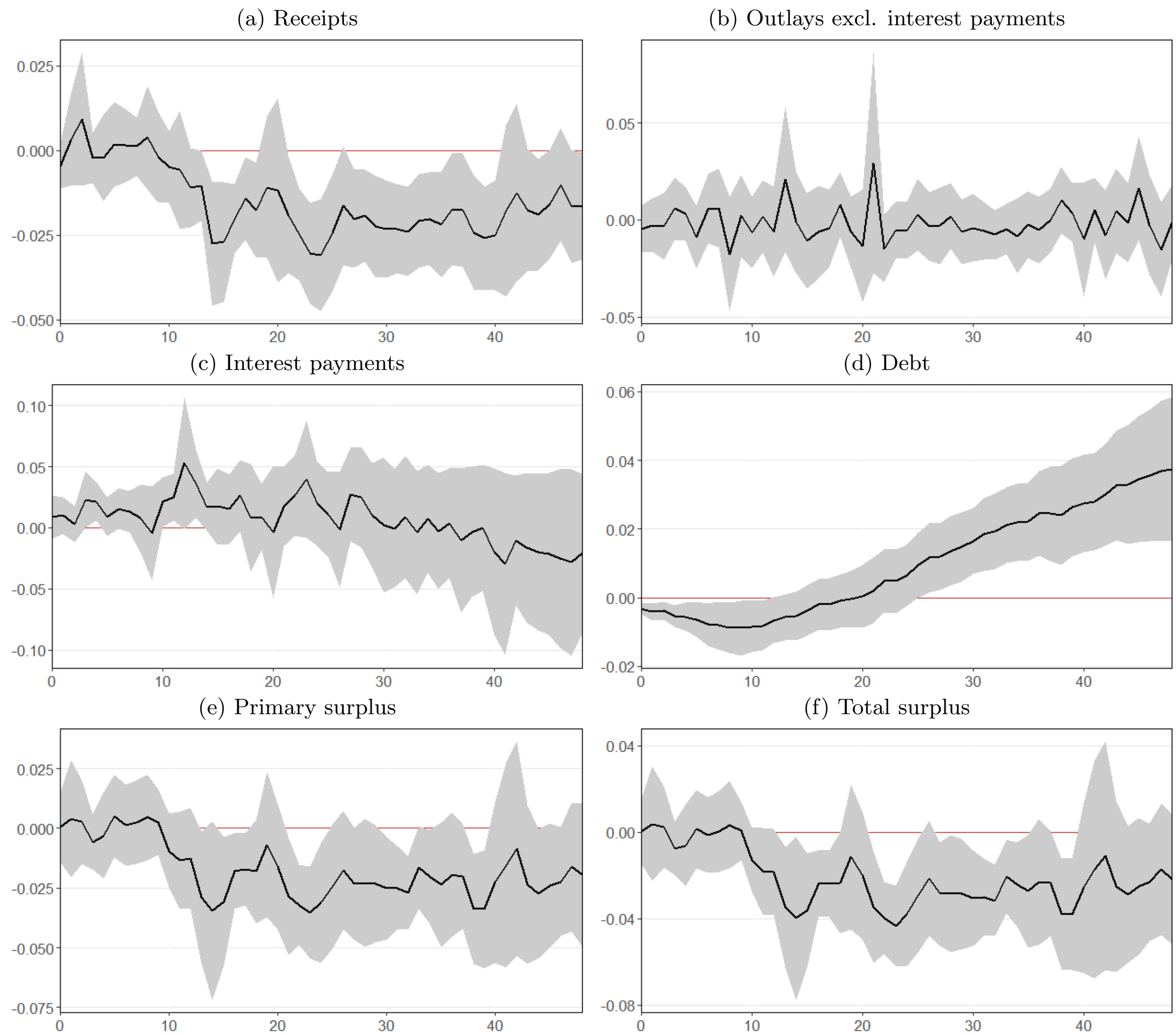
Figure 2: Context



Note: response to a 100 basis point increase in the FFR target. The grey area is the 95% confidence interval with HAC standard errors. Time is in months.

Figure 2 is context, figure 3 shows results. The response of receipts mimics that of output with a slight lag: they fall by about 2-3% within two years, linger at that lower level for another year and revert in the fourth year. Outlays are flat: there is no counter-cyclical response of government spending. Interest payments increase with the FFR and revert back with the latter. Real debt builds up after a year and increases by about 4% after four years.

Figure 3: Results



Note: response to a 100 basis point increase in the FFR target. The grey area is the 95% confidence interval with HAC standard errors. Time is in months.

In the appendix, I explore several variations on the baseline specification. First, I increase the number of lags without much consequence for the results (figure A.2). Second, I use plain-vanilla RR shocks which are constructed without fiscal forecasts (figure A.3).[3] Their inclusion in equation (1) turns out to be of little influence for the results: this is because, as Croushore and van Norden (2018) showed, the two shock series are highly correlated. The correlation coefficient of the standard RR shocks with those that I estimate is 0.96. Third, I redo the analysis with data for all government entities. Since I am not aware of systematic monthly data for state and local governments, the main analysis was restricted to the federal level. From a theoretical

[3]I use the shock series updated by Coibion et al. (2017).

point of view, however, the behavior of non-federal entities is also interesting. At quarterly frequency, the NIPA tables and Flow of Funds provide time series for the general government sector. While the national accounts' accounting concepts are not directly comparable to those used in the *Treasury Bulletin*,[4] redoing the analysis with those series is a rough test of whether the findings are robust to including non-federal governments and using a different data source. As figure A.4 shows, and even though statistical significance is harder to achieve with quarterly data, the dynamics exhibited by general government series after a monetary shock are similar to those obtained for the federal government.

3.2 Interpretation

3.2.1 Output-Driven vs. Legislated Changes in Tax Receipts

There are three possible explanations for the response of receipts: (i) tax revenues fall with output for a given tax schedule, (ii) Congress systematically changes the tax schedule after monetary policy shocks, (iii) chance correlation. Numbers (i) and (ii), though they highlight different mechanisms, would be valid causal effects of monetary policy. Number (iii) is worrisome in this context: the biggest RR monetary policy shocks occurred in the early Volcker era (Coibion, 2012); at about the same time, Ronald Reagan was presiding over one of the largest tax cuts in US history. Luckily, an informal piece of evidence suggests that the response of receipts is mostly due to number (i): on figure 3, the response of receipts follows that of output. Moreover, the fact that the fall in receipts dissipates after a few years doesn't seem consistent with a change in the tax schedule, which one would expect to last longer.

To investigate this question more formally, I use the database of *legislated* tax changes created by Romer and Romer (2010). They analyze the narrative record to quantify changes in the tax schedule, and classify them according to their underlying motivation. They thus distinguish four rationales that can drive a legislated tax change: finance extra spending, fight a recession, remedy an inherited deficit, and spur long-run growth. The first three categories may be endogenous to monetary policy.[5] The latter category is exogenous to monetary policy, but it is a first order of concern for it includes the Reagan tax cuts of 1981. In any case, my strategy to deal with these legislated changes is to add them as controls. If they are endogenous reactions to monetary policy, these are bad controls, no doubt. But whether these controls affect the results will indicate whether receipts fall because of legislated changes.

[4] In particular, the *Treasury Bulletin* considers government employee retirement funds as intra-governmental holdings, whereas they are part of the financial sector in financial accounts (Federal Reserve Board, 2019).

[5] Romer and Romer (2010) are interested in a different question — what are the effects of tax cuts on output. Hence their assessment of which tax changes are endogenous differs from mine. From their point of view, remedying an inherited deficit is exogenous since it is not driven by economic conditions. From my point of view, an inherited deficit can be the result of past monetary policy actions — the FOMC decides to generate less seigniorage for instance —, hence should be treated as potentially endogenous.

I estimate the following variation on equation (2):

$$y_{q+k} - y_{q-1} = \omega^k + \psi^k \hat{\epsilon}_q + X'_{q-1}\chi^k + \phi^k \left(z_{q-1}^{q+k}\right) + \xi_q^k \tag{4}$$

where y_q are receipts in quarter q and z_{q-1}^{q+k} is the accumulated legislated tax change between quarters $q-1$ and $q+k$ — the legislated tax changes database is quarterly so I switch to quarterly frequency for this exercise.[6] To measure legislated tax changes, I use the absolute amount of each tax change, retrieved by Romer and Romer (2010), divided by receipts collected in the year that preceded the tax change. I also experimented with expressing tax changes as a share of GDP, without a notable influence on the results.

The results (figure 4a) confirm the conclusion reached three paragraphs ago: legislated tax changes, be they exogenous or endogenous, do not explain the response of receipts. Adding exogenous tax changes as a control lessens the response of receipts in the third year but mostly preserves it.[7] This dispels the worry that the latter be driven by the coincidence of Volcker and Reagan shocks. Adding endogenous tax changes as a control has no bearing on the response of receipts. A final piece of evidence is given by figure 4b: once I add a year of lagged changes in industrial production as a control, the response of receipts is almost entirely gone. Again, industrial production is a bad control in so far as it responds to monetary policy. That its response, however, explains the response of receipts suggests monetary policy affects receipts *through* output.

3.2.2 Unpacking the Response of Receipts and Debt

Federal receipts incorporate many kinds of revenues: income, social security or excise taxes, customs duties, earnings by Federal Reserve Banks. In practice, income and social insurance taxes make the rest look trivial. In fiscal year 2007 for instance, they respectively accounted for 60 and 32% of receipts. Figure 4c shows that both categories react similarly.

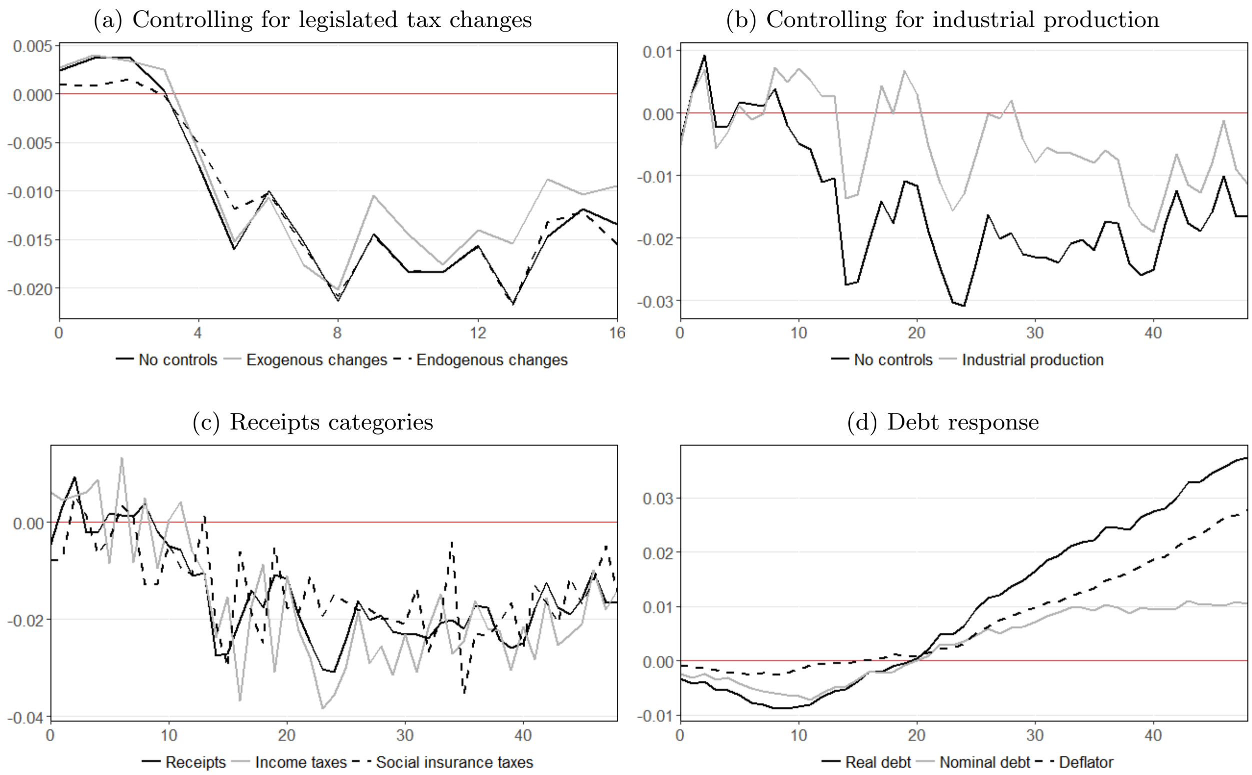
The response of real debt can be driven by two mechanisms: an increase in nominal debt or a fall in its deflator. I plot the response of real debt, nominal debt and the deflator on figure 4d. It turns out these two mechanisms contribute to the buildup in real debt but the bulk of the response is accounted for by the fall in the deflator.

4 A Minimalist Framework

I now show that a parsimonious model fits the data well. The main ingredients of the model are: long-term debt, a tax on output and passive government spending.

[6] I aggregate monthly receipts and shocks by summing them over quarters.
[7] See figure A.5 for pictures with standard errors.

Figure 4: Interpretation



Note: response to a 100 basis point increase in the FFR target. Lines are point estimates. Time is in quarters for figure 4a, in months otherwise.

4.1 Environment

Consider the theoretical equivalent of equation (3):

$$D_t - D_{t-1} = G_t + INT_t - T_t \tag{5}$$

where D_t is the amount of debt at time t and carried into period $t+1$, G_t government spending — outlays excluding interest payments —, INT_t interest payments and T_t tax receipts. All variables are in nominal terms.

A model with one-period debt would be hopeless in fitting the response of interest payments. Indeed, in such a model real interest payments are given by:

$$\frac{INT_t}{P_t} = i_{t-1} \frac{D_{t-1}}{P_{t-1}} \frac{P_{t-1}}{P_t} \tag{6}$$

where i_{t-1} is the interest rate from $t-1$ to t. Since real debt and inflation are roughly constant in the short run, interest payments would increase in proportion to the interest rate. Assuming a steady state nominal interest rate of 6% — the average over the sample —, interest payments would increase by 17% within a month after a 100 basis point hike in i_t. Figure 3 shows that this is strongly rejected by the data.

To introduce long-term debt in a tractable way, I assume that the government issues debt with a geometric maturity structure, in the form of zero-coupon bonds. At time t_0, the government issues $D^n_{t_0}$ in new debt. Of the debt issued at time t_0, it pays back, at time t_0+1, $(1-\rho)D^n_{t_0}$ in principal and $i_{t_0,t_0+1} \times (1-\rho)D^n_{t_0}$ in interest, where i_{t_0,t_0+1} is the interest rate from t_0 to t_0+1. It does not pay interest on debt that matures later since all debt is in the form of zero-coupon bonds. At time t_0+2, it pays back $\rho(1-\rho)D^n_{t_0}$ in principal and $i_{t_0,t_0+2} \times \rho(1-\rho)D^n_{t_0}$ in interest. And so on. Thus, the amount of debt issued at time t_0 and due at time t equals $\rho^{t-t_0-1}(1-\rho)D^n_{t_0}$, which pays interest rate $i_{t_0,t}$. ρ governs the maturity of the debt. $\rho=0$ is the one-period case. $\rho=1$ means that debt is never paid back.

As a result, total interest payments at time t are the sum of interest payments on debt issued in all previous periods and maturing at time t:

$$INT_t = (1-\rho)\sum_{t_0=-\infty}^{t-1} \rho^{t-t_0-1} i_{t_0,t} D^n_{t_0}$$

Provided the expectation hypothesis holds, $i_{t_0,t}$ is:

$$i_{t_0,t} = E_{t_0}\Pi_{s=0}^{t-t_0-1}(1+i_{t_0+s})-1$$

Log-linearizing around a steady state where real variables are constant and the inflation rate is π^*:

$$\hat{int}_t = \kappa \sum_{t_0=-\infty}^{t-1}\left(\frac{\rho}{1+\pi^*}\right)^{t-t_0-1}\left[(1+i^*)^{t-t_0-1}\sum_{s=0}^{t-t_0-1} E_{t_0}\hat{\imath}_{t_0+s} + \left((1+i^*)^{t-t_0}-1\right)\left(\hat{d}^n_{t_0}-\hat{\pi}_{t_0,t}\right)\right] \tag{7}$$
$$\kappa = \frac{(1+\pi^*-\rho)(1+\pi^*-\rho(1+i^*))}{i^*(1+\pi^*)^2}$$

Lower-case letters (int_t, d^n_t) denote the log of real variables and hats deviations from steady state. $\hat{\pi}_{t_0,t}$ is inflation from t_0 to t, in deviation from steady state. $\hat{\imath}_t$ is the deviation from steady state of the nominal interest rate. If all debt is one-period ($\rho=0$), equation (7) collapses to:

$$\hat{int}_t = \frac{\hat{\imath}_{t-1}}{i^*} + \hat{d}_{t-1} - \hat{\pi}_t \tag{8}$$

Which is just the log-linear version of equation (6). As ρ grows, interest payments react more slowly to a change in the interest rate since debt must be rolled-over before the new interest rate is paid.

The response of debt over time is given by the log-linearized budget constraint:

$$\hat{d}_t - \frac{1}{1+\pi^*}\left(\hat{d}_{t-1} - \hat{\pi}_t\right) = \frac{g^*}{d^*}\hat{g}_t + \frac{(1-\rho)i^*}{1+\pi^* - \rho(1+i^*)}\hat{int}_t - \frac{t^*}{d^*}\hat{t}_t \tag{9}$$

supplemented with the law of motion of debt:

$$\hat{d}_t = \left(1 - \frac{\rho}{1+\pi^*}\right)\hat{d}^n_t + \frac{\rho}{1+\pi^*}\left(\hat{d}_{t-1} - \hat{\pi}_t\right) \tag{10}$$

Finally, I make two assumptions on the behavior of the fiscal authority that are suggested by the empirical results of the previous section. To reflect the tendency of receipts to lag the response of output, taxes are a function of the past year's output: $T_t/P_t = \bar{T}(\frac{1}{12}\sum_{s=0}^{11} y_{t-s})$. Moreover, government spending is constant: $G_t/P_t = g^*$. In real log-linear terms these two equations become:

$$\hat{t}_t = \frac{\tau}{12}\sum_{s=0}^{11}\hat{y}_{t-s}, \qquad \tau = \frac{\bar{T}'(y^*)}{\bar{T}(y^*)} \tag{11}$$

$$\hat{g}_t = 0 \tag{12}$$

4.2 Calibration

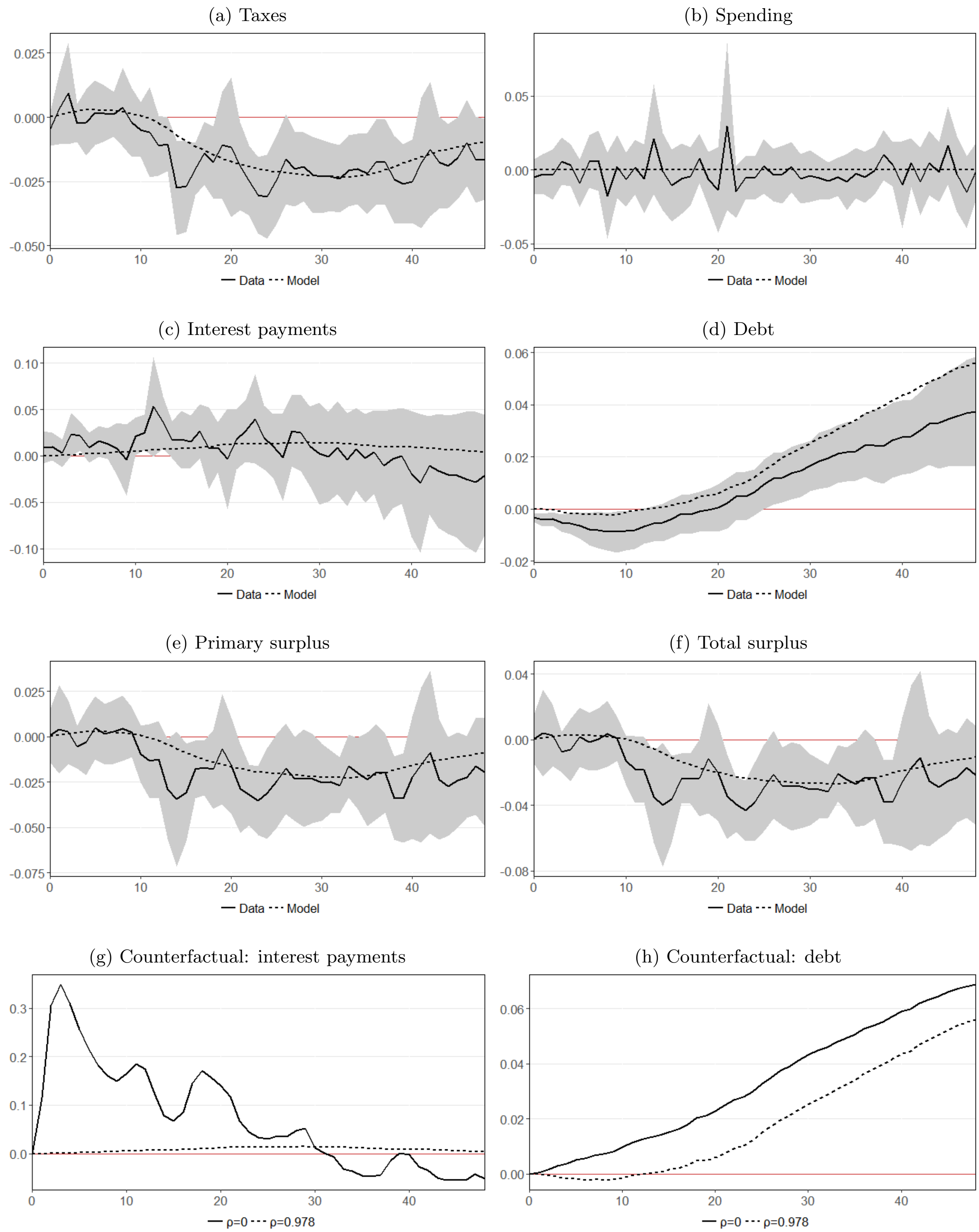
Equations (7) to (12) describe the response of $\hat{t}$, $\hat{g}$, $\hat{int}$ and $\hat{d}$ for given paths of $\hat{y}$, $\hat{\pi}$ and $\hat{\imath}$. I feed the point estimate for the response of the latter three variables into the model, and simulate that of the former four. This exercise requires five parameters to be calibrated: the ratios of tax and spending to debt (t^*/d^* and g^*/d^*), the steady state interest and inflation rates (i^* and π^*), the rate of persistence of debt (ρ) and the elasticity of taxes with respect to output (τ). I make g^*/d^*, i^* and π^* equal to their mean over the sample, and pick t^*/d^* to clear the budget constraint in steady state. I set ρ to give a weighted average maturity of debt of 45 months, which is in line with actual data in the 1980s,[8] and τ to minimize the distance between the simulated and estimated responses of tax receipts. This procedure yields $\tau = 1.358$.[9]

I display the results in figure 5. The model fits the data well. Note that, apart from taxes, I used none of the impulse response functions to calibrate parameters. Interest payments exhibit the hump-shaped response of the data: after the interest rate hike, they increase sluggishly as debt is rolled-over. After about 20 months, the interest rate reverts to 0 and interest payments start declining. Debt accumulates as the budget balance swings into deficit.

To illustrate the importance of long-term debt, I run a simple counterfactual experiment in my model:

[8] See Treasury Department - Office of Debt Management (2018, p. 23).
[9] Table A.1 summarizes these calibration choices.

Figure 5: Theoretical results



Note: figures 5a to 5f compare actual impulse response functions to those generated by the model. The solid line is the point estimate. The grey area is the 95% confidence interval with HAC standard errors. The dashed line is the prediction of the model. Figures 5g and 5h compare the predictions of the model with ($\rho > 0$) and without ($\rho = 0$) long-term debt. Time is in months.

feeding in the same path for $\hat{y}$, $\hat{\pi}$ and $\hat{\imath}$, what happens if all debt is one period? As expected, the response of interest payments is radically different (figure 5g). It looks exactly like the response of the FFR... up to one detail: the magnitude is scaled by $1/i^*$ as equation (8) suggests. This translates into a stronger response of debt: over the simulated horizon, debt is up to 2% higher when $\rho = 0$.

5 Conclusion: Takeaways for HANK Models

Kaplan et al. (2018, pp. 732-34) discuss several possible adjustments to a monetary shock: the government can change transfers, expenditures, tax rates, or let real debt adjust to clear its budget constraint. Judging by my estimates, the latter case is the empirically relevant one. Incidentally, it is also the case that implies the smallest effects of monetary policy as other cases entail changes that amplify the response of output — a decrease in transfers or expenditures, or an increase in tax rates following a contractionary shock.

Another modeling detail might shape the response of the economy to monetary policy: the maturity of government debt.[10] Indeed, Kaplan et al. cite interest payments as the primary reason why monetary policy affects the government's budget constraint. Since their government issues bonds with infinitesimal maturity — they're working in continuous time —, interest payments must react in proportion to the interest rate. In reality, interest payments react only moderately to monetary shocks. In contemporaneous work, Auclert et al. (2020) introduce long-term debt in a HANK model with sticky household expectations, and indeed find the fiscal response to be less important.

[10] Alves et al. (2019) also note this.

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Appendix for "Fiscal Adjustment to Monetary Shocks"

A Tables and Figures

Table A.1: Calibration

	Parameter	Target	Comment
i^*	0.005	Sample mean	Annual: 6%
π^*	0.004	Sample mean	Annual: 4%
g^*/d^*	0.045	Average spending to debt ratio	Annual: 54%
t^*/d^*	0.047	Steady state budget constraint	Annual: 57%
ρ	0.978	Weighted average maturity of debt	45 months
τ	1.358	Response of receipts	Elasticity of taxes with respect to output

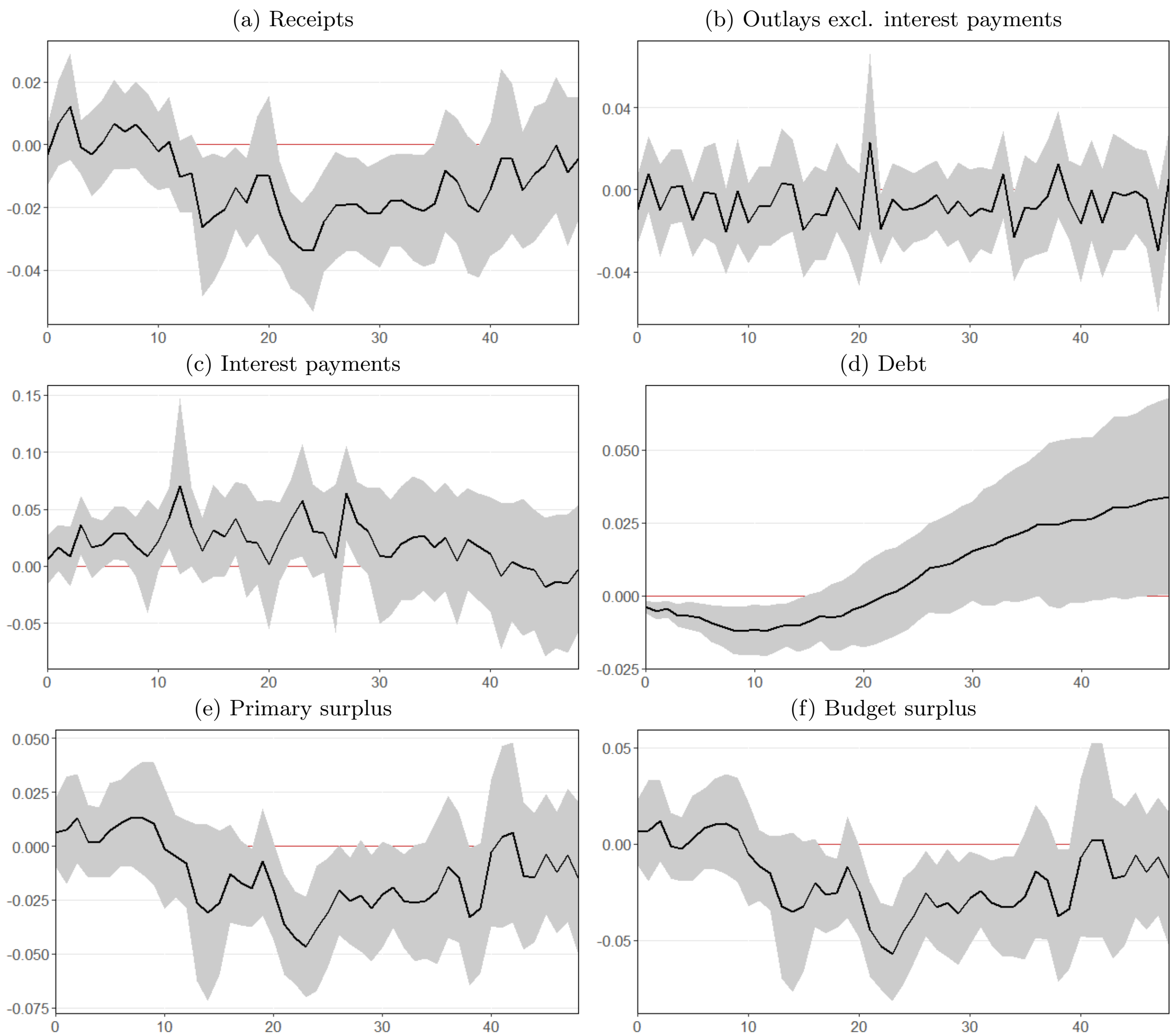
Figure A.1: An Example of the data

Table FFO-1. - Summary of Fiscal Operations

(In millions of dollars)

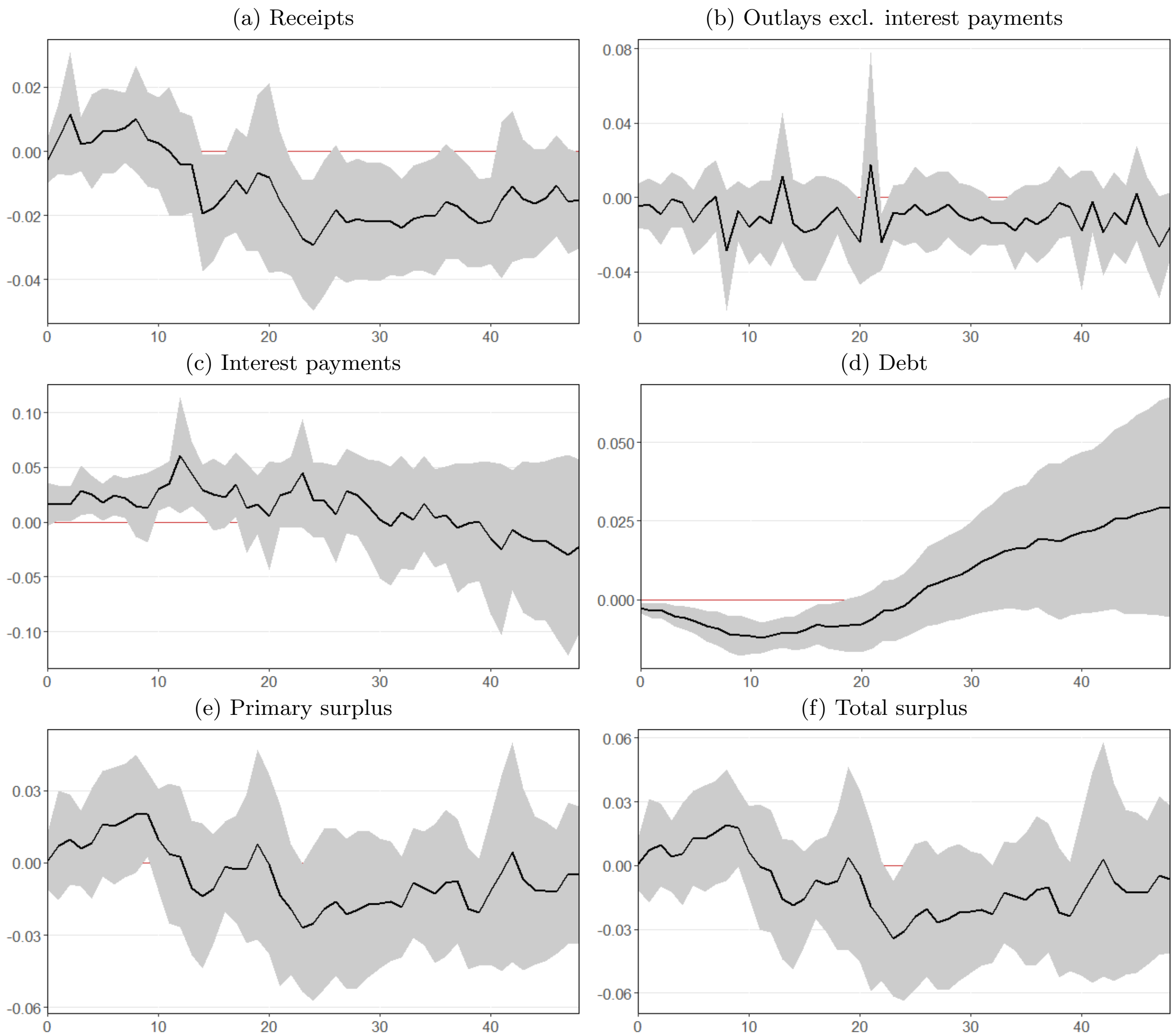
Fiscal year or month	Budget receipts, expenditures, and lending								Means of financing - net transactions				
	The expenditure account			Loan account 1/					Borrowings from the public - Federal securities				
	Net receipts 2/ (1)	Net expend-itures 3/ (2)	Surplus or def-icit (-) (1)-(2) (3)	Loan dis-burse-ments (4)	Loan repay-ments (5)	Net lending 3/ -(4)+(5) (6)	Out-lays 3/ (2)-(6) (7)	Budget surplus or def-icit (-) (3)+(6) (8)	Public debt securi-ties (9)	Agency securi-ties (10)	Invest-ments of Govern-ment ac-counts 4/ (11)	Special notes 5/ (12)	Total bor-rowings from the public (9)+(10)-(11)-(12) (13)
1961	94,389	96,597	-2,208	7,869	6,671	-1,198	97,795	-3,406	2,640	-292	605	316	1,427
1962	99,676	104,462	-4,786	9,621	7,271	-2,351	106,813	-7,137	9,230	1,450	627	284	9,769
1963	106,560	111,456	-4,896	9,646	9,791	145	111,311	-4,751	7,659	196	1,428	339	6,088
1964	112,662	118,039	-5,377	10,237	9,693	-545	118,584	-5,922	5,853	508	2,864	405	3,092
1965	116,833	117,181	-347	10,911	9,662	-1,249	118,430	-1,596	5,561	704	2,330	-126	4,061
1966	130,856	130,820	36	14,628	10,796	-3,832	134,652	-3,796	2,633	4,041	3,244	354	3,076
1967	149,552	153,201	-3,649	17,676	12,623	-5,053	158,254	-8,702	6,314	5,079	9,035	-482	2,838
1968	153,671	172,802	-19,131	20,327	14,297	-6,030	178,833	-25,161	21,357	5,944	5,320	-1,119	23,100
1969	187,792	183,080	4,712	13,167	11,691	-1,476	184,556	3,236	6,142	-10,150	8,522	-1,384	-11,146
1970 (Est.)	199,386	194,985	4,401	9,489	6,589	-2,900	197,885	1,501	9,232	-1,642	8,590	-	-1,000
1971 (Est.)	202,103	200,088	2,014	8,604	7,921	683	200,771	1,331	8,171	-402	8,969	-	-1,200
1968-Dec	15,836r	14,473r	1,363r	1,577	1,649	71	14,402r	1,435r	1,166	-5,203	-267r	-185	-3,586
1969-Jan	15,845	15,798	47	633	670	37	15,761	84	1,383	-33	724	-1,000	1,626
Feb	14,590	14,361	230	756	383	-373	14,734	-144	-648	195	1,433	-	-1,887
Mar	13,727	15,637	-1,910	724	723	-2	15,639	-1,912	782	-91	272	-	418
Apr	23,596	15,922	7,674	796	746	-50	15,972	7,625	-1,080	-559	817	-	-2,456
May	13,346	15,279	-1,932	936	451	-485	15,764	-2,418	1,599	-137	2,946	-	-1,485
June	23,805	13,895	9,910	992	1,365	373	13,522	10,283	-6,345	-188	2,054	-	-8,587
July	12,542	15,542	-3,001	470	318	-152	15,695	-3,153	3.292	1,316	170	-	4,438
Aug	14,999	16,790	-1,791	585	269	-316	17,106	-2,107	3,175	-829	1,667	-	679
Sept	20,406	17,167	3,239	775	327	-448	17,616	2.790	498	-643	230	-	-375
Oct	11,832	17,602	-5,769	819	477	-342	17,944	-6.112	3.709	-47	-727	-	4,388
Nov	14,332	15,225	-894	613	377	-236	15,461	-1,130	3,718	-141	883	-	2,695
Dec	16,704	15,232	1,472	687	827	140	15,092	1,612	113	-85	2,041	-	-2,012
Fiscal 1970 to date	90,818	97,562	-6,744	3,950	2,595	-1,355	98,917	-8,099	14,505	-429	4,265	-	9,811

Figure A.2: Results with a year of lags as controls



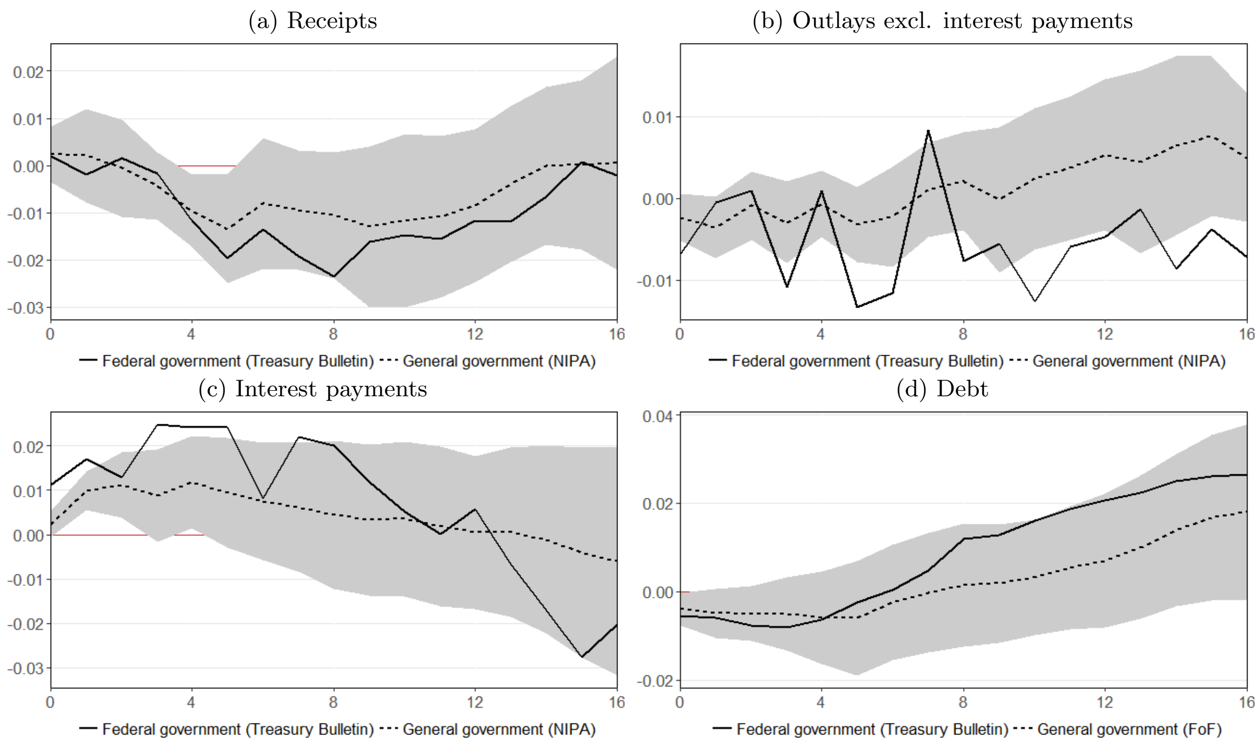
Note: response to a 100 basis point increase in the FFR target. The grey area is the 95% confidence interval with HAC standard errors. Time is in months.

Figure A.3: Results with Coibion et al. (2017) shocks



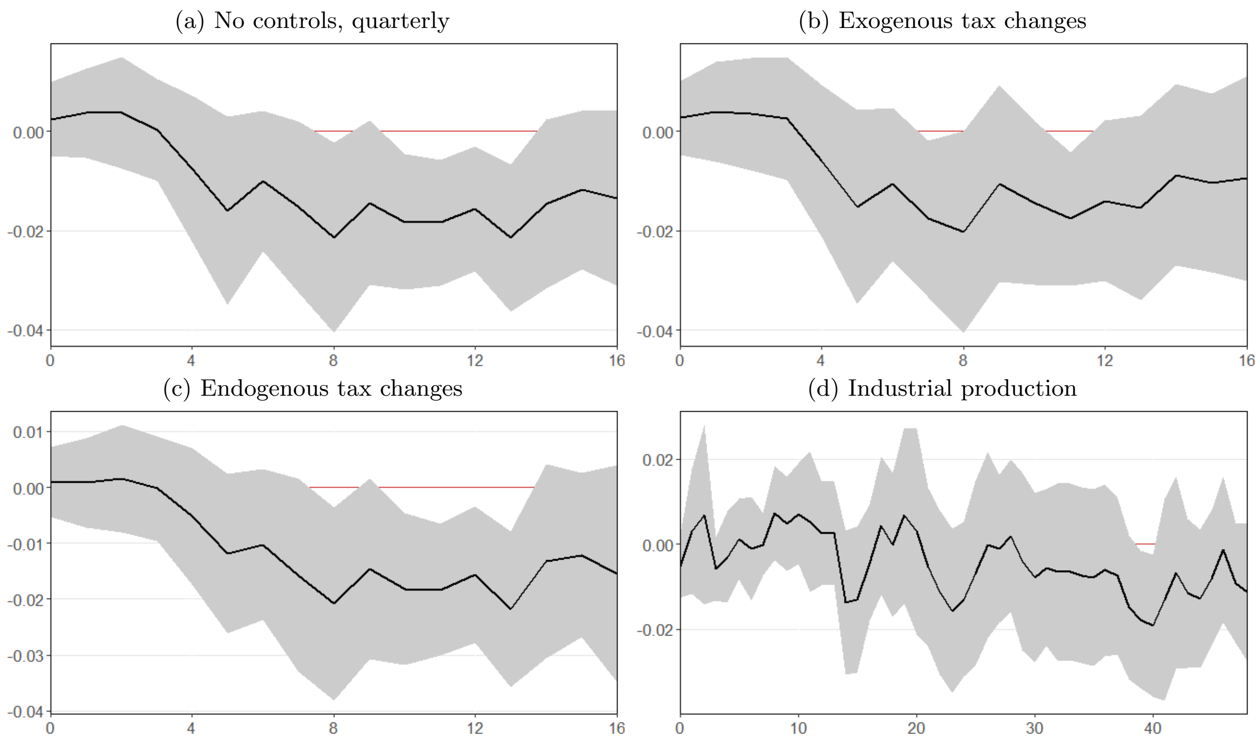
Note: response to a 100 basis point increase in the FFR target. The grey area is the 95% confidence interval with HAC standard errors. Time is in months.

Figure A.4: Results including state and local governments



Note: response to a 100 basis point increase in the FFR target. Lines are point estimates. The grey area is the 95% confidence interval with HAC standard errors, for the general government sector. Time is in quarters. Data series for general government: (a) total receipts (NIPA), (b) total expenditures minus interest payments (NIPA), (c) interest payments (NIPA), (d) consolidated total liabilities of the general government (Flow of Funds).

Figure A.5: Receipts response with controls



Note: response to a 100 basis point increase in the FFR target. The grey area is the 95% confidence interval with HAC standard errors. Time is in months.

B Data Sources

The exact terminology fluctuated over the years. When it did, I checked the underlying accounting concept stayed the same by comparing values for overlapping dates.

Receipts. *Treasury Bulletin* until October 1980 (February or March edition); table: "Summary of Fiscal Operations" (FF0-1); column: "Net receipts" or "Net budget receipts". *Monthly Treasury Statement* from October 1980; available in Excel format from: `https://fiscal.treasury.gov/reports-statements/mts/current.html`; column B.

Outlays: see receipts. Column in 1968: "Net expenditures" minus "Net lending". Column from 1969 to October 1980: "Outlays" or "Net outlays". Column C after October 1980.

Interest paid by the Treasury: *Treasury Bulletin*; table: "Budget Outlays by Agencies" (table FF0-3); column: "Department of the Treasury - Interest on the public debt".

Interest paid to government accounts: *Monthly Treasury Statement of Receipts and Outlays of the United States Government* in 1983 and 1985; table: "Summary of Receipts and Outlays". Line: "Interest on certain Government accounts" until March 1985, "Interest received by trust funds" afterwards. *Treasury Bulletin* otherwise. Table before 1983: "Undistributed Intrabudgetary Transactions" (FF0-4); column: "Interest credited to certain Government accounts - Total". Table after 1985: "On-budget and Off-budget Outlays by Agency"; column: "Interest received by trust funds".

Federal debt in the hands of the public: *Treasury Bulletin*; table: "Summary of Federal Debt" (FD-1); column: "Securities held by the public - Total".

Income taxes: *Treasury Bulletin*; table: "On-budget and Off-budget Receipts by Source"; column: "Net income taxes".

Social insurance taxes: see income taxes. Column: "Net social insurance and retirement receipts".

Legislated tax changes: Romer and Romer (2010). I use the measure that includes retroactive tax changes.

Greenbook forecasts: online appendices of Coibion et al. (2017) and Croushore and van Norden (2018).

Others: FRED.