The Fiscal Multiplier*

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Abstract

We show that the government spending multiplier is typically less than one. Multipliers above one can be achieved only when spending is deficit-financed and monetary policy accommodates the stimulus. We reach these conclusions by measuring the size of the multiplier using a Heterogeneous-Agent New-Keynesian (HANK) model that matches empirically measured marginal propensities to consume (MPCs) and nominal rigidities. The calibrated model is locally determinate. It thus delivers a unique fiscal multiplier, and, in contrast to complete markets models, multipliers much larger than one are ruled out even when the nominal rate is fixed at zero. Counterfactually high MPCs or low wage rigidities yield higher multipliers, *ceteris paribus*, but may result in local indeterminacy.

Keywords: Fiscal Multiplier, Incomplete Markets, Sticky Prices, Determinacy

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1 Introduction

In an attempt to stabilize the economy during the Great Recession and COVID recessions, monetary authorities lowered nominal interest rates to nearly zero and fixed them at that level for several years. Having reached the limit of traditional monetary policy, U.S. legislators stepped in with the largest fiscal stimulus packages since the 1930s. Although attempts to stabilize the economy through spending occur in virtually every recession, the questions of how much and through which channels an increase in government spending affects output, employment and investment are far from settled. In this paper we develop a framework suitable to address these questions and use it to obtain quantitative answers. There are four novel and essential cornerstones underlying our analysis.

First, to measure the size of the fiscal multiplier, one needs a dynamic equilibrium model featuring two key empirically-grounded frictions: incomplete asset markets and nominal rigidities. This leads us to base our analysis on a Heterogenous Agent New Keynesian (HANK) model that incorporates nominal price and wage rigidities into standard Bewley-Imrohoroglu-Huggett-Aiyagari model with capital accumulation.[1] The nominal rigidities generate a meaningful demand channel in the model, implying that workers and firms adjust quantities and not only prices in response to increased government demand induced by fiscal stimulus. Introducing incomplete markets allows the model to match the rich joint distribution of income, earnings and wealth. Such heterogeneity is crucial in generating a realistic distribution of marginal propensities to consume (MPCs) and for measuring the aggregate impact of redistribution induced by economic policies in equilibrium.[2] These two elements allow the model to capture both the direct stimulative effect of government spending and indirect effects through the change in labor and asset income induced by the stimulus.

The failure of Ricardian equivalence in the model (due to incomplete markets) implies that "the fiscal multiplier" is not a single number — its size crucially depends on how the fiscal stimulus is financed (debt, distortionary taxation, reduction of transfers) and on how monetary policy responds. Furthermore, the state of the economy, households' and firms' expectations about future policy changes, and whether stimulus takes the form of spending or transfers all impact the size of the multiplier. These important details are difficult to

[1]See Kaplan and Violante (2018) for a recent review of this emerging literature combining incomplete-markets models with nominal rigidities. Additional references include, among others, Oh and Reis (2012), Guerrieri and Lorenzoni (2017), Gornemann et al. (2012), Kaplan et al. (2018), Auclert (2019), Luetticke (2021), McKay et al. (2016), Bayer et al. (2019), Ravn and Sterk (2017), Den Haan et al. (2017), Bhandari et al. (2021), Auclert and Rognlie (2017), Hagedorn et al. (2019a) and Hagedorn et al. (2019b). Dupor et al. (2023) build on our insights to quantify the size of the fiscal multiplier in the Great Recession in the US exploiting cross-regional evidence and a multi-region HANK model.

[2]Appendix I provides a series of quantitative experiments that illustrate that our incomplete markets model is closer to the empirical findings in the micro consumption literature than other widely used frameworks.

control for in empirical studies (see Ramey, 2011, 2019, for surveys). As a consequence, these studies can reveal the impact of a particular configuration of policies, but are less informative on the implications of alternative combinations of policy choices implemented given specific economic conditions. We fill this gap by considering in the model various combinations of financing the stimulus and how interest rates are set. We focus on two financing schemes, full tax or full deficit financing, since these yield the lowest and highest multiplier, respectively. Any mixture of financing yields a multiplier in between. For monetary policy we consider constant nominal interest rates, as well as inflation and price-level targeting policy rules.

Incorporating capital accumulation into the model is also crucial for assessing the effects of fiscal policy. Stimulus affects demand for both consumption and investment, and the two channels interact significantly in equilibrium. Moreover, if the financing of fiscal spending involves changes in government debt, it may imply a crowding out of investment, the consequences of which need to be taken into account in policy evaluation. Of course, the equilibrium response of investment depends on the elasticity of interest rates and wages as those prices determine firms' substitution between labor and capital. This is why we introduce wage rigidities into the model to match the empirical properties of wages in the data. This allows the model to capture the correct response of investment and the dynamics of firms' profits and labor incomes necessary to reproduce the dynamics of demand.

Second, a prerequisite for measuring the fiscal multiplier is to ensure that the economy is locally determinate, meaning that the equilibrium exists and is (locally) unique. Without (local) equilibrium uniqueness, the results of any experiments conducted in the model are hard to interpret. One can neither focus on a particular multiplier when others are equally possible nor can one make policy recommendations based on multiplicity. The local determinacy properties of HANK models have been largely unknown. We leverage novel theoretical results from Hagedorn (2023) and verify that our calibrated economy is locally determinate.

Third, an important innovation of our framework is to introduce a partially nominally specified government budget constraint (nominal bonds). While nominal bonds are a salient feature of actual economies, most of the extant literature has considered fully real HANK or Representative Agent New Keynesian (RANK) models. We show that the local determinacy properties of a HANK model with real government bonds are sensitive to parameter choices, such as price and wage rigidities, or marginal propensities to consume. They also depend on whether the model includes capital and on the behavior of monetary policy. In contrast, our HANK model with nominal bonds remains locally determinate for all such choices. Indeed, it is the combination of incomplete markets and nominal bonds in our model that generates a locally determinate economy even when the nominal rate is fixed, implying a unique fiscal multiplier under our constant nominal interest rate experiments. In other words, our framework allows us to measure the size of the fiscal multiplier for a wide range of parameterizations and for arbitrary combinations of monetary and fiscal policies of practical interest, including a constant nominal interest rate, without having to impose restrictions on policy rules to ensure determinacy.

Fourth, a quantitative assessment of the fiscal multiplier requires both household and firm decisions in the model to be consistent with their counterparts in the data. This requires a model that, first, features the empirically relevant level of nominal rigidities as in Christiano et al. (2011) and Bayer et al. (2022), implying that the aggregate demand channel is as strong as in the data.[3] Second, it requires generating marginal propensities to consume consistent with micro evidence. Until recently, consensus empirical estimates of the quarterly MPC on non-durable consumption[4] — which matches the notion of consumption in the model (see Kaplan et al., 2018) — were approximately between 15-25%. This consensus was based on quasi-experimental evidence using the 2001 tax rebates and the 2008 fiscal stimulus payments (Johnson et al., 2006; Parker et al., 2013; Misra and Surico, 2014; Broda and Parker, 2014). Recent advances in econometrics (Borusyak and Jaravel, 2017; Borusyak et al., 2021) revealed that MPCs are about half as large as previously thought.[5] Our calibration targets state-of-the-art evidence on MPCs—a quarterly MPC of 10-15%—that implies a substantial deviation from the permanent income hypothesis. In robustness exercises, we show that parameterizing the model in a way that is not consistent with the data — by using the higher MPCs from the older studies or wages that are too flexible relative to the data – would not only bias the estimated size of the multiplier, *ceteris paribus*, but also tend to make the economy with fully real fiscal policy indeterminate, reminiscent of the result in Bilbiie (2008) for Two-Agent New Keyneysian (TANK) models.

Our main substantive findings based on the framework described above are summarized in Table I. The fiscal multiplier is measured as the equilibrium impact of an initial government spending of $1 on output. Thus, if the multiplier is larger than one, the additional government spending represents economic stimulus boosting private economic activity. In contrast, a multiplier less than one implies crowding out of private economic activity by increased government spending. We find that the multiplier is larger than one only if the additional spending is deficit financed and the nominal interest rate is constant. In all other

[3]If we, in contrast with empirical evidence, assumed flexible prices (e.g., Baxter and King, 1993; Heathcote, 2005; Brinca et al., 2016) the demand channel would be weaker and the multiplier would be smaller. On the other hand, if we assumed wages to be more flexible than in the data, the multiplier demand channel would be stronger and the multiplier would be larger, a finding related to the results for Two-Agent New Keynesian (TANK) models (Colciago, 2011; Furlanetto, 2011; Ascari et al., 2017; Bilbiie, 2020). Our results are closer to recent HANK papers studying fiscal policy (e.g., Ferriere and Navarro, 2018; Bayer et al., 2023a,b)

[4]The MPC for total consumption expenditure adds the durable and non-durable MPCs and is higher as for example in Fagereng et al. (2021), who impute consumption using the household budget constraint.

[5]Borusyak and Jaravel (2017) and Borusyak et al. (2021) show that “forbidden comparisons”, i.e. using previously treated households as a control group, leads to an upward bias of the MPC estimates. Orchard et al. (2022) reach a similar conclusion about MPCs.

Table I: Size of Multiplier by Monetary Policy, Financing and Market Completeness

		Constant Nom. Rate	Inflation/Price-Level Target
Incomplete Markets	Tax Financing	< 1	< 1
	Deficit Financing	$> \mathbf{1}$	< 1
Complete Markets		Indeterminate	< 1

cases the multiplier is below one and not very different from the complete-markets version of our model. Note that our framework is fully capable of generating larger multipliers, but only for parameter configurations that generate model moments inconsistent with the data.

Two economic mechanisms explain these findings. First, due to the violation of Ricardian equivalence, the size of the multiplier depends on how it is financed: deficit-financed spending is more effective in stimulating the economy than tax-financed. Increasing spending and taxes at the same time first stimulates demand but then contracts it by raising taxes. In contrast, with deficit financing, the newly issued debt is mainly bought by wealthy low-MPC households whereas high-MPC households consume a large fraction of their additional income. Deficit financing thus implicitly redistributes from asset-rich households with low MPCs who finance their consumption more from asset income to low-asset households with high MPCs who rely more on labor income—so that the aggregate MPC increases. The effect is partially offset due to the crowding out of investment by the expansion in government debt.

Second, the response of the real interest rate is smaller if the nominal interest rate is constant compared with inflation or price-level targeting. A fiscal stimulus increases prices. Inflation and price level targeting thus prescribe an increase in the real interest rate in response to a stimulus, which in turn contracts consumption and investment.[6] As a result, the multiplier with a constant nominal interest rate is almost twice as large as when the monetary authority follows inflation targeting. If we—counterfactually—allow for a quarterly MPC close to 25%, the multiplier is slightly above one for the combination of deficit financing and inflation targeting.

Our findings also have important implications for the conduct of monetary policy. They offer an easy way to overcome the dilemma in complete-markets models or fully real incomplete market models: On the one hand, a standard Taylor rule implies a multiplier smaller than one, but, on the other hand, it is needed for determinacy. In contrast, in the empirically

[6]For inflation and price-level targeting the statements apply to policy rules that have feedback greater than one-for-one.

relevant incomplete-markets models with (partially) nominal fiscal policy, monetary policy can keep the interest rate constant and still ensure determinacy, generating a multiplier larger than one. In particular, determinacy considerations do not require monetary policy to counteract the fiscal stimulus. This is the first paper to establish this result since it is the first paper to conduct a local determinacy analysis in a fully-fledged incomplete markets model with capital.

Local determinacy for our economy with nominal bonds and a constant nominal interest rate also implies that the multiplier puzzles in a liquidity trap that have been documented for RANK models do not carry over to our model as long as fiscal policy is specified in nominal terms. In particular, the multiplier cannot be much lager than one, in contrast to, for example, (Christiano et al., 2011) who found multipliers as large as four using a RANK model. In RANK models, the multiplier increases if prices become more flexible and is unbounded as price rigidities vanish, implying a discontinuity at fully flexible prices where the multiplier is smaller than one. The reason is that the inflation response is larger when prices are more flexible and that the private consumption response is one-to-one related to the inflation rate in RANK models where only the intertemporal substitution channel is operating. In contrast, our quantitative analysis shows that the multiplier in a liquidity trap becomes smaller as prices become more flexible and that the discontinuity at fully flexible prices disappears. The muted intertemporal substitution channel in combination with different responses of inflation and real interest rates explains this finding. In particular, we do not find large deflations as observed in liquidity traps in RANK or fully real HANK models.

Relatedly, our HANK model with nominal bonds does not feature the counterintuitive implication of RANK models that the further the pre-announced spending is in the future the larger is the current impact multiplier (Farhi and Werning, 2016). We show that price level determinacy in our HANK model implies that "forward-spending" is not an effective fiscal policy tool, i.e., the multiplier declines with the date of pre-announced future spending and a pre-announced future spending increase is less effective than an unexpected stimulus.

The rest of the paper is organized as follows. Section 2 presents our incomplete markets model. In Section 3 we present the theory of the fiscal multiplier, including a determinacy check and a decomposition of the economic channels operating in our incomplete markets model. In Section 4 we calibrate the model economy and quantitatively study the size and properties of the fiscal multiplier for various combinations of fiscal and monetary policies. Section 5 concludes.

2 Model

The model is a HANK model with capital and government bonds in positive net supply. Markets are incomplete as in İmrohoroğlu (1989, 1992); Huggett (1993); Aiyagari (1994, 1995). Price setting is constrained by costly price adjustments as in Rotemberg (1982) leading to nominal rigidities. As is standard in the New Keynesian literature, final output is produced in several intermediate steps. Final good producers combine the intermediate goods to produce and sell their output in a competitive goods market. Intermediate goods producers are monopolistically competitive. They set the price they charge to the final good producer to maximize profits taking into account the price adjustment costs they face. The intermediate goods producer rent inputs, capital and a composite of differentiated labor, in competitive factor markets. We also allow for sticky wages and assume that differentiated labor is monopolistically supplied.

2.1 Households

The economy consists of a continuum of agents of measure 1 who are ex-ante heterogeneous with respect to their subjective discount factors, have CRRA preferences over consumption and additively separable preferences for leisure:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t),$$

where

$$u(c,h) = \begin{cases} \frac{c^{1-\sigma}-1}{1-\sigma} - v(h) & \text{if } \sigma \neq 1 \\ \log(c) - v(h) & \text{if } \sigma = 1, \end{cases}$$

$\beta \in (0,1)$ is the household-specific subjective discount factor and $v(h)$ is the disutility of labor.

Agents' labor productivity $\{s_t\}_{t=0}^{\infty}$ is stochastic and is characterized by an N-state Markov chain that can take on values $s_t \in \mathcal{S} = \{s_1, \cdots, s_N\}$ with transition probability characterized by $\gamma(s_{t+1}|s_t)$ and $\int s = 1$. Agents rent their labor services, $h_t s_t$, to firms for a real wage w_t and their nominal assets a_t to the asset market for a nominal rent i_t^a and a real return $(1+r_t^a) = \frac{1+i_t^a}{1+\pi_t}$, where $1+\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation rate (P_t is the price of the final good). The nominal return on bonds is i_t with a real return $(1+r_t) = \frac{1+i_t}{1+\pi_t}$. There are two classes of assets, bonds and capital with potentially different returns, but households can invest in one asset, A, that a mutual fund (described below) collects and allocates to bonds and capital.

To allow for sticky wages in our heterogeneous worker economy we need to extend the literature which models wage rigidities in representative agent models (Erceg et al., 2000).

We follow the literature and assume that each household i provides differentiated labor services which are transformed by a representative, competitive labor recruiting firm into an aggregate effective labor input, H_t, using the following technology:

$$H_t = \left(\int_0^1 s_{it} (h_{it})^{\frac{\epsilon_w - 1}{\epsilon_w}} di \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}, \tag{1}$$

where ϵ_w is the elasticity of substitution across differentiated labor.

A middleman firm (e.g., a union) sells households labor services $s_{it}h_{it}$ at the wage W_{it} to the labor recruiter, which, given aggregate labor demand H_t by the intermediate goods sector, minimizes costs

$$\int_0^1 W_{it} s_{it} h_{it} di, \tag{2}$$

implying a demand for the labor services of household i:

$$h_{it} = h(W_{it}; W_t, H_t) = \left(\frac{W_{it}}{W_t} \right)^{-\epsilon_w} H_t, \tag{3}$$

where W_t is the (equilibrium) nominal wage which can be expressed as

$$W_t = \left(\int_0^1 s_{it} W_{it}^{1-\epsilon_w} di \right)^{\frac{1}{1-\epsilon_w}}.$$

The union sets a nominal wage $\hat{W}_t$ for an effective unit of labor (so that $W_{it} = \hat{W}_t$) to maximize profits subject to wage adjustment costs modeled similarly to the price adjustment costs in Rotemberg (1982). These adjustment costs are proportional to idiosyncratic productivity s_{it}, are measured in units of aggregate output, and are given by a quadratic function of the change in wages above and beyond gross steady state wage inflation, $1 + \pi_{ss}^w$,

$$\Theta \left(s_{it}, W_{it} = \hat{W}_t, W_{it-1} = \hat{W}_{t-1}; H_t \right) = s_{it} \frac{\theta_w}{2} \left(\frac{W_{it}}{W_{it-1}} - (1 + \pi_{ss}^w) \right)^2 H_t = s_{it} \frac{\theta_w}{2} \left(\pi_t^w - \pi_{ss}^w \right)^2 H_t,$$

where $1 + \pi_t^w = \frac{\hat{W}_t}{\hat{W}_{t-1}}$ is wage inflation. Our extension to a heterogeneous agent economy requires assumptions on the aggregation of preferences of heterogeneous workers. There is not a unique way to do so and we choose one that is tractable and delivers the representative agent outcome when all heterogeneity is shut down. The union's wage setting problem maximizes[7]

$$
\begin{aligned}
V_t^w\left(\hat{W}_{t-1}\right) \quad \equiv \quad & \max_{\hat{W}_t} \int \Big(\frac{s_{it}(1-\tau_t)\hat{W}_t}{P_t} h(\hat{W}_t; W_t, H_t) - \frac{v(h(\hat{W}_t; W_t, H_t))}{u'(C_t)}\Big) di \\
- & \int s_{it} \frac{\theta_w}{2}\left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - (1+\pi_{ss}^w)\right)^2 H_t di + \frac{1}{1+r_t} V_{t+1}^w\left(\hat{W}_t\right),
\end{aligned} \tag{4}
$$

where C_t is aggregate consumption and τ_t is a proportional tax on labor income.[8]

Some algebra (see Appendix II) yields, using $h_{it} = H_t$ and $\hat{W}_t = W_t$ and defining the real wage $w_t = \frac{W_t}{P_t}$, the wage inflation equation

$$
\theta_w\left(\pi_t^w - \pi_{ss}^w\right)(1+\pi_t^w)s = (1-\tau_t)(1-\epsilon_w)w_t + \epsilon_w \frac{v'(h(\hat{W}_t; W_t, H_t))}{u'(C_t)} + \frac{1}{1+r_t}\theta_w\left(\pi_{t+1}^w - \pi_{ss}^w\right)(1+\pi_{t+1}^w)\frac{H_{t+1}}{H_t}. \tag{5}
$$

Thus, at time t an agent faces the following budget constraint:

$$
P_t c_t + a_{t+1} = (1+i_t^a)a_t + (1-\tau_t)P_t w_t h_t s_t + T_t,
$$

where T_t is a nominal lump sum transfer. Households take prices as well as wages and hours from the middleman's wage setting problem as given. Thus, we can rewrite the agent's problem recursively as follows:

$$
\begin{aligned}
V(a, s, \beta; \Omega) = & \max_{c \geq 0, a' \geq 0} u(c, h) + \beta \sum_{s \in \mathcal{S}} \gamma(s'|s) V(a', s', \beta; \Omega') \\
& \text{subj. to} \quad Pc + a' = (1+i^a)a + P(1-\tau)whs + T \\
& \qquad\qquad\;\; \Omega' = \Upsilon(\Omega),
\end{aligned} \tag{6}
$$

where $\Omega(a, s, \beta)$ is the distribution on the space $X = \mathcal{A} \times \mathcal{S} \times \mathcal{B}$ of agents' asset holdings $a \in \mathcal{A}$, labor productivity $s \in \mathcal{S}$ and discount factor $\beta \in \mathcal{B}$, across the population, which will, together with the policy variables, determine the equilibrium prices. Let $\mathbb{B}(X) = \mathcal{P}(\mathcal{A}) \times \mathcal{P}(\mathcal{S}) \times \mathcal{P}(\mathcal{B})$ be the σ-algebra over X, defined as the Cartesian product over the Borel σ-algebra on $\mathcal{A}$ and the power sets of $\mathcal{S}$ and $\mathcal{B}$. Define our space $M = (X, \mathbb{B}(X))$, and let $\mathcal{M}$ be the set of probability measures over M. Υ is an equilibrium object that specifies the evolution of the distribution Ω.

[7] Equivalently one can think of a continuum of unions each setting the wage for a representative part of the population with $\int s = 1$ at all times.

[8] Any decision problem in a heterogeneous group requires assumptions on the aggregation of individual needs and this wage setting problem is no exception. Fortunately, our choices here have virtually no effect on our findings. We divide $v(h(\hat{W}_t; W_t, H_t))$ by $u'(C_t)$ but using individual consumption and dividing by $u'(C_{it})$ instead has virtually no effect. We discount with $\frac{1}{1+r_t}$ but discounting using $\frac{1}{1+r_t^a}$ or β instead also has negligible effect our findings.

2.2 Production

2.2.1 Final Good Producer

A competitive representative final goods producer aggregates a continuum of intermediate goods y_{jt} indexed by $j \in [0,1]$ and with prices p_{jt}:

$$Y_t = \left(\int_0^1 y_{jt}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}},$$

where ϵ is the elasticity of substitution across goods. Given a level of aggregate demand Y_t, cost minimization for the final goods producer implies that the demand for the intermediate good j is given by

$$y_{jt} = y(p_{jt}; P_t, Y_t) = \left(\frac{p_{jt}}{P_t} \right)^{-\epsilon} Y_t, \tag{7}$$

where P is the (equilibrium) price of the final good which can be expressed as

$$P_t = \left(\int_0^1 p_{jt}^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}.$$

2.2.2 Intermediate-Goods Firms

Each intermediate good j is produced by a monopolistically competitive producer using the technology:

$$Y_{jt} = \begin{cases} K_{jt}^{\alpha} H_{jt}^{1-\alpha} - F & \text{if} \geq 0 \\ 0 & \text{otherwise} \end{cases}, \tag{8}$$

where $0 < \alpha < 1$, K_{jt} is capital services rented, H_{jt} is labor services rented and the fixed cost of production is denoted $F > 0$.

Intermediate-goods firms rent capital and labor in perfectly competitive factor markets. A firm's real marginal cost is $mc_{jt} = \partial \Xi_t(Y_{jt}) / \partial Y_{jt}$, where

$$\Xi_t(Y_{jt}) = \min_{K_{jt}, H_{jt}} r_t^k K_{jt} + w_t H_{jt}, \text{ and } Y_{jt} \text{ is given by (8).} \tag{9}$$

Given our functional forms, we have

$$mc_t = \left(\frac{1}{\alpha} \right)^{\alpha} \left(\frac{1}{1-\alpha} \right)^{1-\alpha} (r_t^k)^{\alpha} (w_t)^{1-\alpha} \tag{10}$$

and

$$\frac{K_{jt}}{H_{jt}} = \frac{\alpha w_t}{(1-\alpha) r_t^k}. \tag{11}$$

Prices are sticky as intermediate-goods firms face Rotemberg (1982) price adjustment costs. Given last period's individual price p_{jt-1} and the aggregate state (P_t, Y_t, w_t, r_t), the firm chooses this period's price p_{jt} to maximize the present discounted value of future profits, satisfying all demand. The intermediate-goods firm's pricing problem is

$$V_t^{IGF}(p_{jt-1}) \equiv \max_{p_{jt}} \frac{p_{jt}}{P_t} y(p_{jt}; P_t, Y_t) - \Xi(y(p_{jt}; P_t, Y_t)) - \frac{\theta}{2}\left(\frac{p_{jt}}{p_{jt-1}} - (1+\pi_{ss})\right)^2 Y_t - F + \frac{1}{1+r_t} V_{t+1}^{IGF}(p_{jt}),$$

where $1+\pi_{ss}$ is steady-state inflation. Some algebra (see Appendix II) yields the New Keynesian Phillips Curve

$$(1-\epsilon) + \epsilon mc_t - \theta(\pi_t - \pi_{ss})(1+\pi_t) + \frac{1}{1+r_t}\theta(\pi_{t+1} - \pi_{ss})(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t} = 0.$$

The equilibrium real profit of each intermediate goods firm, fully taxed by the government, is

$$D_t^{IM} = Y_t - F - \Xi(Y_t).$$

2.3 Mutual Fund

The mutual fund collects households savings $A_{t+1}/P_{t+1} \equiv \int a_{it}/P_{t+1}\, di$, pays a real return $\tilde{r}_t^a$, and invests them in real bonds B_{t+1}/P_{t+1} and capital K_{t+1}. It maximizes

$$V^{MF}(K_t) \equiv \max_{K_{t+1}, \frac{B_{t+1}}{P_{t+1}}} (1 + r_{t+1}^k - \delta)K_{t+1} + (1 + r_{t+1})B_{t+1}/P_{t+1} - (1 + \tilde{r}_{t+1}^a)(A_{t+1}/P_{t+1}) + \frac{V^{MF}(K_{t+1})}{(1 + \tilde{r}_{t+2}^a)}$$

$$\text{subj. to} \quad A_{t+1}/P_{t+1} = K_{t+1} + B_{t+1}/P_{t+1} + \Phi(K_{t+1}, K_t)$$

for adjustment costs $\Phi(K_{t+1}, K_t)$ and taking K_t and K_{t+2} as given. Note that we drop expectation operators for simplicity since we consider perfect foresight experiments only. The equilibrium first-order conditions are

$$\begin{aligned} r_{t+1} &= \tilde{r}_{t+1}^a, & (12)\\ 1 + r_{t+1}^k - \delta &= (1 + \tilde{r}_{t+1}^a)(1 + \Phi_1(K_{t+1}, K_t)) + \Phi_2(K_{t+2}, K_{t+1}), & (13)\\ A_{t+1}/P_{t+1} &= K_{t+1} + B_{t+1}/P_{t+1} + \Phi(K_{t+1}, K_t). & (14) \end{aligned}$$

The total dividends of the fund are

$$D_{t+1}^{MF} = (1 + r_{t+1}^k - \delta)K_{t+1} + (1 + r_{t+1})B_{t+1}/P_{t+1} - (1 + \tilde{r}_{t+1}^a)(A_{t+1}/P_{t+1}),$$

and after-tax per unit of investment they are $d_{t+1}^{MF} = (1 - \tau_k)D_{t+1}^{MF}/(A_{t+1}/P_{t+1})$. Households therefore receive (or have to pay) $d_{t+1}^{MF} A_{t+1}/P_{t+1}$ in period $t+1$ per unit invested such that households' real return equals

$$1 + r^a_{t+1} = 1 + \tilde{r}^a_{t+1} + d^{MF}_{t+1}$$

and corresponding nominal return is

$$1 + i^a_{t+1} = (1 + r^a_{t+1})\frac{P_{t+1}}{P_t}.$$

2.4 Government

Fiscal Policy The government obtains revenue from taxing labor income, profits and dividends and issuing bonds. We will consider both nominal and real government budget constraints. We begin by specifying the nominal government budget constraint. Household labor income is taxed progressively with a nominal lump-sum transfer T and a proportional tax τ:

$$\tilde{T}(wsh, T) = -T + \tau P wsh.$$

The government issues nominal bonds denoted by B^g, with negative values denoting government asset holdings and fully taxes away profits of intermediate goods firms. The government also taxes dividend income at the rate τ_k. The government uses the revenue to finance exogenous nominal government expenditures, G_t, interest payments on bonds and transfers to households. The government budget constraint is therefore given by:

$$B^g_{t+1} = (1 + i_t)B^g_t + G_t - P_t D^{IM}_t - \tau_k P_t D^{MF}_t - \int \tilde{T}(w_t s_t h_t, T_t) d\Omega. \tag{15}$$

When the government budget constraint is specified in real terms, the government issues real bonds b^g_{t+1}, specifies real spending g_t and pays real lump-sum transfers T^{real}, yielding the following budget constraint:

$$b^g_{t+1} = (1 + r_t)b^g_t + g_t - D^{IM}_t - \tau_k D^{MF}_t - \int \tilde{T}^{real}(w_t s_t h_t, T^{real}_t) d\Omega, \tag{16}$$

where

$$\tilde{T}^{real}(wsh, T^{real}) = -T^{real} + \tau wsh.$$

Monetary Policy The monetary authority follows a Taylor rule, which sets the nominal interest rate according to:

$$i_{t+1} = \max(\tilde{i}_{t+1}, 0), \text{ where} \tag{17}$$

$$\tilde{i}_{t+1} = \left(\frac{1}{\zeta}\right)\left(\frac{1+\pi_t}{1+\pi_{ss}}\right)^{\phi^\pi_1(1-\rho_R)} \left(\frac{P_t}{P_{ss}}\right)^{\phi^P_1(1-\rho_R)} \left(\frac{Y_t}{Y_{ss}}\right)^{\phi_2(1-\rho_R)} [\zeta(1+i_t)]^{\rho_R} - 1.$$

which is flexible enough to accommodate a constant nominal rate ($\rho_R = 1$), inflation targeting ($\phi_1^\pi > 0, \rho_R < 1, \phi_1^P = 0$) or price-level targeting ($\phi_1^P > 0, \rho_R < 1, \phi_1^\pi = 0$) rules.

2.5 Equilibrium

Market clearing requires that the labor demanded by firms is equal to the aggregate labor supplied by households, that the demand for bonds issued by the government and for capital equal their supplies and that the amount of assets provided by households equals the demand for them by the mutual fund:

$$H_t = \int H_{jt} dj = H_{jt} = \int h_{it} di = h_{it} \tag{18}$$

$$B_t = B_t^g \tag{19}$$

$$K_t = \int K_{jt} dj \tag{20}$$

$$K_{t+1} + B_{t+1}/P_{t+1} + \Phi(K_{t+1}, K_t) = A_{t+1}/P_{t+1} = \int \frac{a_{t+1}(a_t, s_t, \beta)}{P_{t+1}} d\Omega_t, \tag{21}$$

where $a_{t+1}(a_t, s_t, \beta)$ is the asset choice of an agent with asset level a_t, labor productivity s_t and discount factor β. The time subscript includes dependence on all future variables.

The aggregate resource constraint is given by

$$Y_t = K_t^\alpha H_t^{1-\alpha} = \int c_t(a_t, s_t, \beta) d\Omega_t + \frac{G_t}{P_t} + F + K_{t+1} - (1-\delta)K_t + \Phi(K_{t+1}, K_t). \tag{22}$$

It does not include price and wage adjustment costs because we follow the preferred interpretation of those costs in Rotemberg (1982) as being virtual—they affect optimal choices but do not cause real resources to be expended. This modeling choice allows to avoid these adjustment costs becoming a non-trivial fraction of output in e.g., the liquidity trap. In a liquidity trap prices fall, leading to large price adjustment costs, which, if they were actual resource costs, would lead to a boom in the price adjustment cost industry and may imply an increase in aggregate output (see Hagedorn et al., 2018, for details). As explained in Eggertsson and Singh (2019), assuming that price adjustment costs are as-if avoids these outcomes and moves our model closer to one with price setting à la Calvo.

Definition: A monetary competitive equilibrium is a sequence of tax rates τ_t and τ_k, nominal transfers T_t, nominal government spending G_t, supply of government bonds B_t^g, value functions $V_t \colon X \times \mathcal{M} \to \mathcal{R}$ with policy functions $a_t \colon X \times \mathcal{M} \to \mathcal{R}_+$ and $c_t \colon X \times \mathcal{M} \to \mathcal{R}_+$, hours choices $H_t, H_{jt}, h_{it} \colon \mathcal{M} \to \mathcal{R}_+$, capital decisions $K_t, K_{jt} \colon \mathcal{M} \to \mathcal{R}_+$, bond choices $B_t \colon \mathcal{M} \to \mathcal{R}_+$, price levels $P_t \colon \mathcal{M} \to \mathcal{R}_+$, pricing functions $r_t, r_t^a, r_t^k, \tilde{r}_t^a \colon \mathcal{M} \to \mathcal{R}$ and $w_t \colon \mathcal{M} \to \mathcal{R}_+$, and a law of motion $\Upsilon \colon \mathcal{M} \to \mathcal{M}$, such that:

1. V_t satisfies the Bellman equation with corresponding policy functions a_t and c_t given price sequences r_t^a, w_t and hours h_t.
2. Firms maximize profits taking prices P_t, r_t^k, w_t as given.
3. Wages are set optimally by middlemen.
4. The mutual fund maximizes profits taking prices as given.
5. For all $\Omega \in \mathcal{M}$ market clearing conditions (18) - (21) and the resource constraint (22) are satisfied.
6. For all $\Omega \in \mathcal{M}$ the government budget constraint (15) or (16) is satisfied.
7. Aggregate law of motion Υ generated by a' and γ.

3 The Fiscal Multiplier: Theoretical Prerequisites

In this section, we explain the different channels that account for the magnitude of the fiscal multiplier in incomplete markets models. In our model, the fiscal multiplier affects both aggregate consumption and investment. In terms of consumption, the stimulus operates through two interdependent channels — intertemporal substitution and redistribution. The intertemporal substitution channel describes how government spending changes real interest rates and how this affects private consumption. The distributional channel describes the impact on private consumption when government spending redistributes resources across households due to the induced changes in prices, income, taxes, etc. In terms of investment, the multiplier operates through changes in real interest rates, through crowding-out of capital when deficit financing is used, and through stimulating demand, which makes firms hire not only more labor but also more capital.

This section also conducts a determinacy analysis, a prerequisite before any fiscal policy experiment can be considered. Without determinacy, long-run expectations would not be pinned down, multiple equilibria with very different multipliers may exist, or the economy could be unstable.

To better understand the properties of the fiscal multiplier in incomplete markets models, it is instructive to start this section by analyzing a simple RANK model where labor is the only factor of production. We discuss the link between the complete markets multiplier and the intertemporal substitution channel. Further, we review the determinacy property in RANK, which typically requires that the nominal interest rate responds more than one-for-one with the inflation rate. Next, we show that the criteria for determinacy can be quite different in incomplete markets models and that the standard RANK determinacy condition can induce indeterminacy in HANK.

3.1 Fiscal multiplier: Complete Markets

To understand the workings of the intertemporal substitution channel in our model it is instructive to start with the complete markets case where this is the only channel that is operating.

With complete markets, the size of the multiplier m is determined by the response of real interest rates only. The consumption Euler equation for our utility function is

$$C_t^{-\sigma} = \beta(1 + r_{t+1})C_{t+1}^{-\sigma}. \tag{23}$$

Iterating this equation and assuming that consumption is back to the steady-state level at time T, $C_T = C_{ss}$, we obtain for consumption at time $t = 1$ when spending is increased,

$$C_1^{-\sigma} = \Big(\prod_{t=1}^{T-1} \beta(1 + r_{t+1})\Big) C_T^{-\sigma}, \tag{24}$$

so that the initial percentage increase in consumption equals

$$\frac{C_1}{C_{ss}} = \Big(\prod_{t=1}^{T-1} \beta(1 + r_{t+1})\Big)^{\frac{-1}{\sigma}} = \Big(\prod_{t=1}^{T-1} \frac{1 + r_{t+1}}{1 + r_{ss}}\Big)^{\frac{-1}{\sigma}}, \tag{25}$$

where we have used that $\beta(1 + r_{ss}) = 1$ in a complete markets steady state. The fiscal multiplier m − the dollar change in output for each dollar increase in g − is one-to-one related to the percentage change in private consumption

$$m = 1 + \Big(\frac{C_1}{C_{ss}} - 1\Big)\frac{C_{ss}}{\Delta g} \tag{26}$$

and is thus one-to-one related to the accumulated response of the real interest rate which is induced by the fiscal stimulus,

$$m = 1 + \frac{C_{ss}}{\Delta g}\Bigg(\Big(\prod_{t=1}^{T-1} \frac{1 + r_{t+1}}{1 + r_{ss}}\Big)^{\frac{-1}{\sigma}} - 1\Bigg). \tag{27}$$

The multiplier is then proportional to the consumption response

$$\log\Big(\frac{C_1}{C_{ss}}\Big) = \underbrace{\frac{1}{\sigma}}_{\text{Intertemporal Substitution}} \sum_{t=1}^{T-1} \underbrace{(\log(1 + r_{ss}) - \log(1 + r_{t+1}))}_{\text{Change of real interest rates}}, \tag{28}$$

which can be decomposed in the change in the real interest rate, $\approx r_t - r_{ss}$, and the effect of this change on consumption, whose strength is governed by the IES, $\frac{1}{\sigma}$.

3.2 Fiscal multiplier: Incomplete Markets

Using our HANK model with nominal debt and constant nominal rates we conduct the following experiment. Assume that the economy is in steady state with nominal bonds B_{ss}, government spending G_{ss}, transfers T_{ss}, labor tax rate τ_{ss}, dividend tax $\tau_{k,ss}$, and where the price level is P_{ss}, implying zero steady state inflation. The real value of bonds is then B_{ss}/P_{ss}, the real value of government expenditure is G_{ss}/P_{ss} and so on. We then consider an M.I.T. (unexpected and never-again-occurring) shock to government expenditures and compute the impulse response to this persistent innovation in G.[9] Agents are assumed to have perfect foresight after the shock. For expositional purposes, we consider a path for fiscal policy that returns the nominal level of debt back to the original steady-state value, namely $B_{ss}^{new} = B_{ss}$. This could be because the government runs a balanced budget or finances the stimulus with deficits to be repaid later on. Eventually the economy will reach the new steady state characterized by government spending $G_{ss}^{new} = G_{ss}$, transfers $T_{ss}^{new} = T_{ss}$, tax rates $\tau_{ss}^{new} = \tau_{ss}$ and $\tau_{k,ss}^{new} = \tau_{k,ss}$, and the price level P_{ss}^{new}.

The complete market intertemporal substitution channel also operates in the incomplete markets model, but the two coincide only under very special assumptions, first described in Werning (2015). In particular, it requires that total income for all households responds proportionally to changes in output, so called "equal-incidence" of income. With positive asset holdings and progressive taxation equal-incidence does not hold (since total income for households will depend on their earnings level and asset holdings). Thus, in our framework the complete markets multiplier, m^{CM}, and the incomplete markets multipliers, m^{IM}, are different. We refer to this difference for the same sequence of spending as the distribution multiplier,

$$m^{Distribution} = m^{IM} - m^{CM},$$

as it arises due to the redistribution of resources across agents that is not captured by equal-incidence. As we show below, this difference can be negative or positive, and of large or small magnitude, meaning that the multiplier in the incomplete markets model can be larger, smaller or basically equal to the complete markets multiplier.

Intertemporal substitution yields the same multiplier as in complete markets only if the sequence of real interest rates is the same across models, but in general they will be different. To understand why the sequence of real interest rates is different, assume for simplicity that the nominal interest rate is fixed at i_{ss} and that the steady state is reached after T periods

[9] Boppart et al. (2018) show that for small shocks this generates a first-order approximation of the model dynamics to the aggregate shock.

so that

$$\prod_{t=1}^{T-1}(1+r_{t+1}) = \prod_{t=1}^{T-1}\big(\frac{1+i_{ss}}{1+\pi_{t+1}}\big) = \prod_{t=1}^{T-1}(1+i_{ss})\frac{P_1}{P_T} = \prod_{t=1}^{T-1}(1+i_{ss})\frac{P_1}{P_{ss}^{new}}, \tag{29}$$

i.e., the response of $\prod_{t=1}^{T-1}(1+r_{t+1})$ is one-to-one related to the response of P_{ss}^{new}/P_1. When the nominal interest rate is constant, this response can be quite large in complete market models (Christiano et al., 2011) and in a version of our model with real debt, but is small in our incomplete markets model with nominal debt.

This is a consequence of the result that incomplete markets combined with fiscal policy specified partially in nominal terms delivers a determined price level independently of how monetary policy is specified. We refer the reader to Hagedorn (2016, 2018) for details and only provide the intuition for the key result that $P_{ss}^{new} = P_{ss}$. Define households' real steady-state asset demand as S. The asset demand S, the real stock of capital, K_{ss}, and the amount of nominal bonds is the same, $B_{ss}^{new} = B_{ss}$, in both steady states and therefore both price levels solve the same asset market clearing condition

$$S(1+r_{ss},...) = K_{ss} + \frac{B_{ss}}{P_{ss}} = K_{ss} + \frac{B_{ss}^{new}}{P_{ss}} = K_{ss} + \frac{B_{ss}^{new}}{P_{ss}^{new}}. \tag{30}$$

Together these arguments imply that the intertemporal substitution channel is weaker in our incomplete markets model with nominal debt than in the corresponding version with real debt or the complete markets version of our model, where $P_{ss}^{new} > P_{ss}$. Note that since P_1 typically increases in response to a stimulus, $P_1/P_{ss}^{new} > 1$, and thus from eq. (29), $\prod_{t=1}^{T-1}(1+r_{t+1}) > \prod_{t=1}^{T-1}(1+i_{ss}) = \prod_{t=1}^{T-1}(1+r_{ss})$, i.e., the intertemporal substitution channel by itself implies a multiplier smaller than one,[10]

$$m = 1 + \frac{C_{ss}}{\Delta g}\Bigg(\underbrace{\Big(\prod_{t=1}^{T-1}\frac{1+r_{t+1}}{1+r_{ss}}\Big)^{\frac{-1}{\sigma}} - 1}_{<0}\Bigg) < 1. \tag{31}$$

We can conduct that same experiment with inflation and price-level targeting rules with nominal bonds and transfers. The reason why such rules are typically used is that they deliver determinacy in complete markets models with real bonds. Applications to incomplete markets models (HANK) adopted the assumption of real bonds and inflation/price level targeting based on the hope that those rules would also deliver determinacy.[11] To ease comparison

[10]The multiplier here is smaller than one whereas it is equal to one in Woodford (2011) since the real interest rate is constant in the small-open economy experiment considered in Woodford (2011) but endogenous and time-varying here.

[11]Ravn and Sterk (2021) provide an example where the standard criteria for determinacy in the RANK model using an inflation targeting rule do not carry over to the HANK model.

with the existing literature we therefore assume that bonds are real when we use inflation or price level targeting rules. This approach is justified by two findings. First, the results with nominal or real bonds are similar if we use these specific interest rate rules. Second, we verify that our economy is locally determinate, but also point out that this is not a universal finding for HANK models with real bonds, but depends on a proper calibration of the model.

3.3 Local Determinacy

Steady-state price level determinacy does not guarantee local determinacy, which we turn to now. The economy is locally determinate if in the absence of any shocks the steady state is the locally unique equilibrium. In other words, there is no other equilibrium in the neighborhood of the steady state. As mentioned above, establishing local determinacy is a theoretical prerequisite before conducting fiscal experiments. Without determinacy the economy might feature multiple equilibria each associated with a different multiplier or there might be no stable equilibrium.

Local determinacy in complete markets models has attracted a lot of attention since the seminal paper of Sargent and Wallace (1975). The standard result is that an inflation targeting rule

$$1 + i_{t+1} = (1 + \bar{i})\big(1 + \pi_t\big)^{\phi_1^\pi} \tag{32}$$

delivers determinacy if $\phi_1^\pi > 1$. The local determinacy properties of incomplete markets models have been largely unknown. The key difference between complete and incomplete markets models is that an Euler equation holds for aggregate consumption in the former, but consumption is a function of the sequences of all future real interest rates, taxes, and output in the latter. The standard approach for assessing local determinacy, Blanchard and Kahn (1980), requires finite leads and so cannot be applied to the incomplete markets case. Recent work by Hagedorn (2023) provides theoretical results and derives a characterization of local determinacy in incomplete markets models that can be checked numerically. In particular, the Onatski (2006) criterion can be applied to a linearized representation of the model.[12] We can represent our model in the form:

$$\sum_{k=-j}^{\infty} A_k E_t x_{t+k} = \Gamma z_t, \tag{33}$$

for the vector x of endogenous and the vector z of exogenous variables. The matrices A_k and Γ depend on various elasticities and marginal propensities to consume and j is the number of lags (predetermined variables). For example, in the basic New Keynesian complete-markets

[12] More precisely, this is the linearization of a model which very closely approximates our incomplete markets model.

model,[13] where the endogenous variables are the consumption gap c_t and inflation π_t, the representation is (Galí, 2015):

$$\underbrace{\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}}_{=A_0} \begin{bmatrix} c_t \\ \pi_t \end{bmatrix} + \underbrace{\frac{-1}{\sigma + \kappa\phi^\pi} \begin{pmatrix} \sigma & 1 - \beta\phi^\pi \\ \sigma\kappa & \kappa + \beta\sigma \end{pmatrix}}_{=A_1} \begin{bmatrix} E_t c_{t+1} \\ E_t \pi_{t+1} \end{bmatrix} = \underbrace{\frac{1}{\sigma + \kappa\phi^\pi} \begin{pmatrix} 1 \\ \kappa \end{pmatrix}}_{=\Gamma} (r_t^n - \rho - \nu_t), \tag{37}$$

for the exogenous variable $r_t^n - \rho - \nu_t$ and parameters ρ and κ.

If markets are incomplete, however, aggregate consumption generically cannot be described through an Euler equation as in complete markets. Instead, individual household's consumption c_t at time t depends on the sequence of transfers T, tax rates τ, labor income wh, prices P, and nominal interest rates i^a, so that aggregate private consumption satisfies

$$C_t\big(\{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l \geq t}\big) = \int c_t(a, s, \beta; \{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l \geq t}) d\Omega_t. \tag{38}$$

While the methodology works for arbitrary consumption functions, for illustrative purposes, consider a simpler scenario in which aggregate consumption can be written as a function of the sequence of future inflation rates only,[14]

$$C_t\big(\{\pi_l\}_{l \geq t}\big) = \int c_t(a, s, \beta; \{\pi_l\}_{l \geq t}) d\Omega_t. \tag{39}$$

Linearizing the market clearing condition

$$C_t\big(\{\pi_l\}_{l \geq t}\big) = Y_t = \frac{1}{\kappa}(\pi_t - \beta\pi_{t+1})$$

[13] The basic model is described through three equations:

$$\begin{aligned} i_t &= \rho + \phi^\pi \pi_t + \nu_t && \text{[Interest rate rule]} && (34) \\ c_t &= -\frac{1}{\sigma}(i_t - E_t\pi_{t+1} - r_t^n) + E_t c_{t+1} && \text{[Consumer Euler equation]} && (35) \\ \pi_t &= \beta E_t \pi_{t+1} + \kappa c_t, && \text{[Phillips curve]} && (36) \end{aligned}$$

where ν_t is an exogenous shock and r_t^n is the natural rate of interest.

[14] For example, this would hold if bonds are real and fixed, labor is the only production input, taxes are only used to cover interest rate expenses, there is no government spending and there is an interest rate rule. Output (income) is determined through the Phillips curve given the sequence of inflation rates. Interest rates and taxes can then be expressed as functions of inflation rates.

yields the 1-dimensional matrices

$$A_0 = \frac{\partial C_t}{\partial(1+\pi_t)} \frac{1+\pi_{ss}}{C_{ss}} - \frac{1}{\kappa} \frac{1+\pi_{ss}}{Y_{ss}}, \tag{40}$$

$$A_1 = \frac{\partial C_t}{\partial(1+\pi_{t+1})} \frac{1+\pi_{ss}}{C_{ss}} + \frac{\beta}{\kappa} \frac{1+\pi_{ss}}{Y_{ss}}, \tag{41}$$

$$A_k = \frac{\partial C_t}{\partial(1+\pi_{t+k})} \frac{1+\pi_{ss}}{C_{ss}} \qquad \text{for } k \geq 2, \tag{42}$$

where the inflation elasticities capture both the direct effect of a change in inflation plus the indirect effects through interest rates, taxes, and income.

For a model representation (33), Onatski (2006) defines a complex function

$$\Theta(\lambda) = det \sum_{k=-j}^{\infty} A_k e^{-ik\lambda},$$

for $\lambda \in \mathbb{R}$ and $i = \sqrt{-1}$ is the imaginary unit. Onatski (2006) shows that the economy has a locally unique solution if $\Theta(\lambda)$ does not rotate around zero when λ goes from 0 to 2π. Our numerical evaluation requires computing the matrices A_k and we truncate the series at 1000 quarters since the matrices are virtually 0 then.

Note that for the complete markets New Keynesian model described in Footnote 13, the Onatski function equals

$$\Theta(\lambda) = 1 + \frac{(\kappa + \sigma(1+\beta))e^{-i\lambda} + \beta\sigma e^{-2i\lambda}}{\kappa\phi^{\pi} + \sigma} = (1 + e^{-i\lambda}\lambda_1)(1 + e^{-i\lambda}\lambda_2),$$

where λ_1 and λ_2 are the eigenvalues of the A_1 matrix in Eq. 37. The equilibrium is determinate if both eigenvalues $-(\lambda_1)^{-1}$ and $-(\lambda_2)^{-1}$ of $-(A_1)^{-1}$ are outside the unit circle (Woodford, 2003), which is equivalent to the Onatski function not rotating around zero since λ_1 and λ_2 are then located inside the unit circle.[15] The Onastski citerion for determinacy in the complete markets New Keynesian model is thus equivalent to the well known condition $\phi^{\pi} > 1$. As we will establish below, the condition $\phi^{\pi} > 1$ is, however, neither necessary nor sufficient to ensure local determinacy in our incomplete markets model.

[15]The eigenvalues of the matrix $-(A_1)^{-1}$ are relevant for the complete markets models since the Blanchard and Kahn approach is applied to the representation

$$\begin{bmatrix} E_t c_{t+1} \\ E_t \pi_{t+1} \end{bmatrix} = -(A_1)^{-1} \begin{bmatrix} c_t \\ \pi_t \end{bmatrix}.$$

3.4 Checking for Local Determinacy

We assess determinacy for two different specifications of fiscal and monetary policy. First, for the standard choice of real bonds and an inflation-targeting Taylor rule, $\phi_1^\pi = 1.5$. And second for nominal bonds and a constant nominal interest rate. For both policy specifications we start with our benchmark calibration (detailed in Section 4.1 below) before considering different choices for wage and price rigidities. To ease the comparison with the New Keynesian literature we first consider a version of our model without capital.

Table II shows determinacy results for the real bond economy with an inflation targeting rule, $\phi_1^\pi = 1.5$, and government budget constraint (16) in real terms. We obtain determinacy in our incomplete markets model as the plot of the Onatski function in panel (a) of Figure A-3 shows (the plots of the Onatski function for this and all other specifications are in Appendix III). The red cross indicates the $(0, 0)$ point which is located outside the Onatski function, showing determinacy for our specification.

This determinacy result for an economy with real bonds and an inflation-targeting Taylor rule, however, depends on a high degree of wage and price rigidities. If wages are flexible, the economy is indeterminate, reminiscent of the indeterminacy finding in two-agent economies (Bilbiie, 2008). With flexible wages, wages and the profits of the intermediate goods sector become very volatile and induce large shifts in aggregate demand, which overturn the determinacy result for the benchmark economy. Adding capital to the model yields determinacy for rigid prices but induces indeterminacy if prices are less rigid (Phillips curve slope of 0.3 instead of our 0.03). Indeterminacy also arises in the model without capital if the price Phillips curve is much steeper and average MPCs are higher.[16] While the finding that adding capital alters the determinacy condition for certain slopes of the Phillips curve is known from complete markets models (Carlstrom and Fuerst, 2005) we are the first to establish that it carries over to incomplete market models. These findings demonstrate that the correct choices for the degree of rigidities and MPCs not only matters for the size of the multiplier, but also for the determinacy properties.

Table III shows the outcome of the same determinacy analysis but under the alternate assumption that the government budget constraint (15) is specified in nominal terms and monetary policy follows a constant nominal interest rate rule. The economy is locally determinate for all degrees of wage/price rigidities, regardless of whether capital is included in the model. It also remains determinate for all empirically plausible levels of MPCs, from zero to those much higher than the previous consensus estimates. Perhaps surprisingly, the economy is determinate despite the constant nominal interest rate.

These findings have important and new — compared to complete markets economics —

[16] This refers to MPCs in the upper range of the previous consensus estimates, i.e. quarterly MPCs of 20-25% and higher.

Table II: Local Determinacy: Real Bonds

Interest Rate Rule: $\phi_1^\pi = 1.5$

		Sticky Wages	Flexible Wages
Sticky Prices	With Capital	**Determinate (Our Calibration)**	Indeterminate
	No Capital	Determinate	Indeterminate
Less Sticky Prices	With Capital	Indeterminate	Indeterminate
	No Capital	Determinate	Determinate

implications for the conduct of monetary policy. In complete-markets models, determinacy requires that the interest rate rule has an inflation-coefficient larger than one, typically around 1.5. Such a rule leads to a fiscal multiplier smaller than one, since the real interest rate increases in response to the fiscal stimulus. We show that incomplete-markets models with nominal fiscal policy can overcome this dilemma. Determinacy considerations thus do not trigger an aggressive interest rate response and do not require monetary policy to counteract the fiscal stimulus. Thus, a constant nominal interest rate can deliver a multiplier larger than one.

3.5 Consumption and Investment Channels

Having established the determinacy properties of our model, it is now meaningful to examine the role of the consumption and the investment responses in shaping the (unique) fiscal multiplier.

3.5.1 Consumption Channels

An increase in spending, the necessary adjustments in taxes and transfers, and the resulting responses of prices and hours induce redistribution across economic agents. For example, changes in the tax code naturally deliver winners and losers. An increase in the price level or labor income leads to a redistribution from households who finance their consumption more from asset income to households who rely more on labor income. Changes in interest rates redistribute between debtors [the government] and lenders [the private sector] (Erosa and Ventura, 2002; Doepke and Schneider, 2006).

Table III: Local Determinacy: Nominal Bonds

Interest Rate Peg: $i_t = \bar{i}$

		Sticky Wages	Flexible Wages
Sticky Prices	With Capital	**Determinate (Our Calibration)**	Determinate
	No Capital	Determinate	Determinate
Less Sticky Prices	With Capital	Determinate	Determinate
	No Capital	Determinate	Determinate

These distributional effects matter due to the endogenous heterogeneity in empirical MPCs that the model replicates. MPC heterogeneity together with the properties of the redistribution determine the aggregate consumption response, and, since output is demand determined due to price rigidities, also affect output. Aggregate consumption demand D is defined as the sum of aggregate private consumption demand $C_t\big(\{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l\geq t}\big)$ (see Eq. 38) and real government consumption $g_t = G_t/P_t$, which both determine output. Denoting pre-stimulus variables by a bar, we obtain the full decomposition of the total demand effect $(\Delta D)_t$,

$$
\begin{aligned}
(\Delta D)_t &= D_t\big(\{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l\geq t}\big) - D_t\big(\{\bar{T}, \bar{\tau}, \bar{w}\bar{h}, \bar{P}, \bar{i}^a\}_{l\geq t}\big), && (43)\\
&= \underbrace{(\Delta g)_t}_{\text{Direct G Impact}} && (44)\\
&+ \underbrace{C_t\big(\{\bar{T}, \bar{\tau}, \bar{w}(\bar{h}+\Delta h^g), \bar{P}, \bar{i}^a\}_{l\geq t}\big) - C_t\big(\{\bar{T}, \bar{\tau}, \bar{w}\bar{h}, \bar{P}, \bar{i}^a\}_{l\geq t}\big)}_{\text{Direct G Impact on C}} && (45)\\
&+ \underbrace{C_t\big(\{T_l, \tau_l, \bar{w}(\bar{h}+\Delta h^g), \bar{P}, \bar{i}^a\}_{l\geq t}\big) - C_t\big(\{\bar{T}, \bar{\tau}, \bar{w}(\bar{h}+\Delta h^g), \bar{P}, \bar{i}^a\}_{l\geq t}\big)}_{\text{Indirect Tax/Transfer Impact}} && (46)\\
&+ \underbrace{C_t\big(\{T_l, \tau_l, w_l h_l, \bar{P}, \bar{i}^a\}_{l\geq t}\big) - C_t\big(\{T_l, \tau_l, \bar{w}(\bar{h}+\Delta h^g), \bar{P}, \bar{i}^a\}_{l\geq t}\big)}_{\text{Indirect Labor Income Impact}} && (47)\\
&+ \underbrace{C_t\big(\{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l\geq t}\big) - C_t\big(\{T_l, \tau_l, w_l h_l, \bar{P}, \bar{i}^a\}_{l\geq t}\big)}_{\text{Indirect Price and Interest Impact}}. && (48)
\end{aligned}
$$

A fiscal stimulus is an increase of government demand by Δg, which has a direct impact on demand D by Δg in (44). The private consumption response does not directly depend on G/P, but will respond indirectly as other prices and quantities adjust in equilibrium. First, the initial policy-induced demand stimulus leads to more employment by firms, $\bar{h} + \Delta h^g$, where Δh^g is the amount of hours needed to produce Δg while keeping the capital stock unchanged, and thus higher labor income, which in turn increases consumption demand, what we label the *Direct G Impact on C* in (45). Similarly to the textbook multiplier logic, the equilibrium response does not stop after the initial impact, but this first round is followed by "second, third, ... rounds." Those rounds arise in our model since an initial policy-induced demand stimulus leads to more employment by firms, and thus higher labor income which in turn implies more consumption demand, which again leads to more employment and so on until an equilibrium is reached where all variables are mutually consistent, yielding the *Indirect Labor Income Impact*, (47). The remainder of the private consumption response also takes into account the indirect impact of transfers and taxes and the indirect equilibrium effects of price and interest rate adjustment shown in Eqs. (46) and (48).

3.5.2 Investment Channels

Investment demand is another component of aggregate demand and the strength of this channel depends both on the cost of investment — the real interest rate r_t^k — and the demand for intermediate goods. Intermediate goods firms set prices subject to Rotemberg adjustment costs and have to satisfy the resulting demand Y_{jt} for their product through hiring labor H_{jt} or renting capital goods K_{jt}, which leads to the cost minimization condition in Eq. 11: $\frac{K_{jt}}{H_{jt}} = \frac{\alpha w_t}{(1-\alpha) r_t^k}$. Given prices w_t and r_t^k, a higher demand Y_{jt} leads to an increase both in capital and employment, the demand channel of investment. Higher capital costs r_t^k dampen investment demand but only if they increase more than wages. Since firms have to satisfy demand, the relative costs of the factor inputs matter. As an example, suppose that r_t^k increases by 1% but that wages increase by 2%, so that $\frac{\alpha w_t}{(1-\alpha) r_t^k}$ increases. In this case, firms would substitute from labor to capital although capital costs have increased because the costs of the other input factor, wages, has increased by even more.[17] In addition to these partial equilibrium considerations, general equilibrium requires asset market clearing, that is the real interest rate received by households has to be such that they are willing to hold all assets created, bonds and capital,

$$
\begin{aligned}
S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l \geq t}\big) &= \int \frac{a_{t+1}(a, s; \{T_l, \tau_l, w_l h_l, P_l, i_l^a\}_{l \geq t})}{P_{t+1}} d\Omega_t && (49) \\
&= K_{t+1} + B_{t+1}/P_{t+1} + \Phi(K_{t+1}, K_t), && (50)
\end{aligned}
$$

[17]The findings of Rupert and Šustek (2019), derived in a complete markets New Keynesian model with capital, flexible wages and low adjustment costs of capital, suggest that this is not only a theoretical possibility.

such that the change in aggregate savings equals the sum of the change in capital, real bonds and adjustment costs,

$$\Delta S_{t+1} \quad = \quad \Delta K_{t+1} + \Delta \frac{B_{t+1}}{P_{t+1}} + \Delta\Phi(K_{t+1}, K_t). \tag{51}$$

This asset market clearing condition implies that, if the stimulus is deficit financed, capital could be partially crowded out since the increase in savings is partially absorbed by higher government debt. To assess the magnitude of this channel we compute the sequence of real interest rates $r^{a,Crowding}$ and capital stocks K^{Crowd} which would clear the asset market if bonds were fixed at their steady-state level B_{ss},

$$S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, r_l^{a,Crowding}\}_{l\geq t}\big) = K_{t+1}^{Crowd} + B_{ss}/P_{t+1} + \Phi(K_{t+1}^{Crowd}, K_t^{Crowd}), \tag{52}$$

such that the difference in capital stocks,

$$K_{t+1} - K_{t+1}^{Crowd}, \tag{53}$$

is the effect of crowding out.

The asset market clearing condition also has a supply side. Households have to be willing to increase their savings. We decompose the change in aggregate savings into two channels. The same redistributive forces that affect consumption behavior in turn affect the savings behavior of households, the redistributive channel of savings. The second channel describes the effect of higher real interest rates on savings. The decomposition of aggregate savings is

$$(\Delta S)_{t+1} \quad = \quad S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, r_l^a\}_{l\geq t}\big) - S_{t+1}\big(\{\bar{T}, \bar{\tau}, \bar{w}\bar{h}, \bar{P}, \bar{r}^a\}_{l\geq t}\big) \tag{54}$$

$$= \quad \underbrace{S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, \bar{r}^a\}_{l\geq t}\big) - S_{t+1}\big(\{\bar{T}, \bar{\tau}, \bar{w}\bar{h}, \bar{P}, \bar{r}^a\}_{l\geq t}\big)}_{\text{Distributional Impact}} \tag{55}$$

$$+ \quad \underbrace{S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, r_l^a\}_{l\geq t}\big) - S_{t+1}\big(\{T_l, \tau_l, w_l h_l, P_l, \bar{r}^a\}_{l\geq t}\big)}_{\text{Interest Rate Impact}}. \tag{56}$$

4 Quantitative Assessment

4.1 Calibration

To quantitatively assess the size of the fiscal multiplier, we now calibrate the model. We set the model period to one quarter.

Preferences. We set the risk-aversion parameter, σ, equal to 1. Following Krueger et al. (2016), we assume permanent discount factor heterogeneity across agents. We allow for two values of the discount factor (0.999 and 0.993), which we choose along with the relative proportions (0.2 and 0.8, resp.) to match the Gini coefficient of net worth net of home equity, the ratio of median and 30th percentile of net worth net of home equity in the 2013 SCF, and the ratio of aggregate savings net of home equity to quarterly GDP of 11.46. This allows us to capture the overall level of wealth in the economy and important distributional moments. We assume the functional form for the disutility of labor v:

$$v(h) = \psi \frac{h^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}. \tag{57}$$

We set the Frisch elasticity, $\varphi = 0.5$, following micro estimates. We choose $\psi = 0.6$ so that in steady state $h = 1/3$.

Productivity Process. Krueger et al. (2016) use data from the Panel Study of Income Dynamics to estimate a stochastic process for labor productivity. They find that log disposable labor income consists of a persistent and a transitory component. They estimate that the persistent shock has an annual persistence of 0.9695 and a variance of innovations of 0.0384. The transitory shock is estimated to have variance 0.0522. We follow Krueger et al. (2016) in converting these annual estimates into a quarterly process. We discretize the persistent shock into a seven state Markov chain using the Rouwenhorst method and integrate over the transitory shock using Gauss-Hermite quadrature with three nodes.

Production Technology. We set the capital share $\alpha = 0.36$. We choose the quarterly depreciation rate $\delta = 0.032$ to generate the same real return on capital net of depreciation and on bonds when the capital output ratio is 10.26. We assume the functional form for Φ:

$$\Phi(K', K) = \frac{\phi_k}{2} \left(\frac{K' - K}{K} \right)^2 K, \tag{58}$$

and set $\phi_k = 17$ to match estimates of the elasticity of investment to Tobin's q from Eberly et al. (2008). We choose the elasticity of substitution between intermediate goods, $\epsilon = \epsilon_w = 10$, to match an average markup of 10%. The adjustment cost parameter on prices and wages is set to $\theta = \theta_w = 300$ yielding a slope of the NK price and wage Phillips curves, $\epsilon/\theta = \epsilon_w/\theta_w = 0.03$, consistent with Christiano et al. (2011) and with more recent estimated HANK models (Bayer et al., 2022). We set the firm operating cost F equal to the steady-state markup such that steady-state profits equal zero (Basu and Fernald, 1997). Profits, which are nonzero only off steady state, are fully taxed.

Government. We set the proportional labor income tax τ equal to 25%, and the dividend tax τ_k equal to 36% (Trabandt and Uhlig, 2011). We set nominal government spending G in steady state equal to 6% of output (Brinca et al., 2016). The value of lump-sum transfers T is set to 8.55% of output such that roughly 40% of households receive a net transfer from the government (Kaplan et al., 2018). This generates a government debt to quarterly GDP ratio of 1.2 in steady state.

Steady State Model Fit. In the calibrated model, 3% of agents are at the borrowing constraint with 0 wealth, and 10% of agents have less than $1,000. The wealth to annual income ratio is 4.9. The quarterly MPC out of transitory income equals 0.12, which is within the range of modern empirical estimates in Borusyak and Jaravel (2017) and Borusyak et al. (2021).

4.2 Fiscal Multipliers in the Data and in the Model

Having calibrated our model to match salient moments on household consumption behavior and nominal rigidities, we now validate that our framework provides a useful laboratory for studying the fiscal multiplier. In particular, we ask how well our model can replicate the aggregate responses to government spending reported in Ramey and Zubairy (2018). They use well-identified government spending shocks to calculate the 2- and 4-year multipliers as the sum of output responses within the first two or four years divided by the corresponding sum of government spending changes:

$$m^{2years} = \frac{\sum_{k=0}^{2years} Y_k - Y_{ss}}{\sum_{k=0}^{2years} g_k - g_{ss}} \qquad \text{and} \qquad m^{4years} = \frac{\sum_{k=0}^{4years} Y_k - Y_{ss}}{\sum_{k=0}^{4years} g_k - g_{ss}}. \tag{59}$$

Balancing the government budget when government spending or transfers are increased requires taxes, debt, or both to adjust. To the extent that Ricardian equivalence does not hold, different paths of taxes and debt will have different implications for the path of aggregate consumption and therefore prices and output. Moreover, the size of the fiscal multiplier will depend on how monetary policy chooses to respond to a fiscal stimulus. Thus, to properly replicate the empirical experiment within the model requires estimating and using as inputs the impulse responses of fiscal and monetary policy in response to the spending shock. We estimate the monetary policy response to the spending shocks using the data and identification from Ramey and Zubairy (2018).[18] In Figure 1, we plot the response of the three-month Treasury bill interest rate to the same fiscal stimulus used in Ramey and Zubairy (2018), and used to calculate the empirical results shown in Table IV. We find that the interest rate is not significantly affected, which is consistent with monetary policy not responding to the fiscal stimulus. The flat response holds for both post WWII data and the larger historical sample starting in 1889. One could interpret the flat response as monetary policy supporting fiscal policy.

To conduct the equivalent empirical experiment in the model, we compute the impulse response to an MIT shock where we feed in the empirical impulse response to government

[18] The response of spending, taxes, and deficits is reported in Figure 5 in Supplementary Appendix to Ramey and Zubairy (2018)

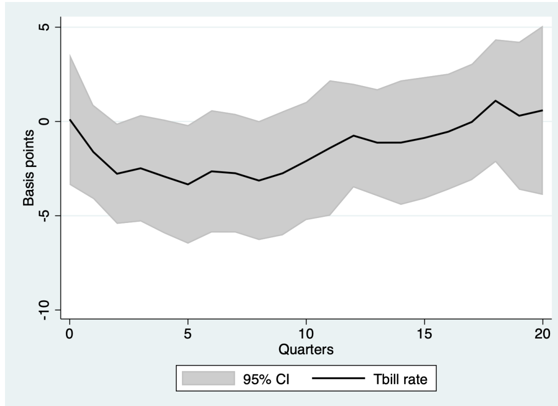


Figure 1: Monetary Policy Response to Fiscal Stimulus (Ramey-Zubairy Shock)

Table IV: Fiscal Multiplier: Empirical Results and Model

Multiplier	Empirical Results	Model Results
m^{2years}	0.75	0.73
m^{4years}	0.51	0.58

spending shock of: taxes, the deficit and the nominal interest rate. We then calculate the 2-year and 4-year multipliers in the model. The first column "Empirical Results" of Table IV reports the empirical findings for post WWII data, and the second column "Model Results" reports the corresponding findings from our model. We conclude that our theoretical model replicates the results in the data and thus represents a good laboratory for studying the fiscal multiplier. We now proceed to study how different configurations of monetary and fiscal policy affect the size of the multiplier. In particular, we can conduct experiments where the data are less informative but the results are of keen interest to policymakers e.g., when the economy is in a liquidity trap.

4.3 The Fiscal Multiplier: Definition and Policy Specifications

As discussed in the previous section, the size of the multiplier depends on the conduct of both monetary and fiscal policy in response to a stimulus. It may also exhibit dependence on the other shocks affecting the economy, e.g., a large negative demand shock triggering a liquidity trap. Unfortunately, it is not possible to conduct randomized experiments in the data to isolate the pure effect of additional spending on the economy from the consequences of other shocks and policy responses. We can, however, use our quantitative model for this purpose. Thus, our objective is to quantify how different financing schemes and policy responses shape the size of the fiscal multiplier.

To be able to compare the results across the experiments we put all of them on the same footing by considering the effect of the same change in government spending (or transfers in Appendix VI.1). Specifically, we compute the equilibrium responses of prices, employment, output and consumption to a persistent increase in government spending for 20 quarters, consistent with the empirical duration of elevated spending in Ramey and Zubairy (2018). We assume that spending increases by one percent[19] in period t and after that the amount of additional spending decays at rate $1-\rho_g$ per quarter for the subsequent 19 quarters. We set $\rho_g = 0.9$ in the baseline experiments (implying a half-life of 7 quarters) and vary this parameter in Appendix VI.4. We consider different scenarios for fiscal policy about the financing of the additional spending and different specifications of the interest rate response of monetary policy.

Monetary Policy

We consider three different specifications for monetary policy.

- Constant nominal interest rate: $i_{t+1} = i_{ss} \geq 0$.
- Inflation targeting:

$$i_{t+1} = \max(\tilde{i}_{t+1}, 0), \qquad \tilde{i}_{t+1} = \left(\frac{1}{\zeta}\right)\left(\frac{1+\pi_t}{1+\pi_{ss}}\right)^{\phi_1^\pi(1-\rho_R)}[\zeta(1+i_t)]^{\rho_R} - 1.$$

  We follow the literature in setting $\rho_R = 0.8$, $\phi_1^\pi = 1.5$ and $\zeta = 1/(1+r_{ss})$.

- Price level targeting:

$$i_{t+1} = \max(\tilde{i}_{t+1}, 0), \qquad \tilde{i}_{t+1} = \left(\frac{1}{\zeta}\right)\left(\frac{P_t}{P_{ss}}\right)^{\phi_1^P(1-\rho_R)}[\zeta(1+i_t)]^{\rho_R} - 1.$$

  We set $\rho_R = 0.8$, $\phi_1^P = 1.5$ and $\zeta = 1/(1+r_{ss})$, i.e., the standard values in the literature.

Fiscal policy

We assume that bonds are nominal if nominal interest rates are constant and bonds are real for standard interest rate rules. For balancing the government budget when government spending is increased, we consider two benchmark scenarios:

1. Transfer are adjusted period by period to keep nominal or real debt constant.
2. Deficit financing and delayed future reduction of transfers (or future cuts in govrnment spending in Appendix VI.5) to eventually pay back the accumulated debt.

[19]In Appendix VI.3 we show that the multiplier is decreasing in the size of the spending stimulus. One should be cautious about proposals that for government spending to be effective it has to be large. Interpreting higher effectiveness as a higher multiplier, we find that scaling up the stimulus decreases its effectiveness.

In both scenarios we keep the labor and dividend tax rates, τ and τ_k, fixed. The two scenarios capture the two extreme financing schemes which are associated with the lowest and highest fiscal multiplier in the tax/deficit financing space.

Combining the fiscal and monetary scenarios yields 6 specifications for which we calculate the fiscal multiplier in our incomplete markets model. For comparison with the literature, we also conduct the same experiments in the corresponding complete markets model. The RANK model is the counterpart of our HANK model (all parameters identical) but where households have access to a full set of Arrow securities and thus are fully insured against productivity shocks. Note that a constant nominal rate cannot be used in the RANK model, since this delivers indeterminacy. The two fiscal scenarios yield the same result in the RANK model due to Ricardian equivalence.

4.3.1 Multiplier: Definition

We summarize the effects of spending on output in several ways. The government spending elasticity of date t real output equals

$$\frac{\frac{Y_t - Y_{ss}}{Y_{ss}}}{\frac{\frac{G_0}{P_0} - \frac{G_{ss}}{P_{ss}}}{\frac{G_{ss}}{P_{ss}}}}, \tag{60}$$

where P_{ss}, G_{ss}, Y_{ss} are the steady state price level, nominal spending and real output respectively and $\frac{G_0}{P_0}$ is real government spending at date $t = 0$.

We multiply this elasticity by $\frac{Y_{ss}}{G_{ss}/P_{ss}}$ to convert it to dollar equivalents, which yields the path of incomplete markets multipliers as the sequence of

$$m_t^{IM} = \frac{\frac{Y_t}{Y_{ss}} - 1}{\frac{G_0 P_{ss}}{P_0 G_{ss}} - 1} \frac{Y_{ss}}{G_{ss}/P_{ss}}. \tag{61}$$

We also compute the period t *present value* multipliers for a discount factor $\tilde{\beta}$ as

$$m_t^{PV} = \frac{\sum_{k=0}^{t} \tilde{\beta}^k (\frac{Y_k}{Y_{ss}} - 1)}{\sum_{k=0}^{t} \tilde{\beta}^k (\frac{G_k P_{ss}}{P_k G_{ss}} - 1)} \frac{Y_{ss}}{G_{ss}/P_{ss}}, \tag{62}$$

where the two statistics coincide at $t = 0$ and represent the impact multiplier. In the quantitative implementation we set $\tilde{\beta}$ equal to the discount factor of the patient household. Another useful statistic is the cumulative multiplier (Mountford and Uhlig, 2009), which represents the discounted percentage change in real output relative to the discounted percentage change in real government spending for any path of government spending, which is equivalent to the present value multiplier at infinity $\overline{M} := m_{\infty}^{PV}$.

Measuring the effectiveness of spending using the impact multiplier or the cumulative multiplier does not always point in the same direction. For example, the results in Appendix VI.4 reveal that while the impact multiplier increases when we increase the persistence of stimulus spending from 0.1 to 1, the cumulative multiplier falls sharply. This difference reflects the intertemporal trade-off of a stimulus − potentially large initial gains come with potentially larger cost later on, − which is absent from the standard Keynesian cross logic but which is present and can be measured in our dynamic model.

For each experiment considered below, we report the dynamic response of hours, consumption, output, prices, tax revenue and debt as well as the paths of the incomplete markets multiplier m_t^{IM} and the cumulative multiplier. In all experiments we start from a steady state except for our "Liquidity Trap" experiment studied in Section 4.7.

4.4 Fiscal Multiplier: Results

Table V collects various statistics including the impact and cumulative multipliers across the experiments we conduct in the body of the paper. The main conclusion is that the impact multipliers are very different between financing schemes with fixed nominal interest rates. They become quite similar when inflation or price level targeting is used and identical in complete markets models in which Ricardian equivalence holds. The impact multiplier is higher than one only for deficit financing and a constant nominal rate. Otherwise if monetary policy follows an inflation or price level targeting rule, the fiscal stimulus leads to a strong response of monetary policy, which largely undoes the stimulus even for deficit financing. With tax financing, fiscal policy is not very stimulative to begin with and monetary policy remains largely unchanged. The next subsections describe the results for these various combinations of monetary and fiscal policy in detail. For all model specifications, including a constant nominal interest rate, inflation, and price-level targeting, we verified that the economy is locally determinate.

4.5 Tax Financing

4.5.1 Constant Nominal Interest Rate

Under the tax financing scheme, we assume that the government adjusts lump-sum transfers period by period to keep the level of nominal debt constant. Monetary policy keeps the nominal interest rate constant which, as we explained above, delivers determinacy in our incomplete markets model with nominal bonds. We do not consider the complete markets economy or the HANK economy with real bonds in this section since they are indeterminate for this monetary policy specification. The four panels of Figure 2 show the results for the

Table V: Main Results: Consumption, Investment and Multipliers

	Incomplete Markets						Complete Markets	
Experiment:	Constant rate		π-Target		P-Target		π-Target	P-Target
Financing:	Tax	Deficit	Tax	Deficit	Tax	Deficit	Tax/Deficit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact Mult.	0.61	1.34	0.56	0.77	0.44	0.45	0.78	0.44
Cumul Mult.	0.43	0.55	0.49	0.61	0.41	0.30	-0.06	-0.49
$100 \times \Delta C_0$	-2.7	1.4	-2.8	-0.2	-3.0	-1.0	-1.1	-1.6
$100 \times \Delta I_0$	0.3	0.6	0.1	-1.3	-0.4	-2.6	-0.3	-1.9
Decomposition of Consumption ($100 \times \Delta$)								
Direct G on C	1.2	1.2	1.2	1.2	1.2	1.2	0.1	0.1
Tax/Transfers	-3.1	0.5	-3.1	-0.1	-3.0	-0.4	-0.1	-0.1
Indirect Income	-0.7	0.2	-0.7	-0.5	-0.9	-1.0	-0.0	-0.1
Prices	-0.1	-0.5	-0.2	-0.8	-0.3	-0.9	-1.0	-1.5

Note - The table contains the impact and the cumulative multiplier $\overline{M}$ (using definition (A10) for the last column and (A11) otherwise) as well as the initial consumption and investment responses, ΔC_0 and ΔI_0 (as a % of output). The last four rows show the decomposition of the initial aggregate consumption response (also multiplied by 100) into the direct G impact on C (Eq. 45), the effect of taxes/transfers (Eq. 46), indirect income effects (Eq. 47) and the price and interest rate effects (Eq. 48).

private consumption and output response, the different multipliers, the decomposition of private consumption, and the evolution of government bonds.

The bottom right panel plotting the evolution of fiscal policy illustrates that the level of nominal government bonds is unchanged since the stimulus is tax-financed. The top left panel shows that on impact G increases by 1% (0.06% of output) and consumption decreases by 0.027% of output. As illustrated in the top right panel, this leads to an impact multiplier of 0.61. The incomplete markets multiplier converges to zero since the consumption response, although negative, slowly dies out and becomes small relative to the initial government spending increase. The decomposition of the consumption response in the bottom left panel reveals the quantitative importance of the direct, the indirect and the price effects. The stimulus of 0.06% directly increases households' labor supply by the same amount, leading to a aggregate consumption increase of 0.012% of output (Eq. 45). The contemporaneous cut in transfers lowers aggregate consumption by -0.031% on impact (Eq. 46), implying a total initial negative effect of -0.019%. This effect is negative since an increase

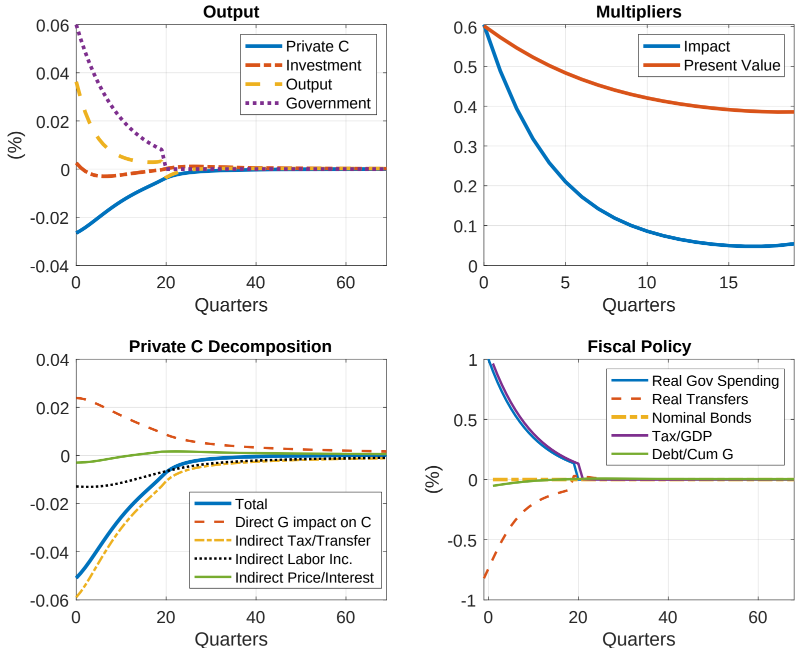


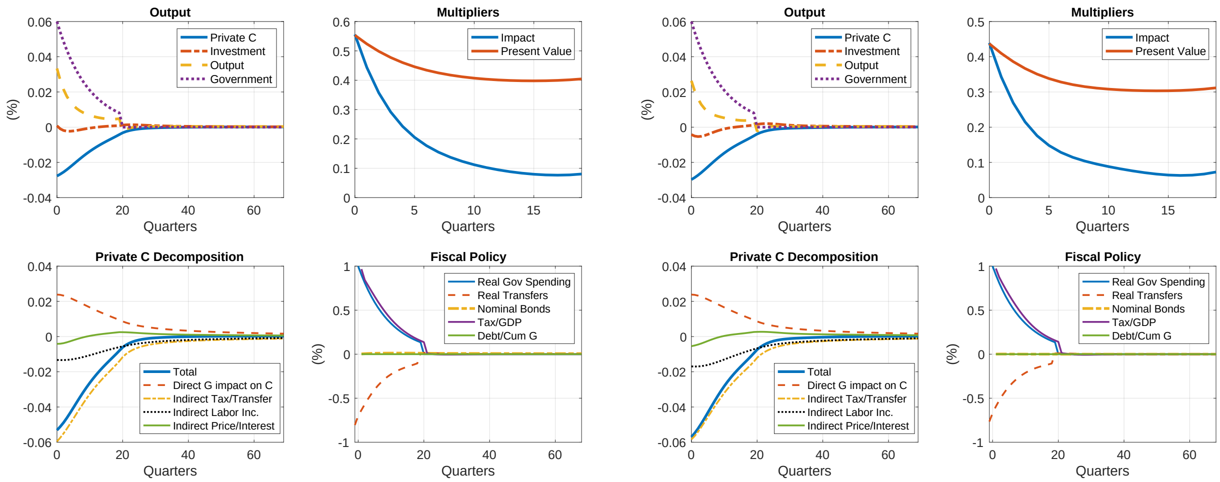
Figure 2: Fiscal Multiplier and Aggregate Consumption: Tax Financing

in government spending increases household income in proportion to their productivity and thus predominantly benefits high-income households. In contrast, the transfer cut is uniform across all income groups and thus negatively affects high MPC households. This decrease leads to lower consumption demand, which in turn leads to lower labor demand, lower labor income and again lower consumption demand until an equilibrium is reached. These indirect income effects sum up to -0.007% (Eq. 47) further lowering the consumption response.[20] Finally, the decomposition shows that the price increase and (the unchanged) interest rate effects are small (Eq. 48). The investment channel is also contributing very little. The impulse response of the remaining variables to a 1% innovation in government spending are plotted in Figure 22(a) in the appendix. The cumulative multiplier, in Table V, is 0.43. The difference between complete markets with inflation targeting (impact multiplier 0.78) and incomplete markets with a constant nominal interest rate (impact multiplier 0.61) equals $-0.17 = 0.61 - 0.78$. This is because the dampening effect of monetary policy response in the complete markets model is dominated by the negative demand effects of tax-financing in the incomplete markets model.

4.5.2 Interest Rate Rules: Inflation and Price Level Targeting

We find that – with tax financing – the multipliers change little if monetary policy follows an inflation or price level targeting rule. In the inflation-targeting case, the impact multiplier

[20]The total income effect is the sum of the direct effect of G on C (0.012%) and the indirect effect, (-0.007%) and is positive, $0.005\% = 0.012\% - 0.007\%$.



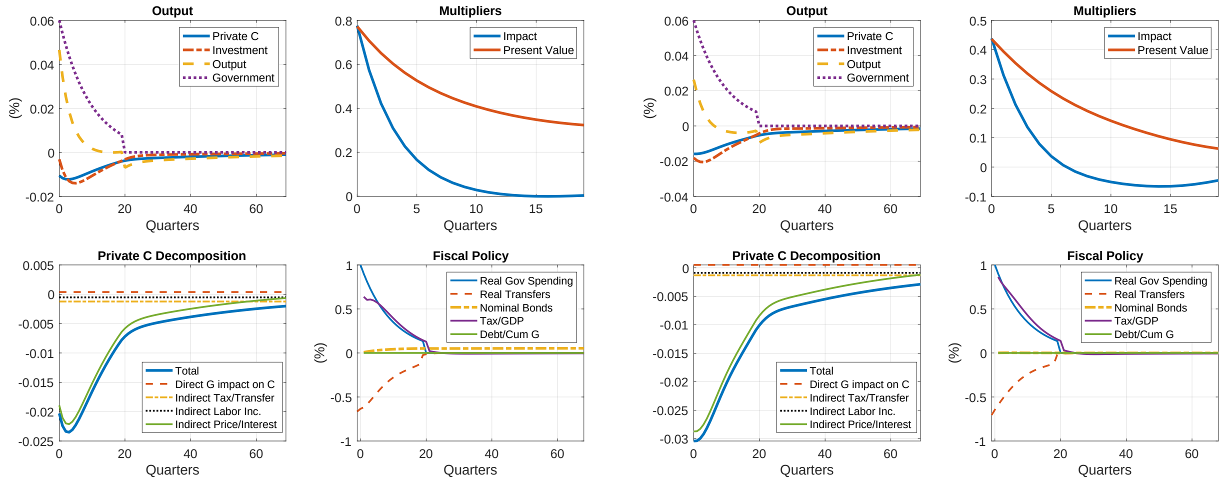
(a) Inflation Targeting (b) Price Level Targeting

Figure 3: Incomplete Markets with Tax Financing: Inflation or Price-Level Targeting

drops to 0.56 and the cumulative multiplier increases to 0.49 (see Figures 3(a) and 23(a)). Whereas in the price-level-targeting case the incomplete markets multiplier falls to 0.44 (see Figures 3(b) and 24(a)). The multipliers are quite similar regardless of monetary policy because tax financing is the primary driver of private demand (because the uniform cut in transfers also affects high MPC households). As a result, output and prices do not change much. Small changes in prices imply only small differences in the nominal rate under inflation or price level targeting relative to the constant nominal rate case, and thus it is not surprising that inflation-targeting yields similar outcomes in response to fiscal stimulus. The reason for the relative sizes of the three multipliers is that price level targeting yields the highest real interest rate, followed by inflation targeting, and finally the constant nominal rate as panel (a) of Figure 5 shows. More generally, the figure shows that the magnitude of the multiplier tends to be the larger the lower the real rate is. Note that the real interest rate falls on impact in spite of a positive fiscal stimulus due to nominal interest rate smoothing (recall $\rho_R = 0.8$), which implies that the monetary authority raises interest rates slowly in response to the stimulus-induced inflation.

4.5.3 Distributional channel

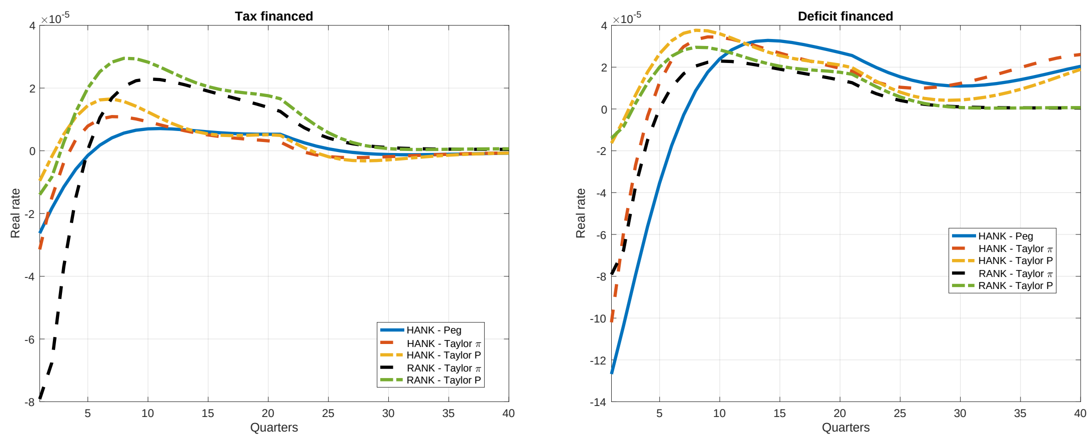
To quantify the role of the distribution and incomplete markets, we compute the distribution multiplier by comparing the complete markets multiplier to the incomplete markets one. Figure 4 shows the equivalent response of the complete markets model under inflation and price level targeting in panels (a) and (b), respectively. This complete markets multiplier is less than one due to higher interest rates following the Taylor principle which basically accounts for the full drop in output. In both cases, the complete markets multiplier is larger than the incomplete markets one. The difference is largely driven by the smaller impact



(a) Inflation Target

(b) Price Level Target

Figure 4: Complete Markets: Inflation or Price-Level Targeting



(a) Tax Financing

(b) Deficit Financing

Figure 5: Real Interest Rate $1 + r_t = \frac{1+i_t}{1+\pi_t}$

of the cut in transfers on demand in the latter model. The distribution multiplier is thus negative, e.g. $m_0^{Distribution} = 0.56 - 0.78 = -0.22$ in the inflation targeting case.

4.6 Deficit Financing

We now turn to the case where the fiscal stimulus is deficit financed at first. Under this scenario we assume that real transfers are kept constant after the innovation to government spending. Eventually, the debt must be repaid. We assume that the repayment occurs sufficiently far into the future - after 40 quarters - from the onset of stimulus and the reduction of transfers is gradual for computational convenience.[21] Variations in the way the eventual

[21]Specifically, we assume that real transfers are kept constant during the first 40 quarters after the innovation to government spending. Then, they are reduced linearly over eight quarters, kept constant for

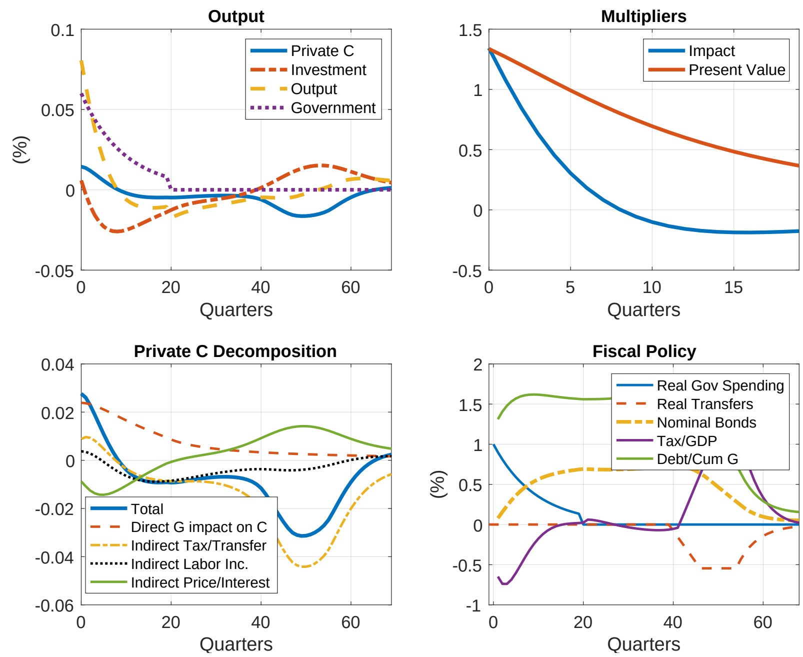


Figure 6: Constant Nominal Rate and Deficit Financing

repayment is modeled is inconsequential for our substantive findings. The four panels of Figure 6 summarize the evolution of the key variables of interest.

4.6.1 Constant Nominal Interest Rate

Deficit instead of tax financing increases the impact multiplier m_0^{IM} from 0.61 to 1.34 and the initial aggregate consumption response from -0.027% to 0.014% when the nominal interest rate is kept constant. The decomposition of the consumption response makes clear why. The direct impact of the spending stimulus is identical (0.012%) but now there is no initial offsetting effect from contemporaneously higher taxes/lower transfers. This benefits high MPC households, who primarily rely on labor income and not asset income, and allows them to increase consumption demand. The indirect income effects now accumulate to 0.002%. Deficit financing leads to an increase in government bonds bought by low MPC households, which reduces their consumption. In total, this redistribution towards high MPC households increases aggregate consumption demand, implying that the redistribution channel is positive.

The consumption response becomes negative only from period 9 onwards. However, the increase in government spending is ultimately financed through a future reduction in transfers, which results in a contraction in future output. Thus, the cumulative multiplier, reported

another eight quarters, and then revert back to the real steady state level with an autocorrelation parameter of 0.8. Thus, under this timing scheme, the government chooses only the level of adjustment to transfers to guarantee that nominal government debt returns to its original level. We use the same timing when the deficit is repaid using a cut in government spending rather than a decline in transfers in Appendix VI.5.

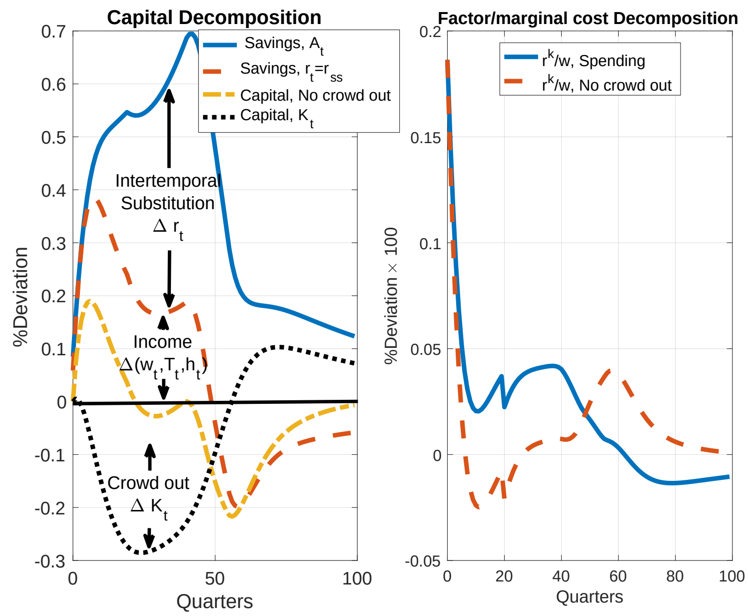


Figure 7: Aggregate Investment: Constant Nominal Rate and Deficit Financing

in Table V is only 0.55, significantly smaller than the impact multiplier. The difference between the incomplete markets and the complete markets multiplier with inflation targeting equals $0.56 = 1.34 - 0.78$ which is the combination of the contribution of redistribution and of a different interest rate rule. The impulse responses of the remaining variables are plotted in Figure 22(b) in the appendix.

Another difference between deficit and tax financing is a negative impact of investment demand on the multiplier with deficit financing. Figure 7 illustrates why this is the case. The right panel shows that r^k/w increases (because of a strong response of capital adjustment costs and thus of r_t^k to capital changes, and wage rigidities which dampen the movement of wages in response to demand fluctuations), making firms substitute from capital towards labor. The left panel shows that total savings increase (the blue line "Savings, A_t") by more than they would have increased if the real interest rate r^a were to remain constant (the red line "Savings, $r_t = r_{ss}$"), reflecting the "Interest Rate Impact" on savings (Eq. 56). The red line is however not zero, indicating that savings would have increased due to the distributional effects even if the real interest rate did not change. This "Distributional Impact" on savings (Eq. 55) is reflected by the difference between the red line and the solid black horizontal line through zero.

But while total savings increase, capital still falls below its steady-state level since the increase in savings is smaller than the increase in additional government debt, $K - K^{Crowd} < 0$ (Eq. 53). This crowding out of capital (the difference between the yellow "Capital, No crowd out" and the black dotted line "Capital, K_t") with deficit financing explains the drop in investment and its negative contribution to aggregate demand and the multiplier. This crowding out of capital through higher debt is also reflected in a higher required return on capital. Indeed, the right panel shows that r^k/w in the counterfactual crowding out experiment where debt is held constant (Eq. 52) is lower than in the benchmark. This is expected in the presence of crowding out since aggregate savings are lower without than with crowding out and accordingly households require a lower interest rate in the former than in the latter case.

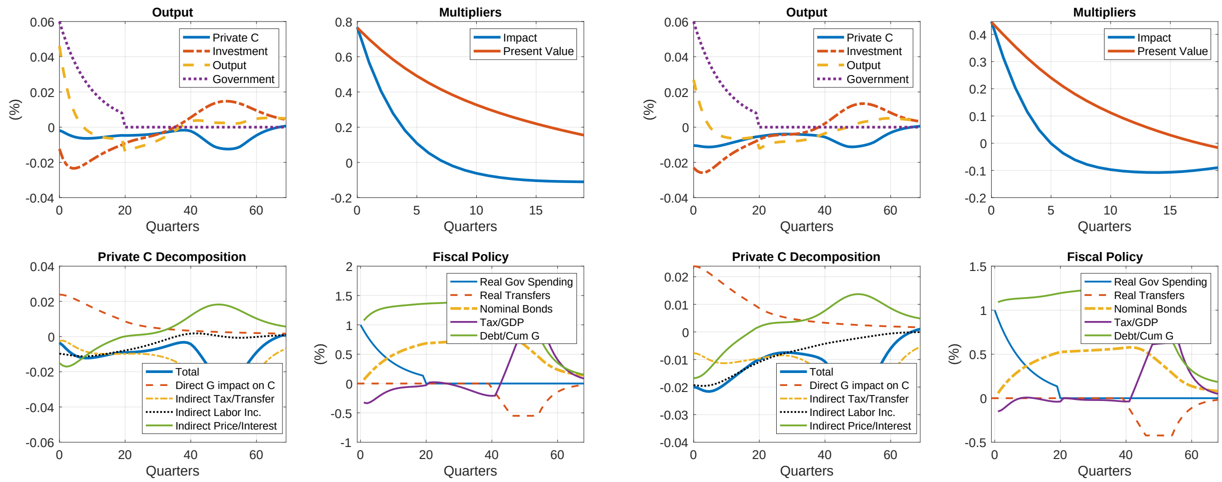
4.6.2 Interest Rate Rules: Inflation and Price Level Targeting

If monetary policy targets inflation, the impact multiplier with deficit financing drops to 0.77 and the cumulative multiplier is 0.61 (see Figures 8(a), 12(a) and 23(b)). Similarly, the impact multiplier falls to 0.45 in the case of price level targeting (see Figures 8(b), 12(b) and 24(b)). In both cases, the lower multiplier is a result of a drop in output due to tighter monetary policy. A higher nominal interest rate contracts consumption demand and thus reduces income, which in turn reduces savings and investment. Lower investment reduces income and thus contracts consumption which again reduces income and so on. Combining the expansionary output effects of the fiscal stimulus and the contractionary effects of monetary policy yields a multiplier of 0.77 for inflation targeting. The monetary response is even stronger in the price level targeting case (the yellow dot-dash line in panel (b) of Figure 5), yielding the lower impact multiplier.

The crowding out effect pushes investment down for all three monetary policy choices, and explains why investment falls in all cases. Initially, investment is higher if nominal interest rates are kept constant instead of being raised, since in this case household income, consumption, and savings are all higher. The Taylor rule induced decline in the size of the multiplier is smaller with tax than with deficit financing because monetary policy responds less if tax financing is used. Indeed, the real interest rate elasticity of output is unchanged but the smaller price responses with tax financing require a much smaller increase in interest rates.

4.7 Implications for Fiscal Multipliers at the Zero Lower Bound

Our results for constant nominal interest rates have immediate implications for the magnitude of the fiscal multiplier at the zero lower bound. We find that the multiplier is smaller than one if the stimulus is tax-financed and larger (but not much larger) than one for deficit financing. We obtain this finding for all constant nominal interest rates: zero or any positive value. What matters is that the interest rate is constant and does not increase in response to higher government expenditure, and thus does not counteract the fiscal stimulus.



(a) Inflation Targeting

(b) Price Level Targeting

Figure 8: Incomplete Markets with Deficit Financing: Inflation or Price-Level Targeting

With complete markets, any constant, not necessarily zero, nominal interest rate implies indeterminacy and thus the fiscal multiplier can be quite large (depending on the equilibrium selected by the researcher) as in Christiano et al. (2011). As we discussed above, our economy is locally determinate and thus there is a unique equilibrium and a unique multiplier.

What motivates the zero lower bound literature is that monetary policy cannot set too negative a nominal interest rate in a response to a large recessionary shock. Thus, instead of lowering the interest rate it is kept at zero (or some effective lower bound, which could potentially be negative). To replicate this setting, we also measure the government spending multiplier when the economy suffers a large demand shock and the nominal rate is zero. Therefore, we generate a liquidity trap in the model, where the ZLB on nominal interest rates is binding. In doing so we follow Cochrane (2017) and increase the quarterly discount factor $\{\beta_t\}_{t=0}^{9}$ by 50 basis points. We set the duration of this shock to 10 quarters (approximately the amount of time U.S. inflation was below target following the Great Recession).[22] Following Christiano et al. (2011), we introduce an investment wedge, τ_t^I, to the mutual fund problem, set to 3.6% for 10 quarters.[23] The investment wedge is necessary to prevent an investment boom following a preference-driven recession in New Keynesian models with capital. All other parameters are unchanged.

We then feed the $\{\beta_t, \tau_t^I\}_{t=0}^{9}$ series into our model and assume that the government keeps the real value of government spending and the nominal value of government debt constant, and adjusts lump-sum transfers period-by-period to satisfy its budget constraint. Figure

[22] In a linearized complete-markets model this would generate a fall in the natural real rate of interest — the real interest interest rate in a world with flexible prices and wages — of 2 pp (annualized) for 10 quarters and then a return to zero afterwards.

[23] In the liquidity trap if the mutual fund invests in K_{t+1} units of capital it will receive $(1+(1-\tau_{t+1}^I)(r_{t+1}^k-\delta))K_{t+1}$.

A-12 shows the response of the economy. The resulting recession is quite large as output initially drops by about 7 percent.

We then compute the effect of a simultaneous (at the same time as the liquidity trap starts) 1% increase in nominal government spending under the same balanced-budget and deficit financed schemes as outside the liquidity trap. Thus, we can compute the fiscal multiplier as the percent increase in output under each financing scenario, relative to the liquidity trap benchmark with no increase in spending, divided by the relative percent differences in government spending. The multipliers are plotted in Figure A-13. Figure A-14 shows the transfer multiplier associated with stimulus spending taking a form of an increase in transfers instead of government spending (see Appendix VI.1), where only deficit financing is meaningful. The corresponding impulse responses are reported in Appendix VII.7.

Both the spending and the transfer multipliers in a liquidity trap are not very different from their counterparts in the benchmark experiments outside the liquidity trap when we keep the nominal interest rate constant. For deficit financing, the impact spending multiplier, $m_0^{IM} = 1.39$ (1.34 in the benchmark) and the cumulative one $\bar{M} = 0.51$ (0.55 in benchmark). For tax financing, the impact multiplier, $m_0^{IM} = 0.73$ (0.61 in the benchmark) and the cumulative one $\bar{M} = 0.48$ (0.43 in the benchmark). The transfer multiplier, $m_0^{IM} = 0.86$ (0.66 in the benchmark) and the cumulative one $\bar{M} = -0.11$ (-0.3 in benchmark). We conclude that multipliers much larger than one (as in complete markets models) at the zero lower bound are ruled since our economy is determinate. We obtain this conclusion both with and without a recession.

The determinacy/non-determinacy difference between our model and complete markets environments also explains another puzzling result in New Keynesian complete markets models. In this model class, the size of the multiplier increases if prices become more flexible. There is, however, a discontinuity at fully flexible prices. The multiplier is smaller than one if prices are fully flexible, but is arbitrarily large if the degree of rigidity is close to but not equal to zero. The reason for the puzzle is that the response of inflation (and thus real interest rates) when prices are rigid. The more flexible prices are, the larger is the deflation in a liquidity trap and the larger is the inflation increase in response to the stimulus. Since the inflation response is one-to-one related to the output gain, the multiplier and the inflation rate are decreasing when rigidities are increased, i.e. $\theta = \theta_w$ increases.

In contrast, with fully flexible prices, an increase in the discount factor stimulates savings and thus implies a fall in the real interest rate or equivalently an increase in inflation. A fiscal stimulus raises the real interest rate in a fully flexible price economy that is the inflation rate falls and the multiplier is smaller than one.

Figure A-15 shows the multiplier in our HANK economy when we vary $\theta = \theta_w$ between 0 (flexible prices and wages) and 500 (very rigid wages and prices). Two stark differences to the complete markets version emerge. The multiplier is now decreasing instead of increasing when rigidities are reduced, i.e. $\theta = \theta_w$ falls. And the multiplier converges to the flexible price outcome when rigidities vanish, i.e. $\theta = \theta_w$ converges to zero. The discontinuity and the associated exploding multipliers which characterize the standard complete markets model disappear. The reason for these different findings is price level determinacy for a constant nominal interest rate in our model.

Relatedly, our HANK model does not feature the counterintuitive implication of complete markets New Keynesian models that the further the pre-anounced spending is in the future the larger is the current impact (Farhi and Werning, 2016). In Appendix VI.2 we show that price level determinacy in our HANK model implies that the multiplier declines with the date of pre-announced future spending and a pre-announced future spending increase is less effective than an unexpected stimulus.

5 Conclusion

The fiscal multiplier is not a single number. The effectiveness of a fiscal stimulus potentially depends, among many other things, on whether it takes the form of an increase in government consumption or an increase in transfers to households, on how this additional spending is financed, on how monetary policy responds to a fiscal stimulus, and on various shocks affecting the economy at the time of implementing the fiscal stimulus. Unfortunately, it is not possible to conduct randomized experiments in the data to isolate the pure effect of additional spending on the economy from the consequences of other shocks and policy responses. In this paper, we help address that challenge by providing a quantitative economic theory with the necessary ingredients to study a fiscal stimulus: incomplete markets generating realistic MPCs, the empirically relevant nominal rigidities, a locally-determinant equilibrium, and a realistic specification of the (partially nominal) government budget constraint. Our controlled experiments in the model isolate various economic mechanisms that affect the size of the multiplier. We find that the spending multiplier is larger than one only if government spending is deficit financed and the nominal interest rate is constant. All remaining policy specifications that we consider yield a multiplier smaller than one, implying crowding out of private economic activity by increased government spending.

Motivated in part by the last two recessions, an active literature has studied the effectiveness of fiscal policy when the economy is in a liquidity trap. We show that our determinate incomplete markets model with fiscal policy specified in nominal terms resolves liquidity trap puzzles documented in this literature using complete markets models. In particular, multipliers much larger than one are ruled out in contrast to complete markets models (Christiano et al., 2011). Further, the multiplier in a liquidity trap becomes smaller as prices become more flexible, and there is no discontinuity at fully flexible prices.

Finally, our insights stand to significantly influence the ongoing debate of whether the presence of heterogeneity and market incompleteness requires a re-thinking of the conduct of monetary policy and its interaction with fiscal policy. In 2020, the Federal Reserve announced a new monetary policy stance that "stresses the importance of understanding how various communities are experiencing the labor market." Recent work by Hagedorn et al. (2024) shows that an increase in nominal interest rates has distributional effects that disadvantage black households, implying that the Fed faces a tradeoff between price-stability and inclusiveness. Our framework shows that nominal fiscal policy plays a more important role in anchoring the inflation rate and ensuring determinacy than in the traditional complete markets model view. As a consequence, monetary policy does not have to increase the nominal interest rate in response to an increase in inflation. An accommodative monetary policy response—like keeping the nominal rate fixed when fiscal policy increases spending—leads to a higher multiplier than when following the Taylor rule, yet the model remains determinate. Our results show that monetary authorities can safely include objectives, beyond price stability, without risking indeterminacy.

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I Households' Demand and Marginal Propensity to Consume

In this Appendix we provide several partial equilibrium consumption results to build intuition for our general equilibrium findings and to show that our incomplete markets model is closer to the empirical findings in the micro consumption literature than standard frameworks. In all of the following experiments, we consider standard household consumption/savings problems for prices fixed at their steady-state values. To illustrate the properties of the MPC in our model, the experiments differ in the timing and the amount of transfers households receive.

Each of the four panels in Figure A-1 plots four separate experiments, where each line corresponds to the aggregate consumption path in response to finding out at date 0 that all households will receive a transfer either at date 0, or at date 4, or at date 8, or at date 12 without an obligation to ever repay. The four panels differ in the size of the transfer received, either \$10, \$100, \$1,000 or \$10,000.

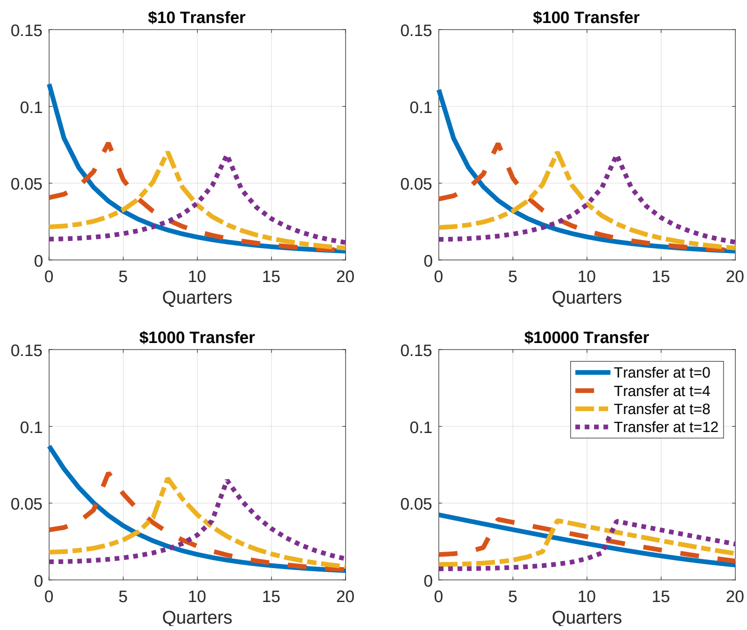
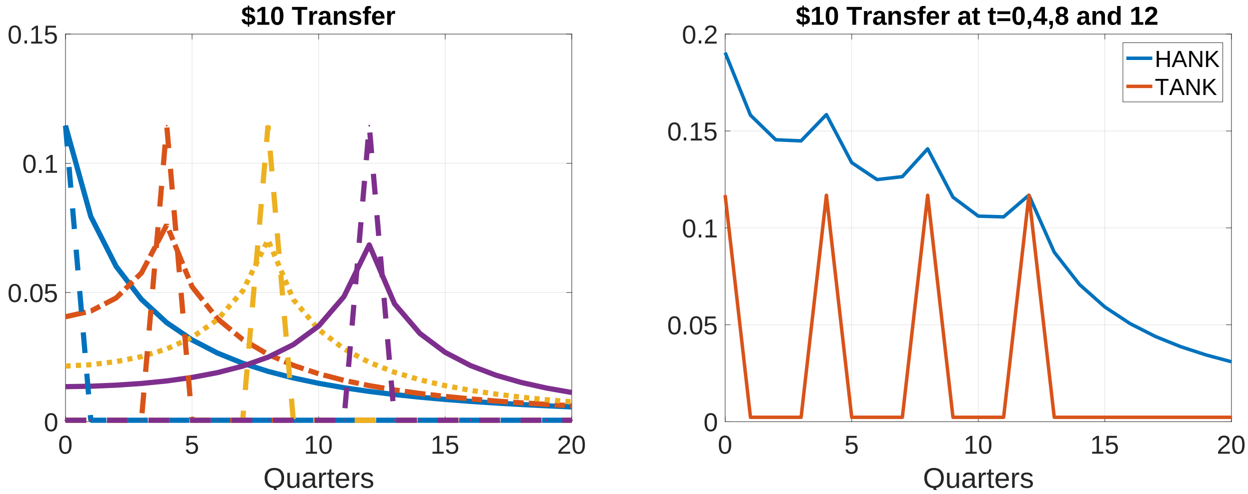


Figure A-1: Propensity to Consume for Transfers of Size $\$10$, $\$100$ $\$1,000$ and $\$10,000$.

Consider first the experiment of giving a household \$10 today. A permanent income household would save basically all of the money and consume a small fraction. In our model households face idiosyncratic income risk, inducing a desire to smooth income but also credit constraints, preventing perfect smoothing. A borrowing constrained household would con-



(a) Propensity to Consume for Transfers of Size \$10 that are Received in Periods 0, 4, 8 OR 12.

(b) Propensity to Consume for Transfers of Size \$10 that are Received in Periods 0, 4, 8 AND 12.

Figure A-2: HANK vs TANK

sume the full \$10. Unconstrained, but low asset households will also consume a large fraction of the transfer because it relaxes precautionary savings motives. These arguments together imply an initial MPC significantly larger than in complete markets models. The fraction of the transfers not spent in the initial period is spent in the following periods at a decaying rate. If households receive larger transfers, the initial MPC falls, mainly because larger transfers are more likely to relax the credit constraints. For example, a \$10,000 transfer is sufficient to relax all households' credit constraints, so that even the borrowing constrained household will not consume the full transfer. Now, suppose households do not receive the transfer today but only learn today that they will receive a transfer in a future period, at date 4, 8, or 12. The credit constrained households cannot respond until the transfer arrives. The unconstrained households are able to smooth consumption, but their MPC is lower, so the initial rise in consumption is smaller than before.

These model properties are consistent with the data but inconsistent with a complete markets RANK model.[24] They are also inconsistent with a TANK model which deviates from the RANK model by introducing two types of agents – a permanent income household and a hand-to-mouth household. The TANK model can match high MPCs and is theoretically tractable. However, as shown in Panel (a) of Figure A-2, when we replicate the same experiment in a TANK model, instead of tent-shaped impulse responses we obtain in our HANK model, the TANK model delivers spiky responses. The TANK model also misses out on the sensitivity to the size of the transfer and all of the dynamic anticipation and propagation effects because the response of permanent income households is minimal and consumption

[24] For a discussion on the empirical evidence on intertemporal MPCs see Auclert et al. (2018).

of hand-to-mouth households responds to current income only. To understand why this is important we need to think about how the general equilibrium Keynesian cross multiplier logic works.

As we saw, if a household receives a transfer in the first period, it is spent over all future periods. In general equilibrium, that would mean an increase in aggregate demand and also in income not only today but also in all future periods. Consumption today increases not only because of the increase in income today but also because of the increases in future income by relaxing precautionary savings motives. To illustrate this point we now combine the four previous experiments, so that households learn in period 0 that they will receive a transfer at *all* dates 0, 4, 8 and 12. Panel (b) of Figure A-2 shows that now the impact response of consumption is nearly twice as high, even though in period 0 the same transfer is received. This is a partial equilibrium example, but in general equilibrium the demand and income increases at different times reinforce each other, generating what Auclert et al. (2018) have coined as an intertemporal keynesian cross. The TANK economy fails to reproduce the dynamic multiplier path because the anticipation and propagation effects in that model are basically zero.

II Derivations

II.1 Derivation Pricing Equation

The firm's pricing problem is

$$V_t\left(p_{jt-1}\right) \equiv \max_{p_{jt}} \frac{p_{jt}}{P_t} y\left(p_{jt}; P_t, Y_t\right) - \Xi_t(Y_{jt}) - \frac{\theta}{2}\left(\frac{p_{jt}}{p_{jt-1}} - (1+\pi_{ss})\right)^2 Y_t + \frac{1}{1+r_t} V_{t+1}\left(p_{jt}\right),$$

subject to the constraints $y_{jt} = Z_t K_{jt}^{\alpha} H_{jt}^{1-\alpha}$ and $y(p_{jt}; P_t, Y_t) = \left(\frac{p_{jt}}{P_t}\right)^{-\epsilon} Y_t$.
Equivalently,

$$V_t\left(p_{jt-1}\right) \equiv \max_{p_{jt}} \frac{p_{jt}}{P_t}\left(\frac{p_{jt}}{P_t}\right)^{-\epsilon} Y_t - \Xi_t(Y_{jt}) - \frac{\theta}{2}\left(\frac{p_{jt}}{p_{jt-1}} - (1+\pi_{ss})\right)^2 Y_t + \frac{1}{1+r_t} V_{t+1}\left(p_{jt}\right).$$

The FOC w.r.t p_{jt} is

$$(1-\epsilon)\left(\frac{p_{jt}}{P_t}\right)^{-\epsilon} \frac{Y_t}{P_t} + \epsilon mc_{jt} - \theta\left(\frac{p_{jt}}{p_{jt-1}} - (1+\pi_{ss})\right)\frac{Y_t}{p_{jt-1}} + \frac{1}{1+r_t} V'_{t+1}(p_{jt}) = 0 \qquad \text{(A1)}$$

and the envelope condition is

$$V'_{t+1} \quad = \quad \theta \left(\frac{p_{jt+1}}{p_{jt}} - (1+\pi_{ss}) \right) \frac{p_{jt+1}}{p_{jt}} \frac{Y_{t+1}}{p_{jt}}. \tag{A2}$$

Combining the FOC and and the envelope condition,

$$\begin{aligned} & (1-\epsilon) \left(\frac{p_{jt}}{P_t} \right)^{-\epsilon} \frac{Y_t}{P_t} + \epsilon mc_{jt} \\ - \quad & \theta \left(\frac{p_{jt}}{p_{jt-1}} - (1+\pi_{ss}) \right) \frac{Y_t}{p_{jt-1}} + \frac{1}{1+r_t} \theta \left(\frac{p_{jt+1}}{p_{jt}} - (1+\pi_{ss}) \right) \frac{p_{jt+1}}{p_{jt}} \frac{Y_{t+1}}{p_{jt}} = 0. \end{aligned} \tag{A3}$$

Using that all firms choose the same price in equilibrium,

$$(1-\epsilon) + \epsilon mc_t - \theta \left(\pi_t - (1+\pi_{ss}) \right) \pi_t + \frac{1}{1+r_t} \theta \left(\pi_{t+1} (1+\pi_{ss}) \right) \pi_{t+1} \frac{Y_{t+1}}{Y_t} = 0. \tag{A4}$$

II.2 Derivation Wage Equation

$$\Theta \left(s_{it}, W_{it}, W_{it-1}; Y_t \right) = s_{it} \frac{\theta_w}{2} \left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - (1+\pi^w_{ss}) \right)^2 H_t.$$

The middleman's wage setting problem is to maximize

$$\begin{aligned} & V^w_t \left(\hat{W}_{t-1} \right) \\ \equiv \quad & \max_{\hat{W}_t} \int \left(\frac{s_{it}(1-\tau_t)\hat{W}_t}{P_t} h(\hat{W}_t; W_t, H_t) - \frac{v(h(\hat{W}_t; W_t, H_t))}{u'(C_t)} di - \int s_{it} \frac{\theta_w}{2} \left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - (1+\pi^w_{ss}) \right)^2 H_t di \right. \\ + \quad & \frac{1}{1+r_t} V^w_{t+1} \left(\hat{W}_t \right), \end{aligned} \tag{A5}$$

where $h_{it} = h(W_{it}; W_t, H_t) = \left(\frac{W_{it}}{W_t} \right)^{-\epsilon_w} H_t$.

The FOC w.r.t $\hat{W}_t$ is

$$\begin{aligned} (1-\tau_t)(1-\epsilon_w) \left(\frac{\hat{W}_t}{W_t} \right)^{-\epsilon_w} \frac{H_t}{P_t} + \epsilon_w \frac{v'(h(\hat{W}_t; W_t, H_t))}{u'(C_t)} \left(\frac{\hat{W}_t}{W_t} \right)^{-\epsilon_w - 1} \frac{H_t}{W_t} \\ -\theta_w \left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - (1+\pi^w_{ss}) \right) \frac{H_t}{\hat{W}_{t-1}} + \frac{1}{1+r_t} V'_{t+1}(\hat{W}_t) = 0 \end{aligned} \tag{A6}$$

and the envelope condition is

$$V'_{t+1} = \theta_w \left(\frac{\hat{W}_{t+1}}{\hat{W}_t} - (1+\pi^w_{ss}) \right) \frac{\hat{W}_{t+1}}{\hat{W}_t} \frac{H_{t+1}}{\hat{W}_t}, \tag{A7}$$

where we have used that $\int s = 1$.

Combining the FOC and the envelope condition,

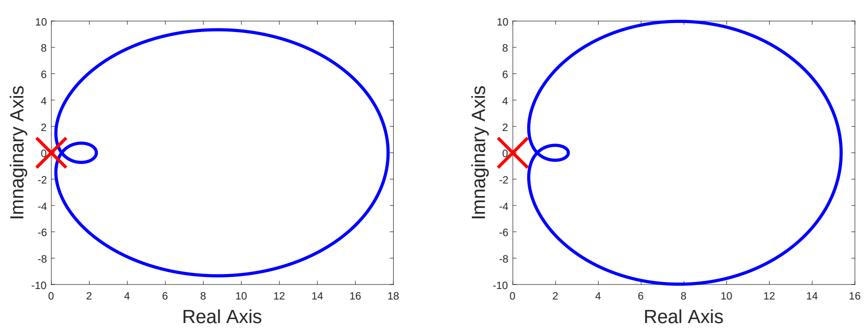
$$\begin{aligned} & (1-\tau_t)(1-\epsilon_w) \left(\frac{\hat{W}_t}{W_t} \right)^{-\epsilon_w} \frac{H_t}{P_t} + \epsilon_w \frac{v'(h(\hat{W}_t; W_t, H_t))}{u'(C_t)} \left(\frac{\hat{W}_t}{W_t} \right)^{-\epsilon_w - 1} \frac{H_t}{W_t} \\ - & \theta_w \left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - (1+\pi^w_{ss}) \right) \frac{H_t}{\hat{W}_{t-1}} + \frac{1}{1+r_t} \theta_w \left(\frac{\hat{W}_{t+1}}{\hat{W}_t} - (1+\pi^w_{ss}) \right) \frac{\hat{W}_{t+1}}{\hat{W}_t} \frac{H_{t+1}}{\hat{W}_t} = 0 \end{aligned} \tag{A8}$$

Using that $\hat{W}_t = W_t$, $1 + \pi^w_t = \frac{W_t}{W_{t-1}} = \frac{\hat{W}_t}{\hat{W}_{t-1}}$ and $h_{it} = H_t$:

$$\begin{aligned} & (1-\tau_t)(1-\epsilon_w) \frac{W_t}{P_t} + \epsilon_w \frac{v'(h(\hat{W}_t; W_t, H_t))}{u'(C_t)} \\ - & \theta_w \left(\pi^w_t - \pi^w_{ss} \right)) \pi^w_t + \frac{1}{1+r_t} \theta_w \left(\pi^w_{t+1} - \pi^w_{ss} \right)) \pi^w_{t+1} \frac{H_{t+1}}{H_t} = 0. \end{aligned} \tag{A9}$$

III Figures: Local Determinacy

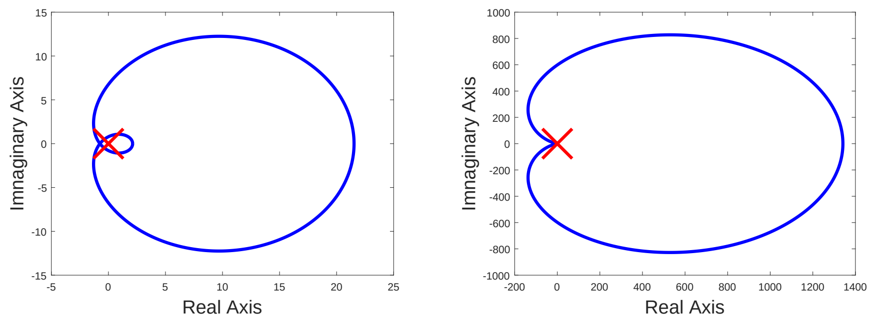
III.1 Onatski Plots: Real Bonds and $\mathbf{i_t = 1.5\pi_t}$



(a) No Capital: determinate (b) With Capital: determinate

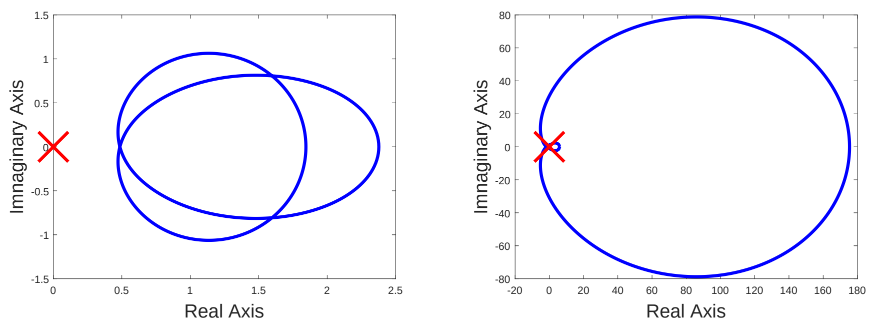
Note - The two figures plot the Onatski function for the economy with real bonds and an interest rate rule $i_t = 1.5\pi_t$. The red cross indicates the $(0,0)$ point which in both figures is located outside the Onatski function, showing determinacy. Panel (a) is for the economy without capital. Panel (b) is for the economy with capital.

Figure A-3: Onatski Function: Inflation Targeting: $i_t = 1.5\pi_t$



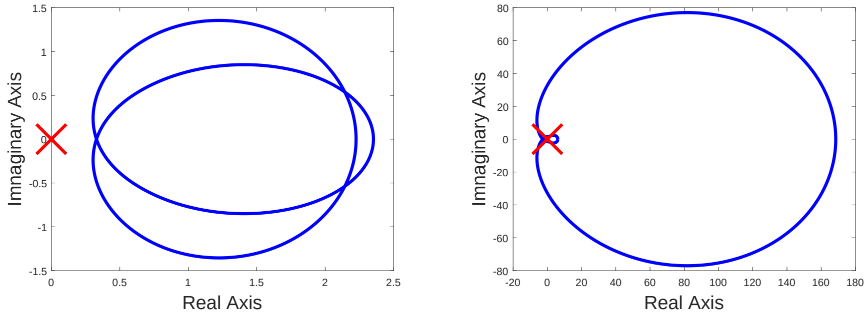
(a) No Capital: indeterminate (b) With Capital: indeterminate

Figure A-4: Onatski Function: $i_t = 1.5\pi_t$, Flexible Wages, Sticky Prices



(a) No Capital: determinate (b) With Capital: indeterminate

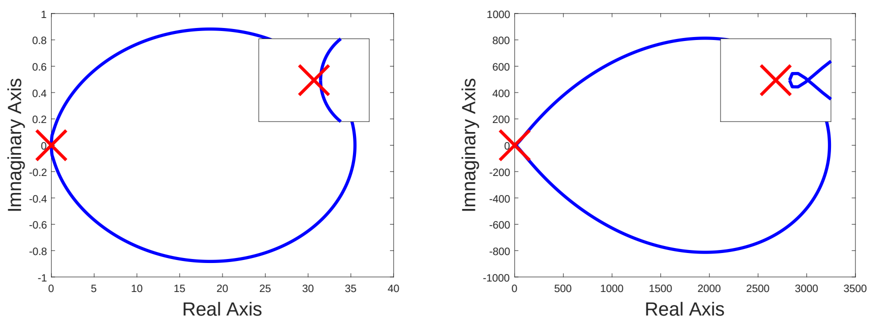
Figure A-5: Onatski Function: $i_t = 1.5\pi_t$, Sticky Wages, Less Sticky Prices



(a) No Capital: determinate (b) With Capital: indeterminate

Figure A-6: Onatski Function: $i_t = 1.5\pi_t$, Flexible Wages, Less Sticky Prices

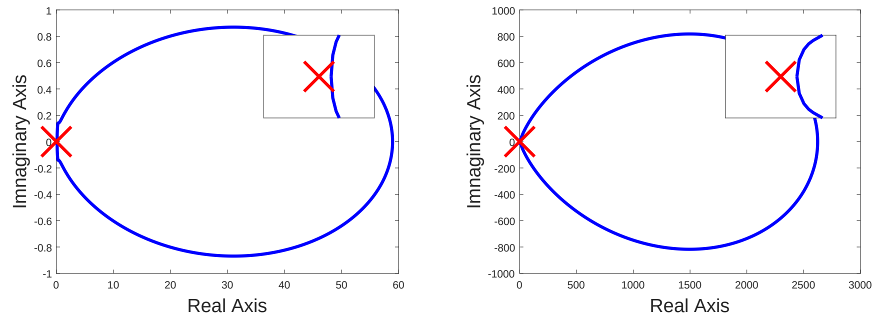
III.2 Onatski Plots: Nominal Bonds and $\mathbf{i_t = \bar{i}}$



(a) No Capital: determinate (b) With Capital: determinate

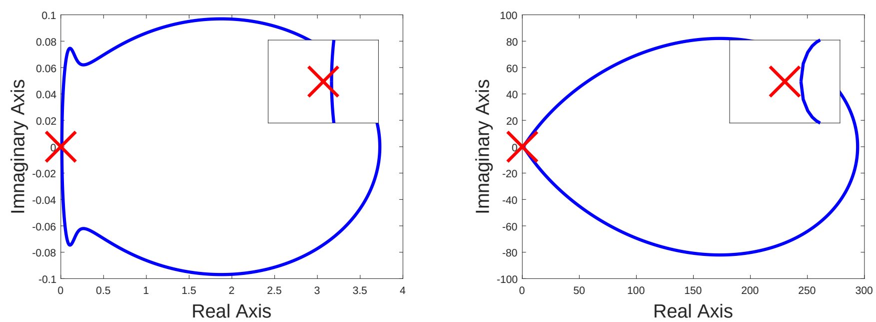
Note - The two figures plot the Onatski function and the red cross indicates the $(0, 0)$ point which in both figures is located outside the Onatski function, showing determinacy. Both panels are for economies with nominal bonds and a constant nominal interest rate. Panel (a) no capital. Panel (b) with capital.

Figure A-7: Onatski Function: Nominal Bond and Constant Interest Rate



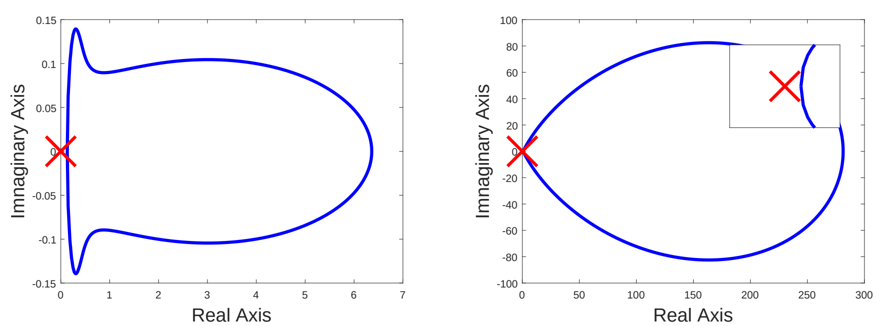
(a) No Capital: determinate (b) With Capital: determinate

Figure A-8: Onatski Function: $i_t = \bar{i}$, Flexible Wages, Sticky Prices



(a) No Capital: determinate (b) With Capital: determinate

Figure A-9: Onatski Function: $i_t = \bar{i}$, Sticky Wages, Less Sticky Prices

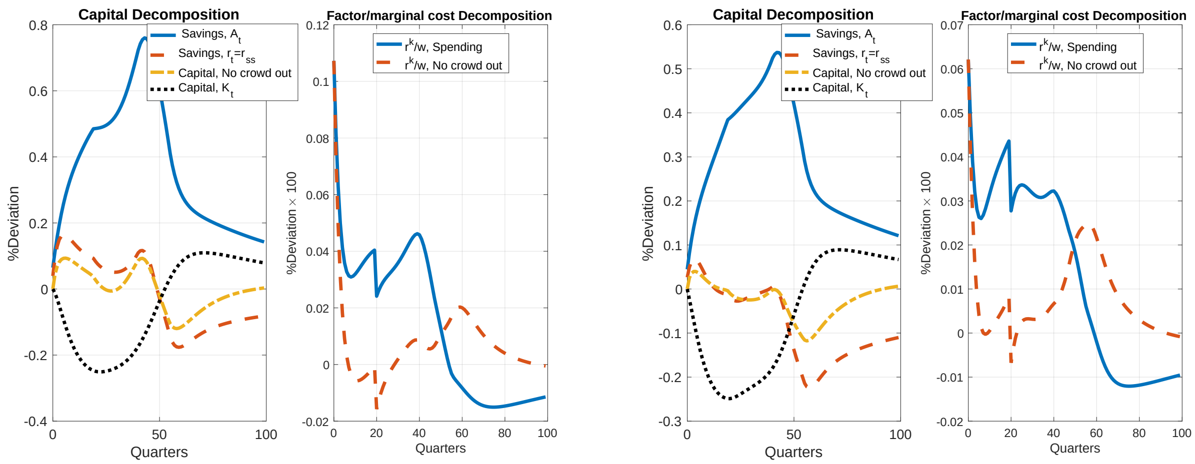


(a) No Capital: determinate (b) With Capital: determinate

Figure A-10: Onatski Function: $i_t = \bar{i}$, Flexible Wages, Less Sticky Prices

IV Aggregate Investment with Deficit Financing: Inflation or Price Level Targeting

Figure A-11: Aggregate Investment, Deficit Financing



(a) Inflation Targeting

(b) Price Level Targeting

V Fiscal Multiplier in a Liquidity Trap: Figures

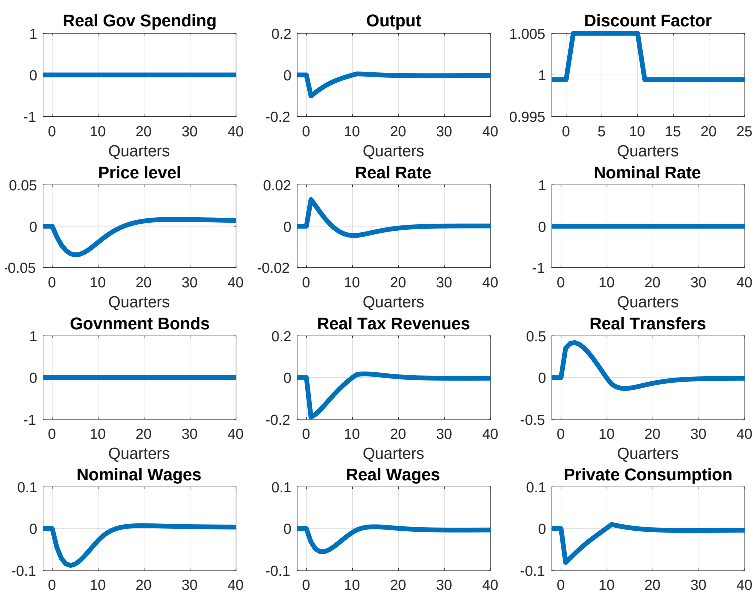
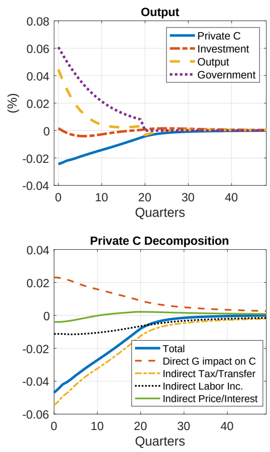
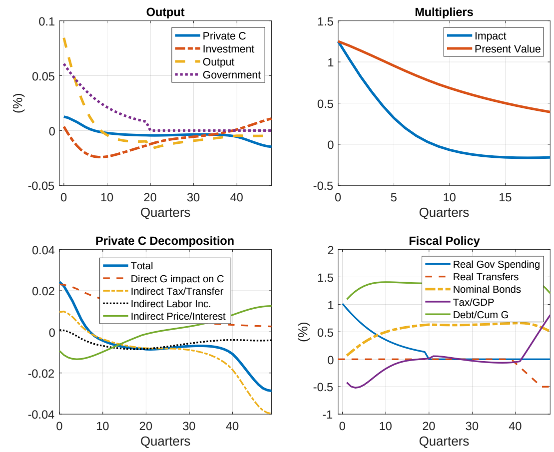


Figure A-12: Economy in a Liquidity Trap



(a) Spending Multiplier (Tax Financed)



(b) Spending Multiplier (Deficit Financed)

Figure A-13: Fiscal Multipliers in a Liquidity Trap

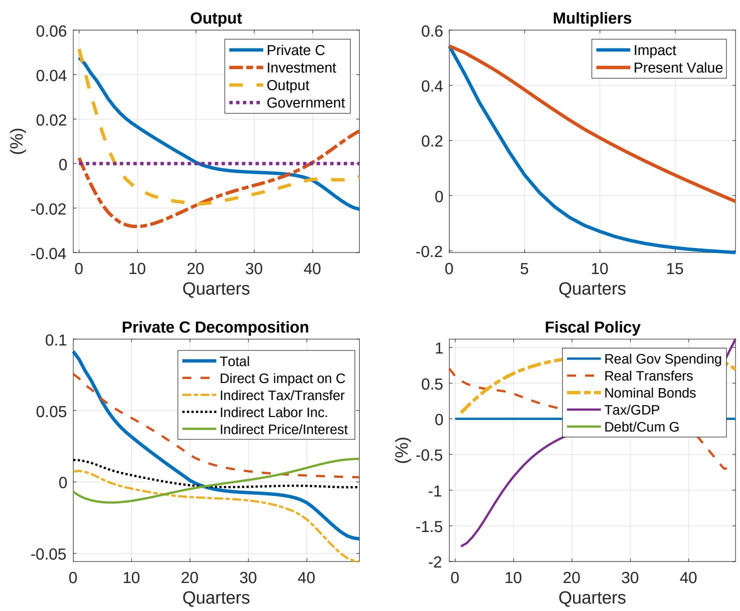


Figure A-14: Transfer Multiplier in a Liquidity Trap (Deficit Financed)

V.1 The Degree of Price and Wage Rigidities

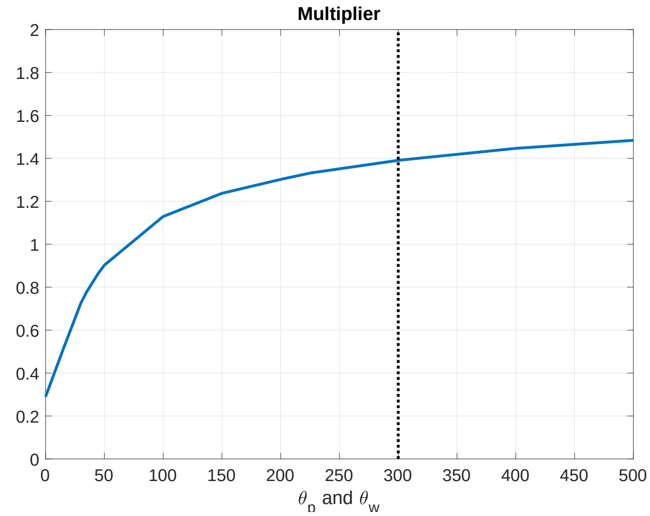


Figure A-15: Liquidity Trap and Degree of Rigidities $\theta_p = \theta_w$: Spending Multiplier at $t = 0$.

VI Further Analysis

In this Appendix we first define and describe the transfer multiplier that measures the responce of output to an increase in transfers rather than government spending. Next, we assess how the size of the fiscal multiplier depends on the timing of spending ("forward spending"), on the scale of spending and on the persistence of the stimulus in Appendices VI.2, VI.3 and VI.4. In Appendix VI.5 we assess the consequences of cutting government spending G instead of transfers to pay back the debt.

VI.1 Transfer Multiplier

In this appendix we consider the multiplier in response to a one percent increase in government *transfers*, again for 20 periods and with persistence $\rho_T = 0.9$. We assume that nominal government spending adjusts to keep real government spending constant in response to the innovation in transfers. We allow the government to deficit-finance the increase in transfers following the same financing scheme as was used to finance an incgease in G in the main text by first increasing government debt, then by decreasing transfers starting 40 quarters later to pay back the debt.

The impulse responses plotted in Figure A-16 are qualitatively and quantitatively similar to the impulse responses to a deficit-financed increase in government spending. Private consumption rises more, however, when transfers increase than when spending increases.

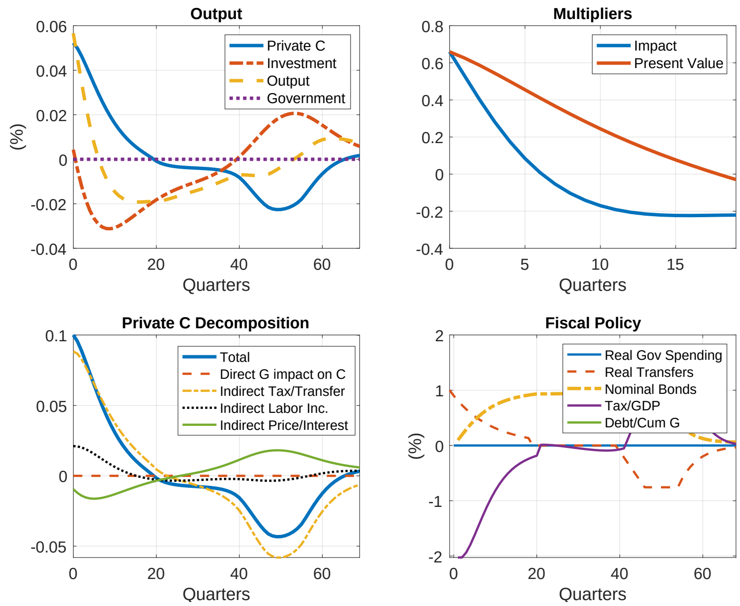


Figure A-16: Transfer Multipliers (Deficit Financed)

This is because an increase in transfers benefits low income, high MPC households since their disposable income increases more (in percentage terms) than that of high income, low MPC households. This implies an impact multiplier of 0.66 using the definition of m_0^{IM} (Eq. 61) but with G replaced by T. Aggregate consumption, the sum of private and government consumption, however, increases less when transfers increase than when spending increases, simply because government spending is unchanged in the former case. As a result, income increases by more in the latter case, implying higher savings and investment such that the output increase is larger.

The cumulative multiplier is now defined as

$$\overline{M} = m_\infty^{PV} = \frac{\sum_{t=0}^{\infty} \tilde{\beta}^t (\frac{Y_t}{Y_{ss}} - 1)}{\sum_{t=0}^{19} \tilde{\beta}^t (\frac{T_t P_{ss}}{P_t T_{ss}} - 1)} \frac{Y_{ss}}{T_{ss}/P_{ss}}, \tag{A10}$$

where in the denominator we sum only over the first 20 periods since summing to infinity would take the repayment period into account and thus would render the denominator equal or close to zero.[25] The cumulative multiplier ends up being quite small around 0.1 because the future decrease in transfers needed to return nominal government debt to its steady state level is sufficiently contractionary to almost offset the contemporaneous gains. Increasing transfers is purely redistributional and thus has no direct effects in the RANK model.

[25]Note that all the quantitative results for the cumulative multiplier reported in the paper (except those in Appendix VI.5 as explained there) would not be affected if this definition was used because G in those experiments reverts back to its steady-state value from period 20 onward.

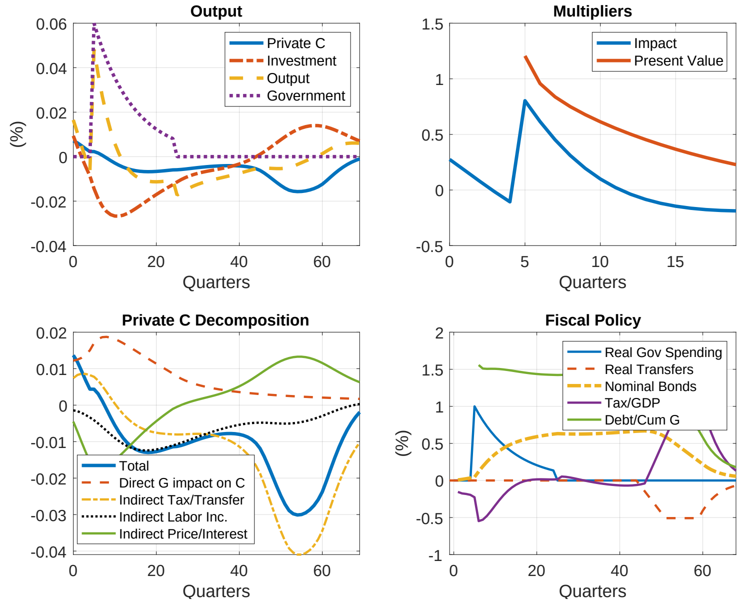
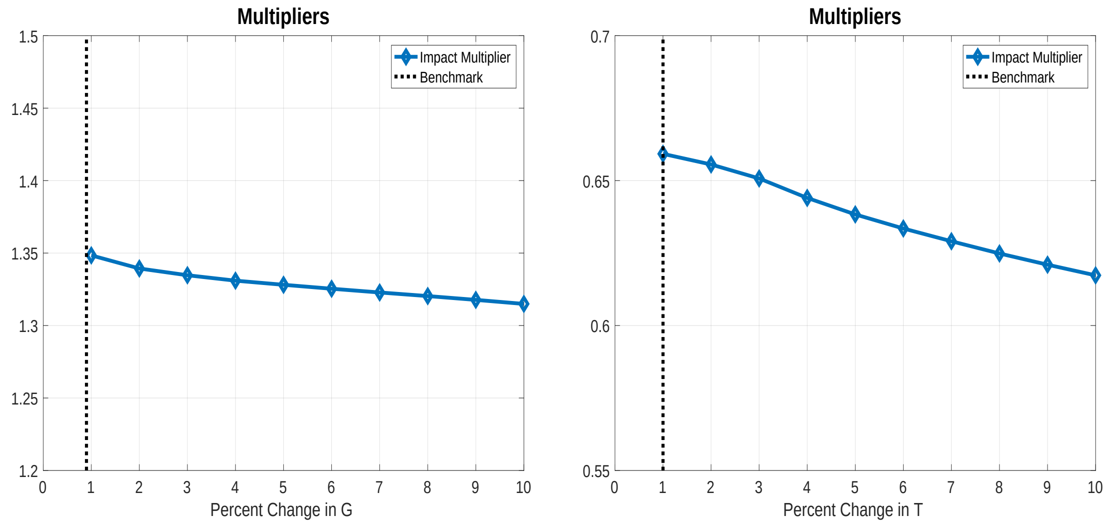


Figure A-17: Future (4 Quarters Ahead) Spending: Deficit Financing

VI.2 Forward Spending

Farhi and Werning (2016) show that in complete markets New Keynesian models the further the pre-announced spending is in the future the larger is the impact today, suggesting that "forward-spending" is an effective fiscal policy tool. In contrast, our analysis implies that the multiplier becomes smaller if the spending is pre-announced to occur at a future date. For concreteness, in Figure A-17 we assess the effects of stimulus pre-announced to occur 4 quarters ahead (the corresponding impulse responses are plotted in Figure A-25). The additional spending is deficit financed. The price level now increases gradually in anticipation of the future increase in government spending implying that initially output and consumption fall before increasing at the time of the spending increase 4 quarters in the future. However, the initial drop in output makes households shift consumption to these earlier periods which dampens the fall in consumption initially but at the same time lowers their demand at the time of the actual spending increase in quarter 4. As a result, the increase in consumption as well as the multiplier at that time are smaller than the corresponding multiplier in the case when the stimulus occurs immediately and is deficit financed. The investment response is, however, larger since debt only starts to increase when spending actually happens, implying that there is no crowding out and thus higher investment in the first periods with future spending. Note that we start the definition of the cumulative multiplier in the first period of the spending, since the increase in spending up until that point is zero, so the cumulative multiplier is undefined.



(a) Scale of Spending (b) Scale of Transfers

Figure A-18: Multiplier as a Function of Scale of Spending/Transfers (Deficit Financing)

VI.3 Scale Effects

We now assess the dependence of the size of the multiplier on the scale of the government spending or transfer stimulus. Panel (a) of Figure A-18 shows the government spending multiplier for one percent intervals between 1% and 10% increase. Panel (b) of Figure A-18 shows the same for the transfer multiplier again for one percent intervals between 1% and 10% increases.

The fall in the multiplier as we increase the scale of spending or transfers is expected in light of our results in Figure A-1 in Appendix I. Those partial equilibrium experiments showed that the propensity to consume falls in the size of the transfer households receive, implying that a larger scale of spending or transfer leads to lower MPCs. The Keynesian cross logic implies that in equilibrium these lower MPCs translate into a lower multiplier. Thus, one should be cautious about proposals that for government spending to be effective it has to be large. Interpreting higher effectiveness as a higher multiplier, we find that scaling up the stimulus decreases its effectiveness.

VI.4 More Persistent Spending

In this appendix we study how the persistence of government spending affects the multipliers. As before, we consider a persistent increase in nominal government consumption by one percent that decays over the subsequent 19 quarters at varying rates of $1 - \rho_g$, $\rho_g \in [0, 1]$, per quarter and then reverts to its steady-state level. Thus, if $\rho_g = 0$, stimulus is purely

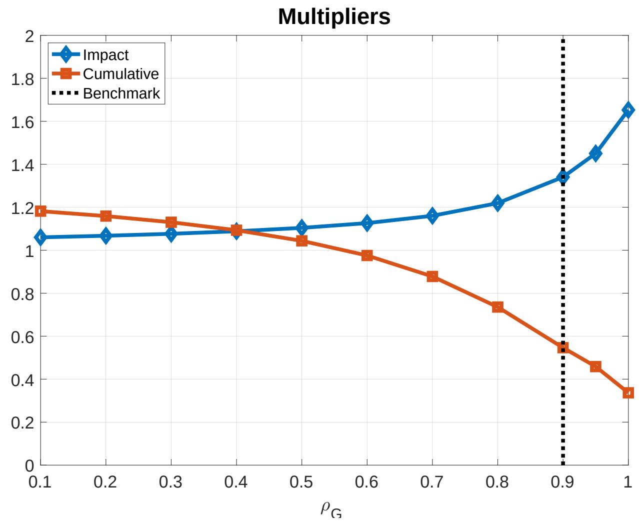


Figure A-19: Multipliers: Persistence ρ_G of Spending

transitory and takes place in one period only, while if $\rho_g = 1$, nominal government spending is increased by the same amount for all 20 quarters. Regardless of the persistence of spending, the policy is deficit financed according to the same scheme as before with repayment starting 40 quarters after the initial increase in spending.

Figure A-19 shows the impact and the cumulative multiplier for various degrees of persistence. As our analysis of household demand in Appendix I suggests, the impact multiplier m_0^{IM} is increasing in ρ_G. A higher persistence means higher government spending and thus higher income in future periods. This relaxes households' precautionary savings motives and increases their period 0 consumption demand, implying a higher initial multiplier, m_0^{IM}. When the spending becomes temporary, $\rho_G \to 0$, these dynamic interactions are minimized and the multiplier approaches 1. The dynamic effects are maximized when the spending becomes almost permanent, $\rho_G \to 1$, and the multiplier reaches 1.65. Note, however, that the cumulative multiplier moves in the opposite direction as the persistence of spending increases. As the spending becomes almost permanent, the cumulative multiplier falls significantly to a value of less than 0.4. This finding of a decreasing cumulative multiplier is a combination of the two previous results. First, our analysis in Appendices I and VI.3 shows that the multiplier is falling in the scale of government spending. As a higher ρ_G translates into a larger increase in total government spending, the multiplier decreases. Second, a higher ρ_G means more spending in future periods while spending in the initial period is unchanged. As Appendix VI.2 shows, future spending is less effective than current spending, making the multiplier smaller again. This effect is reinforced here since a spending increase in, say, period 20 is already paid back starting in period 40. That is the repayment starts 20 periods after the stimulus whereas it starts 40 periods after the stimulus in the benchmark and in

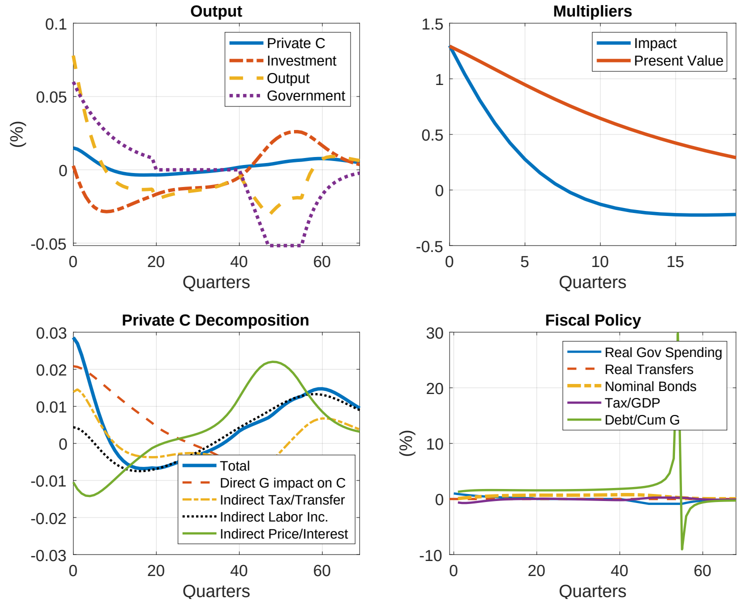


Figure A-20: Spending Multipliers (Deficit Repaid Using G)

Appendix VI.2. Since an earlier repayment is more contractionary, the multiplier falls.

The opposing movements in the impact and cumulative multipliers in responce to a change in the persistence of spending reveals the intertemporal trade-off of a stimulus: potentially large initial gains come with potentially larger cost later on. This trade-off is absent from the standard Keynesian cross logic but it is present and can be measured in our dynamic model.

VI.5 Repayment through G

In this appendix we consider the multiplier in the deficit-financed case, but instead of cutting transfers in order to bring nominal debt back to its steady-state value, we instead cut government spending G following the same scheme that was previously used for transfers.

The results of this experiment are plotted in Figure A-20. They are qualitatively and quantitatively similar to those obtained in Section 4.6 in the main text for when the deficit-financed increase in government spending is paid back by eventually cutting transfers. Output rises more, however, when spending is used to repay the debt than when transfers are used. The reason is that repayment through G or T has different distributional consequences. A reduction in G reduces labor income and thus hurts workers proportionally to their productivity whereas a reduction in transfers hurts workers independently of their productivity. Since high productivity workers have high income and low MPCs while low productivity workers have low income and high MPCs, a reduction in T hurts high MPC households more than a reduction in G does. At the time when the repayment starts, these arguments imply that consumption is higher with repayment through G than through T. The flip side is that the low MPC households are the savers and fewer resources in their hands means a fall in savings and investment at the time when repayment through G instead of T starts. Since a reduction in G reduces aggregate demand one-for-one, the negative output effect is much larger when repayment is through G. The differences between the two financing schemes at the time of repayment feed back into earlier periods. The same arguments explain why consumption is again higher but investment is again lower with repayment through G. Combining the effects on consumption and investment leads to a slightly smaller impact multiplier when the repayment is through G. Note that in order to repay the fiscal stimulus requires a cumulative cut in G greater than the cumulative increase, explaining why debt divided by cumulative G eventually turns negative. Figure A-26 shows the impulse responses.

Analogously to transfer multipliers, the cumulative multiplier is defined as

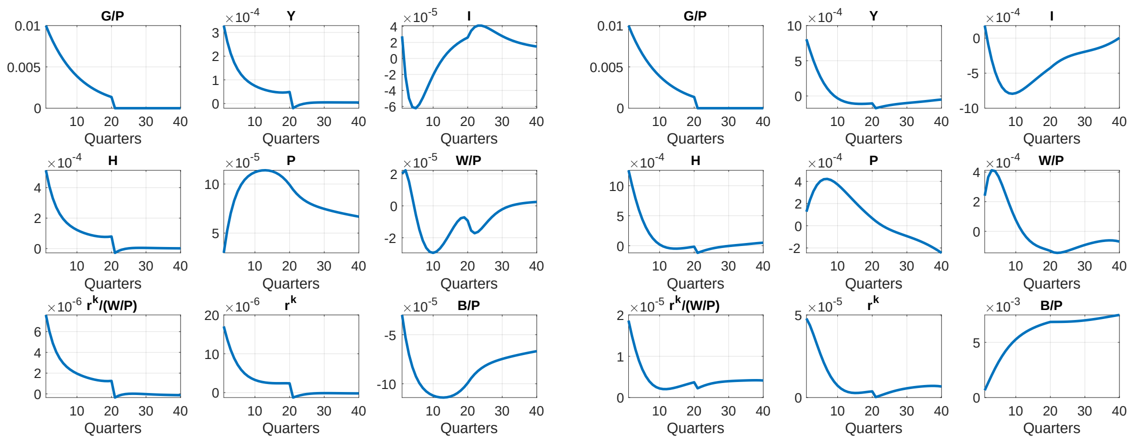
$$\overline{M} = m_{\infty}^{PV} = \frac{\sum_{t=0}^{\infty} \tilde{\beta}^t (\frac{Y_t}{Y_{ss}} - 1)}{\sum_{t=0}^{19} \tilde{\beta}^t (\frac{G_t P_{ss}}{P_t G_{ss}} - 1)} \frac{Y_{ss}}{G_{ss}/P_{ss}}. \tag{A11}$$

where in the denominator we again sum only over the first 20 periods. The larger output drop at the time of repayment explains why the cumulative multiplier is negative -0.15 when repayment is through G while it is positive for repayment through T.

VII Impulse Response Figures

VII.1 Impulse Responses: Constant Nominal Rate

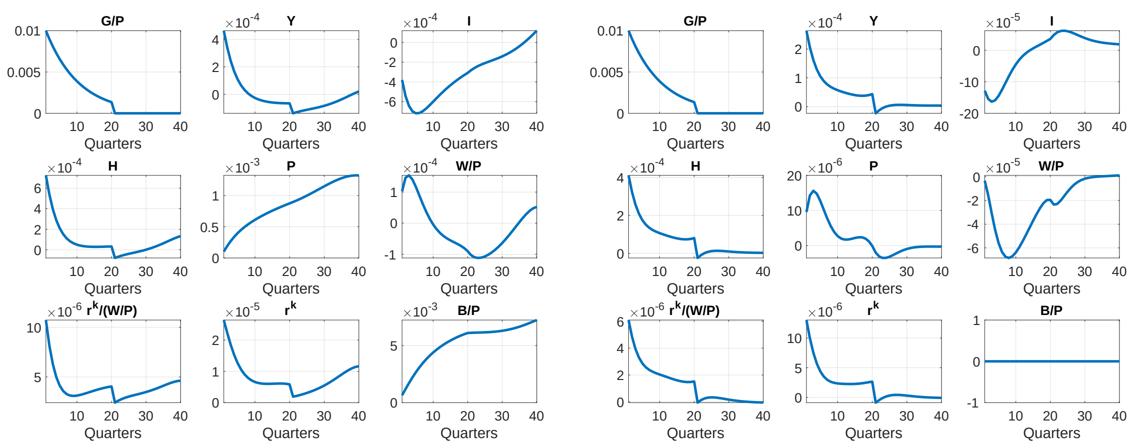
Figure A-21: Impulse Response to a 1% Increase in Nominal Government Spending. (Constant Nominal rate).



(a) **Tax Financing** (b) **Deficit Financing**

VII.2 Impulse Responses: Inflation Targeting

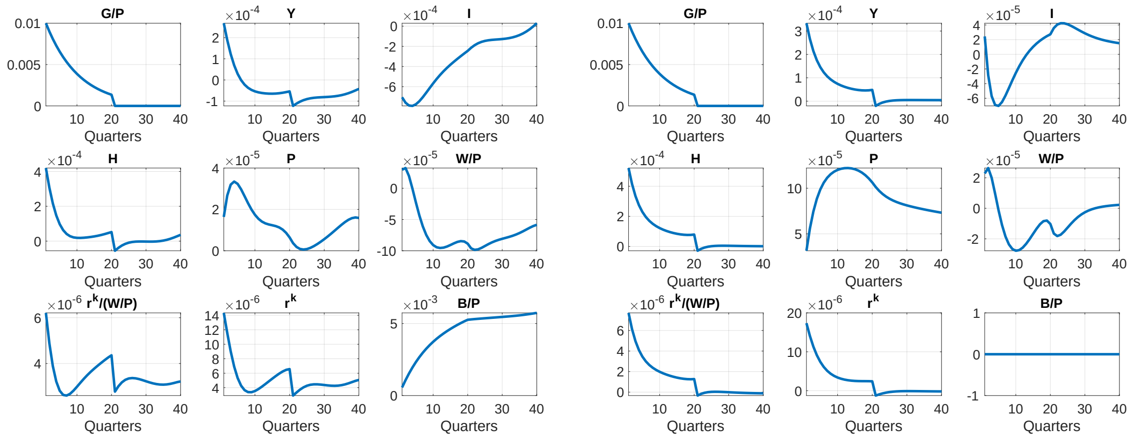
Figure A-22: Impulse Response to a 1% Increase in Nominal Government Spending. (π-Targeting).



(a) **Tax Financing** (b) **Deficit Financing**

VII.3 Impulse Responses: Price Level Targeting

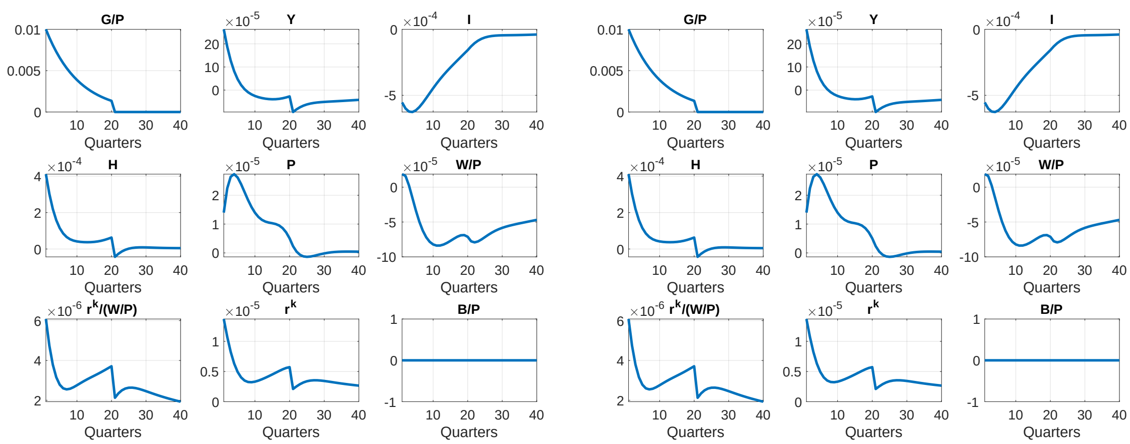
Figure A-23: Impulse Response to a 1% Increase in Nominal Government Spending. (P-Targeting).



(a) **Tax Financing** (b) **Deficit Financing**

VII.4 Impulse Responses: Complete Markets

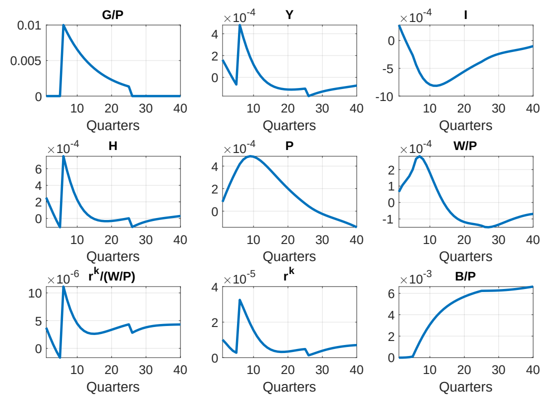
Figure A-24: Impulse Response to a 1% Increase in Nominal Government Spending. **Complete Markets: Inflation Targeting**.



(a) **Tax Financing** (b) **Deficit Financing**

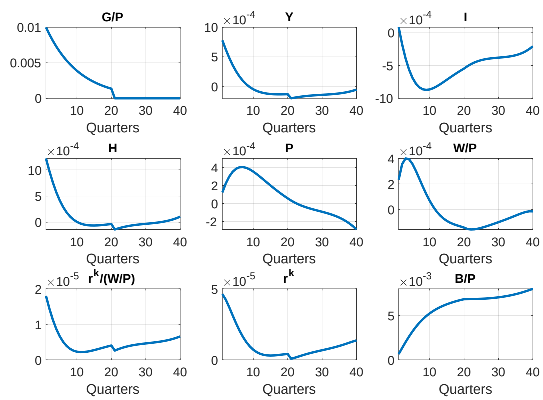
VII.5 Impulse Responses: Forward Spending

Figure A-25: Impulse Response to a *Future* (4 Quarters Ahead) 1% Increase in Nominal Government Spending. **Deficit Financing**.



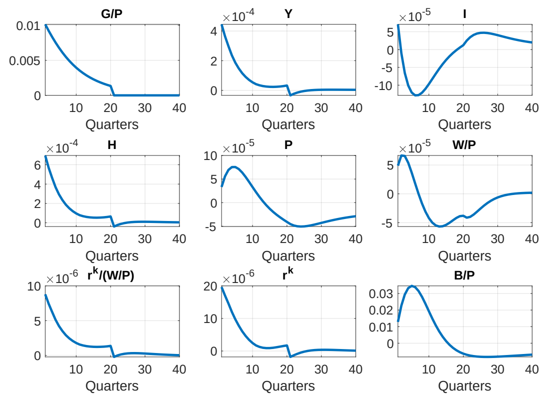
VII.6 Impulse Responses: Deficit Repaid using G

Figure A-26: Impulse Response to a 1% Increase in Nominal Government Spending. **Deficit Financing, Deficit Repaid using** G.

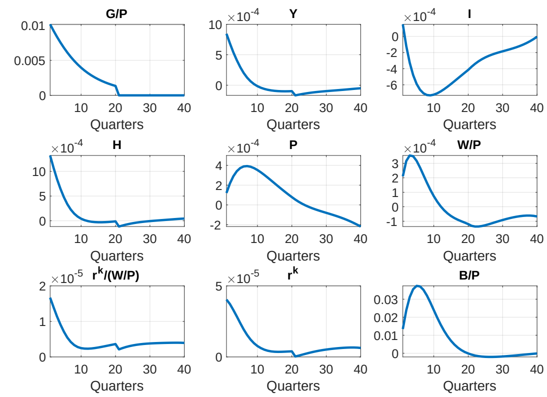


VII.7 Impulse Responses: Liquidity Trap

Figure A-27: Impulse Response to a 1% Increase in Nominal Government Spending. **Liquidity Trap**.



(a) **Tax Financing, Constant Nominal Debt**



(b) **Deficit Financing**

Figure A-28: Impulse Response to a 1% Increase in Nominal Government *Transfers*. **Liquidity Trap, Deficit Financing**.