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Workers, capitalists, and the government: fiscal policy and income (re)distribution

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Abstract

This paper develops a tractable capitalist-worker New Keynesian model to study the interaction of fiscal policy and household heterogeneity. Workers can save in bonds subject to portfolio adjustment costs; firm ownership is concentrated among capitalists who do not supply labor. The model matches empirical intertemporal marginal propensities to consume that shape the private sector's dynamic response to policy interventions, it avoids implausible profit income effects on labor supply and the solution has robust stability properties. This setup delivers both more pronounced redistributive and more muted aggregate effects of fiscal stimulus relative to the traditional two-agent model.

Key words: Business cycles, determinacy, government spending shocks, fiscal policy, New Keynesian, labor share, redistribution.

JEL classification: C52, E12, E25, E32, E62.

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1 Introduction

Macroeconomic models with household heterogeneity produce aggregate dynamics that can significantly diverge from those implied by their representative-agent counterparts. Heterogeneous-agent New Keynesian (HANK) models, in particular, combine nominal rigidities with a Bewley-İmrohoroğlu-Huggett-Aiyagari type incomplete markets environment and aggregate uncertainty. As they require keeping track of the entire distribution of households across idiosyncratic states, their development has been accompanied by a renewed interest in the ability of tractable models to capture some of the fundamental properties of heterogeneous-agent models (e.g., Debortoli and Galí (2018)).

We contribute to that literature by showing how the prototypical two-agent New Keynesian (TANK) model introduced by Galí *et al.* (2007) and Bilbiie (2008) can be extended to match the implications of HANK models better in terms of both consistency with micro data and aggregate implications of fiscal policy. To study heterogeneity in households' intertemporal consumption-savings behavior we model limited asset market participation by allowing one household type, workers, to save in bonds subject to portfolio adjustment costs. The remaining households, capitalists, are unconstrained in this respect and own the economy's firms, but they do not supply labor. This setup gives rise to several attractive properties. The "capitalist-worker two-agent New Keynesian" model matches empirical estimates of intertemporal marginal propensities to consume; it avoids implausible profit income effects on labor supply; and its solution has robust stability properties. In terms of predictions, the model reveals pronounced redistributive effects of fiscal stimulus, as measured by variations in labor's share of total income. These effects are in line with novel empirical evidence and they tend to be more marked than in the traditional TANK model. We next describe each of these points in greater detail.

Considering household consumption behavior first, Auclert *et al.* (2018) and Hagedorn *et al.* (2019) demonstrate that (multi-asset) HANK models are capable of matching dynamic consumption responses to shocks that are in line with micro data in a way that neither the benchmark representative-agent nor the traditional two-agent model can. Using household-level data Auclert *et al.* (2018) show that, in response to an unanticipated increase in income, intertemporal marginal propensities to consume (iMPCs) are, on average, much higher on impact than permanent income considerations would imply, displaying a pattern of gradual decay thereafter.[1] The canonical representative-agent model thus under-predicts the sensitivity of consumption to current income. By introducing a share of hand-to-mouth consumers the prototypical TANK model is able to replicate the high average impact-MPC. But this extreme specification of limited asset market participation makes iMPCs drop sharply thereafter – in contrast to what the evidence suggests. Moreover, the implied heterogeneity in consumption propensities between hand-to-mouth households (for whom the MPC is equal to unity) and unconstrained permanent-income

[1]The matrix of iMPCs is defined as the Jacobian with typical element $\partial c_t/\partial x_s$, interpreted as the response of consumption at date t to an income shock at date s. In simplified HANK models, these iMPCs fully characterize the interaction of the household block with the rest of the economy.

consumers (for whom it is close to zero) is extreme relative to cross-sectional household data.

The first result of this paper is that incorporating portfolio adjustment costs delivers iMPCs that are more consistent with the empirical evidence. We replace hand-to-mouth households in the two-agent setup with intermediately constrained "workers" who likewise solely rely on labor earnings but who can *partially* smooth consumption through borrowing and saving in government bonds. Their behavior resembles that of target-savers. A convex cost function that penalizes workers in case their holdings deviate from some benchmark level (as in Schmitt-Grohe and Uribe (2003) and Neumeyer and Perri (2005)) effectively controls the degree of financial constraints. We show analytically that in a simple partial equilibrium setting the implied consumption dynamics following an income windfall are very close to those found in the data. Workers' consumption is responsive to both past and expected future income shocks, with a declining sensitivity the farther away these are.

Secondly, the introduction of an intermediate degree of asset market participation in form of portfolio adjustment costs gives rise to more robust stability properties compared to the traditional TANK model with hand-to-mouth consumers. Different from the latter setup, it is not necessary to impose an implausible value of the Frisch elasticity of labor supply to guarantee local uniqueness of the rational expectations equilibrium; and the solution remains determinate under an active Taylor rule irrespective of the population share of workers.

Thirdly, even in a two-agent model that features workers alongside unconstrained households, however, the transmission of macroeconomic policies is strongly driven by income effects on labor supply that result from variations in firm profits over the business cycle in the presence of sticky prices. Broer *et al.* (2020) show that in the representative-agent case, output rises in response to a monetary easing only because mark-ups and, hence, total profits fall. This drop in non-labor income triggers a rise in labor supply. They argue that this mechanism is implausible and hard to justify empirically. That same profit income effect on labor supply is more consequential still in the traditional TANK model where limited asset market participation interacts with the labor supply of equity-owning unconstrained households (Bilbiie (2008), also see Bilbiie (2019a,b)). We break this cyclical connection between profits and the labor supply of firm owners by including a "capitalists" type instead of the usual specification of unconstrained households in two-agent models. Capitalists do not participate in the labor market and, consequently, profits no longer directly enter the optimality condition pinning down labor supply. Embedded in an otherwise canonical New Keynesian framework, this characterization of household heterogeneity gives rise to a two-agent model with *C*apitalists (instead of the usual unconstrained households) and *W*orkers (replacing hand-to-mouth consumers), or: "TANK-*CW*." The determinants of both demand and supply of labor in our model differ from those of the prototypical TANK model.

What are the implications of these modeling choices for the transmission and effects of government spending shocks? How does household heterogeneity in income sources interact with fiscal policy?[2] To answer these questions, in a first step we examine the effects of government spending shocks on key macroeconomic variables using vector autoregression tools and the identification approach proposed by Forni and Gambetti (2016). In addition to confirming known features of the data such as the crowding-in of consumption and negative effects on investment, the analysis uncovers previously undocumented redistributive consequences of fiscal stimulus measures: the response of the labor share of income to an unanticipated increase in government purchases is positive, persistent and hump-shaped.

To compare these findings with theoretical predictions and analyze the transmission mechanism as transparently as possible, we start with a bare-bones version of TANK-CW without physical capital, as in Bilbiie (2008). Given our interest in fiscal policy and the interaction between public debt and household consumption choices, we follow Galí *et al.* (2007) in allowing for a public sector and deficit financing. We find that the effects of government spending purchases on output in the capitalist-worker setup tend to be muted relative to the traditional two-agent setup. The primary reasons are twofold. As a result of the empirically realistic pattern of iMPCs, workers' consumption level jumps up less on impact than that of hand-to-mouth consumers. At the same time, even though capitalists' consumption declines following a positive government spending shock due to a rise in real wages, by construction this has no implications for total hours worked. In particular, the drop in profits does not exert an expansionary income effect on labor supply.

If we additionally allow for endogenous capital accumulation and nominal wage rigidity, the consumption response of both workers and capitalists to a government spending shock becomes more positive. Indeed, the model can produce hump-shaped impulse responses to a deficit-financed stimulus for consumption and the labor share without having to introduce frictions such as habits. In line with the data, investment is crowded out, which drags down the output response. In the traditional TANK model, on the other hand, nominal wage stickiness may generate (conditionally) acyclical wages and weakly procyclical investment following a positive government spending shock (e.g., Ascari *et al.* (2017)).

In a final step we use medium-scale versions of the two TANK models to assess the quantitative effects of fiscal stimulus measures. Parameter choices are informed by impulse response matching. We consider variations in the mix of taxes and debt used to finance the additional expenditures by the public sector. The most important findings are, firstly, that fiscal multipliers tend to be lower in TANK-CW than in the TANK model with hand-to-mouth households, but the redistributive effects captured by variations in the labor share are relatively more pronounced. Secondly, aggregate consumption in the benchmark TANK model is highly sensitive to the degree of deficit-financing. This is due to the extreme MPCs of hand-to-mouth households. The model with intermediate portfolio adjustment costs

[2]The case of fiscal policy is of particular interest, as both the predicted effects of policy and the underlying transmission mechanisms tend to differ depending on whether or not household heterogeneity is accounted for. As such, Kaplan and Violante (2018a, p. 182) consider it to be a case of "stark non-equivalence."

implies a relatively smoother response. In these ways, the matching of iMPCs at the micro level has implications for our understanding of fiscal stimulus at the macro level.

Related Literature. Beyond the references cited above, our paper relates to several themes in the economics literature. In the first instance, the role we see for two-agent models is not to 'compete' with HANK models. Instead, they have a different scope of application: TANK models may serve as tractable laboratories to study the aggregate consequences of macroeconomic policy in the presence of household heterogeneity and for approximating distributional effects of such policy at a high level. They are also fast to solve even when a wide range of extensions are added to a baseline specification and, as such, lend themselves to straightforward estimation. Our quantitative exercise is consistent with this perspective.

In view of rich evidence for the importance of household heterogeneity for the aggregate effects of macroeconomic policy, on the one hand, and the complexity of HANK models, on the other hand, there are several other studies exploring the ability of tractable models to mimic properties of heterogeneous-agent models.[3,4] Among these papers, our approach shares particular similarities to studies that introduce bonds in the utility function (Kaplan and Violante (2014, 2018b); Hagedorn (2018a,b); Michaillat and Saez (2019)). We believe the two approaches to be complementary. For instance, the bond-in-utility approach naturally lends itself to the analysis of steady-state properties, whereas adjustment costs are relevant out of steady-state. Meanwhile, our analysis explicitly abstract from another important feature of HANK models: time-varying precautionary savings behavior due to idiosyncratic risk. Challe (2019) and Acharya and Dogra (2020) develop tractable models capturing this mechanism.

As regards the more recent literature on two-agent models, Debortoli and Galí (2018) identify different channels through which household heterogeneity influences aggregate fluctuations and argue that the margin captured by TANK models, that is changes in the average consumption gap between constrained and unconstrained households, is quantitatively the most significant one when evaluating monetary policy, preference, and technology shocks. Their result provides additional motivation for our attempt to bring the consumption behavior of the constrained households better in line with micro data than is the case when they are treated as simple hand-to-mouth consumers. Relative to Debortoli and Galí (2018), furthermore, we focus on fiscal policy and also consider the role of physical investment alongside

[3]The empirical literature on the link between household heterogeneity and the transmission of macro policy is too wide-ranging to list comprehensively. Among others, Patterson (2019) highlights the importance of variation in marginal propensities to consume given the unequal exposure of individuals to recessions; Auclert (2019), Wong (2019) explore the significance of household heterogeneity for the transmission of monetary policy; and consistent with our focus on fiscal policy, Ma (2019) underscores the heterogeneous consumption responses of poor and rich households to government spending shocks.

[4]In terms of theoretical alternatives to the two-agent approach, Werning (2015), McKay and Reis (2016), Ravn and Sterk (2017) and Challe (2019) use a zero-liquidity approach; Acharya and Dogra (2020) exploit convenient properties of CARA preferences; Kopiec (2019) relies on frictional goods markets.

consumption. Meanwhile, Bilbiie (2019a) extends the traditional two-agent model into an analytical HANK framework that incorporates self-insurance against the risk of having to live hand-to-mouth which, in his model, any agent faces (rather than an exogenously fixed fraction). The presence of idiosyncratic risk in his model is another avenue to capture the intertemporal Keynesian cross logic that also underlies some of our results. Bilbiie (2019a) likewise stresses the importance of cyclical inequality – between workers and capitalists, in our terminology – for understanding macroeconomic dynamics but uses his model to different ends, with a particular emphasis on monetary policy.[5]

Our distinction between workers and capitalists, with the former being more financially constrained than the latter, is in line with Walsh (2017), who evaluates the welfare consequences of wage flexibility and interactions with monetary policy. With that paper we also share the emphasis that shifts in the functional distribution of income matter for aggregate economic activity. Unlike Walsh, we allow workers to have (constrained) access to bond markets, which is critical to capturing the intertemporal dynamics of consumption. Also, our concern lies primarily with fiscal policy.[6]

Our use of an adjustment cost friction constraining households' consumption-savings choice is consistent with extensive micro evidence for gradual portfolio adjustment (cf. Chien *et al.* (2012, Section II.)) and a rich literature in finance and international macro showing how such frictions can help capture households' investment behavior (e.g., Bacchetta and van Wincoop (2010, 2019)). As our goal is to preserve tractability when modeling households' consumption behavior, we deliberately use a very stylized, reduced-form penalty function. More generally, staggered portfolio adjustment can be rationalized along the lines of several explanations proposed for limited participation in asset markets.[7]

Lastly, our analysis of the redistributive effects of fiscal policy relates to a growing literature that studies the cyclical behavior of the labor share and, among other things, uses its response to shocks as a useful identified moment (in the terminology of Nakamura and Steinsson (2018)). In particular, Cantore *et al.* (2019) and Kaplan and Zoch (2020) study the labor share response to monetary policy shocks (also see Ríos Rull and Santaeulalia-Llopis (2010); Mangin and Sedláček (2017)). To the best of our knowledge, it is a novel finding that the labor share of income responds positively and in a hump-shaped manner to an unanticipated increase in government purchases.

Outline. In the remainder, Section 2 compares the benchmark and proposed new two-agent models in terms of consumption behavior, labor supply, and stability properties. Section 3 studies the effects of fiscal policy in both data and theory. Section 4 concludes.

[5]Other related contributions to the TANK literature include Bilbiie *et al.* (2013), Farhi and Werning (2016), Giambattista and Pennings (2017), Sims and Wu (2019) and Spector (2020).

[6]Kumhof *et al.* (2015) as well as Cairo and Sim (2018) similarly consider two-agent models with "top earners" and "bottom earners," but focus on household leverage in the run-up to financial crises.

[7]This list includes the presence of monetary trading costs (e.g., Vissing-Jorgensen (2002); Gálvez (2018)); financial sophistication or the lack thereof (e.g., Calvet *et al.* (2007); van Rooij *et al.* (2011); Alvarez *et al.* (2012)); and the absence of trust in financial markets (e.g., Guiso *et al.* (2008)).

2 A tale of two TANK models

We start by outlining a benchmark version of the two-agent New Keynesian (TANK) framework. Drawing on the more recent heterogeneous-agent literature, we identify three key limitations that motivate the subsequent analysis (Section 2.1). We then show step-by-step how to resolve these issues by introducing portfolio adjustment costs and capitalists into the model (Section 2.2). Throughout, time is discrete and denoted $t = 0, 1, 2, \ldots$. Steady-state variables are without time subscript. Real quantities are in terms of the consumption good and denoted by lower case letters, unless otherwise stated.[8]

2.1 Benchmark two-agent model

2.1.1 Model outline

Our point of departure is the canonical TANK model pioneered by Galí *et al.* (2007) and Bilbiie (2008). Here we consider the simplest possible setup for illustration purposes. As in the latter paper we abstract from physical capital; given our interest in fiscal policy we follow the former in incorporating a fiscal sector. Since the model setup is well-known, we only briefly describe its building blocks – households, firms, and government – and summarize the associated equilibrium conditions.

Households. There is a unit mass of households indexed by $i \in [0, 1]$. A fraction λ behaves in hand-to-mouth fashion due to limited asset market participation (indexed by H). The remainder are unconstrained (indexed by U). Both types share preferences characterized by the period utility function $u = \left(\log(c_t^i) - a\frac{(n_t^i)^{1+\varphi}}{1+\varphi}\right)$, where c^i and n^i denote consumption and hours worked, respectively. The inverse Frisch elasticity of labor supply is parameterized by φ and a weights the disutility of working. All households' labor inputs are bundled by a union that sets wages on their behalf according to a wage schedule $w_t = ac_t n_t^{\varphi}$, where $c_t \equiv \int_0^1 c_t^i di$ and $n_t \equiv \int_0^1 n_t^i di$. This specification, used by Debortoli and Galí (2018) among others, keeps the supply side simple and, in particular, allows for a straightforward introduction of wage stickiness (see Section 3.2.3).[9] Unconstrained households earn not only labor income but also receive dividends distributed by firms, whose price setting power gives rise to profits d_t. These households can also trade in coupon bonds that pay a nominal gross return R_t. Lastly, both types of agents are subject to a scheme of lump-sum taxes to finance government purchases. As in Bilbiie (2019b) we impose that total real net taxes t_t are split such that workers pay (or receive) a share $\lambda t_t^H = \nu t^t$, while unconstrained agents pay (or receive) $(1-\lambda)t_t^U = (1-\nu)t_t$, and impose that $\nu = \lambda$.

Firms. A competitive final goods sector aggregates differentiated intermediate goods according to a CES technology, the elasticity of substitution being η. These intermediates are produced by

[8] To aid with orientation, the colored version of this paper uses (shades of) orange for the traditional TANK model and (shades of) blue for the capitalist-worker model throughout the entire paper.

[9] All the key results from this section are unaffected if different household types choose hours separately, instead (results are available upon request). In our proposed capitalist-worker model the distinction dissolves.

Description	Equation
Euler equation U	$\hat{c}_t^U = E_t\hat{c}_{t+1}^U - (\hat{R}_t - E_t\hat{\Pi}_{t+1})$
Budget constraint U	$\hat{c}_t^U + \tilde{b}_t^U = \hat{n}_t + \hat{w}_t + \frac{\tilde{d}_t}{1-\lambda} - \tilde{t}_t + R\tilde{b}_{t-1}^U$
Budget constraint H	$\hat{c}_t^H = \hat{n}_t + \hat{w}_t - \tilde{t}_t$
Aggregate consumption	$\hat{c}_t = \lambda\hat{c}_t^H + (1-\lambda)\hat{c}_t^U$
Aggregate labor supply	$\hat{n}_t = \varphi^{-1}(\hat{w}_t - \hat{c}_t)$
Dividends	$\tilde{d}_t = -\hat{w}_t$
Phillips curve	$\hat{\Pi}_t = \beta E_t\hat{\Pi}_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{w}_t$
Government budget constraint	$\tilde{b}_t = R\tilde{b}_{t-1} + \tilde{g}_t - \tilde{t}_t$
Government spending	$\tilde{g}_t = \rho^g\tilde{g}_{t-1} + \epsilon_t^g$
Fiscal rule	$\tilde{t}_t = \phi^{\tau t}\tilde{t}_{t-1} + \phi^{\tau B}\tilde{b}_t + \phi^{\tau G}\tilde{g}_t$
Taylor rule	$\hat{R}_t = \phi^{\pi}\hat{\Pi}_t$
Fisher equation	$\hat{r}_t = \hat{R}_t - E_t\hat{\Pi}_{t+1}$
Bond holdings	$\tilde{b}_t = (1-\lambda)\tilde{b}_t^U$

Table 1: Log-linearized equilibrium conditions for the TANK-UH model

Notes: This table summarizes the log-linearized equilibrium conditions of a simple two-agent New Keynesian model with hand-to-mouth households.

monopolistically competitive firms. Their pricing decisions are subject to Calvo-type frictions indexed by θ, giving rise to price stickiness and a standard New Keynesian Phillips curve. As in Bilbiie (2019b), the government levies an optimal steady-state subsidy τ^S, financed through lump-sum taxes on all firms, that induces marginal cost pricing. As a result, profits $d_t = y_t - w_t n_t$ are zero in steady-state and they vary inversely with the real wage outside of it.[10]

Government. The fiscal authority finances real spending, g_t, which follows an AR(1) process, by issuing one-period bonds and levying lump-sum taxes as described above. The financing mix to support spending is determined by a tax rule as in Galí *et al.* (2007). Monetary policy sets the short-term nominal interest rate R_t according to a Taylor rule, with a coefficient ϕ^{π} on inflation.

Table 1 summarizes the equilibrium equations for this model. To ease exposition and analysis we log-linearize the model around a steady-state with zero inflation, no government spending or debt, and total income normalized to unity. Variables with " ^ " denote proportional deviations from their respective steady-state, while " ~ " indicates deviations from the steady-state value of total income.

[10]Once we extend the model to include quantitatively important features such as capital and/or sticky wages, we will adopt the more common approach of introducing fixed costs in production to ensure zero-profits in steady-state. The production subsidy used here simplifies the algebra.

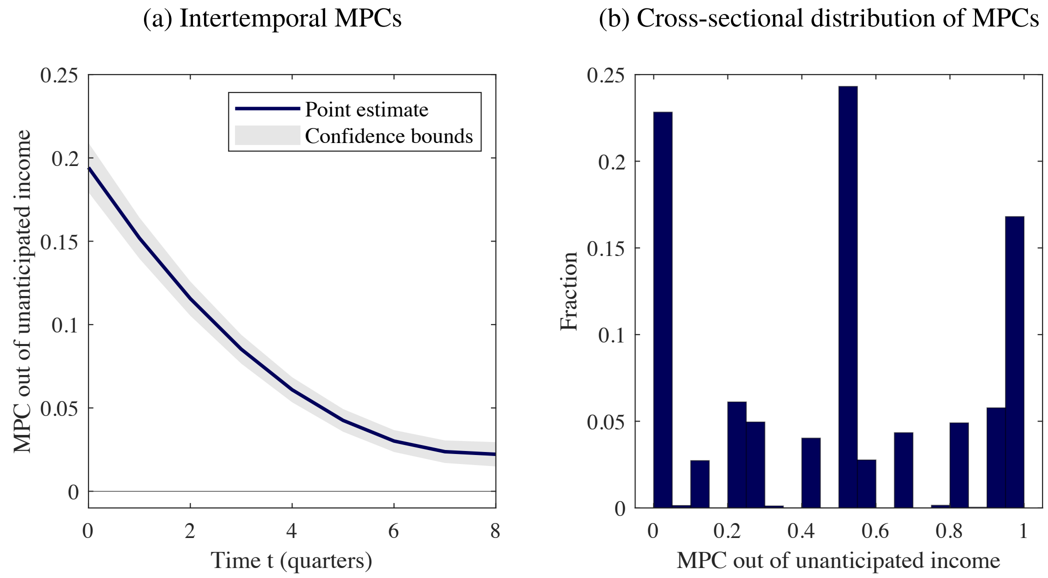

Figure 1: MPCs in the Data

Notes: The left panel shows the dynamic consumption response of a household to an unanticipated income shock estimated by Fagereng *et al.* (2018) and analyzed in Auclert *et al.* (2018). The quarterly figures are constructed from the original annual data by fitting a cubic spline through the cumulative annual iMPC values. This procedure is also applied to the bounds, ignoring any noise due to the interpolation procedure. The horizontal axis shows time measured in quarters. The vertical axis displays the marginal propensity to consume out of unanticipated income $\partial c_t / \partial x_0$. The right panel replicates Fig. 1 from Jappelli and Pistaferri (2014) using data distributed through openICPSR. It describes the distribution of self-reported MPCs out of an unexpected income shock in the 2010 Italian Survey of Household Income and Wealth (SHIW).

2.1.2 Limitations

While tractable and useful in many applications, the macroeconomic literature has pinpointed three distinct problems confronting the traditional TANK model: the implied household consumption dynamics are inconsistent with relevant stylized facts from the data; the transmission mechanism for macroeconomic policies hinges on implausible profit income effects on labor supply; and the model solution is prone to indeterminacy outside a fairly narrow region of the parameter space. We briefly summarize each one of these issues in the following paragraphs, as they provide important context and motivation for the subsequent analysis.

Consumption behavior. Matching the empirical pattern of intertemporal marginal propensities to consume (iMPCs) is important for understanding the aggregate effects of macroeconomic policy such as fiscal stimulus measures. In particular, Auclert *et al.* (2018) demonstrate that in a number of important theoretical benchmark cases, iMPCs are sufficient statistics for the general equilibrium effects of demand shocks such as government purchases. [11] To fix ideas, suppose household behavior can be

[11] The sufficient statistic result of Auclert *et al.* obtains in a setting with sticky wages but flexible prices, passive monetary policy and no capital. Hagedorn *et al.* (2019) similarly underscore the importance of matching observed marginal propensities to consume in order to quantitatively evaluate the dynamic consumption responses to stimulus policies, using a

summarized by an aggregate consumption function $c_t(\{y_s - t_s\})$, so that consumption in any period t depends only on the path of post-tax income in every time period s, where y is pre-tax income and t are net taxes. Then the goods market clearing condition $y_t = c_t(\{y_s - t_s\}) + g_t$ implies a fixed point in the path of output. And the impulse response of output $\{dy_t\}$ to a change in fiscal policy $\{dg_t, dt_t\}$ crucially depends on the iMPC matrix $\mathbf{M}$ of partial derivatives of aggregate consumption with respect to after-tax income x_s at date s, a typical element being $M_{t,s} = \partial c_t / \partial x_s$. Specifically, and to first order, total differentiation yields the New Keynesian cross equation: $dy_t = dg_t + \sum_{s=0}^{\infty} M_{t,s}(dy_s - dt_s)$. Intuitively, the iMPCs fully characterize the interaction of households with the rest of the economy.

What do empirical estimates of these iMPCs look like? Figure 1a summarizes the findings of Fagereng *et al.* (2018) who estimate households consumption responses to lottery winnings using Norwegian administrative data. Following an unanticipated temporary increase in disposable income the average household's consumption jumps up, with a quarterly point estimate for $\partial c_0 / \partial x_0$ of approximately 0.2. Importantly, the iMPCs remain elevated thereafter, displaying a pattern of gradual decay. Cumulatively over the first four quarters after the shock, the average households consumes around half of the windfall.

Auclert *et al.* (2018) find that among popular modeling approaches, only heterogeneous-agent models with multiple assets can match such empirical estimates of iMPCs. The traditional representative-agent and two-agent models, in particular, cannot replicate these dynamics. Consider Figure 2, which describes a household's consumption response to an unanticipated, one-off income raise according to a partial equilibrium consumption-savings choice problem.[12] As a temporary windfall barely affects lifetime resources, under the permanent income hypothesis individual iMPCs are flat at a low level (dotted line).[13] On the other hand, if a household is hand-to-mouth such that consumption moves one-for-one with disposable income, the impact MPC is unity but subsequent consumption is entirely unaffected (dashed line). The traditional two-agent model – "UH" for short – features a fraction $\lambda \in [0, 1]$ of households that behave in a hand-to-mouth fashion, while the remainder are unconstrained permanent-income consumers. By varying λ it is straightforward to match the fairly high average

heterogeneous-agent model with incomplete markets, physical capital and rigidities in both prices and wages.

[12]This approach generates individual iMPCs, which appear to be the natural analogue to empirical estimates of household spending responses to sudden *individual* income changes such as the winnings of lotteries studied by Fagereng *et al.* (2018)). The aggregate iMPC matrix $\mathbf{M}$ is then a convex combination of individual iMPCs (see Auclert *et al.* (2018, Lemma 3)), taking account of the responsiveness of private incomes to aggregate income. More precisely, the aggregate MPC (at time t) out of an increase in aggregate income (in period s) is $M_{t,s} = \frac{\partial c_t}{\partial x_s} = \int_i \frac{\partial c_t^i}{\partial x_s} di = \int_i \frac{\partial c_t^i}{\partial x_s^i} \frac{\partial x_s^i}{\partial x_s} di$. Bilbiie (2019b) underscores and carefully dissects the role of the income elasticity of hand-to-mouth household with respect to aggregate income in determining the properties of the TANK-UH model. More generally, Wolf (2019) provides a detailed and lucid discussion of the mapping between partial equilibrium response of household consumption to an income shock (as identified, for instance, off cross-sectional heterogeneity in shock exposure), on the one hand, and the aggregate response of consumption to shocks, on the other hand.

[13]The theoretical iMPCs in Fig. 2 abstract from endogenous adjustments in household earnings due to, most significantly, income effects on labor supply. Doing so allows us to squarely focus on the direct implications of portfolio adjustment costs, as introduced below, without having to worry about interaction effects (see Wolf (2019, footnote 8) for additional reasons to adopt this definition). We address income effects on labor supply separately below.

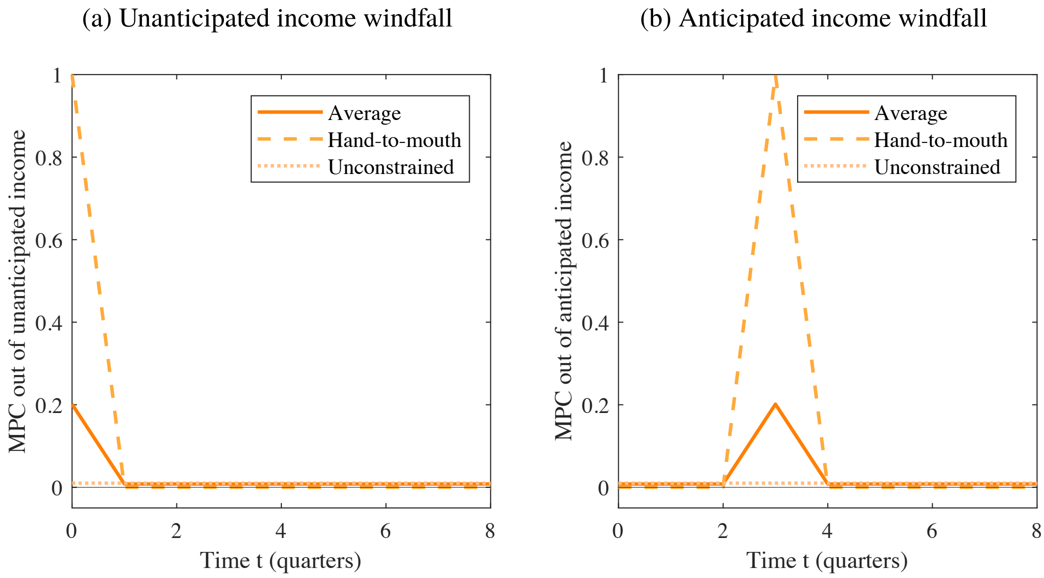

Figure 2: Theoretical iMPCs in the traditional two-agent model

Notes: The figure shows the dynamic consumption response to an unanticipated income shock (panel 2a) and an anticipated income windfall (panel 2b), respectively, for the two-agent model with unconstrained and hand-to-mouth consumers. The horizontal axis shows time measured in quarters. The vertical axis displays the (individual) marginal propensity to consume $\partial c_t^i / \partial x_s^i$, where $s = 0$ in the left panel and $s = 3$ in the right panel. The fraction of unconstrained households is set to $1 - \lambda = 0.2$. This yields a simple weighted average for the quarterly impact MPC for an unanticipated income windfall approximately equal to the average value of 0.2 in the data (see Fig. 1a).

impact effect found in the data (solid line). But the iMPCs sharply drop in the following periods – contrary to what the micro evidence suggests (Fagereng *et al.* (2018, Section 3.2)). As diagnosed by Auclert *et al.* (2018, p.17): "Due to the absence of intermediately constrained agents, [the traditional two-agent model] cannot generate elevated iMPCs in year one and later, which are a key characteristic of the data."[14]

Consider, secondly, an income windfall that is anticipated to materialize three periods into the future. Because hand-to-mouth agents consume all of the extra disposable income in the period when the shock hits, the aggregate iMPC diagram for the UH model resembles a narrow tent. The underlying stark form of limited asset market participation means that the model entirely misses the intertemporal path of iMPCs when it comes to past income shocks (Bilbiie (2019b); Hagedorn *et al.* (2019)).[15]

Figure 2 invites a third observation: The UH model implies an extreme degree of heterogeneity in MPCs in the period of the shock, the difference between the value for hand-to-mouth and that implied

[14]Auclert *et al.* (2018) remark that a model combining a fraction of hand-to-mouth agents with the assumption that holding bonds yields a utility gain also manages to fit micro consumption data well. Appendix A.2.2 provides a comparison of our approach to the bond-in-utility method.

[15]The empirical literature has mostly focused on the evaluation of unanticipated income shocks, but see Agarwal and Qian (2014), Di Maggio *et al.* (2017), and Fuster *et al.* (2018) for some empirical evidence supporting the presence of anticipation effects in households' consumption response to income shocks (though also note Kueng (2018)).

by the permanent income hypothesis being close to unity. By contrast, as Fig. 1b illustrates based on Jappelli and Pistaferri (2014), even though there is significant dispersion in the cross-sectional data, the extent of it is relatively more limited. The noticeable bunching around intermediate values appears to be a robust feature across data sources (see, e.g., Behringer and Gechert (2020)). This is significant, in part, as Debortoli and Galí (2018) show that variations in the consumption gap between constrained and unconstrained households are important in approximating the role of heterogeneity in richer HANK models. To summarize, the introduction of limited asset market participation in the (extreme) form of hand-to-mouth households is only partially successful in reconciling theory with empirical evidence as far as household consumption is concerned.

Profit income effects on labor supply. The second issue concerns the presence of both profits and labor income in the budget constraint of unconstrained households, as a result of which variations in markups over the business cycle (given price stickiness) generate labor supply effects. This mechanism is shared by both representative-agent and heterogeneous-agent models.[16] In the present setting, this is most easily seen by combining the equation for supply, private and public budget constraints, and assuming no debt issuance (cf. Broer *et al.* (2020)). This yields an expression for total hours worked:

$$\hat{n}_t = \frac{\tilde{g}_t - \tilde{d}_t}{1 + \varphi}, \tag{1}$$

where profits move inversely to the labor share. As the latter corresponds to wages in the simple model ($\frac{w_t n_t}{y_t} = w_t$), we have that $\tilde{d}_t = -\hat{w}_t$. Thus, with King-Plosser-Rebelo preferences – and, specifically, log utility – monetary policy that does not induce a fiscal response (i.e., $\tilde{g}_t = 0$) has *no* effects on hours worked and, hence, output were it not for the income effect on labor supply caused by cyclical profit variations.[17] Importantly, insofar as additional demand from government purchases $\tilde{g}_t > 0$ pushes up (down) the labor share (profits), the profit income effect on labor supply *amplifies* the effects of fiscal measures. Broer *et al.* (2020) argue that this crucial role attributed to cyclical profit fluctuations in determining the effectiveness of macroeconomic policy is implausible as it appears in RANK. But in the benchmark TANK model this mechanism is even more forceful. An initial exogenous increase in demand pushes up wages, raising hand-to-mouth households' income, which they immediately and one-to-one use for consumption because they have no option to smooth consumption through saving. This pushes up wages further and beyond the level occurring under full participation. For production to meet this increased demand, hours worked must rise. Given preferences under which the direct substitution and income effects of wage changes cancel out, this occurs because of a negative income

[16]The findings of Alves *et al.* (2019) demonstrate that the distribution of profits plays just as critical a role in HANK settings (also see Werning (2015) and Evans (2020)).

[17]This result is the TANK-counterpart to the argument advanced in Broer *et al.* (2020), who show that the textbook monetary transmission mechanism critically hinges on such income effects: output falls in response to a monetary tightening because mark-ups and, hence, total profits rise; this increase in non-labor income triggers a rise in the household's demand for leisure.

effect on labor supply arising from a fall in profits, which move inversely with wages. Following Bilbiie (2008), the distribution of profits is, thus, critical to the amplification of demand shocks in TANK because of the very tight interdependence of labor and financial markets.

Stability. Lastly, for the benchmark TANK model to have a unique saddle-path stable solution under the standard Taylor principle, it is necessary to impose a Frisch elasticity of labor supply (marginal disutility of labor φ) that is very high (low) relative to the values typically found in the empirical literature.[18] Figure 3 concisely summarizes this point.[19] It plots in the parameter space $(\lambda, \varphi, \phi^{\pi})$ the regions that are associated with the presence of uniqueness and multiplicity of the rational expectations equilibrium in a neighborhood of the steady-state, respectively. For a sufficiently strong degree of non-participation in asset markets and/or a labor supply curve that is relatively inelastic, the solution is indeterminate if $\phi^{\pi} > 1$.

To add intuition, Bilbiie (2008) shows that it is precisely the interplay between labor markets and asset markets described above that underpins these determinacy properties. This point is most easily seen in a special case of the model that imposes budget balance and zero persistence government spending, and assumes that the central bank responds to expected next-period inflation. Then the model can be reduced to a two-equation system:

$$\hat{c}_t = E_t \hat{c}_{t+1} - \zeta \left(E_t \hat{\Pi}_{t+1}(\phi^{\pi} - 1) + \epsilon_t^m \right) - \chi^{-1} \frac{\lambda \varphi}{\lambda - 1} \left(\epsilon_t^g - \epsilon_{t+1}^g \right) \tag{2}$$

$$\hat{\Pi}_t = \beta E_t \hat{\Pi}_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \left(\kappa \hat{c}_t + \frac{\varphi + 1}{\varphi^{-1} + 1} \epsilon_t^g \right), \tag{3}$$

where $\zeta = \frac{1-\lambda}{1-\lambda\chi}$ and $\kappa = \frac{\chi + \varphi^{-1}}{\varphi^{-1}+1}$, with $\chi = \varphi + 2$ denoting the elasticity of hand-to-mouth households' consumption to aggregate income.[20] The crucial parameters pinning down the stability properties of the system are those appearing in ζ, which is interpretable as the elasticity of aggregate demand with respect to the real interest rate. These parameters are the share of hand-to-mouth households λ and the inverse Frisch elasticity φ. When ζ is strictly positive, the standard Taylor principle applies. Aggregate demand becomes a *negative* function of the real interest rate, however, when $\lambda > \frac{1}{2+\varphi}$. Under this "inverted aggregate demand logic," the central bank needs to obey an inverted Taylor principle ($\phi_{\pi} < 1$) for stability to obtain. If asset market participation is sufficiently limited (λ is high) and labor supply inelastic enough (φ is high), a fall in the real interest rate can become contractionary due to the negative demand effect arising from the strong fall in profit income – $(1-\lambda)^{-1} > 1$ units per type-U household for any unit drop in total profits d_t – that occurs due to hand-to-mouth households'

[18] For surveys of labor supply elasticity estimates, see, e.g., Chetty *et al.* (2013) and Attanasio *et al.* (2018).

[19] For details, see Gali *et al.* (2004), Galí *et al.* (2007) and Bilbiie (2008), but also note Maliar and Naubert (2019).

[20] Differences from the value of the same elasticity reported in Bilbiie (2019b) are due to different assumptions on the determination of labor supply – other things equal the value of χ is higher in the present setup – and the fact that we abstracted from fiscal redistribution of profits.

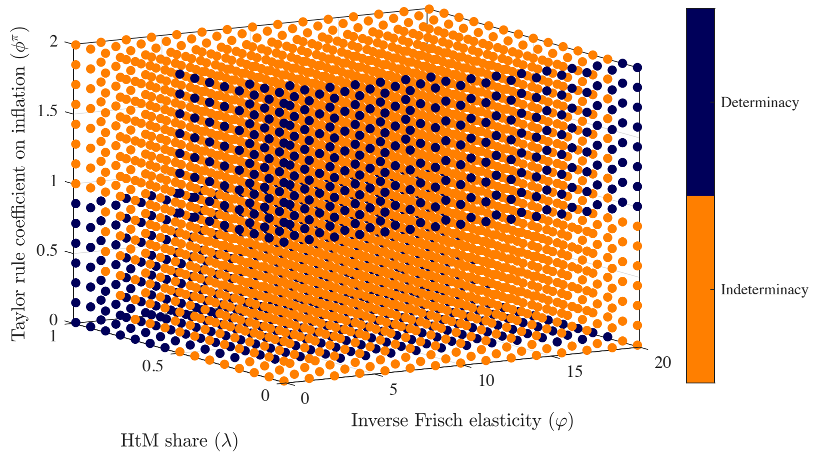

Figure 3: Stability regions in the benchmark TANK-UH model

Notes: This figure shows regions in parameter space that are associated with the presence of uniqueness and multiplicity of the rational expectations equilibrium in a neighborhood of the steady-state, respectively. For details on the values of other parameters, which the plots are conditional on, see Table 3.

high marginal propensity to consume, which reinforces the fall in profits relative to the case where all households smooth consumption by participating in financial markets. Under the standard Taylor principle, a non-fundamental increase in inflation expectations can then be self-fulling: it triggers a rise in the real interest rate which pushes up demand and inflation, thus validating expectations.

2.2 Capitalist-worker model

The three limitations of the traditional two-agent model just sketched have a shared source: the presumed degree of limited asset market participation is extreme, as it entirely prevents hand-to-mouth households from consumption smoothing through borrowing and saving. As a consequence, the consumption behavior of hand-to-mouth households is at once very different from that of the unconstrained households yet similarly amounts to an extreme case.

The solution offered in this paper is to model an intermediately-constrained household. We do so by replacing hand-to-mouth consumers with "workers" who likewise do not own any firm equity, but who *can* participate in financial markets subject to bond portfolio adjustment costs ("PACs" for short). workers behave as target savers who are penalized when their holdings deviate from some benchmark level. This financial friction gives rise to intertemporal marginal propensities to consume in line with micro data, more robust stability properties, and the possibility of ruling out profit income effects on labor supply by replacing the standard unconstrained household type with capitalists who own firms but do not supply labor (cf. Broer *et al.* (2020)); that latter approach proves infeasible in the benchmark TANK model. We coin the resulting two-agent New Keynesian model with workers (indexed by W)

and capitalists (indexed by C) TANK-CW.

To develop this argument as transparently as possible we proceed step-by-step, starting with the partial equilibrium consumption-savings problem facing a worker household. Consider a worker that receives exogenous total post-tax labor income x_t^W every period, which she allocates to maximize the present discounted value of lifetime utility $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^i)$. As in Section 2.1, the period utility function is of log form.[21] Unlike a hand-to-mouth household, the worker is able to trade one-period nominal bonds. The real value of assets carried into period t is b_{t-1}^W and the gross inflation-adjusted return is $\frac{R_{t-1}}{\Pi_t}$.[22] Different from the unconstrained type of household, however, workers' savings choices are subject to a cost: As in Schmitt-Grohe and Uribe (2003), the household is penalized when their holdings deviate from some benchmark level; the strength of this financial friction is indexed by ψ^W (also cf. Neumeyer and Perri (2005) and Dolado *et al.* (2018)). The adjustment cost proposed here is of a simple quadratic form; and the target-level is equal to the steady-state value b^W. The per-period budget constraint accordingly is

$$b_t^W + \frac{\psi^W}{2} \frac{\left(b_t^W - b^W\right)^2}{x^W} = x_t^W + b_{t-1}^W \frac{R_{t-1}}{\Pi_t} + f_t - c_t^W, \quad t = 0, 1, 2, \ldots . \tag{4}$$

Thus, the cost of increasing bond holdings by one unit is greater than unity because it includes the marginal cost of adjusting the size of the portfolio. To rule out any wealth effects, the costs are rebated to the workers as a lump-sum, f_t, without this being taken into account by workers when making savings decisions. Scaling the adjustment cost by steady-state income x^W ensures comparability across different model specifications.

This formulation is clearly very simplistic, our key objective being to relax the extreme assumption of non-participation in asset markets by hand-to-mouth households.[23] That the cost is measured in deviations from steady-state is consistent with an interpretation where the household has, for instance, a target allocation for liquidity or long-term savings and is penalized for deviating from that target. The quadratic form is likewise stylized but very common in the literature and could be generalized.[24]

[21] The extension to allow for a non-unitary elasticity of intertemporal substitution is straightforward.

[22] We allow for time variation in the return on savings and the inflation term already at this point to ensure consistency with the subsequent general equilibrium treatment, even though we largely abstract from these considerations in this section.

[23] In principle, one could specify a more general form of the cost function $\varrho(b_t^W; \mathbf{\Psi}^W, \bar{b}^W)$, parameterized according to a vector of parameters $\mathbf{\Psi}^W$. For instance, we could have $\mathbf{\Psi}^W = (\psi_0, \psi_1, \psi_2)$ where ψ_0 denotes a linear, fixed cost component that introduces a discontinuity into the policy function for savings; ψ_1 is a proportionality factor multiplying the convex component; and ψ_2 determines the strength of the convexity. Here we focus on the simplest possible case. Notice also that it is not quantitatively significant whether the adjustment cost is real or nominal, but assuming the latter is expositionally more convenient.

[24] In addition to the references listed in Section 1, Gârleanu and Pedersen (2016) and Bacchetta and van Wincoop (2017), among others, have explored microfoundations for portfolio adjustment costs. The empirical findings of Fagereng *et al.* (2019) on the importance of capital gains for rationalizing savings behavior across the wealth distribution are also consistent with theories of portfolio adjustment frictions. Data from the 2016 Survey of Consumer Finances are at least suggestive: Fewer than 6 percent of U.S. households adjust their portfolio of stocks and other securities through a broker on a monthly

Solving the household's problem for the optimal choice of a process for consumption and bond holdings $\{c_t^i, b_t^i\}_{t=0}^{\infty}$ yields the Euler equation

$$u'(c_t^W) = \beta E_t u'(c_{t+1}^W) \frac{(R_t/\Pi_{t+1})}{1 + (\psi^W/x^W)(b_t^W - b^W)}. \tag{5}$$

Equation (5) thus features an endogenous wedge in form of the multiplicative term $\left(1 + (\psi^W/x^W)(b_t^W - b^W)\right)^{-1}$ that is not present in the 'standard' Euler equation of an unconstrained household. That latter case is nested for $\psi^W = 0$, whereas if $\psi^W \to \infty$ the worker household behaves in hand-to-mouth fashion.

It proves instructive to consider a log-linear approximation of the household's optimal consumption-savings behavior. The Euler equation (5) can be written as

$$\hat{c}_t^W = E_t \hat{c}_{t+1}^W - \hat{r}_t + \psi^W \tilde{b}_t^W, \tag{6}$$

where $\hat{r}_t = \hat{R}_t - \hat{\Pi}_{t+1}$ refers to the change in the gross real interest rate. The household's budget constraint, upon canceling out adjustment costs and rebate, is

$$\tilde{b}_t^W = \hat{x}_t + R\tilde{b}_{t-1}^W - \hat{c}_t^W. \tag{7}$$

Given this setup, we next consider the same three themes that we diagnosed in Section 2.1.2 as being limitations of the traditional two-agent model: consumption dynamics, profit income effects on labor supply, and stability.

2.2.1 Consumption dynamics in a model with workers

To understand the consumption-savings dynamics in a model with PACs, we combine Euler equation and budget constraint, yielding

$$\hat{c}_t^W = \frac{1}{1+\psi^W}\left[E_t \hat{c}_{t+1}^W - \hat{r}_t\right] + \frac{\psi^W}{1+\psi^W}\hat{x}_t + \frac{\psi^W}{1+\psi^W} R\tilde{b}_{t-1}^W. \tag{8}$$

From equation (8) we see that for $\psi^W \in (0, \infty)$ current consumption is a function not only of (i.) expected consumption and the real interest rate, as it would be according to the permanent income-hypothesis. Instead, it also depends on (ii.) current income, and (iii.) savings from last period. The latter component encodes the differences in past savings behavior of the worker household relative to the extreme case of pure hand-to-mouth consumption assuming $\psi^W < \infty$. At the same time, for $\psi^W > 0$ the responsiveness of current consumption to shocks to future income, or the interest rate, is more modest the farther away they lie in the future. This behavior is different from both the unconstrained household (who

basis; over an annual horizon this figure rises to 68 percent.

spend a constant fraction of the present value of lifetime income) and hand-to-mouth consumers (who consume all disposable income). The muted sensitivity of household consumption to interest rates and the greater responsiveness to variations in current income is characteristic of heterogeneous-agent models when compared to representative-agent economies (Kaplan and Violante (2018a)).

We can sharply characterize the worker household's behavior following an income shock by solving the system formed by equations (6) and (7), together with the usual transversality condition, for savings. Given $\hat{r}_t = 0$ it holds that

$$\tilde{b}_t^W = \mu_1 \tilde{b}_{t-1}^W - \sum_{l=0}^{\infty} \mu_2^{-(1+l)} E_t \left[\hat{x}_{t+l+1}^W - \hat{x}_{t+l}^W \right], \tag{9}$$

where $\mu_1 = \frac{1+R+\psi^W}{2} - \sqrt{\left(1+R+\psi^W\right)^2 - 4R}$ is the stable root, satisfying $|\mu_1| < 1$, and $\mu_2 = \left(1+R+\psi^W\right) - \mu_1$ such that $|\mu_2| > 1$, guaranteeing convergence toward zero (see derivations in Appendix A.2.1). Consumption can then be computed from the budget constraint and we can analytically characterize iMPCs as follows.

Proposition 1 (iMPCs for an unanticipated income shock)**.** *Following an unanticipated one-off income windfall the response of a worker household's consumption on impact is*

$$\frac{d\hat{c}_0^W}{d\hat{x}_0^W} = 1 - \mu_2^{-1}. \tag{10}$$

The subsequent expected path of consumption, for $t \geq 1$ *obeys*

$$\frac{E_0 \left[d\hat{c}_t^W \right]}{d\hat{x}_0^W} = (R - \mu_1)\, \mu_1^{t-1} \mu_2^{-1}. \tag{11}$$

For $\psi^W \to \infty$*, the roots* $\mu_1 = 0$ *and* $\mu_2 \to \infty$*, so that the worker's consumption response reduces to that of a hand-to-mouth household.*

Proof. See Appendix A.2.1. □

Drawing on these results Figure 4a demonstrates that a model with equal shares of permanent-income consumers and workers ("UW" for short) can produce average iMPCs following an unanticipated increase in exogenous income that are remarkably close to those found in the data. We chose the parameter ψ^W to match an average impact MPC equal to 0.2 (see Section 3.2.1 for details), while subsequent moments are not targeted. For workers the marginal impact effect on consumption of an income windfall is high, but not equal to unity, and instead of dropping to zero thereafter, the iMPCs remain elevated for several periods (dashed line). As a result, even if the UH and UW models are parameterized to produce the same impact MPC, the subsequent iMPC shape is in line with the empirical evidence only for the model with intermediate portfolio adjustment costs, whereas it is highly counterfactual for the specification with hand-to-mouth households. Additionally, the impact MPC for workers lies squarely in the middle region between 0 and 1 – consistent with what data suggest for the behavior of the median household. Thus, the degree of MPC heterogeneity is still substantial but less extreme. Workers subject to PACs thus represent a class of intermediately constrained agents.

Why exactly does the introduction of portfolio adjustment costs help with matching iMPCs? One way to gain intuition is to note that the left-hand side of the Euler equation (5) represents the marginal cost of saving, whereas the right-hand side captures the marginal benefit of doing so. Adding the portfolio adjustment costs implies that the marginal benefit is declining in the level of savings in an approximately proportional way as it exceeds the steady-state benchmark, the proportionality factor being ψ^W. Thus, following an increase in resources at its disposal the household's consumption smoothing motive means that it wants to save more than in steady-state. At the same time, however, the presence of the adjustment cost wedge in the denominator on the right-hand-side of (5) reduces the marginal benefit of savings, and more so the higher those 'excess savings' already are. Thus, PACs push the household to consume more in the present. It is the interplay of these two countervailing forces that determines the household's allocation of the extra income between consumption and saving at the margin.[25]

Finally, consider once more the consumption response to an income windfall that is anticipated to materialize several periods into the future.

Proposition 2 (iMPCs for an anticipated income shock)**.** *The response of consumption when news arrives at $t = 0$ of a one-off income windfall that materializes $s \geq 1$ periods later is*

$$\frac{d\hat{c}_0^W}{E_0\left[d\hat{x}_s^W\right]} = \mu_2^{-s}\left(1 - \mu_2^{-1}\right). \tag{12}$$

The subsequent expected path of consumption, for $t \geq 1$ obeys

$$\frac{E_0\left[d\hat{c}_t^W\right]}{E_0\left[d\hat{x}_s^W\right]} = \begin{cases} (1-\mu_2^{-1})\left\{\mu_2^{-(s-t)} - (R-\mu_1)\mu_1^{t-1}\sum_{l=1}^{t}\mu_2^{-(s+1)+l}\mu_1^{1-l}\right\}, & \text{for } t \leq s \\ (R-\mu_1)\mu_1^{t-1}\left\{\mu_2^{-1} - \sum_{l=1}^{s}\left(\frac{\mu_1}{\mu_2}\right)^l\left(1-\mu_2^{-1}\right)\right\}, & \text{for } t > s \end{cases} \tag{13}$$

Proof. See Appendix A.2.1. □

Figure 4b shows that unlike the model with hand-to-mouth consumers – which missed dynamic

[25] Yet another way of seeing this is to note that for a constant interest rate, a small perturbation of the Euler equation around the steady-state implies $dc_{t+1}^W - dc_t^W = -\psi^W db_t^W$. Consumption growth is negatively related to the increase in current savings.

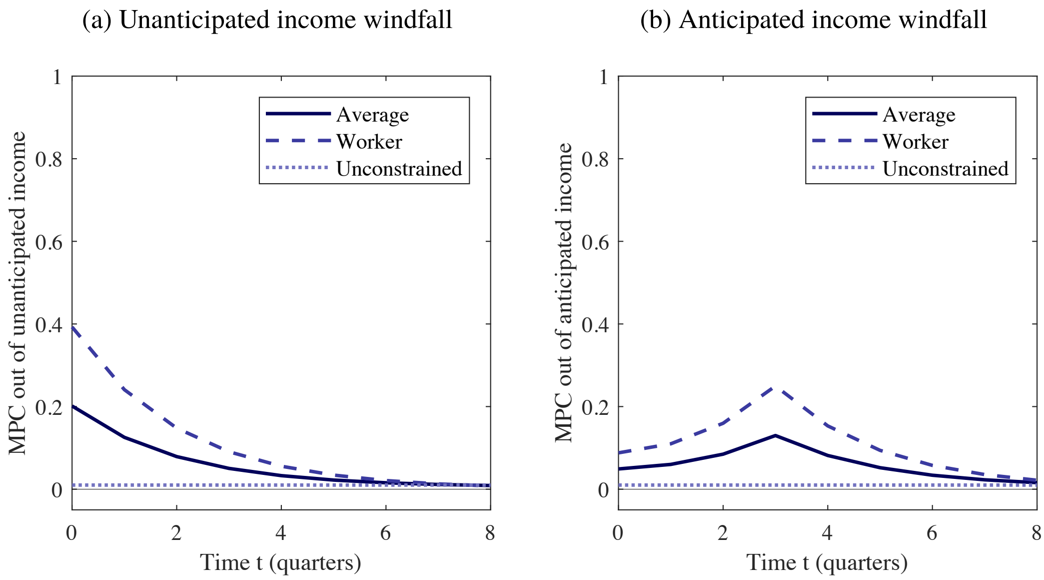

Figure 4: Theoretical iMPCs in the model with portfolio adjustment costs

Notes: The figure shows the dynamic partial equilibrium consumption response to an unanticipated income shock (panel 4a) and an anticipated income windfall (panel 4b), respectively, for the two-agent model with unconstrained (or capitalist) and worker households. The horizontal axis shows time measured in quarters. The vertical axis displays the (individual) marginal propensity to consume $\partial c_t^i / \partial x_s^i$, where $s = 0$ in the left panel and $s = 3$ in the right panel. The fraction of unconstrained households is set to $1 - \lambda = 0.5$ and the degree of PACs is set to target a simple weighted average for the quarterly impact MPC for an unanticipated income windfall approximately equal to the average value of 0.2 in the data.

anticipation effects almost entirely, because of households' limited ability (Ws) or desire (Us) to respond to increases in future income – the predictions here are closer to those of a HANK model as studied in Hagedorn *et al.* (2019). All households in our two-agent model act on expectations for future income changes, but there exists important heterogeneity across types in terms of how this manifests in current consumption. Specifically, being subject to a friction that interferes with their ability to fully smooth consumption, workers likewise consume *more* in period $t = 3$ when the positive income shock materializes. Yet they also borrow against the future prior to the windfall and save some of it afterwards. As a result, the iMPC tent is wider.

2.2.2 Stability properties

Paralleling our analysis of the benchmark TANK model, we next turn to the stability properties of our proposed alternative as well as the interaction between cyclical variations in profits and labor supply. To that end, we embed the generalized household block with portfolio adjustment costs into the TANK framework outlined in Section 2.1.1, replacing hand-to-mouth households with workers.[26] This adds one endogenous variable to the system, that is workers' bond holdings, as well as an associated Euler equation (5). For now we continue to assume that a share $1 - \lambda$ of households are unconstrained.

Adding PACs gives rise to more plausible determinacy properties than TANK-UH possesses. Figure 5 plots the stability properties of the rational expectations equilibrium (in a neighborhood of the steady-state) as a function of the population share parameter λ, the inverse Frisch elasticity φ, as well as the strength of PACs as indexed by ψ^W (panel 5a) or the Taylor rule coefficient on inflation ϕ^π (panel 5b). For higher values of ψ^W the behavior of workers approximates that of hand-to-mouth households and, consequently, the indeterminacy problems for parameter combinations other than low λ and low φ reappear under a conventional value of $\phi_\pi = 1.5$. By contrast, for lower values such as $\psi^W = 0.25$ the standard Taylor principle is restored for *any* combination of λ and φ.

The logic behind these results follows very closely the argument of Hagedorn (2018b), who shows that the class of policy rules that lead to local determinacy is much larger in HANK-type models than in RANK, because government bonds are net wealth in the former but not the latter. The reason is that when government bonds are nominal and have net worth to the public, shifts in the price level affect the real value of debt and real aggregate demand. Prices and inflation are then jointly and uniquely determined by fiscal and monetary policy. Hagedorn explains his findings in a setting where households derive utility from holding bonds. In line with our focus on the effects of fiscal policy shocks, the setup here differs from Hagedorn's analysis insofar as PACs do not affect the non-stochastic steady state. The key insights for local determinacy carry over, however. Intuitively, the workers' Euler equation (5) defines a trade-off between the real interest rate and the real value of bonds. The reason is that

[26]As such, relative to the partial equilibrium specification the income is determined endogenously as $x_t^W = w_t n_t^W - t_t^W$.

(a) Stability in $(\varphi, \lambda, \psi^W)$ space

(b) Stability in $(\varphi, \lambda, \phi^\pi)$ space

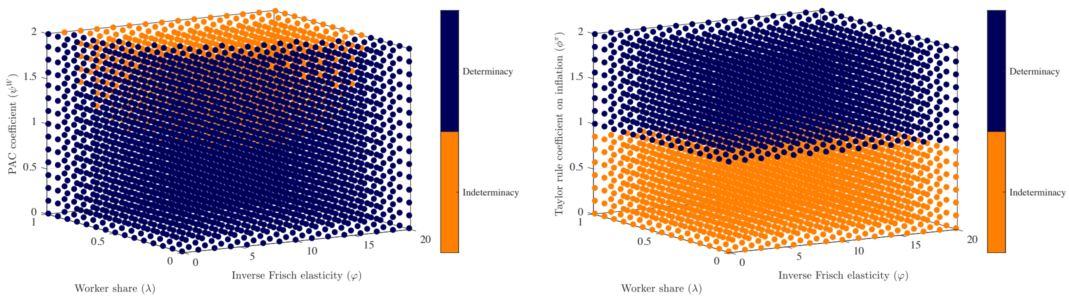

Figure 5: Stability regions in the model with portfolio adjustment costs

Notes: This figure shows regions in parameter space that are associated with the presence of uniqueness and multiplicity of the rational expectations equilibrium in a neighborhood of the steady-state, respectively. For details on the values of other parameters, which the plots are conditional on, see Table 3. Notably, panel 5a assumes $\phi^\pi > 1$.

given convex PACs worker households require a higher (lower) real interest rate to compensate them for absorbing a greater (smaller) allocation of bonds relative to the target b^W. Holding constant the outstanding stock of nominal government debt, a non-fundamental increase in inflation expectations decreases workers' desire to consume, pushing down aggregate demand and (through the Phillips curve) inflation, thereby contradicting the initial expectation. By contrast, in the UH model one type of households (Hs) holds no bonds; to the other (Us) government bonds do not represent net worth.

2.2.3 Introducing capitalists

Although the introduction of portfolio adjustment costs alone aligns household consumption behavior better with available micro evidence and the predictions of HANK models, the transmission of shocks to the economy still relies on cyclical variations in profits that trigger shifts in the labor supply curve. To eliminate this channel, we extend to the TANK framework the idea articulated by Broer *et al.* (2020) in their critique of the textbook RANK model. Thus, we replace the usual unconstrained type of household with "capitalists" (indexed by C), who receive firm profits but do not supply labor. This amendment short-circuits the implausible profit income effect on labor supply. The only difference between the U and C types is that the latter are assumed not to participate in the labor market ($n_t^C = 0$) and, consequently, labor income does not enter into their budget constraint.[27] As such, cyclical variations in profits no longer determine the effectiveness of fiscal policy through their income effect on labor supply. Table 2 summarizes the log-linearized equilibrium conditions of the resulting basic version of

[27]Of course, this is unrealistic insofar as even the majority of the wealthiest ten percent of individuals's income in the U.S., for instance, derives from labor, according to the Survey of Consumer Finances. From a modeling perspective, the point, though, is to eliminate the income effects on labor supply of variations in markups. Our "capitalist" specification captures this idea in a stylized form. An alternative approach that gives rise to virtually identical dynamics out of steady-state but is analytically slightly less convenient is to suppose that the capitalist-type does supply labor but inelastically, so that her labor supply curve does not shift in response to cyclical variations in her profit income.

Description	Equation
Euler equation C	$\hat{c}^C_t = E_t\hat{c}^C_{t+1} - (\hat{R}_t - E_t\hat{\Pi}_{t+1})$
Budget constraint C	$\tilde{b}^C_t = \frac{\tilde{d}_t}{1-\lambda} - \tilde{t}_t + R\tilde{b}^C_{t-1} - \hat{c}^C_t$
Euler equation W	$\hat{c}^W_t = E_t\hat{c}^W_{t+1} - (\hat{R}_t - E_t\hat{\Pi}_{t+1}) + \psi^W\tilde{b}^W_t$
Budget constraint W	$\tilde{b}^W_t = \left(\hat{n}^W_t + \hat{w}_t\right) n^W + R\tilde{b}^W_{t-1} - \hat{c}^W_t$
Aggregate consumption	$\hat{c}_t = \lambda\hat{c}^W_t + (1-\lambda)\hat{c}^C_t$
Labor supply	$\hat{n}^W_t = \varphi^{-1}\left(\hat{w}_t - \hat{c}^W_t\right)$
Dividends	$\tilde{d}_t = -\hat{w}_t$
Phillips curve	$\hat{\Pi}_t = \beta E_t\hat{\Pi}_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{w}_t$
Government budget constraint	$\tilde{b}_t = R\tilde{b}_{t-1} + \tilde{g}_t - \tilde{t}_t$
Government spending	$\tilde{g}_t = \rho^g\tilde{g}_{t-1} + \epsilon^g_t$
Fiscal rule	$\tilde{t}_t = \phi^{\tau t}\tilde{t}_{t-1} + \phi^{\tau B}\tilde{b}_t + \phi^{\tau G}\tilde{g}_t$
Taylor rule	$\hat{R}_t = \phi^{\pi}\hat{\Pi}_t$
Fisher equation	$\hat{r}_t = \hat{R}_t - E_t\hat{\Pi}_{t+1}$
Bond holdings	$\tilde{b}_t = \lambda\tilde{b}^W_t + (1-\lambda)\tilde{b}^C_t$

Table 2: Log-linearized equilibrium conditions for the TANK-CW model.

Notes: This table summarizes the log-linearized equilibrium conditions of a simple two-agent New Keynesian model with workers and capitalists.

the TANK-CW model.

While the focus of this paper lies on the transmission of macro policy, for completeness it is worth mentioning that in the TANK framework introducing capitalists is feasible without compromising on the stability properties only in the presence of intermediate portfolio adjustent costs. Suppose, for the sake of argument, that we are back in the setting with hand-to-mouth households (that is, PACs are infinitely large). Then after replacing aggregate labor supply with an equation for hand-to-mouth households only, a few substitutions show that $\hat{n}_t = \frac{\tilde{g}_t}{1+\varphi}$. Thus, hours worked are independent of profits. Unfortunately, however, solving the problem of profit income effects in this way exacerbates the determinacy problem that already afflicted the benchmark TANK-UH specification: irrespective of the value of λ a unique equilibrium is now unattainable given $\phi_\pi > 1$.[28] In the appendix we show how stability properties vary when C(apitalist)s are substituted for U(nconstrained household)s. In the latter case, there are no combinations of λ and φ that yield determinacy under an active Taylor principle. This changes when the degree of asset market participation is intermediate. With the exception of the corner case $\lambda \to 0$ that is irrelevant for all practical purposes, there is a unique saddle-path stable

[28]More formally, if we write the system as $E_t z_{t+1} = \Gamma_0 z_t + \Gamma_1 \nu_t$, where $z_t(c_t, \Pi_t)'$ and $\nu_t = (\epsilon^m_t, \epsilon^g_t)'$, then for any $\phi^\pi > 1$ it is never the case that both eigenvalues of Γ_0 are outside the unit circle, as required for determinacy (since both consumption and inflation are forward-looking variables).

solution irrespective of the value of λ and φ.[29]

In summary, our preferred TANK-CW model produces empirically credible intertemporal marginal propensities to consume that shape the private sector's dynamic response to shocks; it does not rely on implausible profit income effects on labor supply; and it remains determinate under an active Taylor rule for a wide set of parameter values.

3 Fiscal stimulus and redistribution

What are the implications of these alternative ways of characterizing household heterogeneity within the TANK framework for the transmission of fiscal policy? To answer this question we now compare and contrast the general equilibrium effects of a discretionary increase in government spending according to the benchmark (UH) and our proposed alternative (CW) model. We proceed in three steps. First we document the aggregate and redistributive implications of a government spending shock in the data (Section 3.1). The findings serve as general orientation for the subsequent discussion of theoretical predictions about the effects of fiscal policy. They will also inform the choice of parameter values in a quantitative application. We then examine differences in transmission mechanisms between alternative theoretical frameworks through the qualitative lens of simple versions of TANK models (Section 3.2). Finally, we evaluate aggregate and redistributive effects of fiscal policy in medium-scale models (Section 3.3).

3.1 Empirical evidence

Our baseline econometric tool to document the empirical effects of an unanticipated increase in government purchases is the structural vector autoregression (SVAR) approach devised by Forni and Gambetti (2016). It combines the recursive identification strategy of Blanchard and Perotti (2002) with a news variable constructed based on data from the Survey of Professional Forecasters (SPF). Jointly, these two components allow extracting "surprise" government spending shocks from the data. We find this approach appealing for two reasons. First, it allows purifying recursively identified shocks of any anticipated component. Second, unlike identification methods based on the use of defense spending, this methodology allows analyzing the response of the labor share to government spending shocks in

[29]It can be shown that the model with capitalists and hand-to-mouth households can be represented by the same system (2)-(3), except that the slope of the demand curve now is $\zeta^{CH} = \frac{1-\lambda\chi^{CH}}{1-\lambda}$ and the coefficient on consumption in (3) curve becomes $\kappa^{CH} = \frac{\chi^{CH}(\lambda\varphi+1)}{(1+\varphi)}$. While $\zeta^{CH} < 0$ once the profit income effect on labor supply is removed, we now have that $\kappa^{CH} < 0$. Consider then once more a non-fundamental increase in inflation expectations. Under an active Taylor principle the real interest rises, pushing down consumption. But in the CH model this triggers a rise in inflation that makes the initial sunspot shock self-fulfilling.

general and not only the narrower subset of military spending shocks.[30]

The inclusion of the SPF variable is motivated by concerns over the implications of fiscal foresight. Intuitively, agents receive signals about fiscal changes prior to their implementation because of the existence of lags in the legislative and implementation process (for evidence of fiscal foresight see, among others, Ramey (2011); Leeper *et al.* (2013); Forni and Gambetti (2016)). Such fiscal foresight means that recursive identification, by itself, may not be sufficient to clearly distinguish between unanticipated and anticipated shocks, because some changes in fiscal expenditures are anticipated by agents even though they are unpredictable based on the variables in the econometrician's information set. Including the SPF news variable serves to enrich this information set and thus helps identify spending shocks "purified" of the anticipated component. Specifically, define the implied cumulated forecasts for government spending growth between $t = s$ and $t = h$, $s < h$ as $F_t(s,h) = \sum_{j=s}^{h} E_t^P g_{t+j}$, where E_t^P denotes the median expectation in the SPF in period t and g_{t+j} denotes the realized growth rate of government spending at $t + j$. In practice, we follow Forni and Gambetti (2016) and place $F_t(1,4)$ as the second variable in the SVAR after government spending.

In terms of practical implementation, the benchmark specification is a ten-variable VAR estimated for the U.S. relying on quarterly data spanning from 1981:Q3 to 2007:Q4 and using standard Bayesian methods. The data comprise: log real government spending (consumption plus gross investment); the cumulated forecast of government spending growth over the next four quarters, $F_t(1,4)$; log real net taxes; log real GDP; log real consumption (durables and non-durables); log real investment; log labor share; log real corporate profits; the GDP deflator; and the 10-year real interest rate. The labor share deserves particular attention. Theoretically, it is defined as the share of total compensation of the labor force in the aggregate output of the economy. The empirical counterpart to this theoretical construct is ambiguous, however. As our baseline measure we use the labor share in the domestic corporate non-financial business sector, constructed in line with the methodology of Gomme and Rupert (2004).[31] Appendix A.3 provides further details on data and implementation of the VAR.

Figure 6 depicts the impact of an unanticipated increase in government purchases on selected variables. The shock magnitude is scaled to represent approximately one percent of GDP, and the effect on any given variable is measured in percent deviation from the respective variable's baseline.[32] Three results stand out. Firstly, the response of real output is positive, but for only about one and a half years. The impact multiplier is 0.8, but reflecting the short-lived nature of the expansion, the present-value

[30]The empirical literature on fiscal policy offers a range of other approaches to identifying government spending shocks but is too extensive to summarize comprehensively.

[31]This approach is consistent with recent studies underscoring the importance of adjusting labor share measures for income from self-employment and housing in the context of lower-frequency movements in the labor share, an example being Gutierrez and Piton (2019). Also seem among others, Rognlie (2018). In the present context it is, furthermore, relevant that our benchmark measure excludes the public sector, alleviating any concerns that increased government spending on employment might mechanically increase the labor share of the economy as a whole.

[32]See Appendix A.3.1 for the full set of results as well as robustness checks.

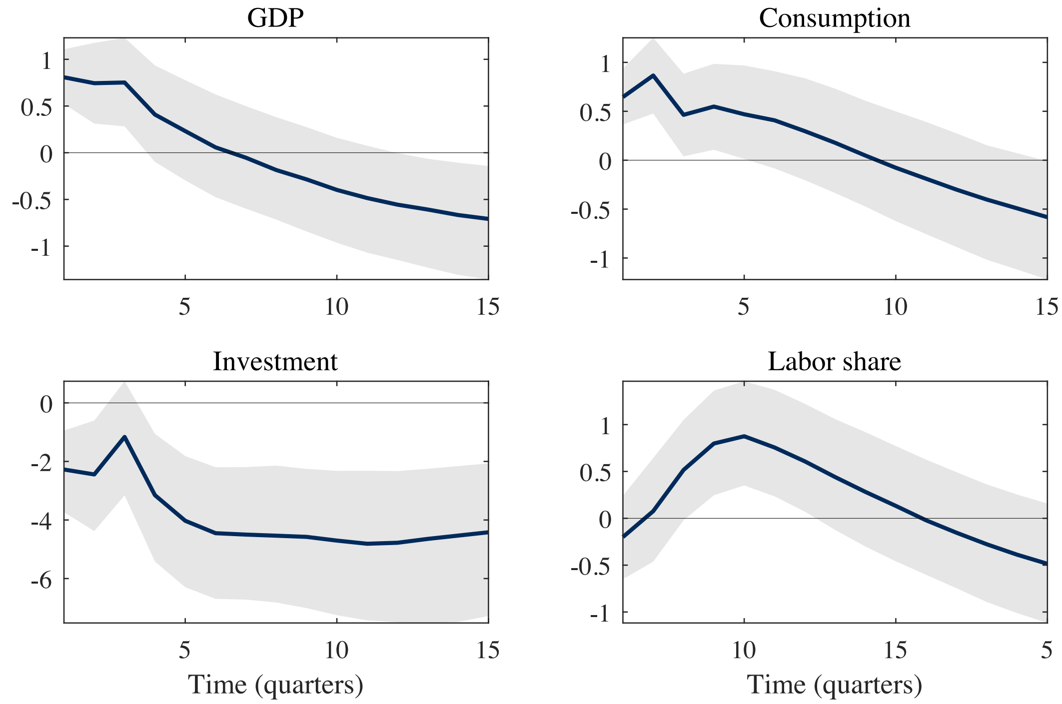

Figure 6: Empirical effects of an unanticipated shock to government spending (U.S.)

Notes: This figure shows empirical impulse responses for an unanticipated government spending shock. Impulse responses are scaled such that the increase in government spending is approximately equal to one percent of GDP. Solid lines indicate the median posterior density of impulse responses, while the shaded area represents the 16th to 84th percentiles. All series are shown in percent deviation from baseline.

cumulative multiplier (Mountford and Uhlig (2009)) after two years is only 0.48; it falls to 0.16 after three years.[33] Secondly, and considering the components of national income, aggregate consumption is crowded *in* following an expansionary unanticipated government spending shock, whereas investment falls sharply (cf. Ramey (2016)).

Finally, and focusing on the novel aspect of our empirical exercise, the labor share exhibits a positive, persistent and hump-shaped response. The peak effect in percentage deviations from baseline is comparable to that of GDP, but the rise is gradual. In addition, the response is statistically significant for several quarters around its peak. This results suggests that the expansionary government spending shock induces a redistribution of national income away from recipients of capital income towards workers.[34]

We have validated these empirical results for the U.S. in robustness exercises that deviate from the baseline specification in several dimensions. Most notably, the response of the labor share to unanticipated government purchases look highly comparable when using data from Canada, Australia and the UK.

3.2 The transmission of government spending shocks in simple TANK models

Against the backdrop of these empirical results and given the differences in building blocks of traditional (UH) and alternative (CW) TANK models, we next compare and contrast the transmission of government spending shocks in both models. For transparency we start with the bare-bones versions of the models outlined in Section 2 and summarized in Tables 1 and 2. By also showing results for the intermediate case that combines unconstrained households and workers (UW), we separately identify what the effects are of convex portfolio adjustment costs (present in both UW and CW) and of removing profit income effects on labor supply (as in CW).

3.2.1 Parameterization

Table 3 summarizes how we parameterize the simple models. As most values are standard, and since the focus here is on relative rather than absolute magnitudes, we limit discussion to three key parameters: the population shares of different types of households, λ; the inverse Frisch labor supply elasticity φ; and ψ^W, which indexes portfolio adjustment costs faced by workers. The values are chosen to maintain maximum comparability across models and stay close to the literature.

[33]The magnitude and (relatively low) persistence of the output response is consistent with other studies that noted the decline of the output effect after 1980 in U.S. data (see, e.g., Perotti (2005) and Caldara and Kamps (2008)).

[34]These cyclical shifts in the functional income distribution – with government spending shocks inducing redistribution from firm owners to workers – may help further motivate the use of a two-agent model that distinguishes, in a stylized fashion, between households primarily relying on labor income (workers) and those owning the economy's dividends-distributing firms (capitalists).

Parameter	Interpretation	Value (H | W)	Source
β	Discount factor	0.99	Annual real interest rate of 4%
φ	Inverse Frisch elasticity	0.05	Determinacy of UH
ρ^G	AR1 Government spending shock	0.9	Benchmark
ψ^W	Portfolio adjustment cost	∞ | 0.25	Definition | iMPC evidence
λ	% of H/W	0.5	Galí *et al.* (2007)
b^W	Workers' steady-state bond holdings	0	Comparability of models
θ	Calvo price stickiness	0.71	Average price duration 3.5q
η	Int. goods elasticity of substitution	6	Steady-state profits excl. subsidy
ϕ^π	Interest rate response to inflation	1.5	Galí *et al.* (2007)
$\phi^{\tau,t}$	Tax smoothing	0	Galí *et al.* (2007)
$\phi^{\tau,g}$	Tax response to government spending	0.1	Galí *et al.* (2007)
$\phi^{\tau,b}$	Tax response to debt	0.33	Galí *et al.* (2007)
τ^S	Production subsidy	$(\eta-1)^{-1}$	Marginal cost pricing
Π	Steady-state inflation rate	1	Benchmark

Table 3: Parameter values for the simple models

Notes: This table lists the parameter values of the simple TANK models. One period in the model corresponds to one quarter.

Following Galí *et al.* (2007) we initially set $\lambda = 0.5$, thus supposing that half of the population is unconstrained. Because the benchmark model requires a high Frisch elasticity of labor supply to avoid indeterminacy, for now we set $1/\varphi$ equal to 20 across all models (see Section 2.1.2 for a detailed discussion). We switch to a more conventional unit value in the quantitatively oriented Section 3.3.

For models involving the worker-type household we calibrate ψ^W based on evidence from micro data on household-level partial equilibrium consumption responses to income changes. Specifically, we exploit the analytical characterization of iMPCs described in Proposition 1 and target an average impact MPC out of unanticipated income equal to 0.2. This implies $\psi^W = 0.25$.[35] We take the targeted MPC value to be reasonable in light of both the empirical literature in general and the example from Fagereng *et al.* (2018) illustrated in Fig. 1a in particular. For instance, Kaplan and Violante (2014) describe 25 percent as a reasonable approximation of the fraction of fiscal stimulus payments households spend on nondurable consumption in the quarter that they are received. Kueng (2018), who studies data from the Alaska Permanent Fund, likewise finds that the average marginal propensity to consume is 25% for nondurables and services within one quarter of the payments. Hagedorn *et al.* (2019) cite the middle range of annual impact iMPCs out of transitory income as 0.4, while the median year-1 iMPC in the

[35] As the impact MPC for permanent income households is equal to $1-\beta = (R-1)/R$, the average impact MPC for an unanticipated income shock is $M\bar{P}C_{0,0} = \lambda\left(1-(1+R+\psi-\mu_1)^{-1}\right) + (1-\lambda)\frac{R-1}{R}$; see Proposition 1. Solving this equation for $M\bar{P}C_{0,0} = 0.2$ given $\lambda = 0.5$ and $R = 1/\beta = 1.0101$ yields $\psi^W = 0.2454$. We round up to two decimal places.

Norwegian administrative data evaluated by Fagereng *et al.* (2018) is approximately equal to 0.55, and in the Italian Survey of Household Income and Wealth it is equal to 0.45, according to Auclert *et al.* (2018). If the simple relationship $M^a_{0,0} = 1 - (1 - M^q_{0,0})^4$ is used to convert between annual and quarterly figures, these data imply quarterly impact values slightly below 0.2. With $\partial c_0 / \partial x_0 = 0.2$ we therefore choose an in-between value as a target.[36]

3.2.2 Baseline results

Figure 7 compares the impulse responses of selected variables to an increase in government spending equal to one percent of steady-state output. Consider first the two TANK variants that differ in one respect only: UH features hand-to-mouth households (dashed line), while UW allows for workers subject to adjustment costs of intermediate strength (dotted line). In both models, the increase in government purchases raises the overall level of aggregate demand and, in the presence of sticky prices, shifts the labor demand curve outwards. Consequently, hours worked and real wages increase (cf. Pappa (2009)); so does labor's share of income. Limited asset market participation raises impact-MPCs above the level implied by the permanent income hypothesis. Accordingly, both Hs and Ws use their now higher levels of disposable labor income to increase their consumption. Meanwhile, for unconstrained households the combination of relatively less benign income dynamics – the flipside of rising wages is a fall in profit income – and the anticipation of higher future taxes and relatively higher absorption of government bonds means that consumption falls (cf. Ma (2019)). In line with the empirical evidence, fiscal policy shocks have not only *aggregate* but also important *redistributive* effects.

Comparing the two models, aggregate dynamics in TANK-UW are significantly more muted. As analyzed already in a partial equilibrium context, the ability of Ws to save in form of government bonds (see panel for b^W_t) reduces their MPC on impact. Their consumption response following the fiscal expansion is accordingly less strong than that of Hs. Furthermore, reflecting the empirically realistic, gradual decay of iMPCs, workers' consumption level not only jumps up less on impact than that of Hs but the rate of decline thereafter is slower. Because workers react to both current and future income changes, the logic underlying their general equilibrium consumption response to fiscal shocks is also inherently dynamic in a way that does not hold true for hand-to-mouth consumers. This feature in the spirit of Hagedorn *et al.*'s (2019) HANK model manifests in two ways. On the one hand, following an increase in disposable income today, the worker (but not the hand-to-mouth) household saves a fraction to be spent in the future, such that not only current but also future consumption is increased. Such an elevated path of demand puts upward pressure on future wages and, hence, expected labor income

[36] To give a further sense of magnitudes, in the partial equilibrium exercise of Section 2.2.1, the value $\psi^W = 0.25$ means that following an unanticipated windfall equal to one percent of steady-state earnings, the perceived effective rate of return on savings for the worker is -3.6% in the impact period $t = 0$, that is, the household accepts a cash loss to be able to smooth consumption; the return turns positive in $t = 2$. This compares to the (invariant) return of $+1.01\%$ faced by an unconstrained household.

and consumption. The anticipation of greater future earnings induce workers to consume even more today (recall equation (8)). At the same time, however, workers unlike hand-to-mouth households are responsive to the anticipated rise in future tax liabilities, depressing their consumption.

The presence of portfolio adjustment costs furthermore generates a mildly hump-shaped path for workers' consumption as well as wages provided the path for the supply of liquidity in form of government bonds is hump-shaped. Intuitively, workers' desire to consume is *greater* when the government issues liquidity to finance its additional spending in excess of the benchmark level defined by workers' steady-state holdings. A by-product of matching the micro data on iMPCs is, therefore, that the model does not necessarily require habits in consumption to generate a hump shaped IRF for aggregate consumption.[37]

Overall, both demand for labor and workers' share of income likewise rise by less and more slowly in the model with intermediately constrained households than in the benchmark model for hand-to-mouth consumers. The reverse is true for profits, and the stimulative income effect on hours worked is consequently weaker. Jointly, these features mean that both aggregate and redistributive effects are more modest in UW than in UH.

Figure 7 also shows the impulse response functions for the TANK-CW model (solid line). Recall that the UW model still features strong profit income effects on labor supply, whereas the CW model does not. As capitalists' disposable income does not include the procyclical component of labor earnings, they are forced to strongly cut back on consumption. By design, this has no direct implications for total hours worked, however, insofar as the drop in profits does not exert an expansionary income effect on labor supply. Reflecting the strength of that mechanism in the benchmark (and UW) TANK model(s), hours worked and production move much less when it is removed. Indeed, in the simple model analyzed here aggregate consumption is crowded out. The combination of an increase in labor demand due to additional government expenditures combined with no labor supply response by capitalists implies that the labor share nonetheless rises robustly, mirrored by a fall in profits, i.e., there is redistribution across the functional income distribution.

Indeed, a sensitivity analysis that varies the value of ψ^W shows that while in the UW model increasing the value of ψ^W reinforces both the aggregate and redistributive effect of fiscal policy, this result does not carry over to the CW model (see Appendix A.1.3). Instead, increasing the strength of PACs reinforces the *redistributive* effect of fiscal policy but reduces its impact on *aggregate* output. Intuitively, the reason is a higher value of ψ^W pushes up workers' consumption on impact, reducing their desire to work, *ceteris paribus*. Other things are not equal, however, because the expansion in demand also pushes up (down) wages (profits). Unlike in the UW model, however, this fails to trigger an increase in labor supply through a profit income effect. As a result, there is no compensating rise in total hours

[37]This possibility is potentially significant in light of the argument of Auclert *et al.* (2020) that the standard way of introducing habits into DSGE models may help capturing "macro humps," but is inconsistent with such empirical evidence on "micro jumps," as exemplified by the study of dynamic consumption responses to income shocks (see Appendix A.2.3).

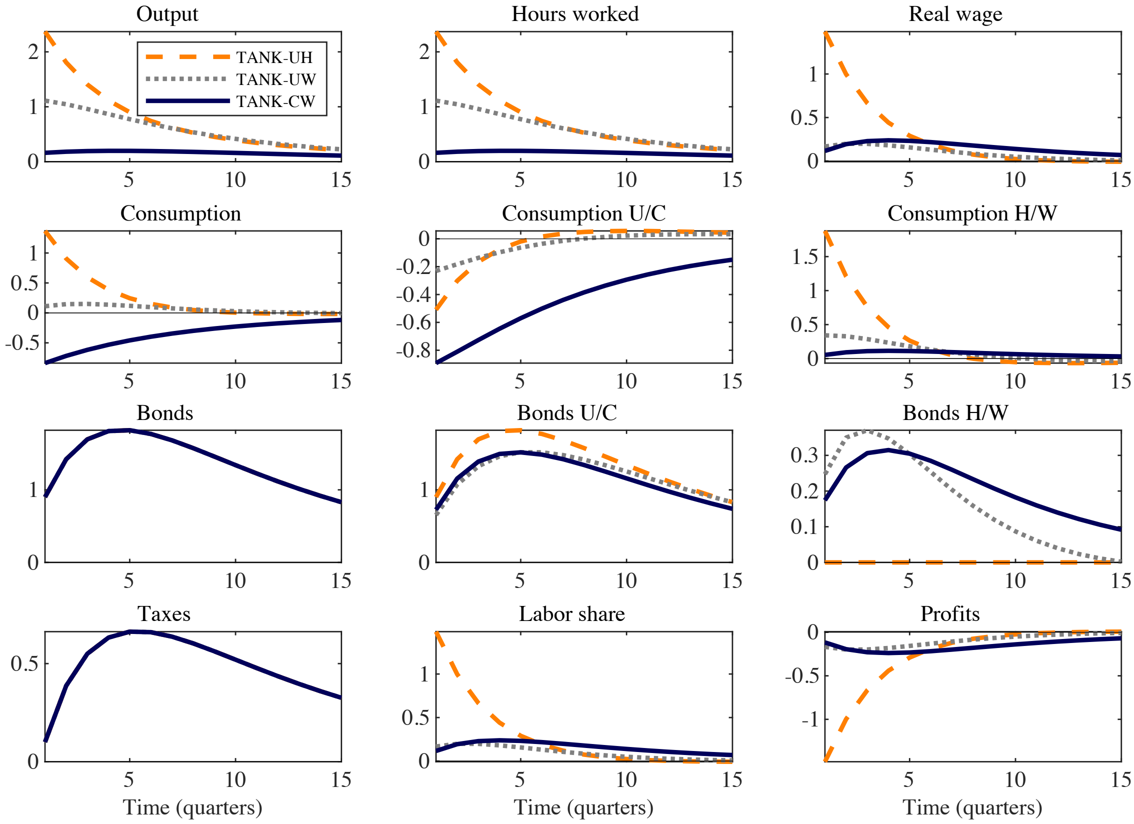

Figure 7: Government spending shocks in the simple TANK models

Notes: This figure shows the impulse responses of selected variables to a government spending shock across alternative TANK models. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

worked and, hence capitalists' income and aggregate output.

In summary, by mimicking the distribution of dynamic iMPCs characteristic of the data and replicated by HANK models, the two-agent model with PACs delivers a more plausible dynamic consumption response. When, additionally, the profit income effect on labor supply is removed, then the resulting TANK-CW model predicts lower fiscal multipliers but still significant redistributive effects. We return to and develop this point in greater detail in Section 3.3, but first consider how the introduction of endogenous capital accumulation and wage stickiness introduces important nuances.

3.2.3 Role of investment and wage stickiness

Up until now we used the simplest possible version of a TANK framework to ensure maximum transparency of the implications of alternative modeling choices. Exploring investment as well as nominal wage rigidities serves two purposes: to verify the robustness of our results, and to show how the interaction of the capitalist-worker household structure with these features gives rise to additional and relevant features in the transmission of fiscal policy. The key takeaway is that the presence of an investment channel and wage stickiness makes the consumption response by both workers and capitalists more positive, yet investment in physical capital falls.

To be specific, we generalize the TANK-CW model by supposing that capitalists receive income not only from holding firm equity ("intangible capital"), but they also invest in physical capital as in Galí *et al.* (2007); investment is subject to conventional adjustment costs indexed by ι. Intermediate firms rent capital and use it alongside labor to produce consumption goods according to a standard Cobb-Douglas specification. An arbitrage condition ensures that the return to these investments, accounting for depreciation, is equal to the return obtained from saving in government bonds. Rigidity in nominal wages is modeled as in Schmitt-Grohé and Uribe (2005). Fixed costs ensure that profits are zero in steady-state. The remaining parameter values are as in the previous section. In these ways, the model under consideration represents a bridge between the simple specification from the previous section and the medium-scale setup used in the next.

Capital accumulation. There are many reasons to extend the model so as to include physical capital as an additional factor of production. For instance, allowing for endogenous capital accumulation has the potential to significantly alter the aggregate mechanics of the basic representative-agent New Keynesian model (Rupert and Šustek (2019)); capital inequality interacts with income inequality in heterogenous-agent settings (Bilbiie *et al.* (2019))[38]; and firms' adjustment of investment represents an important margin to consider when evaluating the aggregate effects of macroeconomic policy (Auclert *et al.* (2020)).

[38] Bilbiie *et al.* (2019) extend Bilbiie's (2019a) analysis to include physical investment and highlight that a complementarity between capital and income inequality leads to a significant amplification of the effects of monetary policy on consumption.

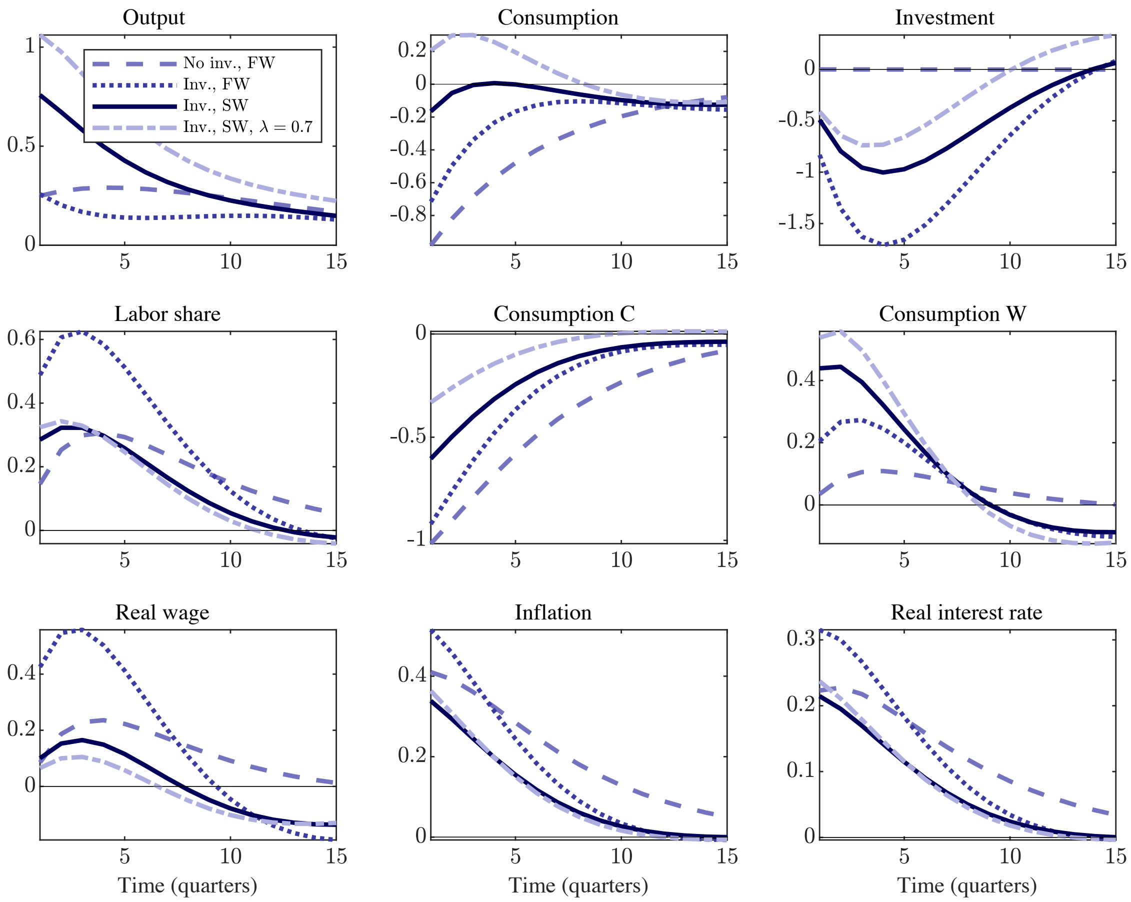

Figure 8: Government spending shock in TANK-CW with capital accumulation and wage stickiness

Notes: This figure shows the impulse responses of selected variables to a government spending shock in TANK-CW with endogenous capital accumulation and nominal wage rigidities. "FW" stands for "flexible wages" and "SW" for "sticky wages." Where applicable, the investment adjustment cost is set to $\iota = 2$, the Calvo wage stickiness is set to target an average duration of 3.5 quarters. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

Figure 8 shows the effect of an increase in government spending equal to one percent of steady-state output. Comparing the dashed line (which corresponds to a model where the investment transmission channel is shut down by letting investment adjustment costs $\iota \to \infty$) to the dotted line (which allows for it) suggests that the introduction of physical capital makes a difference to the predictions of the TANK-CW model in three ways. Firstly, allowing for endogenous capital accumulation opens the door for an important additional transmission channel through which government spending affects the economy: the response of investment is negative. Secondly, there is less crowding out of consumption overall. This is due to a stronger crowding-in of consumption by Ws and a more attenuated negative response of consumption by Cs. Finally, the response of real wages and therefore redistribution along the functional income distribution is more pronounced. The associated reduction in the income of Cs is partially compensated for by the rise in rental income earned on capital. Given a net income loss, the possibility of accessing bond markets, and constrained by investment adjustment costs, they optimally use all three margins of income adjustment in response to a government spending shock. They curtail consumption, cut back on investment spending, and also purchase relatively fewer bonds.

Nominal wage rigidities. We next study the implications of complementing rigidities in product pricing with nominal stickiness of wages. Doing so is not only consistent with ample empirical evidence (e.g., Barattieri *et al.* (2014)). It also serves as an important robustness check, seeing as one potential difficulty besetting TANK models is that the implications of limited asset market participation as in the UH-structure are potentially reversed by the introduction of wage stickiness (see Colciago (2011) and Furlanetto (2011)).

The solid line in Figure 8 suggests that introducing wage stickiness into TANK-CW improves the model performance insofar as the effect of government spending on aggregate consumption is less negative, while investment continues to respond countercyclically but less markedly so. Indeed, with a value of λ above 0.5 aggregate consumption responds positively, the impulse response being distinctively hump-shaped (dashed-dotted line). The TANK-CW model is, thus, capable of generating consumption crowding-in, but *without* relying on profit income effects on labor supply. Instead, given nominal wage rigidity, the shift in labor demand triggered by the fiscal shock results in a stronger increase in hours worked and a more muted response in real wages compared to the flexible wage case. Initially, only a fraction of wages is raised, but gradually, as wages can adjust to a greater degree, labor income grows more rapidly. Workers anticipate this brighter outlook for their income levels and respond immediately by consuming more. Meanwhile, the flip-side of the relatively muted rise in wages is that capitalists experience a less drastic fall in profit income and, consequently, reduce expenditures on consumption and capital formation to a lesser degree compared to the flexible wage case. Aggregate output, thus, reacts more positively than under flexible wages in a reflection of the more benign response of both the consumption and investment component of private sector expenditure.

Comparison to benchmark TANK model. Thus far we focused on variations due to capital accumulation and wage stickiness *within* the class of TANK-CW models. Figure 9 documents how the alternative TANK models compare once these extensions are allowed for. To aid orientation, notice that the solid line here coincides with the solid line in Figure 8. The key takeway is that the UH model may not be robust to the introduction of physical capital and wage stickiness, as argued by Ascari *et al.* (2017), among others. For even if the implied dynamics for consumption and output are reasonable, the dashed line shows that these extensions can generate (conditionally) counter-cyclical wages and weakly procyclical investment following a positive government spending shock – another result that is at odds with the empirical evidence . Indeed, even the UW model (dashed line) fails in this respect. In that sense, the predictions of the CW model for aggregate dynamics tend to be robust to the introduction of nominal wage stickiness in a way that does not hold true for the other models. The main reason is that

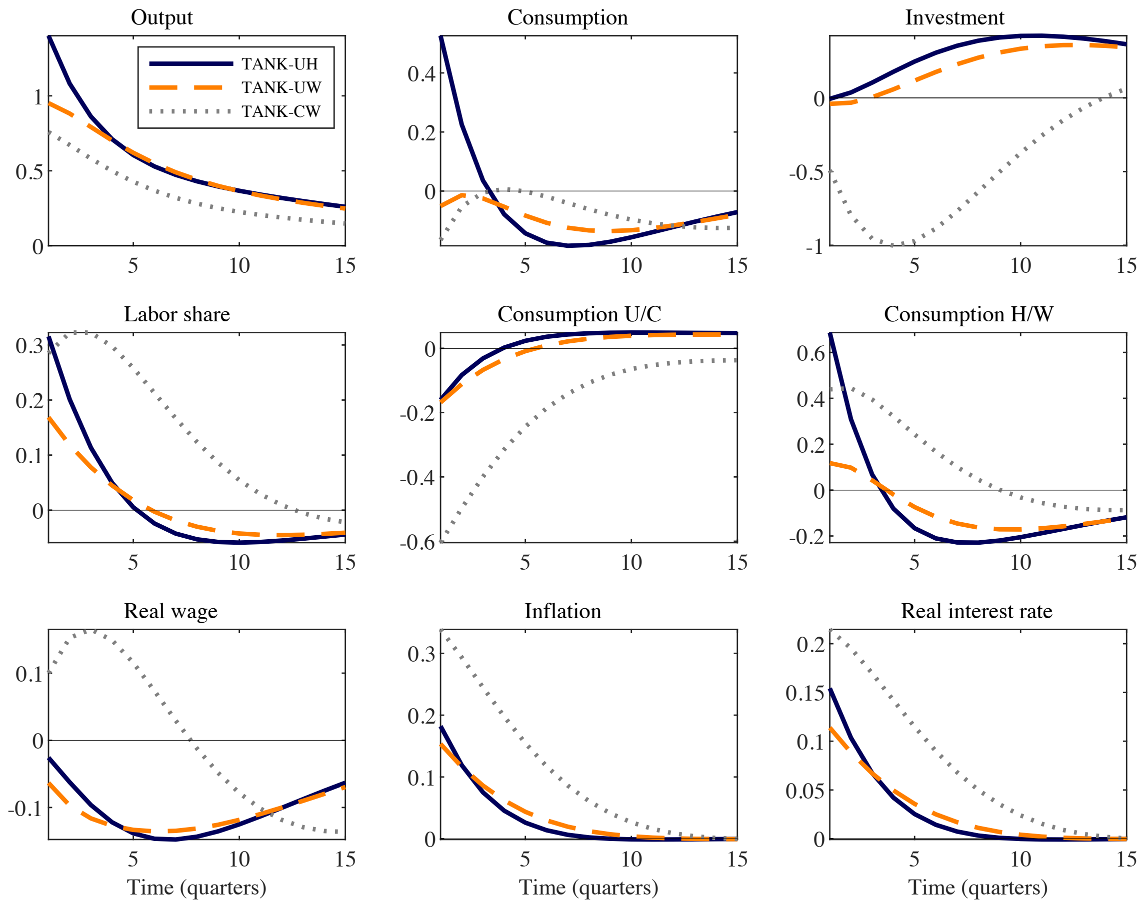

Figure 9: Government spending shocks in TANK models with capital accumulation and wage stickiness

Notes: This figure shows the impulse responses of selected variables to a government spending shock across alternative TANK models, allowing for endogenous capital accumulation and wage stickiness. Consumption components are weighted by population shares. The investment adjustment cost is set to $\iota = 2$, the Calvo wage stickiness is set to target an average duration of 3.5 quarters.

nominal wage stickiness alters the variability of profits. In models that heavily rely on profit income effects on labor supply for propagation, nominal wage stickiness thus strongly affects the transmission of shocks. The same is not true if the direct link between profits and labor supply is severed, as is the case in the model with capitalists.

3.3 Fiscal stimulus design in medium-scale TANK models

We conclude our analysis by using medium-scale versions of the benchmark UH and alternative CW TANK models to assess the quantitative effects of a fiscal stimulus in both the aggregate and distributive dimension. The objective is twofold. First, thus far we traded off quantitative testing and insight to prioritize greater tractability and transparency. Here we allow for additional bells and whistles that improve the models' ability to fit empirical data. Second, when analyzing the transmission of government spending shocks we held constant the financing mix of additional government purchases. We now allow for variation in this dimension and evaluate how this affects theoretical predictions.

Medium-scale models. As our objective here is quantitative in nature, and making use of the fact that TANK models are easily enriched, solved, and estimated, we extend the framework to incorporate other ingredients typically found in medium-scale DSGE models. This includes physical capital accumulation, nominal wage stickiness and fixed costs (the implications of which were analyzed in Section 3.2.3) as well as variable capital utilization, a more general Taylor rule featuring both interest rate smoothing and a non-zero response to the output gap, and also positive government spending as well as debt in steady-state. We refer to Appendix A.5.2 for further details and note that it would be straightforward to add other common frictions such as habits or firm-specific capital.

Methodology. Our approach in this section is to consider differences between TANK-UH and TANK-CW that remain even when we allow parameter values that make them as similar as possible. As far parameter values are concerned – summarized in Table 4 – the most important considerations pertain to λ and ψ^W, as they potentially differ across UH- and CW-variants of the TANK model. Thus far we set $\lambda = 0.5$ in either specification to maintain maximimal comparability. But the household concepts associated with the population share λ are, of course, different across models. Intuitively, one would expect λ to be *higher* in CW, because fully excluded hand-to-mouth consumer are a subset of at least partially constrained households (in terms of asset market participation). To fairly compare both models, we let our choice of parameter values be guided by impulse response matching.[39] That is, we select values of λ (in both UH and CW) and of ψ^W (in CW) by minimizing the distance between the SVAR-based empirical IRFs show in Figure A.8 and the theoretical IRFs. The results, discussed in greater detail in Appendix A.4, are that for UH to match the data an estimated 60% of households are without any access to financial markets. In CW, on the other hand, 72% are workers while 28% rely on capital income, with $\psi^W = 0.16$ imposing a degree of financial constraints on the former that is relatively close to what the micro data on iMPCs suggested. As is inevitable within the confines of a two-agent framework, either division of households is highly simplifying relative to the rich heterogeneity that may be observed in the data. But it is especially hard to countenance the idea that more than half of all households do not have any access to financial markets in the U.S. or in any advanced economy. Typical estimates of the population share of hand-to-mouth consumers are around 20% (Slacalek *et al.* (2020)) to 30% (Kaplan *et al.* (2014)). On the other hand, the CW estimates according to which around 70 % people rely almost exclusively on labor income but have some ability to smooth consumption while 30% have significant asset income seems to capture in a stylized manner the idea that wealth, and ownership of firms in particular, is concentrated. For the remaining estimated parameters, and to avoid biasing our comparison of models through differences in parameterization, we

[39]We follow the Bayesian methodology employed by Christiano *et al.* (2010).

Parameter	Interpretation	Value (H | W)	Source
β	Discount factor	0.99	Annual real interest rate of 4%
φ	Inverse Frisch elasticity	1	Benchmark
$\frac{g}{y}$	Steady-state government spending output ratio	0.2	Average across sample
$\frac{b}{y}$	Steady-state debt output ratio	4*0.57	Average across sample
$1-\alpha$	Steady-state labor share	0.67	Average
n	Steady-state labor supply	1/3	Benchmark
Π	Steady-state inflation rate	1	Benchmark
b^W	Workers' steady-state bond holdings	0	Comparability of models
υ	Capital utilization	0.5	Altig *et al.* (2011)
η	Intermediate goods elasticity of substitution	6	SS price mark-up of 20%
η^w	Differentiated labor elasticity of substitution	6	SS wage mark-up of 20%
$\phi^{\tau,t}$	Tax smoothing	0	Galí *et al.* (2007)
$\phi^{\tau,g}$	Tax response to government spending	0.1	Galí *et al.* (2007)
$\phi^{\tau,b}$	Tax response to debt	0.33	Galí *et al.* (2007)
ρ^G	AR1 Government spending shock	0.92	Average IRF matching
ψ^W	Portfolio adjustment cost	∞ | 0.16	Average IRF matching
λ	% of H/W	0.60 | 0.72	Average IRF matching
θ	Calvo price stickiness	0.86	Average IRF matching
θ^w	Calvo price stickiness	0.74	Average IRF matching
ι	Investment adjustment costs	2.14	Average IRF matching
ϕ^r	Interest rate smoothing	0.57	Average IRF matching
ϕ^π	Interest rate response to inflation	1.74	Average IRF matching
ϕ^y	Interest rate response to inflation	0.13	Average IRF matching

Table 4: Parameter values for the medium-scale models

Notes: This table lists the parameter values used in the analysis of the medium-scale TANK models. One period in the model corresponds to one quarter.

(a) Baseline

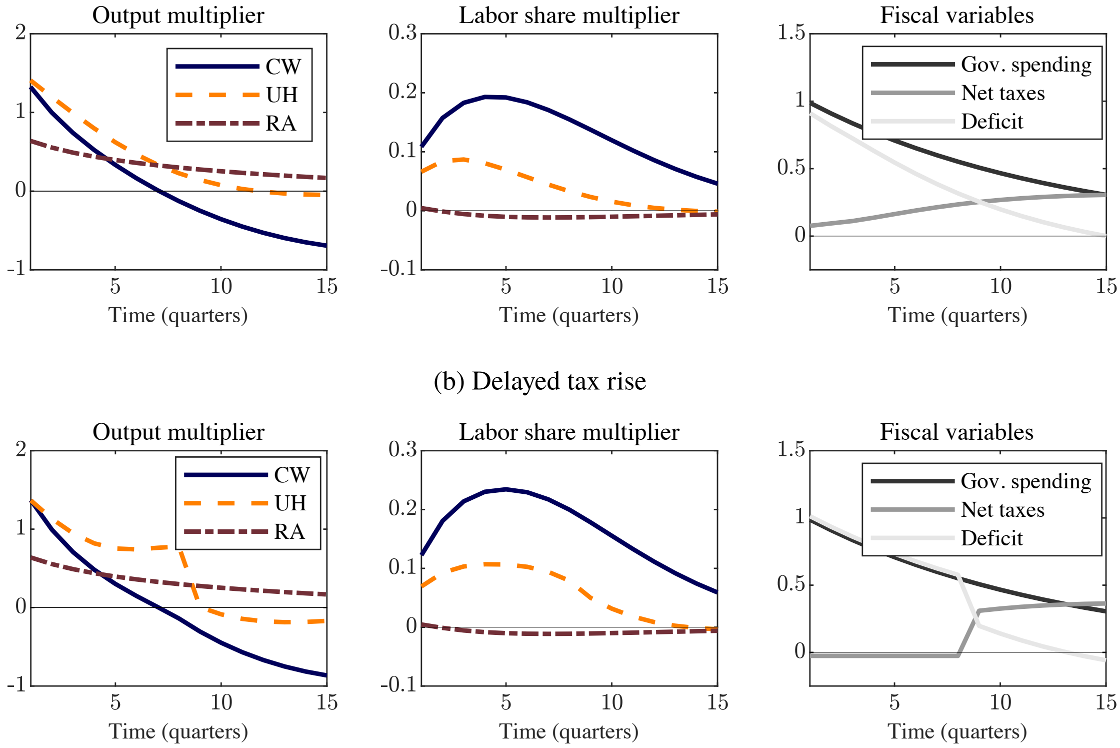

Figure 10: Fiscal stimulus effects in medium-scale TANK models

Notes: This figure shows the aggregate and redistributive effects of a government spending shock according to medium-scale TANK models. The "output multiplier" represents contemporaneous effects of government spending on output, while the "labor share multiplier" captures the contemporaneous impact on labor's share of income.

use the same values in both UH and CW versions of the model by adopting the average of estimates across the two specifications.[40]

Results. Figure 10a illustrates the effects of a fiscal stimulus on output and labor's income share according to the medium-scale TANK models. For comparison purposes, we also display the predictions emerging from a representative-agent (RA) model. In order to summarize the effects along the entire path of impulse responses, Table 5 furthermore shows the cumulative present-value multipliers for both output, as a measure of aggregate effects, and the labor share, which serves as an indicator of redistributive impact. The "cumulative labor share multiplier" k periods after the shock is computed as $\sum_{s=0}^{k}\left(\beta^j ls_j\right)/\sum_{s=0}^{k}\left(\beta^j g_j\right)$, where ls_s and g_s are the de-meaned responses of the labor share and government spending in period s.

The first insight is that even if CW and UH models are parameterized so as to give comparable output

[40]Calibrating instead *all* parameters other than λ and ψ^W in line with standard values in the literature yields results that are highly comparable to those presented here and are available upon request.

Horizon	Cumulative output multiplier		Cumulative labor share multiplier	
	CW	UH	CW	UH
1	1.33	1.41	0.11	0.07
4	0.93	1.12	0.18	0.09
8	0.60	0.84	0.22	0.09
12	0.38	0.67	0.22	0.09

Table 5: Cumulative fiscal effects according to medium-scale TANK models

Notes: This table summarizes the cumulative effects of a government spending shock according to medium-scale TANK models.

effects for a government spending shocks on impact, there remain important differences. First, the model with capitalists and workers implies stronger redistributive effects on impact and especially cumulatively over time than the traditional TANK model. This result is consistent with the analysis of mechanisms in Section 3.2. Second, as the cumulative multipliers underscore, and in line with the empirical results presented in Section 3.1, the stimulative effects on output wear off more quickly.

Considering variations in the mix of debt and taxes used to finance the increase in government spending, it is well-known that the combination of household heterogeneity and limited asset market participation gives rise to potentially significant feedback effects from the private sector (e.g., Bilbiie *et al.* (2013)). Indeed, in both UH and CW varying the coefficient on output ϕ^G in the tax rule, for instance, shows that an increase in the degree of deficit-financing reinforces both aggregate and redistributive effects of government spending shocks (at least on impact, see Appendix A.5.1). Furthermore, aggregate consumption is crowded in only if the degree of deficit financing is sufficiently high. The reason is that under deficit-financing, the offsetting effect through higher taxes is more limited and, hence, constrained agents' post-tax disposable income is higher. Given their relatively high propensity to consume, goods demand increases in a sustained manner. On the other hand, unconstrained and capitalist households act in a Ricardian fashion and, therefore, when the government alters the balance between deficit- and tax-finance this has no direct impact on their consumption choices. There is, however, an important indirect effect based on implicit redistribution. When aggregate demand is higher due to deficit-financing (as per the aforementioned logic), wages are pushed up whereas profits are compressed. As in Hagedorn *et al.* (2019) and Auclert *et al.* (2018), greater deficit-spending also leads to a more positive response of inflation and, hence, of the real interest rate, triggering a stronger crowding-out effect on investment.

While these mechanisms are operative in TANK-CW as well, counterfactual exercises reveal the contemporaneous fiscal multiplier to be less sensitive to the financing mix than implied by the traditional two-agent model. Panel 10b contrasts the benchmark case of panel 10a – in which the tax/debt mix is determined according to the standard tax rule – to an alternative fiscal path that *postpones* any increase in taxes by eight quarters. We think of the latter scenario as corresponding to a government trying to stimulate the economy in a recession without wanting to immediately reduce private sector incomes. The analysis is implemented using perfect foresight simulations. As the dashed line shows, in TANK-UH the contemporaneous output multiplier is extremely sensitive to the path of public revenue variables, that is net taxes and the deficit, according to the traditional TANK-UH model. It remains elevated as long as the stimulus is purely deficit-financed but declines sharply down after eight quarters, closely tracking the rise in taxes. This relationship is due to the extreme MPCs of hand-to-mouth households whose consumption spending tracks net disposable income one-for-one. The model with intermediate portfolio adjustment costs implies a relatively smoother response. In particular, even though workers are not fully Ricardian and, hence, the path of debt and taxes does affect their consumption levels, they *partially* anticipate the implications of higher future taxes, as underscored already in Section 2.2.1. This exercise, hence, shows how the matching of iMPCs at the micro level has implications for predictions about the effects of alternative fiscal stimulus packages at the macro level.

4 Conclusion

This paper introduced a capitalist-worker New Keynesian model for the study of fiscal policy and household heterogeneity. We showed how the introduction of two twists to the benchmark TANK model with hand-to-mouth households (Galí *et al.* (2007), Bilbiie (2008)) brings the transmission mechanism for shocks better in line with micro evidence and explained what the implications are for the aggregate and redistributive effects of fiscal policy. In doing so we incorporated insights from the recent heterogeneous-agent literature.

What we coined the “TANK-CW” model features capitalists who earn income only from firm profits and, potentially, from investing in physical capital. By contrast, workers only receive labor income and their savings choices are subject to convex adjustment costs. In terms of the building blocks this setup has three advantages: we showed analytically that it delivers realistic intertemporal marginal propensities to consume, which matters for labor demand; it avoids implausible income effects on labor supply caused by cyclical variations in profits; and the solution remains determinate under an active Taylor rule for a wide range of parameters. Underlying these results is that the model captures an intermediate degree of limited asset market participation relative to the traditional two-agent model, in which a fraction of households is fully excluded from asset markets.

Applied to the study of fiscal policy, the TANK-CW model generates a hump-shaped rise in the labor share and a contraction in investment following a government spending expansion, consistent with novel empirical evidence, even under sticky wages. On balance, the modifications of the building blocks of the traditional two-agent benchmark tend to render the cumulative effects of government spending purchases on output more muted compared to the traditional TANK setup. At the same time, redistribution from owners of firm equity to recipients of labor income remains pronounced. Crucially, though, such redistribution does not mechanically shift labor supply through profit income effects. Instead, it primarily affects aggregate dynamics through MPC heterogeneity. As such, one way of thinking about the TANK-CW model is that it represents an alternative conceptualization of the channels through which the redistributive effects of macro policy contribute to its overall impact on economic activity.

The model developed here can serve as a tractable framework to study the interaction of macroeconomic policy and household heterogeneity. The role envisioned is distinct from that of full-blown heterogeneous-agent models. For instance, certain questions of interest are not even well-defined in the present setting but can be fruitfully explored in HANK models (an example being the varied impact of aggregate shocks across the entire income distribution, see Bayer *et al.* (2020) among others). TANK models are, however, potentially useful as tractable laboratories for understanding various macroeconomic experiments; as they are fast to solve and estimate, they also lend themselves to quantitative applications incorporating a wide range of empirically relevant frictions. Relevant questions to consider in future applications of the TANK-CW model concern, for instance, the study of distortionary taxation as well as monetary policy (e.g., forward guidance). Extensions could generalize the specification of portfolio adjustment costs or increase the number of household types. Finally, a promising avenue for future research is to combine our approach to household heterogeneity with tractable models of precautionary savings and cyclical uninsurable risk (e.g., Ravn and Sterk (2017); Challe (2019); Acharya and Dogra (2020)).

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Appendix A (For online publication)

A.1 Simple TANK models

In this section we summarize the equilibrium as well as steady-state conditions for the simple TANK models discussed in Section 2. Notation is as in the main text. We also present the stability properties of the simple TANK model with capitalists and hand-to-mouth agents (TANK-CH). Finally we show sensitivity of each simple TANK model to the two key parameters ψ^W and λ.

A.1.1 Equilibrium conditions

A.1.1.1 TANK-UH Table A.1 summarizes the non-linear equilibrium conditions of a simple two-agent New Keynesian model with unconstrained and hand-to-mouth households (TANK-UH).

Description	Equation
Euler equation U	$E_t c^U_{t+1} = \beta r_t c^U_t$
Budget constraint U	$c^U_t + b^U_t = n_t\, w_t - t_t + \frac{d_t}{1-\lambda} + r_{t-1}\, b^U_{t-1}$
Budget constraint H	$c^H_t = n_t\, w_t - t_t$
Aggregate consumption	$c_t = \lambda c^H_t + (1-\lambda) c^U_t$
Labor supply	$n^\varphi_t a = \frac{w_t}{c_t}$
Dividends	$d_t = y_t - n_t w_t$
Production	$y_t = n_t$
Marginal costs	$mc_t = w_t$
Non-linear Phillips curve 1	$J_t - \beta\, \theta\, E_t \Pi^\eta_{t+1}\, J_{t+1} = \frac{mc_t y_t}{c^U_t} \frac{\eta}{\eta-1} / (1+\tau^S)$
Non-linear Phillips curve 2	$JJ_t - \beta\, \theta\, E_t {\Pi_{t+1}}^{\eta-1}\, JJ_{t+1} = \frac{y_t}{c^U_t}$
Non-linear Phillips curve 3	$1 = \theta\, {\Pi_t}^{\eta-1} + (1-\theta)\, (J_t / JJ_t)^{1-\eta}$
Fisher equation	$r_t = E_t R_t / \Pi_{t+1}$
Government budget constraint	$b_t = g_t + r_{t-1}\, b_{t-1} - t_t$
Government spending	$g_t = \rho^g g_{t-1} + \epsilon^g_t$
Fiscal rule	$\tilde{t}_t = \phi^{\tau t} \tilde{t}_{t-1} + \phi^{\tau B} \tilde{b}_t + \phi^{\tau G} \tilde{g}_t$
Taylor rule	$\hat{R}_t = \phi^\pi \hat{\Pi}_t$
Bond holdings	$b_t = (1-\lambda) b^C_t$

Table A.1: Non-linear equilibrium conditions for the TANK-UH model

Notes: J_t and JJ_t are auxiliary variables used to express the non-linear Phillips curve recursively.

The equilibrium conditions are approximated around the zero-inflation steady-state ($\Pi = 1$), in which hours worked are normalized to unity ($n = y = 1$). Then from the Euler condition of unconstrained households we have that $R = \frac{1}{\beta}$. An optimal production subsidy $\tau^S = (\eta - 1)^{-1}$ ensures zero profits in equilibrium, so that $w = mc = (1+\tau^S)\frac{\eta-1}{\eta} = 1$ and $d = 0$. For simplicity, here we assume zero government spending and debt in steady-state ($b = b^U = g = t = 0$). Given equal hours, we have an equal-consumption result; $c = c^U = c^H = 1$. Finally $a = \frac{w}{cn^{\varphi}} = 1$.

A.1.1.2 TANK-UW The equilibrium conditions of what we call the TANK-UW model are identical to those summarized in Table A.1 with the exception of an additional bond holdings variable for workers, an associated Euler equation, and a modified aggregation of bond holdings:

$$
\begin{aligned}
E_t c_{t+1}^W \left(1 + \psi^W / c^W \left(b_t^W - b^W\right)\right) &= \beta \, r_t \, c_t^W, \\
c_t^W + b_t^W &= n_t \, w_t - t_t + r_{t-1} \, b_{t-1}^W, \\
b_t &= \lambda b_t^W + (1-\lambda) b_t^U.
\end{aligned}
$$

The steady-state conditions are as in the UH model, with the additional stipulation that $b^W = 0$.

A.1.1.3 TANK-CW The non-linear equilibrium conditions of a simple two-agent New Keynesian model with capitalists and workers households (TANK-CW). Those are equivalent to the conditions summarizing the UW model apart from: the budget constraint of capitalists includes no labor income; aggregate labor supply is replaced by a condition referring just to workers; and budget constraints include a lump-sum tax τ^W to preserve zero consumption inequality in steady-state. Table A.2 summarizes.

As regards the steady-state, for workers' hours worked we now have that $n^w = \frac{n}{\lambda} = \frac{1}{\lambda}$. To ensure equal consumption in steady-state, we introduce a lump-sum transfer from workers to capitalists $\tau^W = (wn^W) - c^W = \frac{1}{\lambda} - 1$. Labor dis-utility weight is now $a = \frac{w}{c^w {n^W}^{\varphi}} = \lambda^{\varphi}$. Then the remaining conditions are unchanged.

Description	Equation
Euler equation C	$E_t c^C_{t+1} = \beta r_t c^C_t$
Budget constraint C	$c^C_t + b^C_t = \frac{d_t}{1-\lambda} + r_{t-1}\, b^U_{t-1} - t_t + \tau^W$
Euler equation W	$E_t c^W_{t+1}\,\left(1 + \psi^W / c^W\,\left(b^W_t - b^W\right)\right) = \beta\, r_t\, c^W_t$
Budget constraint W	$c^W_t + b^W_t = n^W_t\, w_t - t_t + r_{t-1}\, b^W_{t-1} - \tau^W$
Labor supply W	$n^{W\varphi}_t a = \frac{w_t}{c^W_t}$
Aggregate consumption	$c_t = \lambda c^W_t + (1-\lambda) c^C_t$
Aggregate hours	$n_t = \lambda n^W_t$
Dividends	$d_t = y_t - n_t w_t$
Production	$y_t = n_t$
Marginal costs	$mc_t = w_t$
Non-linear Phillips curve 1	$J_t - \beta\,\theta\, E_t \Pi^\eta_{t+1}\, J_{t+1} = \frac{mc_t y_t}{c^C_t}\,\frac{\eta}{\eta-1} / (1+\tau^S)$
Non-linear Phillips curve 2	$JJ_t - \beta\,\theta\, E_t {\Pi_{t+1}}^{\eta-1}\, JJ_{t+1} = \frac{y_t}{c^C_t}$
Non-linear Phillips curve 3	$1 = \theta\, {\Pi_t}^{\eta-1} + (1-\theta)\, (J_t / JJ_t)^{1-\eta}$
Fisher equation	$r_t = E_t R_t / \Pi_{t+1}$
Government budget constraint	$b_t = g_t + r_{t-1}\, b_{t-1} - t_t$
Government spending	$g_t = \rho^g g_{t-1} + \epsilon^g_t$
Fiscal rule	$\tilde{t}_t = \phi^{\tau t} \tilde{t}_{t-1} + \phi^{\tau B} \tilde{b}_t + \phi^{\tau G} \tilde{g}_t$
Taylor rule	$\hat{R}_t = \phi^\pi \hat{\Pi}_t$
Bond holdings	$b_t = \lambda b^W_t + (1-\lambda) b^C_t$

Table A.2: Non-linear equilibrium conditions for the TANK-CW model

Notes: This table summarizes the non-linear equilibrium conditions of a simple two-agent New Keynesian model with capitalists and workers

A.1.2 Stability properties

Figure A.1 shows that in the simple model with capitalists and hand-to-mouth households, there exist no combinations of the population parameter λ and inverse Frisch elasticity φ for which the rational expectations equilibrium is locally unique given an active Taylor principle $\phi_\pi > 1$. The introduction of an intermediate level of portfolio adjustment costs, with $\psi^W = 0.25$ restores this possibility.

(a) Without PACs (b) With PACs

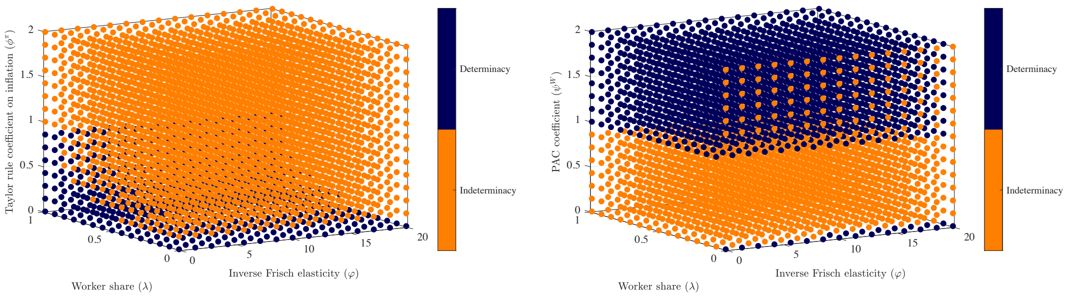


Figure A.1: Stability regions when adding capitalists: with and without portfolio adjustment costs

Notes: This figure shows regions in parameter space that are associated with the presence of uniqueness and multiplicity of the rational expectations equilibrium in a neighborhood of the steady-state, respectively. For details on the values of other parameters, which the plots are conditional on, see Table 3.

A.1.3 Sensitivity results

Figure A.2 shows how a higher value of ψ^W in TANK-UW increases both the aggregate and the re-distributive effect of fiscal policy. The responses of both output and labor share both become more positive the more constrained workers are. On the other hand, once the profit income effect on labor supply is removed as in TANK-CW, higher values of ψ^W *dampen* the aggregate effect (see Figure A.3). The reason is that the stronger rise (fall) in the labor share (profits) that results from workers' increase in consumption – which is greater the more costly saving is at the margin – pushes up unconstrained households' labor supply in TANK-UW, whereas this is not the case in TANK-CW.

Considering perturbations of the population share parameter λ, Figures A.4-A.6 reveals that a higher λ is associated with a higher average marginal propensity to consume and, therefore, generates a more positive consumption and output response in all three model variants. This directly follows from household heterogeneity and the fact that both hand-to-mouth and workers' (impact) MPCs (and for workers also iMPCs in subsequent periods) are higher than those of permanent-income consumers. Compared to the UH benchmark, however, the elasticity of consumption (and output) with respect to discretionary government spending is lower in the CW model.

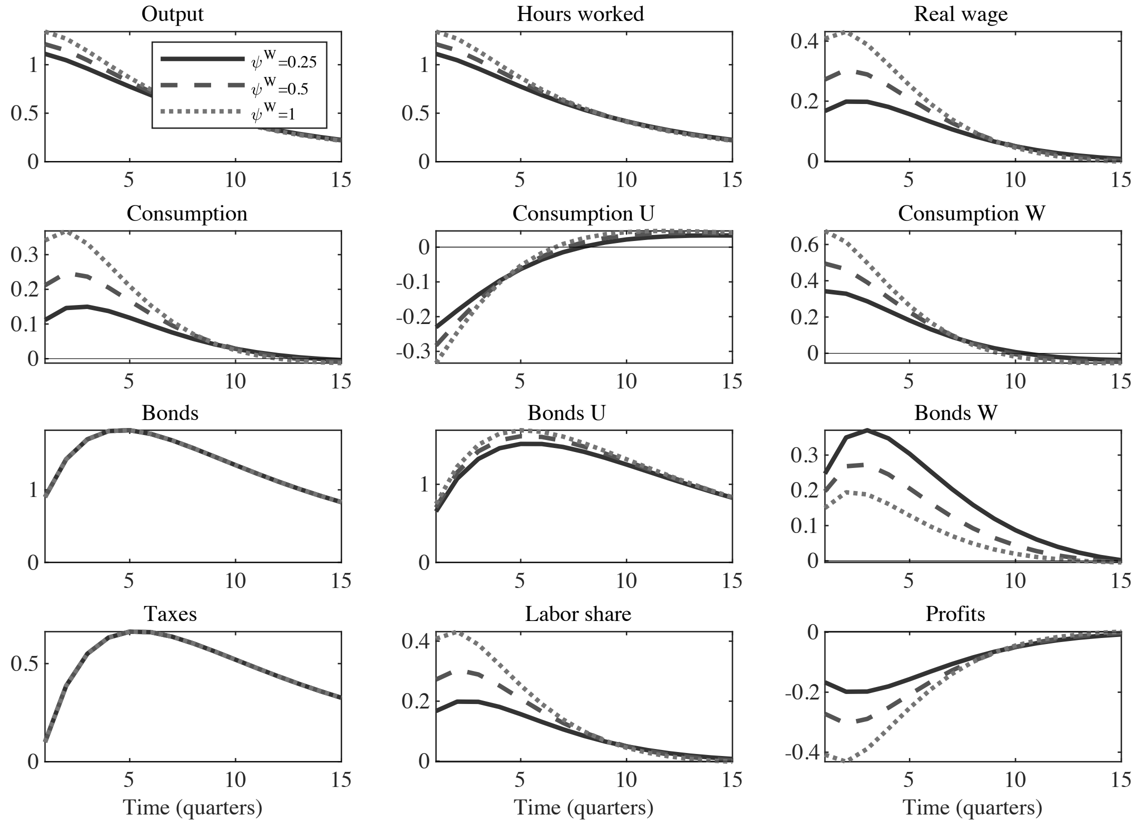


Figure A.2: Sensitivity to ψ^W in TANK-UW

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of ψ^W in TANK-UW. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

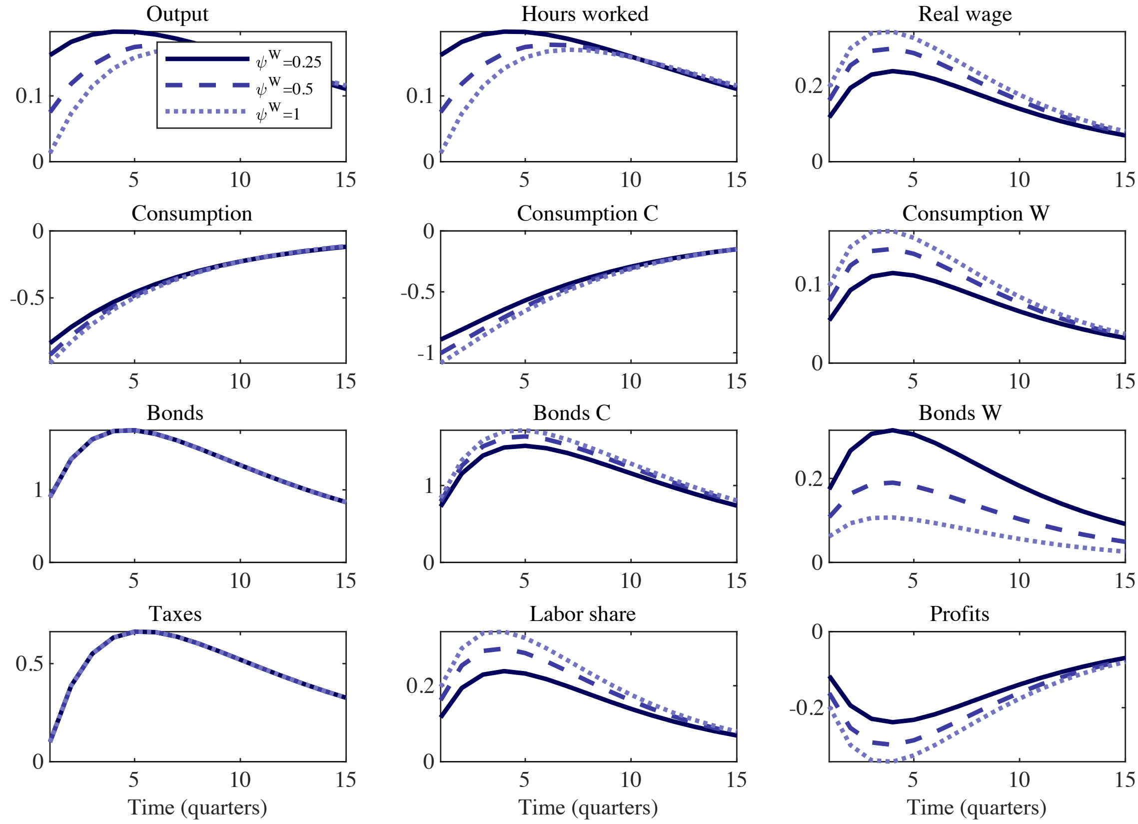


Figure A.3: Sensitivity to ψ^W in TANK-CW

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of ψ^W in TANK-CW. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

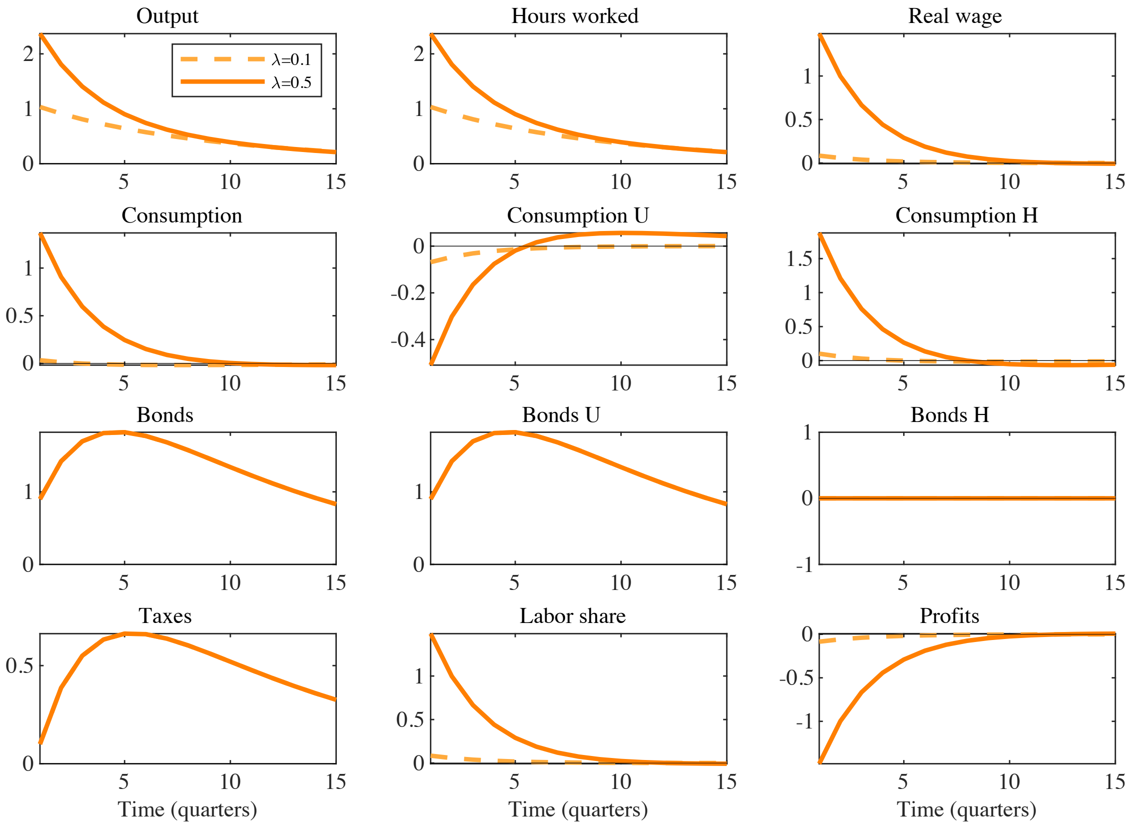


Figure A.4: Sensitivity to λ in TANK-UH

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of λ in TANK-UH. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

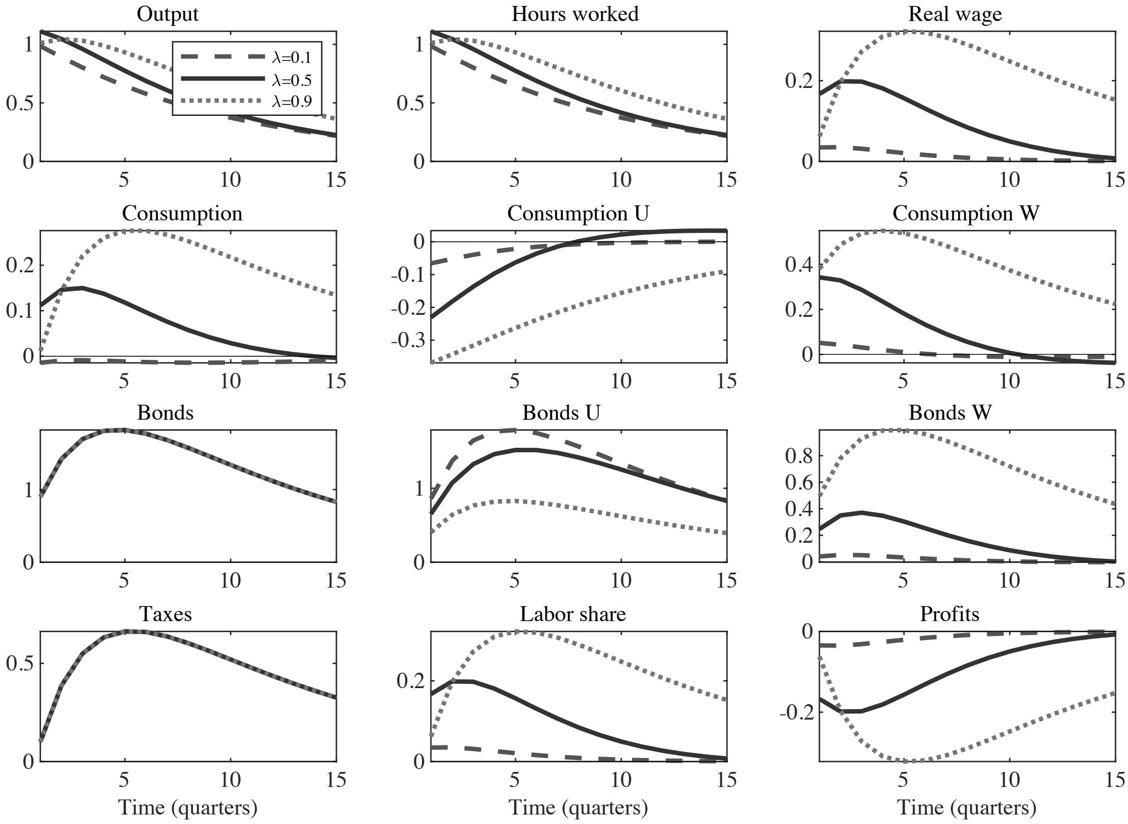


Figure A.5: Sensitivity to λ in TANK-UW

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of λ in TANK-UW. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

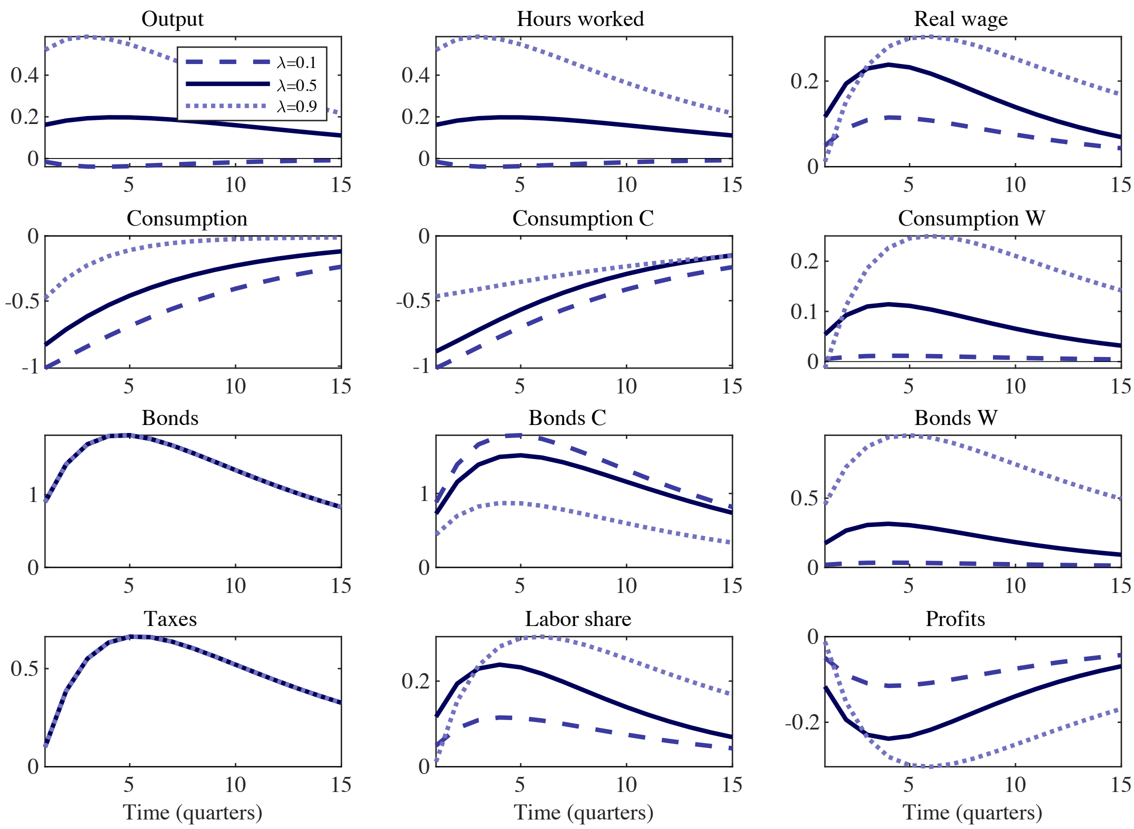


Figure A.6: Sensitivity to λ in TANK-CW

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of λ in TANK-CW. All series are in proportional deviations from their steady-state (in %) except for the fiscal variables (government spending, bonds and taxes), which are measured in percentage of steady-state output. Consumption components are weighted by population shares.

A.2 Alternative consumption models

A.2.1 Proof of Propositions 1 and 2

To solve the partial equilibrium consumption-savings problem with portfolio adjustment costs, first substitute out consumption from the worker household's Euler equation (6) using the budget constraint (7):

$$\left(1 + R + \psi^W\right) \tilde{b}_t^W = E_t \left[\tilde{b}_{t+1}\right] + R\tilde{b}_{t-1}^W - \left[E_t \hat{x}_{t+1}^W - \hat{x}_t^W\right], \tag{A.1}$$

where set set $\hat{r}_t = 0$ given the focus on partial equilibrium iMPCs.

Next, use a factorization method, for instance, to handle the resulting forward-backward system. Denoting the forward operator F we can write equation (A.1) as

$$\left(F^2 - \left(1 + R + \psi^W\right) F + R\right) E_t \tilde{b}_{t-1} = -\left[E_t \hat{x}_{t+1}^W - \hat{x}_t^W\right]$$

Focusing on the saddle-path stable configuration, with roots of the characteristic polynomial $|\mu_1| < 1$ and $|\mu_2| > 1$, the savings choice is

$$\tilde{b}_t^W = \mu_1 \tilde{b}_{t-1}^W - \sum_{l=0}^{\infty} \mu_2^{-(1+l)} E_t \left[\hat{x}_{t+l+1}^W - \hat{x}_{t+l}^W\right], \tag{A.2}$$

where $\mu_1 = \frac{1+R+\psi^W}{2} - \sqrt{\left(1 + R + \psi^W\right)^2 - 4R}$ and $\mu_2 = \left(1 + R + \psi^W\right) - \mu_1$. Consumption is backed out from

$$\hat{c}_t^W = \hat{x}_t + R\tilde{b}_{t-1}^W - \tilde{b}_t^W. \tag{A.3}$$

Equations (10) through (13) then follow by by differentiating $\hat{c}_t^W$ with respect to $\hat{x}_0$ (Proposition 1) and $E_0 [\hat{x}_s]$, $s \geq 1$ (Proposition 2), respectively. Since the log-linearization is done around a steady-state with $x^W = 1$, the results correspond to iMPCs computed from a linearized version of the model.

□

A.2.2 Bond-in-utility

Section 2.2.1 of the main text used a simple partial equilibrium consumption-savings problem to show that the introduction of bond portfolio adjustment costs (PACs) gives rise to a plausible pattern of intertemporal marginal propensities to consume (iMPCs). The relevant Euler equation could be written in the form (cf. equation (5)):

$$u'(c_t) = \beta E_t u'(c_{t+1}) \left(R_t/\Pi_{t+1}\right) \frac{1}{1 + \varrho'(b_t)}, \tag{A.4}$$

where $\varrho'(b_t)$ is the first derivative of a convex adjustment cost function, so that $\varrho''(b_t) > 0$ (assuming $v(\cdot)$ to be twice differentiable for simplicity). In the main text we used a simple quadratic penalization function measured in deviations from steady-state and indexed by a single parameter ($\varrho'(b_t) = \frac{\psi}{2}\left(b_t - b\right)^2$) and showed how this approach produced a pattern of iMPCs consistent with empirical data as well as the predictions of multi-asset HANK models.

Here we briefly compare and contrast our proposal to an alternative model which likewise has this attractive property and relies on the introduction of (real) bonds into the utility function ("BU" for short; see references given in the introduction). The two approaches share some features but there also exist relevant differences and they are not mutually exclusive. Suppose we introduced an additional bond term into the household's objective function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t) + v(b_t)\right], \tag{A.5}$$

where $v(\cdot)$, just like $u(\cdot)$, is increasing and strictly concave; the assumption of separability is for simplicity's sake. Then the analogue to equation (A.4) is

$$u'(c_t) = \beta E_t u'(c_{t+1}) \left(R_t/\Pi_{t+1}\right) + v'(b_t), \tag{A.6}$$

where $v''(b_t) < 0$ by assumption. Both the PAC and the BU specification can, in principle, be introduced into a representative-agent framework. But for a number of reasons a two-agent specification in which only a fraction of the population has these properties is attractive, for instance, in order to describe heterogeneity of marginal propensities to consume and, thus, capture aggregate effects of redistribution.[A.1]

It is not surprising that the introduction of a *convex cost* to savings and a *concave benefit*, respectively, can give rise to similar behavior. Both specifications imply that the marginal benefit from saving is decreasing. Consequently, the household wants to consume more out of an income windfall and the pattern of iMPCs displays a gradual decay in either case.

At the same time, there are a number of differences. Firstly, and viewed through a mechanical lens, the two approaches are not exactly isomorphic. The adjustment cost appears in the budget constraint

[A.1] Of course, one could also suppose that both "types" in a two-agent setting enjoy non-zero utility from holding bonds or are subject to non-trivial financial frictions. While this may be considered more realistic, we find the parsimony of the approach taken in the main text attractive.

and gives rise to a multiplicative wedge in the Euler equation (A.4). By contrast, the bond-in-utility approach implies an additive wedge in equation (A.6).[A.2]

Of more substantive importance is that the bond-in-utility approach naturally lends itself to the analysis of steady-state properties (see, e.g., Hagedorn (2018a,b), Michaillat and Saez (2019), as well as Mian *et al.* (2019)), whereas adjustment costs are generally taken to be zero in steady-state. Consistent with this difference, we focused on the effect of macroeconomic policy away from the steady-state.[A.3]

Thirdly, the BU approach can be viewed as a shortcut to incorporating the effects of the precautionary savings motive due to idiosyncratic risk that is operative in an incomplete markets context. As such, including bonds in the utility function introduces an *additional* savings motive, albeit one that is decreasing in the level of existing savings. We think of the inclusion of portfolio adjustment costs, on the other hand, as a generalization of the hand-to-mouth behavior characteristic of traditional two-agent models in the spirit of Campbell and Mankiw (1989), Galí *et al.* (2007) and Bilbiie (2008).[A.4] This friction *reduces* the incentive to save, other things equal. To some extent, the choice between the two approaches may be a matter of personal preference, but it is suggestive that in their discussion of the BU approach ARS19 suggest a two-agent model that combines one type of agent with bonds in the utility with a fraction of hand-to-mouth agents – thus modifying the consumption behavior of the unconstrained households' – whereas in our model we primarily tackle the consumption behavior of the constrained type of household.

In summary, the bond-in-utility approach and the financial friction considered in this paper are both capable of generating empirically realistic iMPCs and there is room for future empirical research to adjudicate their relative importance in accounting for the pattern of aggregate consumption behavior. Given differences in application and interpretation, though, the two models are potentially complementary.

A.2.3 Habits

In the main text, we propose limited asset market participation modeled through convex portfolio adjustment costs as a tractable way of describing household consumption behavior in line with both micro and macro data. This approach contrasts with the extensively used assumption of 'habit formation' in the utility function, which we briefly consider here.[A.5]

According to a common model of habit formation, the period utility function of a representative

[A.2] Allowing for non-separability in the utility function would dilute this difference.

[A.3] Allowing the target savings level $\bar{b}$ to be different from the steady-state b would make the two approaches more similar in this respect.

[A.4] Since the inclusion of hand-to-mouth consumers is sometimes spoken of as representing "limited asset market participation," one could speak of the approach taken in this paper as "limited limited asset market participation."

[A.5] We consider external habit formation as in Smets and Wouters (2007). Internal habits give rise to similar properties.

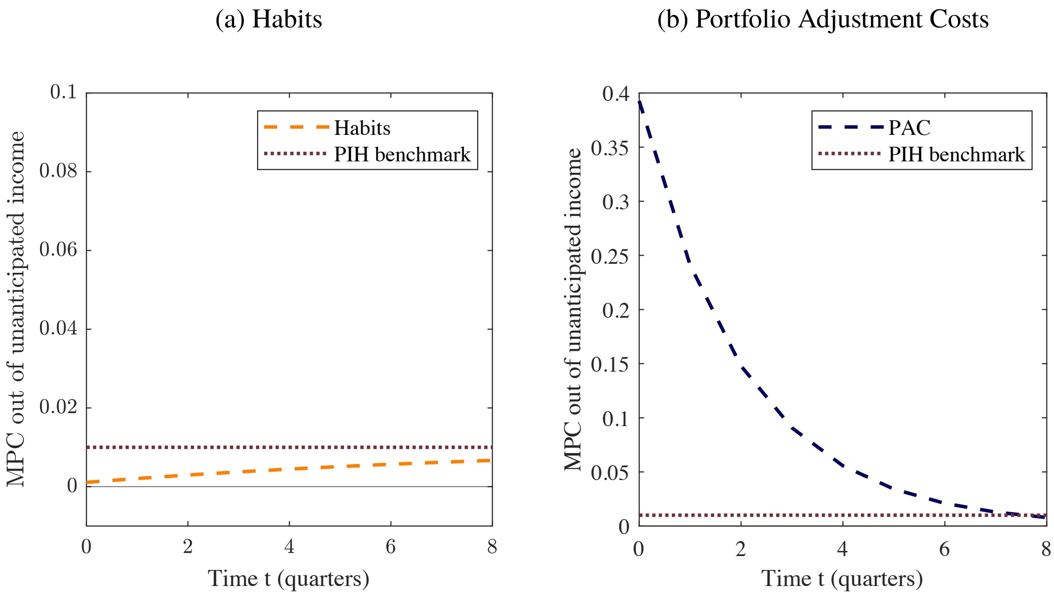


Figure A.7: Theoretical iMPCs: Comparison to Habits Model

Notes: The two panels show the dynamic consumption response to a period $s = 0$ unanticipated income shock under alternative specifications of the consumption/savings problem: the benchmark permanent income hypothesis (PIH), which corresponds to the "unconstrained" household in Figure 2 in the main text; an economy with habit formation (with $\xi = 0.9$); and a household subject to portfolio adjustment costs (PACs), denoted "worker" in the main text. The horizontal axis shows time measured in quarters. The vertical axis displays the marginal propensity to consume $\partial c_t / \partial x_0$.

household i becomes $u(c_t^i) = \frac{1}{1-\sigma}\left(c_t(i) - \xi c_t\right)^{1-\sigma}$, where c_t is aggregate consumption, σ is the coefficient of relative risk aversion, and $\xi \in (0,1)$ is a habit formation coefficient. As is well known, the resulting model can give rise to the kind of persistent and hump-shaped response of aggregate consumption to shocks commonly found in empirical macro studies.

Habit formation implies consumption dynamics that are inconsistent with the *micro* evidence, however, as discussed in greater detail by Auclert *et al.* (2020) (also see Carroll *et al.* (2018)). Figure A.7 illustrates: the left panel compares intertemporal marginal propensities to consume (iMPCs) as implied by the permanent income hypothesis (PIH) with those of a household with habits; the right panel reproduces relevant parts of Fig. 2 in the main text for convenience. It is evident that, at least for the first few quarters, habits imply *lower* MPCs compared to a no-habit economy ($\xi = 0$), thus exacerbating one of the key empirical challenges that the introduction of such frictions as limited asset market participation into theoretical models is intended to address. Second, habits imply *increasing* rather than decreasing first differences for the dynamic consumption response to an unanticipated income shock, making the model with habits look even more at odds with the micro evidence reviewed in Section 2.1 than the standard PIH.[A.6]

[A.6] Havranek *et al.*'s (2017) survey of the micro literature furthermore finds little evidence for the existence of consumption habits sufficiently strong to explain the substantial persistence or 'excess smoothness' of aggregate consumption.

A.3 Empirics

A.3.1 Baseline Specification

The baseline VAR specification is a nine-variable VAR estimated for the U.S. using quarterly data spanning from 1981:Q3 to 2007:Q4 using standard Bayesian methods. The data comprise: (i.) log real government spending (consumption plus gross investment); (ii.) the cumulated forecast of government spending growth over the next four quarters, $F_t(1,4)$;[A.7] (iii.) log real net taxes; (iv.) log real GDP; (v.) log real consumption (durables and non-durables); (vi.) log real investment; (vii.) log labor share; (viii.) log real corporate profits; (ix.) the GDP deflator; and (x.) the 10-year real interest rate. The inclusion of the long-term interest rate helps capture agents' expectation and significantly reduces the forecasteability of government spending shocks.

The starting date is dictated by the availability of SPF data for fiscal variables and coincides approximately with the beginning of the Great Moderation. The end date is prior to the start of the Great Recession to avoid potential structural breaks, but below we also report results obtained ending the sample in 2016, and using rolling windows. The lag length is chosen based on information criteria, which suggest the use of two lags for the baseline SVAR. The equations are estimated in levels to preserve potential cointegrating relationships among the variables. We include a quadratic time trend as in Ramey (2016) to capture features such as the productivity slowdown or the effect of the baby boom. Results are robust to the inclusion of a linear trend (or a constant) only. In line with standard Bayesian practice, the (reduced-form) VAR is estimated using Markov Chain Monte Carlo Methods employing a normal-diffuse ("Jeffrey's") prior for the coefficient matrix and the covariance matrix of the reduced-form innovations, respectively. Impulse responses and posterior credible sets are generated based on 10,000 draws.

As far as the inclusion of the forecast variable $F_t(1,4)$ is concerned, a defining property of SVAR models is that the structural shocks, denoted ϵ_t, can be recovered linearly from past and present values of the observed data, y_t. Yet this assumption may be violated if the econometrician does not observe all variables relevant to the decisions of forward-looking agents. The problem of 'non-fundamentalness' or 'non-invertibility', of which fiscal foresight is one specific cause, may accordingly be understood as reflecting deficient information, akin to an omitted variables problem. Our use of SVAR methods in the face of this potential threat to validity is then premised on the insight that, in applied work, the necessary condition for recovering the IRFs for a particular shock is not fundamentalness but sufficient information (Forni and Gambetti, 2014), a shock-specific generalization of the fundamentalness concept.

[A.7] Including the one-step-ahead forecast ($h = 1$) as the second variable in the SVAR, instead, and identifying the "purified" surprise spending shock as the first Cholesky shock would essentially be equivalent to the strategy followed by Auerbach and Gorodnichenko (2012) as well as Born *et al.* (2013). However, if the number of periods of anticipation exceeds one, then this variable will *not* include the news shock. By contrast, using $F_t(1,4)$ as the news variable in the VAR increases the chances of capturing all relevant anticipation effects. We have also experimented with a news variable capturing expectations revisions ($N_t(1,3)$ in the notation of Forni and Gambetti (2016) and the results are very similar to the $F_t(1,4)$ approach.

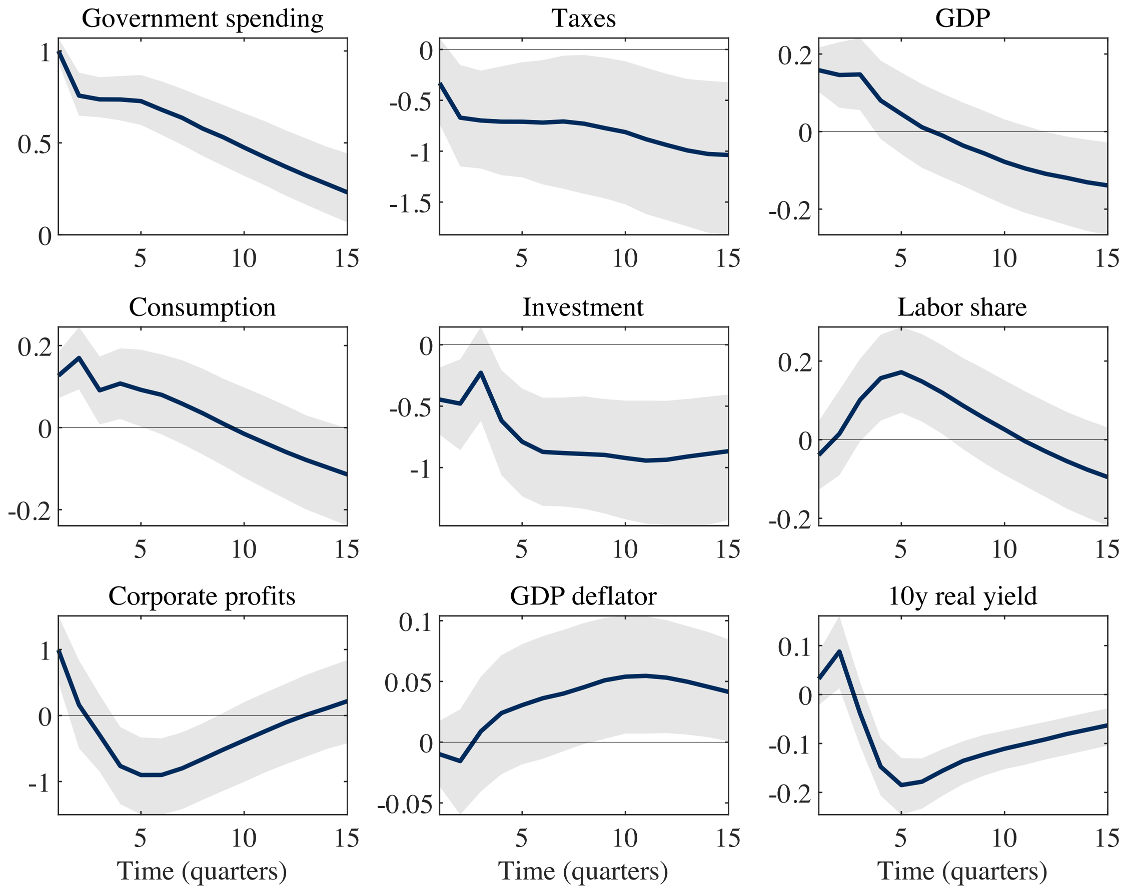


Figure A.8: VAR evidence on the effects of an unanticipated shock to government spending (U.S.)

Notes: This figure shows empirical impulse responses for an unanticipated government spending shock. Impulse responses are scaled such that the log change of government spending is unity at its peak. Solid lines indicate the median posterior density of impulse responses, while the shaded area represents the 16th to 84th percentiles. All series except interest rate and inflation rate shown in proportional deviations from baseline.

Suppose that the structural shock of interest is $\epsilon_{1,t}$ and denote as H_t^y the econometrician's information set based on VAR data y_t. Then the VAR is informationally sufficient for $\epsilon_{1,t}$ if $\epsilon_{1,t} \in H_t^y$. We may relate this concept to fundamentalness noting that ϵ_t is fundamental for y_t if and only if y_t is informationally sufficient for $\epsilon_{i,t}, i = 1, ..., n_\epsilon$.

Figure A.8 reports the full set of impulse responses for a one percent increase in government spending. Notice that in the main text we considered an approximately five times larger shock (approximately one percent of GDP) in order to facilitate a more direct comparison with theoretical results coming from models with zero and positive government spending in steady-state, respectively.

A.3.2 Data Sources and Transformation

A.3.2.1 USA The components of national income, government receipts and the GDP deflator are taken from the NIPA tables of the Bureau of Economic Analysis. Further series are retrieved from the FRED database of the Federal Reserve Bank of St. Louis. All national income series are seasonally adjusted by the source and, unless otherwise stated, are deflated using the GDP deflator. Where necessary we take the arithmetic average of monthly figures to obtain quarterly series. Data from the Survey of Professional Forecasters is available on the website of the Federal Reserve Bank of Philadelphia.[A.8] Table A.3 lists the data sources used.

Construction of the labor share. Our baseline measure, which in the table corresponds to **LS6**, considers the domestic non-financial corporate (NFC) sector. As is frequently done especially in sectoral studies, gross value added (GVA) is used. The formula is

$$LS6 = 1 - \frac{CP^{gva} + NI^{gva} - Tax^{gva}}{NVA}.$$

A.3.2.2 Canada, Australia and United Kingdom For Australia, Canada and the United Kingdom data are retrieved from the Australian Bureau of Statistics, Canada Statistics and the UK Office for National Statistics, respectively. Table A.4 summarizes.

A.3.3 Results for Australia, Canada, and the UK

The scope of the new stylized fact about the response of the labor share to government spending shocks is not restricted to the US, as this section demonstrates by examining the cases of Canada, Australia and the UK. In all three cases, we limit ourselves to recursive identification given limited data availability in terms of proxies for news shocks, and we study the sample 1970:I-2007:IV for which high-quality data is available for all three countries.[A.12] Figure A.9 shows that in all three countries, in response to a surprise government spending shock, the labor share initially increases in a statistically significant manner before reverting back to the mean, potentially with a degree of undershooting after several

[A.8] The SPF provides separate forecasts for state, local and federal government spending, whereas our variable of interest is total government spending. We aggregate the individual components to obtain a forecast for the latter, and constructed news variables on this basis. This procedure may introduce bias in our estimates, because in 1996, the U.S. Bureau of Economic Analysis (BEA) switched its method for aggregating the headline components of real GDP and the associated price indexes from the fixed-weight aggregation method to the chain-weight aggregation method. Under the latter ("Fisher ideal"), additivity of real levels does not hold (Whelan 2002). We have verified that the results obtained are robust to using news variables based on federal spending only.

[A.9] Before 1953:II, interpolated annual data available on Robert Shiller's database at http://www.econ.yale.edu/ shiller/-data.htm

[A.10] http://econweb.ucsd.edu/ vramey/research.html

[A.11] Seasonally adjusted fiscal data for the UK going back to 1963 were were kindly provided by the ONS.

[A.12] For a description of the variables and data sources, see the appendix. We use two lags for Canada and Australia and three for the UK.

Mnemonic	Description	Source
GOV	Gov. consumption expenditures + gross investment	NIPA 1.1.5.
GOVCON	Gov. consumption expenditures	NIPA 3.9.5
GOVINV	Gov. gross investment	NIPA 3.9.5
TAX	Current receipts - current transfer payments - current interest payments	NIPA Table 3.1
GDP	Gross Domestic Product	NIPA 1.1.5
RINT	10Y Tsy constant maturity rate (quarterly avg.), adjusted by GDP deflator	FRED: GS10[A.9]
HOURS	Total hours worked, including military	V. Ramey's database[A.10]
WAGES	Real Hourly Compensation, Business Sector	BLS: PRS84006153
PGDP	GDP deflator	NIPA 1.1.4
LS1	LS in the non-farm business sector	BLS
LS2	LS in the non-financial business sector	BLS
CE	Compensation of employees	NIPA 1.12
CE_{gov}	Wages and salaries: government	NIPA 1.12
RI	Rental income (with CCAdj)	NIPA 1.12
CP	Corporate profits (with IVA and CCAdj)	NIPA 1.12
NI	Net interest income	NIPA 1.12
δ	Consumption of fixed capital	NIPA 1.7.5
PI	Proprietors' Income	NIPA 1.12
TAX^P	Taxes on production - subsidies on production	NIPA 1.12
BCTP	Business current transfer payments	NIPA 1.12
Sdis	Statistical discrepancy	NIPA 1.12
GE	Current surplus of government enterprises	NIPA 1.12
GNP	Gross national product	NIPA 1.7.5
CP^{gva}	Corporate profits, GVA (NFC)	NIPA 1.14
NI^{gva}	Net interest and miscellaneous payments (NFC)	NIPA 1.14
TAX^{gva}	Taxes less subsidies on production and imports (NFC)	NIPA 1.14
NVA	Net value added (NFC)	NIPA 1.14

Table A.3: Data Sources – US

Mnemonic	Australia	Canada	UK
GOV	General government final consumption expenditure + general government gross fixed capital formation	General government final consumption expenditure + general governments gross fixed capital formation	General government total current expenditure + total net investment[A.11]
TAX	General government total gross income - general government total income payable - subsidies	General government revenue - current transfers to households - interest on debt	General government total current receipts - net social benefits
GDP	GDP adjusted using the GDP deflator	GDP adjusted using the GDP deflator	GDP adjusted using the GDP deflator
LS	Naive measure calculated as total wages and salaries (including social security contributions) over GDP	Naive measure calculated as compensation of employees over total factor income, computed as (GDP-taxes less subsidies on products and imports)	Naive measure calculated as compensation of employees over gross value added at factor cost
RINT	10 year government bond yield (FRED: IRLTLT01AUQ156N) deflated using the GDP deflator	10 year government bond yield (FRED: IRLTLT01CAM156N) deflated using the GDP deflator	10 year government bond yield (FRED: IRLTLT01GBM156N) deflated using the GDP deflator

Table A.4: Data Sources – Australia, Canada, and UK

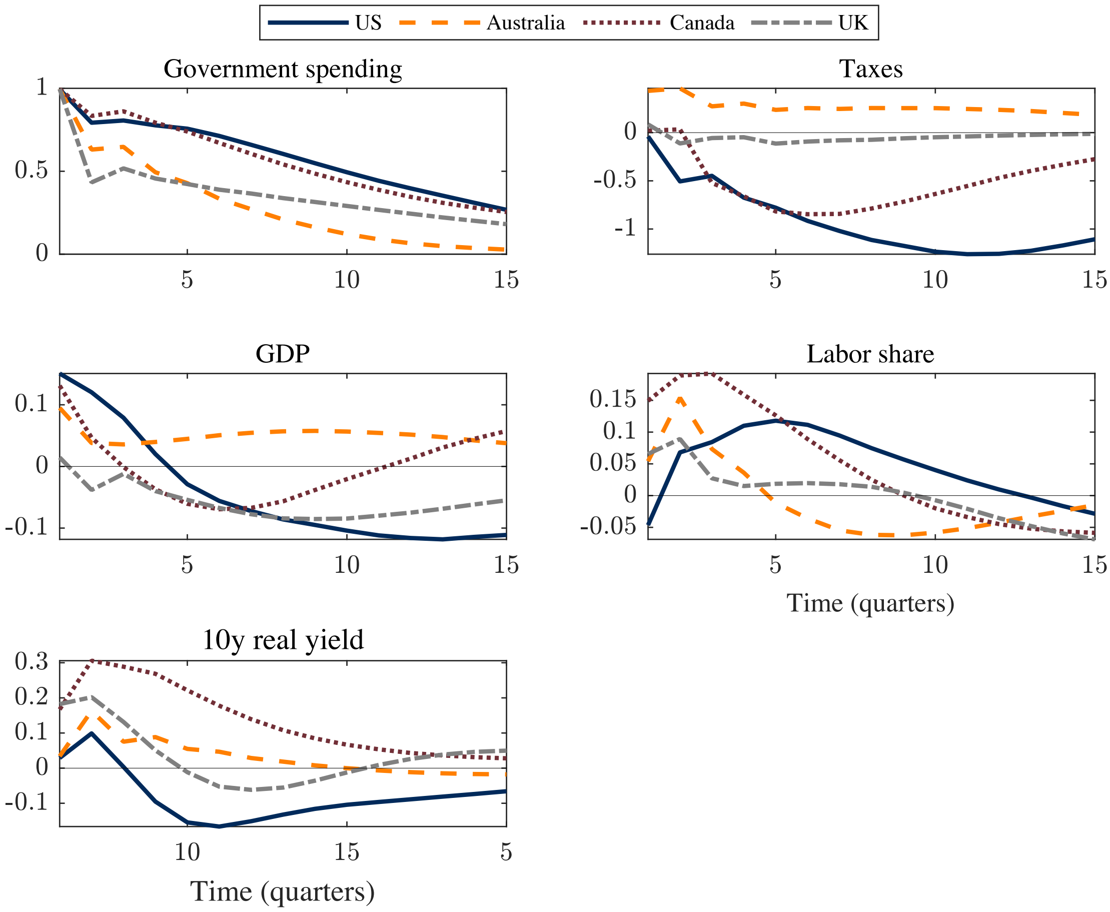


Figure A.9: Effects of an unanticipated shock to government spending (Australia, Canada, UK)

Notes: This figure shows impulse responses for a recursively identified government spending shock, estimated separately for Australia, Canada, and the UK (1970:I-2007:IV). The U.S. case is shown for comparison purposes. It is identified and estimated using the same method over the same sample. The median posterior density of impulse responses is displayed in form of a solid line while the 16th and the 84th percentiles are shown as dotted lines. Impulse responses are scaled such the log change of government spending is unity at its peak. All series except interest rate shown in %.

years. Qualitatively, these dynamics are remarkably close to those reported earlier for the US.[A.13]

A.3.4 Robustness checks

This appendix section provides a number of robustness checks for our main, novel empirical results: that the response of the labor share to an unanticipated increase in government purchases is positive, persistent and hump-shaped during the Great Moderation period in the U.S. We verify that our results are robust to (a.) different countries; (b.) Jordà's (2005) local projections to compute impulse responses as in Ramey (2016) and Ramey and Zubairy (2018); (c.) different labor share proxies; and (d.) varying sub-samples. We use a smaller VAR for sake of expositional clarity. Additional details and figures are

[A.13]The magnitude of the labor share increase for the Canada and Australia is notably larger than observed for the US, but it is significantly smaller for the UK where, in addition, the multiplier is negative (consistent with ?).

available upon request.

A.3.4.1 Local projections In the spirit of Ramey (2016) and Ramey and Zubairy (2018), we next use local projection methods as an alternative econometric approach to obtaining estimates of IRFs to government spending shocks. LP-based impulse responses are sometimes seen as more robust to non-fundamentalness issues caused by fiscal foresight, the reason being that the multivariate system is not specified and estimated in the first place (for details and questions about this view, see Stock and Watson, 2018). Our estimation strategy exactly follows Ramey (2016). All regressions include two lags of the shock (to eliminate any serial correlation), real GDP, real government spending and net taxes. Regressions for variables other than these three also include two lags of the left-hand side variable.

Figure A.10 reports one example of local projection based impulse responses: those identified recursively à la Blanchard and Perotti (2002) and estimated over the baseline sample.[A.14] The figure shows that the immediate hump-shaped increase in the labor share in response to a surprise shock is robust to the use of local projection methods. If anything, the magnitude of the response of the labor share to a surprise shock thus computed is greater than implied by SVAR methods.

A.3.4.2 Alternative labor share proxies Empirically measuring the labor share of income represents a major challenge, perhaps the most important difficulty confronting the researcher being the question how to ascribe the mixed income of self-employed to labor and capital. Our baseline measure of the labor share is constructed using data for the domestic corporate non-financial business sector extracted from the US NIPA tables following the methodology proposed by Gomme and Rupert (2004) (see Appendix A.3.2). Here we consider five additional metrics of the labor share. These measures differ in several dimensions, including their coverage and how they handle mixed income. Several of the measures exclude the government sector altogether, thus addressing the potential critique that the increase in the labor share is simply due to the direct effect of government spending on public sector employees. Notice that 'LS6' denotes the measure used previously as our baseline measure.

Construction of the labor share. Table A.5 provides an overview of the properties of alternative labor share proxies. For **LS5**, the key assumption is that the shares of capital (K) and labor (L) in ambiguous income are the same as in unambiguous income. As set out by McAdam *et al.* (2015), we begin by decomposing total income into ambiguous (AI) and unambiguous (UI) income. AI is the sum of proprietors' income, taxes on production less subsidies, business current transfers and statistical discrepancies (none of which is attributable to K or L).

$$AI_t = PI_t + (Tax_t^P - Sub_t) + BCTP_t + SDIS_t.$$

[A.14] Since the BP shock is just the part of government spending orthogonal to the lagged values of fiscal spending, GDP and taxes, it is identified from a standard four lag regression of government spending on lagged spending, GDP and taxes.

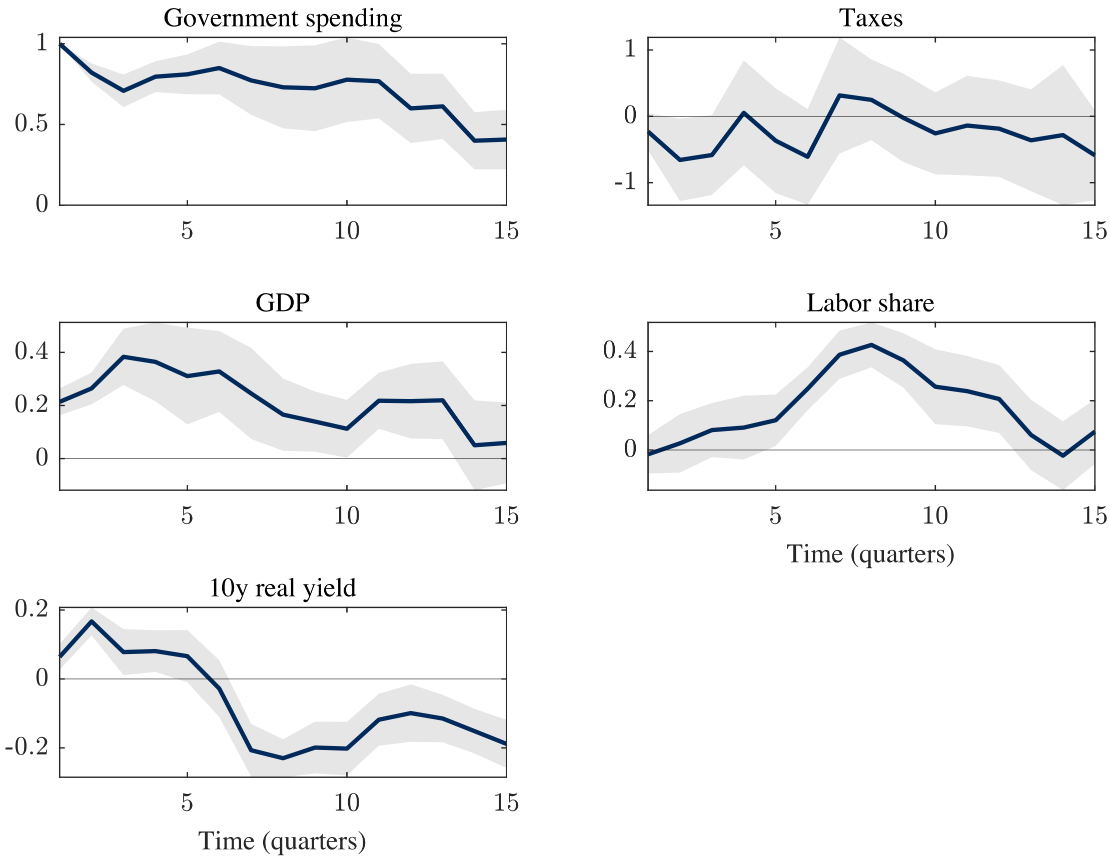


Figure A.10: Local projections evidence on the effects of a government spending shock (U.S.)

Notes: Local projection based impulse responses for a recursively identified government spending shock (1981:III-2007:IV). Grey areas represent one standard deviation confidence bands based on Newey-West corrections of standard errors. Impulse responses are scaled such the log change of government spending is unity at its peak. All series except interest rate shown in %.

UI is straightforwardly separable into compensation of employees and unambiguous capital income.

$$UI_t = ULI_t + UKI_t = CE_t + UKI_t.$$

The latter is the sum of corporate profits, rental income, net interests, and current surplus of government enterprises.

$$UKI_t = CP_t + RI_t + NI_t + GE_t.$$

The share of capital in unambiguous income (KS_t^U) is then obtained as

$$KS_t^U = 1 - LS_t^U = \frac{UKI_t + DEP_t}{UI_t} = \frac{RI_t + NI_t + GE_t + CP_t + DEP_t}{RI_t + NI_t + GE_t + CP_t + CE_t},$$

where DEP_t is the consumption of fixed capital. Next, make the following key assumption that factor shares in AI are the same as in UI:

$$AKI_t = KS_t^U AI_t.$$
$$ALI_t = 1 - (KS_t^U AI_t).$$

Finally, we obtain the labor share as follows:

$$LS5_t = (1 - KS_t) = 1 - \frac{UKI_t + DEP_t + AKI_t}{GNP_t} = \frac{ALI_t + CE_t}{GNP_t}$$

For LS3:

$$LS3 = \frac{CE - CE_{gov}}{(CE - CE_{gov}) + RI + CP + NI + \delta} = \frac{Y^{UL}}{Y^{UL} + Y^{UK}}.$$

LS4 is essentially the same concept, except not adjusted for inventory valuation and capital consumption when considering RI and CP.

Results. Figure A.11 compares the response of the labor share to an unanticipated government spending shock over our baseline sample. The central observation is that the patterns are very similar for measures LS2, LS3, LS4, LS5 and LS6, but that the response for LS1 is shifted downwards. Noting that LS1 suffers from many of the measurement difficulties, we consider the results therefore to be positive in terms of verifying the robustness of our findings hitherto. It is also worth noting that there is no clear pattern in terms of which labor share makes for the most clear-cut results.

A.3.4.3 Sub-sample robustness Finally, we check the robustness of our result across different subsamples.[A.17] As figure A.12 illustrates (using the median response for expositional clarity), the qualitative properties of the labor share response to unanticipated shock holds across samples. However, there are interesting differences in terms of the magnitude of the deviations from baseline and the persistence of the response. For the two later samples, the labor share reacts more sensitively to fiscal shocks, an observation of note since it is generally held that the *aggregate* effects of government spending shocks have become weaker in more recent samples (see, e.g., Bilbiie *et al.* (2008)).

[A.15] See https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.h tm

[A.16] "Naive" meaning labor compensation divided by dollar output, see https://www.bls.gov/lpc/lpcmethods.pdf, page 7; also see https://www.bls.gov/news.release/prod2.tn.htm. This measures excludes e.g. general government; nonprofit institutions; private households; unincorporated business; and those corporations classified as offices of bank holding companies, offices of other holding companies, or offices in the finance and insurance sector. Nonfinancial corporations

Mnemonic	Description	Methodology	Source
LS1	Non-farm business sector (excludes e.g. government, nonprofits, farms)	GVA[A.15]; imputed SE income	BLS
LS2	Non-financial business sector	GDP; naive[A.16]	BLS
LS3	Economy-wide excl. gov. sector	GDP; PI and indirect net taxes apportioned to K and L in same proportion as unambiguous components	Following Gomme and Rupert (2004)
LS4	Economy-wide excl. gov. sector	GDP; PI and indirect net taxes apportioned to K and L in same proportion as unambiguous components. No corrections for inventory valuation adjustment and capital consumption.	Following Gomme and Rupert (2004)
LS5	Economy-wide LS adjusted for PI	GDP; proportions in ambiguous income (PI, net taxes on production, business current transfers, statistical discrepancy) assumed to be the same as in unambiguous.	Following McAdam *et al.* (2015)
LS6	Non-financial business sector	GVA; excludes PI and rental income	Following Gomme and Rupert (2004)

Table A.5: Description of alternative labor share proxies

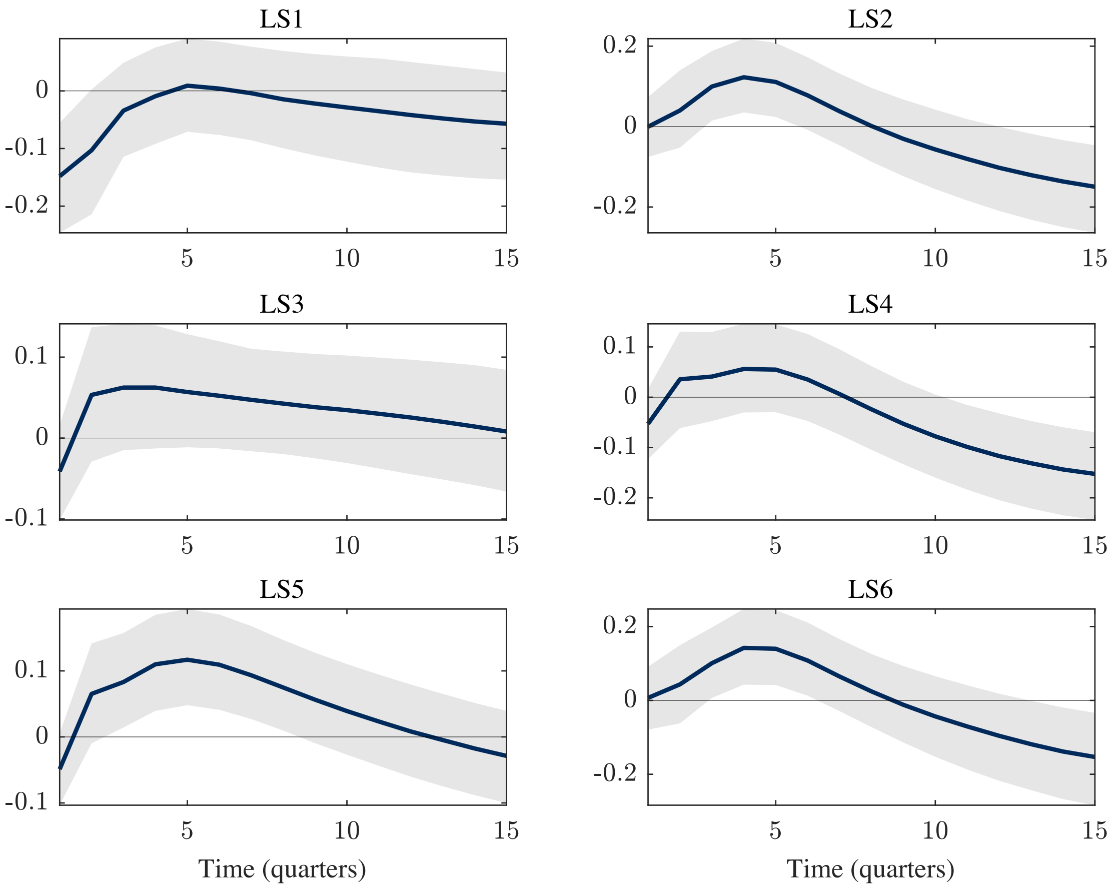


Figure A.11: Effects of an unanticipated government spending shock on alternative labor share proxies

Notes: This figure shows impulses responses for a one standard deviation government spending surprise shock obtained using the F(1,4) identification method. The median posterior density of impulse responses is displayed in form of a solid line while the 16th and the 84th percentiles are shown as dotted lines. All series shown in %.

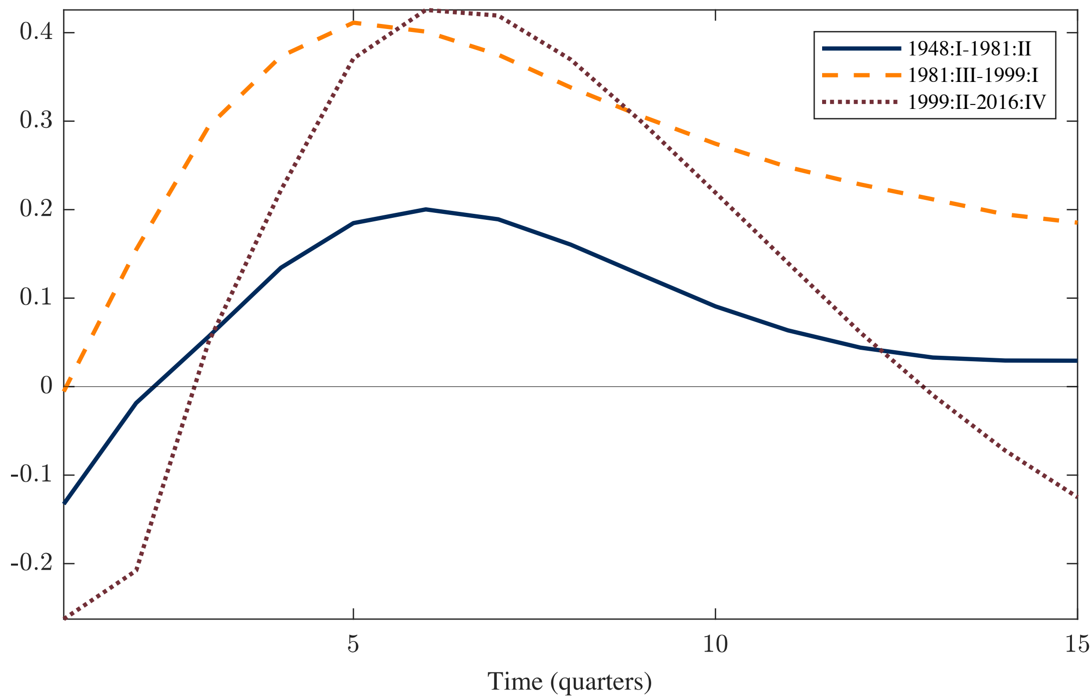


Figure A.12: Labor share response to an unanticipated government spending shock across sub-samples

Notes: IRs for a government spending surprise shock across different sub-samples. For 1948:I-1981:II, the shock is identified á la BP. For 1981:III-1999:I and 1999:II-2016:IV, the F(1,4) method is employed. IRs are scaled such that the log change of government spending is unity at its peak. Solid lines indicate the median posterior density of impulse responses, while the shaded area represents the 16th to 84th percentiles. All series shown in %.

A.4 Impulse response matching

The two questions we ask in this section are whether the TANK-CW model (i.) is able to match the empirical impulse responses to a government spending shock, and (ii.) can do so for a plausible set of parameter values. As our objective is to match the empirical impulse responses, and making use of the fact that TANK models are easily enriched, solved, and estimated, we extend the framework to allow for other ingredients typically found in medium-scale DSGE models. In addition to physical capital accumulation and nominal wage stickiness, these are: variable capital utilization, fixed costs, and a more general Taylor rule featuring both interest rate smoothing and a non-zero response to the output gap.[A.18]

accounted for about 50 percent of the value of GDP in 2016.

[A.17]Given data availability, we employ the natural approach of dividing sample period for which SPF data is available into two and use the preceding years from 1948:I onwards as a third sub-sample period.

[A.18]Also, given that we now calibrate the model with a positive debt-to-GDP ratio in steady-state, we no longer need to write the fiscal rules in deviation from output as before and can adopt a more conventional specification. It would be no problem to add yet further frictions. Here we restrict ourselves to a "small medium-scale" model to demonstrate the ability of such a model to match the empirical IRFs.

Methodology. We follow Christiano *et al.* (2010) and estimate the DSGE model using Bayesian impulse response matching (also see, among others, Christiano *et al.* (2016) and Lewis and Winkler (2017)). This technique consists in estimating a selected number of parameters in the model by minimizing the distance between the SVAR- and the theoretical IRFs of interest.[A.19] We partition the model's parameters into two groups. The first group comprises parameters for which there exist conventional values in the literature (see Table 4). The values of the discount factor ($\beta = 0.99$) and of the capital depreciation rate ($\delta = 0.025$) are standard for models calibrated at a quarterly frequency. We set the Frisch elasticity of labor supply equal to unity ($\varphi = 1$). Intertemporal elasticities of substitution in the goods and labor market ($\eta = \eta^w = 6$) are set in order to match average mark-ups in the product and labor markets equal to 1.2. In line with historical U.S. data, at the steady state, we set a government spending share of output of 20% ($g/y = 0.20$). The gross inflation rate ($\Pi = 1$) implies a zero-inflation steady state, while the steady-state labor supply is set equal to 1/3 of the available time ($n = 0.33$). However, results do not hinge on these last two assumptions. Government debt is set to 67% of annual output ($\frac{b}{y} = 4 \times 0.57$), which corresponds to the average value of the U.S. government debt to GDP ratio during the great moderation. Workers' steady-state bond holdings and benchmark level for the portfolio adjustments costs (b^W) are set equal to 0.[A.20] Finally, in line with the bulk of the TANK literature, steady-state lump sum transfers/taxes are set such that there is no steady-state consumption inequality, since in this paper we are only interested in deviations from steady-state.

The second group of parameters is estimated such as to minimize the distance between the SVAR responses and the model's responses of six key variables: government spending, GDP, the labor share, private consumption, investment and inflation. Table A.6 shows the choice of prior distributions. We use a Gamma distribution for the standard deviation of the government spending shock and a Beta distribution for the autoregressive parameter. For the percentage of H-t-m/workers in the economy we use a Normal distribution centered around 0.5. The prior distribution for ψ^W is a normal centered around 0.25, a value chosen following the same rationale applied in calibrating the simple model.[A.21] Furthermore, for the Calvo price and wage rigidity parameters we use a Beta distribution centered around 0.5. A Gamma distribution centered around usual values found in the literature is also used for investment adjustment costs, variable capital utilization, the response to inflation and output in the Taylor rule. Lastly, we use a Beta distribution for interest rate smoothing.

Results. Results show that common parameters between the two models are estimated to be very close. The substantial difference however lies in the proportion of different agents in the two models. UH

[A.19] We refer the interested reader to Christiano *et al.* (2010) for a detailed technical discussion of the minimum distance estimator used here.

[A.20] This choice is justified also by the analysis of Kaplan *et al.* (2017) who shows that the top decile of the wealth distribution holds 86% of liquid wealth.

[A.21] The presence of fixed costs in this setup changes the steady-state value of net output and accordingly changes the prior mean of ψ^W compared to the calibration presented for the simple model.

requires 60% of the population not to have any access to financial markets. Figure A.13 shows as both models do a good job in matching the targeted IRFs with UH missing the persistence of the negative response of investment while CW missing the sluggish response of inflation.

Description	Parameter	Prior	Posterior mean (95% HDP interval)	
			UH	CW
G shock	ε^G	$\Gamma(1, 0.05)$	0.96 (0.90, 1.02)	0.97 (0.91, 1.03)
AR1 government spending shock	ρ^G	$B(0.7, 0.15)$	0.92 (0.90, 0.94)	0.92 (0.90, 0.94)
Inv. adj. costs	ι	$\Gamma(4, 2)$	2.46 (0.83, 4.04)	1.81 (0.60, 2.98)
Calvo prices	θ	$B(0.5, 0.2)$	0.86 (0.79, 0.94)	0.86 (0.80, 0.92)
Calvo wages	θ^w	$B(0.5, 0.2)$	0.71 (0.60, 0.82)	0.78 (0.68, 0.88)
% of H/W	λ	$N(0.5, 0.2)$	0.60 (0.50, 0.69)	0.72 (0.51, 0.98)
Portfolio adj. costs	ψ^W	$N(0.25, 0.1)$	∞	0.16 (0.03, 0.28)
Interest rate smoothing	ϕ^r	$B(0.7, 0.2)$	0.54 (0.30, 0.78)	0.60 (0.39, 0.81)
Interest rate response to inflation Π	ϕ^π	$\Gamma(1.7, 0.15)$	1.73 (1.48, 1.97)	1.75 (1.50, 1.99)
Interest rate response to output	ϕ^y	$\Gamma(0.1, 0.05)$	0.13 (0.04, 0.22)	0.12 (0.04, 0.21)

Table A.6: Bayesian impulse response matching: parameter estimates

Notes: This table summarizes prior and posterior distributions for the set of parameter values estimated according to IRF matching. Distributions are abbreviated as follows: Γ - Gamma; B - Beta; N - Normal.

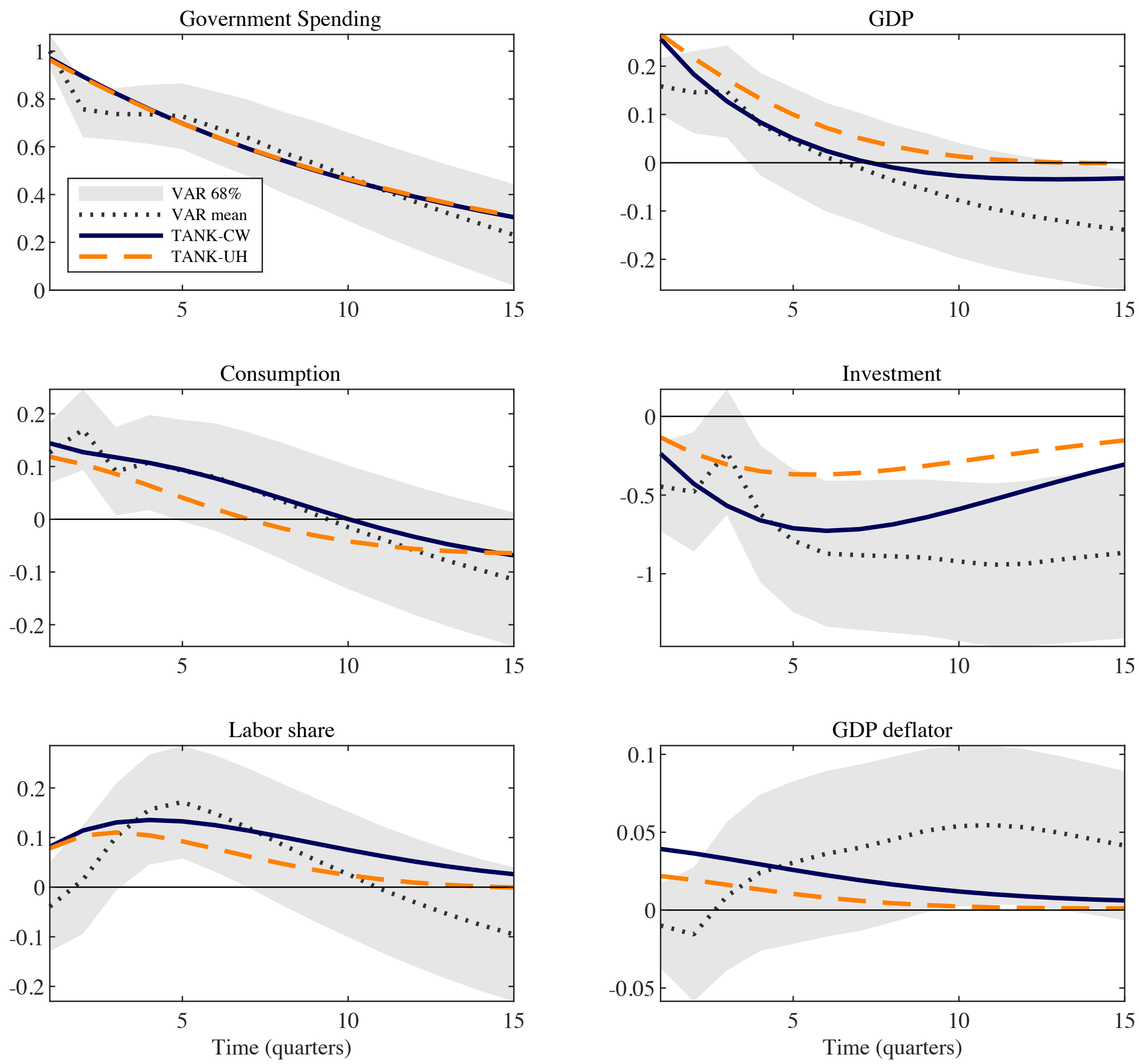


Figure A.13: Bayesian impulse response matching: model fit

Notes: This figure shows the fit of the estimated TANK models relative to the empirical, VAR-based impulse response for an unanticipated one percent increase in government spending. The dotted line indicates the median posterior density of empirical impulse responses, with shaded area representing the 16th to 84th percentiles. All series except the GDP deflator shown in %.

A.5 Fiscal stimulus design in medium-scale models

A.5.1 Fiscal stimulus design: varying fiscal rule parameters

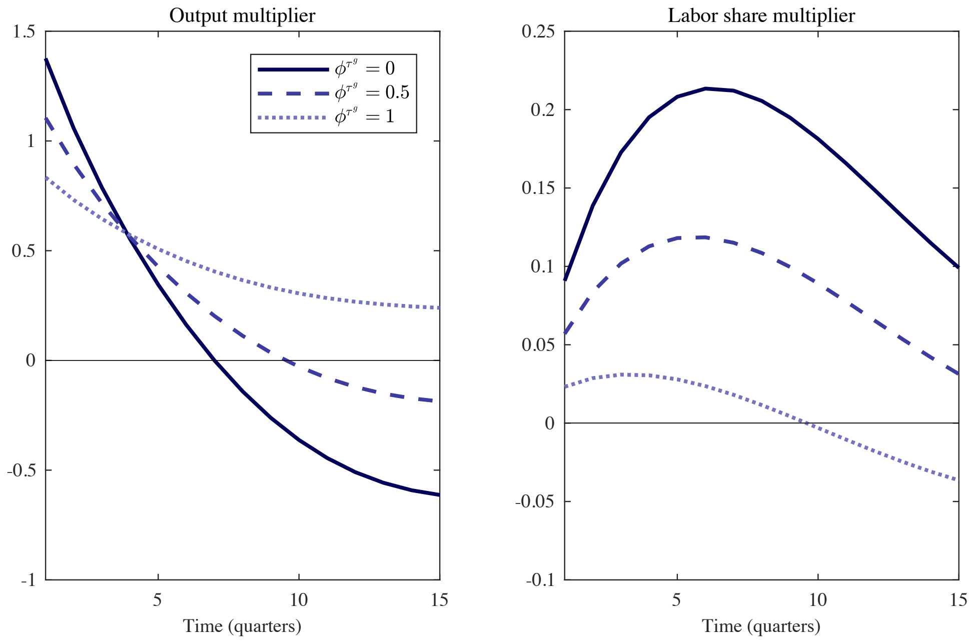
Figure A.14 shows, using the estimated medium-scale version of TANK-UH and TANK-CW, that in either model making taxes less responsive to government spending by lowering the fiscal rule parameter ϕ^{tg} *increases* the fiscal multiplier on impact. The reason is that debt financing implicitly redistributes from low-MPC to high-MPC households in either setting. As described also in the main text, the cumulative multiplier in TANK-CW is lower, however, primarily because investment falls more deeply, but gradually so given adjustment costs. Indeed, a strong degree of deficit financing (solid line) can create a short-lived boom. Overall, however, one of the results from this exercise is that it is *possible* to make the two models similar in their predictions: the parameter perturbations we look at here are conditional on picking a set of parameter values that allows both models to fit the empirical impulse responses as closely as possible. For the TANK-UH model to accomplish a good fit, though, it is necessary to assume that around 60% of households have no access to consumption smoothing through saving and borrowing, thus behaving in hand-to-mouth fashion. Additionally, the simulations in Section 3.3 revealed that – in a direct reflection of the extreme MPCs of both unconstrained and hand-to-mouth households – aggregate consumption and output are extremely sensitive to changes in the time path of the mix of taxes and debt when these changes are not themselves smooth.

A.5.2 Equilibrium conditions of the medium-scale TANK-CW model

Table A.7 summarizes the non-linear equilbrium conditions of the medium-scale TANK-CW model. Relative to the simple model described in Appendix Section A.1, new endogenous variables are as follows: capital, k; investment, i; the real rental rate r^K; investment adjustment costs s, which imply that Tobin's q, denoted q, is no longer necessarily equal to unity; utilization of capital, u, and the associated cost Ψ; workers' marginal rate of substitution, mrs. Given nominal wage stickiness, we also have the optimal reset wage w^o; gross wage inflation, Π^w; as well as auxiliary variables to express the wage Phillips curve recursively. Notice, furthermore, that now variables in the fiscal rule are expressed in deviations from their own (positive) steady-state.

As far as additional parameter values are concerned, notice that α denotes the capital share, while the utilization elasticity is $\upsilon = \frac{\gamma^1}{\gamma^2}$. Steady-state relationships involve the parameter a scaling the dis-utility of working: $a = \frac{w\frac{\eta^w-1}{\eta^w}}{n^{W\varphi}}$. Additionally, we impose fixed costs in production to ensure zero monopoly profits in steady-state, $F = n\left(\left(\frac{k}{n}\right)^\alpha - \left(w + r^K\frac{k}{n}\right)\right)$.

(a) TANK-CW



(b) TANK-UH

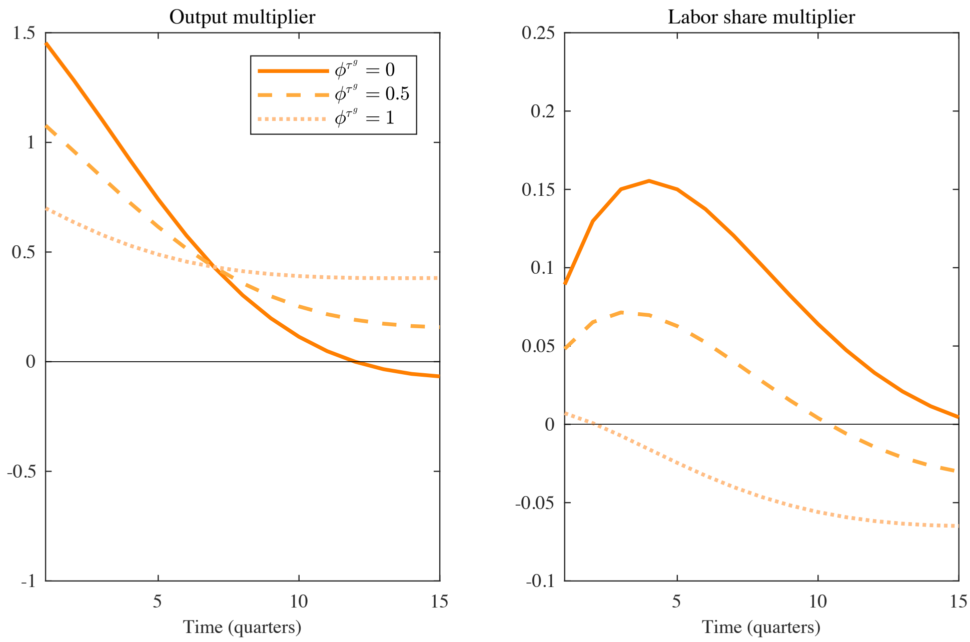


Figure A.14: Fiscal stimulus design: alternative fiscal rule parameters

Notes: This figure shows the impulse responses of selected variables to a government spending shock for different values of the coefficient on spending in the tax rule, ϕ^{tg}. The underlying TANK models are the estimated medium-scale versions described in Section 3.3 of the main text.

Description	Equation
Euler equation C	$E_t c^C_{t+1} = \beta r_t c^C_t$
Euler equation W	$E_t c^W_{t+1} \left(1 + \psi^W / c^W \left(b^W_t - b^W\right)\right) = \beta\, r_t\, c^W_t$
Budget constraint W	$c^W_t + b^W_t = n^W_t\, w_t - t_t + r_{t-1}\, b^W_{t-1} - \tau^W$
Aggregate consumption	$c_t = \lambda c^W_t + (1-\lambda) c^C_t$
Aggregate hours	$n_t = \lambda n^W_t$
Aggregate capital	$k_t = (1-\lambda) k^C_t$
Aggregate investment	$i_t = (1-\lambda) i^C_t$
Resource constraint	$y_t = i_t + c_t + g_t + k_{t-1}\, \Psi_t$
Dividends	$d_t = y_t - n_t w_t - r^k_t u_t k_{t-1}$
Production	$y^m_t = n_t^{1-\alpha}\, (u_t\, k_{t-1})^{\alpha}$
Net output	$y_t = {y^m}_t - F$
Real wages	$w_t = mc_t\, (1-\alpha)\, (n_t / (u_t\, k_{t-1}))^{(-\alpha)}$
Rental rate of capital	$r^k_t = mc_t \alpha\, ((u_t\, k_{t-1})/n_t)^{\alpha-1}$
Capital utilization 1	$\Psi_t = \gamma^1\, (u_t - 1) + \frac{\gamma^2}{2}\, (u_t - 1)^2$
Capital utilization 2	$r^k_t = \gamma^1 + (u_t - 1)\, \gamma^2$
Capital accumulation	$k^C_t = (1 - s_t)\, i^C_t + (1-\delta)\, k^C_{t-1}$
Investment adjustment costs	$s_t = \iota\, \left(i^C_t / i^C_{t-1} - 1\right)^2$
Tobin's q	$q_t = \frac{1}{r_t}\, E_t\, \left(u_{t+1}\, r^k_{t+1} - \Psi_{t+1} + (1-\delta)\, q_{t+1}\right)$
Investment	$q_t\, \left(1 - s_t - i^C_t / i^C_{t-1}\, {s'}_t\right) + E_t q_{t+1}\, c^C_t \beta / c^C_{t+1}\, {s'}_{t+1}\, (i^C_{t+1} / i^C_t)^2 = 1$
Non-linear Phillips curve 1	$J_t - \beta\, \theta\, E_t \Pi^{\eta}_{t+1}\, J_{t+1} = \frac{mc_t\, y_t}{c^C_t}\, \frac{\eta}{\eta-1}$
Non-linear Phillips curve 2	$JJ_t - \beta\, \theta\, E_t {\Pi_{t+1}}^{\eta-1}\, JJ_{t+1} = \frac{y_t}{c^C_t}$
Non-linear Phillips curve 3	$1 = \theta\, {\Pi_t}^{\eta-1} + (1-\theta)\, (J_t / JJ_t)^{1-\eta}$
Non-linear wage Phillips curve 1	$J^w_t = n^W_t\, \left(c^W_t\right)^{-1}\, w^o_t\, \frac{\eta^w - 1}{\eta^w}\, \left(\frac{w_t}{w^o_t}\right)^{\eta^w} + \beta\, \theta^w\, {\Pi_{t+1}}^{\eta^w - 1}\, \left(\frac{w^o_{t+1}}{w^o_t}\right)^{\eta^w - 1}\, J^w_{t+1}$
Non-linear wage Phillips curve 2	$JJ^w_t = \left(a n^W_t\right)^{\varphi+1}\, \left(\frac{w^o_t}{w_t}\right)^{(-\eta^w)} + \beta\, \theta^w\, {\Pi_{t+1}}^{\eta^w}\, \left(\frac{w^o_{t+1}}{w^o_t}\right)^{\eta^w}\, JJ^w_{t+1}$
Non-linear wage Phillips curve 3	${w_t}^{1-\eta^w} = (1-\theta^w)\, {w^o_t}^{1-\eta^w} + \theta^w\, {w_{t-1}}^{1-\eta^w}\, \Pi_t^{\eta^w - 1}$
Wage inflation	$\Pi^w_t = w_t / w_{t-1}$
Fisher equation	$r_t = E_t R_t / \Pi_{t+1}$
Government budget constraint	$b_t = g_t + r_{t-1}\, b_{t-1} - t_t$
Government spending	$\hat{g}_t = \rho^g\, \hat{g}_{t-1} + \epsilon^g_t$
Fiscal rule	$\hat{t}_t = \phi^{\tau t}\, \hat{t}_{t-1} + \phi^{\tau B}\, \hat{b}_t + \phi^{\tau G}\, \hat{g}_t$
Taylor rule	$\hat{R}_t = \phi^r\, \hat{R}_{t-1} + (1-\phi^r)(\phi^{\pi}\, \hat{\Pi}_t + \phi^y\, \hat{y}_t)$
Bond holdings	$b_t = \lambda b^W_t + (1-\lambda) b^C_t$

Table A.7: Non-linear equilibrium conditions for the TANK-CW model

Notes: This table summarizes the non-linear equilibrium conditions of the medium scale two-agent New Keynesian model with capitalists and workers. The capitalist household's budget constraint may be omitted given Walras' Law.