Stimulus effects of common fiscal policies: a quantitative analysis*

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Abstract

We quantify the cost-effectiveness of commonly used fiscal policies for stabilizing unemployment using a quantitative equilibrium model with incomplete asset markets, sticky prices and a frictional labor market. The model's sequence-space representation provides an analytical summary of fiscal propagation as a circular relation among three blocks that, individually, determine policy-specific first-round effects and, together, a common general-equilibrium multiplier. The baseline calibration of the model predicts large differences in fiscal multipliers across policies and identifies their key determinants.Relative to an increase in government spending, the efficacy of universal or conditional transfers to households hinges on the degree of partial consumption insurance (through marginal propensities to consume and the response of precautionary savings) which we calibrate to consumption dynamics in unemployment. That of hiring or job-retention subsidies is sensitive to the elasticities of vacancies and separations to job values (disciplined by observed dynamics of labor market flows in response to macro-shocks) and the marginal propensity to consume out of profit income.

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1 Introduction

Fiscal stimulus is back: ever since the Great Recession, governments have spent unprecedented resources on a multitude of discretionary fiscal measures to sustain their economies, from stimulus checks via short-time work schemes to unemployment benefit increases or extensions. While not their only purpose, the output stimulus that these policies provide is a key input to policy design that we know little about, partly because data are not informative about the relative effects of policies that are simultaneously deployed in response to the same shocks.

We propose a structural general-equilibrium framework whose features allow to quantitatively capture heterogeneous stimulus effects of common fiscal policy measures. Despite the model's richness, its sequence-space representation provides an analytical summary of fiscal propagation as a circular transmission of shocks through three blocks associated with, respectively, incomplete markets, labor-market and pricing frictions. This allows to identify which model features and parameters make different policies effective at boosting output, which seems important when policymakers may have their own views about particular parts of the transmission mechanism. The benchmark calibration of our framework implies strong differences in cumulative fiscal multipliers, which range from 0.3 to 1.6. Relative to the benchmark of government consumption, the efficacy of transfers to households, -in the form of universal stimulus checks or conditional transfers to the (long-term) unemployed - is particularly sensitive to the degree of partial consumption insurance that determines marginal propensities to consume (MPCs) and their effects in precautionary savings. The efficacy of transfers to firms - n the form of retention or hiring subsidies, - hinges on the elasticity of separation and vacancy posting to firm profits and the marginal propensity to consume these.

To quantify the stimulative impact of different fiscal policies, we need to capture their effect on current demand and supply, as well as the general equilibrium feedback between the two. This guides our choice of modeling elements. The effects of changes in household tranfers and taxes hinge, in particular, on the propensities to consume transfer payments of different households, but also on movements in precautionary savings in response to policy-induced changes in post-government income risk. Our framework therefore includes a detailed heterogeneous-agent (HA) block,with incomplete markets and idiosyncratic income risk, carefully calibrated to capture the degree of partial consumption insurance observed in the U.S. economy. To capture the nature of employment risk in the U.S. our framework features a "SAM" block with search-and-matching frictions, unemployment-duration-dependent search efficiency, endogenous separations and sluggishness in vacancy-creation that can replicate observed dynamics of separations and job-finding. By matching the response of both match creation and separation to innovations in productivity, we also discipline the effect on hiring and firing of any policy-induced movement in the revenue product of labor, which is a key determinant of the effect of firm subsidies. Finally, to give rise to output movements in response to demand fluctuations, and to create realistic general-equilibrium feedback between demand and supply, we include a New-Keynesian (NK) block with nominal rigidities in our framework.

Using this HA-NK-SAM framework, in addition to the benchmark of increasing government consumption we study three household transfer policies (an extension of the duration or generosity of unemployment benefits, and a homogeneous transfer to all households) as well as subsidies to existing, or newly created jobs. A fomulation in the space of (infinite) sequences of variables that converge back to steady state after a fiscal shock allows a novel analytical characterisation of the equilibrium. This highlights how policy effects result from a common multiplier that leverages policy-specific first-round effects determined, respectively, by the structure of the HA block (for household transfers) and the SAM block (for firm subsidies).

The quantitative analysis focuses on fiscal multipliers (defined as the policy-induced cumulated increase in output relative to that in taxes) and their determinants. Associated with a small increase in government consumption, our benchmark policy, is a multiplier of around 1, in line with common empirical estimates. Spending on government consumption is stimulative because it is immediately absorbed into final demand and crowding out is limited when households' horizons are shortened by potentially binding borrowing constraints while much of the spending is financed through taxes far away in the future. Universal transfers through stimulus checks, in contrast, stimulate demand substantially less, with a multiplier of 0.3 This is because most households save for future consumption much of their transfer, whose universal nature leaves incentives for precautionary savings largely unaffected. This contrasts with increases in unemployment benefits that take advantage of the higher MPCs of currently unemployed households and reduce precautionary savings by lowering the consumption-effect of future unemploymentshocks, implying a multiplier of 0.4.Unemployment duration extensions are even more targeted to high-MPC households and effective at lowering precautionary savings by raising resources in a particularly bad contingency of long unemployment.Their high multiplier of 1 is of limited value, however, because duration extensions are inherently limited in scale. The clear winner according to our benchmark calibration are subsidies to firms. These provide effective stimulus because our benchmark calibration targets a high marginal propensity to consume out of dividends (Di Maggio et al. (2020)), and the strong responses of match formation and separations to productivity shocks in U.S. data, which makes firm hiring and firing rather responsive to policy-induced changes in the labor revenue product. In alternative calibrations we show how, when either element of propagation is weaker, subsidies quickly loose their stimulative edge. In addition to these relative fiscal multipliers, we also illustrate how the features of our model determine their absolute size. For example, market incompleteness raises fiscal multipliers, by about 50 percent in the case of government spending, accounted for in roughly equal parts by higher marginal propensities to consume and countercyclical movements in precautionary savings.

Less general versions of our model that abstract from some of its features provide useful analytical benchmarks for the quantitative analysis, and highlight the need for a rich set of frictions to study fiscal-policy effects. With *complete asset markets*, where household consumption behavior obeys Ricardian equivalence, changes in unemployment insurance or the tax rule have no effect on output or employment because they leave the net present value of average household income unaffected at a given interest rate. In the popular *zero-liquidity limit*, where borrowing is ruled out and government bonds in zero net supply (as in Krusell et al. (2011); Ravn and Sterk (2021) or Krusell et al. (2011); Ravn and Sterk (2021))l), the "marginal saver" is an employed worker whose savings behavior is determined by the likelihood of moving to unemployment and the benefits received in that case, but independent of unemployment duration risk and benefits in later periods of unemployment. The effect of unemployment benefit extensions, which raise current consumption demand of the long-term unemployed one-for-one and leave household behavior unaffected otherwise, is thus identical to that of an equivalent increase in government consumption. In the limit of *flexible prices*, government spending and transfer policies have no effect on output or employment, in contrast to models in the real-business-cycle tradition (see Ramey (2011) for a survey). This is because these policies do not directly affect firm profits or labor demand (as taxes are levied on households), and our labor-market setup with constant real wages rules out wealth effects on labor supply. Finally, with a *standard search-and-matching labor market* (with free entry to vacancy-posting and constant separations, as in many contributions following Diamond (1982)Pissarides (2000); Mortensen (1982), DMP)), retention and hiring subsidies affect the equilibrium only through firm vacancy posting. Retention and hiring subsidies that impliy an identical change in the expected profits from posting a vacancy thus have identical effects (but retention subsidies are more expensive as immediately paid to all matches, not just new ones).

Relation to the literature

Our model environment is related to several strands of the quantitative macroeconomic literature that have partly remained separate so far. Relative to recent studies that quantify government-spending multipliers in heterogeneous-agent new-keynesian (HANK) environments and discuss their determinants (Auclert et al. (2018); Hagedorn et al. (2019a))[1] we show that different *kinds* of government spending differ strongly in their potency to stabilise the economy, and discuss the features of the economic environment that determine these differences. The only other study that has a similar comparative focus is Carroll et al. (2023). Their analysis focuses on demand-stimulus policies in partial equilibrium with exogenous labor-market risk and is thus silent about firm subsidies, the feedback from endogenous risk to incomplete markets and the general-equilibrium amplification that we show are key features of the transmission of fiscal policies.

We identify as key frictions that determine the effects of fiscal policies incomplete asset markets, sticky prices and a frictional labor market. Such"HANK-SAM" environments (Ravn and Sterk (2021)) have been previously studied in Den Haan et al. (2018), McKay and Reis (2020), Challe (2020) and Gornemann et al. (2021).[2] Several previous studies look at the stabilising effect of individual labor-market-centered fiscal policies in this class of models. Dengler and Gehrke (2021) find a strong stabilising effect of a short-time work scheme that differs from our retention subsidies because it allows firms to partly avoid the continuation costs that, in their framework like in ours, lead to endogenous separations. Kekre (2021) shows how unemployment benefit extensions at longer horizons have a higher output multiplier than those at shorter horizons, or increases in unemployment benefits. We show how this finding hinges on an intermediate degree of risk sharing.[3]

[1] See Ramey (2011) for a survey of earlier contributions in the neoclassical and new keynesian tradition with a representative consumer.

[2] Like these studies, we thus connect the literature on heterogenous agent new-keynesian macroeconomcis without search-and-matching frictions (see, e.g., Oh and Reis, 2012; McKay and Reis, 2016; Guerrieri and Lorenzoni, 2017; Bayer et al., 2019; Hagedorn et al., 2019b; Auclert et al., 2020b; Luetticke, 2021), to that studying representative-agent models with frictional labor markets (see, e.g., Walsh, 2005; Krause and Lubik, 2007; Gertler et al., 2008; Trigari, 2009; Gertler and Trigari, 2009; Galí, 2010; Ravenna and Walsh, 2012; Christiano et al., 2016, 2021).

[3] Graves (2020) studies the ability of institutional, i.e. expected, unemployment insurance to stabilise business cycles. Cho (2023) shows how precautionary savings contribute little to demand fluctuations when the degree of self-insurance is low and MPCs thus high. In our benchmark calibration, whose degree of self-insurance is disciplined by observed consumption responses to unemployment shocks, we find that, relative to a complete-markets version of the model, higher MPCs and cyclical precautionary savings contribute about equally to the

Relative to all these studies, we point out that a careful quantification of unemployment risk, including the dynamic responses of separation and job-finding rates to business-cycle shocks, is an important factor for the propagation of business cycles and of fiscal policy. Such cyclicality has previously been pointed out by, e.g., Challe and Ragot (2016), McKay (2017) and Harmenberg and Öberg (2020). In contrast to these studies, we focus on its role for the effectiveness of fiscal policy.[4]

The observed lead-lag relation betwen separation and job-finding rates implies, in the context of our model like in many others, sluggishness in vacancy creation. Following Fujita and Ramey (2005), several recent papers have studied labor-market dynamics under the lens of finitely elastic vacancy creation, with contrasting micro-foundations (see, e.g., Leduc and Liu (2020), Haefke and Reiter (2020), Mercan et al. (2021), Engbom (2021) and Den Haan et al. (2021)). We rely on new evidence from our companion paper (Broer et al. (2021)) where we study the response of separation and job-finding to identified demand and supply shocks, show that the delay between the peak of the separation rate and the trough of the job-finding rate identifies the elasticity of firm vacancy creation, and highlight its importance for the unemployment-risk channel of business-cycle propagation.

2 Model

2.1 Overview

The economy consists of infinitely-lived workers indexed by $i \in [0,1]$, different types of firms, and a government. A mass θ of the workers consume their income hand-to-mouth (HtM), while the remaining workers self-insure against unemployment risk by accumulating government bonds.[5] Households can be employed, in which case they provide one unit of labor, or unemployed.

Production has three layers:

amplification of shocks.

[4] The importance of separations for unemployment fluctuations is discussed in Fujita and Ramey (2009) and Shimer (2012). Elsby et al. (2009), Barnichon (2012) and Elsby et al. (2015) argue that separations are more important when unemployment starts to increase from a low point or begin to fall from a peak. Mueller (2017) shows that the separation rate of high-wage earners is particularly highly counter-cyclical.

[5] One may think of hand-to-mouth households as having preferences implying a sufficiently strong degree of impatience to make them constrained in equilibrium.

1. Intermediate-goods producers can hire labor by posting vacancies if they pay a one-time stochastic entry cost. Once matched with a worker, they produce Z_t units of a homogeneous good sold in a perfectly competitive market at price P_t^x. Stochastic idiosyncratic cost shocks imply that a time-varying fraction of them terminates their match every period.

2. Wholesale firms buy intermediate goods and produce differentiated goods that they sell in a market under monopolistic competition. The wholesale firms set their prices subject to a Rotemberg (1982) adjustment cost.

3. Final-good firms buy goods from wholesale firms and bundle them into a final good, which is sold in a perfectly competitive market.

The government issues bonds and collects taxes to finance an unemployment-insurance system, and discretionary fiscal expenditures. A monetary authority sets the interest rate according to a Taylor rule.

We first describe the within-period timing in the model, then the model equations. We denote all variables that are subject to fiscal policy shocks with the color red.

2.2 Timing

Step 0: Stocks and shocks. At the beginning of each period t, all aggregate shocks are revealed. The endogenous labor-market state variables are the (beginning-of-period) stocks of unemployed workers u_{t-1} and of vacancies v_{t-1}.

Step 1: Vacancy creation and destruction. Vacancies are destroyed, for simplicity, at a constant rate equal to the steady state separation rate, δ_{ss}. For idle firms, firm-specific costs of entering the labor market are realized and firms that pay this cost post a new vacancy, generating an endogenous, time-varying vacancy entry rate ι_t. The post-entry-and-destruction vacancy rate is denoted by $\tilde{v}_t$, and is given by

$$\tilde{v}_t = (1 - \delta_{ss})v_{t-1} + \iota_t. \tag{1}$$

Step 1: Separations and matching. After observing their continuation-cost shock, the intermediate-goods producers decide whether to continue or exit, implying an endogenous, time-varying separation rate δ_t in a manner that we describe below. Concurrently, unemployed workers and vacancies match randomly. The matching technology is Cobb-Douglas with matching elasticity α. Market tightness is denoted by

$$\theta_t = \frac{\tilde{v}_t}{S_t u_{t-1}}, \tag{2}$$

where S_t is the average search intensity of workers (described below). The job-filling rate λ_t^v and job-finding rate λ_t^u are given by, respectively, $\lambda_t^v = A\theta_t^{-\alpha}$ and $\lambda_t^u = S_t A \theta_t^{1-\alpha}$. The resulting stocks of (end-of-period) unemployed workers and vacancies evolve according to

$$u_t = (1 - \lambda_t^u) u_{t-1} + \delta_t (1 - u_{t-1}), \tag{3}$$

$$v_t = (1 - \lambda_t^v) \tilde{v}_t. \tag{4}$$

Step 3: Production, consumption and saving. Production takes place, dividends and wages are paid, taxes are levied. All workers, both employed and unemployed, make their consumption-saving decisions.

2.3 Intermediate goods producers

The setup of the labor market is very similar to that of our earlier work in Broer et al. (2021).

Separations and vacancy creation.

A continuum of firms produce a homogeneous intermediate good X_t sold in a competitive market. The price of the intermediate good, relative to that of the numeraire, is P_t^x and one unit of labor produces Z_t units of the intermediate good. The total production of intermediate goods is thus given by

$$X_t = Z_t (1 - u_t). \tag{5}$$

To hire a worker, firms must post vacancies which are filled with probability λ_t^v, taken as given by each one-worker firm.

Match value and separations. V_t^j denotes the value of a match for the firm. While the actual stochastic discount factors are heterogenous in the population, we assume for simplicity that the firms discount profits at the steady-state risk-free interest rate. To produce, a firm must pay a virtual continuation cost $\chi_t \sim G$ at the beginning of the period.[6] There is no additional heterogeneity among operating firms. Consequently, there exists a common cost cutoff $\chi_{c,t}$, such that for all $\chi_t > \chi_{c,t}$, firms choose to separate. The Bellman equation for the value of a match after the separation decision is

$$V_t^j = P_t^X Z_t - W_t + \text{rs}_t + \beta \mathbb{E}_t \left[\int^{\chi_{c,t+1}} (V_{t+1}^j - \chi_{t+1}) dG(\chi_{t+1}) \right] \tag{6}$$

where W_t is the real wage, and rs_t is a transfer that may be paid out by the government in the event of a successful match. Upon receiving such a transfer, the cutoff value for separations $\chi_{c,t}$ increases— we therefore call these transfers *retention subsidies*. We choose the functional form of G so that total separations δ_t respond with a constant elasticity ψ to the value of a match V_t^j,[7]

$$\delta_t \quad = \quad \delta_{ss} \left(\frac{V_t^j}{V_{ss}^j} \right)^{-\psi}. \tag{7}$$

In the special case with $\psi = 0$, separations occur exogenously at rate δ_{ss}.

Vacancy creation. The value of a vacancy is denoted by V_t^v. Its Bellman equation is

$$V_t^v = -\kappa + \lambda_t^v (V_t^j + \text{hs}_t) + (1 - \lambda_t^v)(1 - \delta_{ss}) \beta \mathbb{E}_t [V_{t+1}^v], \tag{8}$$

where κ is a vacancy-posting cost to be paid every period, and hs_t is a transfer that may be paid out by the government. Vacancies are destroyed with exogenous probability δ_{ss}. Vacancy creation stems from a constant mass F of prospective firms that in each period draw a stochastic virtual idiosyncratic entry cost c from a distribution H. The prospective firm posts a vacancy if and only if the realized entry cost is larger than a common reservation entry cost, equal to the value of a vacancy. Upon recieving a transfer from the government, the reservation entry cost increases—we therefore call these transfers *hiring subsidies*.

[6] Following Mortensen and Pissarides (1994), separation decisions are typically modeled as a result of idiosyncratic productivity shocks, such that low-productivity firms optimally decide to exit. The assumption of stochastic idiosyncratic continuation cost shocks have similar material consequences, but avoid ex-post heterogeneity in firm outcomes.

[7] The continuation-cost distribution G is a mixture of a point mass and a Pareto distribution with shape parameter ψ, location parameter Y and mixture parameter p. We choose p and Y so that in steady state, job separations are δ_{ss} and the continuation costs are approximately zero, $\mu_{ss} \approx 0$. See Appendix A for details.

The total number of vacancies created is $\iota_t = F \cdot H(V_t^v)$. Following Coles and Kelishomi (2018), we choose the functional form of H so that vacancy creation ι_t responds with a constant elasticity ξ to the value of a vacancy V_t^v,[8]

$$\iota_t = \iota_{ss} \left(\frac{V_t^v}{V_{ss}^v} \right)^{\xi}. \tag{9}$$

Wage rule

Wages W_t are constant in real terms. Section XXX includes a specification where wages respond to fluctuations in the unemployment rate.

2.4 Wholesale and final goods producers

A continuum of wholesale firms indexed by $k \in [0,1]$ produce differentiated goods using the production function $Y_{kt} = X_{kt}$ where X_{kt} is the amount of the intermediate good purchased by firm k at the intermediate-good price P_t^X. The representative final-good firm has the production function $Y_t = \left(\int_k Y_{kt}^{\frac{\epsilon_p - 1}{\epsilon_p}} dk \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$ where Y_{kt} is the quantity of the input of wholesale firm k's output used in production. The implied demand curve is $Y_{kt} = \left(\frac{P_{kt}}{P_t} \right)^{-\epsilon_p} Y_t$ where $P_t = \left(\int_k P_{kt}^{1-\epsilon_p} dk \right)^{\frac{1}{1-\epsilon_p}}$ is the aggregate price level. The wholesale firms face virtual Rotemberg (1982) price adjustment costs, with scale factor ϕ. Since production is linear, the marginal cost of production is the input price P_t^X. In a symmetric equilibrium, optimal price setting implies a standard Phillips curve

$$1 - \epsilon_p + \epsilon_p \cdot P_t^X = \phi(\Pi_t - 1)\Pi_t - \beta\phi\mathbb{E}_t \left[(\Pi_{t+1} - \Pi_{ss})\Pi_{t+1} \frac{Y_{t+1}}{Y_t} \right], \tag{10}$$

[8] The entry-cost distribution has a cumulative distribution function $H(c) = F \cdot (c/h)^{\xi}$ on $c \in [0, h]$. With the parameter h sufficiently large so that $h > V_t^v$, the resulting number of vacancies created is $\iota_t = F \cdot (V_t^v)^{\xi}$. In the limit where $\xi \to \infty$, we must have $V_t^v = V_{ss}^v$ so that all entrants pay the same deterministic entry cost. We set $V_{ss}^v = \kappa_0$ and treat κ_0 as a free parameter. The free entry model is the double limit $\xi \to \infty$ and $\kappa_0 \to 0$, which implies $V_t^v = 0$. To facilitate comparisons with the free entry model we fix κ at a small positive value across all calibrations.

where $\Pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate. Total output given by

$$Y_t = \int_k X_{kt} dk = (1 - u_t) Z_t, \tag{11}$$

2.5 Households

Worker problem

A mass Θ of the workers consume income hand-to-mouth. The remaining workers may self-insure against unemployment risk by accumulating government bonds. All workers face the same earnings process.

Earnings process The worker earnings process $y(u_{it})$ captures the key features of the US unemployment insurance system, in particular the duration dependence in replacement rates and limited take-up rates. If $u_{it} = 0$, then the worker is employed and receives wage W_t. For $u_{it} > 0$, u_{it} denotes months of unemployment. With probability π^{UI} the worker claims the unemployment benefit and receives a high replacement rate $\overline{\phi}_t$ for the first $\overline{u_t}$ months and a lower replacement rate $\underline{\phi}$ thereafter. With probability $1 - \pi^{UI}$, the worker receives the lower replacement rate directly, allowing for limited take up. We include time subscripts on the replacement rate $\overline{\phi}_t$ and the UI duration $\overline{u}_t$, as these are subject to shocks. If $\overline{u}_t$ is not an integer (as in our policy experiment, where we consider a marginal change to UI duration), the worker receives a weighted average of the high and the low replacement rate in the month of expiration. Let E_{it} be an indicator for those households that claim unemployment benefits. We summarise the earnings process as,

$$y_t(u_{it}, E_{it}) = \begin{cases} W_t & \text{if } u_{it} = 0, \\ \text{UI}_{it}\overline{\phi_t} W_t + (1 - \text{UI}_{it})\underline{\phi} W_t & \text{otherwise,} \end{cases}$$

where

$$\text{UI}_{it} = \begin{cases} 1 & \text{if } u_{it} \leq \overline{u}_t \text{and } E_{it} = 1, \\ u_{it} - \overline{u_t} & \text{if } u_{it} \in (\overline{u}_t, \overline{u_t} + 1) \text{ and } E_{it} = 1, \\ 0 & \text{if } u_{it} \geq \overline{u}_t + 1 \text{ or } E_{it} = 0. \end{cases}$$

Employed workers transit to unemployment with the separation probability δ_t. To capture the observed decline in job-finding rates for workers with longer unemployment duration, the search intensity of an unemployed worker depends, exogenously, on the length of the unemployment spell. Let $u_{i,t-1}$ denote the length of the unemployment spell of worker i at the end of period $t-1$ (with $u_{i,t-1} = 0$ indicating that the worker was employed). Then the worker-specific job-finding rate is given by $\lambda^u_{it} = A\theta_t^{1-\alpha}s(u_{i,t-1})$ and the average economy-wide search effort is given by $S_t = \mathbb{E}_i[s(u_{i,t-1})|u_{i,t-1} > 0]$. The function $s(\cdot)$ is chosen in the calibration to match evidence from the US on duration dependence in job-finding rates.

Value functions The self-insuring workers can save in government bonds subject to a no-borrowing constraint, where a_{it} denotes the quantity of bond holdings at the beginning of period t. Bonds pay an ex-post real gross return R_t^{real}. A worker's state is given by her unemployment duration u_{it}, an indicator for UI take-up E_{it}, and her assets from the previous period, a_{it-1}. The self-insuring worker's Bellman equation is

$$\begin{aligned} V_t^w(u_{it}, E_{it}, a_{it-1}) = &\max_{c_{it}, a_{it}} \frac{c_{it}^{1-\sigma}}{1-\sigma} + \beta \underline{V}_{t+1}^w(u_{it}, E_{it}, a_{it}) \\ &\text{s.t. } a_{it} + c_{it} = R_t^{\text{real}} a_{it-1} + (1-\tau_t) y_t(u_{it}, E_{it}) + T_t + Div_t, \\ &\quad a_{it} \geq 0, \end{aligned}$$

where $y(u_{it})$ is earnings, T_t is a uniform lump-sum transfer from the government, Div_t are profits from firm ownership, and τ_t is a flat earnings tax levied by the government. Profits are distributed equally to all households implying that the aggregate MPC out of profit income is the same as out of government transfers. The continuation value of the employed equals

$$\underline{V}_t^w(0, E_{it-1}, a_{it-1}) = (1-\delta_t)V_t^w(0,0,a_{it-1}) + \delta_t \pi^{UI} V_t^w(1,1,a_{it-1}) + \delta_t(1-\pi^{UI})V_t^w(1,0,a_{it-1})$$

where $1 - \pi^{UI}$ is the probability that workers are not eligible for unemployment benefits. The continuation value of the unemployed ($u_{it-1} > 0$) is

$$\underline{V}_t^w(u_{it-1}, E_{it-1}, a_{it-1}) = \lambda_t^u s(u_{it-1}) V_t^w(0,0,a_{it-1}) + (1 - \lambda_t^u s(u_{it-1})) V_t^w(u_{it-1}+1, E_{it-1}, a_{it-1}). \tag{12}$$

The hand-to-mouth workers face an identical earnings process, but simply consume all of the income in each period.

2.6 Fiscal policy

The government raises taxes, issues bonds and spends funds on unemployment insurance, government consumption G_t, universal transfers to all households T_t, retention subsidies to matched firms, and hiring subsidies to newly formed matches. As in Auclert et al. (2020b), one unit of government bonds is a promise to a sequence of geometrically decaying coupon payments, paying out δ_q^{k-1} units of consumption k periods into the future. The government's budget is thus given by

$$q_t(B_t - \delta_q B_{t-1}) = B_{t-1} + \text{expenditure}_t - \tau_t(1-u_t)w_t \tag{13}$$

where expenditure_t is given by

$$\begin{aligned}\text{expenditure}_t =& (1-\tau_t)\left(\overline{\phi}_t \text{UI}_t^{hh} + \underline{\phi}\left(u_t - \text{UI}_t^{hh}\right)\right) w_t \\ &+ \text{T}_t + G_t \\ &+ \text{rs}_t \cdot (1-u_t) \\ &+ \text{hs}_t \cdot \lambda_t^v((1-\delta_{ss})v_{t-1} + \iota_t),\end{aligned}$$

q_t is the price of government bonds and $\text{UI}_t^{hh} = \int \mathbb{1}\{u_{it} > 0\}\text{UI}_{it} E_{it} di$ is the mass of unemployed households that take up unemployment insurance . The ex-post return of purchasing government bonds is

$$R_{t+1}^{\text{real}} = \frac{1 + \delta_q q_{t+1}}{q_t}.$$

The government smooths taxes τ_t in the following way: let $\tau_{direct,t}$ be the per-period tax rate that brings outstanding liquidity immediately back to its steady-state level $q_{ss}B_{ss}$. This is given by

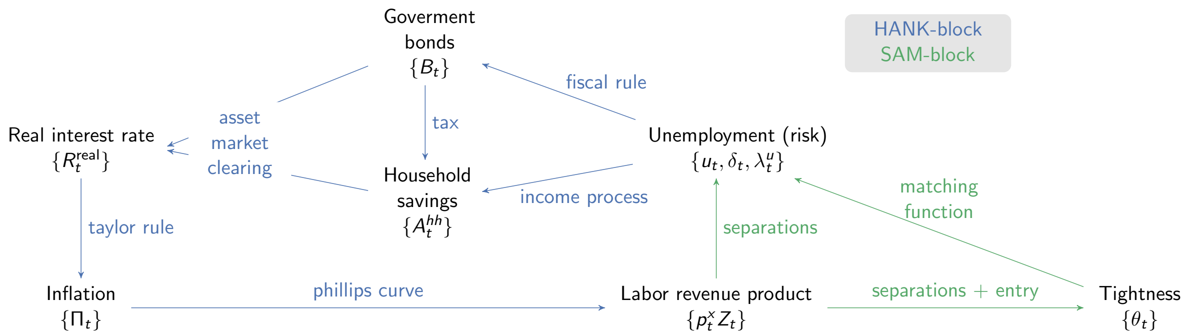

Figure 1: A diagrammatic depiction of the model.

$$\tau_{direct,t} = \frac{1}{(1-u_t)w_t}\left((1+q_t\delta_q)B_{t-1} + \text{expenditure}_t - q_{ss}B_{ss}\right). \tag{14}$$

The tax rate is then set as a weighted average between $\tau_{direct,t}$ and the tax rate in steady state, τ_{ss},

$$\tau_t = \omega\tau_{direct,t} + (1-\omega)\tau_{ss},$$

where ω determines the response in government debt. With $\omega = 1$, any increase in expenditure is fully tax financed, with $\omega = 0$, any increase in expenditure is fully debt financed.

2.7 Monetary policy

A monetary authority sets the nominal interest rate according to a conventional Taylor rule,

$$R_t = R_{ss}\Pi_t^{\phi_\pi}, \tag{15}$$

where R_t is the ex-ante nominal interest rate on the government bonds.

3 An analytical summary of the model: circular propagation through three blocks

Our model contains a large number of parameters and has an an infinite-dimensional state space. It therefore needs to be solved numerically. Nevertheless, we can characterize parts of the propagation mechanism analytically under mild simplifying assumptions. We do so by formulating the model dynamics in sequence space (Auclert et al. (2020a)) and categorize the equilibrium conditions into three blocks. We consider the response of equilibrium variables to "MIT shocks": with the economy initially at steady state, at time 0 the paths of exogenous variables are announced and we trace out the perfect-foresight paths of the endogenous variables. To a first order, each block of the model can be summarized by a linear mapping which takes a path of input variables and generates a path of output variables (where paths are defined as percent deviations from their stead-state values). In Auclert et al. (2020a), the model blocks are arranged as a directed *acyclical* graph for computing the model equilibrium. Our model blocks can be arranged in a directed *cyclical* graph: in response to any shock, the sequence-space equilibrium can be decomposed into a shock-specific direct effect, and a shock-invariant feedback loop that determines the propagation of all shocks. An implication is that the model feature what we call block separability: the relative strength of different policy shocks that enter the model in the same block only depends on the parameters of that block, and not the parameters all the other blocks.

3.1 The model's three blocks

In this section, we make the simplifying assumption (relaxed in the subsequent quantitative analysis) that all profits are taxed by the government and used for expenditure within the period. With this assumption, under a first order approximation, the model can then be summarized by the diagram in Figure 1. The three blocks of the model constitute three linear mappings from the paths of input to those of output variables:

$$\mathbf{f} = M_{SAM}\mathbf{p}^{\mathbf{x}}, \tag{16}$$

$$\mathbf{r}^{\mathbf{real}} = M_{HA}\mathbf{f}, \tag{17}$$

$$\mathbf{p}^{\mathbf{x}} = M_{NK}\mathbf{r}^{\mathbf{real}} \tag{18}$$

The search-and-matching (SAM) block is a mapping from a path of the revenue product of labor, which in the absence of productivity shocks equals the intermediate-goods price, to a path of labor-market flows (the job-separation rate and the job-finding rate). Under a log-linearization, this mapping is described by a linear mapping M_{SAM},where $\mathbf{p}^{\mathbf{x}} = [p_0^x, p_1^x, p_2^x, \ldots]$ denotes the path of log-linear deviations from steady state for the intermediate-goods price and the path of labor-market flows is given by $\mathbf{f} = [\delta_0, \lambda_0^u; \delta_1, \lambda_1^u; \ldots]$. The path of equilibrium unemployment is implied by **f**.

The heterogeneous-agent (HA) block is a mapping from a path of labor-market flows to a path for the real interest rate. The labor-market flows affect the household income process, i.e., current employment status and perceived unemployment risk, and, therefore, the household demand for savings. The labor-market flows also affect the government budget constraint through spending on unemployment benefits, implying paths for government bonds and taxes. The taxes, in turn, enter the household consumption-savings problem while the path for government bonds determines asset supply. Together, the government bond supply and the asset demand of the households determine the market clearing real interest rate, $\boldsymbol{r}^{\text{real}} = [r_0^{\text{real}}, r_1^{\text{real}}, r_2^{\text{real}} \ldots]$.

Finally, the new-Keynesian block provides a link from the real interest rate to the intermediate-goods price. For a given path of real interest rates, the Taylor rule 15 implies a path of inflation. Given a path of inflation, the first-order approximation of the Phillips curve 10 implies a path of intermediate-goods prices.[9] Note that M_{NK} is not a *causal* link strictu sensu, but an equilibrium condition.

3.2 The propagation of policies

We can characterize the dynamics of the model in response to shocks to the paths of policy variables in terms of the three linear mappings M_{SAM}, M_{HA} and M_{NK}. Specifically, we are interested in the response of the path of labor-market flows, $\mathbf{f} = [\delta_0, \lambda_0^u; \delta_1, \lambda_1^u; \ldots]$, to these policy paths.

The propagation of demand-side policies

Let $\mathbb{D}$ be the set of *demand-side policies*, consisting of all possible paths of government spending, the UI replacement rate, UI duration and uniformly distributed transfers to the households. These policy paths share the feature that they act as shocks within the HA block, therefore affect

[9] Under a log-linearization, the Taylor rule and the Phillips curve are given by $i_t = \phi_\pi \pi_t$ and $\pi_t = \beta\pi_{t+1} + \kappa p_t^x$ which, together with $r_t^{\text{real}} = i_t - \pi_{t+1}$, yield the explicit description $p_t^x = \frac{1}{\kappa(\phi-1)}\left(\left(1-\frac{1}{\phi}\right)\sum_{k=0}^{\infty}\left(\frac{1}{\phi}\right)^k (r_{t+k}^{\text{real}} - \beta r_{t+k+1}^{\text{real}}\right)$ of the linear mapping M_{NK} from the path of the real interest rate to the path of the intermediate-goods price. Thus, M_{NK} is proportional to κ^{-1}. As a result, $M_{\text{NK}} = 0$ in the limit of flexible prices ($\kappa^{-1} \to 0$).

the equilibrium unemployment rate through the excess demand for assets. Let D$\in \{G, \bar{u}, \phi, T\}$ denote the type of policy shock. Associated with each policy shock D is a matrix $M_{D,r}$, which maps the shock to the real interest rate within the HA block. Similiarly, there is matrix $M_{D,\text{tax}}$, which maps the shock to the path of government tax revenue within the HA block. We can show two results:

Proposition 1. *Assume that $(I - M_{SAM}M_{NK}M_{HA})$ is invertible. For an exogenous policy sequence $\mathbf{d} \in \mathbb{D}$ of type D, the first-order response of the path of labor-market flows $\mathbf{f}$ is given by*

$$\mathbf{f} = (I - M_{SAM}M_{NK}M_{HA})^{-1}M_{SAM}M_{NK}M_{D,r}\mathbf{d}. \tag{19}$$

Furthermore, for any two demand-side policies $\mathbf{d}$,$\mathbf{d}^* \in \mathbb{D}$ of type D and D that implies the same labor market path $\mathbf{f}$, the difference between their respective fiscal costs is given by*

$$\Delta \textit{Fiscal cost} = M_{D^*,tax}\mathbf{d}^* - M_{D,tax}\mathbf{d},$$

Proof: see Appendix B.

Consider, for example, the response to a government expenditure shock $\mathbf{g} = [g_0, g_1, ...]$. The labor-market response $\mathbf{f}$ is composed of a first-round direct effect $M_{\text{SAM}}M_{\text{NK}}M_g\mathbf{g}$, which then feeds through the diagram in Figure 1, generating the feedback loop described by the geometric sum $(I - M_{\text{SAM}}M_{\text{NK}}M_{\text{HA}})^{-1}$. The direct effect is specific to this particular shock. Given the first round response of $\mathbf{f}$, the feedback loop is policy-invariant. The circular propagation mechanism implies the second result. Compare the government expenditure shock to a shock to UI duration $\bar{\mathbf{u}} = [\bar{u}_0, \bar{u}_1, ...]$. . These policies enter the HA block and therefore the labor market flows through the real interest rate in the first round. Given that they imply the same labor market path and that the mapping between the real interest rate and the labor market state is invertible, these policies must have the same effect on the initial real interest rate path. Therefore, to the extent that they imply different fiscal costs, this can only arise through the different cost in generating the initial interest rate path, which only depend on the parameters within the HA block, as contained in $M_{D^*,\text{tax}}, M_{D,\text{tax}}$.

The propagation of supply-side policies

An analogous result to Proposition 1 holds for *supply-side policies*. Let S be the set of *supply-side policies*, consisting of paths of retention subsidies and hiring subsidies. These policies act as shocks to the SAM block and affect the labor market state directly through changing the incentives to separate and hire workers. Associated with each type of policy shock S$\in \{rs, hs\}$ is a matrix$M_{S,f}$, which maps the shock on the labor-market flows with the SAM block, and a matrix $M_{S,\text{tax}}$, which maps the shock on the path of government tax revenue with the SAM block.

Proposition 2. *Assume that $(I - M_{SAM}M_{NK}M_{HA})$ is invertible. Given an exogenous policy sequence $\mathbf{s} \in \mathbb{S}$ of type S, the first-order response of the path of labor-market flows $\mathbf{f}$ is given by*

$$\mathbf{f} = (I - M_{SAM}M_{NK}M_{HA})^{-1}M_{S,f}\mathbf{s}. \tag{20}$$

Furthermore, for any two supply-side policies $\mathbf{s}$,$\mathbf{s}^* \in \mathbb{S}$of type S and S that implies the same labor market path $\mathbf{f}$, the difference between their respective fiscal costs is given by*

$$\Delta \textit{Fiscal cost} = M_{S^*,tax}\mathbf{s}^* - M_{S,tax}\mathbf{s},$$

Proof: see Appendix B.

Propositions 1 and 2 imply that the pair-wise comparison of some policies only depend on a subset of the model parameters. This is especially useful given that we consider a large model with many parameters. We will use these results to guide the analysis of how different policy multipliers are affected by the model parameters in Section XXX.

The results here where derived under the simplifying assumption that all profits are taxed by the government and used for expenditure within the period. As we will show in our quantitative analysis in Section XXX, although these profit effects are quantitatively important for assessing the relative strength across the sets of supply vis-a-vis demand-side policies, they are not of first-order importance for assessing the relative multipliers within each set. That is, block separability approximately holds in the baseline model. This is because profits of intermediate-goods firms (which, when distributed to households, break the circular propagation in Figure 1 by creating a direct link from the NK block to the HA block) fluctuate little when wages are rigid. And profits in the wholesale-goods sector (which, when distributed to households, create a link from the supply-side policies to the household block that bypasses the labor market) respond similarly to the two supply-side policies, such that their comparison is not much affected.

Parameter	Value	Source / Target
Substitution elasticity, ϵ_p	6	Standard
Rotemberg cost, φ	355	Standard
Taylor rule parameter, ϕ_π	1.5	Standard

Table 1: NK parameters

4 Parameter choice

Our parameterization approach is to set most model parameters to conventional values in the literature or to target conventional moments for the U.S. economy in the steady state of the economy. Given these parameters, we then calibrate the parameters of the HA and the SAM block that are key to the relative strength of the fiscal policies under consideration. Specifically, because the dynamics of savings and consumption are at the heart of transmission, we calibrate the parameters of the HA block to match micro-level consumption profiles upon unemployment shocks. similar to Kekre (2021). Because time-variation in unemployment risk is another central determinant of policy effectiveness, we choose the parameters of the SAM block to match the dynamics of unemployment risk (job-finding and job-separation rates) at the macro level, following our earlier work (Broer et al., 2021).

A time period in the model is one month. Tables 1-3 summarize the parameters of our model.

4.1 NK block

The parameters of the NK block are displayed in Table 1. The Rotemberg adjustment cost is set so that the implied slope of the Phillips curve is the same as with a Calvo model with average price duration of 9 months.[10]

4.2 HA block

We choose the parameters governing individual income risk and consumption-savings behavior to match average statistics from U.S. micro data in the steady state of our model.

[10] The implied relation between inflation and real marginal costs—the Phillips curve—with our adjustment cost specification has a slope of $(\epsilon - 1)/\varphi$. With a Calvo survival probability θ_p, the slope is instead $(1-\theta_p)(1-\beta\theta_p)/\theta_p$. The two are the same when $\varphi = (\epsilon-1)\theta_p/((1-\theta_p)(1-\beta\theta_p))$. We set φ consistent with a Calvo survival probability of $\theta_p = 8/9$, which implies an average price duration of 9 months.

Following Kekre (2021), we target a structure of unemployment insurance that captures the temporary nature of unemployment benefits, and the observed income drops during unemployment, in U.S. micro data. Specifically, individuals who become unemployed receive unemployment benefits equivalent to 76 percent of their last wage for 6 months, after which the replacement rate drops to 55 percent. These replacement ratios are higher than the statutory ones, but in line with observed drops in household income (accounting for, e.g., the presence of a second earner). To capture that only 39 percent of unemployed individuals receive unemployment benefits (Chodorow-Reich and Karabarbounis, 2016), 51 percent of newly unemployed individuals immediately receive the low replacement rate. Finally, average search efficiency in steady state S is normalized to 1 and we set the relative search efficiencies $s(u_{it-1})$ to match the documented decline of job-finding rates with increasing unemployment duration reported in Eubanks and Wiczer (2016), see Appendix ??? for details.

The parameters that govern consumption-savings behavior are set to replicate the observed consumption profile after unemployment shocks. We choose this strategy, as opposed to targeting moments of the observed wealth distribution, because the degree of consumption insurance, which determines the precautionary-savings motive and the marginal propensity to consume (MPC), is a key determinant of the transmission in our model. We calibrate the share of hand-to-mouth households, the discount factor and the supply of government bonds to match (i) an annual steady-state real interest rate of 2 percent per year, (ii) an average consumption level of the unemployed relative to the employed of 80 percent (Chodorow-Reich and Karabarbounis, 2016), and (iii) a percentage drop in consumption upon expiration of unemployment benefits that equals 43 percent of the drop in income (Ganong and Noel, 2019). With a fraction of hand-to-mouth households just under 40 percent, a bond supply 130 percent of period output, and a discount factor $\beta = 0.971$, the model matches these moments well. The implied average quarterly MPC is 40.7 percent, which is line with empirical estimates (see, e.g., Johnson et al. (2006)). Since profits are distributed equally and lump sum to all households, this also implies that the average quarterly MPC out of profit income is 40.7 percent, which is roughly line with Di Maggio et al. (2020), who report an annual average MPC between 40 and 60 percent.

Following Auclert et al. (2020b), we set the bond maturity parameter δ, so that average bond maturity is 5 years, and the tax-smoothing parameter ω to target that the government runs a deficit for two years following an $AR(1)$ government consumption shock with a quarterly autocorrelation of 0.899.

HA Parameters	Value	Source / Target
Discount factor β^{12}	0.971	Avg. cons. drop during unemp.
Share of HtM agents Θ	0.38	Consumption drop at UI expiration
CRRA coefficient, σ	2	Standard
High UI, $\overline{\phi}$	0.76	Kekre (2021)
Low UI, $\underline{\phi}$	0.55	Kekre (2021)
UI duration, $\overline{u}$	6.0	UI duration in the US
UI prob, π^{UI}	0.48	UI recipients / unemployed = 39 percent
Relative search effectiveness, $s(u_{it-1})$	(see Figure **??**)	Eubanks and Wiczer (2016)
Tax-smoothing parameter, ω	0.05	Two-year deficit following neg. gov. cons. shock
Bond maturity, δ_q	$1/60 * (60 - 59R^{\text{real}})$	Bond maturiy of 5 years
Tax rate, τ	0.3	Standard
Value of bonds, $\frac{q_{ss}B_{ss}}{Y^{hh}_{ss}}$	1.27	Steady state interest rate at 2 percent

Table 2: HA parameters

4.3 SAM block

To parameterize the SAM block, we first set a number of parameters to standard values in the literature or to match a set of standard steady state moments, such as steady state tightness and separation rates. In addition, the model contains a scale parameter in the idiosyncratic entry cost function. We choose this to satisfy to ensure that our model converges to the standard free-entry model when the elasticity of vacancy creation with respect to vacancy values tends to infinity, details are given in Appendix ???.

We choose the wage level and the elasticities of separations and entry to capture the cyclical features of U.S. labor-market variables , estimated in Broer et al. (2021). In response to a one percent shock with estimated quarterly autocorrelation of 0.907, the overall size of the unemployment response (measured as its standard deviation) is 0.94 percentage points, the separation rate accounts for about 45 percent of the total response in unemployment, and that the peak of the job-separation rate response leads the peak of the job-finding rate reponse by 9 months. As in Broer et al. (2021), the delayed response of the job-finding rate identifies the sluggishness of vacancy creation, the contribution of the separation rate to unemployment volatility identifies the separation elasticity, and the overall unemployment volatility identifies the wage level (which determines the *fundamental surplus* as in Ljungqvist and Sargent (2021)).

Parameter	Value	Source / Target
Firm discount factor, β^{firm}	$0.98^{\frac{1}{12}}$	Standard
Matching function elasticity, α	0.60	Petrongolo and Pissarides (2001)
Separation rate, δ_{ss}	0.027	Broer et al. (2021)
Tightness, θ_{ss}	0.60	Hagedorn and Manovskii (2008)
Separation elasticity, ψ	2.96	EU share of unemployment volatility w.r.t TFP shock from Broer et al. (2021)
Entry elasticity, ξ	0.01	UE lag relative to EU w.r.t TFP shock from Broer et al. (2021)
Wage level, w_{ss}	0.67	Unemployment var. w.r.t. TFP shock from Broer et al. (2021)

Table 3: SAM parameters

5 The propagation of government spending shocks and the role of frictions

This section discusses how the frictions in the model shape the propagation of a government spending shock in the baseline calibration. Figure 2 shows the responses of key variables in the baseline model to a one-standard-deviation increase in government consumption G_t that follows an $AR(1)$ process with persistence $\rho_G = 0.965$. Separation rates fall on impact while the job-finding rate follows a hump-shape increase. This change in labor-market flows implies a hump-shaped fall in unemployment and a reduction in unemployment risk that is consistent with a higher real interest rate and inflation.[11]

To identify how the key features of our model—price rigidity, incomplete markets, labor markets with endogenous separations and sluggish entry—contribute to the propagation of fiscal shocks, Figure 2 also includes IRFs for three comparison models. Holding all other parameters constant, the three comparison models feature (i) flexible prices, (ii) a standard DMP labor market, with exogenous separations and free entry, and (iii) a full set of insurance contracts, effectively replacing the HA block with a corresponding representative agent (RA).

All three comparison models imply dampened responses to a government spending shock. And, importantly, the baseline response exceeds the sum of the other three counterfactuals responses: the frictions mutually re-inforce each other in the transmission of government spending shocks. This reflects the circular feedback loop discussed in Section 3: with a stronger mapping from unemployment to labor-revenue productivity (the HA-NK block), the marginal effect of a stronger mapping from labor-revenue productivity to unemployment (the SAM block) is

[11] In the initial periods, the increase in the job-finding rate is masked by a composition effect: the fall in the separation rate reduces the number of recently laid off workers, who have a higher job-finding rate.

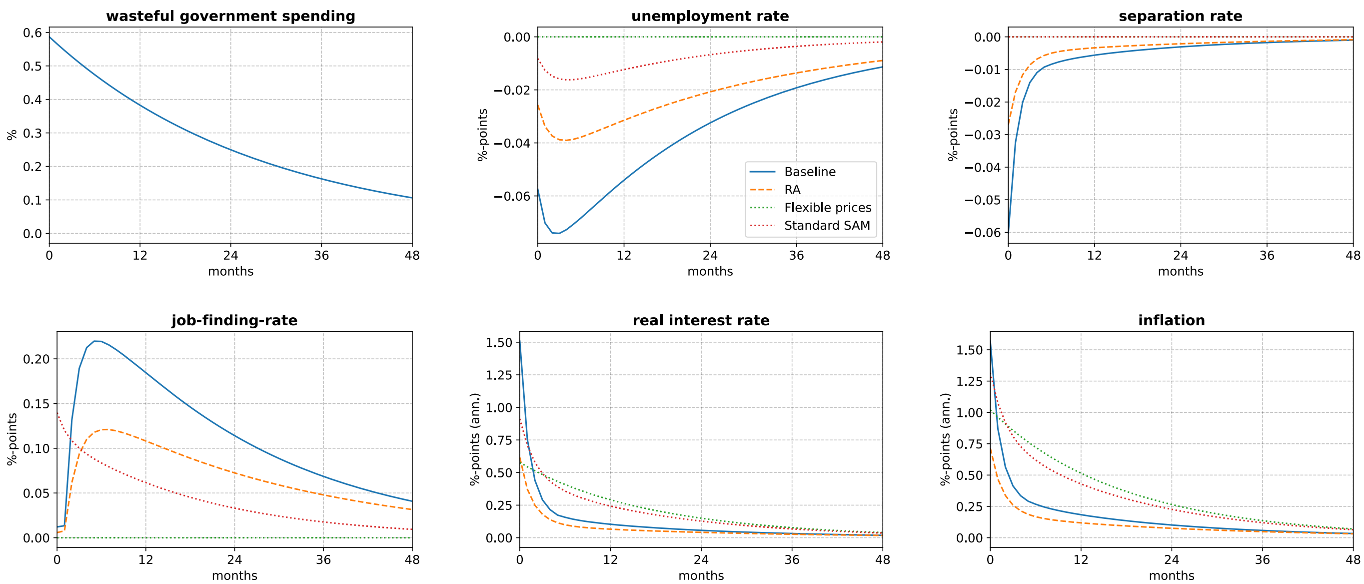

Figure 2: Respones to a government spending shock. The graphs display either the percent or the percentage-point deviation of the response from its steady state value.

larger.

The rest of this section studies the transmission mechanism through the HA, NK and SAM blocks of the model in more detail.

5.1 Nominal rigidities: the NK block

The NK block of the model can be viewed as a linear mapping from a sequence of real interest rates to labor-revenue productivity. With flexible prices, that mapping is simply the zero operator and the transmission is broken (reflecting the absense of labor-supply effects of tax changes in our model). With rigid prices and monetary policy determined by the Taylor rule (15), real interest rates are tied to intermediate-goods prices via consumer-price inflation. Real rates are above steady state when inflation is, associated with increased markups and labor-revenue productivity and, therefore, labor demand. As a consequence, separations fall, vacancy creation increases, and equilibrium unemployment falls.

5.2 Incomplete markets: the HA block

The heterogeneous-household (HA) block of the model can be viewed as a linear mapping from a sequence of labor-market variables to a path for the real interest rate that clears the asset market. That mapping reflects both shifts in the asset demand curve, determined by households saving behavior, and in the asset supply curve, determined by government debt issuance in response to the shock. In this subsection, we analyze how heterogeneity and market incompleteness amplify this mapping. For this, we compare the asset demand and supply responses in the baseline model to those with a representative agent. At the core of propagation through the HA block of the baseline model is a substantially smaller increase in household asset demand relative to the RA model when an expansionary fiscal shock reduces unemployment risk. This difference amplifies the effect of fiscal shocks, and is accounted for about equally by higher marginal propensities to consume, and a reduction in precautionary savings in response to lower risk that is absent with a representative agent.

The solid lines in the top-left panel of Figure 3 compare the time paths of asset supply and asset demand in a partial equilibrium of our baseline model where interest rates remain at their steady state level. Asset supply shifts out due to the exogenous increase in government spending. Asset demand shifts out due to the endogenous change in the income process. Quantitatively, asset supply shifts out substantially more than asset demand and in asset-market equilibrium this excess supply of savings increases equilibrium interest rates in response to the shock. To identify the role of incomplete markets and household heterogeneity for asset demand, the dashed line contrasts the baseline response to that of a representative agent who faces the baseline path of total post-tax labor income including profits, and whose consumption abides by the permanent-income hypothesis. Market incompleteness substantially lowers the asset-demand response, implying stronger excess supply in the asset market and upward pressure on interest rates.

The top-right panel decomposes these asset demand responses into contributions from changes in the paths of the two income components: non-labor income (firm profits and income taxes) and the stochastic process of labor income implied by the paths of the job-finding and separation rate, λ_t^u and δ_t. The representative consumer simply consumes the permanent-income equivalent of temporary changes in non-labor income, implying a hump-shaped response of assets. Household heterogeneity increases the maginal propensity to consume out of incomes, and thus dampens asset demand out of non-labor income.

In response to the change in labor income, asset demand by the representative consumer rises persistently. By contrast, asset demand in the baseline model is essentially unresponsive to the change in the labor-income process.The bottom-left panel of Figure 3 shows why. Here, we decompose the asset-demand response to a changed income process into an “income-effect” and a precautionary-savings effect. The income effect is computed as a counterfactual that conditions on the changes in the labor-income process in the baseline response but keeps household behavior, as embodied in the consumption policy functions, unchanged at its steady state level. The difference between the asset demand response corresponding to this income effect and that of a representative agent therefore summarises the effect of higher marginal propensities to consume on asset demand. The precautionary-savings effect, in contrast, is computed by conditioning on the dynamic evolution of consumption policies in the baseline response, but with the steady-state labor-income process.

Relative to permanent-income behavior, higher propensities to consume in steady state flatten asset demand in response to rising labor income: the yellow dashed line rises substantially less than the black line. In addition, the fall in labor-income risk reduces precautionary savings at unchanged labor income, further dampening the response of asset demand in our baseline model relative to one without heterogeneity. Overall higher marginal propensities to consume and time-variation in precautionary savings thus contribute about equally to the amplification of shocks coming from incomplete markets.

The bottom-right panel of Figure 3 compares the response of precautionary savings in the baseline model to an alternative where separations remain at their steady-state value and the baseline path of unemployment is generated only through an increase in job-finding. Precautionary savings fall even more in this case, about twice as much relative to steady state. This is because in our calibration, which captures the relatively gentle decline in average consumption during unemployment spells in U.S. micro data, most households smooth even longer-than-expected unemployment spells. Therefore, increases in job-finding rates that make low-consumption outcomes further in the spell less likely have a stronger effect on precautionary savings than reductions in separation rates that cause the same change in unemployment but mainly increase the likelihood of short unemployment spells that are relatively well insured.

5.3 Endogenous separations and sluggish vacancies: the SAM block

The search-and-matching (SAM) block of the model can be viewed as a linear mapping from a path of labor revenue productivity, which with constant productivity equals the intermediate goods price, to the path of labor-market variables. Our calibrated labor market features endogenous separations and relatively inelastic vacancy creation. Both these features amplify the labor-market response. In Figure 4, we compare the response of unemployment in our baseline calibration to that in alternative specifications with exogenous separations and/or free entry to vacancy posting, evaluated at the baseline path of the intermediate goods price.

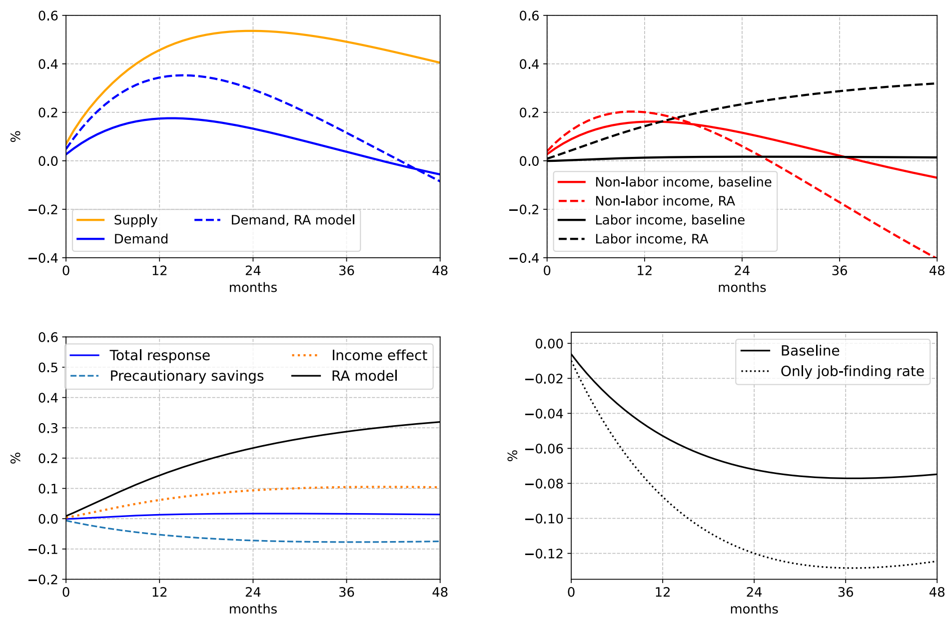

Figure 3: The Asset Market Equilibrium and Its Determinants.

With exogenous separations, the labor-market response is strongly muted. With free entry, the endogenous fall in the separation rate is partially offset by a decrease in vacancy creation. In the baseline model, with relatively inelastic vacancy creation, this offsetting effect is much weaker.

6 The cost effectiveness of fiscal policies

This section quantitatively compares the effectiveness of six common government spending policies in stabilizing employment: i) an increase in government consumption G_t (our benchmark policy discussed in the previous section); ii) an increase in T_t, the univeral lump-sum transfer to all workers; iii) an increase in the generosity of unemployment insurance $\overline{\phi}_t$; iv) an extension of the duration of unemployment benefits $\overline{u}_t$; v) a retention subsidy rs_t ; and vi) a lump-sum hiring subsidy hs_t.

First, we demonstrate substantial heterogeneity in the effectiveness of different policies to stimulate employment: long-run fiscal multipliers range from 0.27 (for universal transfers) to 1.61 (for retention subsidies) in our baseline calibration. Second, we identify the determinants of the average size and ranking of multipliers. Both crucially hinge on the degree of partial consumption insurance, and the dynamics of unemployment risk, which makes data-consistency in calibrating these frictions crucial. Third, the relative multipliers approximately obey the block

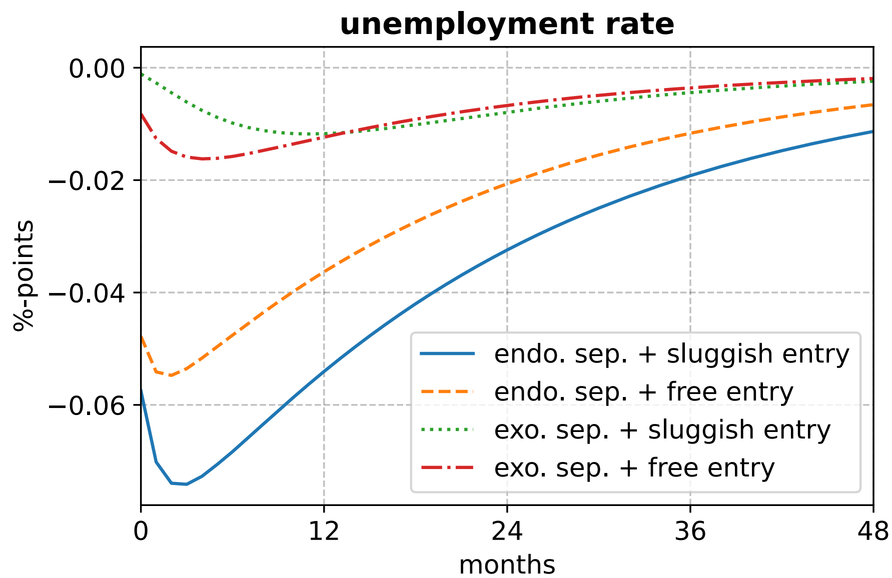

Figure 4: The response of equilibrium unemployment with different SAM-block assumptions.

recursiveness of Propositions 1 and 2: the parameters governing partial insurance (respectively the dynamics of unemployment risk) leave the relative multipliers *within* the set of supply-side (respectively demand-side) subsidies unaffected even in the quantitative model where profits are distributed equally to all households. As we finally show, the way profits are distributed, and the implied propensity to consume them, however, is a particularly important determinant of the overal level of fiscal stumulus effects and of their relative values *across* supply- and demand-side policies

6.1 Paths of taxes and unemployment

We choose as the benchmark policy the small, persistent increase in government consumption from the previous section. We then compare the path of taxes under this benchmark policy to those of the alternative policies. The right panel of Figure 5 depicts the equilibrium paths of taxes for alternative policies whose paths are chosen to deliver an identical response of the unemployment rate (depicted in the left panel of Figure 5).

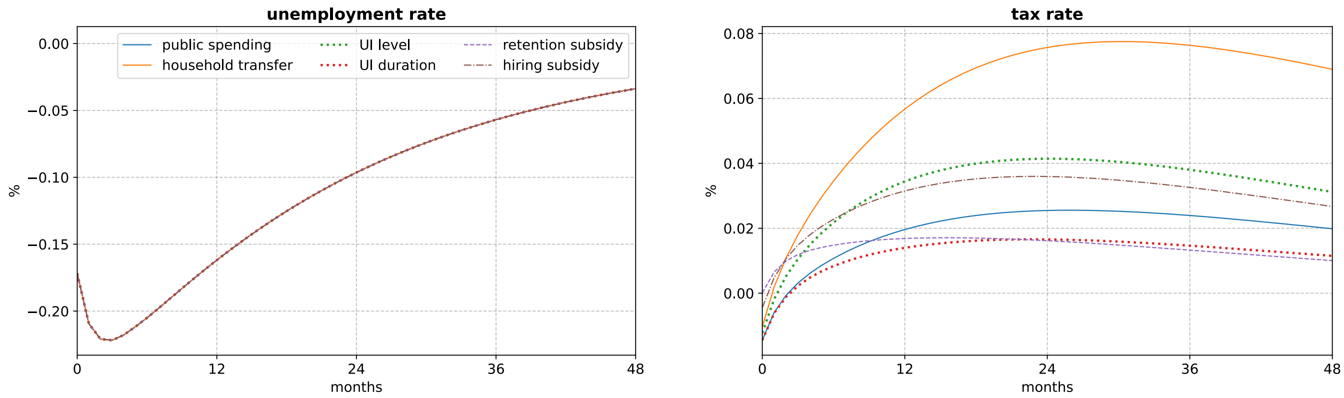

Figure 5: Tax rate responses with different policies.

6.2 Fiscal multipliers in the baseline model

We summarize the paths of employment and tax revenue implied by Figure 5 by computing the cumulative fiscal multipliers implied by the different policies in the first row of Table 4. The multipliers are calculated as the ratio of cumulative deviations from their steady-state values of, respectively, output (which is proportional to employment) and tax revenue,

$$\text{Cumulative Fiscal Multiplier } = \frac{\sum_{t=0}^{\infty} d\text{employment}_t}{\sum_{t=0}^{\infty} d\text{tax revenue}_t}.$$

The multiplier associated with the benchmark increase in government consumption equals 1.02—output rises about one-for-one with spending on government consumption. This is an untargeted moment in our calibration, but nevertheless within the range of values commonly found in the literature(see, e.g., Ramey (2011)). As suggested by the paths of taxes in Figure 5, uniform transfers, which are only partially consumed within the period, are substantially less effective, yielding only about a fourth of the benchmark increase in output per dollar spent. Transfers concentrated on the unemployed are more stimulative. UI duration extensions are about as effective as the benchmark. Among supply-side policies aimed at increasing labor demand, hiring subsidies achieve about two-thirds the benchmark output response. The clear winner is the retention subsidy: its cumulative fiscal multiplier is more than 50 percent higher than the benchmark. The remainder of our analysis unpacks how the different model components affect the size and heterogeneity of the fiscal multipliers associated with each policy.

	G	transfer	UI level	UI duration	retention	hiring
Baseline	1.02	0.27	0.42	0.99	1.61	0.70
Flexible prices	0.00	0.00	0.00	0.00	0.31	0.22

Table 4: Cumulative fiscal multipliers: baseline and with flexible prices.

6.3 Nominal rigidities: the NK block

Table 4 also shows the multipliers associated with the model absent sticky prices. In this case, there is no feedback from changes in the HA block to the determination of the unemployment and output in the SAM block. Thus, there is no output response to any fiscal intervention that takes place within the HA block: the multipliers associated with spending and different household transfers are all zero. The multipliers associated with supply-side policies are also greatly reduced. This shows the direct first-round effect of these policies on unemployment is small, and the bulk of the multipliers associated with these policies stem from the feedback loop generated through sticky prices.

6.4 Incomplete markets: the HA block

Table 5 shows the multipliers associated with different specifications of the HA block. To facilitate comparison, the multipliers are now normalized by the government spending multiplier in the same model.

To understand how the relative effectiveness of fiscal policies is affected by market incompleteness, remember from the previous section that it acts by increasing the average marginal propensity to consume out of current relative to future income, and because buffers of precautionary savings fluctuate in the phase of changing income risk. To see how this changes multipliers, consider first the fiscal multipliers in a version of our model with full insurance agains idiosyncratic risk, that is, when the heterogeneous households in the HA block are replaced with a representative household who receives all income and pays all taxes. In this case, household consumption is determined by total lifetime wealth and relative prices. Because household transfers are exactly offset by a rise in the present discounted value of taxes, the shift in the demand curve for government bonds is exactly offset by the shift in supply in response to transfer policies. So the real interest rate stays constant and fiscal multipliers are 0. The multipliers associated with the remaining policies are positive, but greatly reduced as there is no amplification from income-effects on consumption or countercyclical precautionary savings. This also implies that there is no effect on demand of reduced labor-market risk in response to supply-side policies, which substantially dampens their relative multipliers.

In rows 3 and 4 of Table 5 , we identify the effect on fiscal multipliers of a high average MPC and time-varying precautionary savings separately. Specifically, in row 3 we lower the average MPC by reducing the number of HtM households in the model. In this case, the absolute size of all multipliers goes down. Relative multipliers associated with universal transfers and higher unemployment benefits fall, but, interestingly, the relative multiplier of UI duration extensions increases. This is because a larger share of households now holds precautionary savings that fall in response to longer UI duration. This precautionary-savings effect dominates the reduction in the marginal propensity to consume out of transfers for this policy.

Row 4 considers a specification without any role for precautionary savings. We do so by computing the equilibrium in which households maintain a (false) belief that future labor-market transition rates will always be at their steady-state values, and adjust the expected wage path so that they still have the correct belief about expected income. That is, we eliminate all fluctuations in beliefs about the higher moments of the income process stemming from fluctuations in labor market transisiton rates. Again, the absolute size of all multipliers goes down. The effectiveness of uniform transfers is barely changed, while that of UI policies is substantially reduced when we shut off their effect on precautionary savings in this way.

Because MPCs and precautionary savings are jointly determined by the average supply of assets, or liquidity,in the economy, Rows 5-7 consider levels of liquidity that are, respectively, higher and lower than in the baseline calibration. The benchmark government-expenditure multiplier falls when liquidity rises. This is because asset demand reacts more (as stronger self-insurance reduces MPCs and countercyclical movements in precautionary savings) and because the supply of government debt rises less in relative terms. Because precautionary savings fluctuate less and MPCs are less heterogeneous, household transfer policies, and particularly UI duration extensions, become relatively less effective.Recall from row 2 that in the limit of full insurance, the multiplier of transfers policies fall to zero, whereas the government spending multipliers is bounded from below by 0.71.

Row 7 considers an extreme specification where steady-state liquidity approaches zero, motivated by the popular zero-liquidity specification of HANK-SAM models in the literature (see, e.g., Ravn and Sterk (2021); McKay and Reis (2020); Broer et al. (2021)). The large increase in the absolute size of the multipliers stems from the extreme increase in relative liquidity implied by debt financing. More interestingly, the relative effectivness of UI duration extensions, which increased when we reduced liquidity from its steady-state level in row 6, is now decreased rela-

	G norm. [level]	**transfer**	**UI level**	**UI duration**	**retention**	**hiring**
Baseline	1.0 [1.01]	0.26	0.42	0.97	1.57	0.70
Full insurance	1.0 [0.71]	0.00	0.00	0.00	0.69	0.19
Fewer HtM	1.0 [0.82]	0.20	0.39	1.02	1.88	0.66
No Prec. sav.	1.0 [0.88]	0.27	0.25	0.77	1.54	0.69
More liquidity	1.0 [0.91]	0.20	0.32	0.68	1.54	0.68
Less liquidity	1.0 [1.20]	0.35	0.55	1.49	1.60	0.72
Near-zero liquidity	1.0 [12.19]	0.98	0.68	0.30	1.13	0.98

Table 5: Relative cumulative fiscal multipliers: consumption dynamics.

tive to the benchmark To understand this hump-shaped pattern of the effectiveness of UI duration extensions when liquidity falls, note that, in the limit of zero liquidity, where all households consume their per-period income in equilibrium, the demand curve for savings stems from a single ´´marginal saver" in the economy. The marginal saver is the agent with the steepest slope in expected income between this and the next period. In our model, the marginal saver is an employed household, all unemployed household are constrained in equilibrium. Thus, changing UI duration, which amounts to a change in expected income next period among a subset of the unemployed, have no effect on the demand curve for savings. By implication, the popular zero-liquidity specification of HANK-SAM models fails to quantitatively capture the effects of unemployment insurance policies.

Finally, note that across most of these comparisons, the relative effectiveness of the two supply-side policies are barely affected by changes in the HA block. This indicates that the block-separability result derived in Section 3 approximately holds true also in the baseline model, where we redistribute profits back to the households. The exception is the extreme case with close-to-zero liquidity, for which the differential effect of the two subsidies on the incentives to hire and separate matter less; retention and hiring subsidies primarily operate as cash transfers to the households who are essentially hand-to-mouth. As a result, the fiscal multiplier of the supply side policies is quantitatively close to the fiscal multipliers of government spending and unconditional transfers.

6.5 Endogenous separations and sluggish vacancies: the SAM block

Table 6 shows the cumulative fiscal multipliers for alternative specifications of the SAM block. Row 2 shows the multipliers in a model without endogenous separations and where we change

	G norm. [level]	**transfer**	**UI level**	**UI duration**	**retention**	**hiring**
Baseline	1.0 [1.01]	0.26	0.42	0.97	1.57	0.70
Standard DMP	1.0 [0.14]	0.33	0.50	0.98	1.35	3.50
Free entry	1.0 [0.55]	0.29	0.45	0.97	1.45	1.18
Exo. sep.	1.0 [0.13]	0.33	0.50	0.98	1.35	3.45

Table 6: Relative cumulative fiscal multipliers: labor-market dynamics.

the elasticity of vacancy creation to be infinitely elastic ("free entry"), that is, the standard DMP model. Consistent with Figure 4, all multipliers are reduced. With a standard DMP labor market, the ordering of the two supply-side policies has changed: hiring subsidies are now substantially more effective in stimulating unemployment. This is because both subsidies reduce unemployment only by increasing the expected present discounted profits from new matches, but retention subsidies "waste" money on also subsidising existing matches. The relative size of the multipliers associated with demand-side policies is close-to unaffected - block separability again holds approximately.

In row 3 and 4, we show the relative multipliers when only changing the elasticity of vacancy creation and separations one by one. Both assumptions work in the same direction. Increasing the vacancy-creation elasticity and reducing the separation elasticity both dampen the endogenous propagation by muting the vacancy-depletion channel. As a result, the absolute level of the fiscal multipliers are now reduced. They also both dampen the elasticity of separations relative to that of vacancy creation. As a result, in relative terms, hiring subsidies become more effective than retention subsidies, reversing the order of the two policies relative to the baseline models.

Overall, our baseline result of retention subsidies being the most effective stimulus policy thus quantitatively depends on our empirical result that vacancy creation is relatively sluggish and separations are relatively elastic compared to the standard DMP benchmark.

6.6 Sensitivity to the distribution of profits

It is well known that different distributional assumptions regarding profit income can greatly affect the aggregate dynamics of New-Keynesian models (Broer et al. (2020)). Moreover, the difference between the quantitative model used here, and the simplified model used to derive analytical results in Section 3, is that here, profits are distributed uniformly to all households. In

	G norm. [level]	**transfer**	**UI level**	**UI duration**	**retention**	**hiring**
baseline	1.0 [1.01]	0.26	0.42	0.97	1.57	0.70
all div. to HtM	1.0 [1.30]	0.25	0.40	0.97	4.12	1.79
95% of div. to PIH	1.0 [0.84]	0.26	0.41	0.92	1.01	0.30

Table 7: Relative cumulative fiscal multipliers: the role of profits.

so doing, the average MPC out of profit income equals that out of labor income, in line with the evidence from Di Maggio et al. (2020). Because there remains substantial uncertainty regarding the MPC out of profit income, we investigate alternative specifications here.

In Table 7, we highlight how the fiscal multipliers change when we adopt two alternative specifications of profit distribution. In row 2, we consider the same assumption as in Section 3, that is, we distribute all profits to hand-to-mouth households, increasing the average MPC out of profit income to 100 %. In row 3, in contrast, we assume that 95 % of profits accrue to a new third category of households that accounts for five percent of the population and has a high discount factor β such that their consumption behavior approximately obeys the permanent-income hypothesis (implying a low propensity to consume out of profits).

A higher MPC out of profit income raises the average MPC in the economy, and thus increasesthe level of the government spending multiplier. But the relative multipliers associated with demand-side policies remain approximately unaffected. To understand the reason for this, note that profits are earned and distributed by the wholesale producers in the NK block and by the intermediate goods producers in the SAM block. In terms of Figure 1 different assumptions about how profits are distributed therefore affect the mapping from the NK and SAM blocks to the household income process, but not the mapping from the household income process to the real interest rate in the HA block. Therefore, block separability applies: shocks that enter the model through the HA block, are, in relative terms, unaffected by changing the NK and SAM mappings.

On the other hand, different assumptions about profit income greatly affect the relative multipliers of supply-side policies. Retention and hiring subsidies are direct shocks to profit income from inframarginal matches. Increasing the MPC out of profit income therefore greatly boosts their efficacy relative to demand-side policies. Retention subsidies do however remain the most cost-effective policy even when most profits are distributed to low-MPC agents.

6.7 Robustness to maintained model assumptions

6.7.1 Cyclical wages

[To be added.]

6.7.2 Endogenous search effort

[To be added.]

7 Conclusion

[To be added.]

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Appendix

A Model

A.1 Separation decision

In Equation 6, we assume that G is a mixture of a point mass at 0 and a Pareto distribution with location parameter $\Upsilon > 0$ and shape parameter ψ,

$$G(\chi_t) = \begin{cases} 0 & \chi_t < 0, \\ 1 - p & 0 \leq \chi_t < \Upsilon, \\ (1-p) + p(1 - (\chi_t/\Upsilon)^{-\psi}) & \chi_t \geq \Upsilon, \end{cases} \tag{21}$$

This implies

$$\begin{aligned} \delta_t &= \int_{V_t^j}^{\infty} G(\chi_t) d(\chi_t) \\ &= \begin{cases} p & \text{if } V_t^j \leq \Upsilon \\ p\left(\frac{V_t^j}{\Upsilon}\right)^{-\psi} & \text{else} \end{cases} \end{aligned} \tag{22}$$

and

$$
\begin{aligned}
\mu_t &= \int_0^{V_t^j} \chi_t dG(\chi_t) \qquad (23)\\
&= \frac{\mathbb{E}[\chi_t] - \text{Prob.}[\chi_t > V_t^j]\mathbb{E}[\chi_t|\chi_t > V_t^j]}{1 - \text{Prob.}[\chi_t > V_t^j]}\\
&= \begin{cases} 0 & \text{if } V_t^k \leq \text{Y} \\ \frac{p\frac{\psi \text{Y}}{\psi-1} - p\left(\frac{V_t^j}{\text{Y}}\right)^{-\psi}\frac{\psi V_t^j}{\psi-1}}{(1-p)+p(1-(\chi_t/\text{Y})^{-\psi})} & \text{else} \end{cases}\\
&= \begin{cases} 0 & \text{if } V_t^k \leq \text{Y} \\ \frac{p\frac{\psi}{\psi-1}\text{Y}\left[1-\left(\frac{V_t^j}{\text{Y}}\right)^{1-\psi}\right]}{1-p\left(\frac{V_t^j}{\text{Y}}\right)^{-\psi}} & \text{else} \end{cases}\\
&= \mu(V_t^j)
\end{aligned}
$$

We always choose $\text{Y} = \left(\frac{\delta_{ss}}{p}\right)^{\frac{1}{\psi}} V_{ss}^j$ which implies Equation (7) in the main text. Furthermore, with $p = \delta_{ss}$ we have $\text{Y} = V_{ss}^j$ which implies $\delta_t = \delta_{ss}$ when $V_t^j \leq V_{ss}^j$. Instead we set $p = (1 + \Delta_\delta)\delta_{ss}$ where $\Delta_\delta > 0$ is a small positive number. This implies that δ_t can rise above δ_{ss} when V_t^j falls below V_{ss}^j. It also implies that μ_{ss} is a small positive number.

B Appendix to Section 3

B.1 Proof to Proposition 1

Consider two demand-side policies$\mathbf{d}$,$\mathbf{d}^* \in \mathbb{D}$ that imply the same path of labor-market flows $\mathbf{f}$. The fiscal cost associated with each policy is given by

$$
\begin{aligned}
\text{Fiscal cost}_{\mathbf{d}} &= M_{f,tax}\mathbf{f} + M_{D,\text{tax}}\mathbf{d}\\
\text{Fiscal cost}_{\mathbf{d}^*} &= M_{f,tax}\mathbf{f} + M_{D,\text{tax}}\mathbf{d}^*
\end{aligned}
$$

where $M_{f,tax}\mathbf{f}$ maps the equilibrium labor market flows on government income taxes net of unemployment benefits. We therefore have that

$$\Delta\text{Fiscal cost} = M_{D^*,\text{tax}}\mathbf{d}^* - M_{D,\text{tax}}\mathbf{d}.$$

Q.E.D.

B.2 Proof to Proposition 2

Consider two demand-side policiess,$\mathbf{s}^* \in \mathbb{S}$ that imply the same path of labor-market flows $\mathbf{f}$. The fiscal cost associated with each policy is given by

$$\begin{aligned}\text{Fiscal cost}_{\mathbf{s}} &= M_{f,tax}\mathbf{f} + M_{S,\text{tax}}\mathbf{s}\\ \text{Fiscal cost}_{\mathbf{s}^*} &= M_{f,tax}\mathbf{f} + M_{S^*,\text{tax}}\mathbf{s}^*\end{aligned}$$

where $M_{f,tax}\mathbf{f}$ maps the equilibrium labor market flows on government income taxes net of unemployment benefits. We therefore have that

$$\Delta\text{Fiscal cost} = M_{S^*,\text{tax}}\mathbf{s}^* - M_{S,\text{tax}}\mathbf{s}.$$

Q.E.D.

C Calibration

C.1 Steady state

From Table 3, we have the externally calibrated parameters (β, ρ, ϑ,ϵ_p, ϕ, δ_π, α), the steady targets (δ_{ss}, λ^u_{ss}, θ_{ss}), and the internally calibrated parameters ($\tilde{m}_{ss}$, ψ, ξ). Together with the two auxiliary parameters ($\kappa_0 = 0.1 \approx 0$, $\Delta_\delta = 0.1 \approx 0$), the remaining model parameters can be deduced. From the matching function, we directly have

$$A = \frac{\lambda^u_{ss}}{\theta^\alpha_{ss}}.$$

This implies that the steady states of labor markets stocks and flows can be found by,

$$\begin{aligned}
\lambda^v_{ss} &= A\theta_{ss}^{-\alpha}, \\
u_{ss} &= \frac{\delta_{ss}(1-\lambda^u_{ss})}{\lambda^u_{ss}+\delta_{ss}(1-\lambda^u_{ss})}, \\
\tilde{u}_{ss} &= \frac{u_{ss}}{1-\lambda^u_{ss}}, \\
\tilde{v}_{ss} &= \tilde{u}_{ss}\theta_{ss}, \\
v_{ss} &= (1-\lambda^v_{ss})\tilde{v}_{ss}, \\
\iota_{ss} &= \tilde{v}_{ss} - (1-\delta_{ss})v_{ss}.
\end{aligned}$$

We can now also calculate both the value of a job and the value of a vacancy,

$$\begin{aligned}
V^j_{ss} &= \frac{\tilde{m}_{ss}}{1-\beta(1-\delta_{ss})}, \\
V^v_{ss} &= \kappa_0.
\end{aligned}$$

Hereby, we can infer p, F, κ, Y and W_{ss} by

$$\begin{aligned}
p &= (1+\Delta_\delta)\delta_{ss} \\
F &= \iota_{ss}(V^v_{ss})^{-\xi} \\
\kappa &= \lambda^v_{ss}V^j_{ss} - (1-\beta(1-\lambda^u_{ss})(1-\delta_{ss}))V^v_{ss} \\
\mathrm{Y} &= \left(\frac{\delta_{ss}}{p}\right)^{\frac{1}{\psi}} V^{ss}_j \\
\mu_{ss} &= \frac{p\frac{\psi}{\psi-1}\mathrm{Y}\left[1-\left(\frac{V^j_{ss}}{\mathrm{Y}}\right)^{1-\psi}\right]}{1-p\left(\frac{V^j_{ss}}{\mathrm{Y}}\right)^{-\psi}} \\
M_{ss} &= \tilde{m}_{ss}P^x_{ss}Z_{ss} + \beta\mu_{ss} \\
W_{ss} &= P^x_{ss}Z_{ss} - M_{ss}
\end{aligned}$$

Hereafter the steady state values of all other variables can be found as well.