Taking off into the Wind: Unemployment Risk and State-Dependent Government Spending Multipliers*

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Abstract

We propose a model with involuntary unemployment, incomplete markets, and nominal rigidity, in which the effects of government spending are state-dependent. An increase in government purchases raises aggregate demand, tightens the labor market and reduces unemployment. This in turn lowers unemployment risk and thus precautionary saving, leading to a larger response of private consumption than in a model with perfect insurance. The output multiplier is further amplified through a composition effect, as the fraction of high-consumption households in total population increases in response to the spending shock. These features, along with the matching frictions in the labor market, generate significantly larger multipliers in recessions than in expansions. As the pool of job seekers is larger during downturns than during expansions, the concavity of the job-finding probability with respect to market tightness implies that an increase in government spending reduces unemployment risk more in the former case than in the latter, giving rise to countercyclical multipliers.

Keywords: Government spending, Multipliers, Precautionary saving, State dependence, Unemployment risk.

JEL Class.: D52, E21, E62.

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1 Introduction

An important branch of the recent empirical literature on fiscal policy has focused on the question of whether the macroeconomic effects of government spending depend on the amount of slack in the economy. Building on the original work of Auerbach and Gorodnichenko (2012b,a), several empirical studies relying on non-linear time-series models find that government spending has a significantly larger effect on aggregate output during recessions than during expansions, with a multiplier that often exceeds 1 in the former state.[1] Based on a meta-regression analysis of 98 empirical studies, and controlling for regime dependence, Gechert and Rannenberg (2018) also conclude that spending multipliers are much higher during downturns.

This is a topic, however, where measurement is still far ahead of theory, as there are very few theoretical models capable of generating meaningful asymmetry in the effects of government spending in good and bad states.[2] Michaillat (2014) proposes a model in which search and matching frictions in the labor market imply that public employment crowds out private employment less in recessions than in expansions because it generates a smaller increase in labor-market tightness.[3] Canzoneri, Collard, Dellas, and Diba (2016) develop a model with countercyclical variations in the bank intermediation cost, making the spread more sensitive to fiscal policy during recessions than during expansions. Finally, Shen and Yang (2018) generate state dependence in a model with involuntary unemployment subject to a downward nominal wage rigidity constraint. All of these papers, however, assume perfect risk sharing among consumers, neglecting two important channels that can shape the aggregate effects of government spending and their dependence on the business cycle: unemployment risk and changes in the composition of aggregate consumption resulting from changes in the fraction of unemployed agents.

When insurance markets are incomplete, unemployment risk gives rise to a precautionary-saving motive that affects consumption decisions and thus the spending multiplier. Furthermore, since employed households earn and consume more on average than unemployed households, a change in the unemployment rate will be associated with a change in aggregate consumption, even if the per capita consumption levels of unemployed and employed households remain unchanged. In

[1] Examples include Bachmann and Sims (2012), Mittnik and Semmler (2012), Candelon and Lieb (2013), Fazzari, Morley, and Panovska (2015) and Holden and Sparrman (2018). Owyang, Ramey, and Zubairy (2013) find some evidence of state dependence in Canada but not in the U.S.

[2] Numerous theoretical studies show that the spending multiplier can be substantially larger during episodes in which the nominal interest rate is stuck at its zero lower bound (ZLB) than in normal times. While ZLB episodes are usually accompanied by severe recessions, the larger multipliers found in this case essentially reflect monetary-policy-regime dependence rather than state dependence *per se*, as the proposed models are either linear or lack the type of non-linearity required to generate countercyclical multipliers outside the ZLB. One exception is the model developed by Roulleau-Pasdeloup (2016), in which, however, the multiplier — albeit countercyclical — remains smaller than 1 even in deep recessions.

[3] Michaillat and Saez (2018) show that a similar mechanism leads to countercyclical government *purchase* multipliers (as opposed to public employment multipliers) in a model with search and matching frictions in the goods market.

this paper, we show that these two channels lead to (*i*) larger spending multipliers than under perfect insurance and (*ii*) substantial asymmetry in the aggregate effects of government spending in recession and expansion, implying state-dependent spending multipliers.

We propose a model of search and matching frictions in the labor market, in which unemployed risk is not fully insurable. The model also allows for price and real wage rigidity, an intensive margin of labor adjustment, and nominal government debt. Our framework shares several features with those developed by Gornemann, Kuester, and Nakajima (2016), Ravn and Sterk (2020), and Challe (2020).[4] Gornemann, Kuester, and Nakajima (2016) study how systematic monetary policy endogenously affects unemployment risk in an environment with multiple sources of household heterogeneity. Ravn and Sterk (2020) show analytically that nominal rigidities and endogenous income risk are complementary in amplifying the economy's response to shocks. Challe (2020) examines the implications of uninsured unemployment risk for the optimal conduct of monetary policy. Our paper differs from these earlier studies in that it focuses on the role of precautionary saving in generating state-dependent effects of government spending shocks. As in Gornemann, Kuester, and Nakajima (2016), but unlike Ravn and Sterk (2020) and Challe (2020), our model yields a non-degenerate distribution of households along government bond holdings in equilibrium, giving rise to meaningful wealth heterogeneity. The model is calibrated to represent a sclerotic labor market akin to that prevailing in the majority of European economies, characterized by relatively low separation and job-finding rates and a relatively high replacement rate. In a rigid labor market, workers' exposure to unemployment risk has an important bearing on their precautionary saving, and policies that can alleviate this risk are likely to induce a large reduction in aggregate saving and thus a large response of aggregate consumption.

Before assessing the degree of state dependence of the effects of government spending, we evaluate those effects when the economy is initially in the steady state. The purpose of this exercise is to ensure that the model is capable of generating empirically plausible *average* spending multipliers. Under our benchmark calibration, we obtain a present-value output multiplier of 0.86, well within the range of available estimates (see Ramey (2019) for a recent overview). This value is roughly 35% larger than that obtained in an otherwise identical economy with complete insurance markets (0.64). By raising aggregate demand in an economy with nominal rigidity, higher public spending raises both employers' future profits and the rate at which those profits are discounted. The net result of these two opposite effects, however, is an increase in the marginal value of a filled position, which leads firms to post more vacancies. As a result, unemployment falls, thus lowering unemployment risk and reducing precautionary saving, which fuels the rise in aggregate demand

[4]Krusell, Mukoyama, and Şahin (2010) were the first to introduce unemployment risk in a model with a frictional labor market.

and further lowers unemployment.[5] At the same time, the fall in the unemployment rate increases the share of high-consumption households in total population. Aggregate output therefore increases by a larger amount than in a counterfactual economy in which unemployment risk is fully insurable. The difference in the output multiplier between the incomplete- and complete-market economies suggests that alleviating idiosyncratic income risk can be an important source of amplification of the aggregate effects of fiscal policy.

We then evaluate the state dependence of the spending multiplier by comparing the effects of an increase in government spending in recession and expansion. These states are generated by equal-sized adverse and favorable productivity shocks that occur while the economy is in the steady state. Under our benchmark parameter values, the *conditional* output multiplier is 0.8 in expansion and 1.02 in recession — a difference of roughly 28%. This state dependence results from three interconnected features: the matching frictions, the precautionary motive, and the composition effect. As the pool of job seekers is larger during downturns than during expansions, the concavity of the job-finding probability with respect to market tightness implies that employment increases more in the former case than in the latter, in response to a given increase in government spending. Because unemployment risk is reduced substantially more when government spending occurs while the economy is in recession, unemployed households curtail their precautionary saving by a larger amount. The larger reduction in the fraction of low-consumption households in total population further contributes to the larger difference in the output multiplier between recession and expansion.

More generally, we show that the spending multiplier is decreasing and highly convex in the size of the productivity shock. That is, it increases exponentially with the severity of the recession but decreases fairly linearly with the size of the expansion. This strong curvature implies that the state dependence of the effects of government spending becomes increasingly salient when business-cycle fluctuations become larger, exhibiting higher peaks and deeper troughs. We also show that a counterfactual economy that abstracts from unemployment risk (*via* complete insurance markets) severely understates the extent of state dependence, implying a difference in the output multiplier of less than 13% between recession and expansion under our benchmark calibration. An economy with fully flexible prices, on the other hand, yields a larger multiplier in expansion than in recession — implying an inverted state dependence — as it predicts that an increase in government spending *raises* unemployment. Price flexibility implies that employers' current and future profits remain constant but are discounted at a higher rate, causing a fall in the value of a filled job and in vacancy posting.

Recent studies based on models with heterogeneous agents and sticky prices — which have come

[5] Beaudry, Galizia, and Portier (2018) propose an alternative model in which unemployment risk and precautionary saving also lead to an amplification of the effects of demand shocks. However, unlike the mechanism put forward in our model, which relies on nominal price rigidity, theirs is based on the existence of coordination failure that limits gains from trade between individuals.

to be known as HANK models — have shown that the distributional effects of first- and second-moment shocks can alter significantly their transmission mechanisms and thus their aggregate implications.[6] In a related paper to ours, Hagedorn, Manovskii, and Mitman (2019) extend this class of models by allowing for wage rigidity to evaluate the size of the fiscal multiplier. Our model, however, differs from Hagedorn et al.'s in that the source of household heterogeneity in our paper is not an (exogenous) idiosyncratic level of productivity but the employment status of households. We believe that there are three advantages to the latter approach. First, it implies that income risk is endogenous and is affected by aggregate variables, which brings about a feedback loop that amplifies both the aggregate effects of government spending shocks and their state dependence. Second, the composition effect can be directly mapped into the relative fraction of unemployed households, which is readily observable in the data. Finally, allowing employment to adjust both along the intensive and extensive margins enables us to generate spending multipliers that are more in line with existing empirical estimates than the multipliers obtained by Hagedorn, Manovskii, and Mitman (2019). A version of our economy in which hours worked are constrained to remain constant underestimates the average output multiplier by more than 40%.

2 Model

The model is a new-Keynesian economy with search and matching frictions in the labor market and incomplete insurance markets. Labor can also adjust along the intensive margin through changes in hours worked. The only asset available for self-insurance is a one-period nominal government bond, in positive net supply. Finally, the model features rigid nominal prices are real wages.

2.1 Households

The economy is populated by a unit-size continuum of heterogeneous households. An endogenously determined fraction $(1 - u_t)$ of households is employed and a fraction u_t is unemployed. The timing of the labor market is the following. Separations — whereby an exogenous fraction s of employed workers lose their jobs and become unemployed — and new matches occur at the beginning of period t. Separated workers do not rematch within the period, but newly hired workers become immediately productive, which is consistent with our (quarterly) calibration. We assume that the number of matches in the economy is determined randomly by the following matching function:

$$m_t = \chi \frac{u_t v_t}{(u_t^\alpha + v_t^\alpha)^{\frac{1}{\alpha}}}, \tag{1}$$

[6] For instance, Kaplan, Moll, and Violante (2018) and Kaplan and Violante (2018) focus on monetary policy shocks, while Bayer, Luetticke, Pham-Dao, and Tjaden (2019) focus on uncertainty shocks. Bilbiie (2019) analytically characterizes the conditions — about household heterogeneity — under which the aggregate effects of shocks and policies are amplified or dampened.

where v_t is the number of vacancies posted by firms, $\chi > 0$ is the matching-efficiency parameter, and $\alpha > 0$ is the matching-curvature parameter, which governs the elasticity of substitution between unemployment and vacancies (given by $\frac{1}{1+\alpha}$). From the perspective of households, the probabilities of changing employment status are the constant separation rate, s when employed, and the time-varying job-finding probability, $f_t \equiv m_t/u_t$, when unemployed. Defining $\theta_t \equiv v_t/u_t$ as labor-market tightness, the job-finding probability satisfies $f_t = \chi\left(1+\theta_t^{-\alpha}\right)^{-\frac{1}{\alpha}}$.[7] From the employers' perspective, the worker-finding (or vacancy-filling) probability is $q_t \equiv m_t/v_t = \chi\left(1+\theta_t^{\alpha}\right)^{-\frac{1}{\alpha}}$.[8] Denoting by $\mathcal{E}_t^i = \{e, u\}$ the set of possible employment statuses of household i, with e and u referring to, respectively, employment and unemployment, the optimization problem of household i is given by

$$
\begin{aligned}
&\max_{\{c_t^i, a_t^i\}} \mathbb{E}_t \left\{ \sum_{s=t}^{\infty} \left(\frac{1}{1+\rho}\right)^{s-t} \left(\log\left(c_s^i\right) - \mathbb{1}_e^i \omega \frac{\ell_t^{1+\psi}}{1+\psi} - \left(1-\mathbb{1}_e^i\right)\Phi \right) \right\} \\
&\text{s.t.} \quad a_t^i + c_t^i = \left(1+r_{t-1}\right) a_{t-1}^i + \left(1-\tau_t\right)\left(\mathbb{1}_e^i w_t \ell_t + \left(1-\mathbb{1}_e^i\right) h\overline{w}\right) + \mathbb{1}_e^i\left(\Pi_t^i - T_t^i\right), \\
&\qquad a_t^i > 0, \\
&\qquad \Pr(\mathcal{E}_t^i|\mathcal{E}_{t-1}^i) \equiv \Lambda_t = \begin{bmatrix} 1-s & s \\ f_t & 1-f_t \end{bmatrix},
\end{aligned}
$$

where $c_t^i > 0$ is the household's consumption, ρ is the subjective discount rate, and $\mathbb{1}_e^i$ is an indicator function that takes the value of 1 if household i is employed and 0 otherwise. When employed, households experience a disutility from the number of hours worked, $\omega\frac{\ell_t^{1+\psi}}{1+\psi}$, where ψ is the inverse of the Frisch elasticity and ω a disutility parameter. When unemployed, they incur a non-pecuniary cost of unemployment, $\Phi = \omega\frac{\ell^{1+\psi}}{1+\psi}$, that corresponds to the steady-state disutility from hours worked.[9] In the budget constraint of household i, $a_t^i > 0$ is the household's aggregate wealth and r_{t-1} the real return on government bonds between periods $t-1$ and t. When employed, household i works ℓ_t hours paid at the hourly real wage w_t, and receives $\Pi_t^i - T_t^i$, with Π_t^i being profits received from firms and T_t^i a lump-sum tax. Hours worked and the real wage are taken as given by households; their determination is discussed in the following subsection. When unemployed, household i receives unemployment benefits $h\overline{w}$, where h is the replacement rate and $\overline{w}$ denotes the steady-state real wage. Labor income and unemployment benefits are taxed at the same rate, τ_t.

2.2 Firms

The final (consumption) good is produced using differentiated varieties sold by monopolistically competitive retailers. Varieties are produced using an intermediate good, which is itself produced

[7] As one can easily see, f_t is an increasing and concave function of θ_t, with a curvature that depends on α. The concavity of f_t captures the degree of matching frictions, which are minimized when $\alpha \to 0$ (in which case, f_t becomes linear in θ_t).

[8] Note that the following restrictions must hold: $\theta_t \geq 0$, $f_t \in [0, 1]$, and $q_t \in [0, 1]$.

[9] This assumption follows McKay and Reis (2016) and allows to trace the difference between the steady-state net values of being employed and unemployed only to the difference in the consumption levels associated with these two labor-market statuses.

by firms using labor. For simplicity, and without loss of generality, we assume that each firm in the intermediate-good sector is a job.

Intermediate-good producers. Firms in the intermediate-good sector post vacancies, out of which a fraction q_t will be filled in period t, increasing the total number of employed households. The unit-cost of posting a vacancy is ξ. The intermediate good is produced using the following technology:

$$y_t^m = z_t \ell_t, \tag{2}$$

where z_t denotes an exogenous stochastic productivity factor, and is sold to retailers at the (real) price p_t^m. The marginal value of a filled position is[10]

$$J_t = p_t^m z_t \ell_t - w_t \ell_t + \mathbb{E}_t \left\{ \frac{1}{1+r_t} \left((1-s) J_{t+1} + s V_{t+1} \right) \right\}, \tag{3}$$

where $p_t^m z_t \ell_t$ is the gross contribution of the marginal worker (i.e. her marginal product), and $w_t \ell_t$ her wage bill. The continuation value depends on the separation rate s and the expected value of a vacancy V_t. Since vacancies can be filled within a period, V_t writes

$$V_t = -\xi + q_t \left(J_t - V_t \right) + \mathbb{E}_t \left\{ \frac{V_{t+1}}{1+r_t} \right\}. \tag{4}$$

The free entry condition $V_t = 0$, $\forall t$ holds, which implies $q_t J_t = \xi$.[11] The aggregate profits (net of vacancy-posting costs) made by intermediate-good producers are

$$\Pi_t^m = (1-u_t) \left(p_t^m z_t - w_t \right) \ell_t - \xi v_t. \tag{5}$$

As is well known, in models with search and matching frictions, the equilibrium real wage in not uniquely determined, as there is a range of wages that firm are willing to pay and workers are willing to accept. Following Blanchard and Galí (2010), we assume that the real wage is determined according to the following rule:

$$w_t = \overline{w} z_t^{\eta}, \tag{6}$$

where $\eta \in [0,1]$ is a parameter. Whenever η is strictly less than 1, the rule above implies that the difference between the marginal product of labor and the real wage is large when productivity is

[10] We assume that intermediate-good producers discount J_{t+1} and V_{t+1} at the equilibrium real interest rate r_t and not at the subjective rate of the owners (employed households). Since the real interest rate is essentially driven by the saving behavior of firm owners, this approximation is innocuous.

[11] As shown by Petrosky-Nadeau and Zhang (2020), shocks with large adverse effects on the labor market can lead vacancies and thus tightness to hit the zero bound. In this case, the free-entry condition becomes impossible to meet. A general way of writing the free-entry condition under the non-negativity constraint on labor-market tightness is: $\max(\theta_t, 0)(q_t J_t - \xi) = 0$.

high, thus giving rise to real wage rigidity, the extent of which is inversely related to the value of η.[12] To preserve tractability, we also assume that workers are represented by a union that determines the amount of hours worked by each employed household.[13] The union equates the marginal rate of substitution between the average consumption of employed agents, c_t^e, and their hours worked to the after-tax real wage

$$\omega \ell_t^{\psi} c_t^e = (1 - \tau_t)\, w_t. \tag{8}$$

Retailers. There is a continuum of monopolistically competitive retailers indexed by $k \in [0, 1]$, each of which produces a single differentiated variety using the intermediate good as input. The production function of retailer k is given by $y_t(k) = x_t^m(k)$, where $x_t^m(k)$ is the quantity of the intermediate input used by retailer k. The differentiated varieties are sold to a representative assembler that aggregates them into a final good. Let $P_t\,(k)$ denote the nominal price set by retailer k for its variety. Demand for this variety by the final-good producer is given by $y_t^d\,(k) = (P_t\,(k)\,/P_t)^{-\varepsilon}\, y_t$, with $\varepsilon > 1$ denoting the elasticity of substitution between varieties, and y_t denoting total demand for the final good. Adjusting prices by the retailers entails Rotemberg-type price-adjustment costs, the magnitude of which is governed by the parameter $\varphi \geq 0$. Let $P_t\,(k)$ denote the nominal price set by retailer k, the latter solves

$$\max_{P_t(k)} \mathbb{E}_t \left\{ \sum_{s=t}^{\infty} \left(\frac{1}{1 + r_{s-1}} \right)^{s-t} \Pi_s^r(k) \right\}, \tag{9}$$

where

$$\Pi_t^r(k) = \left[\frac{P_t\,(k)}{P_t} - p_t^m - \frac{\varphi}{2} \left(\frac{P_t\,(k)}{P_{t-1}\,(k)} - 1 \right)^2 \right] y_t^d\,(k)\,. \tag{10}$$

Assuming symmetry across retailers ($P_t\,(k) = P_t$ and $y_t^d\,(k) = y_t$), denoting by $\pi_t = P_t/P_{t-1} - 1$ is the inflation rate, and recalling that $y_t = x_t^m = (1 - u_t) y_t^m$, total profits, are given by

$$\Pi_t = \Pi_t^m + \Pi_t^r = (1 - u_t) \left[\left(1 - \frac{\varphi}{2} \pi_t^2 \right) z_t \ell_t - w_t \ell_t \right] - \xi v_t. \tag{11}$$

Profits are fully redistributed to employed households so that $\Pi_t^e = \Pi_t / (1 - u_t)$.

[12] In a previous version of the paper, we also considered a wage-setting mechanism whereby the real wage is a linear combination of the steady-state wage and a newly bargained wage between employers and a union that represents workers (e.g., Krause and Lubik (2007) and Albertini and Fairise (2013)). The union negotiates based on the average value functions of employed and unemployed households, W_t^e and W_t^u. The newly bargained wage, w_t^n, is determined as the solution to a Nash-bargaining problem that consists in maximizing a geometric average of the union surplus and the marginal value of a filled job

$$w_t^n = \arg\max \left(W_t^e - W_t^u \right)^{\beta} J_t^{1-\beta}, \tag{7}$$

where β is the bargaining power of the union/workers. To the extent that the wage equation exhibits sufficiently high inertia, results based on this alternative wage-setting mechanism are very similar to the ones reported in this paper.

[13] This assumption ensures that all workers supply the same number of hours even though their marginal utilities of consumption differ. Otherwise, one would have to keep track of a non-degenerate distribution of hours worked, which would further increase the computational burden involved in solving the model.

2.3 Government, monetary authority, aggregation, and market clearing

The government purchases public goods, g_t, and provides after-tax unemployment insurance to unemployed households. It finances this stream of expenditure by issuing one-period bonds and by levying lump-sum and labor-income taxes on employed households. We assume that the labor-income tax is constant, $\tau_t = \tau$. The government budget constraint, expressed in real terms, is therefore given by

$$b_t = (1 + r_{t-1})\, b_{t-1} + g_t + (1 - \tau)\, u_t h \overline{w} - \tau\, (1 - u_t)\, w_t \ell_t - (1 - u_t)\, T_t^e, \tag{12}$$

where $T_t^e = T_t / (1 - u_t)$ denotes the lump-sum tax paid by each employed household. In addition, we assume that lump-sum taxes evolve according to

$$T_t = d_T \left(b_t - \overline{b} \right), \tag{13}$$

where $\bar{b}$ denotes the steady-state level of debt, and $d_T > 0$ is the tax-feedback parameter.

The monetary authority sets the nominal interest rate, i_t, according to the following simple rule:

$$i_t = \overline{r} + \bar{\pi} + d_\pi \left(\pi_t - \bar{\pi} \right), \tag{14}$$

where $\overline{r}$ and $\bar{\pi}$ are the steady-state interest and inflation rates, respectively, and $d_\pi > 1$.[14]

The market clearing conditions on the bonds and goods markets are, respectively

$$b_t = \sum_i \Omega_t^{e,i} a_t^i + \sum_i \Omega_t^{u,i} a_t^i, \tag{15}$$

$$y_t = (1 - u_t)\, z_t \ell_t \left(1 - \frac{\varphi}{2} \pi_t^2 \right) - \xi v_t = \sum_i \Omega_t^{e,i} c_t^{e,i} + \sum_i \Omega_t^{u,i} c_t^{u,i} + g_t, \tag{16}$$

where $\Omega_t^{e,i}$ and $\Omega_t^{u,i}$ are the time-varying distributions of, respectively, employed and unemployed households over assets, and $c_t^{e,i}$and $c_t^{u,i}$ denote their respective consumption functions defined over assets.

2.4 Shocks

The economy is driven by two exogenous disturbances, public spending and productivity shocks, governed by the following AR(1) processes:

$$\ln g_t = (1 - \rho_g) \ln g + \rho_g \ln g_{t-1} + \epsilon_t^g, \tag{17}$$

$$\ln z_t = (1 - \rho_z) \ln z + \rho_z \ln z_{t-1} + \epsilon_t^z, \tag{18}$$

where $0 < \rho_g, \rho_z < 1$, and ϵ_t^g and ϵ_t^z are serially and mutually uncorrelated innovations.

[14] In none of the simulations carried out in this paper does the nominal interest rate become negative. Therefore, we ignore the ZLB constraint in the presentation of the monetary policy rule.

2.5 Calibration and solution method

The model is calibrated at a quarterly frequency. In what follows, we justify our chosen values for the model parameters, which are summarized in Table 1.

We impose a subjective discount rate of 4% annually, implying $\rho = 0.01$, The equilibrium steady-state real interest rate, $\bar{r}$, is lower than the subjective rate due to precautionary saving, which is used by the households to self-ensure against unemployment risk. Our calibration implies a 3.4% annual real interest rate. We fix the Frisch elasticity of labor supply at $1/\psi = 1$ and adjust the labor-disutility parameter, ω, to get $\ell = 1$ in the steady state. We set the elasticity of substitution between the differentiated varieties to $\varepsilon = 6$, implying a steady-state mark-up of 20%, and the price-adjustment-cost parameter to $\varphi = 80$.

We seek to replicate key characteristics of the European labor market. We set the matching-curvature parameter to $\alpha = 1$. The quarterly separation rate is set to $s = 0.025$, which implies a monthly separation rate of 0.63%, very close to the numbers reported by Elsby, Hobijn, and Şahin (2013) for Continental Europe. We target an unemployment rate of 7.6%, the value measured in the Euro Area at the end of 2019.[15] Given the value of the separation rate, this target is consistent with a steady-state quarterly job-finding probability of 0.3039, or 0.08125 on a monthly basis, close to the numbers found by Elsby, Hobijn, and Şahin (2013). Following den Haan, Ramey, and Watson (2000) and Ravenna and Walsh (2008), we set the worker-finding probability to $q = 0.7$, which implies a matching-efficiency parameter of $\chi = 1.0039$. To determine the steady-state real wage, $\overline{w}$, we assume that it solves a Nash bargaining problem between employers and a union that represents workers and negotiates based on the average value functions of employed and unemployed agents (see Footnote 13). The union's bargaining power is calibrated to $\beta = 0.75$. The replacement rate is set to $h = 0.6$, in line with the relatively high replacement rates prevailing in European countries (see, for instance, Esser, Ferrarini, Nelson, Palme, and Sjüberg (2013)). Conditional on the values of the remaining parameters, this replacement rate yields a unit vacancy cost of $\xi = 0.5452\overline{w} = 0.4402$. Although the cost per vacancy is somewhat larger than what Hagedorn and Manovskii (2008) suggest for the U.S., total steady-state vacancy costs, $\xi\overline{w}v$, represent 1.6% of GDP, which remains within the range of values used in the literature. Given the chosen parameter values, we obtain $\overline{w} = 0.8797$. Finally, we set the elasticity of the real wage to productivity, η, to 0.45, as in Gornemann, Kuester, and Nakajima (2016)

We set the government spending to GDP ratio to $g/y = 0.2$, and adjust the labor-income tax rate to match a 60% steady-state debt-to-annual-output ratio ($b/(4y) = 0.6$), which implies $\tau = 0.3076$. The tax-rule feedback parameter is set to a rather low value — yet sufficiently high to induce stable debt dynamics — $d_T = 0.1$. The steady-state inflation rate, $\bar{\pi}$, is assumed to be

[15] This figure is computed using data from the Area Wide Model (AWM) dataset. See Fagan, Henryand, and Mestre (2001) for a description of the dataset.

equal to 0, and the monetary-policy-rule parameter is set to $d_\pi = 1.5$. Finally, the autocorrelation coefficients are set to $\rho_g = 0.8$ for government spending shocks and $\rho_z = 0.9$ for productivity shocks.[16]

Table 1: Parameter values.

Subjective interest rate	$\rho = 0.01$
Steady-state quarterly real interest rate	$r = 0.8977\%$
Frisch elasticity of labor supply	$1/\psi = 1$
Labor-disutility parameter	ω adjusted to get $\ell = 1$
Steady-state markup	$(\varepsilon - 1)^{-1} = 0.2$
Price-adjustment-cost parameter	$\varphi = 80$
Separation rate	$s = 0.025$
Job-finding rate	$f = 0.3039$
Worker-finding rate	$q = 0.7$
Matching curvature	$\alpha = 1$
Wage elasticity w.r.t to labor productivity	$\eta = 0.45$
Matching efficiency	$\chi = 1.0039$
Unit vacancy-posting cost	$\xi = 0.5452\overline{w} = 0.4402$
Replacement rate	$h = 0.6$
Labor-income tax rate	$\tau = 0.3076$
Government spending in GDP	$g/y = 0.2$
Debt to annual GDP ratio	$b/(4y) = 0.6$
Tax-rule-feedback parameter	$d_T = 0.1$
Steady-state inflation rate	$\bar{\pi} = 0$
Monetary-policy-rule parameter	$d_\pi = 1.5$
Persistence of government spending shocks	$\rho_g = 0.8$
Persistence of productivity shocks	$\rho_z = 0.9$

The model is solved in two separate steps. The first step consists in finding the steady state, including the stationary distribution of asset holdings and the policy functions over an asset grid. The second step solves for the transition dynamics around the steady state using a non-linear algorithm. The details of both steps are given in Section A of the Online Appendix.

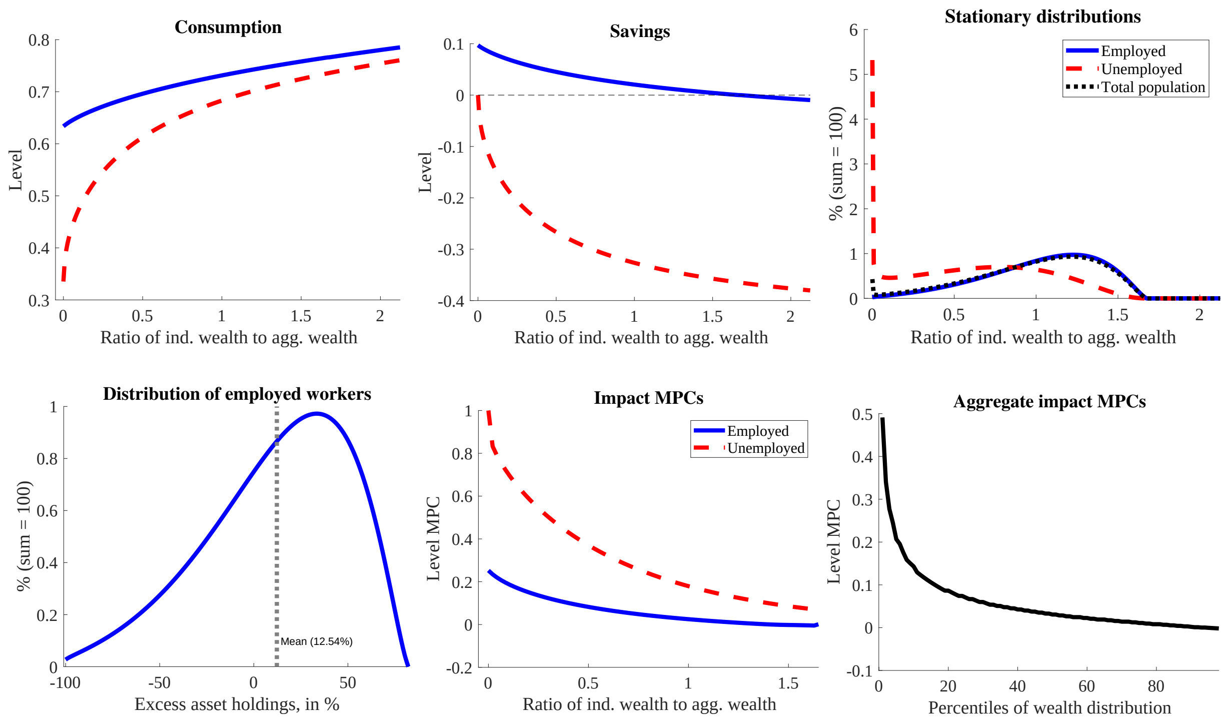
2.6 Policy functions, stationary distributions, and MPCs

Figure 1 plots the steady-state policy functions, stationary distributions over the asset grid, and marginal propensities to consume (MPCs). The consumption functions are increasing in the level of assets held, but the slope is steeper for low levels of assets, especially for unemployed households. Saving is positive for employed households, which reflects the precautionary motive, especially at low levels of assets. Richer employed households save relatively less because their asset level already provides insurance against potential unemployment spells. Unemployed households, on the

[16]In Section C of the Online Appendix, we examine the sensitivity of our results to changes in the values of key parameter values. We also study a version of the model calibrated to the U.S. labor market.

contrary, always dissave to smooth consumption.

Figure 1: Policy functions, stationary distributions and MPCs.



Notes: MPCs are computed conditional on a transfer shock. Excess asset holdings are measured as the difference between the amount of assets held by an employed household under incomplete and complete markets.

The top left panel of Figure 1 depicts the stationary distributions of unemployed and employed households on the asset grid. Some of the unemployed households experience prolonged unemployment spells and become constrained, i.e., end up holding zero assets. Their proportion amounts to slightly more than 5% of unemployed households, which is not surprising given the steady-state transition matrix, featuring a relatively low job-finding probability. On the other hand, all employed households hold strictly positive levels of assets. To determine how much of these holdings can be attributed to the precautionary motive, we compute excess asset holdings, defined as the difference in employed workers' asset holdings implied by the model and those obtained under complete markets. The stationary distribution of excess asset holdings is reported in the bottom right panel of Figure 1. It implies that, on average, employed workers hold 12.5% more assets to self-insure against unemployment risk. This relatively small figure is consistent with the evidence provided by Hurst, Lusardi, Kennickell, and Torralba (2010), which indicates that the size of precautionary saving with respect to labor-income risk is modest and accounts for less than 10 percent of total household wealth.[17]

[17] This evidence is based on U.S. data. When we calibrate our model to the U.S. economy, the average level of excess asset holdings is 11.6% (see Section C.2 of the Online Appendix).

What does our model predict in terms of marginal propensities to consume (MPCs)? To answer this question, we carry out the following experiment. We feed the model with an exogenous lump-sum transfer that is distributed equally across all households, and compute the change in the current consumption of each household. The transfer has a half-life of 6.5 quarters and — given the low value of d_T — is financed mostly by public debt in the first periods. Eventually, the deficit is financed by an increase in the lump-sum taxes levied on employed households in the subsequent periods. This financing scheme ensures that all households experience an increase in their current income, thus allowing for a comprehensive comparison of the impact MPCs across households.

The bottom left panel of Figure 1 reports the impact MPCs of employed and unemployed households for different ratios of individual to aggregate wealth. Two main observations stand out. First, the impact MPC decreases with (relative) wealth, regardless of households' employment status. Second, it is larger for unemployed households at any level of asset holdings, consistently with the empirical regularity reported by Carroll, Slacalek, and Tokuoka (2014), and is equal to 1 for unemployed households holding zero assets. This differential consumption response between employed and unemployed households will be at the heart of the mechanism underlying the results presented in the following sections. Using the stationary distribution of households, one can also generate the distribution of aggregate MPCs in our economy, which is shown in the bottom middle panel of Figure 1. Aggregate MPCs are slightly lower than 0.5 for the lowest percentiles, around 0.15 at the 10^{th} percentile, and below 0.1 at the 20^{th} percentile. By and large, our model is capable of replicating the shape of the distribution of aggregate MPCs observed in the data, at least qualitatively.[18] Interestingly, we obtain a very similar distribution of aggregate MPCs to that reported by Luetticke (2019) without relying on participation shocks to generate a large fraction of wealthy hand-to-mouth households.

3 Unconditional Effects of Government Spending Shocks

We start by discussing the effects of an increase in public spending occurring while the economy is initially in the steady state. The dynamic effects of a government spending shock are illustrated by means of impulse response functions. Following common practice in the literature, we quantify these effects using the present-value multiplier, defined as the expected discounted sum of the changes in a generic variable x_t up to a given horizon, $\mathcal{H}$, divided by the expected discounted sum

[18] Quantitatively, the mean aggregate impact MPC implied by the model (0.06) is somewhat smaller than that observed in the data (between 0.08 and 0.5 according to various empirical studies). In Section D of the Online Appendix, we provide an extended version of the model that replicates the observed empirical distributions of asset holdings and Gini coefficient on liquid wealth. The extended model embeds the same features that drive the results in the stripped-down version presented in Section 2, but allows for two additional sources of household heterogeneity. More specifically, we distinguish between patient and impatient households, and introduce a third labor-market status (in addition to employment and unemployment): entrepreneurship, with entrepreneurs receiving all the profits.

of changes in government spending over the same horizon

$$\mathcal{M}(\mathcal{H}) = \frac{\mathbb{E}_t \sum_{j=1}^{\mathcal{H}} (x_{t+j} - x) / (1+r)^{j-1}}{\mathbb{E}_t \sum_{j=1}^{\mathcal{H}} (g_{t+j} - g) / (1+r)^{j-1}}, \tag{19}$$

where r is the steady-state real interest rate implied by the model. Unless otherwise stated, $\mathcal{M}(\mathcal{H})$ refers to the output multiplier, which is the main focus of this paper. Table 2 reports $\mathcal{M}(\mathcal{H} \rightarrow \infty)$.

3.1 Benchmark economy

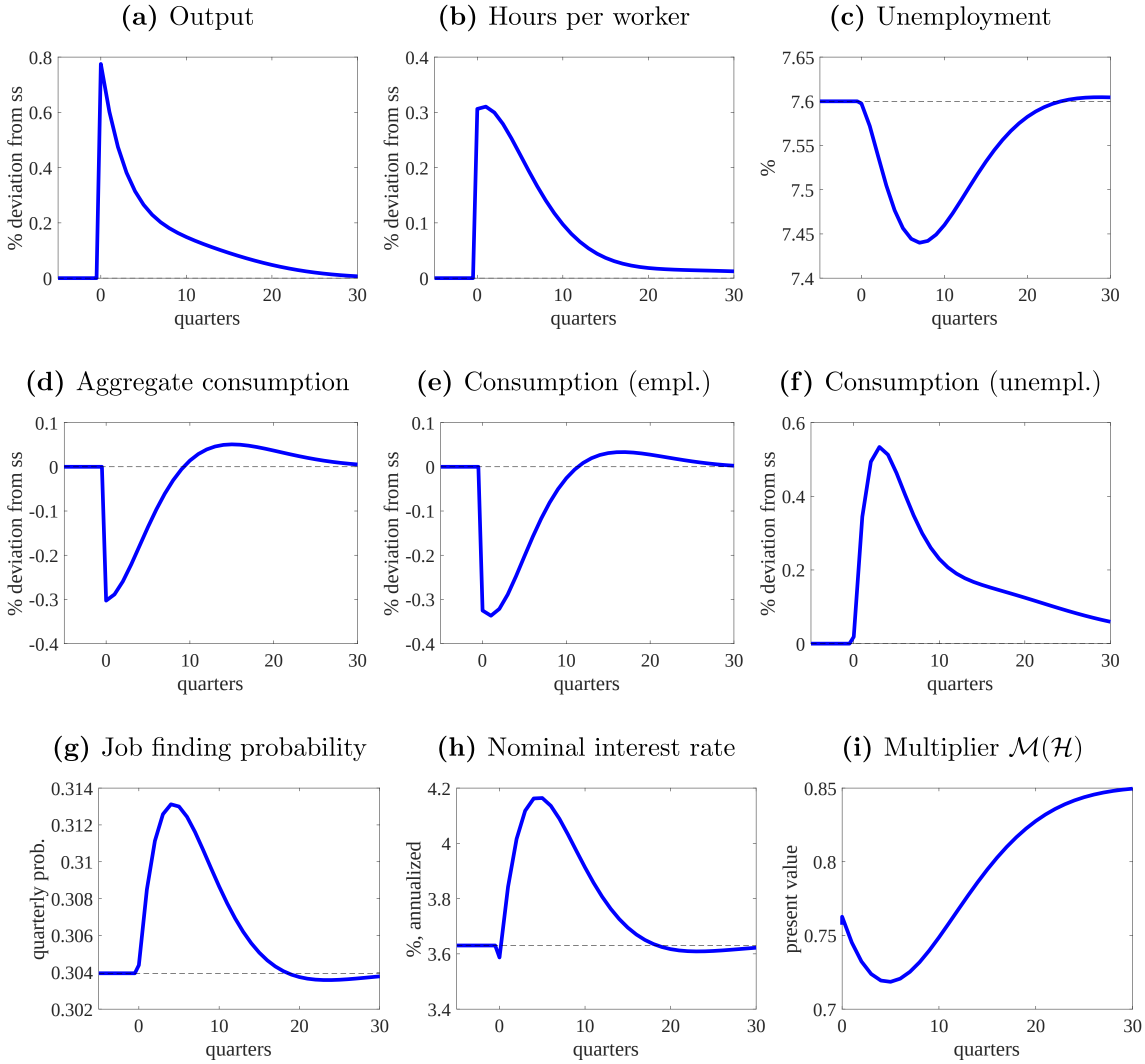
Figure 2 depicts the impulse responses of key variables to a 5% increase in government spending relative to its steady-state level, which represents 1 percentage point of steady-state GDP (raising the spending ratio from 20% to 21%). The shock increases aggregate demand in the economy, thus raising demand for intermediate goods. Whether intermediate-good producers respond by posting more vacancies to meet the additional demand depends on whether the marginal value of a filled position, J_t, increases. As can be seen by iterating Equation (3) forward (and noting that $V_t = 0$ in equilibrium), the response of J_t is driven by two effects: the change in employers' current and future profits, and the change in the rate at which future profits are discounted.

Price rigidity in the retail sector implies that the retailers' real marginal cost (or, equivalently, the real price of intermediate goods, p_t^m) increases persistently in response to the shock. To the extent that hours worked increase (which they do in equilibrium, as we explain below) and since the real wage remains constant, intermediate-good producers' period-by-period profits will also increase persistently.[19] We refer to this channel as the *undiscounted-profit* effect. At the same time, the increase in aggregate demand raises the real interest rate, thus lowering the present discounted value of future profits, *ceteris paribus*. We dub this channel the *discounting* effect. In our economy, the undiscounted-profit effect dominates the discounting effect, such that the marginal value of a filled position rises in response to the increase in public spending, inducing firms to post more vacancies. The resulting increase in labor-market tightness raises the job-finding probability, boosting hiring and driving unemployment down in a persistent manner. These predictions are consistent with the empirical evidence on the labor-market effects of government spending shocks, documented, for instance, by Monacelli, Perotti, and Trigari (2010) and Holden and Sparrman (2018).

The increase in public spending gives rise to a negative wealth effect for employed households — due to the implied hike in future taxes needed to finance the fiscal expansion — leading them to cut their consumption. This crowding-out, however, is mitigated by the fall in precautionary saving triggered by the reduction in unemployment risk. The negative wealth effect also leads the union to raise the supply of hours. Since the real price of intermediate goods rises while the real

[19] This result still holds when we assume that the real wage is governed by a Nash-bargaining mechanism. In this case, the real wage rises in response to the government spending shock, but does so to a much lesser extent than does the real price of intermediate goods.

Figure 2: Impulse responses to a 5% government spending shock around the steady state.



wage remains constant, the increase in labor along the intensive margin amplifies the increase in the marginal value of a filled position. The per capita consumption of unemployed households increases significantly and persistently. This crowding-in is explained by the increase in the job-finding probability, which shortens the expected duration of unemployment spells and induces unemployed households to use their precautionary saving to consume more. This effect is only marginally mitigated by the expected increase in the tax burden of unemployed households as they anticipate to start contributing to the financing of government purchases as soon as they change status and become employed.

Aggregate output is defined as the sum of aggregate consumption and government spending. For a given level of public spending, the output response to shocks is therefore larger the larger the response of aggregate consumption. In our economy, two interconnected mechanisms contribute to amplifying the response of aggregate consumption to shocks: the precautionary motive and the composition effect. By reducing unemployment, higher government spending mitigates unemployment risk — thus reducing precautionary saving, which in turn fuels the increase in aggregate demand — and raises the fraction of employed households, who consume more on average than unemployed households. The conjunction of these two channels yields a spending multiplier of 0.86, as reported in the first line of Table 2. This value lies well within the range of empirical estimates reported in the literature (see Ramey (2019) for a recent overview).

Table 2: Unconditional output multipliers.

	Present-value multiplier
Benchmark economy	0.8558
Variants	
No composition effect	0.8133
Complete markets	0.6562
No intensive margin	0.4870
Flexible prices	0.6679
Tax financing	0.5598
Endogenous spending rule	0.8512

Note: The unconditional multipliers are derived by assuming that the economy is initially in the steady state.

The spending multiplier delivered by our model is significantly larger than the counterfactually low multipliers typically obtained in models with search and matching frictions but with perfect insurance (e.g., Monacelli, Perotti, and Trigari (2010)), or in models with incomplete insurance markets but with a frictionless labor market (e.g., Hagedorn, Manovskii, and Mitman (2019)). Monacelli, Perotti, and Trigari (2010) show that it is possible to increase the size of the multiplier in a standard model with search and matching by assuming large average steady-state values of non-work to work activities — the equivalent of the replacement rate, h, in our model. But even when this parameter is assumed to be very close to its upper limit of 1, their model falls short of matching the spending multiplier estimated in the data. By contrast, our model generates an empirically plausible multiplier without relying on implausibly large values of the replacement rate.

3.2 Counterfactual economies

To shed light on the role of our assumptions in generating an empirically plausible multiplier, we study four counterfactual variants of the model, and report the corresponding present-value output multipliers in Table 2.[20]

Consider first an economy that is identical to our benchmark in every respect except for the way aggregate output is computed. The latter is evaluated using the steady-state fractions of employed

[20] The dynamic responses of output, unemployment, and the job-finding probability implied by each of the counterfactual economies are shown in Figure 1 in Section B of the Online Appendix.

and unemployed households, thus neutralizing the composition effect on aggregate consumption stemming from changes in the unemployment rate.[21] The output multiplier obtained in this case (0.81) is only slightly smaller than that implied by benchmark economy, reflecting the fact that, in the neighborhood of the steady state, the unemployment rate falls by a few percentage points in response to the government spending shock. As we will show below, however, the contribution of the composition effect to the size of the output multiplier becomes significantly larger when government spending occurs during a downturn.

Next, consider an economy with complete insurance markets, that is, one in which a perfect risk-sharing mechanism exists whereby households enjoy the same level of consumption irrespective of their employment status. In this environment, household heterogeneity becomes irrelevant for the size of the output multiplier since both the precautionary-motive and composition-effect channels are inoperative, even if the unemployment rate varies. The fall in unemployment following the increase in government spending is smaller and less persistent than in the benchmark economy. This reflects the absence of a feedback loop between the reduction in unemployment risk and the increase in aggregate demand. The resulting present-value output multiplier is barely 0.66, suggesting that the government's ability to alleviate unemployment risk through higher public spending amplifies the multiplier by roughly 30%.

In the third variant, we shut down the intensive margin of labor adjustment, as in the vast majority of existing models of involuntary unemployment.[22] Thus, aggregate output can only increase through the entry of new firms — recall that each firm is a job. Because the adjustment of hours worked is inhibited, the unemployment rate declines more than in the benchmark economy. This effect, however, is largely dominated by the fact that the output of each intermediate-good producer is smaller than in the benchmark economy, leading to a much smaller output multiplier (0.49). This exercise highlights the critical importance of considering both the extensive and the intensive margins of labor adjustment to generate empirically plausible spending multipliers.

Finally, we abstract from price rigidity and assume instead that retailers set prices in a fully flexible manner. This leaves their real marginal cost — and thus the real price of intermediate goods — unchanged in response to the spending shock ($p_t^m = p^m$). Because the real wage also remains constant, current and future profits of intermediate-good producers do not change, which nullifies the undiscounted-profit effect. However, the discounting effect is still operative as the real interest rate rises, causing the marginal value of a filled position to fall. This leads to a decline in vacancies and in the job-finding probability. As a result, unemployment *rises* persistently in response to the increase in public spending, as opposed to the *fall* obtained under sticky prices. The increase

[21] The calculation is made after the equilibrium has been computed. Hence, the experiment does not fully shut down the general-equilibrium effects of the change in the relative fraction of unemployed agents in total population, and therefore underestimates the contribution of the composition channel to the output multiplier.

[22] We assume that hours worked remain equal to their steady-state level in response to shocks.

in unemployment risk triggers an increase in precautionary saving on the part of employed and unemployed households, who cut their consumption by more than under rigid prices. Although the supply of hours worked increases more than in the benchmark economy, the net effect of the spending shock on aggregate output is smaller, producing a present-value output multiplier of 0.67.

3.3 Alternative fiscal-policy arrangements

The spending multiplier is not invariant to the conduct of fiscal policy. Below, we examine the implications of two alternative policy arrangements whereby public spending is (*i*) financed through lump-sum taxes, and (*ii*) determined endogenously.

Tax-financed spending. We study a version of our economy in which the increase in public spending is entirely financed through lump-sum taxes. More specifically, we assume that the fiscal rule now takes the following form:

$$T_t = g_t - \overline{g} + d_T \left(b_t - \overline{b} \right). \tag{20}$$

When the increase in public spending is tax-financed, it tends to lower the current income of employed households, since taxes rise immediately rather than in the future as with the debt-financing scheme of the benchmark model.[23] Since Ricardian equivalence does not hold in our economy, this leads to a larger fall in the consumption of employed households, who bear the tax burden. On the other hand, the consumption of unemployed households rises more than in the benchmark economy since they do not expect to pay higher taxes in the future once they find a job. This effect, however, is not sizable enough to compensate the larger decline in the consumption of employed workers. The resulting output multiplier (0.56) is 35% lower than in the benchmark economy.

Endogenous spending rule. Rather than assuming that public spending is fully exogenous, we consider an alternative specification in which a fraction of government expenditure responds endogenously to the state of the economy. More specifically, we follow Fève and Sahuc (2015) and assume that government spending evolves according to

$$g_t = g \left(y_t / y_{t-1} \right)^{\varphi_g} \tilde{g}_t, \tag{21}$$

$$\ln \left(\tilde{g}_t \right) = \rho_g \ln \left(\tilde{g}_{t-1} \right) + \epsilon_t^g. \tag{22}$$

We impose $\varphi_g = -0.75$, the value estimated by Fève and Sahuc (2015) for the Euro Area. This negative value means that the systematic component of public spending is countercyclical, which in turn implies that a given exogenous increase in government purchases should lead to a smaller

[23] Strictly speaking, the increase in government spending in the benchmark economy is financed using a mix of debt and lump-sum taxes. Given the calibrated value of d_T, however, additional spending is mostly financed by debt in the short run.

increase in aggregate output than in the case $\varphi_g = 0$. Table 2 confirms this conjecture; quantitatively, however, the difference in the spending multiplier relative to the benchmark economy is negligible.

4 State-Dependent Effects of Government Spending Shocks

In this section, we study how the effects of an increase in government spending differ depending on whether the economy is in recession or expansion. We generate theses states by assuming that the economy is initially in the steady state when a productivity shock occurs. A negative shock will result in a recession whereas a positive shock will lead to an expansion. We start by discussing the dynamic effects of these shocks, before turning to those associated with an increase in government spending conditionally on the state of the economy.

4.1 The economy's response to productivity shocks

Figure 3 shows the economy's response to negative and positive shocks to labor productivity, z_t. The shocks are calibrated to $\pm 3\%$. Consider first the negative shock. A fall in labor productivity lowers the marginal value of a filled position, inducing intermediate-good producers to post less vacancies, and lowering labor-market tightness and the job-finding probability. As a result, the number of successful matches falls and unemployment rises in equilibrium. At the peak, the unemployment rate surges by roughly 3 percentage points below its steady-state level. The magnitude of the unemployment response suggests that the model is capable of delivering sizable fluctuations in hiring activities in response to productivity shocks, a result that standard search and matching models typically fail to generate, as was first emphasized by Shimer (2005).[24]

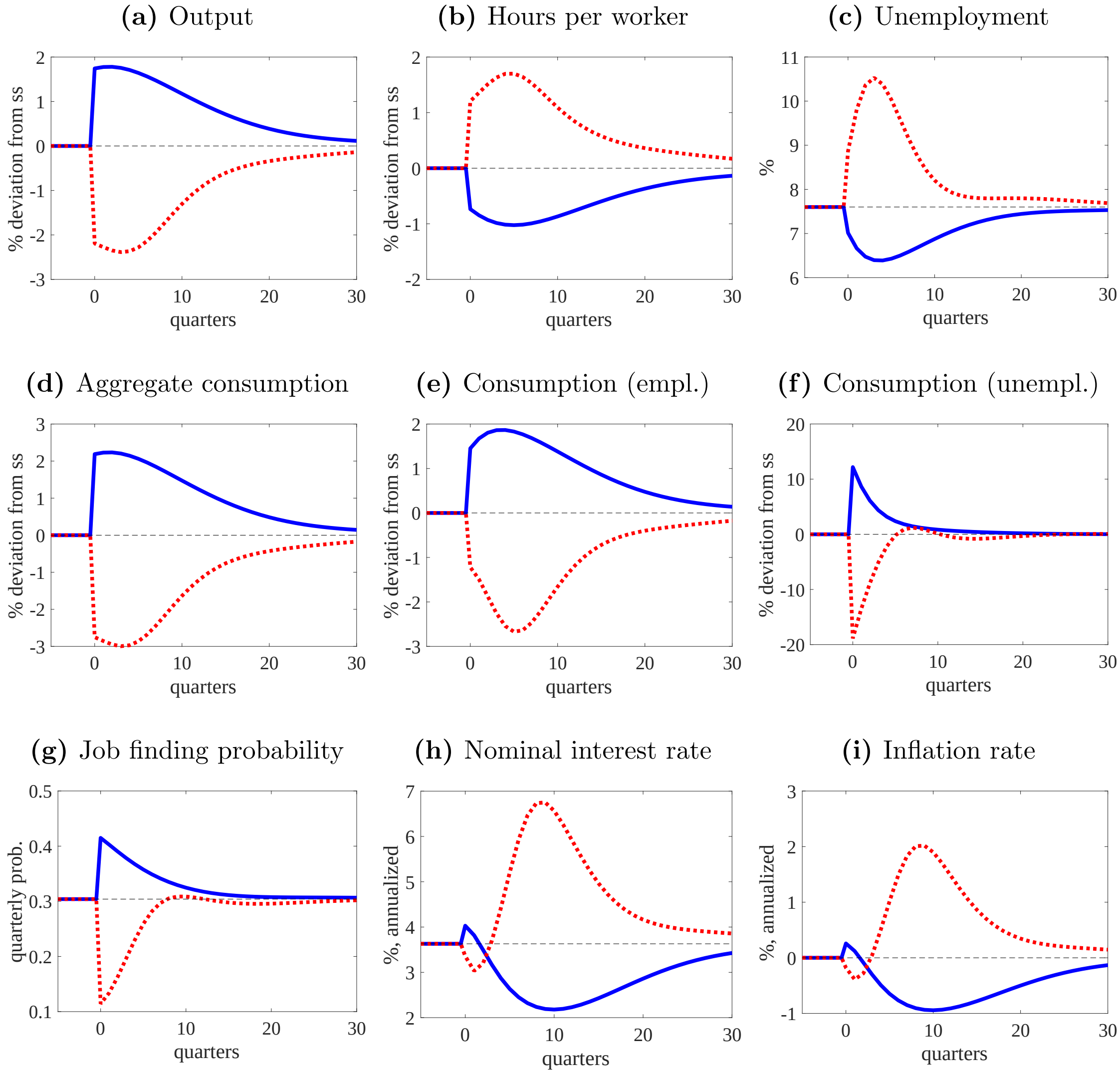
The negative productivity shock lowers aggregate output, consumption, and the real wage, but raises the number of hours per worker.[25] At the trough, aggregate output falls by approximately 2.4% relative to its steady-state level. Again, the precautionary motive drives the dynamics of the (per capita) consumption of unemployed households: the perspective of longer unemployment spells leads them to consume much less (almost 20%) and to save more. The resulting decline in aggregate consumption is significantly larger than that predicted by a model with perfect insurance.

A positive productivity shock produces the opposite effects: output, consumption, the real wage, and posted vacancies rise, while hours per worker and the unemployment rate both fall. Quantitatively, the effects of positive and negative productivity shocks are highly asymmetric: the expansion in economic activity resulting from the favorable shock is much less pronounced than the contraction caused by the (equal-sized) adverse shock. For instance, while output falls by 2.4%

[24]Real wage rigidity enables the model to yield substantial variability in labor-market variables following a productivity shock without having to rely on extreme values of the replacement rate, as proposed by Hagedorn and Manovskii (2008).

[25]Total hours worked, however, fall in equilibrium.

Figure 3: Impulse responses to 3% productivity shocks.



Solid blue: 3% positive shock. Dotted red: 3% negative shock.

(at the trough) relative to its steady-state level in response to the negative productivity shock, it only rises by roughly 1.8% (at the peak) following the positive shock. The asymmetry is even more striking in the response of the unemployment rate, which increases by almost 3 percentage points (at the peak) in response to the negative productivity shock but falls by only 1.2 percentage points (at the peak) after the favorable shock.

The asymmetry (or sign dependence) in the effects of productivity shocks hinges on two generic properties of models with search and matching frictions in the labor market. First, the law of motion of unemployment implies that there is more job destruction when the job-finding probability falls than job creation when the job-finding probability increases by the same amount.[26] Second, the concavity of the job-finding probability (and hence employment) with respect to labor-market tightness (recall that $f_t = \chi \left(1+\theta_t^{-\alpha}\right)^{-\frac{1}{\alpha}}$) means that unemployment falls less when the labor market tightens than it rises when the market becomes slack, for a given change (in absolute value) in the degree of market tightness. Under incomplete insurance markets, these two properties imply that precautionary saving and the fraction of low-consumption (unemployed) households in total population rise more following an adverse shock than they drop following a favorable shock of the same size, further exacerbating the asymmetry in the economy's response to positive and negative productivity shocks.

4.2 The effects of government spending in recessions and expansions

We now study the state dependence of the effects of government spending. For this purpose, we perform the following experiment. We first consider a baseline scenario in which only a productivity shock hits the economy. Then, we consider an alternative scenario in which the economy is simultaneously subjected to a productivity shock and to an increase in government spending. The net effect of government spending can then be computed by subtracting the economy's response in the baseline scenario from its response in the alternative scenario.[27] Figure 4 shows the effects of a 5% increase in government spending conditional on a positive and a negative productivity shock of equal size, identical to those considered in the previous section ($\pm 3\%$).

Figure 4 shows that the response of aggregate output to the spending shock is larger in recession than in expansion. The present-value output multiplier is 0.8 in the latter case and 1.02 in the former (see the first row of Table 3). The difference of roughly 28% reflects both the larger response of aggregate consumption and the larger decline in the unemployment rate at short and medium horizons. This state dependence results from the joint influence of the matching frictions, the precautionary motive, and the composition effect. As the pool of job seekers is larger during downturns than during expansions (due to the non-linearity of the effects of productivity shocks), the concavity of the job-finding probability implies that employment increases more in the former case than in the latter, in response to a given increase in government spending.[28] Because unemployment risk is reduced substantially more when government spending occurs while the economy is in recession, employed and unemployed households curtail their precautionary saving by a larger amount, leading to a smaller crowding-out of aggregate consumption at short horizons and

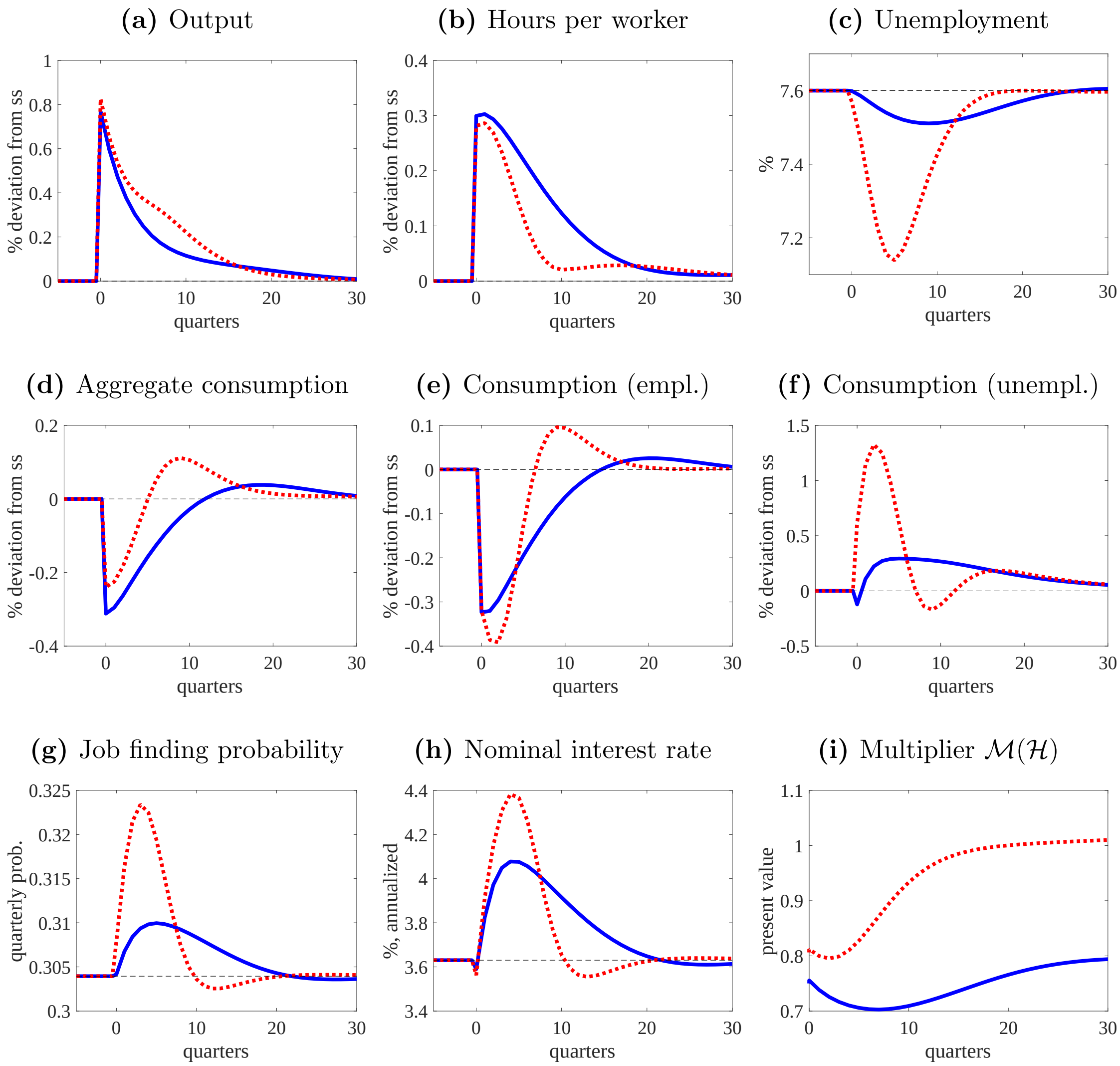
[26]To see this, notice that unemployment evolves according to $u_t = s(1-u_{t-1}) + (1-f_t)u_{t-1}$. Thus, the effect of a fall (rise) in f_t on u_t is amplified (dampened) by the fact that unemployment is large (small) in recessions (expansions).

[27]We also studied government spending shocks conditional on recessions and expansions generated by demand shocks, and reached similar conclusions.

[28]Graphically, when the economy is in a recession, it lies on the steep portion of the curve representing the job-finding probability as a function of market tightness, whereas it lies on the flat portion of the curve when it is in an expansion.

a larger crowding-in at medium horizons. The larger reduction in the fraction of low-consumption households in total population further contributes to the difference in the consumption response between expansion and recession. Under our calibration, the present-value consumption multiplier is positive in recession, implying an output multiplier that exceeds 1.

Figure 4: Impulse responses to a 5% government spending shock. Net effect in recession and expansion.



Solid blue: conditional on an expansion. Dotted red: conditional on a recession.

The previous discussion suggests that the aggregate effects of public spending are not just asymmetric in good and bad times but that they are also non-linear in the size of recessions. To illustrate this property, we compute the spending multiplier for aggregate output, unemployment, aggregate consumption, and the per capita consumption of employed and unemployed households conditional on different sizes of the productivity shock, ranging from -4% to 4%. The results are depicted in Figure 5. The number obtained when the value of the productivity shock is nil (i.e., when $z = \bar{z} = 1$) is the unconditional multiplier.

Table 3: State-dependent output multipliers.

	Present-value multiplier		
	Expansion	Recession	Difference
Benchmark economy	0.7995	1.0207	27.67%
Variants			
No composition effect	0.7779	0.9166	17.82%
Complete markets	0.6344	0.7149	12.69%
No intensive margin	0.3484	1.1124	219.32%
Flexible prices	0.6839	0.6342	−7.27%
Tax financing	0.4432	0.8593	93.88%
Endogenous spending rule	0.7984	1.0000	25.25%

Note: Expansions (resp. recessions) are generated by assuming that the economy is hit by a positive (resp. negative) productivity shock.

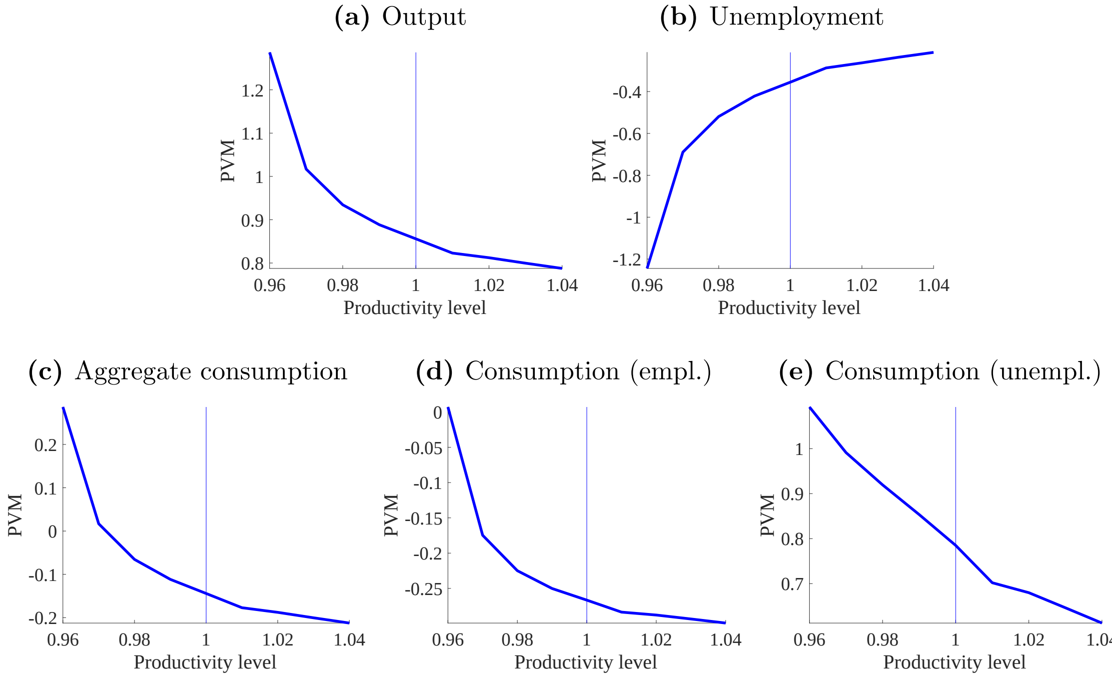
Figure 5 clearly shows the state dependence of the spending multiplier. For all the variables shown in the figure, the multiplier conditional on a negative productivity shock is larger (in absolute value) than the multiplier conditional on a positive shock of the same size. Interestingly, the multiplier for the consumption of unemployed households is always positive, whereas that for the consumption of employed households is always negative when the spending shock occurs in an expansion, but tends towards positive values as recessions become more severe. As a result, the aggregate consumption (output) multiplier is positive (larger than one) as long as the decline in productivity exceeds 2.5%.

Figure 5 also reveals that the spending multipliers are decreasing (increasing for unemployment) and highly convex in the size of the productivity shock. Put differently, the multipliers increase exponentially with the severity of the recession but decrease fairly linearly with the size of the expansion. This strong curvature implies that the state dependence of the effects of government spending becomes increasingly salient when business-cycle fluctuations become larger, exhibiting higher peaks and deeper troughs. For instance, the present-value output multiplier surges from 0.79 when it is conditional on a 4% positive productivity shock to 1.29 when it is conditional on an equal-sized negative productivity shock, an amplification of more than 63%.

The remaining rows of Table 3 show the output multipliers in recession and expansion obtained from the counterfactual economies discussed in Section 3.2. The size of productivity shocks is ±3%, as in the benchmark economy.[29] Relative to the benchmark economy, neutralizing the composition effect only marginally lowers the multiplier conditional on an expansion (from 0.80 to 0.78) but significantly reduces it conditional on a recession (from 1.02 to 0.92). As a result, the multiplier is 18% larger in the latter state than in the former. On the other hand, under complete markets,

[29] In the model without an intensive margin, a 3% drop in productivity leads the response of output and unemployment to explode. Hence, in this case, we consider smaller (±2.5%) productivity shocks.

Figure 5: Present-value multipliers conditional on productivity shocks.



Notes: Present-value multiplier are computed according to Equation (19) with x_t being the variable of interest. The productivity shock ranges from -4% to 4%.

this difference is less than 13%. Together, these two observations highlight the importance of the precautionary-saving channel in accounting for the countercyclicality of the spending multiplier. When we abstract from the intensive margin of labor adjustment, the output multiplier in more than three times larger in recession than in expansion. This is due to the fact that, with constant hours of work, all the necessary adjustment occurs through the extensive margin, magnifying the implied effects on unemployment risk and precautionary saving. These effects are highly asymmetric due to the concavity of employment with respect to market tightness. Finally, a version of the model in which prices are fully flexible generates an *inverted* state dependence, with a larger output multiplier in expansion than in recession. This result can be easily understood by recalling that, under price flexibility, an increase in government spending raises unemployment and, by extension, unemployment risk and precautionary saving.

The last two rows of Table 3 report the results under alternative fiscal-policy arrangements. When spending is tax-financed, the conditional multipliers are lower than in the benchmark economy (see Section 3.3) but exhibit much larger state dependence. The chief reason is that the fraction of unemployed households — whose consumption rises more in response to a tax-financed than a debt-financed increase in government spending — is larger in recession. Considering an endogenous spending rule (Equation (21)) implies that the systematic component of fiscal policy mitigates unemployment risk through countercyclical variations in government spending. Quantitatively, however, this channel barely affects the multiplier — regardless of whether the economy is in recession or expansion — leading to marginal changes in the extent of state dependence, compared to the benchmark economy.

5 The Spending Multiplier in the Covid-19 Recession

The first quarter of 2020 has witnessed the worldwide outbreak of the Covid-19 pandemic, which led the vast majority of governments to adopt strict lockdown policies and to shut down many sectors of the economy during the subsequent months. This has resulted in massive layoffs and a surge in job losses in virtually every country of the world. While there is a consensus among observers that this event has initially shifted aggregate supply leftward — and is therefore better characterized as a supply shock — the modest decline inflation that ensued suggests that the shock has triggered an even larger leftward shift in aggregate demand, giving rise to a deep recession. A shock of this nature was coined 'Keynesian supply shock' by Guerrieri, Lorenzoni, Straub, and Werning (2020). In this section, we use our model to evaluate the spending multiplier in the context of the current Covid-19 recession.

To capture the adverse effects of the lockdown on hiring activities, we model the Covid-19 shock as a combination of two disturbances occurring in 2020Q1: a fall in the matching-efficiency parameter, χ, which lowers both the job-finding and the vacancy-filling probabilities, *ceteris paribus*, and a rise in the separation rate, s.[30] Both shocks are assumed to be moderately persistent (with an autocorrelation coefficient of 0.5) in order to account for the gradual lift of lockdown restrictions. Finally, we constrain the number of hours worked by each employee to remain constant during the first two quarters of 2020.[31]

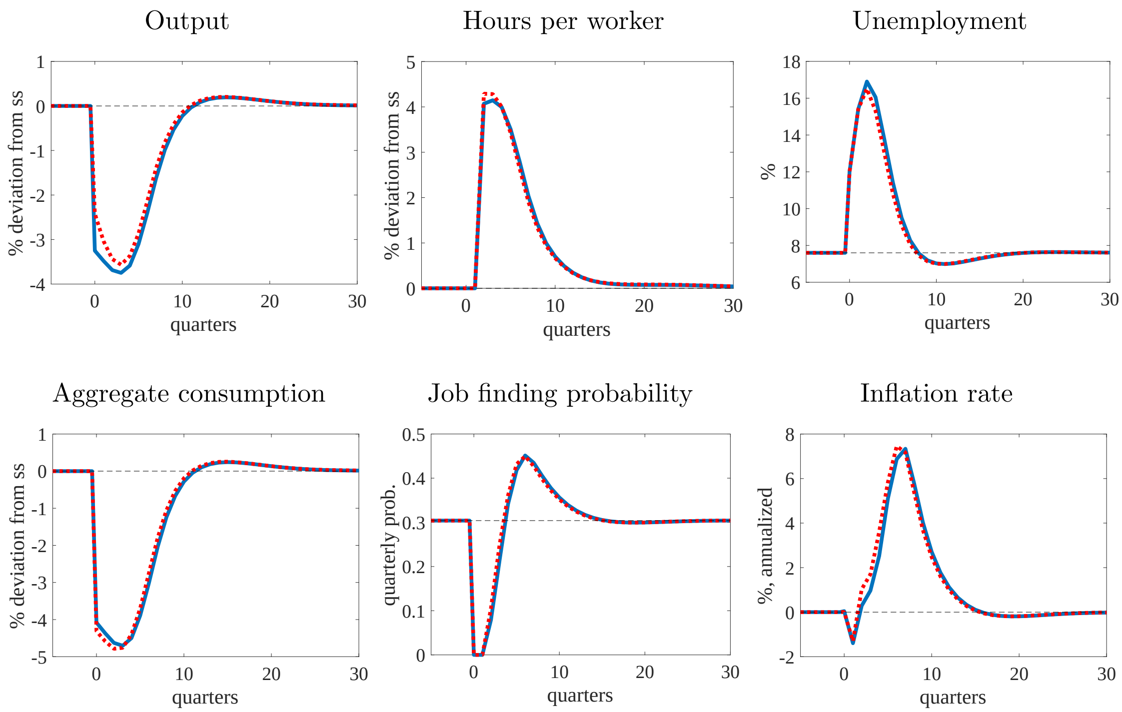
The dynamic effects of the Covid-19 shock are represented with the blue solid lines in Panel (a) of Figure 6. After hitting its lower bound of 0 during the first two quarters of 2020, the job-finding probability remains below its steady-state level for four more quarters. Unemployment rises gradually until it hits a maximum of 17% and remains higher than its steady-state level for 2 years. The rise in current and future unemployment translates into a 4.7% decline in aggregate consumption at the trough. Importantly, the shock causes inflation to *fall* in the first three quarters after the shock, thus indicating a larger fall in aggregate demand than in aggregate supply. These predictions are consistent with the narrative of the Covid-19 pandemic, and suggest that the mechanisms embodied in our model enable it to account for Keynesian supply shocks.

[30] We assume that, initially, matching efficiency falls by 50% while the separation rate rises by 100%. This calibration ensures that the model reproduces the large decline in output (more than 3%) that was observed in the Euro Area at the end of 2020Q1.

[31] This assumption is meant to account for the fact that, during the lockdown, some workers — for instance, those providing health-care services — were asked to work more hours while other workers — in other sectors — were constrained to accept part-time work arrangements.

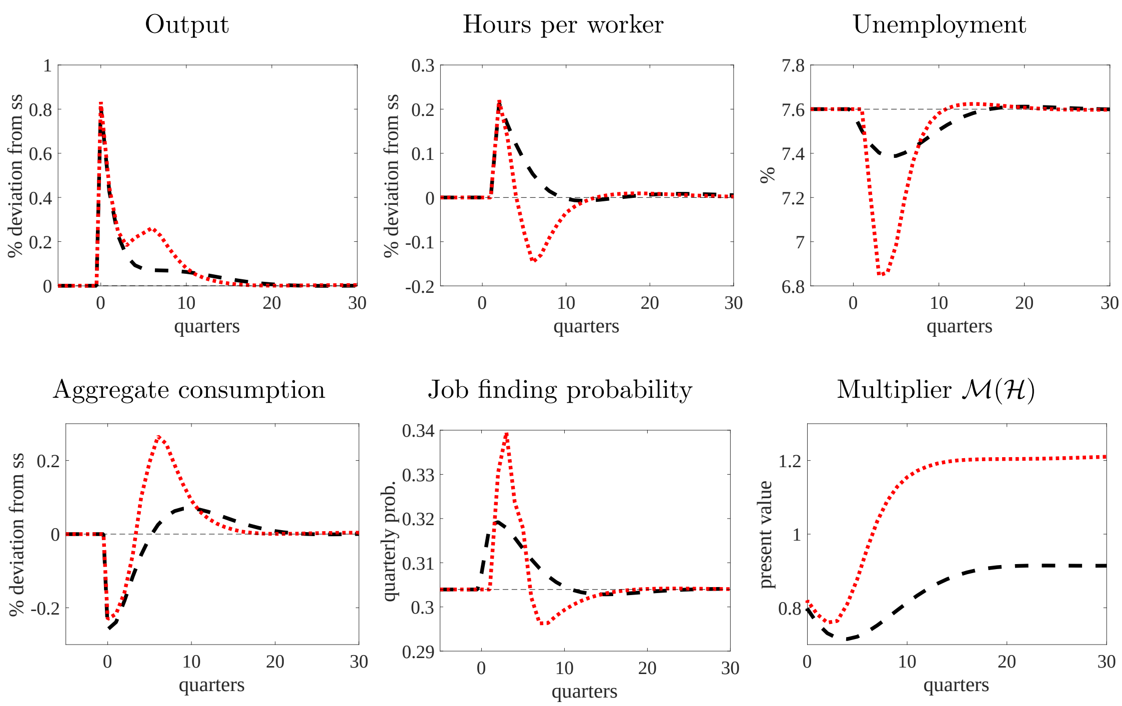
Figure 6: The effects of government spending in the Covid-19 recession.

(a) Effects of the Covid-19 shock.



Solid blue: Covid-19 shock only. Dotted red: Covid-19 & spending shocks.

(b) Net effects of the government spending shock.



Dashed black: around steady state. Dotted red: conditional on the Covid-19 shock.

The red dotted lines in Panel (a) of Figure 6 illustrate the economy's response when the Covid-19 shock is accompanied by a simultaneous and equally persistent increase in government spending. The fiscal expansion raises aggregate demand, which mitigates the rise in unemployment and the output loss via the mechanisms discussed in Section 3 (except for the fact that the intensive margin labor adjustment is temporarily inhibited). Panel (b) of Figure 6 shows the net effects of the increase in public spending (i.e., conditional on the Covid-19 shock) and contrasts them with those obtained when the same spending shock occurs at the steady state. The effects are clearly state dependent, being significantly larger in the Covid-19 recession than around the steady state. The present-value spending multiplier is 30% larger in the former case than in the latter (1.221 versus 0.945).[32]

6 Concluding Remarks

In this paper, we have developed a model with involuntary unemployment, incomplete markets and real wage rigidity, in which government spending increases labor-market tightness and lowers unemployment. Because markets are incomplete, precautionary saving and changes in the fraction of unemployed households in the population amplify the aggregate effects of government spending. The non-linearity arising from endogenous variations in unemployment risk implies that those effects are state dependent, spending multipliers being larger in recessions than in expansions. In particular, the output and consumption multipliers increase exponentially with the size of the recession but fall linearly with the size of the expansion. The extent of state dependence generated by the model is substantially larger than that obtained from an otherwise identical economy in which unemployment risk is fully insured.

The mechanism put forward in this paper is certainly not the only channel through which spending multipliers can exhibit state dependence; some earlier studies have succeeded in generating highly countercyclical multipliers — even exceeding 1 in recession — without relying on incomplete insurance against unemployment risk. However, by taking into consideration unemployment risk, our framework contains the key ingredients to analyze other aspects of fiscal policy for which household heterogeneity is of first-order importance — such as social transfers and unemployment insurance. Those questions, as well as the normative implications of our results, are left for future research.

[32] The value of the unconditional multiplier (i.e., computed around the steady state) differs from that reported in Section 3 because the spending shock does not feature the same persistence.

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Online Appendix to

Taking off into the Wind: Unemployment Risk and State-Dependent Government Spending Multipliers

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A Solution method

Our solution method is fully non-linear and takes advantage of the continuous-time formulation of the heterogeneous-agent problem solving the Hamilton-Jacobi-Bellman and Kolmogorov forward equations. Our codes are adapted from those of Bence Bardoczy taken from the HACT project page maintained by Benjamin Moll: http://www.princeton.edu/~moll/HACTproject.htm.

A.1 Steady state

The algorithm solving for the steady state is the following.

1. Based on the calibrated separation rate and the target value for the unemployment rate, $\bar{u}$, compute $\bar{f}$, $\bar{q}$, and $\bar{\theta}$.
2. Guess initial values of the real interest rate, $\bar{r}$, and the vacancy-posting cost, ξ.
3. Compute output, $\bar{y}$. Based on the calibration targets, compute government spending, $\bar{g}$, and public debt, $\bar{b}$, and infer the tax rate, τ.
4. Compute profits and income levels for employed and unemployed households.

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5. Given income levels and the real interest rate:
   - Solve the Hamilton-Jacobi-Bellman equation.
   - Solve the marginal value of a job, $\bar{J}$.
   - Solve the steady-state Nash-bargaining problem to obtain the real wage, $\bar{w}$.
   - Adjust the value of the disutility parameter ω, such that hours per worker are normalized to one ($\bar{\ell} = 1$) in the steady state.
   - Update the value functions $\bar{W}$, $\bar{J}$, as well as $\bar{w}$.
6. Solve the Kolmogorov forward equation to recover the distributions of households over the asset grid.
7. Compute residuals from the goods-market-clearing and free-entry conditions.
8. If the residuals are larger than a tolerance level, update $\bar{r}$ and ξ. Use $\bar{r}^{new}$ and ξ^{new} as new guesses in Step 2.
9. Iterate until both residuals are smaller than the tolerance level.

A.2 Transition dynamics

The algorithm solving for the transitional dynamics is the following:

1. Guess initial sequences of the real interest rate $\{r_t\}_{t=1}^{t=T}$ and labor market tightness $\{\theta_t\}_{t=1}^{t=T}$.
2. Set all the endogenous variables to their steady-state values in all periods.
3. For $t = \{1 : T\}$, given θ_t, compute the transition probabilities f_t and q_t, as well as the transition matrix, Λ_t.
4. For $t = \{1 : T\}$, given r_t, compute the value of public debt b_t.
5. For $t = \{1 : T\}$, compute the the inflation rate, π_t, using the Taylor rule, and the associated nominal interest rate, i_t^n.
6. For $t = \{T : 1\}$, compute backward the price of intermediate goods, p_t^m.
7. For $t = \{T : 1\}$, starting from the terminal (steady-state) values of the variables:
   - Compute profits, lump-sum taxes, and income levels for employed and unemployed households.
   - Solve the Hamilton-Jacobi-Bellman equation and compute the value function W_t.
   - Solve the marginal value of a job, J_t.
   - Compute the real wage, w_t, according to the wage rule.
   - Compute hours per worker, ℓ_t.

8. For $t = \{1 : T\}$, solve the Kolmogorov forward equation to obtain the distributions of households over the asset grid.

9. From those distributions, compute the paths of the unemployment rate $\{u_t\}_{t=1}^{t=T}$ and vacancies $\{v_t\}_{t=1}^{t=T}$ (using $\{v_t\}_{t=1}^{t=T} = \{\theta_t\}_{t=1}^{t=T} \times \{u_t\}_{t=1}^{t=T}$).

10. Compute the sequence of residuals in the asset-market-clearing and free entry conditions, denoted, respectively, by $\{\zeta_{asset,t}\}_{t=1}^{t=T}$ and $\{\zeta_{fe,t}\}_{t=1}^{t=T}$.

11. If the residuals are larger than a tolerance level, update $\{r_t\}_{t=1}^{t=T}$ and $\{\theta_t\}_{t=1}^{t=T}$. The updating process for the real interest rate is: $\{r_t^{new}\} = \{r_t\} - d_r \{\zeta_{asset,t}\}$ where d_r is a small number: whenever households hold assets in excess of asset supply, lower the real interest rate. Similarly, we impose $\{\theta_t^{new}\} = \{\theta_t\} + d_\theta \{\zeta_{fe,t}\}$ where d_θ is a small number: whenever the labor market is not tight enough, raise tightness $\{\theta_t\}$. Use $\{r_t^{new}\}$ and $\{\theta_t^{new}\}$ as new guesses in Step 1.

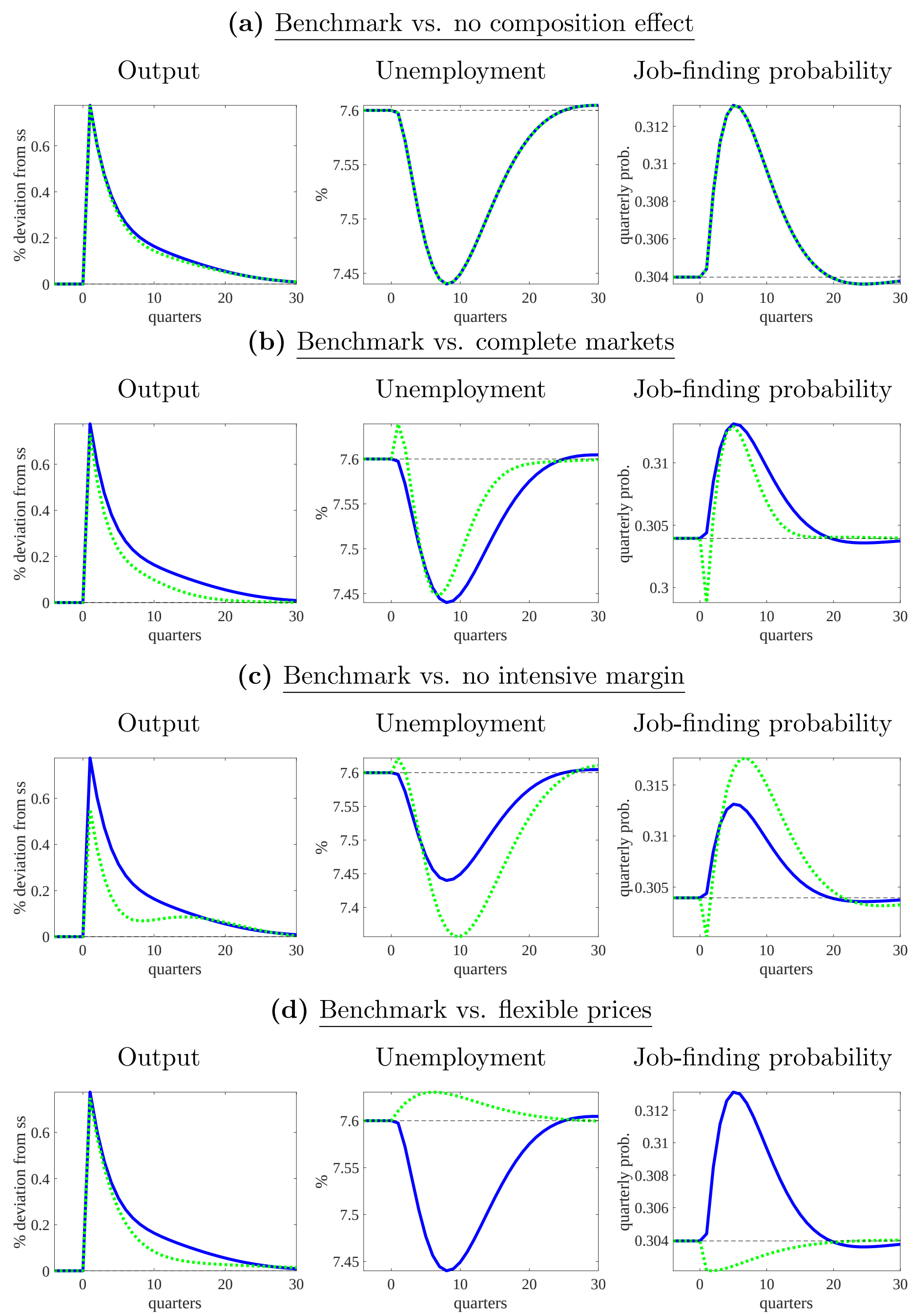
12. Iterate until the largest absolute value of each of the sequences$\{\zeta_{asset,t}\}$ and $\{\zeta_{fe,t}\}$ is less than the tolerance level.

Solving for the transition dynamics takes a few minutes depending on the size and nature of the shocks and the assumptions considered.

B Unconditional Effects of Government Spending Shocks in Counterfactual Economies

In this section, we report the dynamic responses of output, unemployment, and the job-finding probability to a 5% increase in government spending, assuming that the economy is initially in the steady state. The Figure superimposes on the responses implied by the benchmark model those obtained from each of the counterfactual economies studies in Section 3.2 of the paper.

Figure 1: Impulse responses to a 5% government spending shock: Benchmark vs. counterfactual.



Blue solid: Benchmark. Light green: Counterfactual.

C Sensitivity Analysis

In this section, we study the sensitivity of our results along two dimensions. First, we consider alternative values of the following parameters, one at a time: the replacement rate, h; the matching-curvature parameter, α; the inverse of the Frisch elasticity of labor supply, ψ; the tax-feedback parameter, d_T, and the value of steady-state inflation, $\bar{\pi}$. In each case, we evaluate the present-value multiplier for aggregate output, unemployment, aggregate consumption, and the per capita consumption of employed and unemployed households conditional on different sizes of the productivity shock. The results are depicted in Figure 2. Second, we calibrate the model to represent the U.S. labor market.

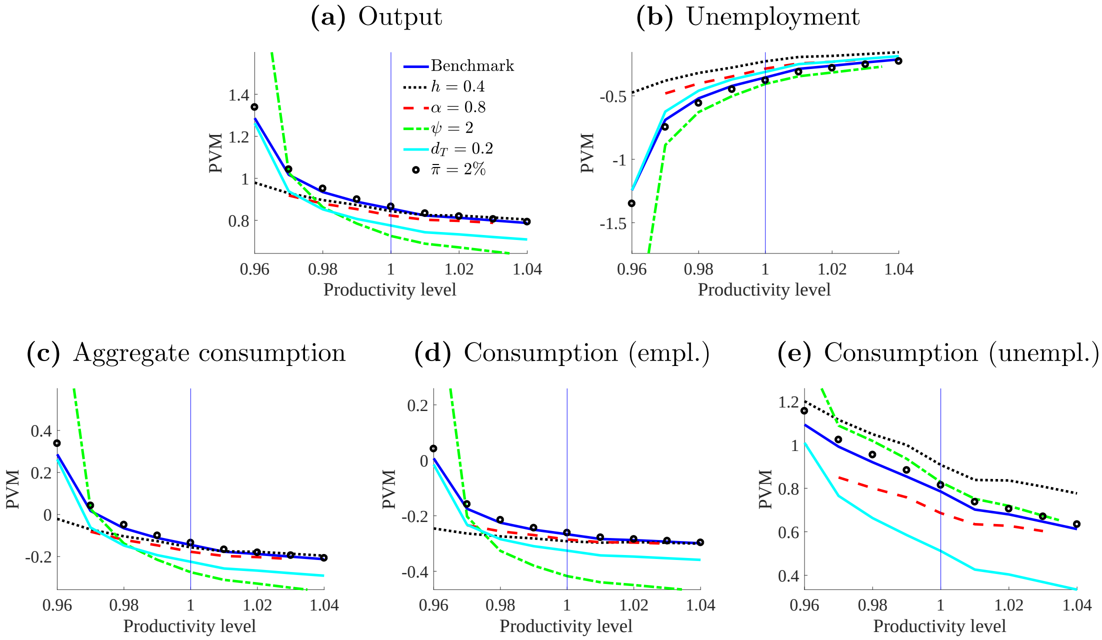
C.1 Alternative parameter values

As an alternative value for the replacement rate, we choose $h = 0.4$, a value commonly used in search and matching models calibrated to the U.S. economy, which arguably has a lower replacement rate than most of European countries. All else equal, a lower replacement rate has two effects. First, it exacerbates income losses during unemployment spells, which strengthens the precautionary motive, leading households to accumulate more assets while employed. This attenuates the decline in their consumption in response to an increase in government spending, and results in a larger spending multiplier. Second, because the replacement rate pins down the vacancy-posting cost (conditional on the values of the remaining parameters), the latter increases when h falls. Larger vacancy-posting costs imply that firms' accounting profits are larger and less sensitive (in terms of percentage changes) to shocks, mitigating firm's incentives to post vacancies,[1] and by extension, the fall in unemployment following an increase in government spending (as in Monacelli, Perotti, and Trigari (2010)). This in turn translates into a smaller output multiplier. During large expansions, the first effect dominates, such that a lower replacement rate raises the spending multiplier. For smaller expansions and recessions, the second effect dominates, reducing the multiplier when the replacement rate is lower. The reason for this result lies in the fact that lower replacement rates dampen the response of output and unemployment to productivity shocks, and that this dampening is larger the more negative is the shock. Together, these results imply that the extent of state dependence falls with the replacement rate.

Next, we lower the matching-curvature parameter, α, from its benchmark value of 1 to a value of 0.8. As shown in Figure 2, the spending multiplier falls (rises for unemployment) for any given value of the productivity shock. This is simply due to the fact that a smaller value of α implies a smaller job-finding probability for any given labor-market tightness. More importantly, the figure shows that the spending multiplier becomes less sensitive to the size of recessions/expansions. The reason is that the job-finding probability becomes less concave with respect to the labor-market tightness. In our model, the concavity of the job-finding probability plays a key role in generating asymmetric changes in unemployment, which translate into asymmetries in precautionary saving

[1] See Hagedorn and Manovskii (2008).

Figure 2: Present-value multipliers conditional on productivity shocks.



Notes: Present-value multiplier are computed according to Equation (19) in the main text, with x_t being the variable of interest. The productivity shock ranges from -4% to 4%.

and in the composition effect.[2] With a less concave job-finding probability, these asymmetries are less important.

In the third experiment, we consider a Frisch elasticity of labor supply of 0.5 by increasing ψ from 1 to 2. Larger values of ψ imply that the union is less willing to increase the supply of hours after a given shock, *ceteris paribus*. As ψ tends to infinity, the model boils down to the economy without an intensive margin of labor adjustment, described in Section 3.2 of the paper. By a continuity argument, it is obvious that the unconditional output multiplier will be smaller the larger the value of ψ. This continues to be the case in expansions and in mild recessions. However, because larger values of ψ amplify the economy's response to productivity shocks, recessions will be more severe for a given fall in productivity, and this tends to increase the multiplier and thus the extent of state dependence.

In a fourth experiment, we increase the value of the tax-feedback parameter, d_T, from 0.1 to 0.2. This alternative parameter value tilts the tax schedule needed to finance the increase in government spending towards the present. Since Ricardian equivalence does not hold in our model, this further raises the real interest rate and exacerbates the fall in the consumption of employed households at short horizons. Because the present-value multiplier assigns a larger weight to changes in aggregate variables that occur in the near future, it will tend to fall (in absolute value) as d_T rises. This outcome should hold regardless of the size of productivity shocks since d_T has little effect on the economy's response to those shocks. One should therefore expect the multiplier curves to simply

[2]Conceptually, the parameters h and α affect the results through the same channel: the elasticity of unemployment in response to shocks. However, while changes in h affect this elasticity indirectly — through steady-state tightness — changes in α do so directly.

shift downward (upward for unemployment) compared to the benchmark economy, which is exactly what Figure 2 shows. Based on this discussion, we can safely conclude that the amount of state dependence implied by the model exhibits very little sensitivity to changes in the value of d_T.

In the last experiment, we consider a strictly positive inflation target of 2% per annum. Alves (2018) shows that, in a model with Calvo-type price contracts, non-zero trend inflation can help generate volatile labor-market variables. This continues to be the case under the Rotemberg-type price stickiness assumed in our model. However, raising steady-state inflation from 0 to 2% per annum generally raises the spending multipliers (in absolute value) by a negligible amount, except when the economy is a in deep recession.

C.2 Calibrating the model to the U.S. labor market

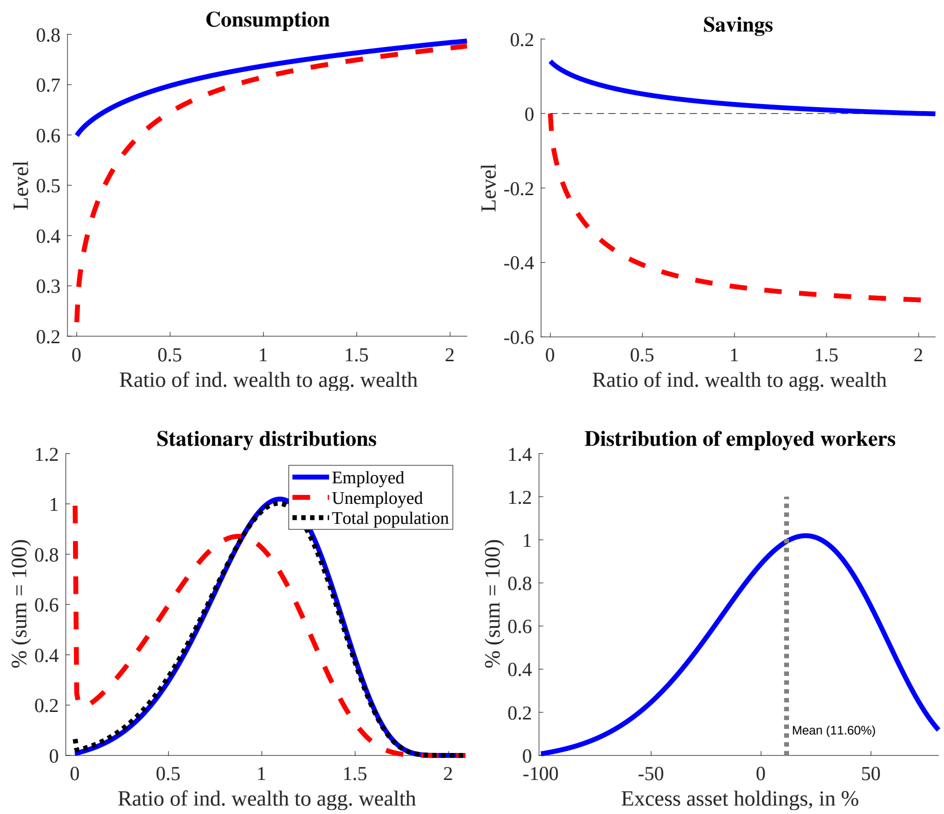
So far, we have focused on a model that captures the specificities of the labor market prevailing in major European countries, and studied the sensitivity of results by perturbing some of the structural parameters one at a time. In what follows, we evaluate the spending multiplier and its state dependence in a version of the model calibrated to the U.S. economy. The U.S. labor market is not only characterized by a lower replacement rate than our benchmark economy, it also features significantly larger separation and job-finding rates, i.e., larger labor-market turnover.[3] To capture these characteristics, we set the replacement rate to $h = 0.4$ and impose a separation rate of $s = 0.05$ — twice the benchmark value, along with a targeted unemployment rate of $u = 0.059$, which yields a job-finding probability $f \simeq 0.8$ — almost four times the benchmark value. These numbers are almost identical to those used by Challe (2020), who targets the U.S. labor market at a quarterly frequency. Finally, we impose a slightly lower bargaining power for the union, $\beta = 0.7$, in the determination of the steady-state real wage.

Keeping the remaining parameters unchanged, we obtain the stationary distributions and policy functions reported in Figure 3. Compared with the results based on the European calibration, the higher transition rates produce much more similar stationary distributions of asset holdings for employed and unemployed households. These distributions indicate that a much smaller number of unemployed households hold zero assets: since unemployment spells are significantly shorter, unemployed households get to keep a larger fraction of the (precautionary) asset holdings they accumulated in the past, when they were employed. Note that this feature tends to lower the aggregate MPC of unemployed households. In addition, employed households accumulate less assets to self-insure against unemployment risk since the higher turnover tends to reduce unemployment risk, even though the income loss associated with unemployment spells is larger than under the European calibration. Figure 3 also reveals that the consumption function is steeper at low levels of asset holdings under the U.S. calibration, especially for unemployed households, implying that these households have a larger marginal utility of consumption at low levels of assets than their counterparts in the benchmark economy. Importantly, this feature tends to raise the MPC of un-

[3]From this perspective, the alternative calibration of the replacement rate performed in the sensitivity analysis above, while informative, would be insufficient to draw conclusions about the effects of government spending shocks and their state dependence in the U.S. simply because other parameters need to be simultaneously re-calibrated to match the characteristics of the U.S. labor market.

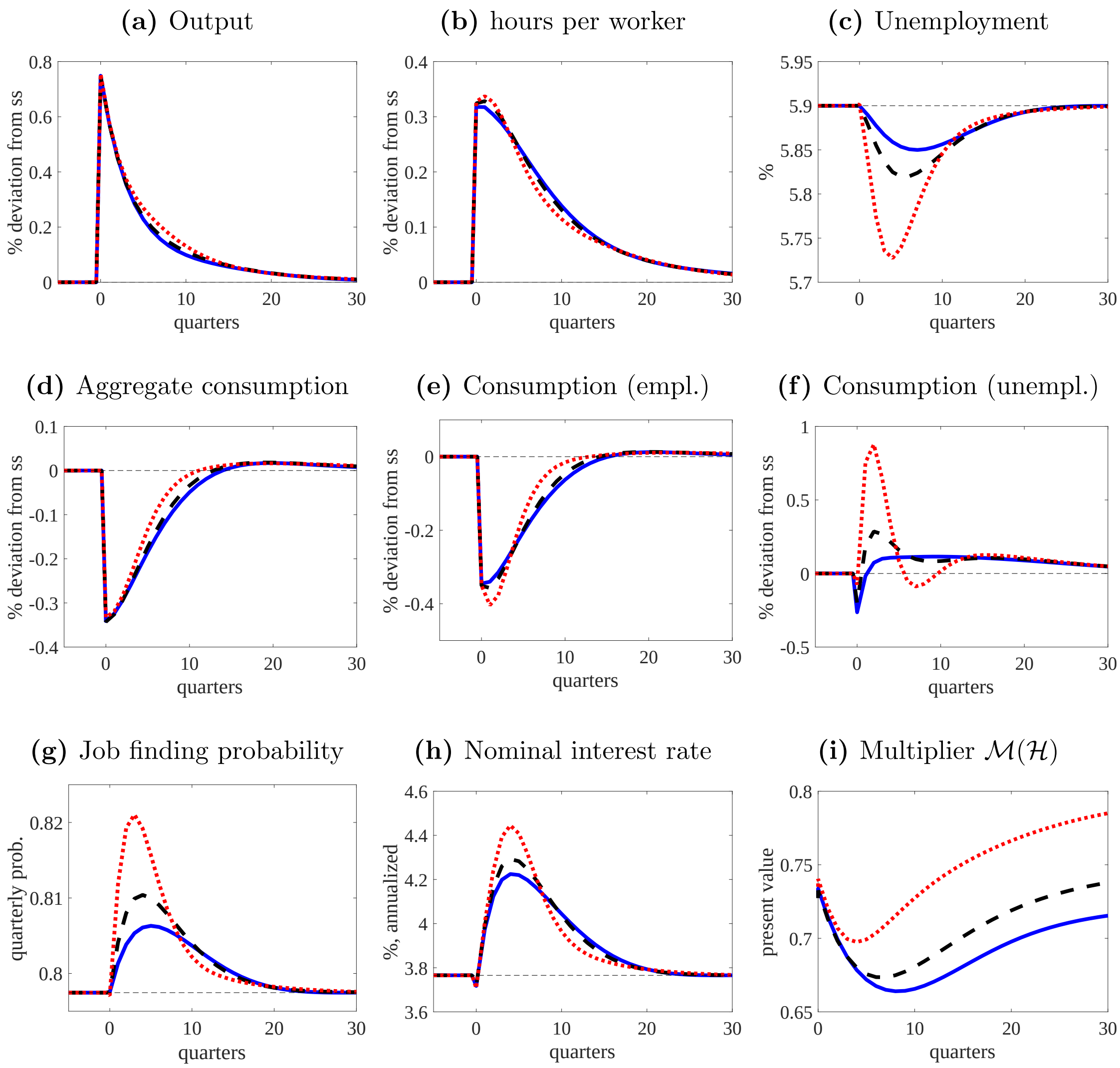
employed households holding small amounts of assets, and thus the aggregate MPC of unemployed households. Finally, the bottom right panel of Figure 3 shows that, on average, employed workers hold 11.6% more assets than in an otherwise identical economy with complete markets — where unemployment risk is fully insured. This figure is consistent with the amount of precautionary saving estimated by Hurst, Lusardi, Kennickell, and Torralba (2010) in the U.S. economy.

Figure 3: Policy functions and stationary distributions under the U.S. calibration.



How does the U.S. calibration affect the degree of state dependence of the spending multipliers? To answer this question, we again evaluate the net effects of a government spending shock conditional on positive and negative 3% productivity shocks. The responses obtained in each state are reported in Figure 4. These responses resemble those obtained under the European calibration: An increase in government spending raises aggregate demand and lowers unemployment. The job-finding probability increases and unemployment risk drops, which eventually crowds-in the consumption of unemployed households, thus fueling the rise in aggregate demand and further lowering unemployment. These effects are larger conditional on a recession than on an expansion. Quantitatively, the output multiplier is 0.73 in expansion and 0.80 in recession, a difference of 9.7%. This amount of state dependence, albeit smaller than under the European calibration is still non negligible.

Figure 4: Impulse responses to a 5% government spending shock. Net effect in recession and expansion. U.S. calibration.



Solid blue: conditional on an expansion. Dashed black: around steady state. Dotted red: conditional on a recession.

D An Extended Model

We propose an extension of the model that comes closer to replicating the distribution of assets and MPCs observed in the data. We introduce two additional sources of heterogeneity. First, we assume that there are patient households, with a discount factor $\rho_p < \rho$, and impatient households, with a discount factor $\rho_i > \rho$. Patient and impatient households represent roughly equal shares of the total population. In line with Krusell and Smith (1998), households can switch type with a very small probability, which helps preserve the equal split of the population into patient and impatient agents. This assumption generates a large density of households close to the zero-asset limit, many of which are impatient employed households. Second, instead of assuming that aggregate profits are distributed to employed households as in the baseline model, we posit that they are distributed to a third type of households: entrepreneurs. We introduce a very small probability p_{e^+} of becoming an entrepreneur and a small probability $p_{e^-} > p_{e^+}$ of losing this status. This implies a relatively low stationary share of entrepreneurs in the economy. Combined with the fact that they receive all the profits from retailers and intermediate-good producers, entrepreneurs are very rich in terms of per capita income compared with the other households. They are also large savers because of the small probability of losing the status, and the extremely small probability of ever becoming an entrepreneur again in the future, once this status is lost. This additional assumption stretches the distribution of asset holdings to the right — a small fraction of the population becomes asset-rich — and generates a fat right tail in the distribution of asset holdings. Formally, the household's budget constraint in the extended model is

$$a_t^i + c_t^i = (1 + r_{t-1})\, a_{t-1}^i + \left(1 - \mathbb{1}_{ent}^i\right) \left[(1-\tau_t)\left(\mathbb{1}_e^i w_t \ell_t + \left(1 - \mathbb{1}_e^i\right) h\overline{w}\right) - \mathbb{1}_e^i T_t^i\right] + \mathbb{1}_{ent}^i \Pi_t^i,$$

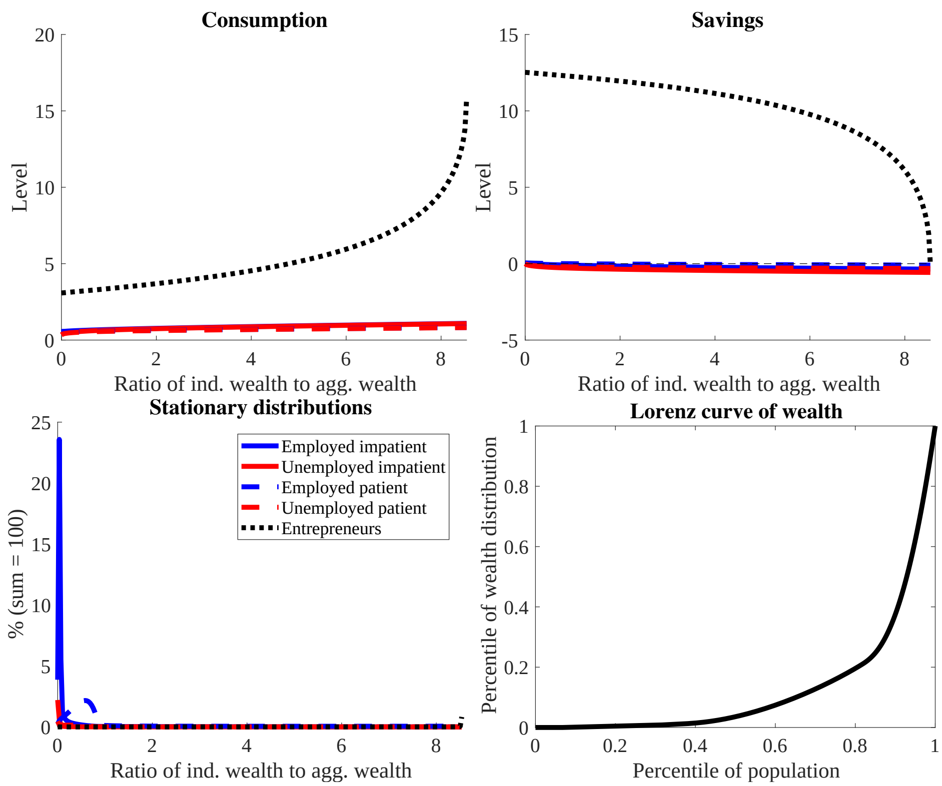
where $\mathbb{1}_e^i$ is an indicator function that takes the value of 1 if household i is employed and 0 otherwise, and $\mathbb{1}_{ent}^i$ an indicator function that takes the value 1 if household i is an entrepreneur and 0 otherwise. In the extended model, the transition matrix expands because we consider a total of 5 states: employed impatient, unemployed impatient, employed patient, unemployed patient and entrepreneur. Hence,

$$\Lambda_t = \begin{bmatrix} (1-p_{e^+})\, p_{oi}\,(1-s) & (1-p_{e^+})\, p_{oi} s & (1-p_{e^+})\,(1-p_{oi})\,(1-s) & (1-p_{e^+})\,(1-p_{oi})\, s & p_{e^+} \\ (1-p_{e^+})\, p_{oi} f_t & (1-p_{e^+})\, p_{oi}\,(1-f_t) & (1-p_{e^+})\,(1-p_{oi})\, f_t & (1-p_{e^+})\,(1-p_{oi})\, 1-f_t & p_{e^+} \\ (1-p_{e^+})\, p_{ni}\,(1-s) & (1-p_{e^+})\, p_{ni} s & (1-p_{e^+})\,(1-p_{ni})\,(1-s) & (1-p_{e^+})\,(1-p_{ni})\, s & p_{e^+} \\ (1-p_{e^+})\, p_{ni} f_t & (1-p_{e^+})\, p_{ni}\,(1-f_t) & (1-p_{e^+})\,(1-p_{ni})\, f_t & (1-p_{e^+})\,(1-p_{ni})\, 1-f_t & p_{e^+} \\ p_{e^-} p_{ni} & 0 & p_{e^-}\,(1-p_{ni}) & 0 & 1-p_{e^-} \end{bmatrix},$$

where p_{oi} is the (large) probability of staying impatient while p_{ni} is the (small) probability of becoming impatient. We assume that entrepreneurs become workers when losing their status. In addition, their discount factor is ρ, in-between the discount factor of patient and impatient households.

The rest of the model remains unchanged and the calibration is adapted when needed to deliver similar targets to those in the benchmark model. We add a couple of targets: a Gini coefficient on wealth of 0.75, the upper bound of the estimates available for European economies (see Carroll, Slacalek, and Tokuoka (2014)), and a share of entrepreneurs of 1%. The latter target is achieved by assuming $p_{e^+} = 0.001$ and $p_{e^-} = 0.05$, while we obtain the former by imposing $\rho_p = 0.0075$, $\rho_i = 0.015$, along with $p_{oi} = 0.995$ and $p_{ni} = 0.005$. The corresponding policy functions and stationary distributions are reported in Figure 5.

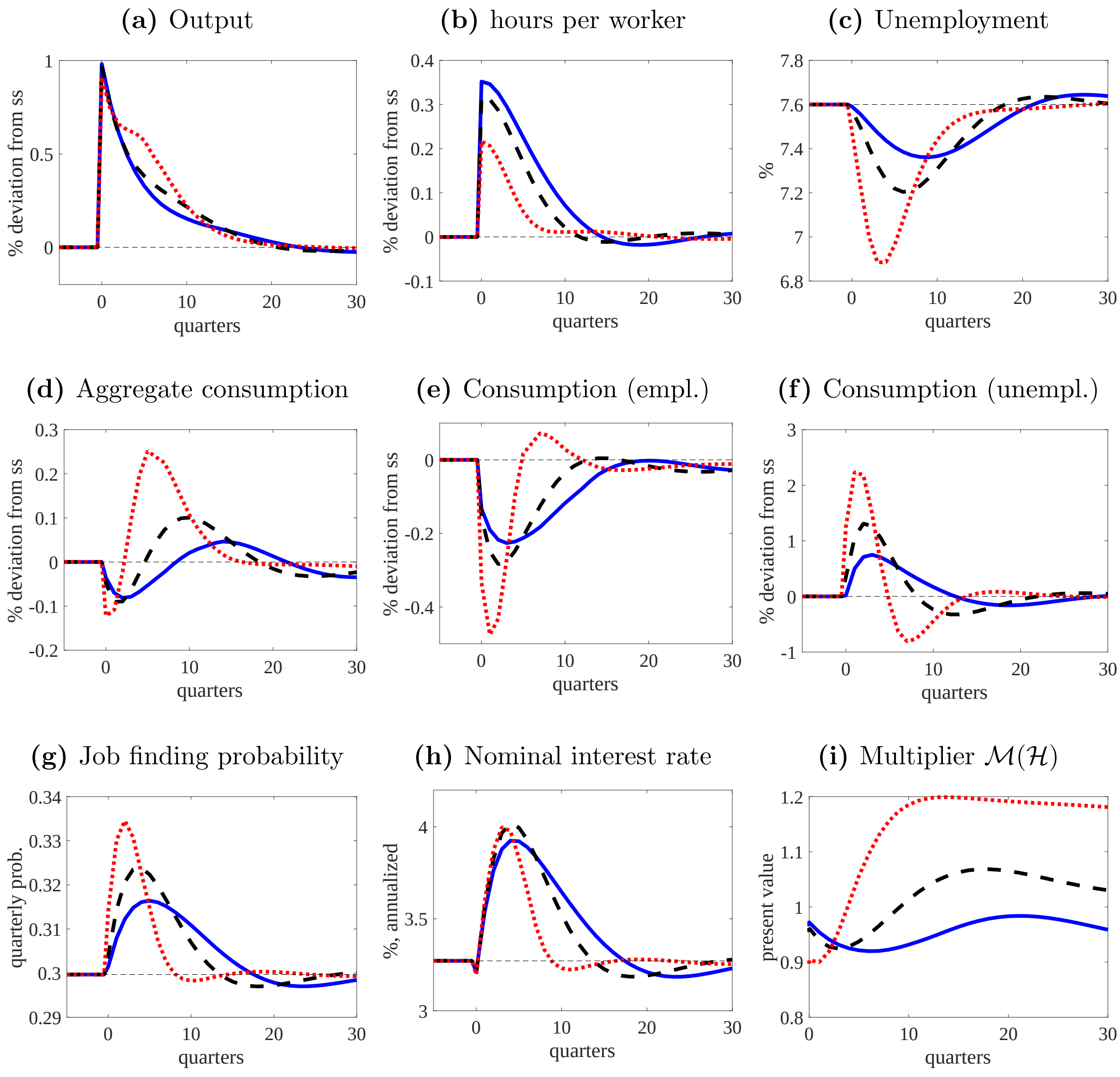
Figure 5: Steady-state distributions and policy functions in the extended model.



The model delivers a 0.7478 Gini coefficient on wealth, and the Lorenz curve for wealth reported in Figure 5. In addition, the distribution of MPCs is now more in line with empirical evidence, as the aggregate MPC is now 0.1973, the average MPCs for impatient and patient employed households are 0.2074 and 0.0556, respectively, and the average MPCs for impatient and patient unemployed households are 0.5679 and 0.4910, respectively. These numbers line-up quite well with those reported by Carroll, Slacalek, and Tokuoka (2014). Finally, we generate impulse responses based on a ±2% productivity shock — this extended model generates much larger variations of output for given values of the productivity shock — and report the net effects of a 5% government spending shock in Figure 6. For completeness, we also report the unconditional effects of the spending shock (i.e., occurring while the economy is initially is in the steady state).

Government spending shocks have very similar qualitative implications to those implied by the benchmark model, and their effects display an equally significant amount of state dependence, being larger in recession than in expansion. The output multiplier is 0.90 conditional on a 2% positive productivity shock (expansion) and 1.15 conditional on a 2% negative shock (recession), a difference of 27.1%.

Figure 6: Impulse responses to a 5% government spending shock in the extended model. Net effect in recession and expansion.



Solid blue: conditional on an expansion. Dashed black: around the steady state. Dotted red: conditional on a recession.

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