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 by more in the former case than in the latter, giving rise to countercyclical multipliers.

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

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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 (2012a,b), 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 lead to state dependence in the effects of government spending: unemployment risk and changes in the composition of aggregate consumption resulting from changes in the fraction of unemployed agents.

When insurance market 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

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[1]Examples include Bachmann and Sims (2012), Mittnik and Semmler (2012), Baum, Poplawski-Ribeiro, and Weber (2012), Candelon and Lieb (2013), Fazzari, Morley, and Panovska (2015), and Furceri and Li (2017). Owyang, Ramey, and Zubairy (2013) find some evidence of state dependence in Canada but not in the U.S.

[2]Numerous theoretical studies have shown that the size of 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 periods where the ZLB constraint in not binding (e.g., Eggertsson (2011), Woodford (2011), and Christiano, Eichenbaum, and Rebelo (2011)). While ZLB episodes are usually accompanied by severe recessions, the larger multipliers found at the ZLB 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), which implies that about two thirds of the spending multiplier at the ZLB is accounted for by the fact that hiring is easier in recession than in expansion. Albeit countercyclical, however, the multiplier 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.

capita consumption of unemployed and employed households remain unchanged. In this paper, we propose an heterogeneous-agent economy with involuntary unemployment and incomplete markets in which the interaction of these two ingredients leads to substantial asymmetry in the aggregate effects of government spending in recession and expansion, implying state-dependent spending multipliers.

We build on the model developed by Krusell, Mukoyama, and Şahin (2010), which we extend to allow for price and real wage rigidity, an intensive margin of labor adjustment, and nominal government debt, while abstracting from physical capital. Market incompleteness gives rise to a non-degenerate stationary distribution of households along the only asset that is available for self-insurance: one-period government bonds. 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 be more effective than in a flexible labor market.

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). By raising aggregate demand in an economy with nominal rigidity, higher public spending raises both employers' current and future profits and the rate at which those profits are discounted. The net effect, however, is an increase in the present discounted value of profits, which raises the marginal value of a filled position and leads firms to post more vacancies. As a result, unemployment falls, thus lowering precautionary saving while increasing 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. Under complete markets, the multiplier drops to 0.67, suggesting 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 adverse and favorable productivity shocks that occur while the economy is in the steady state. Positive realizations of the shock raise labor productivity by 1%, while negative realizations reduce it by the same percentage. Under our benchmark parameter values, the *conditional* output multiplier is 0.82 in expansion and 1.07 in recession — a difference of roughly 30%. 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 more volatile, 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 4% 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.

We also show that our main results are robust to two alternative set-ups: (*i*) one that fully accounts for the observed dispersion in the distribution of wealth by introducing heterogeneous discount factors for households and a third type of rich households with large asset detention, entrepreneurs, and (*ii*) another that accounts for a more flexible labor market such as the U.S., featuring less unemployment insurance but larger transition rates. While the quantitative amount of state dependence is somehow reduced in each set-up, multipliers are still larger in recessions than in expansions by 17-18%. The chief reason is that our results rely on the sensitivity of precautionary saving to changes in the job-finding probability, especially for the unemployed households who are characterized by larger marginal propensities to consume (MPCs).[4] This sensitivity can be large either because the level of precautionary savings is relatively low (for instance when unemployment is relatively well insured and unemployment spells are long, as in the calibration targeted to the European labor market) or because changes in the job-finding probability are large (as in the calibration targeted to the U.S. labor market).

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

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[4]This also explains that, even though fluctuations in unemployment after spending shocks might seem small, they are generated by sizable changes in the job-finding probability, which is the driving force of the precautionary saving motive.

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.[5] 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 idiosyncratic level of productivity but the endogenous employment status of households.[6] An advantage of the latter assumption is that the composition effect can be directly mapped into the relative fraction of unemployed households, which is readily observable in the data. More importantly, 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 60%.

Our paper is also related to the literature that evaluates the spending multiplier within two-agent New Keynesian (TANK) models, in which a constant fraction of households are hand-to-mouth, consuming their current disposable income at any point in time (e.g., Galí, López-Salido, and Vallés (2007) and Bilbiie (2008)). A typical prediction of TANK models is that the output multiplier increases with the fraction of hand-to-mouth households. Our framework models household heterogeneity in a more compelling way, allowing the fractions of low- and high-consumption agents to vary endogenously, and taking into account idiosyncratic income risk. The resulting transmission mechanism of government spending shocks is therefore entirely different from that embedded in TANK models.

The rest of the paper is structured as follows. Section 2 presents the model economy, describes the benchmark calibration and solution method, and discusses the steady-state distributions and policy functions. Section 3 discusses the average (unconditional) effects of government spending shocks both in the benchmark economy and in four counterfactual versions of the model, in which we (*i*) neutralize the composition effect, (*ii*) allow for complete insurance markets, (*iii*) abstract from the intensive margin of labor adjustment, and (*iv*) assume fully flexible prices. Section 4 discusses the state-dependent effects of government spending shocks in the benchmark economy and in each of the four counterfactual economies just described. It also studies the sensitivity of the results to perturbations in parameter values.

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[5]For instance, Bilbiie (2017), 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.

[6]In this sense, our model is closer to the recent contributions of Challe (2018), Gornemann, Kuester, and Nakajima (2016), and Ravn and Sterk (2016).

2   Model

The model builds on that developed by Krusell, Mukoyama, and Şahin (2010), with three key differences. First, we abstract from capital accumulation while introducing an intensive margin of labor adjustment (hours) in addition to the extensive margin (employment). Second, we assume that the only available asset is a one-period public bond, in positive net supply, through which the government is allowed to run budget deficits/surpluses over the business cycle and is therefore not tied by a balanced-budget requirement. Third, the model incorporates nominal (price) and real (wage) rigidities.

2.1   Households

The economy is populated with 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. Let $\mathcal{E}_t^i = \{e, u\}$ denote the set of possible employment statuses of household i, with e and u referring to, respectively, employment and unemployment. The welfare of household i is given by

$$\mathbb{E}_t \left\{ \sum_{s=t}^{\infty} \left(\frac{1}{1+\rho} \right)^{s-t} \left(\log \left(c_s^i \right) - \mathbb{1}_e^i \omega \frac{\ell_t^{1+\psi}}{1+\psi} - \left(1 - \mathbb{1}_e^i \right) \Phi \right) \right\}, \qquad \rho > 0, \psi > 0, \omega > 0, \quad (1)$$

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.[7] The budget constraint of household i writes

$$a_t^i + c_t^i = (1 + r_{t-1}) a_{t-1}^i + (1 - \tau_t) \left(\mathbb{1}_e^i w_t \ell_t + \left(1 - \mathbb{1}_e^i \right) h\overline{w} \right) + \mathbb{1}_e^i \left(\Pi_t^i - T_t^i \right), \quad (2)$$

where $a_t^i > 0$ is the household's aggregate wealth and r_{t-1} the risk-free 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 per-capita total profits from firms and T_t^i a per-capita lump-sum tax. Hours worked and the real wage are taken as given by households; their determination is discussed in the following sub-section. 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.

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[7]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.

We assume that the number of matches in the economy is determined randomly by the following matching function:

$$m_t = \chi \frac{u_t v_t}{(u_t^\alpha + v_t^\alpha)^{\frac{1}{\alpha}}}, \tag{3}$$

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 separation rate, s (constant and exogenous), 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 is $f_t = \chi \left(1 + \theta_t^{-\alpha}\right)^{-\frac{1}{\alpha}}$. 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). From the employers' perspective, the worker-finding (or vacancy filling) probability is $q_t \equiv m_t/v_t = \chi \left(1 + \theta_t^{\alpha}\right)^{-\frac{1}{\alpha}}$. The value of household i is therefore given by

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\begin{aligned}
W\left(a_t^i, \mathcal{E}_t^i\right) &= \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\} \\
&\quad \text{s.t.} \quad a_t^i + c_t^i = (1 + r_{t-1}) a_{t-1}^i + (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 \left(\Pi_t^i - T_t^i\right), \\
&\quad\quad\quad a_t^i > 0, \\
&\quad\quad\quad \Pr(\mathcal{E}_{t+1}^i | \mathcal{E}_t^i) \equiv \Lambda_t = \begin{bmatrix} 1-s & s \\ f_t & 1-f_t \end{bmatrix}.
\end{aligned}
$$

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 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. Each producer posts vacancies, out of which a fraction q_t will be filled in period t, accruing the total number of employed households. The cost of posting a vacancy is denoted by ξ. The intermediate good is produced using the following technology:

$$y_t^m = z_t \ell_t, \tag{4}$$

where z_t denotes productivity, and is sold to retailers at the (real) price p_t^m. Given that operational

profits are also taxed by the government at the rate τ_t, the marginal value of a filled position is[8]

$$J_t = p_t^m z_t \ell_t - w_t \ell_t + \mathbb{E}_t \left\{ \frac{1}{1 + r_t} \left((1 - s) J_{t+1} + s V_{t+1} \right) \right\}, \tag{5}$$

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. The latter is given by

$$V_t = -\xi + \mathbb{E}_t \left\{ \frac{1}{1 + r_t} \left((1 - q_t) V_t + q_t J_{t+1} \right) \right\}. \tag{6}$$

The free entry condition $V_t = 0$ holds, which implies that $\mathbb{E}_t \left\{ \frac{q_t J_{t+1}}{1 + r_t} \right\} = \xi$. The aggregate profits (net of vacancy-posting costs) made by intermediate-good producers are

$$\Pi_t^m = (1 - u_t) (p_t^m z_t - w_t) \ell_t - \xi v_t. \tag{7}$$

As is well known, the equilibrium real wage in not uniquely determined in models with search and matching frictions, 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:

$$w_t = \overline{w} z_t^\eta, \tag{8}$$

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 high, thus giving rise to real wage rigidity, the extent of which is inversely related to the value of η.[9]

We also assume that workers are represented by a union that determines the amount of hours worked by each employed household by equating the marginal rate of substitution between the

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[8]We assume that intermediate-good producers discount the future values of a position filled and of vacancies at the equilibrium real interest rate r_t and not at the subjective rate of the owners (employed households). Since the real rate is essentially driven by the saving behavior of firm owners, *i.e.* employed households, this approximation is innocuous.

[9]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

$$w_t = \arg\max (W_t^e - W_t^u)^\beta J_t^{1-\beta}, \tag{9}$$

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, and are available upon request.

average consumption of employed agents, c_t^e, and their hours worked to the after-tax real wage

$$\omega \ell_t^\psi c_t^e = (1 - \tau_t) w_t. \tag{10}$$

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

$$y_t(k) = y_t^m(k). \tag{11}$$

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 $y_t^d(k) = (P_t(k) / P_t)^{-\varepsilon} y_t^d$, with $\varepsilon > 1$ denoting the elasticity of substitution between varieties, and y_t^d denoting total demand for the final good. Adjusting prices by the retailers entails Rotemberg-type price-adjustment costs. Let $P_t(k)$ denote the nominal price set by retailer k, the latter maximizes the discounted sum of its expected dividends, given by[10]

$$\mathbb{E}_t \left\{ \sum_{s=t}^\infty \left(\frac{1}{1 + r_{s-1}} \right)^{s-t} \Pi_s^r \right\}, \tag{12}$$

where

$$\Pi_t^r = \left[\frac{P_t(k)}{P_t} - p_t^m - \frac{\varphi}{2} \left(\frac{P_t(k)}{P_{t-1}(k)} - 1 \right)^2 \right] y_t^d(k). \tag{13}$$

Assuming symmetry across retailers ($P_t(k) = P_t$ and $y_t^d(k) = y_t^d$), their optimal pricing condition is given by

$$\varepsilon - 1 = \varepsilon p_t^m - \varphi \left[\pi_t (1 + \pi_t) - \mathbb{E}_t \left(\frac{\pi_{t+1} (1 + \pi_{t+1}) y_{t+1}^d}{(1 + r_t) y_t^d} \right) \right], \tag{14}$$

where $\pi_t = P_t / P_{t-1} - 1$ is the inflation rate. Notice that $p^m = (\varepsilon - 1) / \varepsilon$ in the steady state, implying that monopolistic competition distorts the production of intermediate goods.

Finally, total profits are given by

$$\Pi_t = \Pi_t^m + \Pi_t^r = (1 - u_t) \left[\left(1 - \frac{\varphi}{2} \pi_t^2 \right) z_t \ell_t - w_t \ell_t \right] - \xi v_t, \tag{15}$$

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

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[10]Here too, we assume that future profits are discounted using the equilibrium real rate, and this assumption is innocuous.

2.3 Government, aggregation, and equilibrium

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

$$b_t = (1 + r_{t-1}) b_{t-1} + g_t + (1 - \tau) u_t h \overline{w} - \tau (1 - u_t) w_t \ell_t - T_t, \tag{16}$$

where

$$T_t = (1 - u_t) T_t^e, \tag{17}$$

with T_t^e denoting the per-capita lump-sum tax paid by each employed household. In addition, we assume that lump-sum taxes evolve according to

$$T_t = d_T \left(b_t - \overline{b} \right), \tag{18}$$

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

The central bank sets the nominal interest rate, i_t, according to the following simple rule:

$$i_t = \overline{r} + \overline{\pi} + d_\pi (\pi_t - \overline{\pi}), \tag{19}$$

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

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

$$b_t = \sum_i \Omega_t^{e,i} a_t^i + \sum_i \Omega_t^{u,i} a_t^i, \tag{20}$$

$$y_t = (1 - u_t) z_t \ell_t \left(1 - \frac{\varphi}{2} \pi_t^2 \right) - \xi v_t$$

$$= \sum_i \Omega_t^{e,i} c_t^{e,i} + \sum_i \Omega_t^{u,i} c_t^{u,i} + g_t. \tag{21}$$

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. Notice that our measure of aggregate output, y_t, is net of price-adjustment and vacancy costs. Due to Walras' law, the last equilibrium condition is redundant.

2.4 Shocks

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

$$\ln g_t = (1 - \rho_g) \ln g + \rho_g \ln g_{t-1} + \epsilon_t^g, \tag{22}$$

$$\ln z_t = (1 - \rho_z) \ln z + \rho_z \ln z_{t-1} + \epsilon_t^z. \tag{23}$$

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

2.5 Calibration

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.

Preferences and production. We impose a subjective interest 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 3.69% 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. Following Kaplan, Moll, and Violante (2018), we set the elasticity of substitution between the differentiated varieties to $\varepsilon = 10$, implying a steady-state mark-up of 11.11%. The price-adjustment-cost parameter is set to $\varphi = 60$, a conventionally accepted value.

Labor market. We seek to replicate key characteristics of the European labor market. We set the matching-curvature parameter to $\alpha = 1.25$ as in Petrosky-Nadeau and Zhang (2013). The quarterly separation rate is set to $s = 0.025$, which is consistent with 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 8%, in line with the average of natural unemployment rates in European countries over the last few years. Given the value of the separation rate, this target is consistent with a steady-state quarterly job-finding probability of 0.2875, or 0.08125 on a monthly basis, close to the numbers found by Elsby, Hobijn, and Şahin (2013).[11] We set the worker-finding probability to $q = 0.7$ following den Haan, Ramey, and Watson (2000) and Ravenna and Walsh (2008). Accordingly, the matching-efficiency parameter and unit vacancy cost are set to, respectively, $\chi = 0.8787$ and $\xi = 0.4524\overline{w}$. Although the cost per vacancy is somewhat larger than what Hagedorn and Manovskii (2008) suggest for the U.S., the total steady-state vacancy costs, $\xi\overline{w}v$, represent 1.44% of GDP, which remains within the range of values used in the literature. The baseline replacement rate is set to $h = 0.6$, in line with the relatively high replacement rates

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[11]These transition probabilities are almost exactly those reported for France.

prevailing in European countries (see, for instance, Esser, Ferrarini, Nelson, Palme, and Sjüberg (2013)). 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 that negotiates based on the average value functions of employed and unemployed agents (see Footnote 6). Calibrating the union's bargaining power to $\beta = 0.75$, we obtain $\overline{w} = 0.8797$. Finally, following Gornemann, Kuester, and Nakajima (2016), we set the elasticity η to 0.45.

Government, central bank and shocks. 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-output ratio ($b/(4y) = 0.6$), which implies $\tau = 0.2891$. 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 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.

Table 1: Parameter values

Subjective interest rate	$\rho = 0.01$
Steady-state quarterly real interest rate	$r = 0.9116\%$
Frisch elasticity of labor supply	$1/\psi = 1$
Labor disutility parameter	ω adjusted to get $\ell = 1$
Steady-state mark-up	$(\varepsilon - 1)^{-1} = 0.1111$
Rotemberg price adjustment cost	$\varphi = 60$
Separation rate	$s = 0.025$
Job-finding rate	$f = 0.2875$
Worker-finding rate	$q = 0.7$
Matching curvature	$\alpha = 1.25$
Wage elasticity w.r.t to labor productivity	$\eta = 0.45$
Matching efficiency	$\chi = 0.8787$
Unit vacancy posting cost	$\xi = 0.4524\overline{w}$
Replacement rate	$h = 0.6$
Labor income tax rate	$\tau = 0.2891$
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	$\rho_z = 0.9$

2.6 Solution method

The model is solved in two separate steps. The first step solves the steady state, including the stationary distribution of asset holdings and the policy functions over an asset grid. The second step solves the transition dynamics after stationary shocks around the steady state using a non-linear algorithm. The details of both steps are given in the Appendix but the main idea is to rewrite the optimizing conditions (especially the value functions of households) in continuous time to solve the corresponding Hamilton-Jacobi-Bellman equation that describes the households' problem for a given level (for the steady state) or path (for the transition dynamics) of the real interest rate and of the tightness ratio over a given asset grid. Once asset holdings and policy functions are derived, solving the Kolmogorov forward equation gives the corresponding distribution of households over the asset grid. We use 250 grid points and a linear grid. Taking advantage of the continuous-time formulation of the problem is in direct relation with the recent breakthrough in heterogeneous-agent models exemplified by the work of Kaplan, Moll, and Violante (2018).
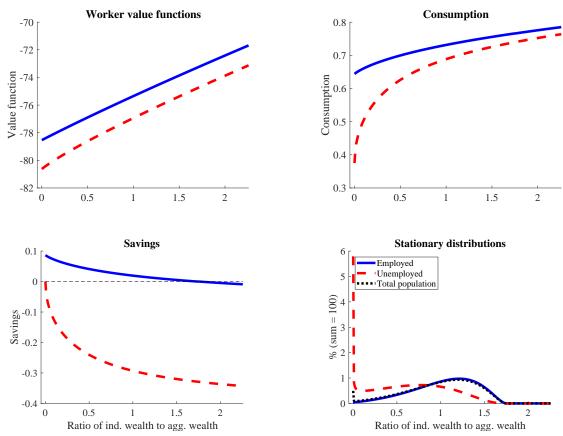
2.7 Steady-state distributions, policy functions and MPCs

Figure 1 plots the steady-state distributions and policy functions over the asset grid. It shows that the worker value function is increasing in the level of asset holdings regardless of her employment status, and that, as expected, the value of being unemployed is always below the value of being employed. The consumption functions are increasing in the level of assets held, but more strongly so 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. When holding more assets, employed households save relatively less because their asset level already provides insurance against potential unemployment spells. Unemployed households, on the contrary, always feature negative saving: consumption smoothing when unemployed requires using savings to sustain consumption. The size of this consumption-smoothing motive increases with the level of assets: unemployed households holding more assets were previously employed and quite wealthy, and used them to sustain large levels of consumption, which they want to preserve as much as possible when unemployed. This explains why unemployed households have large negative savings at high levels of assets.
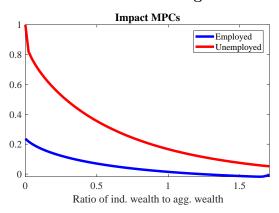
The marginal distributions of employed and unemployed households on the asset grid show that most employed households are willing to hold large levels of assets to self-insure against unemployment risk. In addition, unemployed households that experience long unemployment spells become constrained and end-up holding zero assets. Their proportion is slightly less than 6% of unemployed households, which is not surprising given the transition matrix featuring a relatively low job-finding probability.
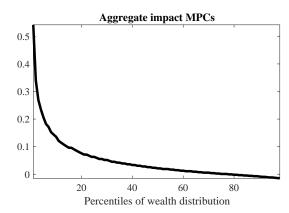
Figure 1: Steady-state distributions and policy functions.

What does our model predict in terms of marginal propensities to consume (MPCs)? To answer this question, we proceed to the following experiment. We feed the model with a persistent transfer shock that increases the income of all households by a lump-sum amount. The transfer is financed mostly by debt in the first periods and then eventually by an increase of the lump-sum taxes paid by the employed households. We set the persistence of the shock at 0.9, and consider a shock that represents between 7.2% of the average income of households, roughly 740 euros when converted using the value of GDP per capita in the euro area in 2018. Since the tax rule responds very little on impact, tracking the distribution of the impact consumption responses of employed and unemployed provides a reliable estimation of the distribution of MPCs. The left panel of Figure 2 below reports the values of MPCs for employed and unemployed for different ratios of individual to aggregate wealth, and the right panel reports the distribution of aggregate MPCs for the different wealth percentiles, to ease the comparison with existing studies.

Figure 2: MPCs to a transfer shock.

The left panel of Figure 2 shows that the distribution of MPCs is very consistent with the shape of policy functions. Households with zero asset holdings increase their consumption one for one with the transfer shock, and unemployed households respond more than employed households, whatever their stationary level of asset holdings. However, given the stationary distributions reported in Figure 1, the mass of unemployed households as a percentage of the total population is relatively small, which, by a composition effect, yields the distribution of the aggregate MPCs reported on the right panel of Figure 2. Aggregate MPCs are relatively high (around 0.55) for the lowest percentiles of the distribution of households, but fall to roughly 0.15 at the 10th percentile and slightly below 0.1 at the 20th percentile. Nevertheless, this graph is remarkably similar to Figure 1 reported by Luetticke (2019) while we do not consider participation shocks to generate a large fraction of wealth hand-to-mouth households. It is also consistent with a much higher MPC for unemployed households, as in the data (see Carroll, Slacalek, and Tokuoka (2014)). However, this simple model is proposed to highlight a mechanism by which state dependent effects of fiscal policy

may arise, not to match the whole distribution of asset holding and MPCs. An extension of the simple model is proposed in Appendix B, that replicates these distributions in a more satisfactory way. The extended model also features a large amount of state dependence, based on the same building blocks as in the simple model, which is why we focus on the later rather than on the former in the rest of the paper.

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. We first present the results based on the benchmark model described above before turning to counterfactual economies in which some of our modeling assumptions are relaxed one at a time. The dynamic effects of a government spending shock are illustrated by means of impulse response functions. Following common practice in the literature, we quantify the effects of the spending shock 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 of changes in government spending over the same horizon

$$\mathcal{M}(\mathcal{H}) = \frac{\mathbb{E}_t \sum_{j=0}^{\mathcal{H}} \prod_{i=0}^{j} (1 + r_{t+i})^{-1} (x_{t+j} - x)}{\mathbb{E}_t \sum_{j=0}^{\mathcal{H}} \prod_{i=0}^{j} (1 + r_{t+i})^{-1} (g_{t+j} - g)}, \tag{24}$$

where r_t is the time-varying real interest rate implied by the model. Throughout the paper, we focus on $\mathcal{M}(\mathcal{H} \to \infty)$. The present-value output multiplier is reported in Table 2.

3.1   Benchmark economy

Figure 3 depicts the impulse responses of key variables to a 1% increase in government spending relative to its steady-state level. 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 (5) 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' current and future profits will also

increase.[12] 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).

Figure 3: Impulse responses to a 1% government spending shock around the steady state.

(a) Output

(b) Hours worked

(c) Unemployment

(d) Aggregate consumption

(e) Consumption (empl.)

(f) Consumption (unempl.)

(g) Job finding probability

(h) Real interest rate

(i) Debt to GDP

The increase in public spending gives rise to a negative wealth effect for employed households

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[12]This result still holds when we assume that the real wage is governed by a Nash-bargaining mechanism, such as that described in Footnote 4. 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.

— due to the implied hike in current and 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 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 initially falls, but to a much lesser extent than that of employed households. It then increases significantly and persistently, converging to its steady-state level from above. This (delayed) 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 — 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).

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 those 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.

Table 2: Unconditional output multipliers.

	Present-value multiplier
Benchmark economy	0.8603
Variants	
No composition effect	0.8246
Complete markets	0.6723
No intensive margin	0.3268
Flexible prices	0.6843

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

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. The dynamic responses of output and unemployment implied by these versions are shown in Figures 4 to 7 (where we superimpose on the counterfactual responses those obtained from the benchmark economy), and the corresponding present-value output multipliers are reported in Table 2.
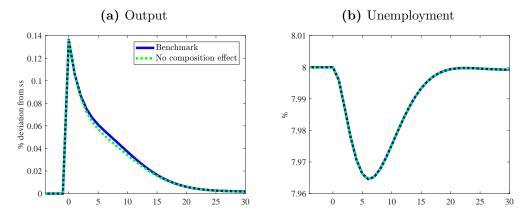
Consider first an economy that is identical to our benchmark in every respect except for the way aggregate output is computed. The latter is evaluated using the steady-state fractions of employed and unemployed households, thus neutralizing the composition effect on aggregate consumption stemming from changes in the unemployment rate.[13] The output multiplier obtained in this case (0.82) 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.[14] 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. Because there is no need for precautionary saving under complete markets, consumption is more crowded out by the increase in public spending

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[13]It should be emphasized, however, that this experiment does not fully shut down the general-equilibrium effects of the change in the relative fraction of unemployed agents in total population. The experiment therefore underestimates the contribution of the composition channel to the output multiplier.

[14]In solving the complete-market model, we adjust the vacancy cost parameter, ξ, to deliver the same labor-market targets as in our benchmark economy.
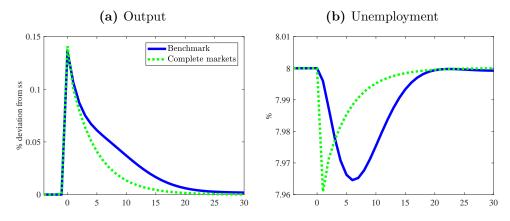
Figure 4: Impulse responses to a 1% government spending shock: Benchmark vs. no composition effect.

(a) Output

(b) Unemployment

than in the benchmark economy. In this case, the multiplier is equal to 0.67, suggesting that the government's ability to alleviate unemployment risk through higher public spending amplifies the present-value multiplier by roughly 30%.
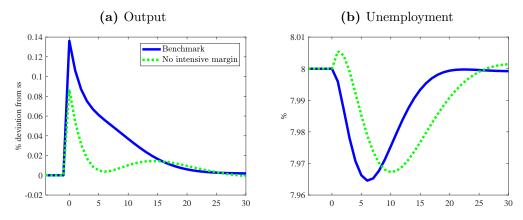
By inspecting Figure (5), one can see that output rises initially less in the benchmark economy than under complete markets, reflecting the fact that the intertemporal-substitution channel is weaker in the former case than in the latter (see Hagedorn, Manovskii, and Mitman (2019)). However, because the consumption adjustment is more gradual in the benchmark economy, it leads to a more persistent increase in aggregate demand and thus a more persistent decline in unemployment, which in turn further mitigates the crowding-out of consumption (even leading to crowding-in) at longer horizons by reducing unemployment risk. As a result, the increase in aggregate output is larger and more persistent in the benchmark economy than when markets are complete, thus accounting for the difference in the output multiplier across the two economies.

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

(a) Output
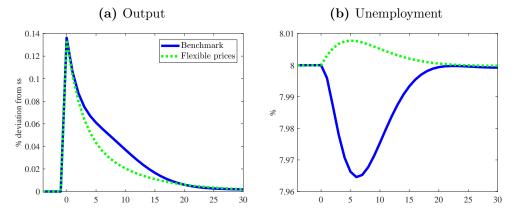
(b) Unemployment

In the third variant, we shut down the intensive margin of labor adjustment, as in the vast majority of existing models of involuntary unemployment, such that as aggregate output can only

increase through the entry of new firms — recall that each firm is a job. To do so, we assume that hours worked remain equal to their steady-state level in response to shocks. Because the adjustment of hours worked is inhibited, the undiscounted-profit effect is smaller than in the benchmark economy, and is in fact dominated by the discounting effect at the time of the shock, leading to a temporary fall in the value of a filled a job and thus to a temporary increase in unemployment. Eventually, unemployment declines under constant hours worked, even more than in the case with an elastic supply of hours, at some horizons. However, this effect 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 (0.33). This exercise highlights the critical importance of considering both the extensive and the intensive margins of labor adjustment to generate empirically plausible spending multipliers.

Figure 6: Impulse responses to a 1% government spending shock: Benchmark vs. no intensive margin.

(a) Output   **(b)** Unemployment

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, implying $p_t^m = p^m$. 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 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 0.68.

Figure 7: Impulse responses to a 1% government spending shock: Benchmark vs. flexible prices.

(a) Output

(b) Unemployment

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 8 shows the economy's response to negative and positive shocks to labor productivity, z_t. The shocks are calibrated to $\pm 1\%$.

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 2 percentage points relative to 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). 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).

The negative productivity shock lowers aggregate output, consumption, and the real wage, but raises the supply of hours worked. At the trough, aggregate output falls by approximately 1.3%, which suggests that the scenario under consideration captures typical recessions experienced by actual economies. Again, the precautionary motive drives the dynamics of the (per-capita)

Figure 8: Impulse responses to productivity shocks.

(a) Output

(b) Hours worked

(c) Unemployment

(d) Aggregate consumption

(e) Consumption (empl.)

(f) Consumption (unempl.)

(g) Job finding probability

(h) Real interest rate

(i) Debt to GDP ratio

Solid black: 1% positive shock. Solid blue: 1% negative shock.
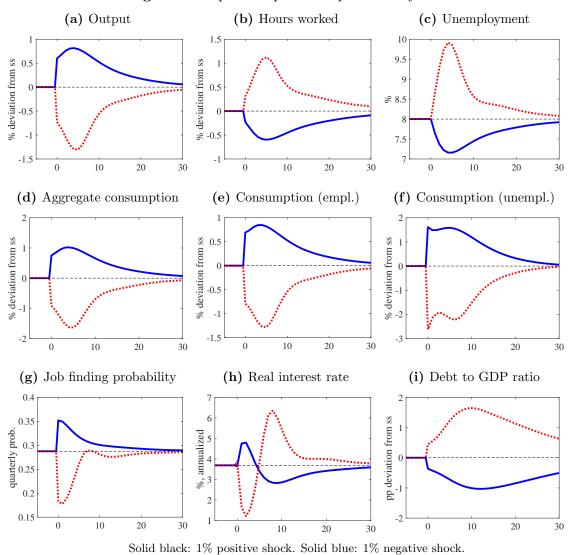
consumption of unemployed households: the perspective of longer unemployment spells leads them to consume much less and to save more. During the quarters following the shock, the fall in the consumption of unemployed households is more than twice larger than the fall in the consumption of employed households. The resulting decline in aggregate consumption is significantly larger than that predicted by a model with perfect insurance, amounting to roughly 1.65% of its steady-state value at the trough.

A positive productivity shock produces the opposite effects: output, consumption, the real wage, and posted vacancies rise, while hours worked and the unemployment rate both fall. Quantitatively, however, 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-size) adverse shock. For instance, while output falls by 1.3% (at the trough) relative to its steady-state level in response to the negative productivity shock, it only rises by roughly 0.8% (at the peak) following the positive shock. The asymmetry is even more striking in the response of the unemployment rate, which increases by more than 1.9 percentage points (at the peak) in response to the negative productivity shock but falls by only 0.8 percentage points (at the peak) after the favorable shock. To the extent that negative productivity shocks are not systematically larger than positive shocks in the data, our model predictions are consistent with the empirical observation that recessions are larger and more persistent than expansions (see, for example, Galí, Gertler, and López-Salido (2007) and Petrosky-Nadeau and Zhang (2013)).

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.[15] Second, the concavity of the job-finding probability (and hence employment) with respect to labor-market tightness (recall that $f_t = \chi \left(1 + \theta_t^{-\alpha}\right)^{-\frac{1}{\alpha}}$) signifies that unemployment falls by less when the labor market tightens than it rises when the market becomes slack, for a given (absolute value of the) change in the degree of market tightness.[16] Under incomplete insurance markets, these two properties imply that precautionary saving and the fraction of low-consumption agents in total population decline by more following an adverse shock than they rise following a favorable shock of the same size, further exacerbating the asymmetry in the economy's response to positive and

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[15]To see this, notice that unemployment evolves according to

$$u_{t+1} = s(1 - u_t) + (1 - f_t)u_t.$$

Thus, the effect of a fall in f_t on u_{t+2} is amplified by the fact that u_{t+1} rises in recession (u_t is predetermined), whereas the effect of an increase in f_t on u_{t+2} is offset by the fact that u_{t+1} falls in expansion.

[16]On the other hand, the fact that the matching function exhibits decreasing marginal returns to vacancies implies that, *ceteris paribus*, labor market tightness increases by more in response to positive productivity shocks than it falls in response to adverse shocks (see Hairault, Langot, and Osotimehin (2010) for further discussion). Nonetheless, in general equilibrium, the job-finding probability falls by more in recession than it increases in expansion.

negative productivity shocks.

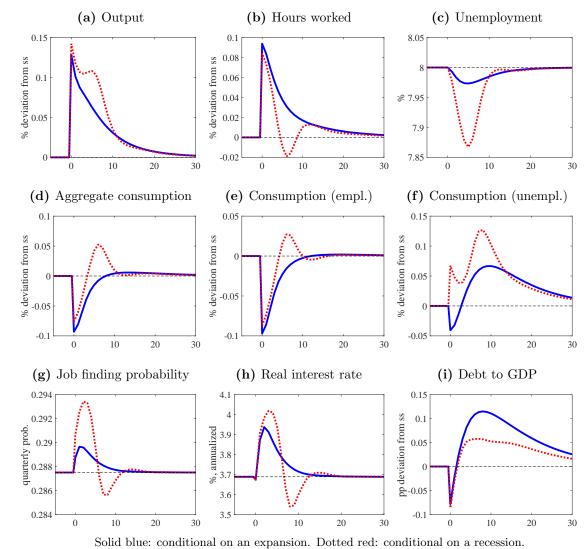## 4.2 The effects of government spending in recessions and expansions

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. Figure 9 shows the effects of a 1% increase in government spending conditional on a positive and a negative productivity shock of equal size, identical to those considered in the previous section (±1%).

Figure 9 shows that the response of aggregate output to the spending shock is larger in recession than in expansion. The present-value output multiplier is 0.82 in the latter case and 1.07 in the former (see the first row of Table 3). The difference of 30% 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.[17] 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 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.

The arguments just discussed suggest that the aggregate effects of public spending are not just asymmetric in good and bad times but that they are also more highly non-linear in the size of recessions than in the size of expansions. 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 −1.15% to 1.15%. The results are depicted in Figure 10. The number obtained when the value of the productivity shock is nil is simply the unconditional multiplier. For output,

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[17]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.

Figure 9: Impulse responses to a 1% government spending shock. Net effect in recession and expansion.

(a) Output

(b) Hours worked

(c) Unemployment

(d) Aggregate consumption

(e) Consumption (empl.)

(f) Consumption (unempl.)

(g) Job finding probability

(h) Real interest rate

(i) Debt to GDP

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

this would be the value reported in the first row of Table 2.

Table 3: State-dependent output multipliers.

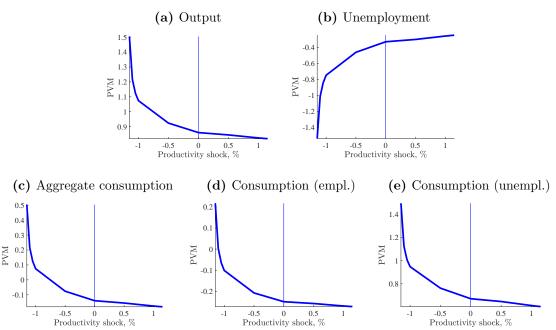|	Present-value multiplier		
	Expansion	Recession	Difference
Benchmark economy	0.8249	1.0738	30.18%
Variants			
No composition effect	0.8016	0.9826	22.58%
Complete markets	0.6612	0.6860	3.76%
No intensive margin	0.2842	0.4698	65.26%
Flexible prices	0.6961	0.6658	−4.35%

Note: Expansions (resp. recessions) are generated by assuming that the economy is hit by a 1% positive (resp. negative) productivity shock, except for the case with no intensive margin, in which the size of the productivity shock is reduced to ±0.5%.

Figure 10 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 flips sign when the economy is in a sufficiently severe recession. Together, these two observations imply that the aggregate consumption multiplier can be positive even for relatively mild recessions. In our economy, this is the case as long as the recession is caused by an initial decline in productivity that exceeds 0.85%.

Figure 10 also shows that the spending multipliers are decreasing (in absolute value) 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 more volatile, exhibiting higher peaks and deeper troughs. For instance, the present-value output multiplier surges from 0.82 when it is conditional on a 1.15% positive productivity shock to 1.5 when it is conditional on an equal-size negative productivity shock, an amplification of more than 80%.

Table 3 also shows the output multipliers in recession and expansion obtained from the counterfactual economies discussed in Section 3.2. The size of productivity shocks is the same as in the benchmark economy, except for the model without an intensive margin, in which the size of the shock had to be reduced for our numerical algorithm to converge. Not surprisingly, the spending multipliers in the counterfactual economies are smaller than the benchmark values regardless of whether the economy is in recession or expansion. Relative to the benchmark economy, neutralizing the composition effect only marginally lowers the multiplier conditional on an expansion

Figure 10: Present-value multipliers conditional on productivity shocks

(a) Output

(b) Unemployment

(c) Aggregate consumption

(d) Consumption (empl.)

(e) Consumption (unempl.)

Notes: Present-value multiplier are computed according to Equation 24 with x_t being the variable of interest. The productivity shock ranges from -0.0115 to 0.0115.

(from 0.82 to 0.80) but significantly reduces the multiplier conditional on a recession (from 1.07 to 0.98). Nonetheless, this economy generates a state dependence of roughly 23%, which highlights the importance of the precautionary-saving channel in accounting for the countercyclicality of the spending multiplier. This conclusion is further supported by the fact that the economy with complete insurance markets generates little difference in the multiplier between recessions and expansions (only 4%).

When we abstract from the intensive margin of labor adjustment, the output multiplier in recession is 65% larger than the value obtained in expansion. This is due to the fact that, with constant hours of work, all the necessary adjustment in employment (and the implied effect on unemployment risk) occurs through the extensive margin, and that the latter is highly asymmetric due to the concavity of employment with respect to market tightness. Note, however, that while the difference in the multiplier is large in relative terms, the size of the multiplier in this economy remains small, even during recessions. 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.
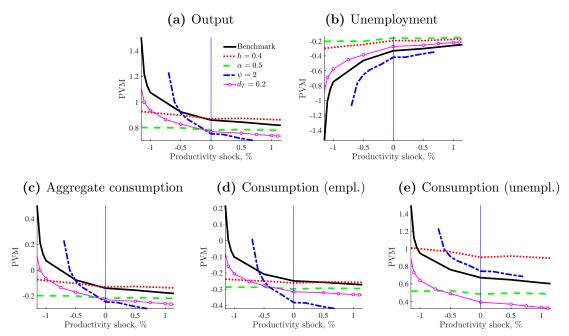
4.3 Sensitivity analysis

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; and the tax-feedback parameter, d_T. 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 11. Second, we calibrate the model to represent the U.S. labor market.

4.3.1 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. A lower replacement rate has two effects. First, it exacerbates income losses during unemployment spells, which strengthens the precautionary-saving motive. To the extent that an increase in government spending reduces unemployment, a lower replacement rate will lead to a smaller fall in the per capita consumption of unemployed households and thus to a larger spending multiplier. Second, it increases the steady-state value of a match, which leads to a larger adjusted value of the vacancy posting cost, from $\xi = 0.4524\overline{w}$ to $\xi = 0.6831\overline{w}$. As a result, the job-creation condition makes it apparent that fluctuations in unemployment become smaller whatever the source of the shock. In particular, the fall in unemployment after an increase in government spending becomes smaller (as in Monacelli, Perotti, and Trigari (2010)). This in turn translates into a smaller output multiplier. During expansions and relatively benign recessions, the first effect dominates, such that a lower replacement rate raises the spending multiplier. For deeper 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 generate milder fluctuations in employment and output also in response to productivity shocks, and those effects are highly convex. Together, these results imply that the extent of state dependence falls with the replacement rate. Figure 11 shows that when $h = 0.4$, the difference in the spending multipliers between recessions and expansions is negligible.

Next, we lower the matching-curvature parameter, α, from its benchmark value of 1.25 to a value of 0.5. As shown in Figure 11, 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 essentially insensitive to the size of recessions/expansions. The reason is that the job-finding probability becomes nearly linear with respect to the labor-market tightness. In our model, the concavity of the job-finding probability plays a key

Figure 11: Sensitivity analysis: Conditional present-value multipliers under alternative parameter values.

(a) Output   **(b)** Unemployment

(c) Aggregate consumption   **(d)** Consumption (empl.)   **(e)** Consumption (unempl.)

Note: Present-value multipliers are computed according to Equation 24 with x_t being the variable of interest.

role in generating asymmetric changes in unemployment, which translate into asymmetries in precautionary saving and in the composition effect. With a nearly linear job-finding probability, these asymmetries essentially vanish. This suggests that search and matching frictions are a prerequisite to generate countercyclical spending multipliers in our economy, though they are not sufficient *per se*, as shown by our results for the incomplete-market economy. Only when those frictions are combined with incomplete insurance markets do they give rise to sizable state dependence in the spending multiplier.

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. 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 benign 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.

Finally, 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
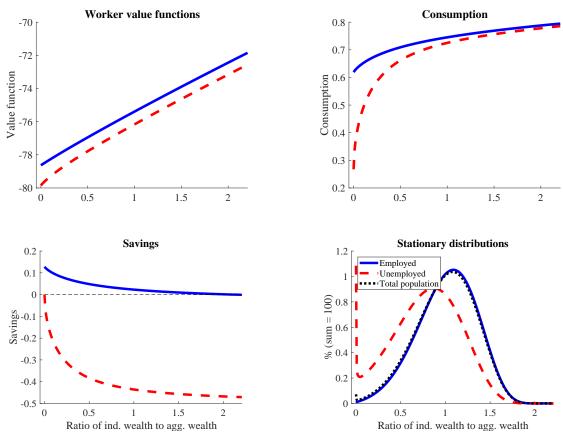
the real interest rate and exacerbates the fall in the consumption of employed households at short horizons. Because the present-value multiplier assigns a larger weight to changes in aggregate variables that occur in the near future, it will tend to decrease (in absolute value) as d_T rises. This outcome 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 shift downward (upward for unemployment) compared to the benchmark economy, which is exactly what Figure 11 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.

4.3.2 Calibrating the model to the U.S. labor market

One might wonder whether the effects highlighted in Section 4.2 are specific to the European countries, characterized by a sclerotic labor market, or if they also apply to the U.S. economy. In particular, we have shown that state-dependence was very low when we lower the replacement rate of unemployment benefits to $h = 0.4$, a number that is arguably closer to the U.S. employment insurance system. However, the U.S. labor market is not only characterized by a lower replacement rate, but also features much larger separation and job-finding rates, *i.e.* larger labor-market turnover. As such, a version of the model calibrated to the U.S. economy is likely to be characterized by a quite different stationary distribution of asset holding, given that the transition matrix Λ_t will feature substantially larger transition rates. In particular, the combination of a relatively high replacement rate and low job-finding/separation rates in the European calibration led to great differences between employed and unemployed households. Employed households held large amounts of precautionary savings while unemployed households held relatively low precautionary stocks. This led precautionary savings, especially those of unemployed households, to be much more sensitive to cyclical fluctuations, producing large levels of state dependence. So what does the model predict for a U.S. calibration on the labor market? We set the replacement rate to $h = 0.4$ and impose a separation rate of $s = 0.05$ — twice the European separation rate, along with a targeted unemployment rate of $u = 0.059$, which yields a job-finding probability $f \simeq 0.8$ — almost four times the European job-finding probability. These numbers are almost identical to those used by Challe (2018), who targets the U.S. labor market in a quarterly set-up. Keeping other parameters unchanged, we obtain the following policy functions and stationary distributions reported in Figure 12.

Two important differences emerge with a U.S. calibration compared to the European calibration. First, the high transition rates produce stationary distributions of asset holdings that are much more similar for employed and unemployed households. The stationary distributions show that a much smaller number of unemployed households hold zero assets: since unemployment spells are much shorter, unemployed households get to keep a more sizable fraction of the (precautionary) asset

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Figure 12: Steady-state distributions and policy functions for the U.S. calibration.
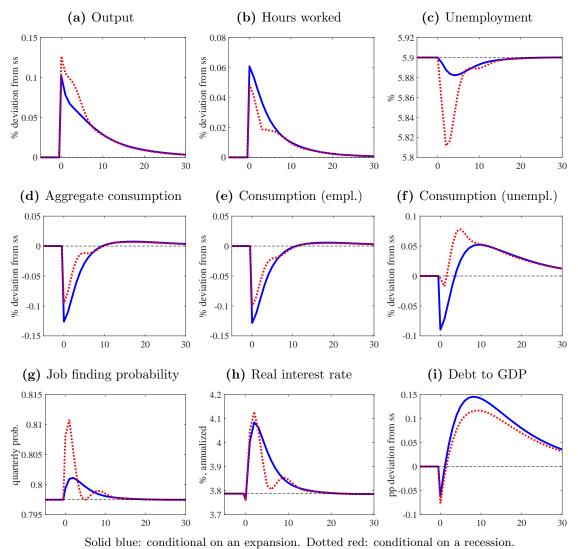
holdings they accumulated in the past, when they were employed. In addition, employed households accumulate less assets to self-insure against unemployment risk, since the large transition rates make the risk less costly, even though the income loss associated with unemployment spells is larger than under the European calibration. Second, looking at policy function suggests that consumption increases more steeply at low levels of asset holdings than under the European calibration, especially for unemployed households. This is consistent with the fact that unemployed households in the U.S. calibration are poorer and hence face a large marginal utility of consumption at low levels of assets. It is also consistent with the fact that those unemployed households save more at low levels of assets because they know that unemployment spells are shorter than in the European calibration. These two features have opposite effects on the distribution of MPCs. On the one hand, the fact that less unemployed households hold little assets lowers the aggregate MPC of unemployed households. On the other hand, the steeper consumption function at low levels of assets raise the MPC of unemployed households holding small amounts of assets, which raises the aggregate MPC of the fraction of the population. How do these features of the model under a U.S. calibration affect the degree of state dependence of spending multipliers? For the above calibration, we consider the net effects of a government spending shock conditional on a 1% positive or negative productivity shock, and obtain the responses reported in Figure 13.

In line with the results featured in the previous sections, Figure 13 shows that a government spending shock raises aggregate demand and lowers unemployment. The job-finding probability increases and unemployment risk drops, which eventually crowds-in the consumption of unemployed households. As for the calibration to European labor markets, these effects are larger conditional on a recession than conditional on an expansion, which leads to larger reductions in precautionary savings for both types of households. On impact, the consumption of unemployed increases and the consumption of employed households falls less when the spending shock hits in a recession than when the shock hits in an expansion. Overall, the multiplier displays a substantial amount of state dependence: the multiplier is 0.7325 conditional on an expansion and 0.8642 conditional on a recession, a difference of almost 18%. While these numbers show slightly less state dependence than for the calibration to European labor markets, it is still quite substantial.

5 Concluding Remarks

In this paper, we have developed a model with involuntary unemployment, incomplete markets and nominal 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

Figure 13: Impulse responses to a 1% government spending shock. Net effect in recession and expansion. U.S. calibration.

(a) Output

(b) Hours worked

(c) Unemployment

(d) Aggregate consumption

(e) Consumption (empl.)

(f) Consumption (unempl.)

(g) Job finding probability

(h) Real interest rate

(i) Debt to GDP

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

effects are state dependent, with 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, such that household heterogeneity is materially irrelevant for aggregate consumption and output. 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.

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Appendix

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. Starting from initial guesses for the real interest rate, r, labor market tightness, θ, and the real wage, w:

1. Compute labor market variables $\{f, q, u, v\}$

2. Compute output y, deduce government spending g and public debt b using calibration targets, and compute the tax rate τ

3. Compute profits and deduce the levels of income for employed and unemployed households

4. At the given levels of income and real interest rate:

   - Solve the Hamilton-Jacobi-Bellman equation
   - Solve the marginal value of a job J
   - Solve the steady-state Nash-bargaining problem and get w
   - Adjust the value of ω, the disutility parameter associated to hours worked. Hours worked are normalized to one ($\ell = 1$) in the steady state.
   - Update the set of value functions W, J and w

5. Solve the Kolmogorov forward equation to recover the distributions of households over the asset grid

6. Check residuals on free entry and goods market clearing conditions

7. Update r and θ respectively using the residuals of the asset market clearing condition, and those of the free entry condition.

Solving for the steady state takes a few seconds. Before computing the steady state, a similar routine solves for the value of ξ that delivers our calibration targets on the labor market. Then the above routine solves for the steady state for the correctly calibrated value of ξ.

A.2 Transition dynamics

The algorithm solving for the transition dynamics is the following. Starting from a steady state sequence of the real interest rate $\{r_t\}_{t=1}^{t=T} = r$, labor market tightness $\{\theta_t\}_{t=1}^{t=T} = \theta$ and all the relevant variables:

1. For $t = \{1 : T\}$, compute labor market variables $\{f_t, q_t\}_{t=1}^{t=T}$ and update the transition matrix $\{\Lambda_t\}_{t=1}^{t=T}$

2. For $t = \{1 : T\}$, compute the dynamics of public debt $\{b_t\}_{t=1}^{t=T}$

3. For $t = \{1 : T\}$, compute the dynamics of the inflation rate using the Taylor rule, and compute the associated path for the nominal interest rate i_t^n

4. For $t = \{T : 1\}$, compute the forward dynamics of the price of intermediate goods p_t^m

5. For $t = \{T : 1\}$, for each t starting from the final (steady-state) allocation:

   - Compute profits, lump-sum taxes, and income paths for employed and unemployed households
   - Solve the Hamilton-Jacobi-Bellman equations and compute the set of value functions W_t
   - Solve the marginal value of a job J_t
   - Compute the wage according to Equation (8)
   - Compute hours worked ℓ_t

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

7. From those distributions, deduce the unemployment rate $\{u_t\}_{t=1}^{t=T}$ and vacancies $\{v_t\}_{t=1}^{t=T}$ from $\{v_t\}_{t=1}^{t=T} = \{\theta_t\}_{t=1}^{t=T} \times \{u_t\}_{t=1}^{t=T}$.

8. Check residuals on the paths of free entry and asset market clearing conditions

9. Update the paths of $\{r_t\}_{t=1}^{t=T}$ and $\{\theta_t\}_{t=1}^{t=T}$. Let $\{\zeta_{asset,t}\}_{t=1}^{t=T}$ denote the path of the excess of asset holdings with respect to the level of public debt and $\{\zeta_{fe,t}\}_{t=1}^{t=T}$ the path of residuals of the free entry condition. The update process is $\{r_t^{new}\} = \{r_t\} - d_r \{\zeta_{asset,t}\}$ where d_r is a small number: whenever households hold assets in excess with respect to 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, until the largest absolute value of $\{\zeta_{asset,t}\}$ and $\{\zeta_{fe,t}\}$ are less than the tolerance value (0.01% of total asset and J_t respectively).

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

B An extended model

We propose an extension of the model that comes closer to replicating empirical evidence about the distribution of assets, its dispersion, and the corresponding distribution of MPCs. We introduce two additional sources of heterogeneity. First, we introduce two types of discount factors, one $\rho_p < \rho$ that characterizes patient households, whether employed or unemployed, and one $\rho_i > \rho$ that characterizes impatient households whether employed or not. In line with Krusell and Smith (1998), households can change discount factor types with a very small probability, which basically amounts to split the population in two roughly equally sized populations of of patient and impatient households. This assumption generates a large density of households close to the zero liquid asset limit, among which many impatient employed households. The second source of heterogeneity is the addition of a third type of households: entrepreneurs. Instead of assuming that aggregate profits are redistributed to the employed households as in the baseline model, we consider that they are distributed to a specific type of households: entrepreneurs. We introduce a very small probability p_{e+} of becoming an entrepreneur and a small probability $p_{e-} > p_{e+}$ losing this status. This implies a relatively low stationary share of entrepreneurs in the economy. Combined with the fact that they receive the totality of retailers and intermediate-good producers profits, entrepreneurs are very rich in terms of per-capita income compared to other households. They are also large savers because of the probability of losing the status, and the extremely small probability of ever becoming an entrepreneur again in the future. 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 budget constraint of households in the extended model is:
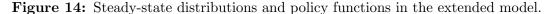
$$a_t^i + c_t^i = (1 + r_{t-1}) a_{t-1}^i + \mathbb{1}_{ent}^i \left[(1 - \tau_t) \left(\mathbb{1}_e^i w_t \ell_t + \left(1 - \mathbb{1}_e^i \right) h \overline{w} \right) - \mathbb{1}_e^i T_t^i \right] + \left(1 - \mathbb{1}_{ent}^i \right) \Pi_t^i$$
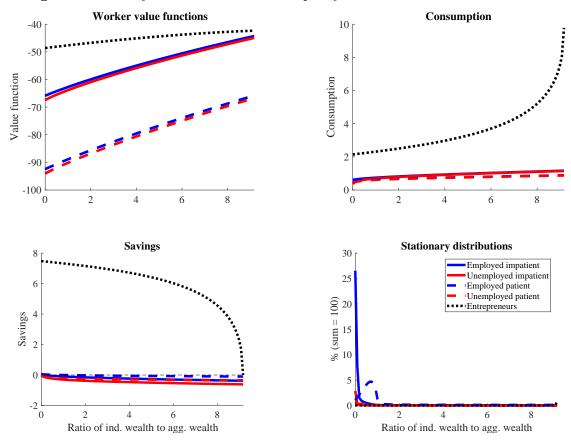
where $\mathbb{1}_e^i$ is an indicator function that takes the value of 1 if household i is employed and 0 otherwise, and $\mathbb{1}_{ent}^i$ an indicator variable that takes the value 1 if household i is an entrepreneur and 0 otherwise. In the extended model, the transition matrix expands because we 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 recall, p_{e+} is the probability of becoming an entrepreneur, p_{e-} is the probability of losing the status. In addition, 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 directly when losing their status. In addition, their discount factor is ρ, in-between the discount factor of patient and impatient.

The rest of the model remains unchanged and the calibration is adapted when needed to deliver similar targets as in the baseline model. We add a couple of targets: a Gini coefficient on liquid wealth of 0.75, the upper bound of the numbers 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 $p_{oi} = 0.995$, $p_{ni} = 0.005$. The corresponding policy functions and stationary distributions are reported in Figure 14.

Figure 14: Steady-state distributions and policy functions in the extended model.

The model delivers a 0.7486 Gini coefficient on liquid wealth, and the Lorenz curve for liquid wealth reported in Figure 15.

In addition, the distribution of MPCs is now more in line with empirical evidence, as the aggregate MPC is now 0.2065, the average MPC of impatient unemployed households is 0.5294, the average MPC of patient unemployed 0.4552, and average MPCs are 0.2094 and 0.0147 respectively for impatient and patient employed households. These numbers line-up quite well with those reported by Carroll, Slacalek, and Tokuoka (2014). Finally, we build IRFs based on a ±1% productivity shock and report the net effects of a government spending shock in Figure 16.

Government spending shocks have very similar qualitative implications as in the simpler model,

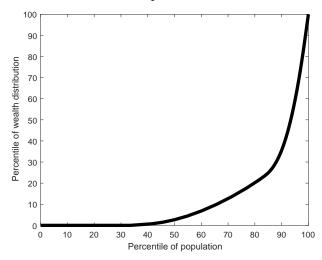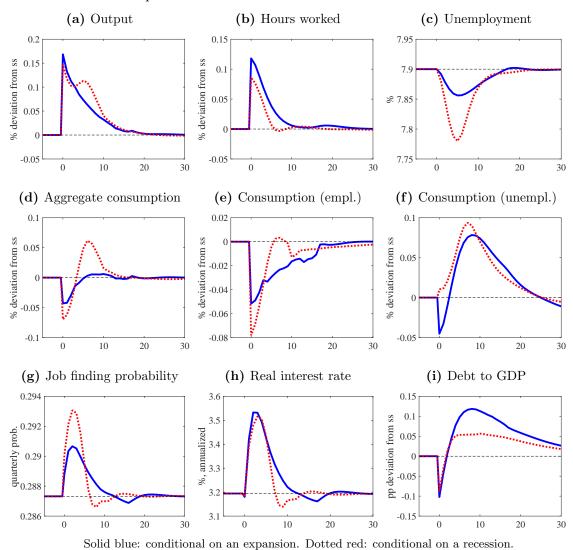**Figure 15:** Lorenz curve of liquid wealth in the extended model.

Figure 16: Impulse responses to a 1% government spending shock in the extended model. Net effect in recession and expansion.

(a) Output **(b)** Hours worked **(c)** Unemployment

(d) Aggregate consumption **(e)** Consumption (empl.) **(f)** Consumption (unempl.)

(g) Job finding probability **(h)** Real interest rate **(i)** Debt to GDP

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

and their effects also display quite a large amount of state dependence, government spending implying a larger effect on output in a recession than in an expansion. The government spending output PVM is 0.8740 conditional on a 1% positive productivity shock (expansion) and 1.0284 conditional on a 1% negative shock (recession), a difference of 17.67%. These numbers suggest a large amount of state dependence, based on the very same mechanisms than in the baseline model.