



**COLLEGIUM OF ECONOMIC ANALYSIS  
WORKING PAPER SERIES**

The Aggregate and Distributional Effects of  
Fiscal Stimuli

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# The Aggregate and Distributional Effects of Fiscal Stimuli \*

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## Abstract

This paper compares the aggregate and distributional effects of three fiscal policy instruments: government expenditures, unemployment benefits and transfers. To this end, the Diamond-Mortensen-Pissarides model of frictional labor market is embedded into an otherwise standard Heterogeneous Agent New Keynesian framework. The model calibrated to match the moments characterizing the US economy successfully replicates the empirical distributions of households across: disposable income, consumption expenditures and net worth. The solution method developed by Reiter (2009) is applied to quantify the aggregate and distributional responses to changes in the analyzed fiscal measures. Moreover, the stabilizing role of government expenditures, unemployment benefits and transfers is assessed.

**JEL Classification:** D30, E62, H23, H30, H31

**Keywords:** Heterogeneous Agents, Frictional Markets, Fiscal Stimulus

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\*I would like to thank the participants of Search and Matching Annual Meeting in Copenhagen and EEA-ESEM 2021 for helpful discussions and comments. Financial support of the Polish National Science Centre (Grant 2018/29/B/HS4/00717) is gratefully acknowledged.

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# 1 Introduction

This paper describes a quantitative exercise that compares the aggregate and distributional consequences of three stimulus packages that work through: higher government expenditures, unemployment benefits or transfers. In particular, I combine the standard Heterogeneous Agent New Keynesian (HANK henceforth) model, which is one of the workhorses of modern macroeconomics that allows for a realistic treatment of household consumption behavior and consumer heterogeneity, with the Diamond-Mortensen-Pissarides (DMP henceforth) model of frictional labor market, which explains unemployment as an equilibrium phenomenon. The calibrated version of the model successfully replicates the empirical moments related to wealth, consumption and income inequality. I use the model to simulate impulse responses of main economic aggregates to changes in government expenditures, unemployment benefits and transfers. Except for the reaction of standard variables like output, aggregate consumption and employment, I study the dynamics of Gini indices associated with net worth, consumption expenditures and disposable income. Furthermore, I simulate the model with aggregate demand shocks using the solution method developed by Reiter (2009) to study the role of counter-cyclical fiscal rules (based on government expenditures, unemployment benefits and transfers) in macroeconomic stabilization.

My findings can be summarized as follows. First, it turns out that stimulus generated by a rise in unemployment benefits features an output multiplier that is substantially larger than multipliers associated with government expenditures and transfers (which are of similar size). Second, I argue that this difference can be attributed to a large and positive response of aggregate consumption when stimulus is driven by a rise in unemployment benefits, which can be explained by the reduction in precautionary motives and by the distributional features of this fiscal instrument. When analyzing the distributional consequences of stimulus packages, I find that the extension of unemployment benefits increases wealth inequality, lowers consumption inequality and it leaves income inequality almost unaffected. Moreover, my simulations indicate that a rise in transfers barely affects wealth inequality and that it lowers both consumption and income inequality. At the same time, I find that government expenditures have no significant impact on the analyzed inequality measures. Finally, I find that countercyclical changes to unemployment

benefits are most effective in dampening business cycle fluctuations when compared to countercyclical policies based on transfers and government purchases.

The remaining sections of the paper are organized as follows. I review the related literature in the next section. Section 3 presents the BHA model with frictional product market and sticky prices. In Section 4 I calibrate the model and analyze its data fit. Section 5 analyzes the aggregate and distributional effects of changes to government expenditures, unemployment benefits and transfers. Section 6 concludes.

## 2 Literature

The paper is related to a growing literature that studies the effects of fiscal policy using different variants of the standard Bewley-Huggett-Aiyagari (BHA) model populated with heterogeneous households and, to the best of my knowledge, it is the first quantitative attempt that compares the propagation of shocks to transfers, government spending and unemployment benefits in the HANK framework combined with the DMP model.

The role of transfers is analyzed in Oh and Reis (2012), McKay and Reis (2016b) and Bayer et al. (2020). Oh and Reis (2012) use the model with elastic labor supply and sticky prices to quantify the aggregate impact of targeted transfers. Oh and Reis (2012) compare it to the effects of a rise in government expenditures but abstract from unemployment insurance in their analysis. In contrast to their paper, I assume that labor supply is constant at the household level and that labor market features search frictions that give rise to uninsured unemployment risk (which is absent in Oh and Reis (2012)). This, in turn, allows for capturing a powerful mechanism through which changes in expected job-finding rates affect current consumption decisions, which was discussed in: Den Haan et al. (2018), Ravn and Sterk (2020), Kopiec (2020), among others. McKay and Reis (2016b) use the standard HANK model that allows for including automatic stabilizers in the U.S. data and find that tax-and-transfer programs that influence inequality have a substantial impact on aggregate volatility. They incorporate transfers, government expenditures and unemployment benefits in their framework but, in contrast to my paper, they assume that the transition matrix between employment status varies exogenously over the

business cycle (in my paper those transition probabilities are endogenized using the DMP framework) and, in addition to my work, McKay and Reis (2016b) allow for elastic labor supply. In their recent paper, Bayer et al. (2020) analyze the effects of a lockdown in a medium-scale HANK framework and quantify the impact of transfers.

The role of unemployment benefits was studied by Krusell et al. (2010) who embedded the DMP model into an otherwise standard BHA framework. They find that higher unemployment insurance allows for better consumption smoothing, but, at the same time, by increasing workers' outside option value, it lowers firm entry. Krusell et al. (2010) abstract from price rigidities (assumed in this paper) and they do not include government debt in their analysis. As the way the stimulus is financed is potentially an important source of its effectiveness, I include government bonds in my analysis but, at the same time, I abstract from aggregate capital (which is analyzed in Krusell et al. (2010)). McKay and Reis (2016a) study optimal unemployment insurance (together with optimal tax progressivity) as an automatic stabilizer in the model with endogenous unemployment risk and search effort and derive an augmented Baily-Chetty formula that allows for the interpretation of forces underlying optimal unemployment insurance scheme. The difference between my work and McKay and Reis (2016a) is that they concentrate on a time-invariant generosity of unemployment benefits, while I study the responses of fiscal instruments to macroeconomic shocks that are based on a counter-cyclical fiscal rule. Den Haan et al. (2018) study the BHA model combined with the DMP framework with nominal wage rigidities to study the interplay between unemployment fears and deflationary spirals. They highlight the role of unemployment benefits in mitigating the feedback loop between deflation and unemployment. Kekre (2019) uses a model with a rich wealth distribution matching that in U.S. data and analyzes the welfare effects of marginal unemployment insurance extensions. In addition to my paper, he includes workers' search effort which allows for capturing the trade-offs between demand externalities, moral hazard and consumption insurance. Graves (2020) constructs a two-asset HANK model with DMP labor market. His analysis suggests that unemployment benefits can have an impact on business cycle volatility through their effects on the flight-to-liquidity that occurs when unemployment rises. My analysis abstracts from that effect as I study the model with one type of asset (i.e. liquid wealth), which improves the tractability of my framework that allows for studying the framework with aggregate uncertainty (Graves (2020) focuses on the analysis of

the so-called MIT shocks).

Navarro and Ferriere (2016), Brinca et al. (2016), Brinca et al. (2017), Auclert et al. (2018), Kopiec (2019), Ma (2019), Kopiec (2020), Bachmann et al. (2020) focus on the role of government expenditures in the BHA models. In addition to fiscal purchases, Hagedorn et al. (2019) analyze the role of transfers in the HANK model and decompose the response of private expenditures to a rise in government expenditures into channels that provide important insights into the propagation mechanism of fiscal shocks. They abstract, however, from endogenous unemployment risk, which is at the heart of my analysis.

From the technical point of view the closest work to mine are: Gornemann et al. (2016) and Kopiec (2020). They study the HANK model blended with the DMP framework and use the algorithm developed by Reiter (2009) to study the welfare implications of various monetary policy rules. Gornemann et al. (2016) abstract from government debt in their analysis (the only asset in their work is capital, which, in turn is not included in my paper), which is taken into account in my work as its main focus is the impact of fiscal stimuli on macroeconomic outcomes and, given that the Ricardian equivalence fails in the HANK model, those outcomes may depend on the way fiscal deficits are financed. Kopiec (2020) uses the HANK model with the DMP labor market to investigate the propagation mechanism of government spending shocks that works through the improvement in the so-called “employment prospects”. By contrast to this paper, Kopiec (2020) abstracts both from unemployment benefits and transfers analyzed in this paper and from aggregate uncertainty (Kopiec (2020) focuses on a one-time unexpected shock to fiscal purchases).

## **3 Model**

### **3.1 Environment**

Time is discrete and infinite. The economy is populated by a continuum of infinitely-lived, heterogeneous households (also referred to as consumers) of measure one. The remaining types of agents in the model are: representative retailer, identical producers (also referred to as firms) and government (which includes both fiscal and monetary authority). There are three markets: product market (featuring price

rigidities), market for liquid assets and frictional labor market as in the canonical DMP model. The sources of the household-level uncertainty are: changes to productivity level and labor status. The source of aggregate uncertainty in the model are shocks to household discount factors which give rise to fluctuations of aggregate demand.

### 3.2 Preferences and Technology

Households value consumption  $c_t$  in period  $t$  using the instantaneous utility function  $u$  that satisfies:  $u' > 0$ ,  $u'' < 0$  and the Inada conditions. Household discount future utility streams with factor  $\beta \cdot Z_t$  where  $Z_t$  is the value of the aggregate discount factor shock in period  $t$  which is identical across consumers and  $\beta \in \{\underline{\beta}, \bar{\beta}\}$  is parameter that is time-invariant at the household level where:

$$0 < \underline{\beta} < \bar{\beta} < 1.$$

In other words, there are two subgroups of households: patient and impatient (of identical mass of 0.5 each). More specifically,  $\underline{\beta} \cdot Z_t$  is discount factor of impatient households while  $\bar{\beta} \cdot Z_t$  is discount factor of patient households (in period  $t$ ). Discount factor heterogeneity is introduced to match the empirical value of the Gini index associated with the distribution of net worth. Firms use linear technology  $F$  to produce goods where effective labor is the only production input.

### 3.3 Matching in Labor Market

Matching technology  $M$  combines vacancies  $v_t$  created by producers with workers that are unemployed at the beginning period of period  $t$ . Measure of the latter is given by  $1 - (1 - \hat{s}) \cdot N_{t-1}$  where  $\hat{s} \in (0, 1)$  is the exogenous rate of job separations and  $N_{t-1}$  is employment level in period  $t - 1$ . More specifically,  $M$  is the number of jobs created, which is given by the following constant-returns-to-scale function:

$$M(1 - (1 - \hat{s}) \cdot N_{t-1}, v_t) = \left( [1 - (1 - \hat{s}) \cdot N_{t-1}]^{-\alpha} + v_t^{-\alpha} \right)^{-\frac{1}{\alpha}}$$

introduced by den Haan et al. (2000), where  $\alpha > 0$  governs the elasticity of substitution of matching inputs.

Labor market tightness  $x_t$  is defined as:

$$x_t \equiv \frac{v_t}{1 - (1 - \hat{s}) \cdot N_{t-1}}$$

and, due to the constant-returns-to-scale property of  $M$ , vacancy-filling rate  $q_t$  and job-finding rate  $f_t$  can be defined as functions of  $x_t$ :

$$q_t \equiv q(x_t) = \frac{M(1 - (1 - \hat{s}) \cdot N_{t-1}, v_t)}{v_t},$$

$$f_t \equiv f(x_t) = \frac{M(1 - (1 - \hat{s}) \cdot N_{t-1}, v_t)}{1 - (1 - \hat{s}) \cdot N_{t-1}}.$$

The law of motion for employment  $N_t$  is:

$$N_t = (1 - \hat{s}) \cdot N_{t-1} + M(1 - (1 - \hat{s}) \cdot N_{t-1}, v_t).$$

The sequence of events on the labor market is the following: proportion  $\hat{s}$  of employed households are separated from their jobs at the end of period  $t-1$ . At the beginning of next period (i.e. in period  $t$ ) they are pooled with the mass  $1 - N_{t-1}$  of consumers that were unemployed at time  $t-1$  and the job creation takes place. Subsequently, the population of employed  $N_t$  produces goods and the unemployed  $1 - N_t$  remains idle.

### 3.4 Households

Households face idiosyncratic Markovian changes to labor productivity  $z_t$  and endogenous changes to job-finding rate  $f_t$ , which is identical across consumers. Labor supply is inelastic and standardized to unity. Household enters period  $t$  with stock of liquid assets  $b_t$ , which is the only saving instrument available to consumers. Labor status  $h_t$  in period  $t$  is either equal to  $e$  (employed consumers) or to  $u$  (unemployed households). Employed households earn labor income  $w_t \cdot z_t$  taxed at rate  $\tau_t$ , where  $w_t$  is the average level of real wage in the economy. Unemployed household featuring productivity  $z_t$  receives unemployment benefit equal to  $\mu_t \cdot w_t \cdot z_t$  where  $\mu_t \in (0, 1)$  is the replacement rate set by fiscal authority. Each household receives transfer  $Tr_t$  which is identical across consumers. Resources available to households (labor/interest income and stock of assets) are divided between consumption  $c_t$  and



the accumulation of assets  $b_{t+1}$ , which is constrained by the following condition:

$$b_{t+1} \geq -\bar{b},$$

where  $\bar{b}$  is a non-negative constant. Nominal interest rate on government debt is denoted by  $i_t$  and the ratio between  $P_t$  (price of consumption goods in period  $t$ ) and  $P_{t-1}$  is denoted with  $\Pi_t$ . Real interest rate is defined as:

$$r_t \equiv \frac{1 + i_{t-1}}{\Pi_t} - 1.$$

Unemployed households in period  $t$  become employed in period  $t+1$  with probability  $f_{t+1}$ , while employed consumer lose their jobs with probability  $\hat{s} \cdot (1 - f_{t+1})$  between periods  $t$  and  $t - 1$ .

Suppose that consumer starts period  $t$  with asset holdings  $b_t$ , productivity level  $z_t$ , labor market status  $h_t$  and the level of aggregate shock is  $Z_t$ . Then the maximization problem of household with discount factor  $\beta \cdot Z_t$  can be described with the following Bellman equation:

$$\begin{aligned} V_t(h_t, z_t, b_t, \beta) = \max_{c_t, b_{t+1}} & \left\{ u(c_t) + \mathbb{I}_{\{h_t=e\}} \cdot \beta \cdot Z_t \cdot \mathbb{E}_t[(1 - \hat{s} \cdot (1 - f_{t+1})) \right. \\ & \cdot V_{t+1}(e, z_{t+1}, b_{t+1}, \beta) + \hat{s} \cdot (1 - f_{t+1}) \cdot V_{t+1}(u, z_{t+1}, b_{t+1}, \beta)] \\ & + \mathbb{I}_{\{h_t=u\}} \cdot \beta \cdot Z_t \cdot \mathbb{E}_t[f_{t+1} \cdot V_{t+1}(e, z_{t+1}, b_{t+1}, \beta) \\ & \left. + (1 - f_{t+1}) \cdot V_{t+1}(u, z_{t+1}, b_{t+1}, \beta)] \right\} \end{aligned}$$

subject to:

$$\begin{cases} c_t + b_{t+1} = (1 + r_t) \cdot b_t + \mathbb{I}_{\{h_t=e\}} \cdot (1 - \tau_t) \cdot w_t \cdot z_t + \mathbb{I}_{\{h_t=u\}} \cdot \mu_t \cdot w_t \cdot z_t + Tr_t \\ b_{t+1} \geq -\bar{b} \end{cases}$$

where  $\mathbb{I}$  is the indicator function,  $V_t$  is the value function associated with the optimization problem of household in period  $t$  and where variables  $r_t$ ,  $w_t$ ,  $\mu_t$ ,  $\tau_t$ ,  $f_{t+1}$ ,  $Tr_t$  are taken as given. Note that the time subscript of function  $V_t$  captures its dependence on the aggregate state of the economy (in particular on variable  $Z_t$  and on the aggregate distribution of households across wealth, productivity levels and labor status).

Analogously to Guerrieri and Lorenzoni (2017), I define the time-dependent optimal rules  $c_t(h, z, b, \beta)$  and  $b_{t+1}(h, z, b, \beta)$  for a consumer characterized with household-level state variables  $h_t = h$ ,  $z_t = z$ ,  $b_t = b$  and  $\beta \in \{\underline{\beta}, \bar{\beta}\}$ .

### 3.5 Representative Retailer

Representative retailer purchases varieties of goods  $\{Y_{j,t}\}_{j \in [0,1]}$  (called intermediate goods, too) from producers indexed with  $j$  and packs them into a single consumption good which is then sold to households. Packing technology is described by the Dixit-Stiglitz aggregator:

$$Y_t = \left( \int_0^1 Y_{t,j}^{1-\frac{1}{\gamma}} dj \right)^{\frac{1}{1-\frac{1}{\gamma}}},$$

where  $\gamma > 1$  is the elasticity of substitution between varieties generated by firms. Retailer chooses  $\{Y_{j,t}\}_{j \in [0,1]}$  to maximize profits:

$$P_t \cdot Y_t - \int_0^1 P_{j,t} \cdot Y_{j,t} dj,$$

where  $P_{j,t}$  is the price of a variety produced by firm  $j$ . The value of the aggregate price level  $P_t$  is given by:

$$P_t = \left( \int_0^1 P_{j,t}^{1-\gamma} dj \right)^{\frac{1}{1-\gamma}}.$$

The necessary condition associated with the maximization problem of the representative retailer is:

$$Y_{j,t} = \left( \frac{P_{j,t}}{P_t} \right)^{-\gamma} \cdot Y_t. \quad (1)$$

which is the demand function for variety  $j$ .

### 3.6 Producers

There is a unit mass of identical, monopolistically competitive firms indexed with  $j \in [0,1]$ . Producer  $j$  posts vacancies  $v_{j,t}$  to hire workers in the frictional labor market. The probability that vacancy is filled equals  $q_t$ .

As in Gornemann et al. (2016), firm's recruitment process features asymmetric information: producers know only the mean productivity of workers in the pool of

jobless workers  $1 - (1 - \hat{s}) \cdot N_{t-1}$  at the beginning of period  $t$  (i.e. while making the recruitment decision). They learn the value  $z_t$  of a hired worker right after employing him or her and pay wage proportional to his or her productivity level until the exogenous separation occurs. The assumptions about asymmetric information and real wages proportional to individual productivity are made to blend the DMP model of frictional labor market with the heterogeneous agent framework in a tractable way. Moreover, the ergodic distribution of worker productivity levels is independent of the aggregate state of economy and its mean is standardized to one:  $\mathbb{E}_z z_t = 1$ . Firm  $j$  manufactures variety  $Y_{j,t}$  using the linear technology  $F$  that takes effective labor  $\mathbb{E}_z z_t N_{j,t}$  as the only input:

$$Y_{j,t} = F(\mathbb{E}_z z_t N_{j,t}) = \mathbb{E}_z z_t N_{j,t} = N_{j,t}$$

where  $N_{j,t}$  is the number of workers employed in firm  $j$ .

Firm  $j$  sets price  $P_{j,t}$  subject to quadratic adjustment costs which are proportional to aggregate output  $Y_t$ :

$$\frac{\phi}{2} \cdot \left( \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} \right)^2 \cdot Y_t$$

where  $\phi > 0$  is a parameter. Producers take demand curves (equation 1) and the firm-level law of motion for labor:

$$N_{j,t} = (1 - \hat{s}) \cdot N_{j,t-1} + q_t \cdot v_{j,t}$$

as given. The real value of profits  $d_{j,t}$  (also referred to as dividends) of firm  $j$  in period  $t$  is defined as:

$$d_{j,t} \equiv \frac{P_{j,t}}{P_t} \cdot Y_{j,t} - \mathbb{E}_z z_t \cdot w_t \cdot N_{j,t} - \kappa \cdot v_{j,t} - \frac{\phi}{2} \cdot \left( \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} \right)^2 \cdot Y_t - \tau_{d,t}$$

where  $\tau_{d,t}$  is tax on profits. Producers use real interest rates  $r_t$  to discount future streams of profits.

All this means that in period 0 firm  $j$  solves the following maximization problem:

$$\max_{\{v_{j,t}, P_{j,t}, Y_{j,t}, N_{j,t}, d_{j,t}\}_{t=0}^{+\infty}} \mathbb{E}_0 \left[ \sum_{t=0}^{+\infty} \prod_{s=0}^t \left( \frac{1}{1+r_s} \right) \cdot d_{j,t} \right]$$

subject to:

$$\begin{aligned} Y_{j,t} &= \left( \frac{P_{j,t}}{P_t} \right)^{-\gamma} \cdot Y_t \\ N_{j,t} &= (1 - \hat{s}) \cdot N_{j,t-1} + q_t \cdot v_{j,t} \\ Y_{j,t} &= \mathbb{E}_z z_t N_{j,t} \\ d_{j,t} &= \frac{P_{j,t}}{P_t} \cdot Y_{j,t} - w_t \cdot N_{j,t} - \kappa \cdot v_{j,t} - \frac{\phi}{2} \cdot \left( \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} \right)^2 \cdot Y_t - \tau_{d,t} \end{aligned}$$

where  $\{P_t, Y_t, q_t, w_t, r_t, \tau_{d,t}\}_{t=0}^{+\infty}$  are taken as given.

In a symmetric equilibrium (in which  $N_{j,t} = N_t$ ,  $P_{j,t} = P_t$ ,  $v_{j,t} = v_t$ ,  $Y_{j,t} = Y_t$ ), the optimal behavior of firms is characterized with the following first order condition:

$$\begin{aligned} &1 - \gamma + w_t \cdot \gamma + \gamma \cdot \frac{\kappa}{q_t} - \mathbb{E}_t \left[ \frac{1}{1+r_{t+1}} \cdot \frac{\kappa \cdot (1 - \hat{s}) \cdot \gamma}{q_{t+1}} \right] \\ &= \phi \cdot (\Pi_t - 1) \cdot \Pi_t - \mathbb{E}_t \left[ \frac{1}{1+r_{t+1}} \cdot \phi \cdot (\Pi_{t+1} - 1) \cdot \Pi_{t+1} \cdot \frac{Y_{t+1}}{Y_t} \right]. \end{aligned}$$

Finally, to reduce the computational complexity of the problem, I follow Hagedorn et al. (2019) by assuming that  $\tau_{d,t}$  is set at the level such that:<sup>1</sup>

$$\forall_{j,t} d_{j,t} = \tau_{d,t}. \quad (2)$$

### 3.7 Government

Government is composed of two branches: fiscal authority and monetary authority. The former applies fiscal rules (which are specified later) to set the values of public debt  $B_t$ , government expenditures  $G_t$ , transfers  $T_t$ , replacement rate  $\mu_t$  and sets the value of labor income tax rate  $\tau_t$  to balance the budget:

$$\tau_{d,t} + \tau_t \cdot w_t \cdot N_t + B_{t+1} = (1 - N_t) \cdot \mu_t \cdot w_t + G_t + Tr_t + (1 + r_t) \cdot B_t \quad (3)$$

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1

This assumption allows to abstract from the second type of assets (equity) in the analysis.

where the left-hand side summarizes the revenues from taxes and debt issuance while the right-hand side describes the expenditures on unemployment benefits, government purchases, transfers and debt repayment.

Central bank uses the standard Taylor rule to set the value of nominal interest rates:<sup>2</sup>

$$i_t = \bar{i} + \phi_\Pi \cdot (\Pi_t - \Pi) + \phi_Y \cdot \left( \frac{Y_t - Y}{Y} \right)$$

where  $\phi_\Pi$  and  $\phi_Y$  are positive parameters,  $\Pi$  and  $Y$  are levels of inflation and output in the stationary equilibrium.

### 3.8 Price-setting on the Labor Market

As the labor market is frictional, an additional condition is needed to pin down the value of real wage  $w_t$  that divides the surplus between firms and workers. A standard approach to address that problem is Nash bargaining, which is challenging from the computational perspective in the analyzed framework as asset holdings would affect worker's bargaining position and, in turn, would influence the level of real wage. To solve that problem, I follow Den Haan et al. (2018) and assume the value of real wage  $w_t$  is governed by the following equation:<sup>3</sup>

$$w_t = w_{t-1} \cdot \Pi_t^{\omega_\Pi - 1}. \quad (4)$$

where  $\omega_\Pi$  is a parameter which is estimated using empirical observations.

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<sup>2</sup>By omitting time subscripts I denote the values of variables in the stationary equilibrium.

<sup>3</sup>More precisely, Den Haan et al. (2018) assume the following rule for nominal wage  $\tilde{w}_t$ :

$$\tilde{w}_t = \omega_0 \cdot \left( \frac{A_t}{\bar{A}} \right)^{\omega_A} \cdot \bar{A} \cdot \left( \frac{P_t}{\bar{P}_t} \right)^{\omega_\Pi} \cdot \bar{P}_t$$

where  $\omega_0$ ,  $\omega_A$ ,  $\omega_\Pi$  are parameters that can be estimated from the data,  $\bar{A}$  is the average productivity level,  $A_t$  is the productivity level in period  $t$ ,  $\bar{P}_t$  is given by:

$$\bar{P}_t = \bar{\Pi}^t$$

i.e. it is the trend price level. As the only source of aggregate uncertainty in the analyzed model are changes to household discount factors, we have  $A_t = \bar{A} = 1$ . Some simple algebra (described in the Appendix) is required to get equation 4.

### 3.9 Market Clearing Conditions and Distribution Dynamics

Measure of households featuring labor market status  $h_t = h$ , productivity  $z_t = z$ , assets holdings  $b_t = b$  and mean value discount factor  $\beta$  in period  $t$  is denoted by  $\pi_t(h, z, b, \beta)$ . The market clearing condition for goods is:

$$\int c_t(h, z, b, \beta) d\pi_t(h, z, b, \beta) + \kappa \cdot v_t + \frac{\phi}{2} \cdot (\Pi_t - \bar{\Pi})^2 \cdot Y_t + G_t = Y_t \quad (5)$$

and the market clearing condition for assets is:

$$B_{t+1} = \int b_{t+1}(h, z, b, \beta) d\pi_t(h, z, b, \beta).$$

In equilibrium, the number of filled vacancies equals the number of workers that are hired:

$$q_t \cdot v_t = f_t \cdot (1 - (1 - \hat{s}) \cdot N_{t-1}).$$

The law of motion for the distribution of households is given by:

$$\begin{aligned} \pi_{t+1}(e, z', \mathcal{B}', \beta) &= (1 - \hat{s} \cdot (1 - f_{t+1})) \cdot \int_{\{b: b_{t+1}(e, z, b, \beta) \in \mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t(e, z, b, \beta) \quad (6) \\ &+ f_{t+1} \cdot \int_{\{b: b_{t+1}(u, z, b, \beta) \in \mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t(u, z, b, \beta) \end{aligned}$$

$$\begin{aligned} \pi_{t+1}(u, z', \mathcal{B}', \beta) &= \hat{s} \cdot (1 - f_{t+1}) \cdot \int_{\{b: b_{t+1}(e, z, b, \beta) \in \mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t(e, z, b, \beta) \quad (7) \\ &+ (1 - f_{t+1}) \cdot \int_{\{b: b_{t+1}(u, z, b, \beta) \in \mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t(u, z, b, \beta) \end{aligned}$$

where  $\mathcal{B}'$  is a Borel subset of  $[-\bar{b}, +\infty)$ ,  $\mathbb{P}(z'|z)$  is the transition probability between states  $z$  and  $z'$  determined by the Markovian process that determines the evolution of household-level productivity.<sup>4</sup>

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<sup>4</sup>For example, equation 6 says that the mass of employed agents featuring productivity  $z'$ , level of asset holdings in set  $\mathcal{B}'$  and the time-invariant component of discount factor  $\beta$  in period  $t + 1$  (left-hand side) is composed of agents (aggregated on the right-hand side) with the time-invariant component of discount factor  $\beta$  who were either employed in period  $t$  (and have not become

As mentioned, the measure of households is standardized to unity, which implies:

$$\int d\pi_t(h, z, b, \beta) = 1. \quad (8)$$

The aggregate demand shock is governed by the following autoregressive process:

$$\log Z_{t+1} = \rho_Z \cdot \log Z_t + \epsilon_{Z,t+1} \quad (9)$$

where  $\rho_Z \in (0, 1)$  and  $\epsilon_{Z,t+1}$  is an innovation, which is normally distributed with mean 0 and standard deviation  $\sigma_Z$ .

### 3.10 Equilibrium

We are in position to define the equilibrium of the model:

**Definition.** *Given an initial government debt level  $B_0$ , initial distribution  $\pi_0$ , exogenous sequences  $\{Z_t, B_{t+1}, G_t, \mu_t, Tr_t\}_{t \geq 0}$ , an equilibrium is given by paths of prices  $\{r_t, i_t, \Pi_t, w_t\}_{t \geq 0}$ , sequences  $\{Y_t, q_t, f_t, N_t, v_t, d_t, \tau_{d,t}, \tau_t\}_{t \geq 0}$ , individual policy and value functions  $\{c_t(h, z, b, \beta)\}_{t \geq 0}$ ,  $\{b_{t+1}(h, z, b, \beta)\}_{t \geq 0}$ ,  $\{V_t(h, z, b, \beta)\}_{t \geq 0}$ , distributions of households  $\{\pi_t(h, z, b, \beta)\}_{t \geq 0}$  such that: households, retailers and producers optimize, government budget constraint holds, Taylor rule, wage rule and consistency conditions hold.*

## 4 Calibration

### 4.1 Functional Forms

It is assumed that utility function  $u$  is specified as:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}$$

where  $\sigma$  is the rate of relative risk aversion.

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unemployed between  $t$  and  $t + 1$ , chose assets  $b_{t+1}$  in set  $\mathcal{B}'$  in period  $t$  and their productivity level transited to  $z'$ ) or were unemployed in period  $t$  but started working in period  $t + 1$  (and chose assets  $b_{t+1}$  in set  $\mathcal{B}'$  in period  $t$ , their productivity level transited  $z'$ ). The interpretation of condition 7 is analogous.

## 4.2 Parameter Values

The period in the model corresponds to a quarter. The model in the stationary equilibrium is calibrated to match the moments characterizing US economy in 2006, the last year before the start of the Great Recession. There are two types of parameters in the model: the values in the first group are set at with reference to the literature and the values in the second group are set so that the moments associated with the stationary equilibrium of the model are equal to their empirical counterparts.

First group of parameters consists of: relative risk aversion  $\sigma$ , separation rate  $\hat{s}$ , steady state value of replacement rate  $\mu$ , parameters associated with exogenous productivity shocks, elasticity of substitution between intermediate goods  $\gamma$ , parameters associated with the Taylor rule  $\phi_\Pi$  and  $\phi_Y$ , price adjustment parameter  $\phi$  and the lower bound on asset holdings  $\bar{b}$ . I set  $\sigma = 2$  which is a standard value in the literature. Following Shimer (2005), I set  $\sigma = 0.1$  and  $\mu = 0.4$ . Similarly to Krueger et al. (2016), I assume that log-labor productivity follows a process with transitory and persistent shocks:

$$\begin{cases} \log z_{t+1} = s_t + \epsilon_{s,t+1} \\ s_{t+1} = \phi_s \cdot s_t + \eta_{s,t+1} \end{cases}$$

where by  $\phi_s$  I denote the persistence of the process and by  $\epsilon_s$  and by  $\eta_s$  I denote innovations associated with the transitory shock and the persistent component, respectively. Variances of the shocks are given by  $\sigma_{\epsilon_s}^2$  and  $\sigma_{\eta_s}^2$ . Values of  $\phi_s$ ,  $\sigma_{\epsilon_s}^2$  and  $\sigma_{\eta_s}^2$  are the quarterly counterparts of the annual persistence and variances taken from Krueger et al. (2016). I use the Rouwenhorst algorithm to discretize the persistent component of the process and I apply the Gauss-Hermite quadrature to approximate the transitory shock.

I set  $\gamma = 11$  to match the monopolistic markup equal to 10%. I assume that parameters associated with the Taylor rule take standard, textbook values  $\phi_\Pi = 1.5$  and  $\phi_Y = 0.125$ . I use the correspondence between the price-setting protocols by Rotemberg (1982) and by Calvo (1983) established by Faia and Monacelli (2007) to set the value of parameter  $\phi$  that is consistent with the probability of 75% of keeping the price unchanged in the Calvo (1983) setting, which implies  $\phi = 115$  in the framework by Rotemberg (1982). Finally, I follow McKay and Reis (2016b) and Krueger et al. (2016) and standardize the liquidity constraint  $\bar{b}$  to 0. Calibrated parameter values of  $\sigma$ ,  $\hat{s}$ ,  $\mu$ ,  $\phi_s$ ,  $\sigma_{\epsilon_s}^2$ ,  $\sigma_{\eta_s}^2$ ,  $\gamma$ ,  $\phi_\Pi$ ,  $\phi_Y$ ,  $\phi$ ,  $\bar{b}$  are summarized in Table 1.



Table 1: Parameters set with reference to the literature

| Parameter               | Description   | Value  | Source                 |
|-------------------------|---|--------|------------------------|
| $\sigma$                | Relative risk aversion                                | 2      | Standard value         |
| $\hat{s}$               | Separation rate                                       | 0.1    | Shimer (2005)          |
| $\mu$                   | Replacement rate in stationary equilibrium            | 0.4    | Shimer (2005)          |
| $\phi_s$                | Persistence of the idios. productivity shock          | 0.9923 | Krueger et al. (2016)  |
| $\sigma_{\epsilon_s}^2$ | Variance of transitory component                      | 0.0131 | Krueger et al. (2016)  |
| $\sigma_{\eta_s}^2$     | Variance of persistent component                      | 0.0099 | Krueger et al. (2016)  |
| $\gamma$                | Elasticity of substitution between intermediate goods | 11     | Standard value         |
| $\phi_\Pi$              | Taylor rule parameter (inflation)                     | 1.5    | Galí (2008)            |
| $\phi_Y$                | Taylor rule parameter (output gap)                    | 0.125  | Galí (2008)            |
| $\phi$                  | Price adjustment parameter                            | 115    | Standard value         |
| $\bar{b}$               | Liquidity constraint                                  | 0      | McKay and Reis (2016b) |

Matching the moments generated by the model with their empirical counterparts allows to pin down the remaining parameter values. First, to pin down  $\bar{\beta}$ , I follow Guerrieri and Lorenzoni (2017) and I use the steady state value of the annual real interest rate equal to 2.5% as calibration target. To account for wealth inequality observed in the data, I adjust the value of  $\underline{\beta}$  to match the Gini coefficient of wealth distribution of 0.77 as in the PSID data (reported by Krueger et al. (2016), see Table 3). Without loss of generality, steady state inflation  $\bar{\Pi}$  is standardized to unity which, together with the targeted level of real interest rate of 2.5%, allows to pin down the value of  $\bar{i}$  in the Taylor rule. Steady state value of real wage  $w$  is set to match unemployment rate  $U$  equal to 6%, where:

$$U \equiv 1 - N.$$

As in Hagedorn and Manovskii (2008), parameter  $\alpha$  characterizing the matching process in labor market is calibrated so that the quarterly vacancy filling rate in the model (i.e.,  $q$ ) equals 97.6%. Parameter  $\kappa$  is chosen to match the ratio between recruitment costs spent on each hired and real wage reported by Silva and Toledo (2009) (which equals 0.14 for quarterly labor earnings). I set the steady state value

Table 2: Parameters calibrated with the model

| Parameter           | Description                                   | Value | Target  | Value |
|---------------------|---|-------|---|-------|
| $\bar{\beta}$       | Mean discount factor of patient consumers     | 0.975 | Annual real interest rate   | 0.025 |
| $\underline{\beta}$ | Mean discount factor of impatient consumers   | 0.936 | Gini coefficient of wealth distribution                                 | 0.77  |
| $w$                 | Real wage in the steady state                 | 0.90  | Unemployment rate   | 0.06  |
| $\alpha$            | Parameter associated with function $M$        | 4.57  | Quarterly vacancy filling rate of 97.6%                                 | 0.976 |
| $\kappa$            | Vacancy posting cost                          | 0.12  | Ratio between recruitment costs and wages as in Silva and Toledo (2009) | 0.14  |
| $B$                 | Aggregate supply of bonds                     | 2.26  | Government debt to GDP ratio in 2006                                    | 0.60  |
| $G$                 | Government spending in stationary equilibrium | 0.141 | Government spending to GDP as in McKay and Reis (2016b)                 | 0.15  |
| $Tr$                | Transfers in the stationary equilibrium       | 0     | Gini coefficient of disposable income distribution                      | 0.42  |
| $\omega_{\Pi}$      | Wage-setting parameter                        | 0.46  | OLS estimate  | —     |

of  $B$  to match the ratio between government debt and annual GDP equal to 61.5% (debt to GDP ratio in 2006). Finally, transfer  $Tr$  is set at the level that allows for matching the Gini index associated with disposable income in the PSID data (that equals 0.42 - see Table 3).

### 4.3 Non-targeted moments: Model vs. Data

Let us now turn to the moments that are not targeted in the calibration exercise and see how well the model fits those patterns.

In particular, let us check to what extent it is able to replicate the shares of aggregate wealth held by the quintiles of population stratified according to individual net worth. Moreover, let us make analogous comparisons for consumption expenditures and disposable income. Table 3 shows the results. It seems that the model can successfully mimic the patterns associated with the distribution of net worth, consumption and disposable income at the beginning of Great Recession (based on both PSID and SCF data as reported by Krueger et al. (2016)). Moreover, the value

Table 3: Non-targeted moments: distribution of wealth, consumption expenditures and disposable income across population quintiles: model vs. data and the associated Gini indices

|      | Net worth |      |      | Consumption |      |      | Disposable income |      |      |
|------|-----------|------|------|-------------|------|------|-------------------|------|------|
|      | Model     | PSID | SCF  | Model       | PSID | SCF  | Model             | PSID | SCF  |
| Q1   | 0.0       | -0.9 | -0.2 | 4.6         | 5.6  | 6.5  | 4.5               | 4.5  | 4.4  |
| Q2   | 1.2       | 0.8  | 1.2  | 11.5        | 10.7 | 11.4 | 10.3              | 9.9  | 10.5 |
| Q3   | 3.8       | 4.4  | 4.6  | 14.9        | 15.6 | 16.4 | 14.7              | 15.3 | 15.9 |
| Q4   | 9.6       | 13.0 | 11.9 | 22.7        | 22.4 | 23.3 | 21.6              | 22.8 | 23.1 |
| Q5   | 85.4      | 82.7 | 82.5 | 46.4        | 45.6 | 42.4 | 48.9              | 47.5 | 46.0 |
| Gini | 0.77      | 0.77 | 0.78 | 0.39        | 0.40 | 0.36 | 0.42              | 0.42 | 0.40 |

Notes: The PSID and SCF moments in the table are based on the estimates reported by Krueger et al. (2016). Moments corresponding to Q1-Q5 are expressed in % and Gini indices are standardized to values between zero and one. The Gini indices that correspond to net worth and disposable income are calibration targets and therefore are shaded (i.e. they are not non-targeted moments).

of Gini index related to consumption inequality equals to 0.39 in the model which is between the values calculated using the SCF and PSID data (equal to 0.36 and 0.40, respectively).

As the propagation of fiscal stimulus crucially depends on households' consumption responses, it is necessary that the model is able to replicate the consumption behavior observed in the data. To check whether it is the case, I compare the quarterly MPC to transitory income shocks in the model with its empirical estimates. More specifically, it is equal to 0.158 in the model, which lies within the range of values typically reported in the literature.<sup>5</sup>

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<sup>5</sup>I refer to the estimates of a quarterly MPC documented in Parker (1999) which is equal to 0.2, in Souleles (1999), which lies between 0.045 – 0.09, and in Parker et al. (2013), which ranges from 0.12 to 0.3. An overview of various MPC estimates in the literature can be found in Carroll et al. (2017).

## 5 Quantitative analysis

### 5.1 Fiscal Stimuli: Impulse Responses

This part describes both the aggregate and distributional effects of the analyzed fiscal policies. In particular, it reports the impulse response functions of main macroeconomic aggregates and Gini indices to fiscal shocks under three scenarios: a rise in government expenditures, an increase in unemployment benefits and higher transfers.

To simulate the transition paths of economic variables associated with an increase in government expenditures (first scenario analyzed in this section), I make the following assumptions about fiscal policy variables. First, I concentrate on the situation when government purchases are governed by the following  $AR(1)$  process:

$$\log G_{t+1} = \rho_G \cdot \log G_t + (1 - \rho_G) \cdot \log G + \epsilon_{G,t} \quad (10)$$

where  $\rho_G$  determines the persistence of the government spending shock  $\epsilon_{G,t}$ . I follow Hagedorn et al. (2019) and assume that impulse responses are generated with a rise in government expenditures equal to 1% of their steady state value and that its persistence  $\rho_G$  equals 0.9.

In what follows, I assume that government expenditures are financed with debt (the results corresponding to the tax-financed stimuli are reported in the Appendix). In particular, the law of motion for public debt is given by the following equation:

$$B_{t+1} = \rho_B \cdot B_t + (1 - \rho_B) \cdot B + G_t - G, \quad (11)$$

where  $\rho_B \in (0, 1)$ . Equation 11 says that changes to government debt absorb the deviations of government spending from their steady state level.<sup>6</sup> The value of parameter  $\rho_B$  that determines the pace at which debt returns to its steady state value  $B$  is set to be equal to  $\rho_G$ .

To simulate the transition paths resulting from a rise in unemployment benefits

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<sup>6</sup>Alternatively, one could assume that  $B_t$  is such that tax rate  $\tau_t$  is constant over time. Nevertheless, this alternative approach implies that changes to  $B_t$  absorb not only the deviations of  $G_t$  from  $G$  but also the deviations of all other variables present in the budget constraint (see equation 3). Moreover, as we shall see, this means that paths  $\{B_t\}$  would differ across three policy scenarios analyzed here, which makes the interpretation of comparisons of wealth inequality dynamics more problematic.

and transfers, I need to guarantee their comparability with the effects of higher government spending. To this end, I assume that paths of unemployment benefits  $\mu_t$  and transfers  $Tr_t$  are such that the rise in aggregate expenditures on those policies are equal to an increase in government expenditures analyzed in the first scenario. In particular, path  $\mu_t$  in the second scenario satisfies:

$$(\mu_t - \mu) \cdot w_t \cdot (1 - N_t) = G_t - G \quad (12)$$

where, slightly abusing the notation,  $G_t$  corresponds to the value of government expenditures in the first scenario (note that  $G_t = G$  under second and third scenarios). Likewise, under third scenario,  $Tr_t$  is set to satisfy:

$$Tr_t - Tr = G_t - G. \quad (13)$$

Those formulations of  $\mu_t$  and  $Tr_t$  together with the assumed law of motion for public debt (see equation 11) guarantee that the evolution of  $B_t$  is the same for all three scenarios. This, in turn, implies that the aggregate net worth is the same across scenarios, which simplifies the comparison of impulse responses of the Gini index related to net worth.

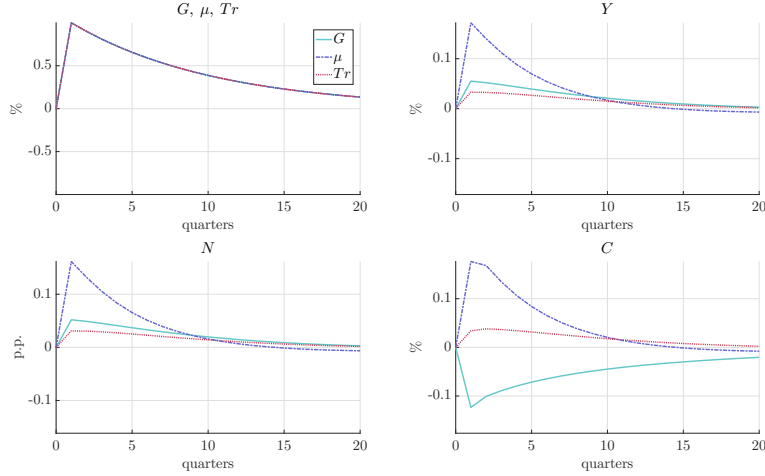
I use the algorithm by Reiter (2009) to solve the model with aggregate shocks and to simulate the business cycle moments in Section 5.2.<sup>7</sup>

Let us now turn to the analysis of reactions of main economic aggregates (output, consumption and employment) to fiscal policy shocks. Results are displayed in Figure 1. As the top-right panel shows, the rise in unemployment benefits leads to the largest increase in output when compared to the effects of government expenditures and transfers. Note that because aggregate product in the model is generated using linear technology with labor as the only input, the impulse responses corresponding to employment are the same as those for output. Finally, the bottom-right panel

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<sup>7</sup>Solution algorithms prepared for the quantitative exercises presented in my paper are partly based on codes provided by A. McKay on his website <https://bitbucket.org/amckay/simplemckayreis/src/master/> (in particular, the collocation method used for solving the system of Euler equations is based on his algorithm) and on the scripts prepared by S. Graves taken from [https://github.com/sebgraves/KS\\_and\\_Reiter](https://github.com/sebgraves/KS_and_Reiter) (in particular, I base on his implementation of the Gensys toolbox by Sims). There are, however, significant differences between the codes used in my paper and those by A. McKay and S. Graves, which follow from the fact that, in contrast to my analysis, they abstract from endogenous unemployment risk in their models.

Figure 1: Impulse response functions, main economic aggregates



Notes: The top left panel displays the changes of aggregate expenditures on government spending (denoted with  $G$  in the legend), unemployment benefits and transfers (denoted with  $\mu$  and  $Tr$ , respectively) expressed as a share of steady state value of government expenditures. The top-right panel displays the response of aggregate output, the bottom-left shows the impulse response function of aggregate employment. The bottom-right panel displays the response of aggregate consumption.

shows the transition paths of aggregate consumption. The one that corresponds to the stimulus generated by higher unemployment benefits features a substantially stronger response than the remaining two paths.

To enable the quantitative interpretation of those results, Table 4 reports the impact and cumulative multipliers for both output and consumption. In particular, the impact multiplier for output is defined in a standard way, i.e., it is given by the following ratio:

$$\frac{Y_1 - Y}{G_1 - G}$$

and the impact multiplier for consumption is defined in an analogous way. When defining cumulative multipliers, I follow Hagedorn et al. (2019). More specifically, the cumulative output multiplier is given by:

$$\frac{\sum_{t=1}^{+\infty} \hat{\beta}^t \cdot (Y_t - Y)}{\sum_{t=1}^{+\infty} \hat{\beta}^t \cdot (G_t - G)}$$

where  $\hat{\beta}$  is equal to the average discount factor in the economy:

$$\hat{\beta} \equiv \frac{\beta + \bar{\beta}}{2}.$$

Table 4: Output and consumption multipliers

|                         | Output    |            | Consumption |            |
|-------------------------|-----------|------------|-------------|------------|
|                         | on impact | cumulative | on impact   | cumulative |
| Government expenditures | 0.37      | 0.34       | -0.69       | -0.67      |
| Unemployment benefits   | 1.14      | 0.58       | 0.98        | 0.57       |
| Transfers               | 0.22      | 0.23       | 0.19        | 0.22       |

Again, the cumulative multiplier for consumption can be defined in an analogous way.

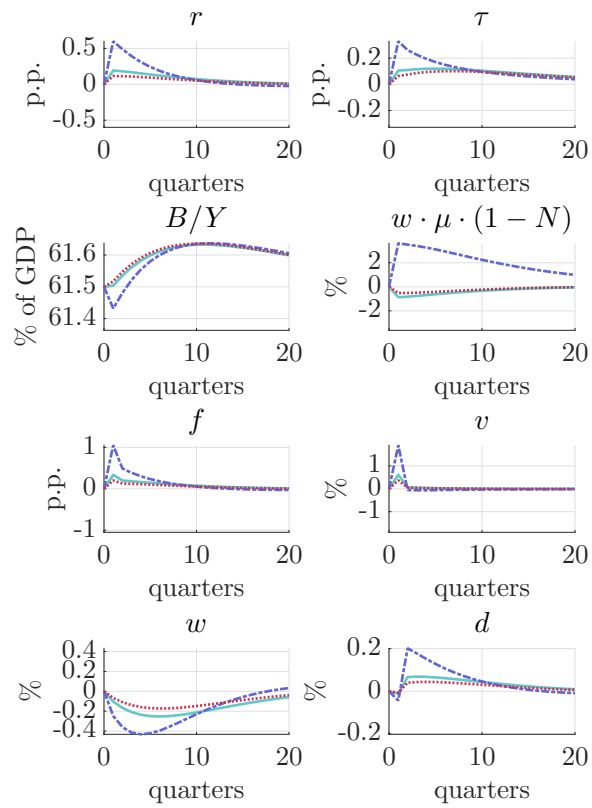
As Table 4 shows, the impact multiplier for output that is associated with the extension of unemployment benefits (which is equal to 1.14) is more than three times larger than the analogous number for government expenditures (that equals 0.37) and more than five times larger than the impact multiplier that corresponds to transfers (which is equal to 0.22). As the second column of Table 4 indicates, the differences between cumulative output multipliers are smaller but, nevertheless, the value that corresponds to the stimulus generated by a rise in unemployment benefits is still larger than for the remaining two policy instruments. As displayed in the last two columns of Table 4, this relatively large output response associated with higher unemployment benefits can be attributed, to a substantial (and positive) reaction of aggregate consumption. An analogous (although significantly weaker), mechanism explains the output response to stimulus based on transfers. Finally, positive output response to government expenditures cannot be attributed to the reaction of aggregate consumption because it is negative. Its main drivers, as the resource constraint (i.e. equation 5) indicates, are: mechanical effect of a rise in government consumption  $G_t$  and firms' investment in job creation  $v_t$  (for the latter see the corresponding transition path displayed in Figure 2).<sup>8</sup>

The output effects of higher transfers and unemployment benefits, by contrast, do not rely on the mechanical effect of higher demand generated by government consumption  $G_t$  and private spending becomes the main determinant of the corresponding multipliers. To understand the difference between the reactions of aggregate consumption to those two stimuli, let us decompose the average MPC in

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<sup>8</sup>The impact of price adjustment costs is negligible in this case so they are not listed among drivers of output dynamics.

Figure 2: Impulse response functions of prices and variables related to fiscal policy, firms and labor market



Notes: To analyze the figure use the legend attached to Figure 1. The panels above display the responses of the following variables to fiscal policy shocks:  $r$  - real interest rate,  $\tau$  - labor tax rate,  $B/Y$  - public debt to GDP,  $w \cdot \mu \cdot (1 - N)$  - aggregate government spending on unemployment benefits,  $f$  - job-finding rate,  $v$  - vacancies posted by firms,  $w$  - real wage and  $d$  - profits of firms.



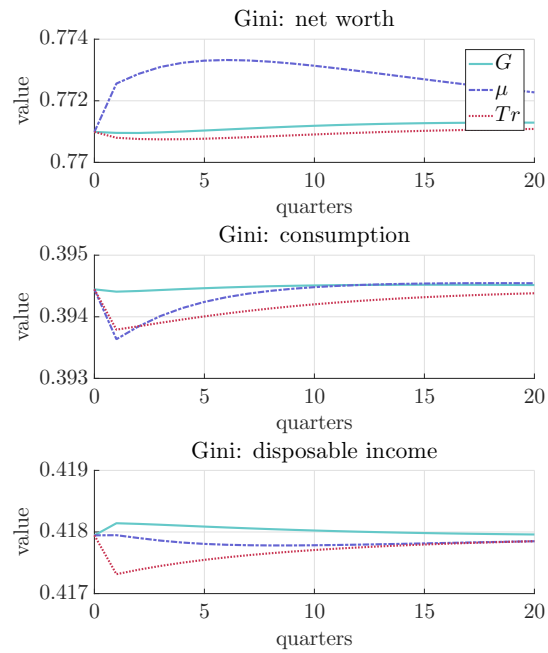
the economy (which, as mentioned above, equals to 0.158) into numbers that correspond to the employed and unemployed agents. More specifically, the former equals to 0.139 (on average), while the latter is equal to 0.443. Therefore, the consumption response of an average unemployed household that receives a dollar of unemployment benefits is almost three times larger than the reaction of spending that corresponds to average household that receives a transfer equal to one dollar. In a sense, unemployment benefits target high-MPC households which is different from the universal, non-targeted character of transfers. Moreover, higher unemployment benefits lower the relative income loss associated with unemployment spells and therefore reduce precautionary motives which, as a consequence, boosts household spending. All those factors, in turn, explain the large difference between aggregate consumption responses to those two stimuli presented in Figure 1.

Additionally, higher demand of households associated with either unemployment benefits or transfers leads to an upward adjustment of output under price rigidities. This, in turn, makes firms post more vacancies, which increases job-finding rates (see Figure 2) and lowers unemployment. The former decreases precautionary motives related to a drop in unemployment risk and boosts household demand even further. The latter works in the same direction: given that the average consumption of unemployed household in the model is 20% lower than the analogous value for employed household, the change in the composition of households driven by the increase in the pool of employed consumers automatically leads to higher private spending.

Note that, as Figure 2 displays, those two forces that raise household spending (i.e. higher job-finding rates and lower unemployment) are also present when the stimulus is driven by higher government expenditures, as it increases both job-finding rates and employment. Their positive impact, however, is in this case outweighed by mechanisms that crowd out private spending: higher tax rates and real interest rates and lower real wages (see Figure 2 ).

Let us now turn to impulse responses of Gini indices related to wealth, consumption and income inequality, which are displayed in Figure 3. It can be seen that the reaction of all three dimensions of inequality to a rise in government spending is negligible and therefore I skip them in my analysis. As shown in the top panel of Figure 3, the extension of unemployment benefits induces a sharp increase in wealth inequality when compared to government spending and transfers. This can

Figure 3: Impulse response functions, Gini indices



Notes: The impulse response functions are labeled with  $G$  (stimuli generated by government spending),  $\mu$  and  $Tr$  (unemployment benefits and transfers, respectively).

be explained with a substantial reduction in precautionary motives in that scenario which, in turn, is driven by factors discussed above: a decrease in unemployment risk and a rise in income during unemployment spells.<sup>9</sup> Note that weaker precautionary motives and the associated reduction in asset positions affect mainly households with low wealth. The impact of reduced precautionary motives on wealthier household is less pronounced because their resembles the one exhibited by a fully insured household. At the same time, higher real interest rates incentivize wealthy consumers to increase their asset positions to soak up the rise in government debt issued to finance the stimulus. All this leads to a rise in wealth inequality. Given the consumption-savings choice faced by households, the simultaneous reduction in consumption inequality driven by higher unemployment benefits (middle panel in Figure 3) can be seen as a different side of the same coin. Moreover, note that transfers lower consumption inequality, too. This occurs because households featuring low consumption levels feature higher MPC and therefore spend a larger proportion of the received sum on consumption than high-consumption households that exhibit lower MPC.<sup>10</sup>

Both stimuli (unemployment benefits and transfers) reduce income inequality, although the impact of the latter is significantly larger and it is negligible for the former. This happens because higher transfers boost disposable incomes equally across the distribution of agents which decreases the convexity of the Lorenz curve and leads to a drop in the value of the corresponding Gini index. The effect of unemployment benefits on income inequality is, however, more subtle: note that unemployment benefits redistribute resources from employed to unemployed agents and therefore the upward shift of the Lorenz curve for incomes of the latter is accompanied with a downward shift of that curve for the former, which explains why the corresponding Gini index barely changes.

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<sup>9</sup>Notice that the former (given the positive responses of job-finding rates and employment) is present for the remaining stimuli, too. Nevertheless, the rise in job-finding rates and employment is most pronounced for the stimulus driven by higher unemployment benefits.

<sup>10</sup>This occurs because consumption levels are positively correlated with wealth levels and because consumers with lower stock of assets feature higher MPC (as they are closer to the liquidity constraint).

Table 5: Business cycle moments: model vs. data

|                        | Std. deviations |       | Corr. with $Y$ |       | Autocorr.   |      |
|------------------------|-----------------|-------|----------------|-------|-------------|------|
|                        | model           | data  | model          | data  | model       | data |
| Output                 | <b>0.015</b>    | 0.015 | <b>1.00</b>    | 1.00  | <b>0.69</b> | 0.87 |
| Consumption            | <b>0.017</b>    | 0.013 | <b>0.99</b>    | 0.86  | <b>0.74</b> | 0.87 |
| Unemployment           | <b>0.014</b>    | 0.007 | <b>-1.00</b>   | -0.88 | <b>0.69</b> | 0.91 |
| Labor market tightness | <b>0.015</b>    | 0.024 | <b>0.91</b>    | 0.88  | <b>0.42</b> | 0.92 |

## 5.2 Fiscal stimuli and macroeconomic stabilization

In this section I analyze the role of the discussed stimuli in macroeconomic stabilization. I first simulate the model in which fiscal policy is passive (in a sense that  $G_t$ ,  $\mu_t$  and  $Tr_t$  are equal to their values in the stationary equilibrium) where the source of macroeconomic fluctuations is aggregate shock to discount factors of households. Second, business cycle moments generated with the benchmark model are compared to their empirical counterparts. Third, I use discount factor shocks used for simulating the benchmark model and I simulate three alternative models in which fiscal policy becomes active and is governed with a countercyclical fiscal rule. More precisely, in each of the three models where fiscal policy is active, stimulus is financed with public debt (according to rule 11) and it is based on countercyclical changes to government spending in the first model (where  $\mu_t$  and  $Tr_t$  are time-invariant), on countercyclical changes to unemployment benefits in the second (where  $G_t$  and  $Tr_t$  are time-invariant) and on countercyclical shifts in transfers in third model (where  $\mu_t$  and  $G_t$  are time-invariant).

As mentioned, the benchmark model assumes passive fiscal policy and that business cycle fluctuations are driven by changes in demand of households, which are specified as the  $AR(1)$  process (see equation 9) where  $\rho_Z$  determines the persistence of demand shock that has normal distribution with mean 0 and standard deviation  $\sigma_Z$ . I use simulated method of moments to estimate the values of  $\rho_Z$  and  $\sigma_Z$  to match the selected business cycle statistics in the US.<sup>11</sup> Table 5 summarizes the results by comparing standard deviations, correlations with output and autocorrelations of four variables (output, consumption, unemployment and labor market tightness) between the model and the data.<sup>12</sup>

<sup>11</sup>The estimated values are:  $\rho_Z = 0.9499$  and  $\sigma_Z = 0.0102$ .

<sup>12</sup>I use empirical data from period 1967-2006. The end of the sample coincides with the beginning

Table 6: Output volatility over the business cycle

| Fiscal tool           | Std. deviation of $Y$ |
|-----------------------|-----------------------|
| Benchmark             | 1.53%                 |
| Government spending   | 1.45%                 |
| Unemployment benefits | 1.28%                 |
| Transfers             | 1.48%                 |

Note: Output volatility is expressed in terms of standard deviations from the steady state (in %).

Let us now turn to the stabilizing role of government spending, unemployment benefits and transfers.<sup>13</sup> In what follows, I simulate the model with aggregate shocks to discount factors in which fiscal policy is governed by the following countercyclical rule:<sup>14</sup>

$$\log G_t - \log G = -\Upsilon \cdot (\log Y_t - \log Y) \tag{14}$$

with  $\Upsilon > 0$ . In particular, I set  $\Upsilon = 1$  in my simulations, which implies that a 1% deviation of output from its steady state value induces a 1% deviation (with the opposite sign) of government purchases from their value in the stationary equilibrium. Table 6 reports the results: it shows that unemployment benefits are most effective in stabilizing output over the business cycle (i.e. it mitigates output drops in recessions and lowers GDP jumps during booms), which is not surprising given the output effects of unemployment benefits discussed in Section 5.1.

## 6 Conclusions

This paper compared the aggregate and distributional effects of stimulus packages based on three fiscal instruments: government spending, unemployment benefits and transfers. To analyze those policies, I embedded the Diamond-Mortensen-Pissarides

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of the Great Recession (and is consistent with the moment when the data on distributional statistics reported in Table 3 were collected). The beginning of the sample coincides with the first year for which the Barnichon index is reported (used for proxying the number of posted vacancies when computing the empirical value of market tightness in my paper). See Barnichon (2010) for details.

<sup>13</sup>Admittedly, the short-run stabilization is usually performed by monetary policy but as the recent two decades show, its tools may become constrained by the ZLB which gives rise to a stabilizing role of fiscal policy.

<sup>14</sup>I use the analogous rules for transfers and unemployment benefits, such that both 14 and 13 for transfers (and 12 for unemployment benefits) are satisfied.

model of frictional labor market into the Heterogeneous Agent New Keynesian framework and I calibrated the resulting model to match the moments characterizing the US economy.

Model simulations indicated that extensions of unemployment benefits feature significantly larger output multipliers than stimuli generated by a rise in government expenditures or transfers. I argued that this difference can be explained by the response of private consumption, which is characterized with a significantly higher multiplier for unemployment benefits than for stimuli based on transfers and government spending. This, in turn, was attributed to the character of redistribution that occurs during the extension of unemployment benefits, which involves a transfer to the unemployed (featuring high MPC levels) and to reduction of precautionary motives. Moreover, I found that this type of stimulus significantly increases wealth inequality and lowers consumption inequality and leaves income inequality almost unchanged. At the same time, my simulations showed that higher transfers barely affect wealth inequality and they reduce both consumption and income inequality. I also showed that government spending has no significant impact on all three inequality measures. Finally, I quantified the role of the analyzed stimulus packages in macroeconomic stabilization and I found countercyclical changes to unemployment benefits are most effective in dampening business cycle fluctuations.

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# Appendix

## Wage rule: derivation and estimation

The assumption  $A_t = \bar{A} = 1$  is applied to reformulate the wage rule from Den Haan et al. (2018) ( $\tilde{w}_t$  is nominal wage and  $\omega_A, \omega_0$  are parameters):

$$\tilde{w}_t = \omega_0 \cdot \left(\frac{A_t}{\bar{A}}\right)^{\omega_A} \cdot \bar{A} \cdot \left(\frac{P_t}{\bar{P}_t}\right)^{\omega_\Pi} \cdot \bar{P}_t = \omega_0 \cdot \left(\frac{P_t}{\bar{P}_t}\right)^{\omega_\Pi} \cdot \bar{P}_t$$

Rewriting:

$$\begin{aligned} \tilde{w}_t &= \omega_0 \cdot \left(\frac{P_t}{\bar{P}_t}\right)^{\omega_\Pi} \cdot \bar{P}_t = \omega_0 \cdot \left(\frac{P_0 \cdot \Pi_1 \cdot \Pi_2 \cdot \dots \cdot \Pi_t}{P_0 \cdot \bar{\Pi}^t}\right)^{\omega_\Pi} \cdot P_0 \cdot \bar{\Pi}^t \\ &= \omega_0 \cdot \left(\frac{P_0 \cdot \Pi_1 \cdot \Pi_2 \cdot \dots \cdot \Pi_{t-1}}{P_0 \cdot \bar{\Pi}^{t-1}}\right)^{\omega_\Pi} \cdot P_0 \cdot \bar{\Pi}^{t-1} \cdot \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\omega_\Pi} \cdot \bar{\Pi} \\ &= \tilde{w}_{t-1} \cdot \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\omega_\Pi} \cdot \bar{\Pi} \end{aligned}$$

which in the analyzed stationary equilibrium in which  $\bar{\Pi} = 1$  gives:

$$\tilde{w}_t = \tilde{w}_{t-1} \cdot (\Pi_t)^{\omega_\Pi}$$

which divided by  $P_t$  yields:

$$\frac{\tilde{w}_t}{P_t} = \frac{\tilde{w}_{t-1}}{P_t} \cdot \frac{P_{t-1}}{P_{t-1}} \cdot (\Pi_t)^{\omega_\Pi} \iff w_t = w_{t-1} \cdot (\Pi_t)^{\omega_\Pi - 1}$$

which is equation 4.

To estimate parameter  $\omega_\Pi$  I reformulate the equivalent equation which is displayed above:

$$\begin{aligned} \tilde{w}_t &= \tilde{w}_{t-1} \cdot (\Pi_t)^{\omega_\Pi} \\ \implies \log \tilde{w}_t - \log \tilde{w}_{t-1} &= \omega_\Pi \cdot (\log \Pi_t - \log \bar{\Pi}) \end{aligned}$$

I use the OLS to estimate the value of  $\omega_\Pi$ . The series used in the estimation are: Average Hourly Earnings of Production and Nonsupervisory Employees from 1964 to 2006, (quarterly, S.A.) and Consumer Price Index for All Urban Consumers (All

Items in U.S. City Average, 1964-2006, quarterly, S.A.) and  $\bar{\Pi}$  is the average CPI inflation in years 1964-2006.

## Tax-financed stimuli

This section discusses the results that correspond to those displayed in the main text for the model in which stimuli are tax-financed.

Figure 4: Impulse response functions, main economic aggregates, tax-financed stimuli

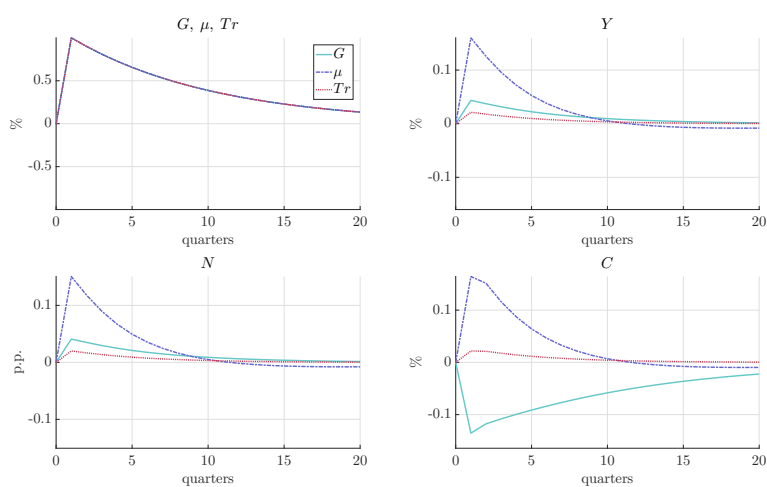


Figure 5: Impulse response functions of prices and variables related to fiscal policy, firms and labor market, tax-financed stimuli

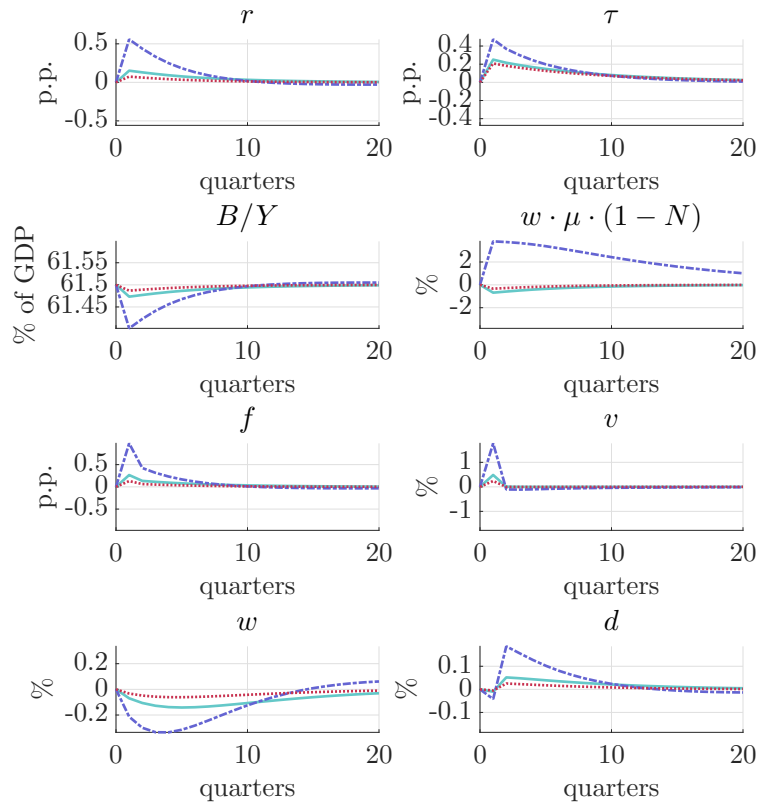


Figure 6: Impulse response functions, Gini indices, tax-financed stimuli

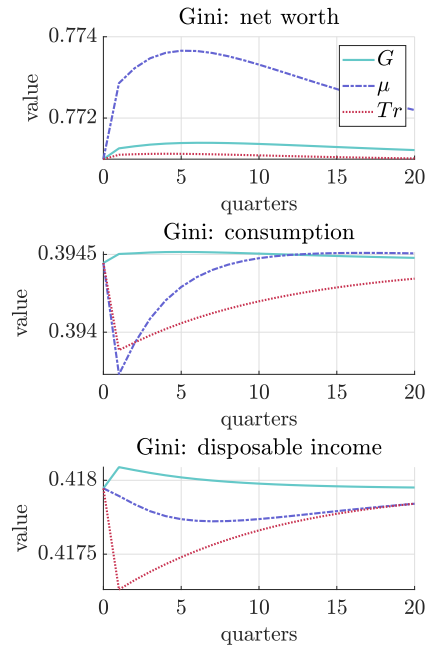


Table 7: Output and consumption multipliers, tax-financed stimuli

|                         | Output    |            | Consumption |            |
|-------------------------|-----------|------------|-------------|------------|
|                         | on impact | cumulative | on impact   | cumulative |
| Government expenditures | 0.29      | 0.21       | -0.75       | -0.79      |
| Unemployment benefits   | 1.06      | 0.45       | 0.91        | 0.44       |
| Transfers               | 0.14      | 0.09       | 0.11        | 0.09       |