When Inequality Matters : Distributional Issues under Optimal Fiscal Response to a Monetary Shock*

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Abstract

We evaluate what should be the optimal simple fiscal response to a monetary shock when inequality and redistribution matter. Due to persistent high indebtedness, unemployment and increasing inequality, the evolution of the income and wealth distributions has become essential to assess the coordination of fiscal and monetary policies. To deal with these distributional issues, we study welfare-maximising fiscal response to a monetary shock using a HANK model with search and matching frictions calibrated on US data. The main results show that the most welfare improving response is through a decrease of labor income taxation. In spite of a worsening of the labor market, this leads to an overall positive macroeconomic expansion, while it provides some distributional welfare improvement for the entire wealth distribution and might trigger a trade-off between higher inequality or higher unemployment.

Keywords: Fiscal Policy, Monetary Policy, Inequality, Heterogeneous Agents

JEL Codes: E21; E62;E52

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1 Introduction

The need for coordination between fiscal and monetary policies has been well known for many years now. While interactions between these two policy areas have important consequences on both macroeconomic and distributional outcomes a perfect synchronisation is difficult because of economic fluctuations, political constraints and electoral pressure. The present paper contributes to this important issue by questioning the repercussion of this interaction. The paper's objective is to identify the optimal simple reaction by the fiscal authority to an unexpected monetary shock. Importantly, some fiscal policy tools might prove inefficient and worsen aggregate and distributional outcomes from an unexpected contractionary shock.

The question of fiscal-monetary interactions has been known for years and was already discussed by Friedman (1948), where fiscal and monetary authorities have often have most of the time their own achievement, and own agenda. Their diverging objectives may have opposite consequences. As Leeper (2010) noticed,

> "We have known at least since Friedman (1948) that monetary and fiscal policies are intricately intertwined and their distinct impacts are difficult to disentangle. [...] Recalcitrant behavior by one policy authority can easily thwart the other authority's efforts to achieve its objectives."

We investigate what should be the optimal simple fiscal response (and its magnitude) when the fiscal authority cares for inequality and redistribution. Indeed, since the latest global crisis, we observe, in many developed countries, an increase in indebtedness, unemployment, inequality while the use for public spending tools is restrained to avoid additional burden over the public indebtedness. In the meantime, political and economic debates focus more and more on income and wealth inequality, shares and redistribution. Many fiscal reforms and monetary policies were implemented to answer the crisis and stabilize the economy although these reforms have very different consequences on the economy. While the aggregate effects of these reforms are well-known for many years, little is known about the detailed distributional consequences of such policies.

With the increasing interest in including inequality and distribution into macroeconomic analysis, we do need to include inequality in the implementation and the study of interaction between of fiscal and monetary policies. In this paper, we aim to fill the lacuna in the literature of the distributional and inequality consequences of the fiscal and monetary policies' interactions. Thus, we study what would be the best fiscal tool and the magnitude of the response from the government.To do so, we use a New Keynesian heterogeneous agents model with idiosyncratic uncertainty and sticky prices. Our model also includes search and matching frictions on the labor market as in Albertini et al. (2020), Gornemann et al. (2016), Ravn and Sterk (2016). The model is calibrated to match key moments in the US economy, especially to reproduce the wealth distribution and inequality measures. The main experiment in this paper investigates the the optimal feedback parameter response from the government to a "MIT" - an unanticipated shock with a deterministic transition path - monetary shock, under two types of monetary regimes. One targets prices stability only, while the second policy targets unemployment stability in addition to prices stability as enunciated in Gornemann et al. (2016). The government can use labor and capital taxes as fiscal instruments to answer an unexpected contractionary monetary shock. These tax rates will then be driven by simple feedback rules as used in Schmitt-Grohe and Uribe (2007) and Philippopoulos et al. (2015), maximizing an aggregate welfare measure, where each tax fluctuates around its steady state value as a function of the gap between the current level of liabilities and their equilibrium level. To answer our research question, we use the method developed in Achdou et al. (2017) to solve heterogeneous agents model in continuous time.

We know that both fiscal and monetary policy have very different effects on both aggregates variables on one's hand, inequality and redistribution on the other hand. The results show that the response of the fiscal policy differs depending on the chosen fiscal instrument and on the monetary policy implemented. We find that the most welfare improving response from the government is through labor income taxation rather than capital taxation. This leads to an overall positive impact on the aggregate variables through a decrease in the labor tax rate despite a worsening situation on the labor market. On the other hand, this policy is welfare's enhancing, as there is an overall welfare gain for all quintiles of the wealth distribution. In detail, this improvement is mainly due to the increase in consumption for employed individuals as their net income is increasing. However, when we consider only short-run distributional welfare measure, the benefit from the government response are even more important for the majority of the population, except for the Top 20% of the wealth distribution, as they tend to accumulate more wealth and decrease their consumption.

Moreover, we emphasize that any reaction from the government through a decrease in labor tax leads to a trade off between a decrease in inequality (through a distributional welfare gain, especially for the bottom of the wealth distribution) or a decrease in unemployment. In addition, we show that when the government uses labor income taxation to adjust in case of monetary shock, the government might overturn the monetary authority's objectives. The positive effects over unemployment and redistribution induced by a change of monetary policy, when the central bank also target unemployment stability in addition to prices stability, become negligible. Finally, we illustrate that these results are robust to alternate definitions of the labor income tax rate dynamic and changes in calibration elements.

Related Literature: Many papers in the literature examine the aggregate and distributional responses of fiscal and monetary policies and their interactions. To have a full overview of this literature, we need to have a full panel on what has already been done in both fiscal and monetary policies paper before targeting papers dealing with both types of policy. At first, papers such as Dyrda and Pedroni (2018), Domeij and Heathcote (2004), Heathcote (2005) and Acikgöz et al. (2018) investigates the consequences on both aggregate and redistribution whether targeting fiscal policies optimality or not. Domeij and Heathcote (2004) investigates the welfare gain of capital tax reduction. Indeed, their main finding is that while a capital tax cut implies welfare gains in a representative agent economy, it leads to welfare losses for most of the households in a heterogeneous agents economy. However, they do not look at the dynamic effect of such policy on wealth distribution, while Heathcote (2005) consider the effects of a unique tax on both capital and labor income when an aggregate productivity shock occurs. Dyrda and Pedroni (2018) studies what should be the optimal path for capital and labor taxation when a social planner care for redistribution and equality. Acikgöz et al. (2018) analyses the optimal taxation on capital labor and debt by solving a Ramsey problem, where they conclude that the optimal capital tax should be lower, debt and labor tax higher than the actual values in the US.

For the study of the consequences of monetary policy, a lot of papers focus on either positive analysis or optimal policies implications. Gornemann et al. (2016), Kaplan et al. (2018) Auclert (2017), Hanson et al. (2006). Hanson et al. (2006) study the empirical consequences of monetary policy in the US on cross sectional distribution of state economic activity. They conclude that expansionary policy benefit less from such policy in case of slow growth and worsen the gap between region for growth rate, i.e for state at the bottom of the distribution. Gornemann et al. (2016) analyse the distributional consequences of a conventional monetary policy in a New Keynesian framework with households heterogeneity. Their founding leads to a majority of individuals favour a monetary policy based on unemployment stabilization over a price stability. The role of distribution in the transmission of monetary policy shock to consumption is explained in Auclert (2017), through three different channels. Leading to a decomposition of consumption change into a contribution of each channel, it is shown that the individuals who benefit the most from the policy are the ones with higher marginal propensity to consume.

The closest papers to this work are Philippopoulos et al. (2015), Sun and Zhou (2018), Le Grand et al. (2020) and Bhandari et al. (2018). Sun and Zhou (2018) investigates the long-run impact of both fiscal-monetary policies on aggregates, inequality an average wealth in a model with idiosyncratic uncertainty for households. They concludes that fiscal and monetary have distinct effects on the variables of interest. We depart from their paper by looking at the distributional consequences in detail and over the whole transition. The work of Philippopoulos et al. (2015) studies the optimal simple response of monetary and fiscal policy in a representative agents model with sticky prices where they investigate the consequences on aggregate level. Le Grand et al. (2020) investigate the redistributive role of optimal monetary policy while taking into account that the role of the fiscal tools is crucial. This paper differs from them by taking into account the importance of labor market frictions in the evolution of the economy and redistribution and study in detail the distributional welfare gain or losses for the whole distribution. Finally, Bhandari et al. (2018) explores the role of redistribution in the definition of a Ramsey plan to determine the optimal monetary-fiscal policy (nominal interest rate, labor income taxation and lump-sum tax) in a HANK model. While they investigate the differences between the optimal Ramsey plan when redistribution is taken into account compared to a representative model, they lack the study of the evolution of wealth distribution and consumption.

The rest of the paper is organized as follows. Section 2 presents the different elements in our baseline economy. Section 3 deals with the properties of our model, presenting the calibration and how our model succeeds to reproduce key moments in the US economy. Section 4 the main results of the paper and section 5 presents alternate policy experiments and sensitivity analysis. Finally, Section 6 concludes.

2 The Framework

We built a continuous time framework based on Albertini et al. (2020), Gornemann et al. (2016), Ravn and Sterk (2016) . The economy is composed of a continuum of infinitively-lived households, normalized to ones, separated in two categories (working population and entrepreneurs), firms and government.

2.1 Labor Market

There are both unemployed workers and vacant jobs. The numbers of matches in the economy is determined by the matching function :

$$M(U_t, v_t) = \chi U_t^{\alpha} v_t^{1-\alpha}, \tag{1}$$

where U_t and v_t are respectively the unmeployment rate and the vacancy rate, χ is the matching efficiency parameter and α the matching curvature. We denote λ_u, the exogeneous job separation rate for a worker and define the endogenous job finding-rate $\lambda_{e,t}$ on the household's side and job filling rate q_t for a firm are then given by the following equations, where the labor market tightness $\theta_t = \frac{v_t}{U_t}$:

$$\lambda_{e,t} = \frac{M(U_t, v_t)}{U_t} = \chi\theta^{1-\alpha} \text{ and } q_t = \frac{M(U_t, v_t)}{v_t} = \chi\theta^{-\alpha} \tag{2}$$

Thus, the evolution of unemployment rate is given by :

$$\dot{U}_t = \lambda_u \left(1 - U_t\right) - \lambda_{e,t} U_t$$

2.2 Households

There is a continuum of infinitively-lived heterogeneous agents distributed among two categories, entrepreneurs in proportion $\Omega_t \in [0, 1]$ and the working population in proportion $(1 - \Omega_t)$ where they can be either employed or unemployed. Each agent maximizes its intertemporal utility function, discounted at rate ρ_j, where $j = UI, UP, EI, EP, F$ (standing respectively for impatient unemployed, patient unemployed, impatient employed, patient employed an entrepreneurs (or firm owners)) and subjected to their individual budget constraint.

$$\max_{c_t^{i,j}, n_t^{i,j}} \mathbb{E}_0 \int_0^{\infty} e^{-\rho_j t} u(c_t^{i,j}, n_t^{i,j}) dt, \tag{3}$$

Households'utility is a function of $c_t^{i,j}$, their individual consumption with wealth i and in category j, and $n_t^{i,j}$ represents either the individual labor supply if the individual is employed or the fixed amount of time looking for a job [1] if the individual is unemployed. Moreover, the preferences of an entrepreneurs will only be a function of its consumption. Thus, we define the binary operator $1_{e=1}$ such that it takes the

[1] When unemployed, $n_t = \overline{n}$ i.e it will remain fixed to the initial individual labor supply determined for employed agents.

value 1 if an individual is in the working population and 0 if he is an entrepreneurs and obtain the general separable preferences for any individual in the economy :

$$u(c,n) = 1_{e=1}\left(\log(c) - \omega\frac{n^{1+\psi}}{1+\psi}\right) + (1-1_{e=1})\frac{c^{1-\gamma}}{1-\gamma}, \tag{4}$$

with ω the labor disutility, ψ the inverse of the Frisch elasticity of labor supply and γ, the coefficient of relative risk aversion of entrepreneurs.

In addition to the discount factor heterogeneity, there are other sources of individual heterogeneity in the economy, leading to multiple sources of revenue. Firstly, all agents differ in their wealth, denoted a, remunerated at real interest rate r_t and taxed at rate τ_t^b. The level of asset held by each individual is driven by the borrowing constraint $a \geq \underline{a}$, where $-\infty < \underline{a} \leq 0$.

The working population faces two heterogeneity levels in both their labor situation, where they can either be employed or unemployed and in their discount rate, where they can either be patient or impatient. In both cases, agents fluctuate between the different situations following Poisson processes.

Employed agents supply labor endogenously, paid at equilibrium wage w_t and taxed at rate τ_t^w. Finally, employed households are also subjected to lump-sum tax. In case of unemployment, individuals receive unemployment benefit, fixed over time as a fraction of the initial equilibrium wage. Thus we obtain the following budget constraint for both types of agents in the working population. For employed individuals, we have :

$$\dot{a}_t = (1-\tau_t^b)r_t a_t + (1-\tau_t^w)w_t n_t - T_t^e - c_t, \tag{5}$$

For unemployed agents, we obtain :

$$\dot{a}_t = (1-\tau_t^b)r_t a_t + \mu\overline{w} - c_t, \tag{6}$$

On the other side, individuals can become entrepreneurs at rate λ_{Ent}, where they will face a discount rate ρ_e and loose their status at separation rate σ_e. While they do not receives any labor income, entrepreneurs receive the total amount of profit generated in the economy which is redistributed among them. Thus, their budget's constraint is :

$$\dot{a}_t = (1-\tau_t^b)r_t a_t + \Pi_t^E - c_t, \tag{7}$$

2.3 Firms

2.3.1 Intermediate Good Producers

Each intermediate firm creates jobs and produce intermediate good y_t^I, sold at the final good producer at price p_t^I, using the following production function :

$$y_t^I = Z_t n_t \tag{8}$$

Each producer posts vacancies that will be filled at rate q_t. The cost of posting each vacancy is denoted ξ. As each intermediate firm discounts profits at rate r_t, we can write the value function of one intermediate firm, denoted J_t, given by the following HJB equation :

$$r_t J_t = p_t^I Z_t n_t - w_t n_t + \lambda_u \left(V_t - J_t\right) + \partial_t J_t$$

We have the same HJB-type equation for a single vacancy $V(t)$,

$$r_t V_t = -\xi + q_t \left[J_t - V_t\right] + \partial_t V_t$$

As we have free entry condition, i.e $V_t = 0$, we finally obtain

$$\left(r_t + \lambda_u\right) J_t = p_t^I z_t n_t - w_t n_t + \partial_t J_t \text{ and } \xi = q_t J_t \tag{9}$$

The aggregate profits generated by all intermediate producers is :

$$\Pi_t^I = (1 - U_t)\Omega_t \left(p_t^I z_t - w_t\right) n_t - \xi v_t \tag{10}$$

2.3.2 Final Good Producers

There is a continuum final good producer, indexed k, producing a differentiated good using as input intermediate good y_t^I. Thus, the production function of each final producer is

$$y_t(k) = y_t^I(k).$$

We define the demand for the final variety as $y_t^d(k) = \left(\frac{P_t(k)}{P_t}\right)^{-\epsilon} y_t^d$, where $P_t(k)$ is and P_t the aggregate price index and y_t^d the total demand for the final good.

Although, each final-good producer is subjected to Rotemberg adjustment costs:

$$\Theta\left(\frac{\dot{P}_t(k)}{P_t(k)}\right) = \frac{\theta}{2}\pi_t^2 y_t^d(k)$$

Moreover, the profit of each retailer is given by :

$$\Pi_t^F(k) = \left[\frac{P_t(k)}{P_t} - P_t^I - \frac{\phi}{2}(\pi_t)^2\right] y_t^d(k) \tag{11}$$

As we assume symmetry between the final-good producers and using the recursive problem of the retailer, we can determine the optimal intermediate price condition. We then obtain :

$$\frac{1}{\theta}\left[1-(1-p_{,t}^I)\epsilon\right] + \dot{\pi}_t = \pi_t\left[r_t - \frac{\dot{y}_t^d}{y_t^d}\right] \tag{12}$$

We can note that, at the steady state, we have : $p_m = \frac{\epsilon-1}{\epsilon}$ and $\pi_t = \frac{\dot{P}_t(k)}{P_t(k)}$, the inflation. Finally, we can compute the aggregate profit generated by :

$$\Pi_t = \Pi_t^I + \Pi_t^F = \Omega_t(1-U_t)\left[(1-\frac{\theta}{2}\pi_t^2)z_t n_t - w_t n_t\right] - \xi v_t \tag{13}$$

2.4 Wage Determination

As we are in a search and matching friction model, the steady state real wage is determined using a Nash bargaining using a weighted average of the surplus of patient and impatient individual where unions negotiate a unique wage for all workers[2]. κ determined the proportion of impatient households among the working population and $(1-\kappa)$, the proportion of patient. We define β as the bargaining power of the worker and $(1-\beta)$ the firm's one. Then, equilibrium real wage (for patient and impatient agents) is implicitly determined by the next equation [3] :

$$w = arg\max_w \left[(1-\kappa)(W_e^p - W_u^p) + \kappa(W_e^i - W_u^i)\right]^\beta J^{1-\beta} \tag{14}$$

Outside of the steady state, as in Blanchard and Galí (2010), the real wage is determined by :

$$w_t = \overline{w}\left(\frac{y_t}{\overline{y}}\right)^\eta \tag{15}$$

Furthermore, we suppose that the individual labor supply is determined through a union's bargaining with the firms and is then common to all individuals regardless

[2] As among the population, there is both patient and impatient individuals, an equilibrium wage is determined for both patient and impatient individuals

[3] W_e^p, W_u^p are the value functions of respectively an employed and an unemployed patient agent while W_e^i, W_e^i are the same respective value functions of impatient households

their asset level or patience type. Thus, n_t is then

$$n_t = \left[\frac{w_t \left(1 - \tau_t^w\right) \overline{c_t}^{-1}}{\omega} \right]^{\frac{1}{\psi}}, \tag{16}$$

where $\overline{c_t}$ is the average consumption among employed individuals (patient and impatient).

2.5 Fiscal and Monetary Authority

The government finances its government spending G_t, the debt interest and the benefit given to unemployed households using three levels of taxation, labor and capital income tax rates denoted τ_t^b and τ_t^w and lump-sum taxes T_t [4]. While labor income taxation and lump-sum tax affects only employees, τ_t^b affects all individuals in the economy. Moreover, we force the level of public spending to remain fixed over time. As B_t is the aggregate level of debt, the budget constraint of the government is given by :

$$\dot{B}_t = r_t B_t + G_t + \Omega_t U_t \overline{w} \mu - \tau_t^b r_t B_t - \tau_t^w \Omega_t (1 - U_t) w_t L_t - T_t \tag{17}$$
$$T_t = T + \gamma_b \left(B_t - \overline{B}\right)$$

The evolution of the different proportional tax rates, τ_t^b and τ_t^w, is driven using the following feedback policy rules, as used in Philippopoulos et al. (2015) and Schmitt-Grohe and Uribe (2007):

$$\tau_t^w = \overline{\tau^w} + \phi_w \left(S_t - \overline{S}\right) \tag{18}$$
$$\tau_t^b = \overline{\tau^b} + \phi_b \left(S_t - \overline{S}\right), \tag{19}$$

$\overline{\tau^w}$ and $\overline{\tau^b}$ are respectively the steady state value of labor capital tax rates, $S_t = \frac{i_t b_t}{Y_t}$, the level of liabilities in the economy and $\overline{S}$ its steady state value. We will investigate an alternate policy taking into account unemployment surplus in addition to the liabilities surplus as stated in Equation 18 in the alternate policy section.

The monetary authority set the nominal interest rate i_t following a conventional monetary policy rule, as a function of the steady state real interest rate $\overline{r}$, the inflation

[4]The aggregate level of lump-sum taxes is : $T_t = \Omega_t(1 - U_t)T_t^e$.
At the steady state, $T_t = T_t^e = 0$

surplus $(\pi_t - \overline{\pi})$ and the unemployment surplus $\left(U_t - \overline{U}\right)$

$$i_t = \bar{r} + \phi_\pi \left(\pi_t - \bar{\pi}\right) - \phi_U \left(U_t - \bar{U}\right) + \epsilon_t^{MP} \tag{20}$$

$$i_t = r_t + \pi_t, \tag{21}$$

where the Taylor rule is also governed through an unexpected monetary shock ϵ_t^M. Our baseline economy is subjected to one transitory shock on monetary policy ϵ_t^M with speed of mean reversion to the initial steady state ν_M, where $\overline{\epsilon^M}$ is the steady state value of the monetary shock, which is set to zero.

$$d\epsilon_t^M = -\nu_M(\epsilon_t^M - \overline{\epsilon^M})dt \tag{22}$$

2.6 Equilibrium

Finally, there are two market clearing conditions given by the following equation where G_t is the distribution function for each wealth level and labor situations:

$$B_t = \int_{\underline{a}}^{\infty} a dG_t(a_i, j) \tag{23}$$

$$Y_t = \Omega_t(1 - U_t)\left[(1 - \frac{\theta}{2}\pi_t^2)Z_t n_t\right] - \xi v_t \tag{24}$$

3 Policy Strategy and Calibration

In this section, we present the policy experiment studied in this paper and the associated calibration strategy, based on US data.

[4]The addition of the unemployment surplus to the Taylor differ from it usual form, using the output gap. The inclusion of the unemployment surplus is twofold. Firstly, it allows to take into account the consequences of the monetary policy on the labor and allow the government to take this element into account to asses the effectiveness of its fiscal response. Moreover, as shown in many papers dealing with heterogeneous agents and later on in the distributional implication discussion in this work, the inclusion of unemployment and labor market frictions highlight the crucial role of precautionary savings to assess the evolution of agents saving decisions. Indeed, the higher risk of unemployment associated with a higher unemployment spell increase savings (and a fortiori decrease consumption) through a modification of precautionary saving behaviour.

3.1 Policy Strategy

Welfare Measure: In this paper, we want to investigate the different optimal fiscal response of the government when a monetary shock occurs under different monetary authority's objectives. To do so, we maximise welfare using a utilitarian social welfare criteria given by the ex-ante expected lifetime utility as in Chang et al. (2015) and Dyrda and Pedroni (2018) given by :

$$W = \mathbb{E}_0 \int e^{-\rho_j t} u\left(c_{j,t}, h_{j,t}\right) dG_0,$$

Then, we compare this measure, denoted W, to a the same welfare measure in case of monetary shock but no response from the government and to the status quo situation (with no monetary shock or fiscal reaction).

Policy implementation: Consecutively to a 1 % contractionary monetary "MIT Shock", i.e an unanticipated (zero-probability) monetary shock, we look for the value of ϕ_w and ϕ_b that will maximize the welfare measure enunciated above. The experiment for the two taxation rates will be conducted separately, i.e when the experiment focuses on the optimal reaction of one tax rate, the remaining fiscal instrument will remain at its equilibrium value. We restrict the range of study for ϕ_w and ϕ_b to $[0.05, 1]$ for two reasons. Firstly, we need to insure that the tax rates remain bounded (between 0 and 100%). Secondly, a very important response from the government would be too difficult to justify as stated in Schmitt-Grohe and Uribe (2007) [5].

3.2 Calibration

The main goal of this paper is to evaluate the distributional consequences of different fiscal response to several monetary policy intervention. To do so, the model is calibrated on a quarterly basis on US data between 1995 and 2007 as targeted in Dyrda and Pedroni (2018) and time is continuous. Table 1 summarizes the calibration.

3.2.1 Preferences and Production

Main preferences parameters are set using standard values in the literature. We set the coefficient of relative risk aversion γ at 0.25 as in Auray and Eyquem (2019), where a small value indicates a higher propension for entrepreneurs to accept risks

[5] Values above 1 for ϕ_w and ϕ_b where tested and does not changes the results, only affecting the amplitude of the reaction.

Definition & Parameters	Values	Sources
Coefficient of RRA Entrepreneurs γ	0.25	Auray and Eyquem (2019)
labor disutility ω	0.25	Calibrated
Frisch labor supply elasticity $\frac{1}{\psi}$	1	Kaplan et al. (2018)
Rotemberg adjustment Cost ϕ	36	Gornemann et al. (2016)
Price elasticity ϵ	6	Campolmi et al. (2011)
TFP scale parameter Z	1	Calibrated
Matching Efficiency χ	0.58	Calibrated
Matching Curvature α	0.5	Krussel et al. (2010)
Wage elasticity η	0.45	Gornemann et al. (2016)
Unemployment Replacement Rate μ	0.3	Nickell and Nunziata (2001)
Bargaining Power of Workers β	0.5	Campolmi et al. (2011)
Exogeneous separation rate λ_u	0.043	Albertini et al. (2020)
Ratio Public Spending Output $\frac{G}{Y}$	18%	Dyrda and Pedroni (2018)
Ratio Debt Output $\frac{B}{Y}$	63%	Dyrda and Pedroni (2018)
Discount Rate Impatient Household ρ_i	0.015	Albertini et al. (2020)
Discount Rate Patient Household ρ_p	0.00705	Albertini et al. (2020)
Switching rate btw time pref λ_k	0.003	Gornemann et al. (2016)
Separation rate from Entrepreneurship σ_E	0.065	Calibrated
Entry rate from Entrepreneurship λ_{Ent}	0.001	Albertini et al. (2020)
Response to Inflation ϕ_π	1.5	Gornemann et al. (2016)
Steady state capital tax rate τ^b	36%	Dyrda and Pedroni (2018)

Table 1 – Summary of calibration

and support aggregate fluctuations. The parameter that determines the coefficient of relative risk aversion for workers is set to 1 leading to a separable utility function with a logarithm form. The Frisch labor supply elasticity $\frac{1}{\psi}$ is set to 1 following Kaplan et al. (2018) and the labor disutility is calibrated so that the individual labor supply is equal to 1 at the steady state, giving us the value of 0.25. One of the sources of heterogeneity among households is rate of time preferences ρ_j. Except entrepreneurs, agents can switch between patient and impatient state following a two-states Poisson process as described in the following matrix, where exit from one state of patience is set to 0.003 as in Gornemann et al. (2016).

$$\Lambda_p = \begin{bmatrix} 1-\lambda_p & \lambda_p \\ \lambda_i & 1-\lambda_i \end{bmatrix}$$

The rates of time preferences for patient and impatient households (workers) are respectively equal to 0.00705 and 0.015 while it is set for entrepreneurs at 0.01 as calibrated in Albertini et al. (2020). The borrowing constraint $\underline{a}$ is exogenously set at -0.032. We normalize Z to 1.

The price elasticity ϵ is equal to 6, targeting a mark-up of 0.2 as in Campolmi et al. (2011) and a Rotemberg adjustment cost of 36 as in Gornemann et al. (2016).

3.2.2 Labor Market

There is second source of heterogeneity is through individual stochastic labor opportunity. In order to match the job finding and filling rate in the data, we target a labor market tightness θ of 0.7, which lead us to parametrize the matching efficiency χ to 0.58 and the matching curvature α to 0.5 as in Krussel et al. (2010). Thus, we obtain a vacancy cost posting ξ of 0.84. The job separation rate λ_u is set to 0.043 which is slightly lower than the value given in Challe (2019). This leads to a steady state unemployment rate of 8 % slightly higher compared to Gornemann et al. (2016), while the job-finding and filling rate are respectively equal to 0.49 and 0.69. As the switching process for the rate of time preferences explained above, individual labor market fluctuations follow a two states Poisson process, leading to the transition matrices presented bellow, where the first matrix is the transition matrix for workers into and out of unemployment while Λ_{Ent} is the transition matrix into and outside the firm owner status. the share of entrepreneurs will then remain fixed over time and is equal to 1.51%. In addition, unemployment benefits are calibrated such that an unemployed worker receives 30 % of the steady state wage, and the union bargaining power is equal to $\frac{1}{2}$ as in Campolmi et al. (2011).

$$\Lambda_l = \begin{bmatrix} 1-\lambda_{e,t} & \lambda_{e,t} \\ \lambda_u & 1-\lambda_u \end{bmatrix}, \; \Lambda_{Ent} = \begin{bmatrix} 1-\lambda_{Ent} & \lambda_{Ent} \\ \sigma_E & 1-\sigma_E \end{bmatrix}$$

The separation rate from entrepreneur status σ_E is fixed to 0.065 while the entry rate into entrepreneurship $\lambda_{Ent} = 0.001$ is calibrated following Albertini et al. (2020). Finally, we impose that when a firm owner looses its status, he automatically becomes either a patient or a impatient employed worker.

3.2.3 Government and Monetary Authority

Following Dyrda and Pedroni (2018), the public debt and public spending ratio to output are respectively set to 63% and 18 %, which are values widely accepted in the literature. Tax rate on capital is set to 36% leading to a labor income tax rate of 24.6%, which is slightly lower than the implicit tax rate targeted in Dyrda and

Pedroni (2018). As done in Gornemann et al. (2016), the response of the monetary authority to inflation surplus ϕ_π is 1.5, while ϕ_U, the reaction of central bank to unemployment gap is either set to 0.107 or to a more accommodative monetary policy toward unemployment when set to 0.5. Finally, the feedback parameter γ_b is set to 0.1 so that the reversion of debt to its initial steady state level is insured, while the mean speed reversion of monetary shock is set to 0.8.

Based on this calibration, we successfully match key moments in the wealth distribution and the labor market in the US economy, as shown in Table 2.

Variables	Target	Model	Source
Unemployment Rate	5.7 %	8.0%	Gornemann et al. (2016)
Job filling Rate	0.7	0.69	Campolmi et al. (2011)
labor Tax Rate	28 %	24.66 %	Dyrda and Pedroni (2018)
Gini Index	0.82	0.82	Dyrda and Pedroni (2018)
1^{st} Quintile	-0.2 %	-0.12 %	Dyrda and Pedroni (2018)
2^{nd} Quintile	1.1 %	1.74 %	-
3^{rd} Quintile	4.5 %	3.50 %	-
4^{th} Quintile	11 %	9.81 %	-
5^{th} Quintile	83.4%	85.07 %	

Table 2 – Model Performance - Inequality Measures

4 Main Results

This section presents the main results of this paper. Firstly, we will present the optimal government response to monetary shock on both aggregate and distributional level. The main element to be highlighted is that the response of the fiscal policy differs depending on the chosen fiscal instrument and on the monetary policy implemented based on the monetary authority's objectives.

4.1 What Optimal Fiscal Answer ?

As shown in Gornemann et al. (2016), monetary policy produces different aggregate and distributional consequences depending on the central bank objectives whether they target only price's stability or a more accommodative policy, i.e when unemployment stability is targeted along price stability. They have shown that a more accommodative policy is welfare improving compared to a monetary policy that targets only prices stability. In our paper, we managed to reproduce this result. However, what interests us is the optimal response of the fiscal policy consecutively to the same contractionary shock.

	$\phi_U = 0.107$	$\phi_U = 0.5$
Monetary Shock Only		
W.r.t Status Quo	-0.07099 %	-0.05769 %
Labour Income Tax Adjustment ($\phi_w = 1$)		
W.r.t Status Quo	0.37 %	0.25 %
W.r.t Monetary Shock	0.44 %	0.31 %
Capital Income Tax Adjustment ($\phi_b = 0.05$)		
W.r.t Status Quo	-0.07104 %	-0.05773 %
W.r.t Monetary Shock	$-4.87.10^{-5}$ %	$-4.02.10^{-5}$ %

Table 3 – Aggregate Discounted Welfare Measures

Table 3 presents the aggregate discounted welfare measure gains or losses of the economy under different scenarios. Firstly, we display the welfare deviation (in %) with respect to the status quo when the economy is only subjected to the monetary shock without any fiscal response and then, the aggregate welfare response when the government respond to the monetary shock through labour income taxation only (with respect to both status quo situation and the reference economy with the monetary shock). Secondly, the two last lines of the table display the welfare deviation with respect to the reference economy in case of capital income taxation as a fiscal instrument. In both cases, we present results under the two types of monetary policies presented earlier. We can see that, compared to the status quo, the more accommodative monetary policy is better off compared to the monetary policy targeting only price stability. When the government responds to the unexpected monetary shock, the optimal response occurs for a response through labour income taxation. This leads to a welfare improving results with respect to the initial situation (monetary shock only) and to a decrease in labour income taxation as shown in Figure 15. However, this answer thwarts the monetary authority's objectives. Indeed, the benefits obtained through a more accommodative monetary policy are canceled as the highest welfare measure is obtained under a coefficient of reaction to unemployment surplus set to $\phi_U = 0.107$. In this case, the optimal simple response is to have the highest possible reaction with the range value for ϕ_w (in our case $\phi_w = 1$) while the central bank focuses only on price's stability $\phi_U = 0.107$. This results concur with the long-run results of Sun and Zhou (2018). They show that, on the long-run, for a given level of inflation, a low labour income tax rate is welfare improving. This statement seems to be validated during the dynamics as, consecutively to a contractionary monetary shock, it is also welfare improving to decrease the labour income tax rate when the level of inflation is decreasing as well.

Based on this statement, we can display the aggregate and distributional consequences of the fiscal policy response chosen by the government maximising the aggregate welfare measure. From now on, the economy's response to the monetary shock only (as presented in Gornemann et al. (2016)) will be referred as the point of reference (and denoted in the figures as "Monetary Only") to compare the results under the different fiscal scenario presented earlier.

4.2 Aggregate Effects

Figure 1 and 2 show the response of the main economic aggregates to a contractionary monetary shock (with and without the optimal fiscal response from the government). Consecutively to this monetary shock, we have, as expected, an overall contraction of the economy, with an increase of the long-run real interest rate, the unemployment rate and debt, while all other values are decreasing such as consumption, output, wage and job-finding rate. Indeed, the long-run increase of the real interest rate leads to a tightening of consumption as present consumption is less profitable. This leads to a decrease in output and in inflation. The decrease in output then leads to an increase in unemployment (and decrease in the job-finding rate).

In Figure 2, we observe different reactions regarding consumption between the different labor categories. Indeed, as the wage of employed individual is decreasing, it leads to a decrease in their consumption, while for unemployed individuals,as the received unemployment benefit are fixed over time, they benefit from the increase of the real interest rate. Finally, in the same way, the consumption of entrepreneurs is increasing is mainly due to the increase in profits, who are only redistributed among entrepreneurs.

When the government responds to the monetary shock, we observe a turnaround for most aggregate variables compared to the economy of reference. Indeed, consecutively to the fiscal response, we have an increase of output, wage, labor supply and consumption, while at the same time we have a decrease of real interest rate. This observation coincides with the results of Bhandari et al. (2018), when we use labor income taxation to answer a negative shock (Bhandari et al. (2018) studied the consequences on the interaction between fiscal and monetary policy consecutively to a negative TFP shock leading to a decrease in output where we have the same reac-

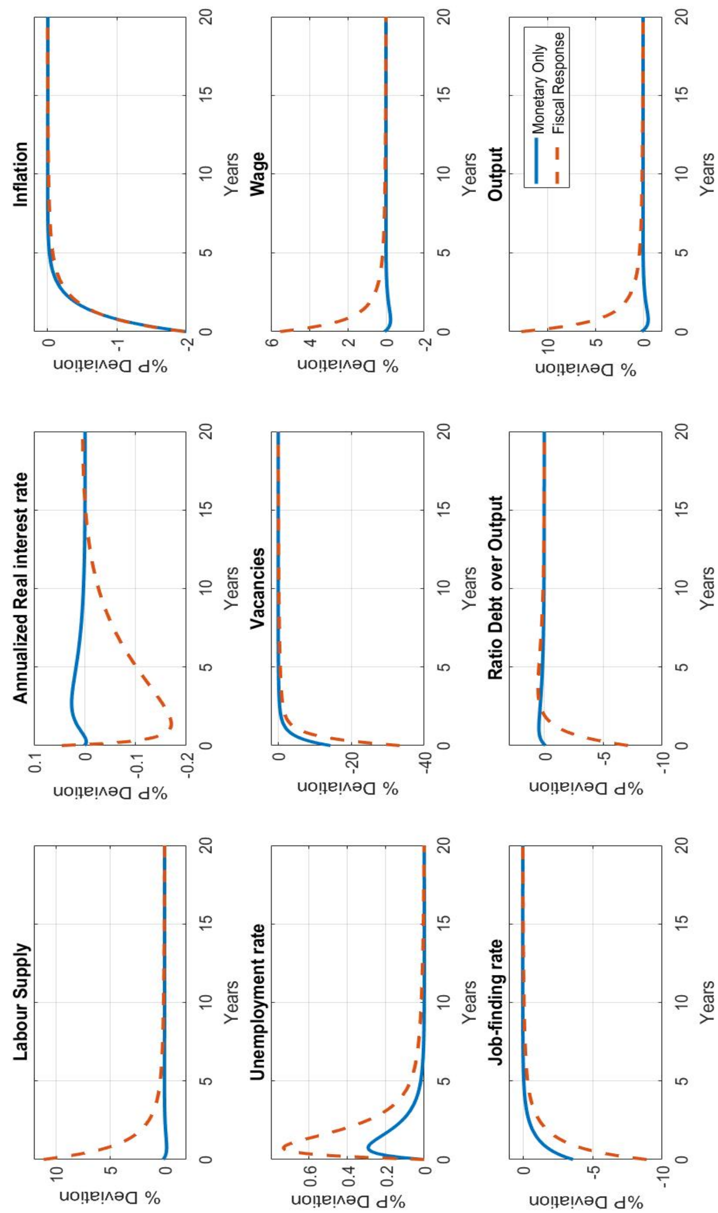


Figure 1 – IRF - Main Aggregate Variables - labor Taxation Adjustment

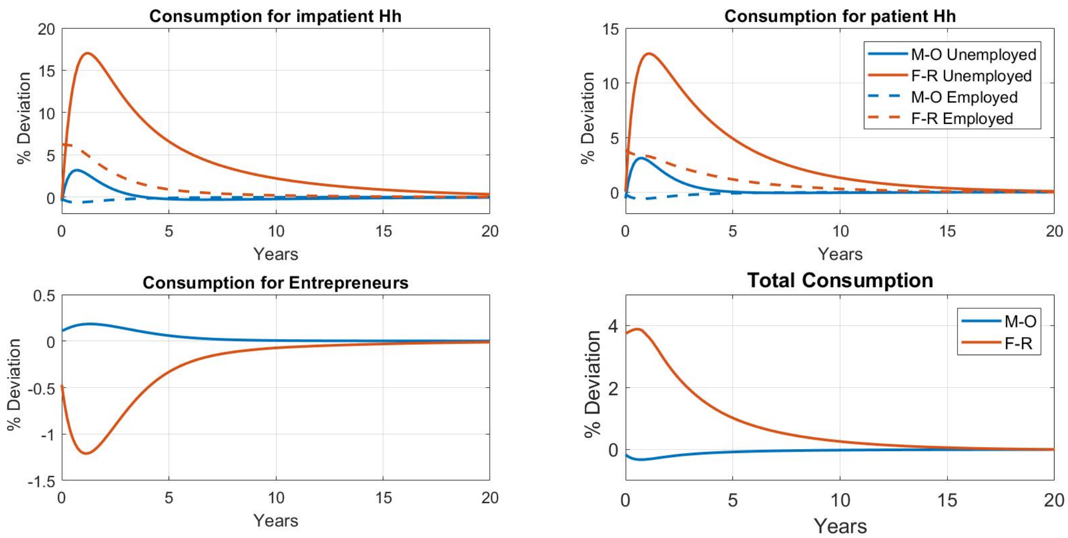


Figure 2 – IRF - Consumption Only - labor Taxation Adjustment

tion on output due to the contractionary monetary shock). However, for the labor market variables, debt and inflation have the same trend than with the monetary shock only or are even worsen by the change in fiscal policy. Indeed, the labor income tax is decreasing up to 4.5% as shown in Figure 15 in Appendix. This decrease in labor taxation is led by the decrease in nominal interest rate and the public debt to output ratio. As τ_t^w is decreasing, it immediately increases the net wage, which triggers an increase in consumption and in labor supply, which is in line with the results described in Le Grand et al. (2020). However, we differ, as shown later on, on the distributional point of view. Indeed, there are two opposite mechanisms. On one side the increase in net wage is directly increasing the individual labor supply, while it is reduced by the increase in consumption. However, the increase in the net wage has the upper hand, leading to the increase in labor supply. It translates into an increase in output. However, regarding the evolution of labor market values and debt, we observe that the fiscal response of the government worsen the "bad" reaction with respect to the monetary shock. Indeed, as the real interest rate is decreasing by -0.2%, the intermediate firms discount less the future which led to a positive impact on the number of vacancies. However, an other mechanism has the upper in our baseline economy, as the mark-up of each intermediate firm is decreasing, the firm cuts off the number of vacancies, leading to a higher unemployment rate and a smaller job-finding rate.

Finally, regarding the evolution of consumption, the decrease in labor income taxation triggers an increase of consumption not only for the unemployed households but also for the employed individuals. Indeed, as their net wages increase, it will translate into an increase of consumption. For the entrepreneurs, their consumption decreases mainly because of the decrease of the decrease in their total income due to the downfall of the real interest rate and the profits that are distributed to the entrepreneurs only.

4.3 Distributional Issues

Even if the aggregate effects have positive effects on the economy, distributional consequences are crucial in assessing the validity of the optimal policy response and not worsen the situation, specially for the poorest individuals. In the current section, we present the main distributional consequences of the optimal response from the government.

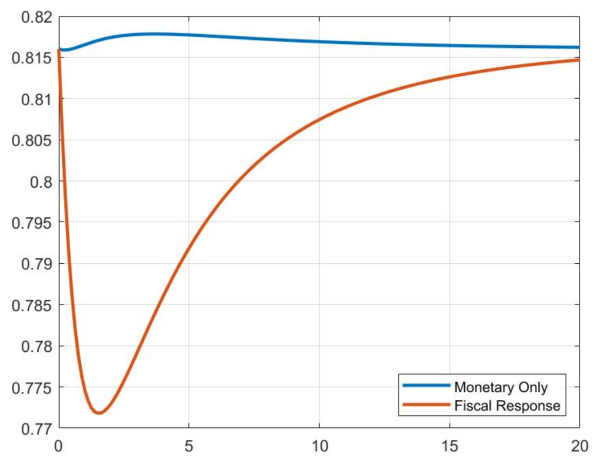


Figure 3 – Evolution of Gini Coefficient

As shown in Figure 3, the optimal fiscal response of labor income taxation leads to an important decrease of wealth inequality while the contractionary monetary shock provokes their increase. Indeed, the Gini index is decreasing up to 0.77. This decrease in inequality translates into the response of discounted welfare measures by quintile and by labor types.

Table 4 presents the main distributional welfare consequences for each quintile, regardless the patience and labor situation of the individuals. We know that a con-

	W.r.t Status Quo		W.r.t Monetary Shock
Quintiles	Monetary Shock	Opt. Fiscal Policy	Opt. Fiscal Policy
1^{st} Quintile	- 0.029	0.141	0.170
2^{nd} Quintile	- 0.049	0.156	0.204
3^{rd} Quintile	- 0.083	0.652	0.734
4^{th} Quintile	- 0.063	0.295	0.357
5^{th} Quintile	- 0.042	0.120	0.162

Table 4 – Distributional Welfare Consequences - By Quintiles (In %)

tractionary monetary shock lead to an overall increase in inequality and it translates into an overall decrease in discounted welfare for every quintile of the distribution as shown in Gornemann et al. (2016). Within our experiment, we note that the most important decrease is for the middle class (3^{rd} and 4^{th} quintiles), while in Gornemann et al. (2016)'s framework the individuals who suffer the most from the monetary shock are the poorest individuals.

The first two columns show the response of the welfare measure with respect to the status quo for both the monetary shock only and the monetary shock associated with the optimal fiscal response determined in the previous subsection. The last column illustrates the benefit (or losses) from the implementation of the fiscal policy with respect to the distributional consequences of the contractionary monetary shock only.

The optimal fiscal response through labor income taxation implemented by the government leads to an increase in the welfare measure for all the different quintiles of the wealth distribution with respect to the status quo(without any monetary shock or fiscal response) while the monetary shock only leads to an overall decrease in welfare. For example, the bottom 20 (the first quintile) see their welfare decrease by -0.029%, while the involvement of the government through labor income provokes a rise of welfare by 0.141%. This result can be translated into a net welfare increase of 0.170% with respect to the monetary shock.

However, this policy benefit mostly to the "middle-class" class households with a net increase of their welfare around 0.65%. The difference in the welfare changes are mainly led by the differentiated behaviour of each labor type and their distribution in the different quintiles. To emphasize this point, we display the response as illustrated in Figure 4

Figure 4 shows the response of the discounted welfare measure by labor types and wealth quintiles with respect to the status quo situation. The left panel shows the

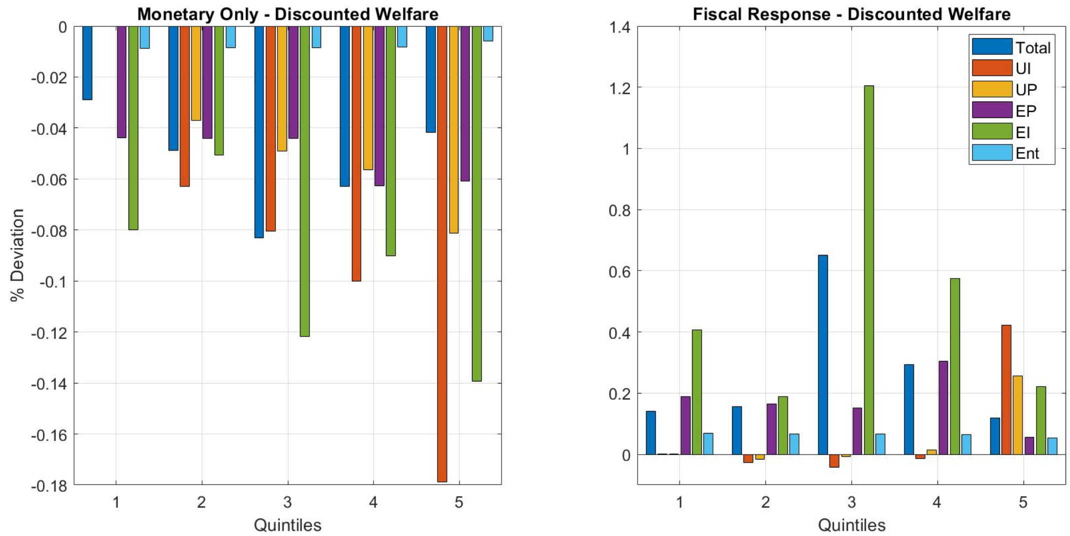


Figure 4 – Discounted Welfare Variation - By Quintiles and labor Categories (In %)

consequences of our point of reference, with the monetary shock only while the right one shows the response of the economy with both monetary shock and the optimal fiscal response. Firstly, we focus on unemployed individuals who are mainly present in the poorest quintiles. Indeed, the welfare of unemployed agents is increasing mainly because they possess a negative amount of wealth (for the 1^{st} quintile only) as described in Table 2. The decrease in the real interest rate consecutively to the fiscal response favour them as the future amount they will need to reimburse in the future will be lower.

Indeed, as shown in Figure 5, most unemployed households are present at the bottom of the distribution and the share of impatient agents are also widely the poorest. This leads to a small increase in welfare for the first quintile while quintile two and three tend to reduce their savings in order not to suffer from the reform as the real interest rate is decreasing.

Moreover, they do not benefit from the decrease in the labor income taxation as their unemployment benefits are fixed over time. In addition, as they are unemployed, they also suffer from the decrease in the job-finding rate, leading to a smaller probability of a higher future income (becoming employed) and a longer unemployment spell, which lead to a smaller increase in consumption that should normally arise due to precautionary saving behaviours. Finally, we observe that the more an unemployed is in a higher quintile, the more the fiscal reform is beneficial. This is even more true for impatient households as they favour more present over future consumption compared to patient individuals.

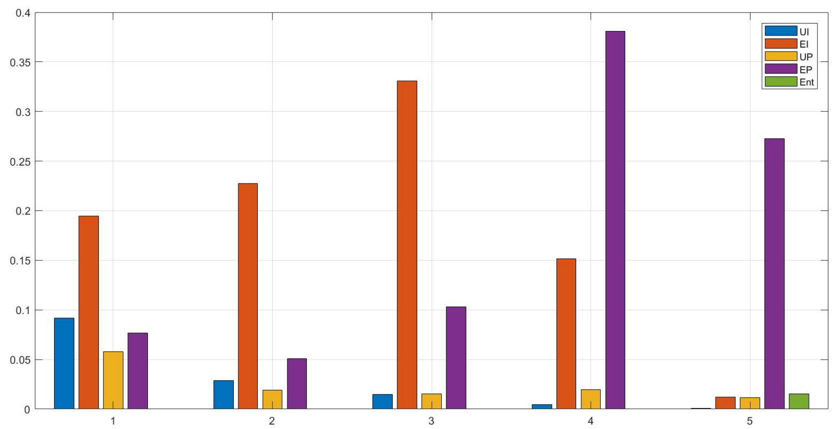


Figure 5 – Initial Share of labor types in each quintiles (In %)

The behaviour of employed agents differs from the unemployed ones as their two sources of income is directly affected by the fiscal policy and will benefit from the decrease in labor income taxation in addition to the negative consequences of the decrease in the real interest rate. With the monetary shock, there is a decrease in welfare for employed households (regardless their patience type, however the patient ones loose less than the impatient in case of monetary shock only) as shown in the left panel of Figure 4. On the right panel, the results show that the fiscal response provokes an increase of the discounted welfare. Indeed, as employed agents benefit from the increase in their net income, consumption increases immediately, however, as explained above, patient households favour less present consumption compared to the impatient households, explaining the smaller increase of their discounted welfare.

To understand the differences among the quintiles, we have to explain the different mechanisms that are at stake. Firstly, as the net labor income increases, the consumption increases as well, while as the same time, the real interest rate decreases, pushing even further the consumption. But on the other side, unemployment is rising and job-finding rate is decreasing, leading to an increase in precautionary behaviour from employed individuals. As they may face a bad income shock (i.e becoming unemployed), they not consume as much as possible and will continue to save despite the depreciation of the real interest rate r_t. This last mechanism is even more important for the poorest households, as the large majority of their total income comes from labor income, thus driving an even more strong precautionary saving behaviour in case of unemployment. Finally, if we focus on the impatient employed agents in the third quintile for whom the increase in welfare is the strongest (around 1.6%). For these agents, the positive consequences of the fiscal response through the increase in net wage has the upper hand over the precautionary saving behaviour. Moreover, this important increase allow to explain why the strongest response favour the third quintile in Table 4, as the majority of agents in this quintile are employed impatient agents as shown in Figure 5.

The case of entrepreneurs is slightly different from the rest of the population. While, they have a common source of income with the rest of the population through capital income, they also face a second source of revenue through the redistributed profit shared between the firms owner population. Indeed, this additional income leads to two additional behaviours. As shown in Figure 16, at the moment of the shock, the firm profits are increasing and the next period, it immediately decrease as soon as the wage and the intermediate prices are increasing. This leads to a decrease in their consumption.

Moreover, a fraction of their income will be used a precautionary savings. Indeed, entrepreneurs can loose their status with separation rate σ_{Ent} and become an employed worker again. The loss of their status will cause a decrease in their total income (as the vast majority of firms owners are in the Top 20 % of the distribution) but they will also benefit from the increase in the labor income consecutively to fiscal response of the government. However, the form of the utility function, associated to a higher propension to accept risks leads to an increasing welfare measure.

A short-run Analysis

The previous analysis relies mainly on a lifetime discounted welfare analysis, taking into account the full transition that is required to return to the initial steady state. So, a shorter-run analysis would be useful as the fiscal authority might be more interesting in short-term benefit of the fiscal reaction towards the monetary shock. We display on Figure 6, and we observe that we obtain different results compared to the results displayed in Table 4. We can see on Figure 6 that our discounted welfare measure evolves over time. Indeed, the fiscal response initiated by the government lead to an increase of the welfare measure but for the richest individuals of the wealth distribution.

Then, as soon as we run forward in time and take into account the dynamic of the different variables, the discounted welfare measure returns to the results presented in Table 4. To explain these differences between the short-run and the long-run results,

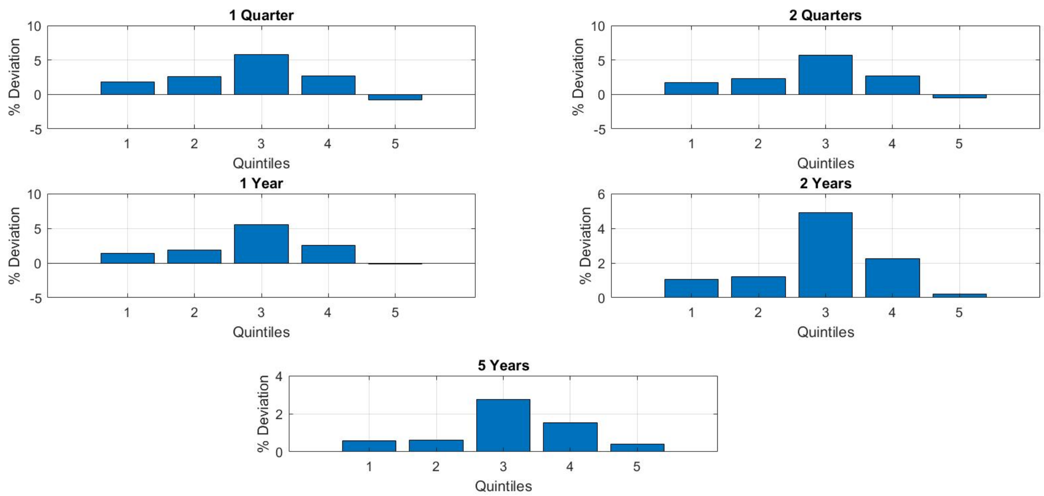


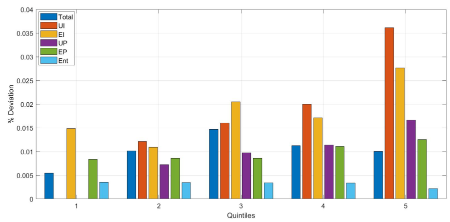
Figure 6 – Short-Run Discounted Welfare Variation - By Quintiles (In %)

we have to highlight that these differences concerns mainly the richest individuals, whose revenue comes mainly from capital income over labor income. Thus, at the moment of the shock, the real interest rate increases before decreasing immediately after. As r_t increases at $t = 0$, agents increase their savings to benefit from this change and decrease their consumption. But as soon as this interest rate decrease, the consumption rises again leading to a smaller decrease in welfare as time run forward, to reach the lifetime welfare measure described above. For the rest of the distribution, where individuals income rely mostly on labor income and fully benefit from the decrease in τ_t^w, see their welfare increase immediately.

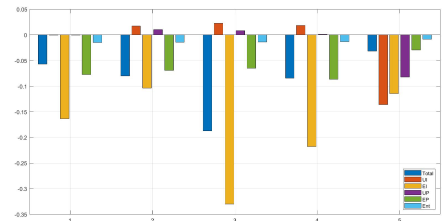
4.4 The consequences on the monetary authority

While the optimal fiscal response from the government shows us the benefit of a reaction through labor income taxation, we observe that this policy thwart the main consequence of the contractionary monetary shock (i.e the increase in real interest rate). However, another element arises apart from the positive redistributional point of view which is the turnaround of the more accommodative monetary policy as enunciated in Gornemann et al. (2016).

Indeed, as shown in Table 3 in subsection 4.1, the aggregate discounted welfare is higher when the monetary authority targets not only prices stability but also unemployment stability in the economy of reference, while this results is overturned with the optimal fiscal response. This overturn of the monetary authority's objectives affects the distributional question as well.



(a) Monetary Shock Only



(b) Optimal Fiscal Response

Figure 7 – Taylor Change : $\phi_u = 0.107$ vs $\phi_u = 0.5$

Figure 7 presents the welfare gain (or losses) when the monetary authority switch to a more accommodating policy, as presented in Gornemann et al. (2016). The left panel shows the discounted welfare measure of switching to $\phi_u = 0.5$ when only the monetary shock occurs while the right one presents the same experiment when the government set the coefficient driving the labor income tax to its optimal value determined above ($\phi_w = 1$). Indeed, as shown on the left panel, this has clearly a positive impact for for all quintiles, with an increasing impact with wealth. On the contrary, on the right panel, in case in fiscal response using labor taxation, we observe that there is a distributional cost compared to the same policy under a monetary policy targeting only prices stability.

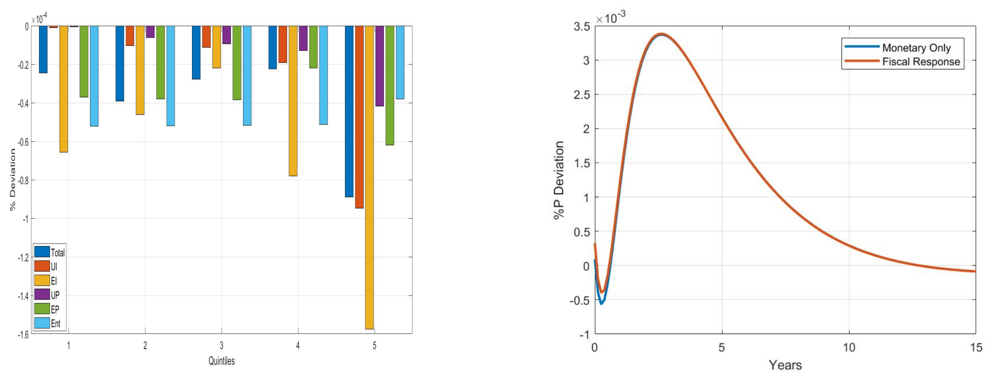
This overturn of the benefit in the discounted welfare for each quintile of the distribution comes from different sources. Firstly, the most obvious reasons comes from the highest increase of unemployment (and the decrease in the job finding rate) going with the optimal fiscal response. As the monetary authority focus as well on unemployment stability, the decrease in the job-finding rate translates into a higher precautionary saving behaviour from the individuals, leading to a lower increase in the welfare for each type of agents in the economy. Moreover, as the real interest rate decrease less when $\phi_u = 0.5$, to hold some wealth is less costly than when $\phi_u = 0.107$ leading also to a smaller increase in welfare. The rise of precautionary savings described above translating the increase of labor market uncertainty highlight the importance of our assumption to include the unemployment surplus into the Taylor. As explained in previous section, the tightening of the labor market frictions lead to an important rise of precautionary savings behaviour and can deeply affect the effectiveness and the redistributive process of the monetary policy and in a second time, of the fiscal response triggered by the government. This finding will be emphasize in Section 5.2 where we consider an alternate rule for the evolution of the labor income tax rate.

5 Alternate fiscal policy responses and sensitivity analysis

In this section, we present alternate versions of fiscal policy responses where the government consider different tools from the baseline model to answer the monetary shock. Firstly, we will focus on the result when the government uses capital income taxation instead of labor taxation. Then in a second time, we will focus on alternate policy rules driving the labor income taxation path and finally, we run some sensitivity analysis to conclude.

5.1 Alternate Fiscal Policy I : Capital Income Taxation

In the model, we presented two fiscal instruments, labor income taxation and capital income taxation and as shown in Table 3, the use of the tax rate of labor is welfare improving compared to the economy with the monetary shock only and to the status quo situation (without any shock or fiscal adjustment). However, if the government decide to use the capital income taxation instead of labor income taxation, this will lead to a decrease in the welfare measure, compared to the status quo and to the welfare measure in the reference economy, only subjected to the contractionary monetary shock. However, if the government wants to minimize the welfare cost of this particular adjustment, the optimal reaction would be to have the smallest reaction of the fiscal instrument in this case, i.e $\phi_b = 0.05$ in our possible range value. It translates into a small reduction of the capital income tax rate τ_t^b (cf Figure 15). In this case, we obtain very similar results compared to the point of reference, when the economy is only subjected to monetary shock without any reaction from the fiscal authority. Figure 17 and 18 as shown in Appendix displays the evolution of the economy when the government adjusts using capital taxation with respect to the economy's response when it is only affected by the monetary shock without any response from the government. Indeed, we observe a decrease, with respect to the reference economy, of the unemployment rate, inflation and long-run real interest rate. There is, as well, a consumption's decrease in the short run for the majority of agents (expect for the patient employed households). This decrease is explained due to the smaller decrease in the net real interest rate, where, consecutively to the monetary shock, the capital income tax decreases. This decrease in capital income taxation mitigates the very short run decrease in the real interest rate, which provokes a negative consequence on the consumption.



(a) Discounted Welfare (b) Net real interest rate

Figure 8 – Distributional consequences : Monetary vs τ^b

However, the main difference between the response to the monetary shock with and without the fiscal response through capital taxation is the very short term. Figure 8 displays on the left panel the discounted welfare measure with respect to the economy of reference subjected only to the monetary shock differentiated by quintile, patience and labor type and the right panel presents the evolution of the net real interest rate. Indeed, the net real interest rate decrease less when the capital income tax is decreasing compared the reference economy. Indeed, the decrease in τ_t^b dampens the negative welfare consequences of the contractionary monetary shock, as the fall in capital income taxation leads to a smaller decrease in the net interest and a rise of unemployment rate, where these two elements combined driving the stronger decrease in welfare. This behaviour leads to a smaller increase in consumption translating in a depreciation of the welfare measure for the distribution. Moreover, this fiscal response from the government will also affect the response of the economy to the monetary shock. The over accumulation of wealth by the agents will push the real interest down and will then reinforce the monetary shock consequences with a stronger decrease in inflation. On the longer run, there are no differences for the evolution of the net real interest rate leading to a very small difference between the reference economy and the economy with both the monetary shock and the fiscal response. To summarise, the more the government react through capital taxation by decreasing its value (ϕ_b between $[0.05; 1]$), the more if amplifies this process, and the worsening of the consequences from the distributional point of view. However, when we investigate the short-run consequences of implementing a response through capital income taxation, there is no major changes compared to the lifetime welfare results as shown in Figure 19 (Appendix), as this policy leads to a general decrease in welfare for all quintiles of the distributions.

5.2 Alternate Fiscal Policy II : Response to Unemployment Surplus

In this section, we present an alternate version of the main fiscal experiment, i.e the response through labor income taxation. Indeed, we introduce an alternate rule to determine the evolution of labor income taxation.

As an alternate version of the policy driving the evolution of the labor income tax, we consider an additional factor driving the rule enunciated in Equation 18. The alternate policy is similar to the Taylor rule as implemented by the monetary authority, taking into account the evolution of prices and unemployment. The new rule driving the labor income tax rate τ_t^w is :

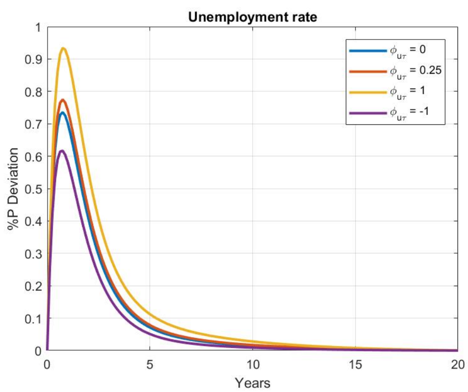
$$\tau_t^w = \overline{\tau^w} + \phi_w \left(S_t - \overline{S}\right) - \phi_{u\tau} \left(U_t - \overline{U}\right) \tag{25}$$

So that, when the unemployment surplus is positive, it leads to a decrease in labor income tax. The results show that we obtain quite similar results compared to the core results presented in Section 4.3 and remain coherent with them. Although, we can notice one additional element that is confirmed with this alternate policy.

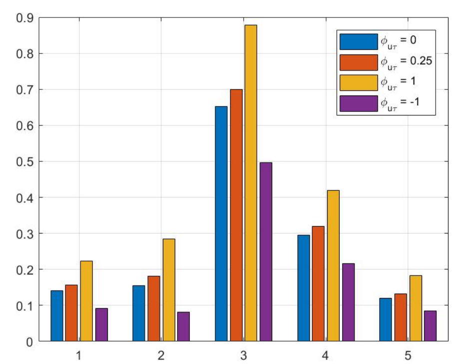
	$\phi_U = 0.107$	$\phi_U = 0.5$
W.r.t Status Quo (%)		
Original Optimal Result	0.37	0.25
τ_t^w ($\phi_w = 1;\phi_{u\tau} = 0.25$)	0.40	0.27
τ_t^w ($\phi_w = 1;\phi_{u\tau} = 1$)	0.54	0.33
τ_t^w ($\phi_w = 1;\phi_{u\tau} = -1$)	0.27	0.19
W.r.t Original Optimal Result (%)		
τ_t^w ($\phi_w = 1;\phi_{u\tau} = 0.25$)	0.03	0.02
τ_t^w ($\phi_w = 1;\phi_{u\tau} = 1$)	0.17	0.07
τ_t^w ($\phi_w = 1;\phi_{u\tau} = -1$)	-0.10	-0.06

Table 5 – Aggregate Discounted Welfare Measures - Alternate Policy II

In the previous section, while the decrease of the labor income taxation triggers a distributional improvement, it also leads to an increase in unemployment and leads to a smaller increase of welfare than what should be expected through the increase of precautionary savings. This new policy rule tend to confirm this finding. As shown in Table 5, the aggregate welfare measure is maximised when $\phi_w = \phi_{u\tau} = 1$. Although, the consequence on the labor income tax rate is illustrated in Figure 15[6]. Moreover, we illustrate through this alternate experiment that the reaction using labor income tax favour an increase of unemployment, leading to an unemployment trap and overturn the welfare consequences maximization under the policy reaction where $\phi_U = 0.107$ instead of $\phi_U = 0.5$. Regarding the short-run consequences of this alternate policy presented in Figure 19 in Appendix, we notice that the distributional welfare consequences are very similar to their lifetime equivalent already displayed in Figure 9, except regarding the magnitude of the distributional response. Also to emphasize this results, we also compute the results for $\phi_{u\tau} = 0.25$ and $\phi_{u\tau} = -1$. This last value is to illustrate the consequences if the government choose to focus on the behaviour of unemployment.



(a) Unemployment



(b) Discounted Welfare

Figure 9 – Unemployment and Discounted Welfare - $\phi_{u\tau} = 0$ vs Alternate Values

The left Panel of Figure 9 shows the evolution of unemployment under the different values for the parameter driving the response of labor income taxation to unemployment variation, while the right panel presents the welfare gains (or losses) for each quintile of the wealth distribution. We can see that the $\phi_{U\tau}$ is high, the more the welfare benefit are important for each quintile of the distribution.

The most striking policy implication of this policy is that the more the govern-

[6]The labor taxation path displayed in Figure 15 is under the feedback parameter $\phi_w = \phi_{u\tau} = 1$

ment cares for unemployment ($\phi_{u\tau} = -1$), the more the welfare gain for population is lower than what could possibly be obtain under alternate values. This is explained as the decrease of τ_t^w is less stronger than expected, leading to a smaller increase of consumption, due the net income is not increasing as much as possible. On the contrary, when $\phi_{u\tau} = 1$, the government will maximise the aggregate welfare, leading to a higher decrease in labor income taxation, boosting the aggregate and distributional consequences described in section 4.2 and 4.3.

5.3 Alternate Fiscal Policy III & IV : Response to Public Spending Surplus and Public Spending Rule

In the baseline model, the fiscal tax rules fluctuate following the evolution of the surplus of liabilities as expressed in Equation 18. In this section, we consider two new rules. Firstly, we determine the evolution of the labor income tax rate, as a function, instead of focusing on liabilities, of public spending surplus. In addition, the level of public debt remains fixed to its steady state level over time while the level of public spending fluctuates. Secondly, we investigate how our results are affected if the government decides to adjust the public spending to the liabilities surplus with capital and labor income taxes remaining fixed at their steady-state level.

Firstly, the new equation driving the labor income taxation based on the public spending surplus is :

$$\tau_t^w = \overline{\tau^w} + \phi_w \left(G_t - \overline{G} \right) \tag{26}$$

The evolution of the labor income tax rate under this new policy rule is displayed in Figure 15 (purple line) and its aggregate welfare consequences in Table 6. The aggregate welfare results suggest that this new policy rule does not affect the main conclusion obtained with the previous fiscal response implemented by the government. However, the response differs regarding the magnitude of the response, which is more important in the baseline model and the distributional welfare consequences differs as well.

The main distributional differences between this alternate policy rule and the baseline results presented in Section 4 are illustrated in Figure 10.

Figure 10 shows, on the left panel, the discounted welfare changes for the baseline results and on the right panel, the same distributional measure for the alternate policy rule enunciated above.

Changes in the distributional welfare results between the two policy rules concern mainly the unemployed individuals and individuals in the second quintile. They are explained regarding a new balance between the change in the net income due to the decrease in labor income tax rate and the precautionary saving behaviour. Firstly,

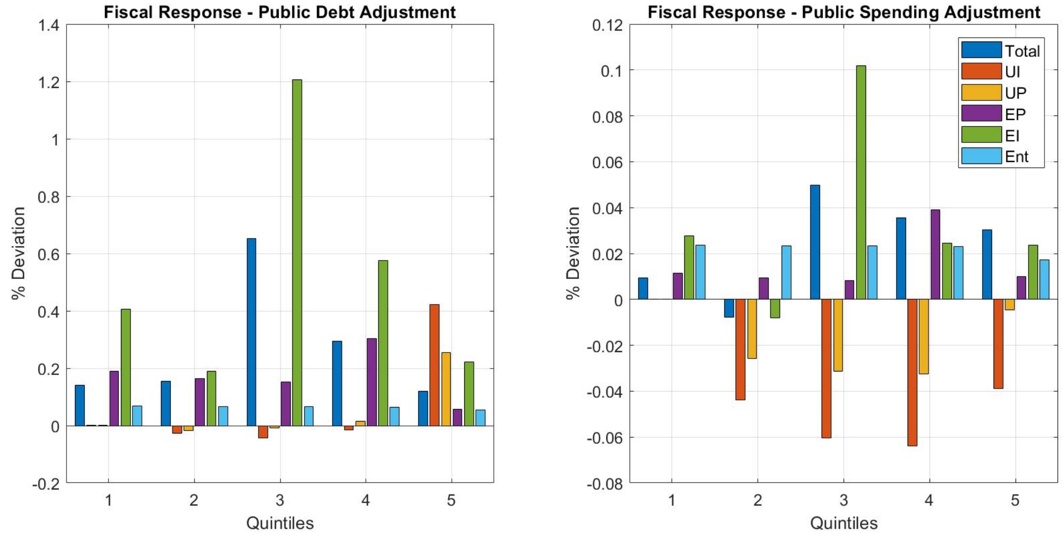


Figure 10 – Discounted Welfare Variation - By Quintiles and labor Categories (In %)

the decrease in labor income tax rate is smaller in case of public spending adjustment. On one's hand, this change in labor income tax leads to a smaller increase in the net labor income and to a lower improvement in consumption. On the other hand, the real interest rate decreases less as well, leading to a lower cost of holding asset. Moreover, as the damage on the labor market are less stronger in case of a labor fiscal adjustment through public spending, the precautionary saving behaviour is also lower. So, as a consequence, one of the differences between the adjustment through public spending instead of public debt leads to a decrease with respect to the status quo (no monetary shock and fiscal response) of the welfare for the second quintile of the distribution. Indeed, as the impatient employed individuals represent a large part of the individuals in this quintile, where the decrease in the welfare for this category is a consequence of the balance between the mechanisms described above. Moreover, for the unemployed individuals, as their unemployment benefit is fixed over time, they do not benefit from the decrease in labor income taxation. But they are affected by the two last mechanisms. The asset accumulation is less affected by the policy in this scenario due to the smaller decrease from the real interest rate and have the upper hand on the decrease in precautionary saving behaviour who should leads to a decrease in savings. As usual, the impatient individuals are more affected by this situation as they favour more presented over future consumption.

When, we consider the second alternative, a public spending follows a similar rule than compared to the labor income tax rule detailed in the baseline model. So, G_t evolves such that :

$$G_t = \overline{G} + \phi_G \left(S_t - \overline{S} \right) \tag{27}$$

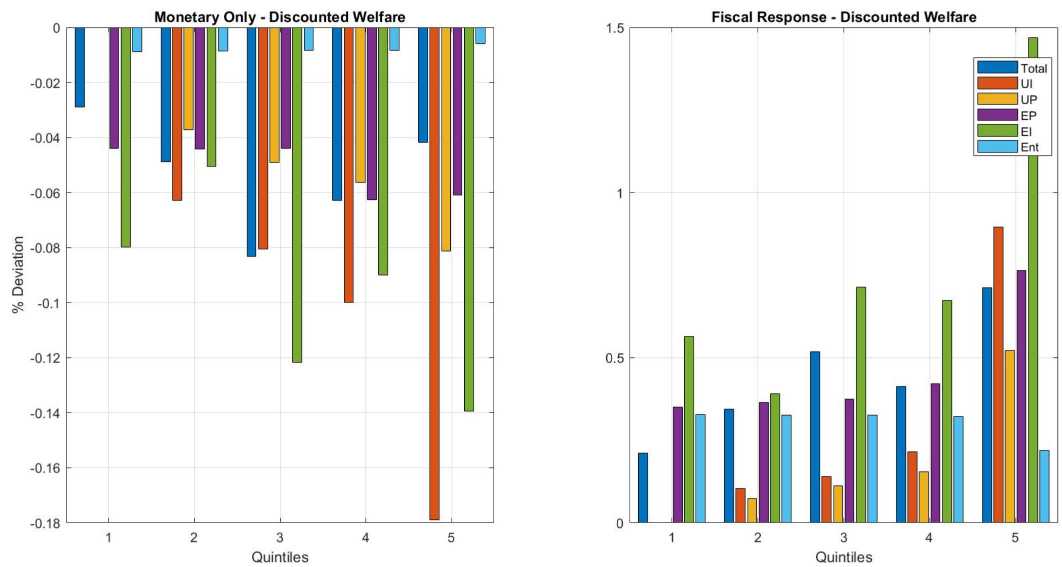


Figure 11 – Discounted Welfare Variation - By Quintiles and labor Categories (In %) - Public Spending Rule

As shown in Table 6 (noted as Alternate Policy IV), a fluctuating public spending rule based on the liability surplus lead to a similar increase of our discounted welfare measure with respect to the status quo and the reference economy with the monetary shock only. Compared to the baseline results presented in section 4, this alternate policy does not thwart the benefit of a more accommodative monetary policy. Indeed, the welfare gain from the government response is higher for $\phi = 0.5$ whereas it was for $\phi_u = 0.107$ in the with our main experiment. On Figure 11, we display the main distributional consequences of this policy compared to the monetary shock only. The major change concerns the population who benefit from the policy. While all quintiles benefit from this new rule (even unemployed individuals), the Top 20 % of the wealth distribution are the main winner of such response. To explain this change, we investigate the implications on the macroeconomic variables. As a consequence to the monetary shock, the public spending decreases. So, it leads to no taxation fluctuations, affecting directly net prices. In addition, this policy attenuate the consequences of the monetary shock on the labor market, while it worsens the reaction of output, investment but increases aggregate consumption. Indeed, as G decreases due to the decrease in debt, it tend to reduce the accumulated wealth and it also decreases the real interest rate. As r_t decreases, it pushes consumption up. In addition, the decrease in public spending will negatively affects the demand for goods and cause a decrease the firms profit. However, the rise in consumption will then provokes a progressive rise in profits in the longer-run due higher demand for intermediate goods, but this rise in consumption will be diminished due to precautionary saving decisions, as the decrease in public spending triggers a reduction in a marginal value of a job and rises unemployment. Thus, as shown in Figure 11, the richest individuals benefit the most from this policy as they are the most like to reduce their savings in order to avoid the consequences of the decrease in real interest rate as a larger share of their revenue rely on capital income. In addition, we notice that this behaviour is even more present for impatient employed agents who favour more present over future consumption.

As highlighted in Figure 19, these two policies does not provide any majors differences regarding the evolution of the discounted welfare measure by quintiles. The results labelled as "Alternate Policy III (and IV)" provide the same distributional implications than the lifetime counterpart.

5.4 Sensitivity Analysis

As shown previously, the fiscal response to a contractionary monetary shock triggers changes in unemployment and distributional welfare consequences. These changes might depend on the sensitivity of some parameter, especially parameter driving the labor market. In this section, we compute the change in welfare results regarding alternate values for specific parameters and, as previously, we focus only on labor income taxation. Thus, the parameters of interest in this section are the replacement rate μ for unemployed individuals, the matching curvature α, the matching efficiency χ and the wage elasticity η as well as the Frisch elasticity ψ. As highlighted in Table 6 in Appendix, the aggregate welfare measure conclusions go into the same direction compared to the baseline results.

Indeed, the optimal fiscal response for the labor income taxation from the government should be to react as strongly as possible in case of contractionary monetary shock ($\phi_w = 1$). Moreover, we can see that the maximised welfare measure is still obtained in case of monetary policy targeting only prices stability as shown in the baseline results (cf Table 6). Now, if we focus on the results in details, most of the distributional welfare changes that occur consecutively to the changes in the parameters values are not significant.

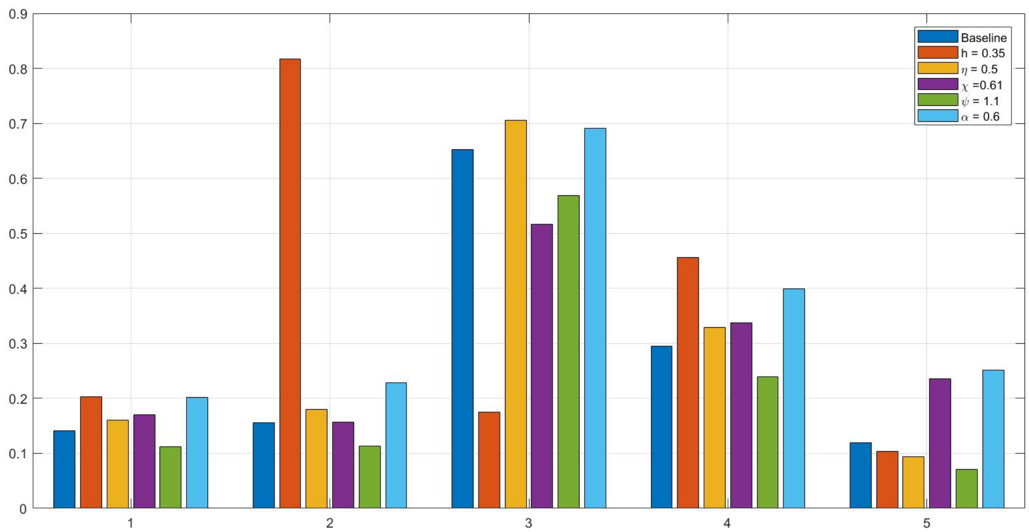


Figure 12 – Discounted Welfare Variation - Baseline vs Sensitivity Analysis - By Quintiles (In %)

Figure 12 displays the response for each quintile of the distribution under the optimal fiscal response with respect to the status quo situation, where the blue column represents the results for the baseline calibration. The most important changes with respect to the core results presented in section 4 concerns an alternate value for the replacement rate for unemployed agents. Indeed, the rise of the replacement rate tend to affect which quintile of the distribution benefit the most from the the fiscal response to the monetary shock. The highest welfare benefits shift from the third quintile towards poorest individuals, (i.e the second quintile). The proportion of unemployed (impatient) households explains this change.

Indeed, unemployment is also higher, which lead to a longer unemployment spell, a higher precautionary saving behaviour and a lower welfare. Meanwhile, as the replacement rate is higher, the unemployment benefit received by unemployed individuals is also higher, leading to a higher possible consumption and welfare gain. Similarly, the decrease in the real interest rate is more important than in the baseline results, pushing even further the consumption. This last behaviour having the upper hand, explaining the higher increase in welfare for the second quintile. Moreover, this higher replacement rate also benefit to employed agents, as in case of bad-employment shock, the decrease in their income will be lower, reducing the precautionary saving behaviour as well.

The second significant difference concerns alternate values for parameters driving labor market frictions, the matching curvature α and the matching efficiency χ. Indeed, we have shown previously how the evolution of labor market variables are crucial in assessing the consequences of the fiscal response. As shown in Figure 20 in Appendix, the unemployment rate is much lower in case of a higher matching curvature parameter. This lower increase in unemployment triggers a lower precautionary saving behaviour and increase consumption. In addition, the decrease in real interest rate is slightly higher in this case. As the share of capital income over total income for agents in the 5^{th} quintile is important compared to the rest of the population, they will decrease their savings and consume as well. Thus, to emphasize this behaviour, we compute as well a similar policy for a more extreme value for the matching curvature, with $\alpha = 0.05$. Indeed, as shown on Figure 21, we can see that we obtain very different results regarding the consequences of the fiscal response from the government. When we consider only the reference economy (with the monetary shock only), the results are quite similar to the baseline results, with an overall decrease for all quintiles in the wealth distribution. However, we observe that the fiscal response from the government leads does not provide a positive reaction from a distributional point of view. To understand this negative reaction and how α ships the results, we need to assess the evolution of the aggregate variables. Indeed, the job finding rate suffer from a much more important decrease than in the baseline results leading to an higher increase in unemployment rate and a longer unemployment spell. This mechanism leads agents to reduce their consumption and increase their saving in order maintain a certain level of consumption in the future increase of revenue losses if an individual become unemployed. On the other side, the decrease in labor income tax does not lead to an increase in consumption as high as in the baseline results. Thus, these two mechanisms where also present in the core results but the decrease in labor income taxation clearly has the upper hand over the precautionary saving one. However, in this case it seems to be the contrary, highlighting clearly the importance of the level of labor market frictions present in this model and how it can affect the results.

Moreover, a change in the matching efficiency ($\chi = 0.61$) lead to a welfare increase for the 5^{th} quintile of the distribution which is more important than in the baseline situation, the mechanism triggered by the smaller increase in unemployment is not present, only the increase in consumption through the decrease in real interest rate is at stake here. The other changes of calibration do not affect significantly the optimal simple fiscal response obtained previously.

6 Conclusion

In this paper, we have studied what should be the optimal fiscal response to different monetary policies when inequality and redistribution matter. We have obtain that in any case, the optimal response from the government is through labor income taxation leading to a general welfare improvement. It leads to an overall positive impact on the aggregate variables through a decrease in labor tax rate despite a worsening situation on the labor market. On the other hand, this policy is welfare's enhancing where there is an overall welfare gain for all quintiles of the distribution. Moreover, this policy, despite its positive effects, thwart the primary objective of the monetary authority when a contractionary shock occurs and leads to a trade-off from the government between labor market stability and redistribution. While these results are robust to changes in the model's calibration, it would be interesting to introduce different skill levels for workers and investigates its consequences on unemployment and welfare redistribution. Moreover, the dynamics of aggregate variables and distributional welfare consequences might differ if, instead of returning to its original steady state, the government targets to reach a new (optimal) steady state maximizing the long-run welfare measure. However, we leave these questions for future research.

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7 Appendix

7.1 Additional Tables and Figures

7.1.1 Stationary Distribution and Policy functions

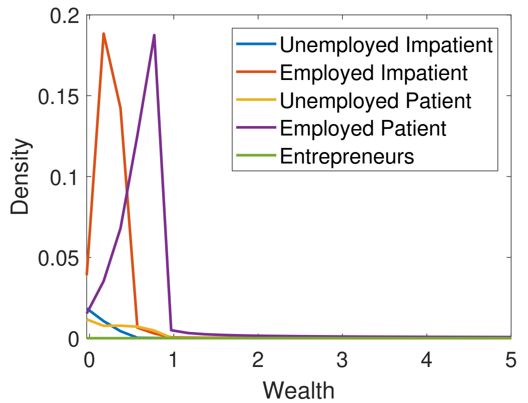


Figure 13 – Stationary Distribution

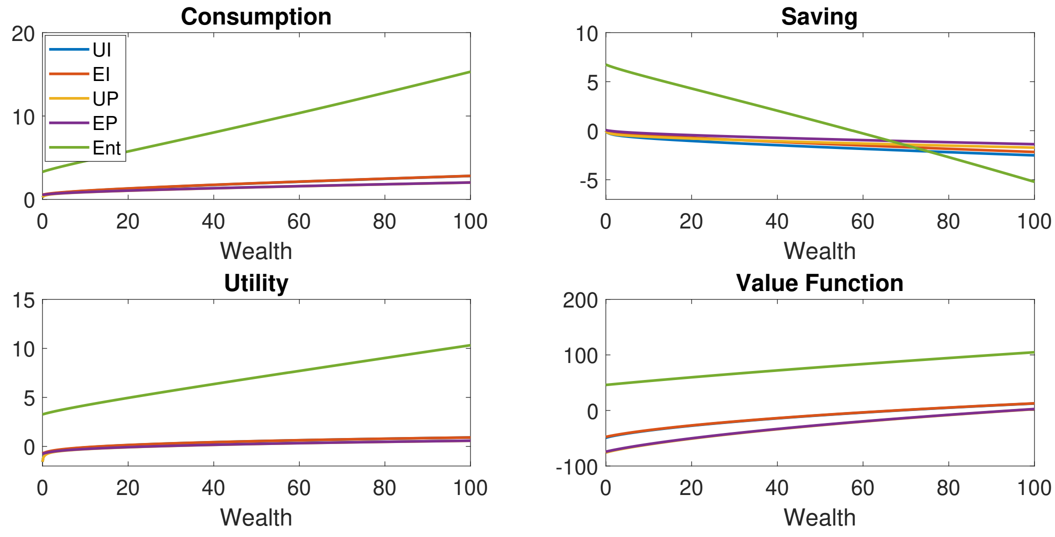


Figure 14 – Policy Functions

7.1.2 Additional Results

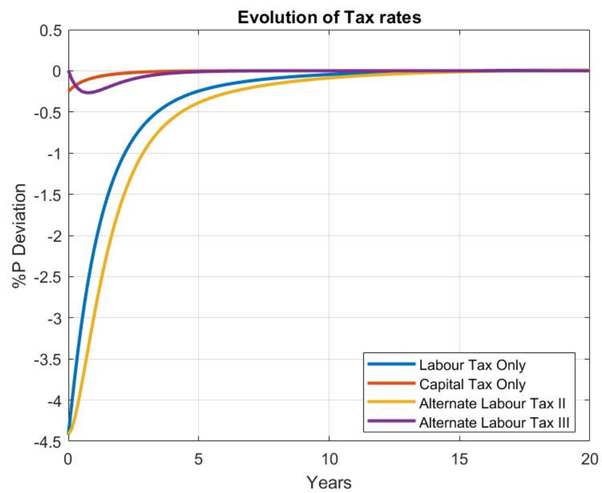


Figure 15 – Evolution of Tax rates

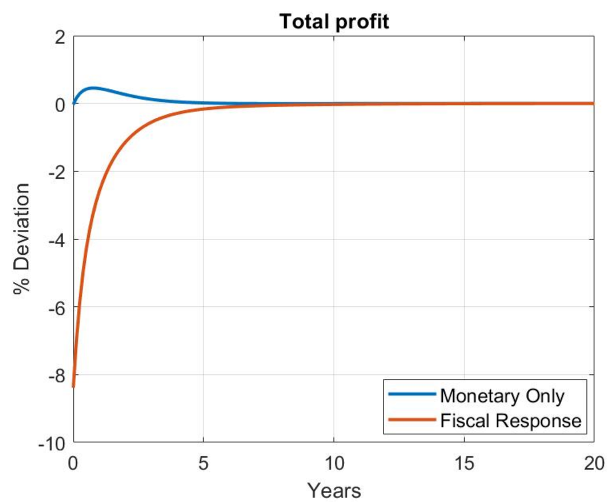


Figure 16 – IRF Firm Profits - labor Taxation Adjustment

7.2 Capital Income Taxation adjustment

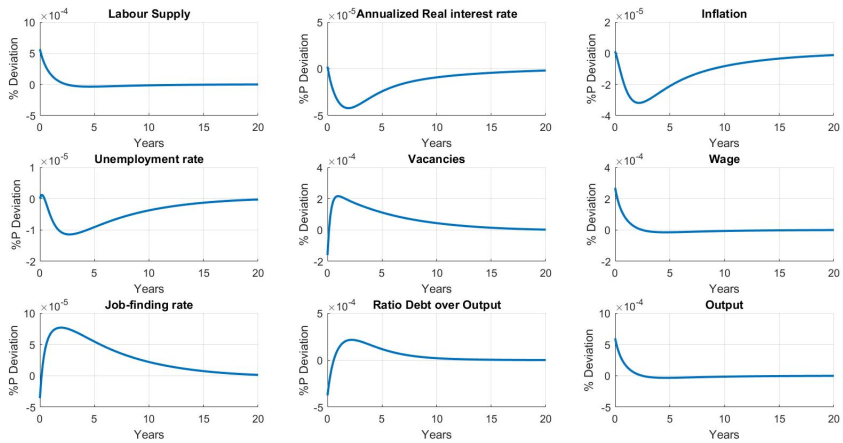


Figure 17 – IRF - Main Aggregate Variables - Capital Taxation Adjustment

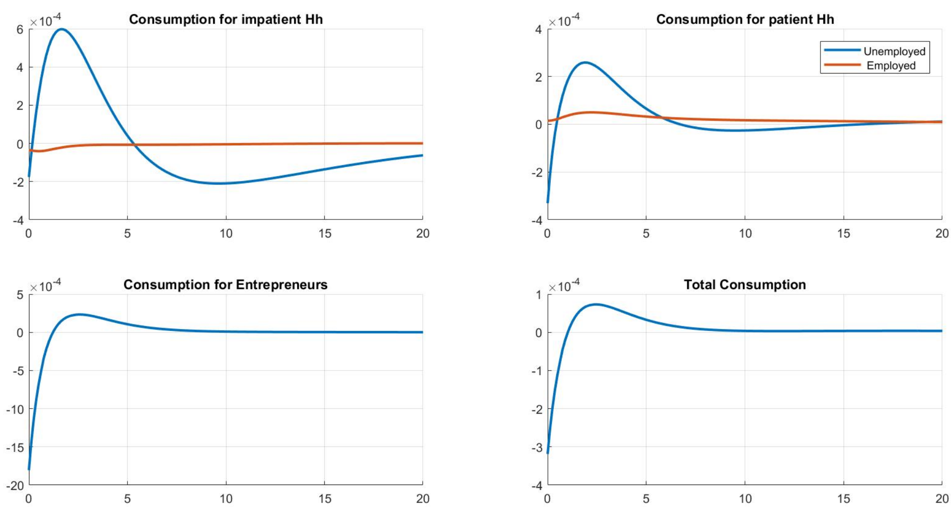
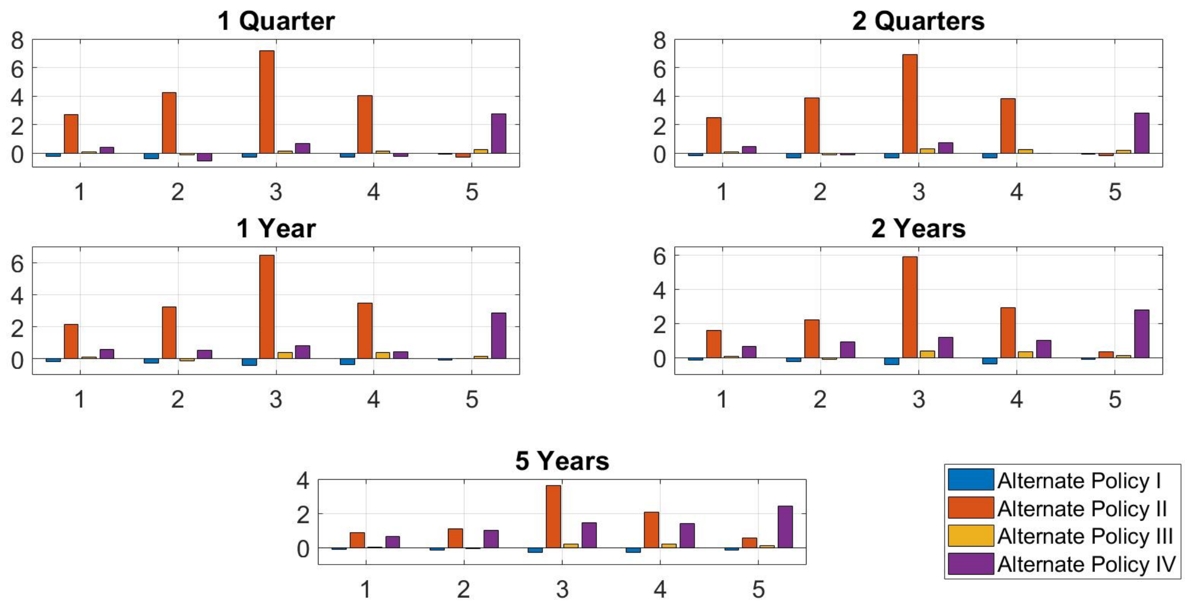


Figure 18 – IRF - Consumption - Capital Taxation Adjustment

Figure 19 – Short-Run Discounted Welfare Variation - Alternate Policies I to IV

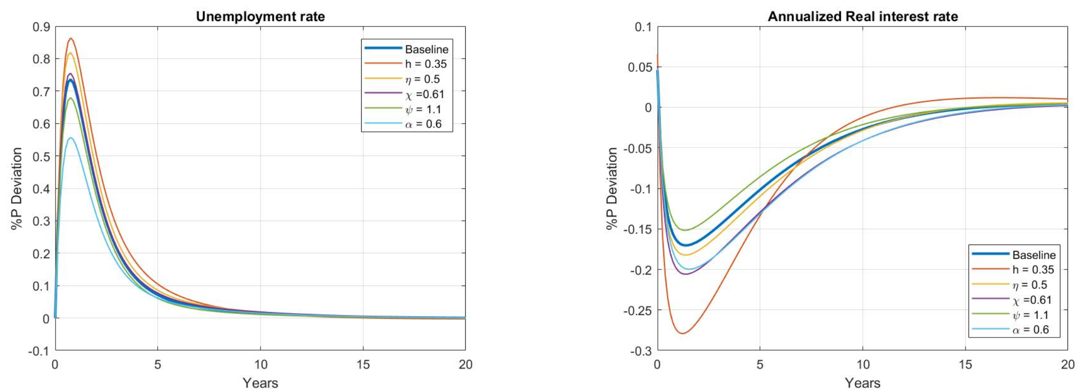


In this figure, we refer as "Alternate Policy I" to the policy where the government decide to respond through capital income taxation (Section 5.1), "Alternate Policy II" the case where the response using labor income tax fluctuations respond to both liabilities surplus and unemployment surplus (Section 5.2). Finally "Alternate Policy III and IV" refer to the case where there is a fiscal response using through different ways public spending G (Section 5.3)

7.3 Additional Elements : Alternate Policy III and Sensitivity Analysis

	$\phi_U = 0.107$	$\phi_U = 0.5$
Alternate Policy III (%)		
W.r.t Status Quo ($\phi_w = 1$)	0.032	0.027
W.r.t Monetary Shock ($\phi_w = 1$)	0.070	0.057
Sensitivity Analysis ($\phi_w = 1$) - W.r.t Monetary Shock (%)		
Alternate Policy IV (%)		
W.r.t Status Quo ($\phi_G = 1$)	0.51	0.53
W.r.t Monetary Shock ($\phi_G = 1$)	0.58	0.59
Sensitivity Analysis ($\phi_w = 1$) - W.r.t Monetary Shock (%)		
Baseline Model	0.44	0.31
$\mu = 0.35$	0.64	0.45
$\chi = 0.61$	0.42	0.30
$\alpha = 0.6$	0.50	0.37
$\eta = 0.5$	0.48	0.34
$\psi = 1.1$	0.37	0.27

Table 6 – Aggregate Discounted Welfare Measures - Alternate Policy III and Sensitivity Analysis



(a) Unemployment (b) Discounted Welfare

Figure 20 – Unemployment and Real Interest Rate - Sensitivity Analysis

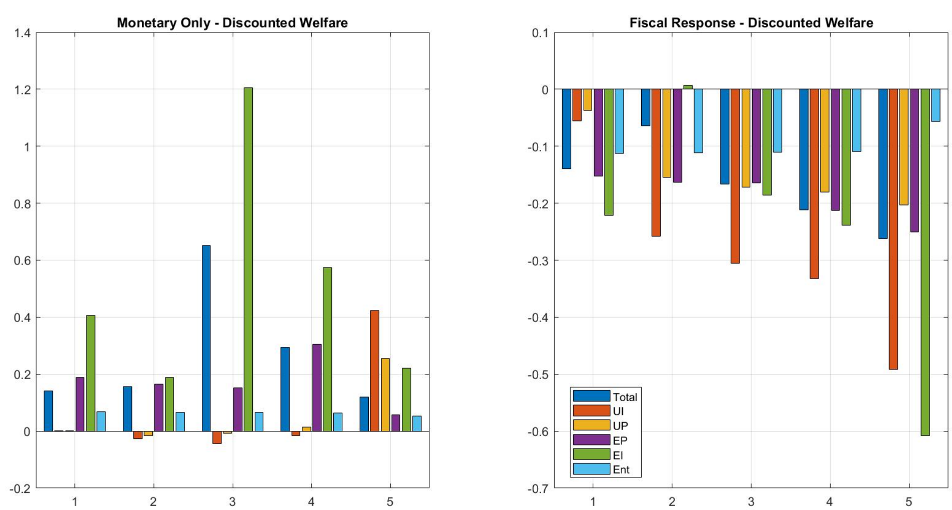


Figure 21 – Discounted Welfare Variation - By Quintiles and Labor Categories (In %) - $\alpha = 0.05$

7.4 Solution Algorithm

Our solution method follows the algorithm of Albertini et al. (2020), using the continuous-time method developed by Achdou et al. (2017). Firstly, we describe the process to solve our steady state and then, we present the transition dynamic solution.

Steady States

1. Choose an initial guess for the real interest rate r, the wage w, the labor market tightness θ and the individual labor supply n,
2. Then, we compute the different labor market component : the job-finding rate f, the job-filling rate q, the unemployment rate u and the vacancies v,
3. We compute the implicit value for the output Y, and then derive the level of public spending G, the level of debt B and the profits Π,
4. Then, compute the individual income for each type of households in the economy (5 types),
5. Solve the HJB equation for each asset level and labor situation, the marginal value of a job J, the equilibrium wage w using Nash bargaining and adjust the labor disutility to insure that $n_t = 1$
6. Derive from the household's problem solution the stationary distribution,
7. Compute the residuals of the free entry condition and the excess demand for the asset market,
8. If both residuals is below our critical value (10^{-5}), the equilibrium is found. Otherwise, we update our initial guesses and return to step 2.

Before solving the full steady state, we run a similar routine to determine the vacancy cost ξ.

Transition Dynamics

1. For the sequence $t = 1, ..., T$, we give an initial guess for the labor market tightness θ_t and the real interest rate r_t,
2. For $t = 1, ..., T$, compute the job finding and filling rate (f_t,q_t),

3. For $t = 2, ..., T$(t=1 is pre-allocated), compute the debt level B_t and the chosen tax rule (τ_w^t or τ_t^b),

4. For $t = 1, ..., T$, compute the inflation π_t, the nominal interest rate i_t and output Y_t,

5. For $t = T, ..., 1$, derive intermediate price p_t^I,

6. For $t = T, ..., 1$, solve household's problem for each wealth level and labor situation and the marginal value of a job, then derive the equilibrium wage w_t and the individual labor supply n_t,

7. for $t = 1, ..., T$, derive from the household's problem solution the stationary distribution,

8. Compute the two market clearing condition (free entry and asset market),

9. If both residuals exceed our critical value, update the labor market tightness θ_t and real interest rate r_t path and return to step 2 until convergence.