WHEN HOUSEHOLD HETEROGENEITY MATTERS OPTIMAL FISCAL POLICY IN A MEDIUM-SCALE TANK MODEL

François Courtoy

LIDAM Discussion Paper IRES
2022 / 09

UCLouvain

LIDAM
IRES | Louvain Institute of Data Analysis and Modeling in economics and statistics

When Household Heterogeneity Matters
Optimal Fiscal Policy in a Medium-Scale TANK Model*

François Courtoy†

April 5, 2022

Abstract

We investigate the role of household heterogeneity in terms of marginal propensity to consume and of labor income for the design of optimal fiscal policy over the business cycle. We estimate a two agent New-Keynesian (TANK) medium scale model introducing aggregate shocks as in Smets and Wouters (2007) and allowing idiosyncratic shocks to impact household behavior. We further ensure that the government can set lump sum transfers and distortionary taxes to redistribute across households and finance deficit fluctuations across the business cycle. Estimating the model with US data on household earnings shows limited influence on the estimated parameters of the model, however it identifies heterogeneity across household types as a key driving force of the business cycle. Using the estimated model we solve an optimal fiscal policy problem assuming that a benevolent government sets taxes and transfers under commitment. Under optimal policy, fiscal variables display considerable volatility and respond considerably to shocks to labor income at the low end of the distribution. These shocks are also important for the optimal policy model to match the properties of fiscal variables seen in the US data.

Keywords: Optimal taxation, marginal propensity to consume, DSGE models, Bayesian estimation, Household Heterogeneity.

JEL classification: E32, E62, H21, H23, H31.

*I am grateful to Boris Chafwehé for his precious comments and advice during the process of writing this paper. I thank my advisor, Rigas Oikonomou, for his guidance on this project. I also thank Jochen Mankart, Goulven Rubin, Gonzague Vannoorenberghe, Vincent Bodart, and seminar participants to the Doctoral Workshop and IRES Lunch Seminar in UCLouvain for their useful comments and suggestions at various stages of this project.

†Université Catholique de Louvain. E-mail: francois.courtoy@uclouvain.be

1 Introduction

A rapidly growing literature studies the impact of economic policies in economies with heterogeneous agents, to identify the transmission channels of fiscal or monetary policy shocks in these economies. This paper contributes to an increasing body of the literature that takes an encompassing approach to study, in an empirically relevant DSGE models, the role of household heterogeneity in terms of marginal propensity to consume (MPC) and labor income for the design of optimal fiscal policy over the business cycle.

The literature has shown that the presence of credit constrained households in the economy (that is, the presence of households that cannot save and that have a high MPC) is necessary to have a thorough understanding of the effectiveness of the fiscal policy to stimulate aggregate consumption, and therefore output. Based on this observation, we seek at characterizing the optimal behavior of taxes and transfers over the business cycle when these households are facing realistic transitory earnings fluctuations. In other words, what we are ultimately concerned about in this paper is whether the existence of households that have a high marginal propensity to consume out an extra dollar of income matters for the US fiscal policy. What we want to know is whether income shocks that are affecting these households that cannot insure themselves – i.e. that cannot smooth consumption through borrowing and savings – affect the way the government should set labor taxes and transfers in the US. We do this for several reasons, including to bridge a gap in the literature of optimal fiscal policy which typically ignore the role of household heterogeneity and the redistribution aspects of fiscal policy, but also because we want to test the relevance of the current US fiscal policy.

Specifically, we construct a medium-scale Two-Agent New-Keynesian (TANK) model where Ricardian households can save by accumulating government bonds and invest in capital, whereas hand-to-mouth households consume their disposable income in every period.[1] Additionally, our model features nominal and real rigidities, capacity utilization, sticky wages and prices, and the standard set of shocks which the literature has identified as key driving forces behind the business cycle. To this standard structure we add shocks that can explain the different incomes paths of Ricardian and Non-Ricardian households over the business cycle. In particular, we allow business cycles to impact relative incomes directly, by impacting the gap in productivity across households. We also allow household for specific shocks, a risk-premium shock for Ricardian households and a productivity shock for hand-to-mouth households. This last shock is particularly important.

We estimate this model with Bayesian methods both with and without cross sectional data measuring income and consumption dispersion among households, to investigate whether adding these cross sectional observations to the standard set of measurement equations affects the estimation output of the model. We find that adding cross sectional data does not change the structural parameters of the model, but it does lead to significant differences in the historical shock decomposition of the US business cycle.[2] In particular when the model needs to match cross sectional

[1] In other words, we introduce two stylized groups of households. In the former, households have a marginal propensity to consume (MPC) close to 0, while in the latter they have a MPC that is equal to 1.

[2] By focusing on measures of inequality at the bottom of the distribution, we complement Bayer, Born, and Luetticke (2020) who study the impact of adding cross sectional data related to the shares of wealth and income held by the

observations, shocks to the labor productivity of non-Ricardian households become quantitatively important and exert a significant impact on the business cycle. Because hand-to-mouth households cannot smooth idiosyncratic income shocks with wealth, their consumption drops significantly with a negative productivity shock (given the estimated parameters determining the labour supply elasticity). The drop in consumption then translates to a drop in aggregate demand that drives down aggregate output.

These shocks that drive inequality and output fluctuations, give rise to a difficult trade-off for the government. On the one hand, they call for redistribution, transfers are used to shield the consumption of hand-to-mouth households. On the other hand, because they lead to an increase in the deficit, these shocks also call for higher distortionary taxation or less transfers, to stabilize the government's budget. The US government (in the data) opts for higher transfers during economic recessions, favoring redistribution over stabilizing finances and deficits.

Is such a policy optimal? We attempt to answer this question in a second step of the analysis, using the estimated medium scale model and studying the cyclical properties of taxes and transfers set by an optimizing benevolent government. Formally, we want to test whether the 'Ramsey' model fits the US data well, simultaneously matching fiscal policy data (taxes and transfers) and the business cycle properties of aggregate consumption, output, investment, etc. (in other words key macroeconomic variables which every successful macro model needs to match). Clearly, because the Ramsey model is literally meant to describe policies under ideal circumstances, we cannot hope that our model will be close to the data in both these dimensions. We show quite the opposite. The Ramsey plan is remarkably close to the actual policies followed by the US government.

Our evaluation is in two layers. First, we find that the optimal steady state taxes and transfers are close to their data counterpart. The model features slightly lower consumption inequality than the data though, implying a slightly higher level of distortionary taxes and transfers. Second, we find that the optimal fiscal variables also behave similar to the data counterparts over the business cycle, and in particular key moments of the data, i.e. the negative correlation between transfers and output and the positive correlation between transfers and deficits, are matched by the optimal policy model.

We interpret these findings to mean that government policy in the US is close to optimal, a conclusion that derives from an empirically relevant DSGE framework, that is widely seen as a good laboratory to study the fluctuations in the US economy. We further find that a key variable that enable to reach this conclusion is the shocks to the earnings potential of low income hand-to-mouth households, which we can accurately identify when we include cross sectional variables in estimation. These shocks are one of the main source of economic fluctuations and require a more active and redistributive fiscal policy over the cycle. They make optimal transfers behave as in the data. These results do not obtain when estimation does not account for cross sectional observations.

top 10% of households on the estimation of a HANK model.

Related literature Our paper contributes to the literature in several ways. First, our findings provide new insights to the growing literature on the dynamics of households earnings and on the redistributive role of fiscal policies. This literature has mostly focused on studying the consequences of the rise in earnings inequality observed since the 1950s in the United States (Katz et al., 1999; Autor, Katz, and Kearney, 2008; Heathcote, Perri, and Violante, 2010b). The focus has mostly been on studying the fanning out of the income distribution cause by the increase in the earnings at the very top. Fewer papers (see Heathcote, Perri, and Violante (2020) and references therein) have paid particular attention to the widening gap between bottom and middle income quintiles. This paper identifies movements of inequality over the business cycle that are primarily driven by fluctuations in the relative incomes of the bottom 20 - 30 percent of the distribution to the average income for the rest of the US population.

A few papers have studied the cyclical properties of labor income risk[3] and the distribution of labor income during recession periods[4], finding that during recessions income inequality increases. This work is relevant here, since we will also assume that income shocks primarily affect low income earners that have a high marginal propensity to consume, therefore leading to redistributive income shocks that are correlated with the business cycle. Thus the empirical facts that motivate our study in Section 2 and our estimated DSGE model complement this body of work. We go a step further, however, by studying the implications of counter-cyclical income risks for the design of fiscal policy. The insights we derive from our model are new to the literature.

There is a sizable literature on TANK models, including papers using medium scale DSGEs.[5] For example Galí, López-Salido, and Vallés (2007); Forni, Monteforte, and Sessa (2009); Traum and Yang (2015); Menna and Tirelli (2017) and Leeper, Traum, and Walker (2017) estimate models with Ricardian and Non-Ricardian households in models that account for a fiscal block, while specifying rules for taxes and transfers. As is the case here, Coenen, Straub, and Trabandt (2012), and Drautzburg and Uhlig (2015) study optimal fiscal policy in TANK models. Here, our contribution to the literature is twofold. First, we study the joint behavior of distortionary taxes and transfers together, thus expanding the set of fiscal instruments considered. Second, in addition to using standard aggregate macroeconomic variables in estimation of the model, we also use detailed data describing the evolution of consumption and earnings in the cross-section. As discussed previously this has an important effect for our conclusions.

Finally, our paper relates to the large strand of literature using the so called Ramsey approach to study optimal fiscal policy over the cycle, e.g. Lucas and Stokey (1983), Aiyagari, Marcet, Sar-

[3]See, for example, Storesletten, Telmer, and Yaron (2004); Guvenen, Ozkan, and Song (2014); Hoffmann and Malacrino (2019)

[4]See Heathcote, Perri, and Violante (2010a); Perri, Steinberg et al. (2012) for the Great Recession and Cajner, Crane, Decker, Grigsby, Hamins-Puertolas, Hurst, Kurz, and Yildirmaz (2020); Cox, Ganong, Noel, Vavra, Wong, Farrell, Greig, and Deadman (2020) for the Covid crisis

[5]A growing literature studies the impact of household heterogeneity on macroeconomic outcomes in models where agents face idiosyncratic risks. Several papers have been using setups with a very rich account of heterogeneity, the so called HANK model (see the seminal contributions of Werning (2015); McKay and Reis (2016); Kaplan, Moll, and Violante (2018)). There are also several papers arguing that the TANK model has a rich enough structure to capture sufficiently the insights of these more complicated models (see for example Debortoli and Galí (2017)). Since the aim here is to estimate the model using Bayesian methods, we rely on the two agent setup. Bilbiie and Ragot (2017), Challe et al. (2017b) and Bilbiie (2018) use this framework to study optimal monetary policies.

gent, and Seppälä (2002) and Faraglia, Marcet, Oikonomou, and Scott (2019). Relative to these papers we emphasize the importance of household heterogeneity, in terms of marginal propensity to consume and labor income, for optimal taxation. Chafwehé and Courtoy (2021) and Bhandari, Evans, Golosov, and Sargent (2017) also study optimal tax policies in the context of heterogeneous households, however, in contrast to us, they do not use an estimated DSGE model. This enables us to directly confront our model to the data and to get a realistic measure of the quantitative impact of the integration of household heterogeneity in models of optimal fiscal policy.

The remainder of the paper is organized as follows. In Section 2, we provide key stylized facts regarding the behaviour of fiscal variables in the US, using both macro and micro data sources. Section 3 describes the building blocks of the model and discusses the value of the estimated parameters. Section 4 delineates the optimal fiscal policy. Finally, Section 5 concludes.

2 The cyclical behavior of earnings and transfers

As sketched above, the paper aims at studying how the presence of household heterogeneity in terms of marginal propensity to consume (MPC) and labor income affects the (optimal) design of the US fiscal policy. In this section, we start by documenting the cyclical properties of household earnings and transfers in the United States. The objective is threefold. First, we want to discuss the choices we make regarding the construction of our theoretical model in Section 3 Second, we want to identify key empirical patterns characterizing the evolution of the most relevant variables for our analysis. Second, we want to delineate the data that will be used to estimate the medium scale model that is presented in the next section.

We rely on three main data sources. First, consistent with the literature, we use data from the NIPA tables to look at the aggregate properties of fiscal variables. Second, we study the distribution of earnings in the cross-section throughout the Annual Social and Economic (ASEC) Supplement of the Current Population Survey (CPS) as reported by IPUMS.[6] Third, we also provide empirical evidence on the behaviour of labor earnings, disposable income and consumption in the cross-section of US households using data from the Consumer Expenditure Survey (CEX), a quarterly household survey conducted by the Bureau of Labor Statistics.

A complete description of the data series /variables that we use in this section is provided in Appendix C. It is, however, worth mentioning here a few elements regarding the procedure that we follow to construct measures of earnings and transfers. All household variables used, concern prime-age men (between 25 and 55) following the convention to treat empirically these agents as household heads (e.g. Heathcote et al. (2020)). We construct household earnings as the sum of annual wage, salary, business and farm income earned. Moreover, our measure of transfers is the sum of unemployment insurance benefits and transfers such as food stamps and income assistance programs (excluding public pensions). Finally, we will report the behavior of earnings and transfers over the period 1961-2019. In contrast, consumption data are available in the CEX

[6] Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. *Integrated Public Use Microdata Series, Current Population Survey: Version 8.0* [dataset]. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D030.V8.0

from 1984 onwards and so we will have to rely on a shorter sample in this case.[7]

We focus on three facts. The first two characterize the cyclical behavior of earnings inequality between household groups. The third one studies the cyclical properties of transfers and affirms their income insurance character. Notice that these facts are not entirely new to the literature; they complement analogous findings in Heathcote et al. (2020); Chafwehé and Courtoy (2021).

Figure 1 traces the evolution of earnings inequality over the past 58 years. The three lines of the figure plot three income ratios of different deciles of the distribution of earnings. In particular we trace the behavior of the 9/2 decile ratio, the 5/2 ratio and the ratio 9/5. We define earnings in a particular decile as the average earnings of households whose income belongs to that decile. Thus, the 9th decile is the average income, of households between the 81st and the 90th percentiles.

As is well known, earnings inequality increased considerably over time, the rise is mainly manifested through a widening of the gap of earnings of the top earners relative to bottom income households. Above the 50th percentile (9/5 ratio) we see little evidence of an inequality trend.

As is the case with trends, cyclical fluctuations of earnings differences mainly concerns the top and bottom ratios. The 9/5 ratio does not display any pronounced cyclical pattern, whereas the 9/2 and 5/2 ratios show strong correlations with the business cycle, most notably the ratios begin to increase during economic recessions (grey shaded areas in the figure) and continue increasing during the recovery that follows. Inequality then drops in economic expansions. However, the decrease in inequality is generally insufficient to fully eliminate the increase observed during recessions, such that overall inequality is actually rising over time.

[Figure 1 approximately here]

We therefore have:

Fact 1: *Inequality trends and cyclical fluctuations mainly concern the ratios of top/middle incomes to the bottom of the distribution.*

This fact is important for our modelling choices in the theoretical model of Section 3. Indeed, since business cycles mostly change the income of bottom earners relative to the rest of households, while barely affecting the relative earnings of medium to top earners households, we restrict the number of households groups to two in our model. On the one hand, we have poor households, representing the bottom 30% of the earnings distribution, and on the other hand, we have rich households, therefore composed of the remaining top 70%.

In our theoretical framework in the next sections, we make the additional assumption that these poor households are credit constrained. They cannot save or borrow. They hold zero asset or liabilities that would enable them to transfers income from one period to the other and, therefore,

[7] In the next section, when we estimate the model, we restrict our data to the period 1984-2007. As we do not model the 2007-2009 financial crisis and the following ZLB periods, our model is unfit for most of the post-2007 periods. Notice that estimating the model over the period 1961-2007, thus excluding data on consumption heterogeneity, leads to similar results.

smooth their consumption. Because these hand-to-mouth households are central to our enquiry, it is necessary to identify them properly. Ideally, in order to match our model with the data, we would identify hand-to-mouth households based on their net holdings of assets. Unfortunately, since none of the CPS and the CEX data contain detailed information on household wealth, we cannot properly identify the type of agents of the economy. Hence, we follow the literature by assimilating credit constraint households to the 30% bottom of the earnings distribution. This is consistent with Kaplan and Violante (2014) who estimate that the total fraction of hand-to-mouth households in the United States is around 1/3 of the population.[8]

The next fact looks at the study properties of labor earnings of these two groups.

Fact 2: *Earnings inequality results from large shocks hitting primarily low earners.*

Table 1 indicates that the log-difference of earnings at the bottom of the distributions (percentiles 0 to 30 percentiles) are positively correlated with the log-difference of earnings at the top (percentiles 31 to 100). The correlation coefficient between the two series is equal to 0.72, implying a strong co-movement in the earnings series across the two considered groups. Table 1 also points out the much larger fluctuations in earnings at the bottom of the distribution relative the top. The standard deviation of the log-difference of earnings at the bottom is almost 3 times larger than at the top.

[Table 1 approximately here]

To inspect the sources of income fluctuations of households at the bottom of the distribution, Panel (a) of Figure 2, plots the mean earnings series (solid blue line) along with wages (dotted red line) and number of weeks worked (dashed black line). To show clearly the magnitude of both the trend and the cycle of all series, the figure plots the series in deviation from the 1967 values. Clearly, both wages and number of weeks in employment contribute to the variability and the trend of earnings. Panel (b) plots weeks worked conditional on reporting positive hours in the CPS survey, along with the fraction of households that work positive hours, and the 'unconditional' number of weeks (for the entire population of low income households). As is evident, the long-run decline in weeks worked at the bottom of the distribution is driven by an increasing fraction of men that do not work at all. The number of weeks worked conditional on working remains stable over decades, however it displays considerable cyclical volatility.

In view of this last fact, two remarks are called for. First, in contrast with Heathcote et al. (2020), the focus of this paper will be on the cyclical properties of earnings in different households groups, we will not consider the macroeconomic implications of the rise of inequality or the drop in hours and employment across decades. However, since these are well known and important trends, a section devoted to analyzing empirical patterns of inequality cannot ignore them.[9] Second, as in

[8] As a robustness check, we also estimate our theoretical model with an alternative calibration. We assume that hand-to-mouth households consist of the 20% bottom earners only. As will be discussed, the empirical patterns presented below do not change much.

[9] The Appendix continues this analysis, showing that the long-run increase in inequality results from two main sources. First, increases in weekly wages mostly benefiting top earners (panel (a)). Second, a decline in the participation rate of low earners over the last 58 years (panel (b)). See Figure 3 in the Appendix.

most of the DSGE literature, we only consider total hours worked and focus on total labor income of each households groups. Therefore, we abstract from the questions related to intensive and extensive margins, participation decisions and the level of unemployment.

[Figure 2 approximately here]

Let us now turn to the 3rd key fact of this empirical section.

Fact 3: *The US transfer system redistributes income towards the bottom income households during economic recessions. This reduces fluctuations in the relative disposable income and consumption of poorer households.*

To show this we use data on income and consumption drawn from the CEX. Figure 4 plots the ratio of income of bottom 30 percent households to average household income, and the analogous ratios for disposable income and household consumption. Notice that the consumption and disposable income ratios are much less cyclical than the household income ratio. For example, during the Great recession we have seen a sharp drop in the relative income of poorer households, and not a substantial drop of relative disposable income/consumption. The same pattern emerged during the early 90s economic downturn. (Interestingly, the 2001 recession was not accompanied by a large drop in the income of the bottom 30 per cent.)

[Figure 4 approximately here]

What make consumption and disposable income less responsive to the cycle? It is evident that transfers programs run by the government, such as unemployment benefits, food stamps and other income assistance programs, help mitigate the loss of income and insulate household consumption. To complement Figure 4 we show in the Appendix, that the fractions of households at the bottom 30 percent of the distribution that participate in unemployment benefits and food stamps programs displays considerable cyclical volatility, increasing substantial during recessions. This is not the case for the rest of the US population.

3 Fiscal policy in an estimated DSGE model

In this section we construct and estimate a medium-scale DSGE with a two-agent structure and a detailed fiscal bloc where taxes and transfers are determined by simple feedback rules. This offers a flexible structure which allows us to make sure that our model can properly match the observed data. In the next section, we turn to the case of optimal policy, where the estimated parameters and shock processes are fed into the Ramsey version of the model.

The remainder of this section is organized as follows. We first provide a description of the model that we use to match US time series. Then, we describe our empirical strategy and provide our estimation results. Finally, we shed light on the main driving forces behind earnings inequality and we discuss the role of fiscal variables.

3.1 Model description

We consider a medium-scale New Keynesian model with two-agent, the so-called TANK model (Galí et al., 2007). As is standard in the DSGE literature, we incorporate several real and nominal rigidities to the model in order to properly match the main US macroeconomic aggregates. More precisely, we add imperfect competition in product and factor markets, price and wage rigidities, habit formation, variable capital utilization, and investment adjustment costs. We consider exogenous shocks to productivity, government spending, preferences, and price and wage markups. Fiscal policy consists of distortionary labor taxes and targeted transfers, but on top of that, we consider a constant tax rate on consumption and capital.

3.1.1 Households and wage setting

The economy is populated by two types of households. A first fraction $1-\lambda$ of agents are Ricardian households that maximize their expected life-time utility and have access to government bonds, which allow them to smooth consumption over time and across states. The remaining fraction λ of agents are hand-to-mouth and consume their entire disposable income.

Ricardian households Within the class of Ricardian households, a continuum of agents optimally choose consumption, investment in capital, bond holdings, labor supply and wages in order to maximize their expected lifetime utility which, for agent $i \in [0,1]$, is expressed as:

$$U^{s,i} = E_0 \sum_{t=0}^{\infty} \beta^t \xi_t^b \Big(u(c_t^s - h\bar{c}_{t-1}^s) - v(n_t^s(i)) \Big) \tag{1}$$

Agents value consumption with respect to an external habit stock $h\bar{c}_{t-1}^s$, where $h \in [0,1]$ governs the degree of habit formation.

Each agent operates under monopolistic competition in the labor market and sets its individual wage $W_t(i)$ and labor supply $n_t^s(i)$ subject to Calvo-type wage rigidities. As is standard in the literature, we assume the presence of state-contingent transfers $\Xi_t(i)$ which ensure that all Ricardian households consume the same amount of goods c_t^s.

For clarity, we separate the exposition of the Ricardian households' optimization problem in two distinct part. In the first part, households choose consumption c_t^s, the level of capital utilization u_t, investment in capital (I_t^s and k_t^s), and holdings of nominal government bonds B_t^s. The second part is devoted to wage setting and is described below.

Agents choose $(c_t^s, B_t^s, I_t^s, K_t^s, u_t)$ to maximize (1) subject to:

$$(1+\tau^c)P_t c_t^s + P_t I_t^s + q_t B_t^s + P_t \Phi(u_t) K_{t-1}^s = (1-\tau_t^n) W_t(i) n_t^s(i) + \Xi_t(i) + (1-\tau^k)(R_t^k u_t K_{t-1}^s + D_t^s) + B_{t-1}^s + T_t^s \tag{2}$$

$$K_t^s = (1-\delta) K_{t-1}^s + \xi_t^i \Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s} \Big) \Big] I_t^s \tag{3}$$

The first equation is the budget constraint of the Ricardian household i. τ^c and τ^k denote the (constant) tax rates on consumption and capital revenues, respectively. Ricardian households are assumed to own the firms populating the economy; D_t^s denotes dividends received from these firms, and R_t^k represents the return on private capital which is lent by Ricardian households to the same firms. q_r is the price of one period, non state-contingent government bonds, which are held in quantity B_t^s by Ricardian households. τ_t^n is the time-varying tax on labor, which evolves according to an exogenous rule specified below. T_t^s denote the per capita lump-sum transfers directed to Ricardian households. The transfer rule is also described in more detail below.

Equation (3) is the law of motion of private capital. Investment adjustment costs are determined by the function $S(\cdot)$, and ξ_t^i denote investment-specific shocks, which follow an AR(1) process.

The first order conditions associated to the above problem can be expressed as:

$$c_t: \quad \lambda_t = \xi_t^b \frac{u_c(c_t^s - hc_{t-1}^{s,a})}{1+\tau^c} \tag{4}$$

$$B_t^s: \quad \lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} \tag{5}$$

$$I_t^s: \quad 1 - \xi_t^i \mu_t \Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big) - \frac{I_t^s}{I_{t-1}^s} S'\Big(\frac{I_t^s}{I_{t-1}^s}\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1} \frac{\lambda_{t+1}}{\lambda_t}\Big(\frac{I_{t+1}^s}{I_t^s}\Big)^2 S'\Big(\frac{I_{t+1}^s}{I_t^s}\Big) \tag{6}$$

$$K_t^s: \quad \mu_t = \beta(1-\delta)E_t \mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{7}$$

$$u_t: \quad \Phi'(u_t) = (1-\tau^k) r_t^k \tag{8}$$

where $\mu_t \equiv \frac{\psi_t}{\lambda_t}$, and λ_t and ψ_t denote respectively the Lagrange multipliers on constraints (2) and (3).

We now turn to the wage-setting block. Individual labor inputs $n_t^s(i)$ are bundled using a CES aggregator to get n_t^s the aggregate Ricardian households' labor supply employed by firms:

$$n_t^s = \Big(\int n_t^s(i)^{\frac{\eta_w - 1}{\eta_w}} di\Big)^{\frac{\eta_w}{\eta_w - 1}} \tag{9}$$

Cost-minimization leads to the demand for individual labor:

$$n_t^s(i) = \Big(\frac{W_t(i)}{W_t}\Big)^{-\eta_w} n_t^s \tag{10}$$

Wage-setting is subject to Calvo-type rigidities. In every period, a single household can update its wage with probability $1-\theta_w$. Otherwise, its past wage is indexed to inflation. Individual wages are therefore given by:

$$W_t(i) = \begin{cases} W_t^* & \text{with prob. } 1-\theta_w \\ \Pi e^{\gamma} W_{t-1}(i) & \text{with prob. } \theta_w \end{cases} \tag{11}$$

where W_t^*, which expression is given in the appendix, is the wage rate which maximizes (1) subject to (10) and the budget constraint (2). We assume that wages that are not re-optimized in the current period are indexed by the steady-state inflation rate Π.

Hand-to-mouth households Hand-to-mouth agents, or non-savers, choose consumption and labor supply optimally to maximize their period utility:

$$U^h = u(c_t^h - h\bar{c}_{t-1}^h) - v(n_t^h) \tag{12}$$

subject to their budget constraint:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + t_t^h \tag{13}$$

The wage rate w_t denotes the aggregate wage rate resulting from the aggregation of the individual wages set by Ricardian agents. For convenience, we do not allow hand-to-mouth agents to set their wage optimally, and the wage rate is therefore taken as given by this class of households.

θ_t^h denotes a labor productivity shock which affects hand-to-mouth agents only. This shock reflects the relative wage dispersion between the two types of agents, and is assumed to evolve as:

$$\frac{\theta_t^h}{\theta^h} = \left(\frac{\theta_{t-1}^h}{\theta^h}\right)^{\rho_\theta} \left(\frac{y_t}{y_t^p}\right)^{\phi_{\theta,y}(1-\rho_\theta)} \exp(\epsilon_{\theta,t}) \tag{14}$$

Utility maximization gives rise to the labor supply condition, which can be expressed as:

$$\frac{v_n(n_t^h)}{u_c(c_t^h - h\bar{c}_{t-1}^h)} = (1-\tau_t^n)\theta_t^h w_t \tag{15}$$

3.1.2 Firms and price setting

A final goods producer aggregates output from a continuum of intermediate firms $j \in [0,1]$:

$$y_t = \left(\int y_t(j)^{\frac{\eta_p-1}{\eta_p}} dj\right)^{\frac{\eta_p}{\eta_p-1}} \tag{16}$$

Cost minimization gives the following demand for intermediate goods:

$$y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\eta_p} y_t \tag{17}$$

where P_t denotes the aggregate price level.

We assume Calvo pricing for intermediate goods producers. Every period, a given firm has a probability $1-\theta_p$ of resetting its price. We have, for firm j:

$$P_t(j) = \begin{cases} P_t^* & \text{with prob. } 1-\theta_p \\ \Pi e^\gamma P_{t-1}(j) & \text{with prob. } \theta_p \end{cases} \tag{18}$$

where P_t^* is the price set by profit-maximizing firms which have the possibility to adjust prices in the current period. The expressions characterizing optimal price-setting are given in the Appendix.

Intermediate firms have access to the following Cobb-Douglas production function:

$$y_t(j) = K_t(j)^\alpha \Big(a_t n_t(j)\Big)^{1-\alpha} - \Omega a_t \tag{19}$$

where Ω is a fixed production cost that will be set so that aggregate profits are zero in the steady-state, and a_t is a labor-augmenting technology shock whose log-differences evolve as an AR(1) process with drift:

$$\xi_t^a \equiv \frac{a_t}{a_{t-1}} = \exp(\gamma)^{1-\rho_a}[\xi_{t-1}^a]^{\rho_a} \exp(\epsilon_{a,t}) \tag{20}$$

where γ is the trend growth rate in the economy, and $\epsilon_{a,t}$ is an i.i.d shock to technology.

Cost minimization by firms gives the demand for firm-specific capital and labor. We get:

$$\frac{w_t}{r_t^k} = \frac{1-\alpha}{\alpha}\frac{K_t(j)}{n_t(j)} \tag{21}$$

3.1.3 Monetary and fiscal policy

Interest rate rule: The (gross) nominal interest rate R_t is set by a central bank according to the following Taylor rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} \left(\frac{y_t}{y_t^p}\right)^{\phi_y}\right]^{1-\rho_r} \xi_t^m \tag{22}$$

where R denotes the steady state level of the nominal interest rate associated with the long-run inflation target Π. The variable y_t^p represents potential output, and is derived in the Appendix. The variable ξ_t^m is an exogenous monetary policy shock which follows an AR(1) process in logs. The parameters ρ_r, ϕ_π and ϕ_y represent respectively the weights given to interest-rate smoothing, and inflation and output stabilization.

Government budget: The government issues bonds and taxes labor, capital and consumption to finance transfers and spending needs. Taxes on capital and consumption are constant, while labor taxes, transfers, government spending and debt are time-varying. The government budget constraint is:

$$\frac{b_{t-1}}{\Pi_t} = -(g_t + T_t + \xi_t^{gb}) + \tau_t^n w_t n_t + \tau^k(r_t^k u_t k_{t-1} + d_t) + \tau^c c_t + q_t b_t \tag{23}$$

Government spending g_t evolves exogenously as an AR(1) process in logs and ξ_t^{gb} is a measurement error term. Labor taxes and transfers are set by the fiscal authority following simple feedback rules.

Labor taxes: The labor tax rate evolves as:

$$\frac{\tau_t}{\tau} = \left(\frac{\tau_{t-1}}{\tau}\right)^{\rho_\tau} \left[\left(\frac{b_{t-1}}{b}\right)^{\phi_{\tau,b}} \left(\frac{y_t}{y_t^p}\right)^{\phi_{\tau,y}}\right]^{1-\rho_\tau} \exp(\epsilon_{\tau,t}) \tag{24}$$

where $\phi_{\tau,b}, \phi_{\tau,y}$ are parameters governing the response of labor taxes to government debt and the output gap, and $\epsilon_{\tau,t}$ is an i.i.d shock.

Transfers: Transfers follow the rule:

$$\frac{T_t}{Y_t} = \left(\frac{T_{t-1}}{Y_{t-1}}\right)^{\rho_T} \left[\left(\frac{y_t}{y_t^p}\right)^{\phi_{T,y}}\right]^{1-\rho_T} \exp(\epsilon_{T,t}) \tag{25}$$

where $\phi_{T,y}$ controls the response of transfers to the output gap and $\epsilon_{T,t}$ is an i.i.d shock.

Therefore, in the government budget constraint, we model transfers as a unique process T_t. These lasts are subsequently split between the two groups of households according to a targeting rule which specifies the share of transfers $\omega \in [0,1]$ going to hand-to-mouth households. The per capita transfers to hand-to-mouth households and savers are therefore respectively given by $T_t^h = \frac{\omega}{\lambda} T_t$ and $T_t^s = \frac{1-\omega}{1-\lambda} T_t$. Imposing ω to be larger than λ allows us to jointly match two empirical facts highlighted by Chafwehé and Courtoy (2021): (i) individual transfers are strongly correlated across households and (ii) transfers are unevenly targeted towards hand-to-mouth households.

Note that in the next section, equations (24) and (25) are removed from the system, and taxes and transfers are set optimally by a Ramsey planner operating under full commitment.

3.1.4 Equilibrium and aggregation

Equilibrium in the market for government bonds implies that $b_t = \frac{1}{1-\lambda} b_t$.

Aggregate production satisfies:

$$\int y_t(j)dj = y_t v_t^p = (u_t k_{t-1})^\alpha (a_t n_t)^{1-\alpha} - \Omega a_t$$

where v_t^p is a variable linked to price dispersion and is provided in the Appendix. Firms' profits have to equal dividends paid to Ricardian households, and we have $d_t^s = \frac{1}{1-\lambda} d_t$.

We define aggregate consumption and aggregate labor supply, respectively, as follows:

$$n_t = \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s \tag{26}$$

$$c_t = \lambda c_t^h + (1-\lambda) c_t^s \tag{27}$$

Merging the two agents' budget constraint with the government budget leads to the following economy-wide resource constraint:

$$c_t + I_t + g_t + \Phi(u_t) k_{t-1} = y_t \tag{28}$$

3.1.5 Detrending, steady-state, and log-linearization

Due to the presence of trend growth in the model, we need to rescale some variables to ensure stationarity. The following variables are rescaled by a_t, the level of technology : y_t, c_t, c_t^h, c_t^s, w_t, b_t, tr_t, g_t, k_t, I_t and λ_t.

Once a sationary system is obtained, we can drop time subscripts and compute the steady-state values of model variables. The equations characterizing the steady-sate of the economy are provided in the Appendix.

We log-linearize the model equations around the steady-state before solving the model using standard perturbation methods. The resulting system of equations is also exposed in the Appendix.

3.2 Estimation

We follow a two-steps procedure to estimate the model. We firstly calibrate the model parameters that cannot be identified with the data series we use. Then, we estimate the model with standard Bayesian methods. The section is structured as follows. First, we present the data used to estimate the model. Second, we describe the calibrated parameters and then the estimated parameters.

3.2.1 Dataset and measurement equations

We estimate the model using mixed-frequency data for the period 1984-2007. The dataset we use for the estimation contains standard quarterly macroeconomic time series widely used in the DSGE literature, along the lines of Smets and Wouters (2007), and detailed information on fiscal variables, as in Leeper, Plante, and Traum (2010). It also contains cross-sectional data describing the evolution of annual earnings of 'hand-to-mouth' and 'Ricardian' households, as well as data series describing the difference in consumption between the two household groups.

The standard macroeconomic time series we use are consumption ($CONS$), GDP (GDP), investment (INV), inflation ($INFL$), the federal funds rate (FFR), hours worked ($HOURS$) and the aggregate wage rate ($WAGE$). On the fiscal side, we use data on government spending (GOV), labor tax revenues ($LTAX$), transfers ($TRANSF$), and the market value of government debt ($MVDEBT$). We used micro data from the Current Population Survey (CPS) to construct series of annual earnings of both hand-to-mouth ($EARN^{HtM}$) and Ricardian ($EARN^{Ric}$) households. In Appendix B, we provide the relationship between the observed annual earnings and their theoretical counterparts. Finally, we also employed the Consumer Expenditure Survey (CEX) to construct a series describing the evolution of the share of total consumption actually consumed by hand-to-mouth households ($C30$).

A complete description of the methodology used to construct the series is provided in Appendix C.

Time series that exhibit a trend (in the model and the data) are specified in log-differences; for the other data, we only take logs. The measurement equations linking model variables and data are given by:

$$\begin{pmatrix} \Delta CONS_t \\ \Delta INV_t \\ \Delta WAGE_t \\ \Delta GOV_t \\ \Delta GDP_t \\ \Delta MVDEBT_t \\ HOURS_t \\ INFL_t \\ FFR_t \\ \Delta LTAX_t \\ \Delta TRANSF_t \\ \Delta EARN_t^{HtM} \\ \Delta EARN_t^{Ric} \\ C30_t \end{pmatrix} = \begin{pmatrix} 100\gamma \\ 100\gamma \\ 100\gamma \\ 100\gamma \\ 100\gamma \\ 100\gamma \\ 100\log(n) \\ 100\log(\Pi) \\ 100\log(R) \\ 100\gamma \\ 100\gamma \\ 0 \\ 400\gamma \\ 0 \end{pmatrix} + \begin{pmatrix} \hat{c}_t - \hat{c}_{t-1} + \hat{\xi}_t^a \\ \hat{I}_t - \hat{I}_{t-1} + \hat{\xi}_t^a \\ \hat{w}_t - \hat{w}_{t-1} + \hat{\xi}_t^a \\ \hat{g}_t - \hat{g}_{t-1} + \hat{\xi}_t^a \\ \hat{y}_t - \hat{y}_{t-1} + \hat{\xi}_t^a + \hat{\xi}_t^{me,y} \\ \hat{q}_t - \hat{q}_{t-1} + \hat{b}_t - \hat{b}_{t-1} + \hat{\xi}_t^a \\ \hat{n}_t \\ \hat{\pi}_t \\ \hat{R}_t \\ \hat{w}_t + \hat{\tau}_t^n + \hat{n}_t - \hat{w}_{t-1} - \hat{\tau}_{t-1}^n - \hat{n}_{t-1} + \hat{\xi}_t^a \\ \hat{T}_t - \hat{T}_{t-1} + \hat{\xi}_t^a \\ \hat{earn}_{ann,t}^{HtM} - \hat{earn}_{ann,t-4}^{HtM} + \hat{\xi}_t^a + \hat{\xi}_{t-1}^a + \hat{\xi}_{t-2}^a + \hat{\xi}_{t-3}^a \\ \hat{earn}_{ann,t}^{Ric} - \hat{earn}_{ann,t-4}^{Ric} + \hat{\xi}_t^a + \hat{\xi}_{t-1}^a + \hat{\xi}_{t-2}^a + \hat{\xi}_{t-3}^a + \hat{\xi}_t^{me,earn} \\ \hat{c}_t^h - \hat{c}_t + \hat{\xi}_t^{me,c} \end{pmatrix}$$

where $\hat{x}_t \equiv \log(x_t) - \log(x)$ denotes the log deviation of the model variable x from its steady-state value.

Because all the elements of the resource constraint of the model economy are present in our dataset, and given that some elements such as net exports are not modelled in our framework, we assume that data on GDP are observed with measurement errors $\hat{\xi}_t^{me,y}$ that act as i.i.d shocks.

It has been documented by Heathcote et al. 2010b that the aggregate consumption data obtained from household aggregation in the CEX dataset do not coincide with NIPA data, which are used in the estimation for aggregate consumption.[10] Therefore, and along the lines of Challe et al. 2017a, we also introduce measurement errors in our series describing the consumption dispersion between households, $\hat{\xi}_t^{me,c}$. We assume that they follow an AR(1) process.

Finally, because there is a downward bias in the CPS income series arising from internal censoring of high income values, we also add a measurement error term in our series on Ricardian households' earnings. Indeed, as discussed in Heathcote et al. (2010b), the dynamics of earnings and wealth dispersion at the top of the income distribution in the CPS are underestimated as compared to the dynamics measured through the Survey of Consumer Finances (SCF).

[10] Among others, Garner, Janini, Paszkiewicz, and Vendemia (2006); Heathcote et al. (2010b) and Aguiar and Bils (2015) document the decline in aggregate consumption reported in the CEX relative to national income and product account (NIPA) personal consumption expenditures. They provide two main explanations for this large and growing gap. On one hand, there are some conceptual differences in the categories of consumption covered in each data (most notably in health expenditure categories). On the other hand, the CEX sample under-represents the upper tail of the income and consumption distributions. Unfortunately, these issues can hardly be corrected. This also means that ratio-based measures of consumption inequality are therefore probably biased (the sign and size of the bias depend on the CEX's under/upper-reporting of consumption expenditure of high income households). To remedy the issue, Aguiar and Bils (2015) propose an alternative measure of consumption inequality based on the share of luxury goods in total consumption of rich and poor households. They find that consumption inequality tracks income inequality much more closely than estimated by direct responses on expenditures. In the estimation, we rather follow Challe, Matheron, Ragot, and Rubio-Ramirez (2017a) who simply introduce measurement errors in their estimation.

3.2.2 Calibrated parameters and functional forms

The functional forms used for the period utility function are $u(c - h\bar{c}) = \log(c - h\bar{c})$ and $v(n) = \chi \frac{n^{1+\phi}}{1+\phi}$. The functional forms for investment adjustment costs and capital utilization costs are standard; their specification is provided in Appendix B.

The values given to calibrated parameters are summarized in Table 3.

[Table 3 approximately here]

We choose the labor disutility parameter χ to be consistent with a normalized value for steady-state aggregate hours of $n = 1$, and a ratio of hand-to-mouth to aggregate consumption of $\frac{c^h}{c} = 63.2\%$, which is the average value in the sample we use for estimation. The fixed cost of production Ω is chosen such that firms do not make profits in steady-state $(d = 0)$.

The capital share in productivity is equal to $\alpha = 0.3$, and the quarterly depreciation rate of capital is set to $\delta = 2.5\%$. Steady-state price and wage markups are set to 1.5 and 1.4 respectively, which is in the range of values typically assumed in the literature.

On the fiscal side, we set the (constant) tax rates on capital and consumption, as well as the steady-state value of the tax rate on labor, equal to their empirical average in our sample. We get $\tau^k = 19.8\%$, $\tau^c = 3\%$ and $\tau^n = 21\%$. We adopt the same strategy for government spending, transfers, and the market value of government debt, and we fix the steady-state values of these variables, as a fraction of GDP, to their historical average. The values are provided in Table 3.

Finally, we assume that the parameter defining the share of hand-to-mouth in the population $\lambda = 30\%$. And we set the parameter targeting the share of transfers going towards hand-to-mouth agents to $\omega = 67.3\%$, which is the empirical average that we observed in the CEX data. This calibration is consistent with Kaplan and Violante (2014) who find that hand-to-mouth households represent 1/3 of the total population.

However, because Kaplan and Violante (2014) also show that there are two types of hand-to-mouth households,[11] we also estimate the model with an alternative calibration. Specifically, we assume that the share of credit constrained households in the economy (λ) is equal to 20%, while the share of transfers that is directed to them (ω) is equal to 53.1%. As will be discussed in the next sections, estimating our model under this alternative calibration shows very limited differences with our baseline estimation.

3.2.3 Estimated parameters w. and w/o. cross-sectional data

The remaining set of parameters are estimated with Bayesian methods. Most of the prior choices are very standard and common with other papers in the literature (see Smets and Wouters (2007)

[11] On the one hand, there are what they qualify as "poor" HtM households who do not hold any assets. They do not hold liquid assets, such as short-term risk free bonds, nor illiquid assets, like cars or house. On the other hand, there are what they call "wealthy" hand to-mouth households who hold sizable amounts of illiquid wealth but who also choose to consume their entire disposable income in each period (and therefore who do not hold any liquid assets). Since these "wealthy" HtM households represent between 40 and 80 percent of overall HtM households, the share of "poor" HtM in total population varies between 10 and 25%.

for the most standard parameters, and Traum and Yang (2011) for an estimated model with a fiscal block similar to ours). Table 4 displays the prior distributions of the estimated parameters, and we refer the reader to this table for more details.

Table 4 also provides with the estimated posterior distributions from two main estimations of our model: the first one only includes aggregate variables in the data used to perform the estimation (TANK) whilst the second one also adds data on earnings and consumption heterogeneity (TANK*). In both cases, the estimates are broadly in line with the literature. The parameter governing wage stickiness is relatively low compared to Smets and Wouters (2007), which estimates amounts to 0.7. However, with a value of 0.3 (in the TANK* and 0.5 otherwise), the parameter remains well in line with Traum and Yang (2011). The estimated parameters of our monetary and fiscal policy rules are also in line with the literature. The coefficients of the Taylor rule are very standards, with coefficients on inflation and output deviations being equal to 1.9 and 0.05. The estimates of the fiscal rule indicate, as previously described in Traum and Yang (2011), that the labor tax rate rises with output and, in a smaller extent, with debt.

What is new to our model –and therefore deserves more attention– is the two-agent structure, the redistributive role given to transfers, and the process describing the evolution of hand-to-mouth agents' relative labor income.

As mentioned above, our transfer rule allows for cyclical responses of transfers through its response to the output gap, which is measured by the parameter $\phi_{T,y}$. The posterior mean of the parameter is negative in our two estimations, therefore indicating that transfers decrease when the economy is booming.[12] Looking at the estimated rule for the income process of HTM households θ_t^h, the posterior mean of the coefficient describing its response to the output gap, $\phi_{\theta,y}$, is positive in both estimations. It is also three times higher when data on income inequality are used in the estimation. Hence, if both estimations point out to the same conclusion – the income of hand-to-mouth households goes down in recessions and recovers in booms – the model needs to be fed with additional data to properly capture the dynamics of households income inequality.

Taken together, these estimates indicate that transfers are counter-cyclical while hand-to-mouth agents's relative income is pro-cyclical. This conclusion also implies that these two processes are likely to be negatively correlated: when the relative income of hand-to-mouth households goes down, transfers tend to go up. Hence, the evidence tells us that the US government respond to negative shocks to output by increasing the amount of transfers, that is, exactly when hand-to-mouth households get relatively poorer than Ricardian households.

With the exception of the parameters governing the dynamics of households earnings, the introduction of households heterogeneity data in the estimation does not affect the estimates of the core parameters of the model. Similarly, adding this data impacts only few parameters characterizing the shock processes affecting the economy. Actually, the estimated persistence and variance

[12] Note that the overall reaction of transfers to a change in output is measured by $(1-\rho_T)\phi_{T,Y}$, which amounts to -0.1 when evaluated with mean estimates. Note also that the response of transfers to output is slightly delayed in the data. The correlation between the growth rate of output and transfers is equal to -.28 when both variables are measured at time t, while it amounts to -.36 when we take the the correlation between the growth rate of transfers in $t+1$ and the growth rate of output in t.

of most of our ’standard’ shocks - aggregate productivity and government expenditure shocks, investment-specific shocks, price-markup shocks, monetary- and fiscal-policy shocks and preference shocks - are comparable to the one obtained in the literature and are robust to the introduction of data on earnings and consumption heterogeneity.[13]

The introduction of data on households heterogeneity affects however the estimated persistence and variance of shocks associated to income processes. For instance, the persistence of wage markup shocks goes from 0.34 to 0.95, while the variance of shocks to the relative productivity of hand-to-mouth households increases drastically from 0.11% to 2.52%. This last change is particularly noticeable. It is large and significant. As such, it might transform our current understanding of the dynamics affecting the economy. Therefore, we further study the US business cycle in the next section.

[Table 4 approximately here]

Robustness Check Before turning to this analysis, it is worth to notice that our calibration of the relative importance of hand-to-mouth households in the economy weights relatively little on the estimation results. In Appendix D, we provide the estimated posterior distributions of the model where we assume that hand-to-mouth households represent the bottom 20% of the earnings distribution (instead of 30%). The estimated parameters are virtually identical to the one described above. One exception stands out though, the variance of shocks to the relative productivity of hand-to-mouth households increases further to reach 5.27%. Note that this elements does not affect the results discussed in the next two sections (see figures in Appendix D).

3.2.4 The US Business Cycles

The estimates of persistence and variance of shock processes are difficult to interpret per se. Instead, by performing variance decomposition and historical decomposition of the business cycle, we can study what these parameters imply in terms of our perception of what shocks drive the US business cycles. This is the concern of this section.

Figure 5 displays the simulated **variance decomposition** of 4 main aggregate variables of the economy – aggregate consumption, output gap, investment and inflation – using our two main estimations. The variance decomposition obtained from the estimation without data on earnings and consumption heterogeneity (TANK) is provided on the left part of each panel of Figure 5. The variance decomposition obtained from the estimation with data on heterogeneity (TANK*) is provided on the right part of each panel.

In general, we find few but significant differences between the two estimations. Without data on earnings and consumption dispersion, we find that, as in the literature, supply shocks (the two markups, TFP and investment-specific shocks) are the main drivers of output volatility (top-right panel). Taken all together, they account for 80% of its variance. The remaining output volatility is related to two main demand shocks: monetary policy shocks and preference shocks. When data

[13]Notice however the increased persistence of TFP shocks, which more than doubles – passing from 0,17 to 0,40 – and the decreased variance of Ricardian households’ preference shocks, which goes from 2.88% to 1.96%.

on heterogeneity are used in the estimation, almost all of the volatility of output is explained by supply shocks. Yet, TFP and investment shocks lose stream to the benefits of wage-markup shocks and shocks to the relative productivity of hand-to-mouth households, which explain 10% of the volatility of output.

This last observation calls for additional comments. First, as already stated in the preceding section, the persistence of wage-markup shocks is much larger when households' income data are introduced directly in the estimation. Hence, it is of no surprise that their estimated impact on real variables is enlarged. Second, shocks to the relative productivity of hand-to-mouth households are of a special kind: they are a mixture of supply and demand shocks.[14] On the one side, they resemble to TFP shocks. They play a similar role in the production function and therefore induce similar responses of aggregate variables like output. As such, these shocks have the potential of capturing part of the explanatory power of TFP shocks. This is exactly what we observe in Figure 5. On the other side, because they directly affect hand-to-mouth households' income, they also look like demand shocks. Indeed, because these shocks primarily affect households who cannot save, they induce large swings in their consumption level, and therefore in aggregate demand and aggregate output.

From the top left panel, we can see the impact of including data on households heterogeneity on the volatility of consumption. Once again, wage-markup shocks and shocks to the relative productivity of hand-to-mouth households gain in importance at the expense of demand shocks (shocks to the preference of Ricardian households, monetary policy shocks and government spending shocks). Similar observations can be drawn for investment in the lower part of Figure 5.

[Figure 5 approximately here]

If the variance decomposition provides the contribution of each shock to the average cycle implied by the model, it does not explain how the model perceives the actual cycles that the US has gone through. This is done with **historical decomposition**, which results are displayed in Figure 8 and 9.

Lets us first concentrate on Figures 8 which provides the historical decomposition of aggregate variable according to our TANK* model (i.e. estimated with data on income and consumption inequality). As expected, markups are the most important drivers of the business cycles. The evidence shows that wage markup shocks had a strong and positive impact on consumption and investment, and ultimately on output, over the recovery period of 1995-1998. Since then, their contribution to the business cycle reduced. If price markups decreased over the course of the 1980s and the beginning of the 1990s, therefore contributing positively to consumption and output, they increased sharply from the early 2000s on wards. This last observation is well in line with the evidence provided by the literature (Bayer et al., 2020).

An interesting feature of the historical decomposition is the behavior of shocks to the relative productivity of hand-to-mouth households which follow closely, though with some delays, TFP

[14] This is one of the main differences between our model and HANK models, such as the one developed by Bayer et al. (2020), which only consider idiosyncratic shocks.

shocks. This way, they seem to act as amplification technologies for the business cycles. Yet, except for the late 1980s, the overall impact of these shocks on the variance of consumption and output is relatively limited.

[Figure 8 approximately here]

As a matter of comparison, we provide in Figure 9 the historical decomposition provided by the estimation without data on households inequality. Roughly speaking, the figure presents a similar picture. Except for shocks on the relative productivity of hand-to-mouth households, which basically disappear, all shocks have the same sign at the same moment. The share of the variance of aggregate variables that is explained by markups shocks diminishes to the benefits of investment and risk premium shocks.

[Figure 9 approximately here]

From this analysis, we find that introducing data on heterogeneity matters for the historical decomposition of the business cycles. Shocks on income processes (markup shocks and the relative productivity of hand-to-mouth agents) gain in relative importance. However, in continuity with Bayer et al. (2020), we find that adding cross-sectional data in the estimation does not change the conclusions drawn by the literature regarding the main sources of fluctuations of the US economy. Markups and TFP shocks remain the main drivers of the US business cycle.

From this stage on, we exclusively focus on the results provided by the estimation with cross sectional data. In the next subsection, we pursue our analysis by digging further on the dynamics of income and consumption inequality between households.

3.2.5 Earnings and Consumption Inequality

To understand further the evolution of households' earnings and consumption over the course of 1984-2007, Figure 10 plots the historical decomposition of these variables. This exercise helps us to understand how the model perceives the dynamics of inequality between the two groups of households as well as the role of the fiscal policy over the business cycle.

From this figure we make a twofold observation. First, as expected, the variations of hand-to-mouth's labor earnings (top-right panel) are much larger than the variations of Ricardian's ones (top-left panel). This difference mainly results from shocks to the relative productivity of hand-to-mouth households.

Second, the variance of households' consumption (bottom panels) is smaller than the variance of their labor earnings. As far as Riccardian households are concerned, this reflects two main things. On the one hand, Ricardian households save in order to smooth consumption across time and states of the economy. Hence, generally shocks have lesser impacts on their consumption than on their earnings and income. On the other hand, since Ricardian households own firms and therefore receive the entire profits as dividends, price markup shocks have much lower impacts on their consumption. When it comes to hand-to-mouth households, the historical decomposition of their consumption would replicate entirely the one of their earnings (since they have a marginal propensity to consume equal to 1) if it was not for the existence of transfers. Indeed, because transfers have a strong counter-cyclical effect on their income, hand-to-month households' consumption is smoothed across time and states.[15]

[Figure 10 approximately here]

Figure 11 shows that the endogenous response of transfers, as captured by our fiscal rule, is responsible for roughly half of its variations over the period 1984-2007.[16] The other half of the variations in transfers came out from exogenous policy shocks. All in all, transfers in the model reproduce the behavior observed in the data. That is, transfers are counter-cyclical.

[Figure 11 approximately here]

From theory, we know that the fiscal authority is facing a dual motive when setting its policy (Chafwehé and Courtoy, 2021). On the one hand, it wants to achieve some degree of redistribution and, on the other hand, it wants to implement the policy that is the least distortionary. Often, these motives are in conflict. Indeed, for a given level of debt, policies that use transfers to redistribute resources across agents come at the cost of increasing the level and volatility of distortionary labor taxes. As measured by the model, the fiscal authority gives the priority to redistribution over efficiency: transfers are one of the main drivers behind changes in primary deficits. This is true whichever data are included in the estimation, however, as described in Table 2, using cross-sectional data leads the model to view fiscal policy even more pro-cyclical.

[Table 2 approximately here]

4 Optimal fiscal policy in the medium-scale model

From the preceding analysis, we show that household heterogeneity and the inclusion of micro data, such as earnings and consumption dispersion across households, matter for the estimation of the frictions and shocks affecting the US business cycle. In particular, we demonstrate that shocks to income processes such as markup shocks and shocks to the relative productivity of hand-to-mouth households are essential for the model to capture realistic dynamics in terms of earnings inequality. In turns, these dynamics call for the intervention of the fiscal authority which adjusts the level of the public transfers to insure the most affected households. However, because the fiscal authority is facing a dual motive when setting its fiscal policy – a redistribution motive and

[15] Figure 6 in the Appendix provides the variance decomposition for variables related to consumption – consumption of hand-to-mouth and Ricardian households, aggregate consumption and consumption heterogeneity. Shocks to hand-to-mouth productivity explain almost 50% of the variance of hand-to-mouth households' consumption. Including data on heterogeneity in the estimation also affects the variance decomposition of Ricardian households' consumption: the importance of risk premium shocks is much reduced while wage markup shocks have a much bigger impact.

[16] Figure 7 in the Appendix provides an overview of the main sources of variation in the fiscal variables of our model – labor tax rate, transfers, deficit and debt – for our two variant estimations. Most of the variations are driven by exogenous shocks. The endogenous response of taxes – i.e. the response to government debt and to output – are limited. A similar pattern can be observed for transfers.

an efficiency one –, it can be asked whether such policy is optimal. This is what we explore in this section of the paper.

This section is organized as follows. We first describe the Ramsey program, we explain how we compute the solution and we outline the basic elements of our theoretical framework influencing the behavior of the main fiscal variables of the model. Then, using our estimated parameters, we briefly describe the optimal fiscal policy at the steady-state. Finally, we compare the cyclical properties of the optimal policy with the behavior of transfers as observed in the data.

4.1 The Ramsey program

The Ramsey planner maximizes aggregate expected lifetime utility, which in the medium scale model is given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \Big[\lambda \xi_t^b \Big(u(c_t^h - h\bar{c}_{t-1}^h) - v(n_t^h) \Big) + (1-\lambda) \Big(u(c_t^s - h\bar{c}_{t-1}^s) - v(n_t^s) \Big) \Big] \tag{29}$$

The constraint set is composed of all the non-linear equations defining the competitive equilibrium of the model, as well as the government budget constraint (23) and the monetary authority's reaction function (22). The full set of equations constituting the constraints accounted for by the planner is described in Appendix B.

To simulate the Ramsey allocation, we proceed as follows. We first compute the first order conditions using the Lagrangian associated to the problem described above. The resulting non-linear system is then log-linearized, and we use first-order perturbation methods to approximate the Ramsey solution and present our results. This way, we ease the comparison between these results and those obtained from the estimation of the model with fiscal rules.

4.2 Inspecting the Mechanism

In this section, we highlight several channels that determine how the Ramsey planner optimally chooses its fiscal policy. To do so, we follow the literature by anchoring our discussion on the complete market case, i.e. when the government can issue debt using state contingent (Arrow-Debreu) contracts. This way, we provide a well-identified reference point, characterized by the stabilisation of the excess burden of taxation and the minimization of the distortion costs of taxation.[17] As described by the optimal fiscal policy literature, this outcome is a powerful result which the Ramsey planner wants to replicate even when she only has access to incomplete financial markets.

The literature has identified several channels enabling the Ramsey planner to overcome the absence of a complete set of contingent securities. We review some of them, the most relevant ones for our model, in the next subsections. We begin with reviewing fiscal hedging through inflation. Then, we outline the role of interest rate manipulation on the optimal labor tax rate and we explain how exogenous shocks to government bond prices ξ_t^b can influence the government's

[17] Our model nests the complete market allocation as a special case. To obtain the complete market outcome, we have to assume that the multiplier on the government budget constraint is constant through time and second we can drop the government budget constraint from the planner's constraint set.

intertemporal budget. Finally, we describe the trade-off faced by planner when, in face of a households heterogeneity, she has to choose between decreasing transfers or increasing labor tax rates to finance expenditure shocks.

4.2.1 Fiscal Hedging through inflation

Iterating forward on the government budget constraint we have:

$$\xi_t^b u_{c,t} \frac{b_{t-1}}{\Pi_t} = E_t \sum_{j=0}^{\infty} \beta^j \xi_{t+j}^b u_{c,t+j} s_{t+j} \tag{30}$$

which equates the present value of the surplus of the government, s_t, to the initial liability (LHS of 30). According to 30 (which needs to hold in every state) there are several ways to finance a rise in g_t. First, through a rise in Π_t and, second, through decreasing transfers or increasing tax rates which will bring back s_t to the level that makes the intertemporal budget hold with equality.

The first channel is one of the standard ways to reduce the variability of taxes highlighted by the previous literature. Notice however that given the structure of our model it is unlikely that the government will find optimal (or feasible) to exploit this channel as much as necessary so that optimal taxes become as volatile as under complete markets. To see this note that for the complete market outcome to be attainable inflation must be volatile enough so that the constraint (30) is slack for all $t > 0$. This would be the case if Π_t could be determined as a residual and would not impact any real variable of the model. Obviously, in the case of sticky prices the above does not hold. Inflation distorts the relative hours in firms that reoptimize in t and firms that do not, and hence has real effects on the economy. Therefore, inducing considerable volatility in Π_t so that (30) holds as equality in every t will be suboptimal from the point of view of the planner (Siu, 2004; Schmitt-Grohé and Uribe, 2004b).[18]

The planner is therefore forced to adjust its fiscal instrument to absorb the shocks to the government deficit. In the following section, we review what drives the optimal behavior of the labor tax rate and how it is affected by the existence of transfers and/or lump-sum taxes.

4.2.2 Interest Rate Manipulation, the Taylor rule and shocks to bond prices

Our model compiles several forces of dynamic adjustment in labor income taxes, which makes it difficult to derive analytical expressions characterizing the behavior of fiscal variables over the business cycle. To highlight a few key channels and illuminate their role in the behavior of taxes over time, we make here several simplifications and assume i) $\tau^c = \tau^k = 0$ and $T_t = 0 \; \forall \; t$. ii) capital is fixed (equivalently capital installation costs are infinite). iii) the habit parameter $h = 0$.

[18]Notice that the maturity of government debt exerts a crucial influence. The longer is the maturity the less is the need to engineer drastic changes in inflation in response to fiscal shocks, since the burden of a higher target price level can be spread across many periods. This way, even small persistent increases in inflation in response to spending shocks may have an important effect on the real payout of public debt (e.g. Lustig, Sleet, and Yeltekin (2008)). In our model, the planner has access to one period bonds only. Therefore, we limit further her ability to use inflation to absorb shocks to the government finances.
Another important channel the planner is unable to exploit due to the debt maturity structure of the model is the volatility of long bond prices (e.g. Angeletos (2002); Buera and Nicolini (2004); Faraglia et al. (2019)).

iv) $\theta_w = 0$ or wages are fully flexible. Under i) to v) our model is similar to the optimal fiscal and monetary policy models of Schmitt-Grohé and Uribe (2004a); Faraglia, Marcet, Oikonomou, and Scott (2013), and others, the noteworthy difference being that we assume the Taylor rule as a further constraint in the planner's program.

Under these assumptions we can derive the following first order condition for Riccardian households' consumption:

$$u^s_{c,t} + \lambda^{bc}_t(u^s_{cc,t}s_t + u^s_{c,t}s_{c,t}) - u^s_{cc,t}\left(\lambda^{bc}_{t-1} - \lambda^{bc}_t\right)\frac{b_{t-1}}{\Pi_{t-1}} + u^s_{cc,t}\left(\lambda^R_t - \frac{\lambda^R_{t-1}}{\Pi_t}\right) + \lambda^{rc}_t + F(x_t, \widetilde{\lambda}_t, \widetilde{\lambda}_{t-1}) = 0$$

where λ^{bc} denotes the multiplier on the government budget constraint, λ^{rc}_t is the analogous multiplier on the resource constraint of the economy and λ^R is the multiplier on the Euler equation constraint $u^s_{c,t} = \beta E_t R_t \frac{u^s_{c,t+1}}{\pi_{t+1}}$. The function F whose arguments are x vector of endogenous variables and $\widetilde{\lambda}$ vector of multipliers on the (sticky price) Phillips curve constraint summarizes the derivative of this constraint with respect to c^s_t. Finally s_t denotes the value of the surplus in t.

In our setting, like in Aiyagari et al. (2002), λ^{bc}_t evolves as a 'risk adjusted random walk' meaning that shocks to the government's budget induce permanent changes in the value of this multiplier and thus have permanent effects on the level of labor taxes. For instance, an increase in g_t will push λ^{bc}_t upwards, this will translate to permanently higher taxes. This is captured by the term $\lambda^{bc}_t(u_{cc,t}s_t + u_{c,t}s_{c,t})$ in the first order condition.

In the empirically relevant case where $b_{t-1} > 0$ the fact that $\left(\lambda^{bc}_{t-1} - \lambda^{bc}_t\right)b_{t-1} < 0$ reveals that the government has an incentive to twist interest rates by varying tax rates at the bond's maturity date in order to minimise funding costs.[19] In the standard case, as in ours, only one period bonds are considered. Therefore, this effect is conflated with the usual impact effect on taxes and the interest rate twisting effect is not easily observed.[20] This channel is also limited by the Taylor rule to which the planner needs to adhere at all horizons, since the sequence of interest rates and taxes promised by the planner should conform with the sequence (22). In the above equation, this is summarized through the term $\left(\lambda^R_t - \frac{\lambda^R_{t-1}}{\Pi_t}\right)$.[21]

Note also that, in contrast to most macroeconomic models of optimal fiscal policy, our model features exogenous shifts in bond prices, through preference and monetary policy shocks. Yet these shocks are important drivers of interest rates and thus also of the cost of financing government debt and deficits. A policy under complete markets will hedge the government's budget against them, as it will hedge against spending and productivity shocks. However, under incomplete markets, a welfare maximizing government will target to reduce the variability of the real payout of debt in response to these shocks, adding further movements in fiscal variables.

[19]Recall that in the case of a complete market the multiplier λ^{bc} is constant over time and therefore the interest rate manipulation channel is mute.

[20]Faraglia et al. (2019) shows how the interest twisting channel induces additional volatility in the labor tax rate when long bonds are considered.

[21]In a model where both the fiscal policy and the monetary policy are chosen optimally, the fiscal authority sets the current taxes while the monetary authority sets the real interest rate. Hence, the fiscal policy cannot commit to change the level of future taxes and the interest rate manipulation is mute. Here, we have a different setup. We assume full commitment but we let monetary policy also commit to (22). Thus interest rate manipulation is not mute but maybe difficult to implement in the presence of constraint (22).

4.2.3 Households heterogeneity, transfers and the labor tax rate

In a representative agent framework, introducing lump-sum transfers/taxes imply a trivial response of fiscal variables:labor taxes would be close to zero, and lump-sum taxes would finance most of the variations in the inter-temporal budget of the government, thereby allowing the government to complete the market. However, the presence of households heterogeneity in our model affects the optimal fiscal policy mix between the two main instruments available to the Ramsey planner. To ease the exposition and discuss its role, we make the assumption that $\theta_w = \theta_p = 0$, i.e. wages and prices are fully flexible. This way, our model resembles to Chafwehé and Courtoy (2021).

The first best allocation, i.e. the result of the maximization process of aggregate welfare subject to the resource constraint of the economy, is characterized by the following two conditions:

$$\frac{v^h_{n,t}}{\theta^h_t u^h_{c,t}} = \frac{v^s_{n,t}}{u^s_{c,t}} = a_t \qquad\qquad u^h_{c,t} = u^s_{c,t} \tag{31}$$

The first equality states that the marginal rate of substitution between consumption and leisure must be equal to the marginal product of labor. Under the above assumptions, this allocation can be attained by the planner if she sets $\tau_t = 0$ for all t. That is, if she only makes use of variations in transfers to finance fiscal deficits. This way, the planner eliminates any tax distortions and households' welfare is no longer impacted by the fiscal policy implemented.[22] The second condition equates marginal utilities of consumption across agents. Thus, given our assumptions regarding the utility function, the first-best allocation features consumption equality. This allocation can be attained by using transfers to redistribute resources across agents. However, such a policy often comes at the cost of increasing the level and volatility of labor taxes.[23]

Taken together, these two equations illustrate the trade-off the government is facing when setting its optimal fiscal policy. Chafwehé and Courtoy (2021) shows that these two forces imply that, for labor taxes to have low volatility, shocks must have limited impact on households' heterogeneity and be financed throughout a policy that limits variations in consumption and hours dispersion between households. In particular, they show that the design of the sharing rule for transfers (the value of our parameter ω) is key. When transfers are designed as to imply some degree of redistribution, as is the case in our model, it is not always optimal to absorb negative shocks to the government's budget constraint by increasing lump-sum taxation (or decreasing transfers). Instead, they show that transfers are efficient in bringing down fluctuations in heterogeneity arising from shocks that affect households unequally, such as shocks to the productivity of hand-to-mouth households (θ^h_t).

[22] Notice also that this result is welfare improving with respect to a situation of complete markets, which is characterized by stable but positive tax distortions.

[23] In a representative agent model, this channel is not operative. Hence, if the planner has access to lump-sum taxation (negative transfers), the Ricardian Equivalence holds and the structure of the financial markets does not matter anymore.

4.3 Steady-state

As explained, the planner's objective when setting its fiscal policy is to smooth taxes. Some features of our model, for instance the existence of inflation and lump-sum taxation, eases her ability to achieve this goal. Some others, wage and price rigidities and the presence of heterogeneity in particular, hinder her capacity to fulfill it. In this section and in the next one, we study what fiscal policy the planner implements, first at the steady-state, and then over the business cycle.

We start by describing the steady-state properties of the Ramsey allocation when the parameters are set at the posterior means of the parameters of the model with fiscal rules estimated with data on heterogeneity (as provided in Table 4). Then, we study further the impact of some key parameters on the steady state level of taxes and transfers.

4.3.1 The steady-sate allocation

Table 6 provides the steady-state values of the key model variables influenced by the fiscal policy. We are particularly interested in the optimal long-run behaviour of labor taxes and transfers, the level of consumption heterogeneity they imply, and to which extent the obtained values deviate from their data counterpart.

[Table 6 approximately here]

The optimal steady-state level of the labor tax is equal to 34%, which is much higher than its empirical average of 21%. Setting a high tax rate on labor is necessary to allow the planner to generate resources and to increase the value of transfers, which in the steady-state are equivalent to 12% of GDP. This is much bigger than the value we used to calibrate the level of transfers to GDP in the preceding section (3%). To make a constructive comparison of these two values, two elements must be emphasized. First, the definition of transfers used in this paper only takes a subset of all transfers to households. We focus on those transfers that are meant either to ensure households against temporary shocks to labor income (unemployment benefits), or to explicitly supplement income to very poor households (such as food stamps). However, many other types of transfers (health insurance programs for instance) have eligibility criteria that include the income level of the household.[24] Second, we only include transfers that are from the federal government. Hence, we abstract from state programs that provide additional income insurance or cash benefits that go beyond what the federal programs. Nonetheless, it remains that such a high and positive level of transfers is striking with respect to the results provided by the optimal fiscal policy literature which has consistently argued that, when the Ramsey planner has access to unconstrained transfers, she should set lump-sum taxation (negative transfers) and keep the labor tax rate as low as possible in order to reduce the distortions on the labor supply. We show, on the contrary, that when earnings inequality are modeled explicitly the optimal long-run labor tax rate is actually higher than the average tax observed in the data. This is also true for the long-run level of transfers.

Because ω, the parameter defining the share of transfers targeted towards hand-to-mouth households, is calibrated to 0.673, a higher value of transfers imply a redistribution towards hand-to-

[24] All types of transfers (from the US federal government) taken together amount to 8% of GDP.

mouth agents. Consequently, the long-run consumption heterogeneity is much lower in the Ramsey allocations than the one observed in the data. The ratio of hand-to-mouth consumption over average consumption is equal to 75%, while in the data this number is 63.2%.[25]

Robustness Check Table 14 in Appendix D provides the steady-state values for the labor tax rate, transfers and the level of consumption heterogeneity using the estimated parameters obtained when the share of hand-to-mouth households is calibrated as to be equal to 20%. The values reported are pretty close to those in table 14.

4.3.2 Steady State sensitivity to key parameters

Let us now analyze what other forces drive the high levels of taxes and transfers observed in the Ramsey allocation. It turns out that, given the share of hand-to-mouth agent in the economy λ, the main determinants of optimal fiscal variables are the strength of habit formation in consumption, determined by the parameter h, the steady-state relative productivity of hand-to-mouth households θ^h, and the parameters determining the share of transfers going to hand-to-mouth households, ω. Figure 12 depicts the impact of these parameters on the optimal tax rate, leaving all the other model parameters at their posterior mean.

[Figure 12 approximately here]

We start by studying the effects of the relative productivity of constrained agents (θ^h) in the top right panel of Figure 12. At low values of θ^h, the optimal tax rate is positive: it is optimal for the planner to increase labor taxes to finance an increase in transfers and bring the consumption of hand-to-mouth agents closer to the one of Ricardian households, even if it comes with an efficiency cost. Instead, at higher levels of θ^h, the optimal labor tax decreases. The relative productivity of hand-to-mouth agents increases and the needs to redistribute resources is less pressing so that transfers and the labor tax rate decrease.

As we can see in the top left panel of the Figure, higher values of h, the parameters measuring households' habits in consumption, imply a higher tax rate and, therefore, a higher transfer and a lower consumption dispersion between households. We interpret the positive relationship between the strength of habits and the tax rate as follows. When habits are high, consumption volatility becomes more costly (in terms of welfare) for households. On top of that, the higher the average consumption level, the less costly are fluctuations over time, due to the concavity of the period utility function. For this reason, high levels of habit formation make redistribution between households welfare improving, and the planner chooses to set high level of labor taxes when h is high to bring the average consumption of hand-to-mouth agents closer to the one of Ricardian households.

The third panel of Figure 12 plots the impact of ω on the optimal tax rate. We see that the influence of this parameter on the labor tax is non-monotonic: at low values of ω, an increase in

[25] Table 6 also provides the steady-state level of the variables as computed with the parameters obtained with the estimation excluding cross-sectional data. The optimal fiscal variables at the steady state are very close from one variant to the other. Since most of the structural parameters of the models are close to one another (see Section 3.2.3 and Table 4), this does not come as a surprise.

this parameter (which means that a higher share of transfers is directed towards hand-to-mouth agents) gives incentives for the planner to increase the labor tax, thereby allowing a rise in transfers, which helps to even out the consumption difference between the two households. However, as ω approaches one, the optimal long-run tax rate starts to decrease. At high values of ω, less transfers (and therefore less taxes) are needed to obtain the desired level of consumption equality between households, as the per capital transfer to hand-to-mouth agents becomes higher for a given level of total transfers. It therefore allows the planner to reduce the distortions associated to taxes while maintaining a low level of consumption dispersion between households.

The last panel of the Figure depicts the impact of the wage rigidity parameter (θ_w) on the optimal labor tax. We can see from the Figure that higher wage rigidity implies a higher tax rate in the long-run, even though the strength of the effect is relatively low. When wages are more sticky, the planner is less able to generate tax revenues from changes in the wage rates (with fully flexible wages, the wage rate is more pro-cyclical and therefore the planner generates higher tax revenues in a boom for a given tax rate), and therefore she has to rely on more volatile taxes to finance the deficit. This volatility of taxes makes agents worse-off, especially when they do not have ways to smooth consumption when income becomes more volatile, as is the case for hand-to-mouth agents, which cannot save. The planner therefore finds it optimal to increase the long-run value of transfers, which therefore provides some consumption insurance for these agents.

4.4 The optimal policy over the business cycle

In this section we study the properties of key model variables over the business cycle when the fiscal variables are set optimally. We first study the impulse response functions of key variables of the model. Then, we discuss the simulated business cycles moments described in Section 3.2.5.

4.4.1 Impulse responses

In Figures 13 and 14 we plot the impulse responses of output, aggregate consumption, transfers, taxes and government debt, to a one standard deviation of the key stochastic shocks of the model. In Figures 15 and 16 we plot the impulse responses of households-specific variables — hours worked and consumption. The solid black lines depict the response of variables in the model with fiscal rules, while the dotted blue lines display the responses to shocks in the Ramsey model.

[Figures 13 to 16 approximately here]

The key takeaways from the comparison of the IRFs between the two regimes, with fiscal rules and under optimal policy, are the following. As can be noticed from the figures, the endogenous response of fiscal variables is much stronger in the Ramsey model. It reflects the fact that the planner wants to use its fiscal instruments to stabilize the fluctuations in welfare-relevant variables, i.e. consumption and leisure of both types of households. This does not mean however that our the model implies smaller fluctuations in our measure of consumption dispersion. Indeed, as described in Chafwehé and Courtoy (2021), the optimal policy cannot be characterized as purely redistributive. Instead, the planner chooses to use fiscal variables to stabilize all the variables of the model at their long-run optimal level.[26]

In order to illustrate clearly the main channels that motivates the planner when setting its policy we zoom in the fiscal response to three main shocks of our model, namely, government expenditure shock, wage markup shock and hand-to-mouth relative productivity shock.

In response to an increase in **government expenditures**, the planner reduces transfers to finance the shock while it leaves the labor tax rate almost constant. Because the shock affects households heterogeneity only marginally, the planner can use variations in transfers to finance her intertemporal budget, therefore limiting tax distortions. Because the financing of the expenditure shock weights relatively more on hand-to-mouth households, since $\omega \geq \lambda$, the dispersion in consumption and hours worked between households types increases. This shows that the welfare cost associated to the fluctuations in inequality is lower than the social cost implied by increases in the labor tax rate.

As already explained, a **shock to the relative productivity of hand-to-mouth**, θ_t^h, acts as a TFP shock. On impact, a positive shock lowers the marginal costs of firms, which lower their prices while re-optimizing. Inflation gets down and the monetary policy responds by lowering its interest rate. However, the long-term increases in inflation and in the monetary policy interest rate that we observe after a TFP shock does not operate following a positive shock to θ_t^h. Therefore, while Riccardian households' consumption decrease in response to a TFP shock, it actually increases slightly following a rise in the relative productivity of hand-to-mouth households. On their part, hand-to-mouth households' revenue and consumption increase.

From Figure 14, we can see that optimal transfers drop in response to a positive shock to the individual productivity of hand-to-mouth households. This can be explained by two factors: first, as hand-to-mouth agents become more productive, they rely less on transfers to finance their consumption, which leaves some room for the planner to reduce them; second, reducing transfers allows the planner to generate a negative wealth effect for these agents, which incentives them to increase their labor supply precisely at the time when their productivity is above average, thus generating efficiency gains. Consequently, the level of government debt decrease and the planner is able to reduce permanently the level of taxes. This has the additional benefits of lowering the long-run marginal cost, the inflation rate and the interest rate, therefore increasing further the consumption level of Ricardian agents.

In our model featuring two types of agents, a **wage markup shock** has the same impact as in a representative agent. It increases marginal costs, prices (for firms that can re-optimize) and triggers a reaction from the monetary authority, which increases its policy rate. Therefore, Ricardian households cut off their consumption. In contrast, hand-to-mouth agents, which cannot do intertemporal substitution, enjoy higher real wage and consume more. In response to the shock, the Ramsey planner lowers transfers which tapers the reaction of hand-to-mouth's consumption. It also allows the planner to reduce the labor tax rate, which attenuates the increase in prices and the monetary policy rate. Therefore, it also limits the decrease in Ricardina households' consumption.

[26]Remind that the steady-state level of consumption/labor inequality is already low. So, even if variations of our measure of consumption heterogeneity are (sometimes) stronger in the Ramsey framework, the average level of consumption inequality remains much lower in the Ramsey version of the model.

However, because this policy cannot be sustained in the long-run, the Ramsey planner cannot kill entirely the inter-temporal effect.

The above impulse response functions demonstrate the two main roles pursued by the benevolent planner when setting its fiscal policy. On the one hand, she wants to use the least distortionary policy to finance shocks to the inter-temporal government budget constraint. That is, the planner prefers to use fluctuations in transfers to compensate for shocks to the deficits. On the other hand, the government wants to use its fiscal instruments to smooth variations in households consumption and labor. She uses transfers to induce income effects and smooth hand-to-mouth households' consumption. She uses labor taxes to manage marginal costs and therefore inflation in a way to manipulate the monetary policy interest rate and smooth the response of Ricardian households' consumption.[27]

4.4.2 Matching moments

In this section, we are particularly interested in the ability of our model to match the data properties already mentioned in Section 3.2.5, namely, the negative correlation between transfers and GDP, and the positive correlation between transfers and the primary deficit.

Our model will meet these properties as long as the following conditions hold: (i) transfers may decrease in expansions without impacting too much on households' welfare; (ii) the government can use decreases in transfers to generate fiscal surpluses in expansions, while they cannot be used to compensate for rising deficits during recessions. This is particularly the case when the economy is hit by shocks to the relative productivity of hand-to-mouth (θ^h). In response to a positive shock, the government is willing to decrease transfers since (i) hand-to-mouth households' income gets relatively bigger and the need to redistribute resources towards them gets less critical, and (ii) the government is willing to motivate hand-to-mouth households to work more by implementing a negative wealth effect. Therefore, when these shocks are among the main drivers of the economy, transfers become the main source behind the changes in primary deficits.

In Table 7 we provide key model moments that we obtained from numerical simulations, using samples of shocks that are drawn from their estimated distribution. Overall, it turns out that our model can match the empirical data very well. It produces a strong negative correlation between transfers and output (-0.53), it also generates a positive correlation between deficits and transfers (0.22) and reproduces the strong counter-cyclicality of deficits that is observed in the data.

[Table 7 approximately here]

For comparison purposes, Table 7 also provides the simulated moments when we use the parameters obtained from the estimation without data on households heterogeneity. In this case, the

[27] Note that the endogenous response of the key variables of our model is roughly the same for the different estimations, i.e. the parameters obtained with and without data on households inequality (see Figure 19 and 20 in the Appendix). This is not surprising as most of the parameters are the same. One exception stands out: the IRFs to a shock to the relative productivity of hand to mouth households (θ^h) are much larger when using the parameters values obtained from the estimation with data on inequality. This is explained by the higher persistence of the shock (see Table 4), which implies larger and long-lasting effects on inflation, the interest rate, Ricardian households' consumption and aggregate output.

Ramsey policy produces little correlation between transfers and output, and between deficits and transfers. This reflects the feature that, in this model, transfers are rather used to stabilize the deficits (the correlation is equal to -0.09). Indeed, the fiscal authority sets transfers as to absorb expenditure shocks. Nonetheless, this does not mean that there is no 'automatic stabilization' operated by transfers. Indeed, the model produces negative correlations between transfers and output (-0.29), but the order of magnitude is less than half of its counterpart in the Ramsey model based on the parameters estimated with data on inequality.

As already sketched, the difference between the two estimations pertains to the distributions of shocks processes, and in particular to shocks affecting hand-to-mouth households earnings. These lasts are necessary strong and frequent enough as to incentivize the planner to use transfers to systematically redistribute resources across agents. Moreover, because these shocks are positively correlated with output, the planner implements a fiscal policy that is characterized by counter-cyclical transfers.

Taken all together, our results suggest that leaving aside earnings and consumption inequality data does not only bear on our understanding of what drives the economy, it also leads to different normative conclusions regarding the conduct of the fiscal policy.

Robustness Check Table 15 in Appendix D provides the simulated moments obtained when the share of hand-to-mouth agents is calibrated to 20% of the population. As it can be observed, the moments obtained remain in line with those discussed above. They indicate nonetheless that the redistribution motive gets weaker as the correlation between transfers and deficits gets smaller. The Ramsey planner is more inclined to use transfers to insulate deficits from shocks.

5 Conclusion

In this paper, we investigate the role of households heterogeneity in terms of marginal propensity to consume and labor earnings dynamics for the design of the optimal fiscal policy. To shed light on the matter, we estimate a state-of-the-art New-Keynesian business cycle model that incorporates a small degree of household heterogeneity with a large set of macro and micro data. As Bayer et al. (2020), we do not find that household heterogeneity and the inclusion of micro data alter the estimation. The estimated shocks and frictions explaining the US business cycles remain consistent with the literature.

However, we find that the dynamics of households earnings at the lower end of the distribution are important drivers of inequality in the US and that micro data are key to be able to capture such dynamics. We also show that because these shocks affect households with high propensity to consume, they lead to significant fluctuations in output. Therefore, in such setting, transfers that redistribute wealth between households contributes to the minimization of income and consumption inequality and to the smoothing of business cycles. However, such policy also forces the government to run on higher deficits which must be absorbed through higher labor taxes. This is particularly costly as it distorts households' labor supply decisions. Hence, building on these observations, we then ask ourselves whether such policy is relevant from a normative point of view.

Because the optimal fiscal policy aims at fulfilling two goals – limiting tax distortions and inducing redistribution – the dynamic response of labor taxes and transfers will be highly responsive to the type of shocks affecting the economy, and to their diffusion within the economy. Shocks that affect all households in the same way will lead to low tax volatility but highly pro-cyclical transfers. Instead, shocks that primarily influence the earnings of poor households with high marginal propensity to consume will trigger higher tax volatility and counter-cyclical transfers. Therefore, the optimal behavior of the fiscal instruments is dependent on the models' ability to identify and reproduce the dynamics of households earnings.

We show that the optimal policy implemented in an economy which characteristics are similar to the one estimated for the US, and which incorporates realistic earnings dynamics for the different groups of households in the economy, closely reproduces the cyclical behavior of transfers, deficits, and output that is observed in the data. A result which cannot be reproduced in an economy which does not integrate enough heterogeneity between households, both in terms of marginal propensity to consume and labor earnings dynamics.

These findings suggest that future research on optimal fiscal policy should take households heterogeneity into account. Besides, further research should include assessing whether the source of heterogeneity matters for the conduct of optimal fiscal policy. As such, including stronger micro-foundation for earnings dynamics, via search and matching for example, and larger set of assets, which price fluctuations would lead to additional income dynamics, is of first-order importance.

References

Aguiar, M. and M. Bils (2015): "Has consumption inequality mirrored income inequality?" *American Economic Review*, 105, 2725–56.

Aiyagari, S. R., A. Marcet, T. J. Sargent, and J. Seppälä (2002): "Optimal taxation without state-contingent debt," *Journal of Political Economy*, 110, 1220–1254.

Angeletos, G.-M. (2002): "Fiscal policy with noncontingent debt and the optimal maturity structure," *The Quarterly Journal of Economics*, 117, 1105–1131.

Autor, D. H., L. F. Katz, and M. S. Kearney (2008): "Trends in US wage inequality: Revising the revisionists," *The Review of economics and statistics*, 90, 300–323.

Bayer, C., B. Born, and R. Luetticke (2020): "Shocks, frictions, and inequality in US business cycles," .

Bhandari, A., D. Evans, M. Golosov, and T. J. Sargent (2017): "Public debt in economies with heterogeneous agents," *Journal of Monetary Economics*, 91, 39–51.

Bilbiie, F. O. (2018): "Monetary policy and heterogeneity: An analytical framework," .

Bilbiie, F. O. and X. Ragot (2017): "Optimal monetary policy and liquidity with heterogeneous households," .

Buera, F. and J. P. Nicolini (2004): "Optimal maturity of government debt with incomplete markets," *Journal of Monetary Economics*, 51, 531–554.

Cajner, T., L. D. Crane, R. A. Decker, J. Grigsby, A. Hamins-Puertolas, E. Hurst, C. Kurz, and A. Yildirmaz (2020): "The US labor market during the beginning of the pandemic recession," Tech. rep., National Bureau of Economic Research.

Chafwehé, B. and F. Courtoy (2021): *Optimal Tax and Transfers with Household Heterogeneity*, Institut de recherche économiques et sociales, UCLouvain.

Challe, E., J. Matheron, X. Ragot, and J. F. Rubio-Ramirez (2017a): "Precautionary saving and aggregate demand," *Quantitative Economics*, 8, 435–478.

Challe, E. et al. (2017b): "Uninsured unemployment risk and optimal monetary policy," *American Economic Journal: Macroeconomics*.

Coenen, G., R. Straub, and M. Trabandt (2012): "Fiscal policy and the great recession in the euro area," *American Economic Review*, 102, 71–76.

Cox, N., P. Ganong, P. Noel, J. Vavra, A. Wong, D. Farrell, F. Greig, and E. Deadman (2020): "Initial impacts of the pandemic on consumer behavior: Evidence from linked income, spending, and savings data," *Brookings Papers on Economic Activity*, 2020, 35–82.

Debortoli, D. and J. Galí (2017): "Monetary policy with heterogeneous agents: Insights from TANK models," *Manuscript, September*.

Drautzburg, T. and H. Uhlig (2015): "Fiscal stimulus and distortionary taxation," *Review of Economic Dynamics*, 18, 894–920.

Faraglia, E., A. Marcet, R. Oikonomou, and A. Scott (2013): "The impact of debt levels and debt maturity on inflation," *The Economic Journal*, 123, F164–F192.

——— (2019): "Long Term Government Bonds," *Cambridge Working Papers in Economics*.

Forni, L., L. Monteforte, and L. Sessa (2009): "The general equilibrium effects of fiscal policy: Estimates for the euro area," *Journal of Public economics*, 93, 559–585.

Galí, J., J. D. López-Salido, and J. Vallés (2007): "Understanding the effects of government spending on consumption," *Journal of the european economic association*, 5, 227–270.

Garner, T. I., G. Janini, L. Paszkiewicz, and M. Vendemia (2006): "The CE and the PCE: a comparison," *Monthly Lab. Rev.*, 129, 20.

Guvenen, F., S. Ozkan, and J. Song (2014): "The nature of countercyclical income risk," *Journal of Political Economy*, 122, 621–660.

Heathcote, J., F. Perri, and G. L. Violante (2010a): "Inequality in times of crisis: Lessons from the past and a first look at the current recession," *manuscript, University of Minnesota*.

——— (2010b): "Unequal we stand: An empirical analysis of economic inequality in the United States, 1967–2006," *Review of Economic dynamics*, 13, 15–51.

——— (2020): "The rise of US earnings inequality: Does the cycle drive the trend?" *Review of Economic Dynamics*, 37, S181–S204.

Hoffmann, E. B. and D. Malacrino (2019): "Employment time and the cyclicality of earnings growth," *Journal of Public Economics*, 169, 160–171.

Kaplan, G., B. Moll, and G. L. Violante (2018): "Monetary policy according to HANK," *American Economic Review*, 108, 697–743.

Kaplan, G. and G. L. Violante (2014): "A model of the consumption response to fiscal stimulus payments," *Econometrica*, 82, 1199–1239.

Katz, L. F. et al. (1999): "Changes in the wage structure and earnings inequality," in *Handbook of labor economics*, Elsevier, vol. 3, 1463–1555.

Leeper, E. M., M. Plante, and N. Traum (2010): "Dynamics of fiscal financing in the United States," *Journal of Econometrics*, 156, 304–321.

Leeper, E. M., N. Traum, and T. B. Walker (2017): "Clearing up the fiscal multiplier morass," *American Economic Review*, 107, 2409–54.

Lucas, R. E. and N. L. Stokey (1983): "Optimal fiscal and monetary policy in an economy without capital," *Journal of monetary Economics*, 12, 55–93.

Lustig, H., C. Sleet, and Ş. Yeltekin (2008): "Fiscal hedging with nominal assets," *Journal of Monetary Economics*, 55, 710–727.

McKay, A. and R. Reis (2016): "The role of automatic stabilizers in the US business cycle," *Econometrica*, 84, 141–194.

Menna, L. and P. Tirelli (2017): "Optimal inflation to reduce inequality," *Review of Economic Dynamics*, 24, 79–94.

Perri, F., J. Steinberg, et al. (2012): "Inequality and redistribution during the Great Recession," *Economic Policy Paper*, 1.

Schmitt-Grohé, S. and M. Uribe (2004a): "Optimal fiscal and monetary policy under imperfect competition," *Journal of Macroeconomics*, 26, 183–209.

——— (2004b): "Optimal fiscal and monetary policy under sticky prices," *Journal of economic Theory*, 114, 198–230.

Siu, H. E. (2004): "Optimal fiscal and monetary policy with sticky prices," *Journal of Monetary Economics*, 51, 575–607.

Smets, F. and R. Wouters (2007): "Shocks and frictions in US business cycles: A Bayesian DSGE approach," *American economic review*, 97, 586–606.

Storesletten, K., C. I. Telmer, and A. Yaron (2004): "Cyclical dynamics in idiosyncratic labor market risk," *Journal of political Economy*, 112, 695–717.

Traum, N. and S.-C. S. Yang (2011): "Monetary and fiscal policy interactions in the post-war US," *European Economic Review*, 55, 140–164.

——— (2015): "When does government debt crowd out investment?" *Journal of Applied Econometrics*, 30, 24–45.

Werning, I. (2015): "Incomplete markets and aggregate demand," Tech. rep., National Bureau of Economic Research.

A Tables and Figures

Table 1: **Data Moments**

Corr($Earn_t^{Low}$,$Earn_t^{Top}$)	Std($Earn_t^{Low}$)	Std($Earn_t^{Top}$)
0.7172	7.6132	2.7571

Notes: The table provides in the first column the correlation between the log-difference of earnings at the lower end of the distribution (percentiles 0 to 30), $Earn_t^{Low}$, and the log-difference of earnings at the top (percentiles 31 to 100), $Earn_t^{Top}$. The second and third columns display the standard deviation of each variables. Data are taken from the CPS.

Table 2: **Simulated Moments**

Moments	Estimation w./o. cross-sect. data	Estimation w. cross-sect. data
corr(def,y)	-0.28	-0.63
corr(def,tr)	0.49	0.82
corr(tr,y)	-0.08	-0.53

Notes: The table provides the simulated fiscal moments of interest – namely, the correlation between deficits and output, between deficits and transfers and between transfers and output – for our two sets of parameters in the model with fiscal rules.

Table 3: **TANK model: Calibrated parameters**

Parameter	**Description**	**Value**
n	Steady-state hours	1
d	Steady-state profits	0
λ	Share of hand-to-mouth households	0.30
α	Capital share in production	0.30
δ	Depreciation rate of private capital	0.025
$\frac{\eta_p}{\eta_p - 1}$	Steady-state price markup	1.5
$\frac{\eta_w}{\eta_w - 1}$	Steady-state wage markup	1.4
ω	Share of transfers going to HTM agents	0.673
τ^c	Consumption tax rate	0.030
τ^k	Capital tax rate	0.198
τ^n	Steady-state labor tax rate	0.210
g/y	Steady-state government expenditures-to-GDP ratio	0.062
$mv/4y$	Steady-state market value of gov. debt-to-GDP ratio	0.352
T/y	Steady-state transfers-to-GDP	0.023
$\frac{c^h}{c}$	Steady-state relative consumption of HTM households	0.632

Notes: The table provides the assumed parameter values in the baseline specification of the model presented in Section 3.

TABLE 4: **Estimated parameters**

Parameter		**Posterior TANK**		**Posterior TANK***		**Prior**		
		mean	90 % interval	mean	90 % interval	distrib	par A	par B
100γ	description	0.474	[0.405 ; 0.541]	0.483	[0.43 ; 0.538]	G	0.5	0.05
$100(\beta^{-1}-1)$	description	0.256	[0.142 ; 0.36]	0.207	[0.108 ; 0.297]	G	0.25	0.1
$100\log\pi$	description	0.528	[0.451 ; 0.603]	0.523	[0.447 ; 0.596]	G	0.5	0.05
ϕ	inv. Frish elasticity	2.493	[1.871 ; 3.107]	2.565	[1.95 ; 3.206]	N	1.5	0.5
h	habit formation	0.759	[0.664 ; 0.856]	0.64	[0.576 ; 0.705]	B	0.5	0.1
Production								
ϕ_u	utilization cost	2.639	[1.811 ; 3.456]	3.068	[2.167 ; 3.911]	G	2	0.5
κ	adjustment cost	4.384	[2.887 ; 5.806]	3.545	[2.579 ; 4.494]	G	4	0.75
Nominal Rigidities								
θ_w	wage rigidity	0.562	[0.298 ; 0.795]	0.341	[0.25 ; 0.42]	B	0.5	0.1
θ_p	price rigidity	0.888	[0.828 ; 0.943]	0.836	[0.804 ; 0.867]	B	0.5	0.1
Monetary Policy								
ρ_r	interest rate smoothing	0.803	[0.75 ; 0.854]	0.763	[0.72 ; 0.81]	B	0.8	0.1
ϕ_π	response to inflation	1.871	[1.666 ; 2.069]	1.961	[1.797 ; 2.121]	G	1.75	0.1
ϕ_y	response to output	0.051	[0.013 ; 0.09]	0.031	[0.015 ; 0.047]	G	0.12	0.05
Labor tax rule								
ρ_τ	lab tax rate smoothing	0.73	[0.593 ; 0.87]	0.721	[0.594 ; 0.851]	B	0.5	0.2
$\phi_{\tau,b}$	response to debt	0.093	[0.048 ; 0.14]	0.122	[0.078 ; 0.167]	G	0.15	0.05
$\phi_{\tau,y}$	response to output	0.739	[0.407 ; 1.098]	0.467	[0.228 ; 0.713]	N	0	0.5
Transfer rule								
ρ_T	tsf smoothing	0.953	[0.923 ; 0.986]	0.95	[0.919 ; 0.985]	B	0.5	0.2
$\phi_{T,y}$	response to output	-0.488	[-0.718 ; -0.253]	-0.5	[-0.736 ; -0.249]	N	-0.5	0.15
HtM productivity rule								
ρ_θ	HtM prod. smoothing	0.522	[0.196 ; 0.932]	0.921	[0.866 ; 0.977]	B	0.5	0.2
$\phi_{\theta,y}$	response to output	0.41	[0.18 ; 0.645]	1.224	[0.601 ; 1.843]	N	0.5	0.15

To be continued

Parameter		Posterior TANK		Posterior TANK*		Prior		
		mean	90 % interval	mean	90 % interval	distrib	par A	par B
Shocks, AR								
ρ_g	gov.spending	0.979	[0.963 ; 0.995]	0.975	[0.959 ; 0.994]	B	0.5	0.2
ρ_w	wage mark-up, sav	0.338	[0.156 ; 0.514]	0.953	[0.922 ; 0.991]	B	0.5	0.2
ρ_p	price mark-up	0.772	[0.644 ; 0.895]	0.938	[0.897 ; 0.981]	B	0.5	0.2
ρ_a	technology	0.173	[0.058 ; 0.283]	0.4	[0.256 ; 0.547]	B	0.5	0.2
ρ_i	investment	0.841	[0.76 ; 0.925]	0.779	[0.677 ; 0.882]	B	0.5	0.2
ρ_b	preference, sav.	0.766	[0.668 ; 0.866]	0.859	[0.801 ; 0.922]	B	0.5	0.2
ρ_m	monetary policy	0.454	[0.337 ; 0.575]	0.447	[0.342 ; 0.558]	B	0.5	0.2
ρ_{gbc}	gov. budget const.	0.203	[0.066 ; 0.33]	0.144	[0.037 ; 0.251]	B	0.5	0.2
$\rho_{c_{30}}$	relative cons.			0.867	[0.784 ; 0.962]	B	0.5	0.2
$\rho_{inc^{Ric}}$	relative inc.			0.48	[0.187 ; 0.758]	B	0.5	0.2
Shocks, Std								
σ_g	gov. spending	2.402	[2.104 ; 2.678]	2.537	[2.211 ; 2.86]	IG	0.1	2
σ_w	wage mark-up, sav	0.249	[0.161 ; 0.341]	0.29	[0.205 ; 0.371]	IG	0.1	2
σ_p	price mark-up	0.065	[0.045 ; 0.084]	0.071	[0.053 ; 0.088]	IG	0.1	2
σ_a	technology	1.12	[0.977 ; 1.268]	1.105	[0.854 ; 1.339]	IG	0.1	2
σ_i	investment	3.34	[2.181 ; 4.397]	2.898	[2.067 ; 3.696]	IG	0.1	2
σ_b	preference, sav.	2.881	[1.594 ; 4.133]	1.959	[1.545 ; 2.36]	IG	0.1	2
σ_m	monetary policy	0.123	[0.104 ; 0.14]	0.129	[0.11 ; 0.147]	IG	0.1	2
σ_τ	lab tax rate	1.947	[1.712 ; 2.187]	1.885	[1.649 ; 2.118]	IG	0.1	2
σ_T	tsf cyclical comp.	2.288	[2.015 ; 2.564]	2.291	[2.018 ; 2.552]	IG	0.1	2
σ_θ	relative productivity	0.112	[0.023 ; 0.21]	2.518	[2.197 ; 2.85]	IG	0.1	2
Measurement errors								
σ_{rc}	output	0.275	[0.243 ; 0.305]	0.28	[0.246 ; 0.312]	IG	0.1	2
σ_{gbc}	gov. budget const.	4.25	[3.721 ; 4.745]	4.252	[3.719 ; 4.773]	IG	0.1	2
$\sigma_{c_{30}}$	relative cons.			3.33	[2.318 ; 4.284]	IG	0.1	2
$\sigma_{inc^{Ric}}$	relative cons.			2.241	[1.608 ; 2.859]	IG	0.1	2

Notes: TANK [TANK*] denote posterior estimates for the model [with households heterogeneity data].

Table 5: **Contribution of shocks to households' earnings and consumption from 1984 to 2007**

	HtM Households		Ric. Households		Consump. Ineq.
	Earn.	Cons.	Earn.	Cons.	
Struct. shocks					
eps_g	-0.03	-0.25	-0.12	-0.02	-0.19
eps_w	1.97	2.17	1.20	2.32	-0.13
eps_p	3.41	3.37	1.84	1.36	1.63
eps_a	0.94	0.91	0.70	1.69	-0.63
eps_i	-0.11	-0.09	-0.22	0.20	-0.24
eps_b	-0.04	-0.18	-0.15	-0.39	0.17
eps_m	0.21	0.11	0.31	0.01	0.08
eps_θ	2.34	2.33	-0.11	0.45	1.52
Fiscal shocks					
eps_τ	-0.01	0.02	0.00	0.00	0.01
eps_{tr}	0.04	-0.05	0.01	0.04	-0.08
eps_{gbc}	0.01	0.14	0.05	0.05	0.08

Notes: The table displays the average contribution of the various shocks to households earnings and consumption that result from our historical shock decomposition. Values are calculated by averaging over the period 1984-2007 and using the estimation using data on earnings and consumption dispersion.

Table 6: **Ramsey steady-state**

	Data	**Ramsey w/o cross-sect. data**	**Ramsey w cross-sect. data**
Labor tax rate	0.21	0.37	0.34
Transfers-to-GDP	0.03	0.15	0.12
Consumption heterogeneity	0.63	0.78	0.75

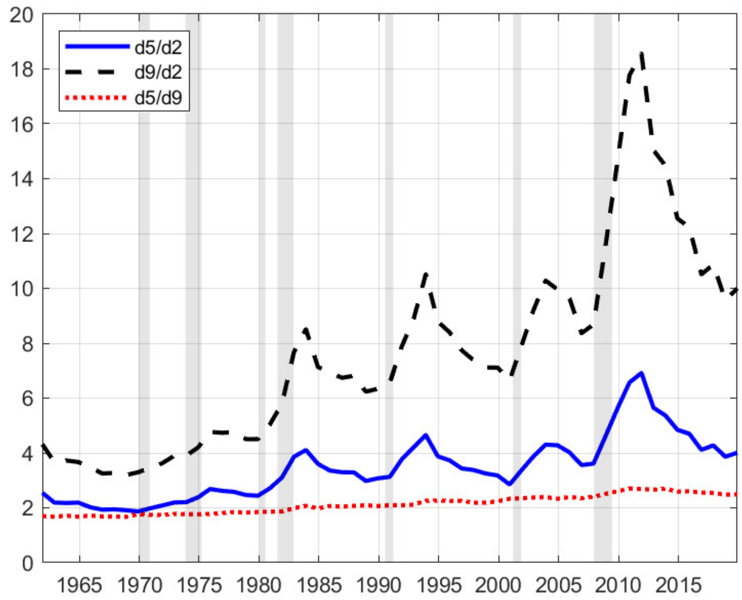
Notes: The table provides the steady state values of the labor tax rate, of the transfers-to-GDP ratio and the level of consumption heterogeneity, measured as the ratio of hand-to-mouth households consumption over aggregate consumption, for the model of optimal fiscal policy, when evaluated with the parameters with (column 2) and without (column 3) data on earnings and consumption inequality. The table also provides the values observed in the data in the first column.

Table 7: **Ramsey simulated moments**

	Ramsey w/o cross-sect. data	**Ramsey w cross-sect. data**
Corr(T,Y)	-0.29	-0.53
Corr(def,T)	-0.09	0.22
Corr(def,Y)	-0.24	-0.53

Notes: The table provides the simulated fiscal moments of interest – namely, the correlation between deficits and output, between deficits and transfers and between transfers and output – for our two sets of parameters in the optimal fiscal policy model.

FIGURE 1: **The evolution of US income inequality**

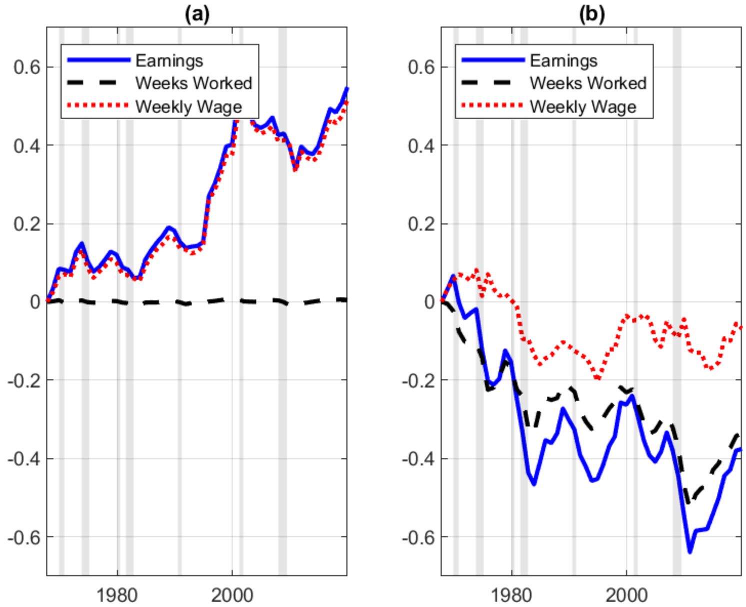


Notes: d5/d2 (solid blue line) measures the ratio of the average earning in the fifth decile of the earnings distribution over the average earning in the second decile. The ratios d9/d2 and d5/d9 are displayed, respectively, with the dashed black line and the dotted red line. Data is from the CPS. The shaded areas indicate NBER dated recession year.

FIGURE 2: **Wages, earnings and weeks worked at the bottom of earnings distribution**

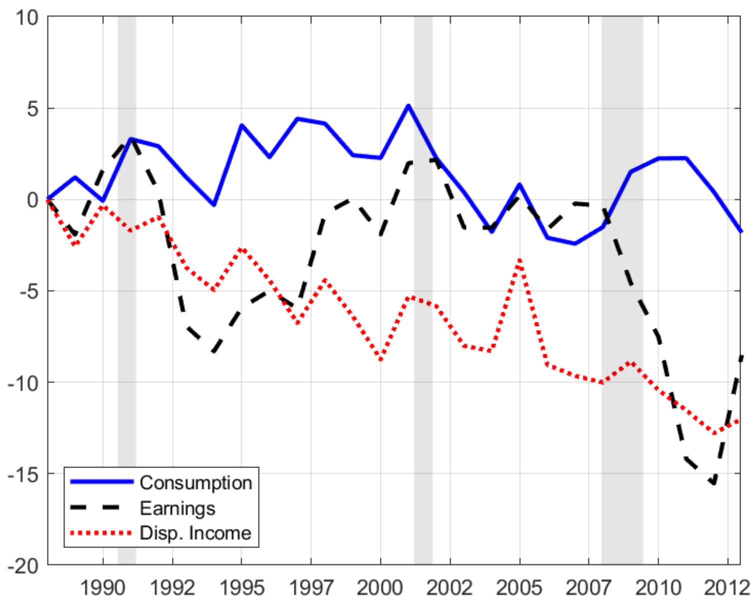
Notes: Panel (a) plots the evolution of average weekly wages (dashed black line), yearly earnings (solid blue line) and the average number of weeks worked (dotted red line) at the bottom 30% of the earnings distribution. Panel (b) decomposes the average weeks worked (solid blue line) in two terms: average weeks worked conditional on working a positive number of weeks (intensive margin of the labor supply) displayed with the dashed black line and the fraction of men who work a positive number of weeks (extensive margin of the labor supply) displayed with the dotted red line. The series measure percentage deviations from 1967 levels. Data is from the CPS. The shaded areas indicate NBER dated recession year.

Figure 3: **The evolution of wages, earnings and weeks worked at the top and the bottom of the earnings distribution**



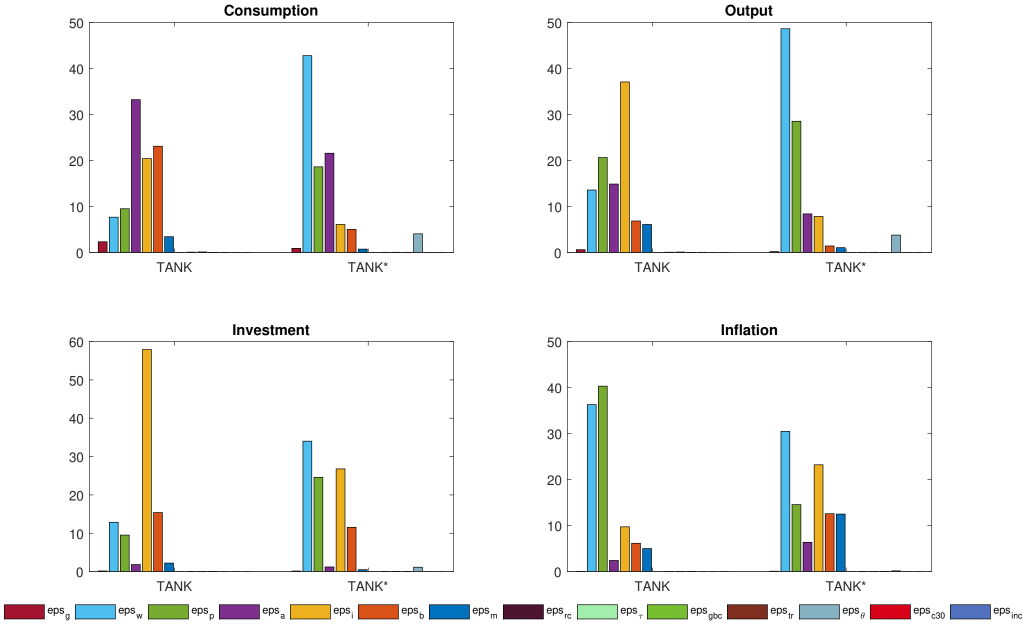
Notes: Panel (a) plots the evolution of average weekly wages(dashed black line), yearly earnings (solid blue line) and the average number of weeks worked (dotted red line) at the bottom 30% of the earnings distribution. Panel (b) reproduces the same exercise for the top 70% of the earnings distribution. The series measure percentage deviations from 1967 levels. Data is from the CPS. The shaded areas indicate NBER dated recession year.

Figure 4: **The evolution of earnings, disposable income and consumption inequality**



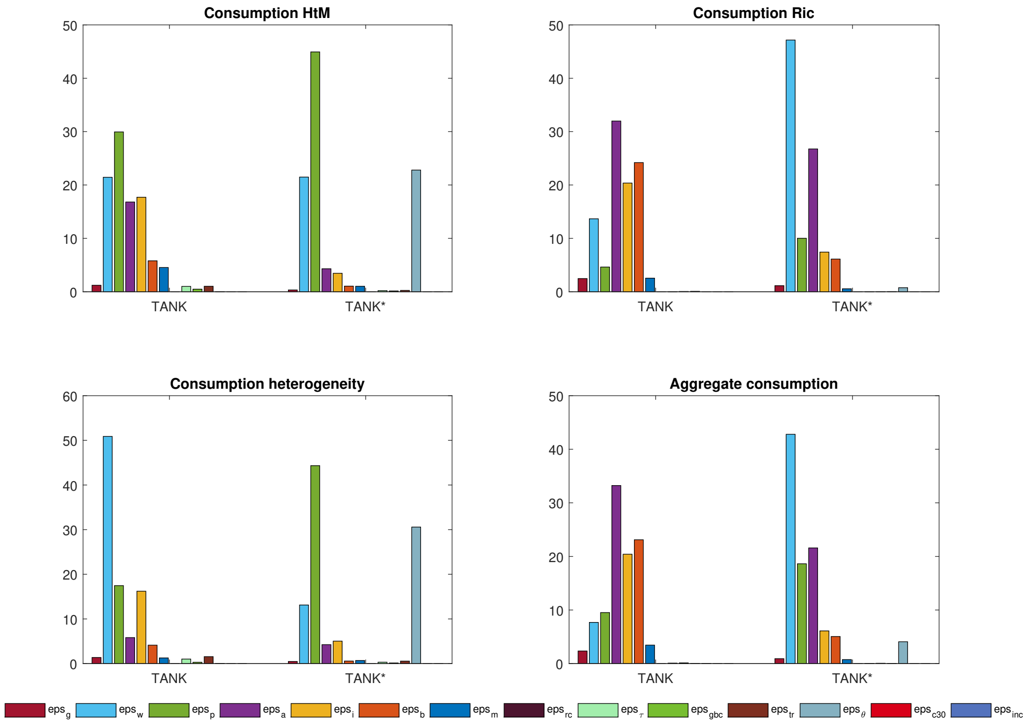
Notes: The figure plots the evolution of households' non-durable consumption expenditures (solid blue line), earnings (dashed black line) and disposable income (dotted red line) inequality. Consumption inequality is measured as the ratio of consumption expenditures at the bottom 30% of the earnings distribution over the average consumption expenditures over the entire distribution. We use similar measures for earnings and disposable income inequality data. The series measure percentage deviations from 1987 inequality level. Data is from the CEX. The shaded areas indicate NBER dated recession year.

FIGURE 5: **Variance decomposition aggregate variables**



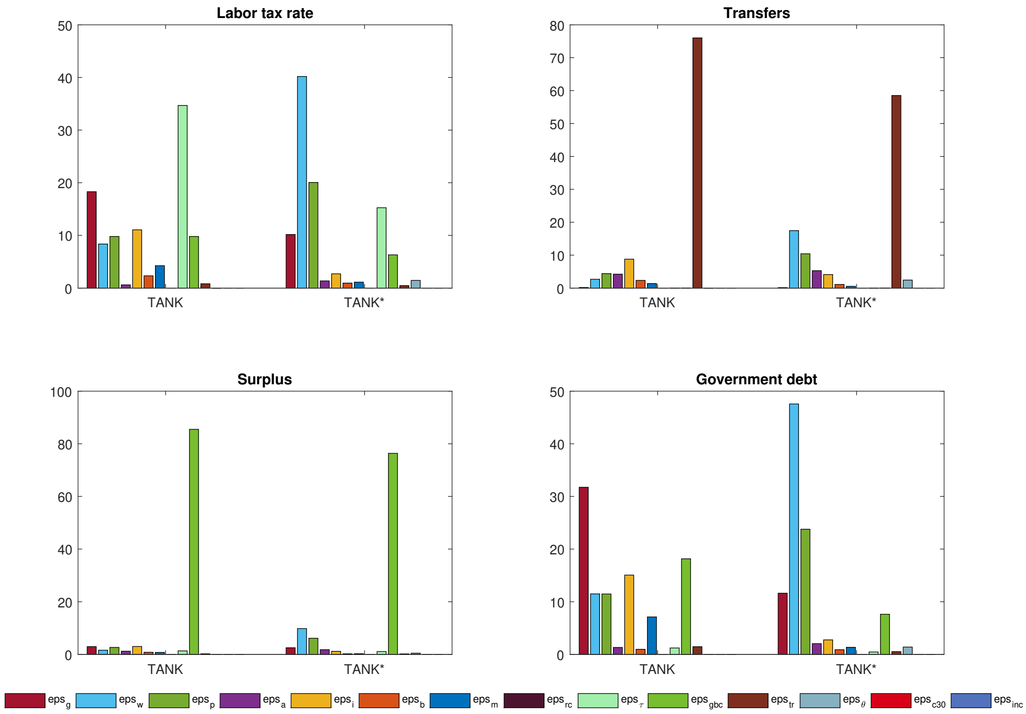
Notes: The Figure plots the variance decomposition of aggregate consumption (top-left), output (top-right), investment (bottom left) and inflation (bottom right) obtained from our two alternative estimations. TANK [TANK*] corresponds to the estimation of the TANK model without data on households heterogeneity [with data on households heterogeneity].

FIGURE 6: **Variance decomposition Consumption**



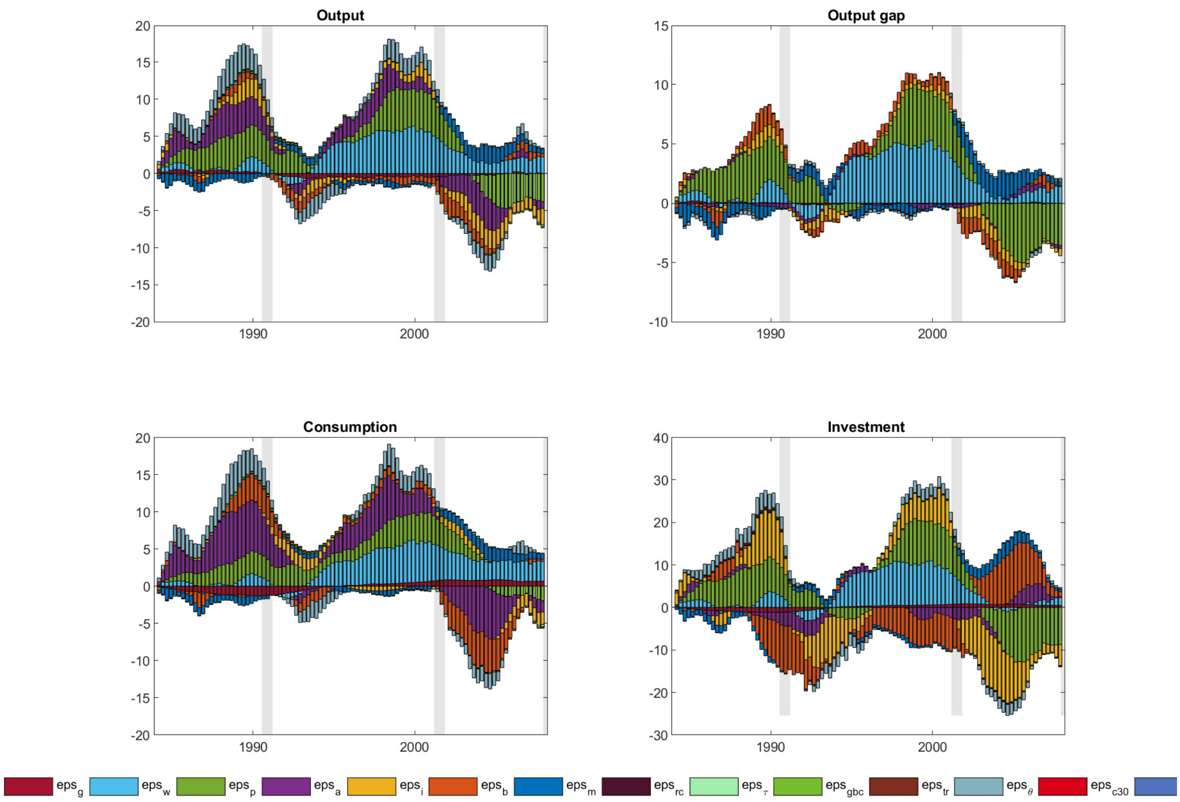
Notes: The Figure plots the variance decomposition of hand-to-mouth households' consumption (top-left), Ricardian households' consumption (top-right), consumption heterogeneity (bottom-left) and aggregate consumption (bottom-right) obtained from our two alternative estimations. TANK [TANK*] corresponds to the estimation of the TANK model without data on households heterogeneity [with data on households heterogeneity].

Figure 7: **Variance decomposition fiscal variables**



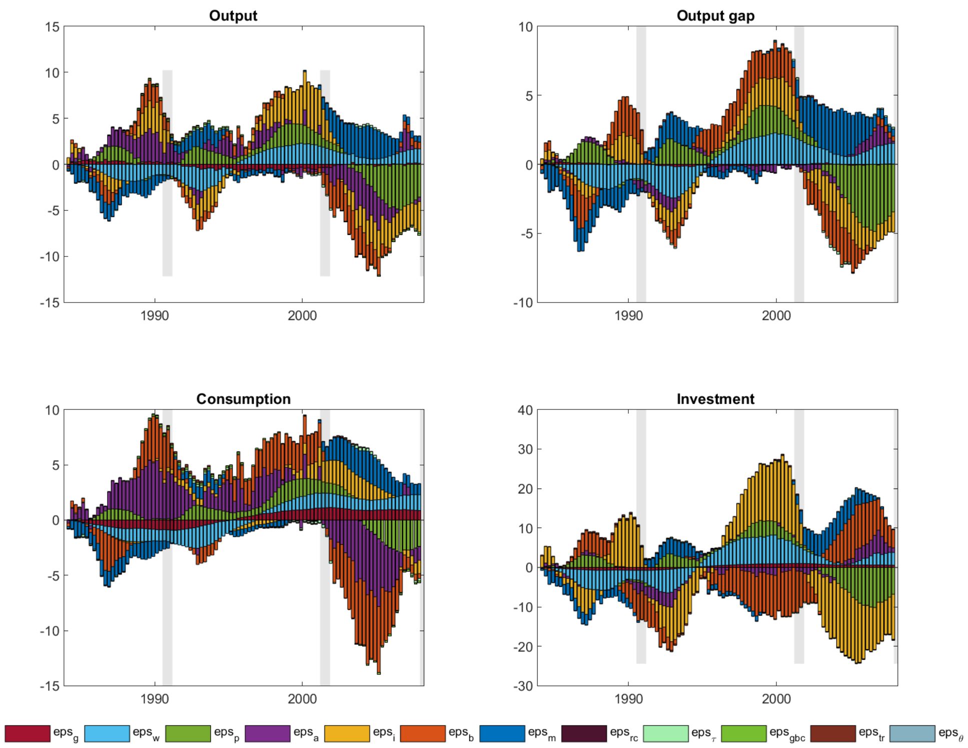
Notes: The Figure plots the variance decomposition of the labor tax rate (top-left), transfers (top-right), the government surplus (bottom-left) and government debt (bottom-right) obtained from our two alternative estimations. TANK [TANK*] corresponds to the estimation of the TANK model without data on households heterogeneity [with data on households heterogeneity].

Figure 8: **Historical decomposition of aggregate variables**



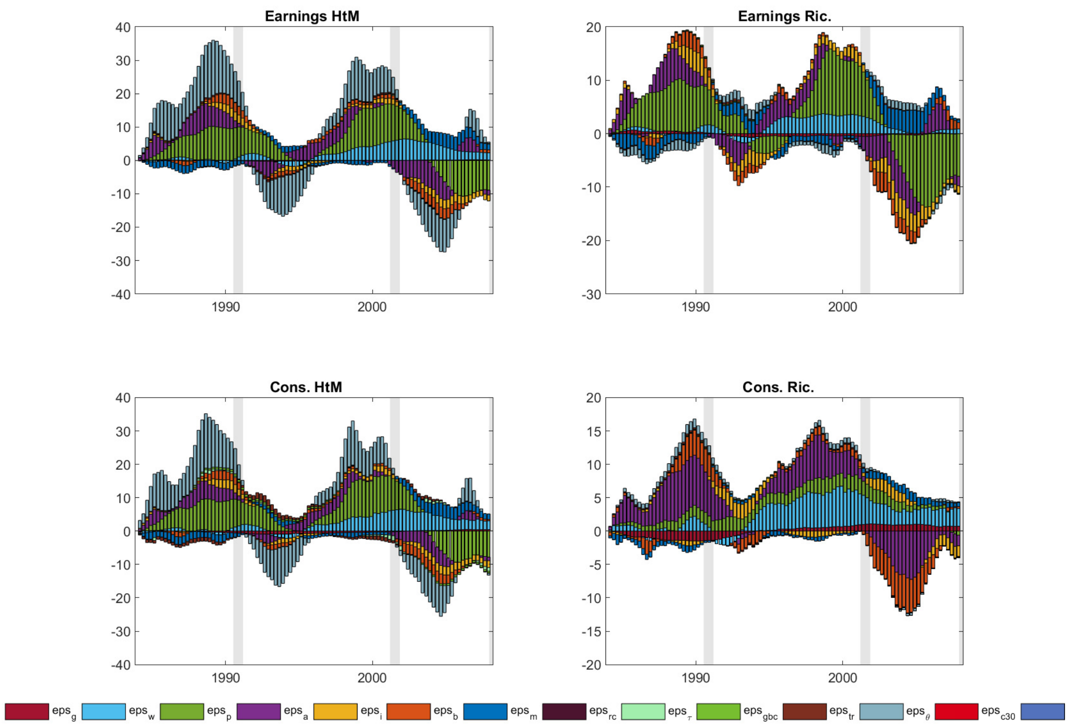
Notes: The figure plots the historical decomposition of the log-deviations of output (top-left panel), the output-gap (top-right), aggregate consumption (bottom-left) and investment (bottom-right) from the estimation of the model with data on earnings and consumption inequality (TANK*). Shaded areas correspond to NBER dated recessions.

Figure 9: **Historical decomposition of aggregate variables**



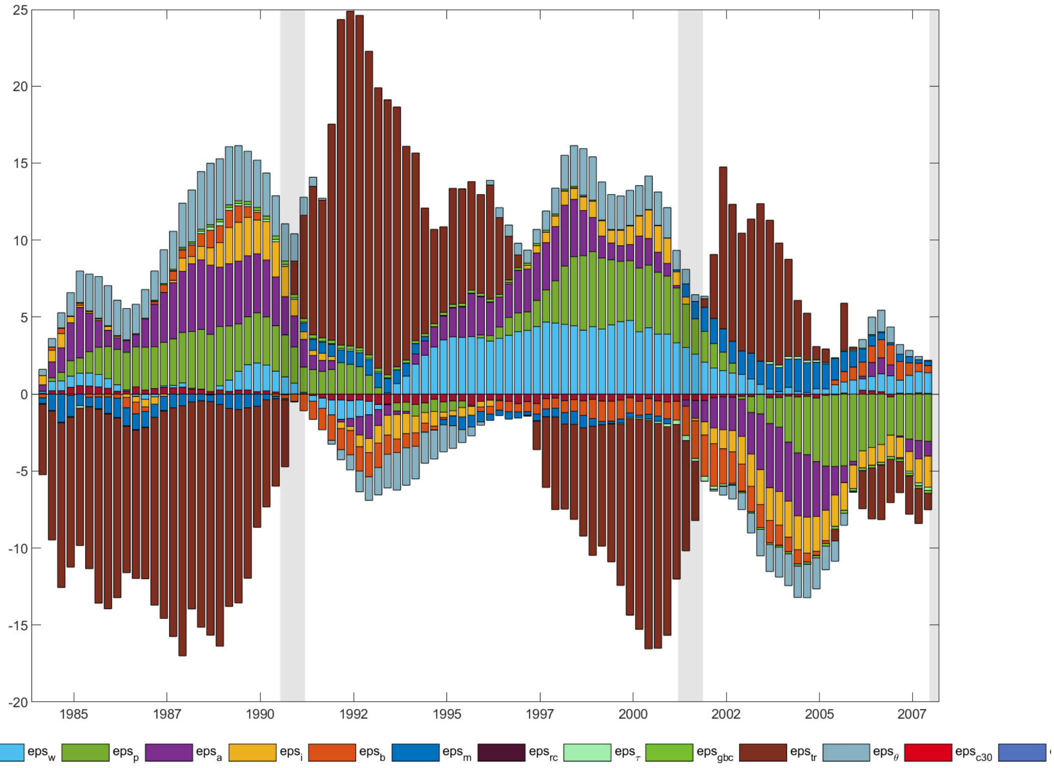
Notes: The figure plots the historical decomposition of the log-deviations of output (top-left panel), the output-gap (top-right), aggregate consumption (bottom-left) and investment (bottom-right) from the estimation of the model without data on earnings and consumption inequality (TANK). Shaded areas correspond to NBER dated recessions.

Figure 10: **Historical decomposition of households' earnings and consumption**



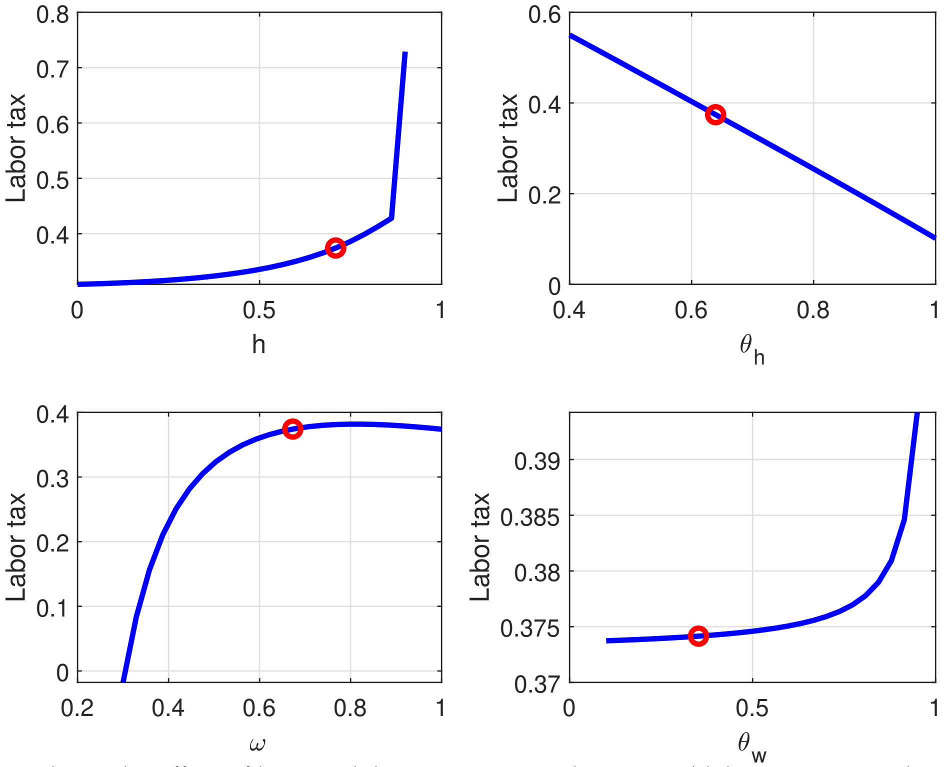
Notes: The figure plots the historical decomposition of the log-deviations of hand-to-mouth households' earnings (top-left panel) and consumption (bottom-left), and Ricardian households' earnings (top-right) and consumption (bottom-right) from the estimation of the model with data on earnings and consumption inequality (TANK*). Shaded areas correspond to NBER dated recessions.

Figure 11: **Historical decomposition of transfers**



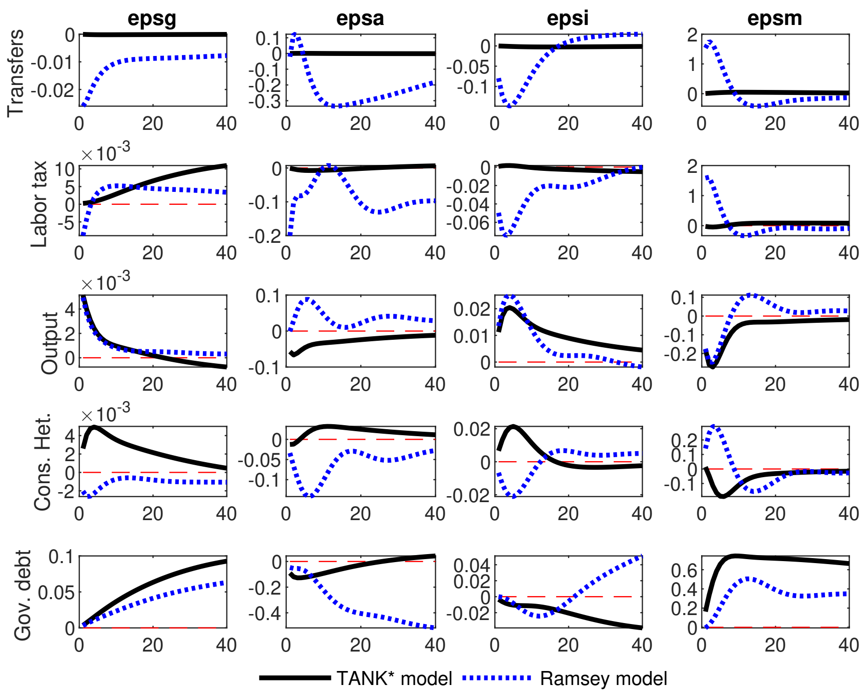
Notes: The figure plots the historical decomposition of the log-deviations of transfers from the estimation of the model with data on earnings and consumption inequality (TANK*). Shaded areas correspond to NBER dated recessions.

Figure 12: **Steady-state in the Ramsey model**



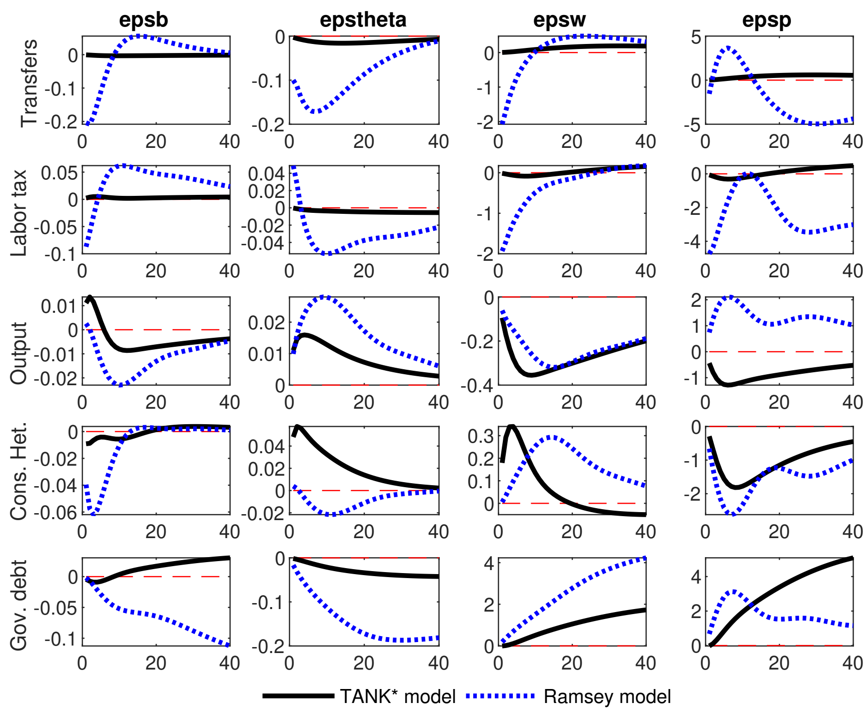
Notes: The figure analyses the effect of key model parameters on the optimal labor tax rate in the steady-state of the baseline model (i.e. based on the parameters obtained from the estimation without data on heterogeneity). Panel (a) displays the effect of h, the parameters measuring households' habits in consumption, panel (b) depicts the effect of θ^h, the long-run value of the relative productivity of hand-to-mouth agents. Panel (b) Panel (c) and (d) present, respectively, the effect of ω, the share of transfers targeted towards hand-to-mouth agents, and θ_w, the wage rigidity parameter. The remaining parameters are set to their baseline values, as presented in Table 3. A close figure can be reproduced with the parameters obtained from the estimation with data on heterogeneity.

FIGURE 13: **IRFs in the medium-scale model - fiscal rules vs. Ramsey**



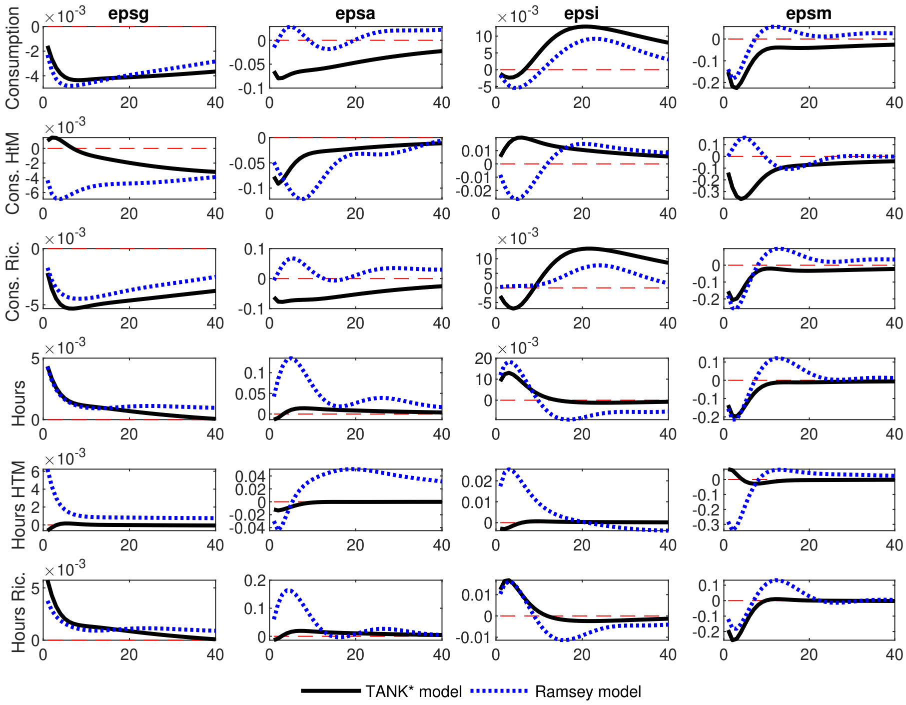
Notes: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black lines display the responses obtained from the TANK model with fiscal rule, the dotted blue lines provide the optimal IRFs as defined by the Ramsey planner. Both variants use the parameters estimated with data on households heterogeneity.

FIGURE 14: **IRFs in the medium-scale model - fiscal rules vs. Ramsey**



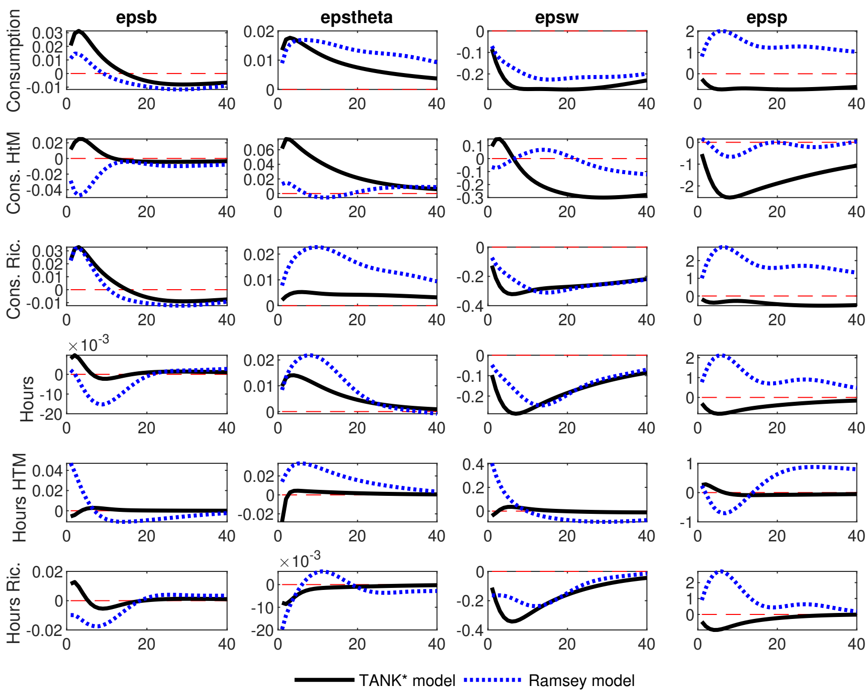
Notes: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups. The solid black lines display the responses obtained from the TANK model with fiscal rule, the dotted blue lines provide the optimal IRFs as defined by the Ramsey planner. Both variants use the parameters estimated with data on households heterogeneity.

Figure 15: **IRFs in the medium-scale model - fiscal rules vs. Ramsey**



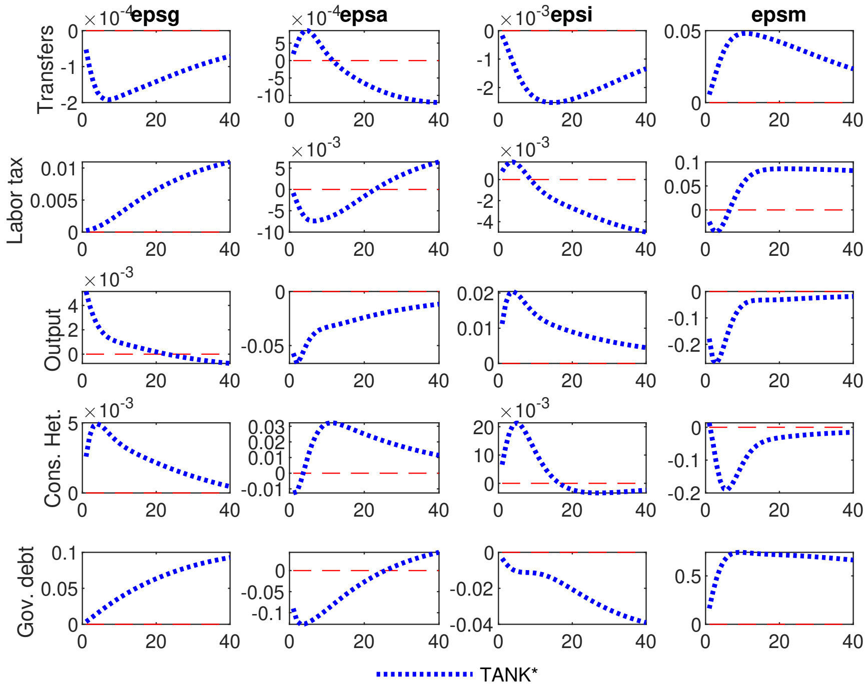
Notes: The figure plots the IRFs of households-specific variables – hours worked and consumption – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black lines display the responses obtained from the TANK model with fiscal rule, the dotted blue lines provide the optimal IRFs as defined by the Ramsey planner. Both variants use the parameters estimated with data on households heterogeneity.

Figure 16: **IRFs in the medium-scale model - fiscal rules vs. Ramsey**



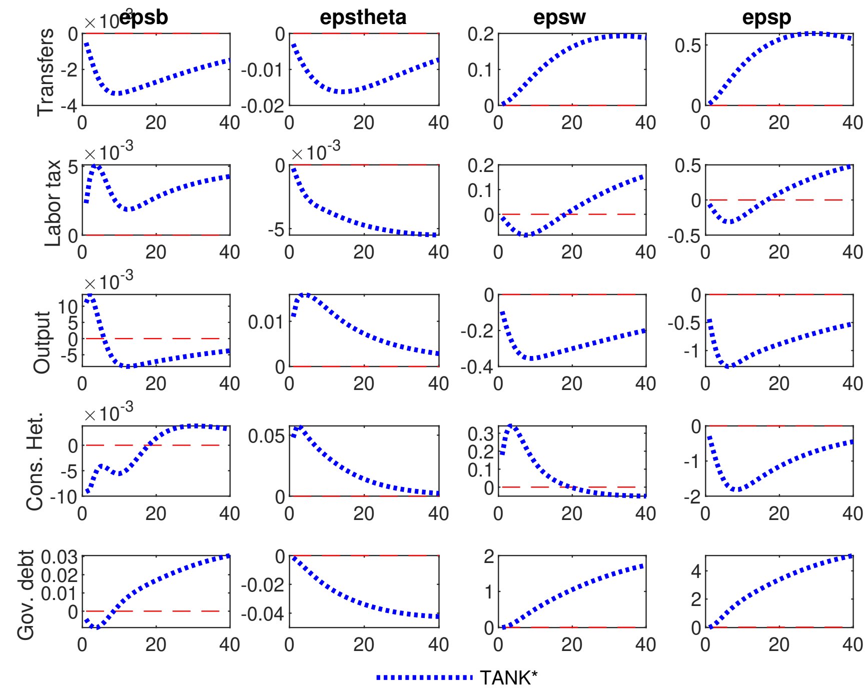
Notes: The figure plots the IRFs of households-specific variables – hours worked and consumption – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups. The solid black lines display the responses obtained from the TANK model with fiscal rule, the dotted blue lines provide the optimal IRFs as defined by the Ramsey planner. Both variants use the parameters estimated with data on households heterogeneity.

FIGURE 17: **IRFs in the medium-scale model with fiscal rules**



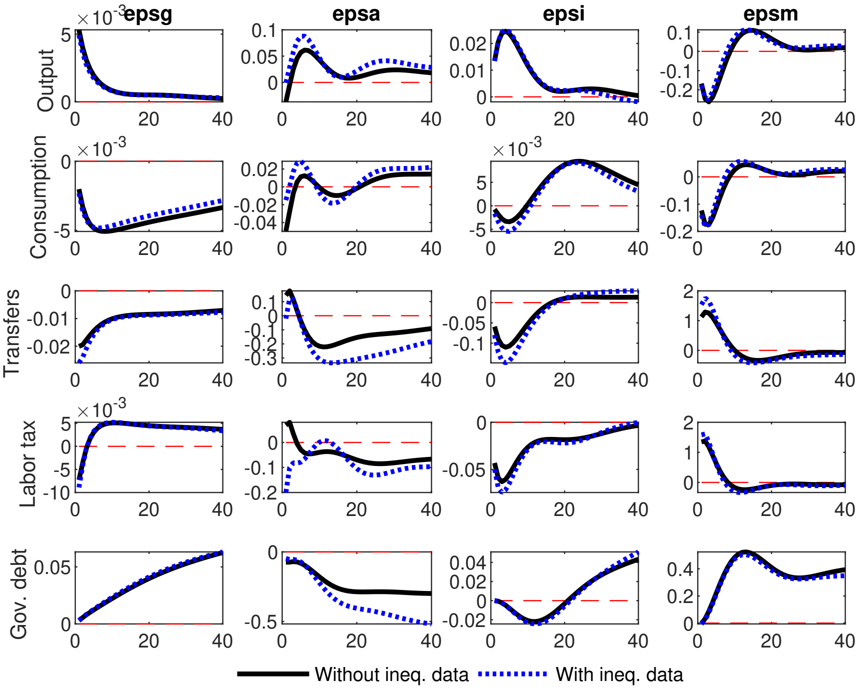
Notes: The figure plots the IRFs obtained from the TANK model with fiscal rule for the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks.

FIGURE 18: **IRFs in the medium-scale model with fiscal rules**



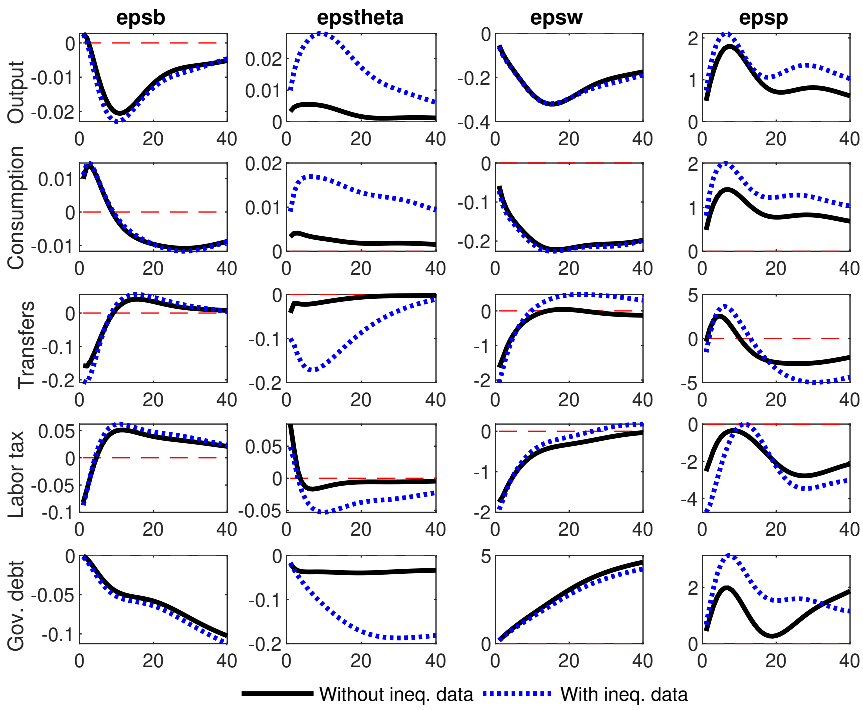
Notes: The figure plots the IRFs of obtained from the TANK model with fiscal rule for the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups.

Figure 19: **Optimal IRFs in the medium-scale model**



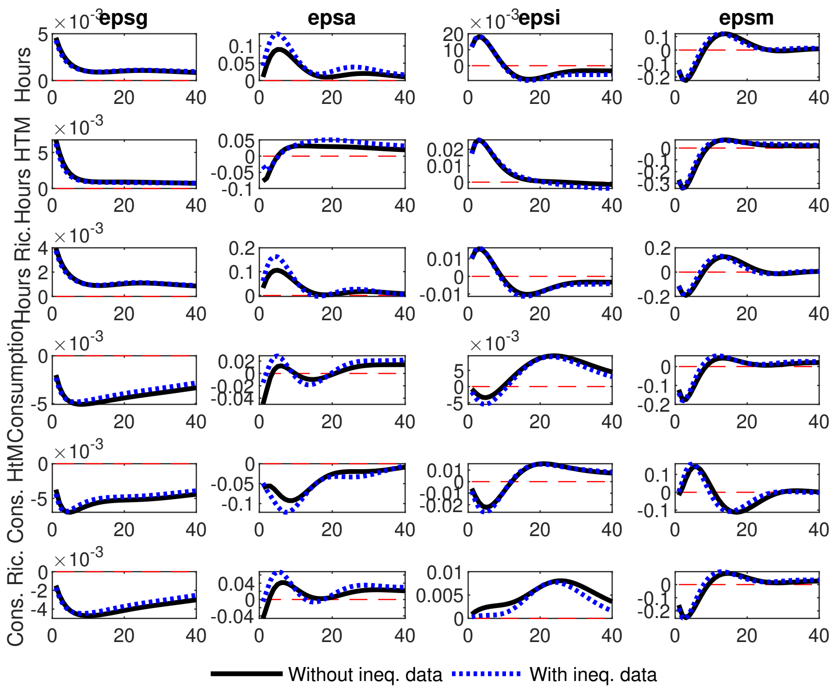
Notes: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black (dotted blue) line displays the optimal response of variables using the parameters obtained from the estimation of the TANK model without (with) data on households heterogeneity.

Figure 20: **Optimal IRFs in the medium-scale model**



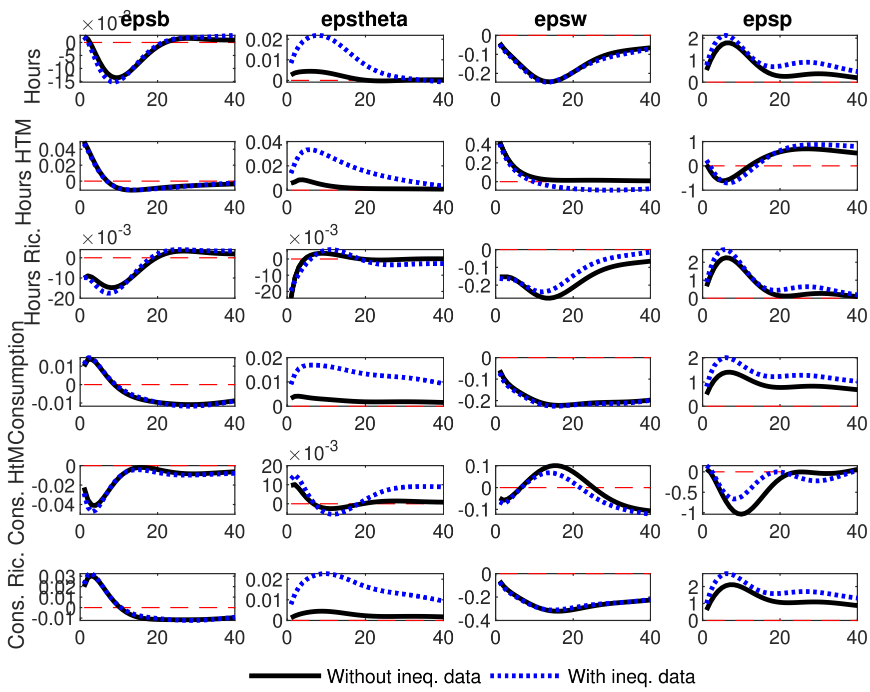
Notes: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups. The solid black (dotted blue) line displays the optimal response of variables using the parameters obtained from the estimation of the TANK model without (with) data on households heterogeneity.

FIGURE 21: **Optimal IRFs in the medium-scale model**



Notes: The figure plots the IRFs of households-specific variables – hours worked and consumption – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black (dotted blue) line displays the optimal response of variables using the parameters obtained from the estimation of the TANK model without (with) data on households heterogeneity.

FIGURE 22: **Optimal IRFs in the medium-scale model**



Notes: The figure plots the IRFs of households-specific variables – hours worked and consumption – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups. The solid black (dotted blue) line displays the optimal response of variables using the parameters obtained from the estimation of the TANK model without (with) data on households heterogeneity.

B The medium-scale DSGE model

B.1 The competitive equilibrium

Non savers:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + tr_t^h \tag{32}$$

$$\chi(n_t^h)^{\phi_h}(c_t^h - hc_{t-1}^{h,a}) = (1-\tau_t^n)\theta_t^h w_t \tag{33}$$

Savers' first order conditions:

$$k_t = (1-\delta)k_{t-1} + \xi_t^i\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\Big)\Big]I_t \tag{34}$$

$$\lambda_t = \xi_t^b \frac{u_c^s(c_t^s - hc_{t-1}^{s,a})}{1+\tau^c} \tag{35}$$

$$\lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} \tag{36}$$

$$1 - \xi_t^i\mu_t\Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big) - \frac{I_t^s}{I_{t-1}^s}S'\Big(\frac{I_t^s}{I_{t-1}^s}\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t}\Big(\frac{I_{t+1}^s}{I_t^s}\Big)^2 S'\Big(\frac{I_{t+1}^s}{I_t^s}\Big) \tag{37}$$

$$\mu_t = \beta(1-\delta)E_t\mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t} + \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{38}$$

$$\Phi'(u_t) = (1-\tau^k)r_t^k \tag{39}$$

Wage setting (by savers):

$$(w_t^*)^{1+\eta_w\phi_s} = \frac{\eta_w\chi}{\eta_w - 1}\frac{F_{1,t}^w}{F_{2,t}^w} \tag{40}$$

$$F_{1,t}^w = \xi_t^b w_t^{\eta_w(1+\phi_s)}(n_t^s)^{1+\phi_s} + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{-\eta_w(1+\phi_s)}E_t\Pi_{t+1}^{\eta_w(1+\phi_s)}F_{1,t+1}^w \tag{41}$$

$$F_{2,t}^w = \lambda_t(1-\tau_t^n)w_t^{\eta_w}n_t^s + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{1-\eta_w}E_t\Pi_{t+1}^{\eta_w-1}F_{2,t+1}^w \tag{42}$$

$$w_t^{1-\eta_w} = (1-\theta_w)(w_t^*)^{1-\eta_w} + \theta_w(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{1-\eta_w}\Pi_t^{\eta_w-1}w_{t-1}^{1-\eta_w} \tag{43}$$

$$v_t^w = (1-\theta_w)\Big(\frac{w_t^*}{w_t}\Big)^{-\eta_w(1+\phi_s} + \theta_w\Big(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^\gamma\Big)^{-\eta_w(1+\phi_s)}\Pi_t^{\eta_w(1+\phi_s)}\Big(\frac{w_t}{w_{t-1}}\Big)^{\eta_w(1+\phi_s)}v_{t-1}^w \tag{44}$$

Price setting:

$$p_t^* = \frac{\eta_p}{\eta_p - 1}\frac{F_{1,t}^p}{F_{2,t}^p} \tag{45}$$

$$F_{1,t}^p = mc_t y_t + \beta\theta_p\Pi^{-\eta_p\nu_p}\Pi^{-\eta_p(1-\nu_p)}E_t\Pi_{t+1}^{\eta_p}\frac{\lambda_{t+1}}{\lambda_t}F_{1,t+1}^p \tag{46}$$

$$F_{2,t}^p = y_t + \beta\theta_p\Pi_t^{(1-\eta_p)\nu_p}\Pi^{(1-\eta_p)(1-\nu_p)}E_t\Pi_{t+1}^{\eta_p-1}\frac{\lambda_{t+1}}{\lambda_t}F_{2,t+1}^p \tag{47}$$

$$1 = (1-\theta_p)(p_t^*)^{1-\eta_p} + \theta_p\Pi_{t-1}^{\nu_p(1-\eta_p)}\Pi^{(1-\nu_p)(1-\eta_p)}\Pi_t^{\eta_p-1} \tag{48}$$

Government budget:

$$\frac{b_{t-1}}{\Pi_t} = -g_t - tr_t + \tau_t^n w_t N_t + \tau^k(r_t^k u_t k_{t-1} + d_t) + \tau^c c_t + q_t b_t \tag{49}$$

Equilibrium and aggregation:

$$y_t v_t^p = (u_t k_{t-1})^\alpha (a_t N_t)^{1-\alpha} - \Omega a_t \tag{50}$$

$$v_t^p = (1-\theta_p)(p_t^*)^{-\eta_p} + \theta_p \Pi_{t-1}^{-\eta_p \nu_p} \Pi^{-\eta_p(1-\nu_p)} \Pi_t^{\eta_p} v_{t-1}^p \tag{51}$$

$$c_t + I_t + g_t + \Phi(u_t)k_{t-1} = y_t \tag{52}$$

$$N_t = \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s \tag{53}$$

$$c_t = \lambda c_t^h + (1-\lambda) c_t^s \tag{54}$$

$$mc_t = \frac{1}{1-\alpha} \frac{w_t}{a_t} \Big(\frac{u_t k_{t-1}}{a_t n_t}\Big)^{-\alpha} \tag{55}$$

Potential output (flexible price block) to determine ($c_t^{flex}, c_t^{h,flex}, c_t^{s,flex}, n_t^{flex}, n_t^{h,flex}, n_t^{s,flex}, \lambda_t^{flex}, k_t^{flex}, I_t^{flex}, \mu_t^{flex}, r_t^{k,flex}, r_t^{flex}, u_t^{flex}, w_t^{flex}, y_t^{flex}$).

$$\lambda_t^{flex} = \frac{\xi_t^b}{(1+\tau^c)(c_t^{s,flex} - h c_{t-1}^{s,flex})} \tag{56}$$

$$\lambda_t^{flex} = \beta r^{flex} \lambda_{t+1}^{flex} \tag{57}$$

$$w^{flex}(1-\tau_t^n) = \frac{\xi_t^b \chi (n_t^{s,flex})^\phi}{\lambda_t^{flex}} \frac{\eta^w}{\eta^w - 1} \tag{58}$$

$$w_t^{flex} = \frac{(\eta^p - 1)}{\eta^p}(1-\alpha)\Big(\frac{u_t^{flex} k_{t-1}^{flex}}{n_t^{flex}}\Big)^\alpha \tag{59}$$

$$r_t^{k,flex} = \frac{(\eta^p - 1)}{\eta^p}\alpha\Big(\frac{u_t^{flex} k_{t-1}^{flex}}{n_t^{flex}}\Big)^{(\alpha-1)} \tag{60}$$

$$k_t^{flex} = (1-\delta)k_{t-1}^{flex} + \xi_t^i(1 - S\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big) I_t^{flex} \tag{61}$$

$$\lambda_t^{flex}\left[1 - \mu_t^{flex}\xi_t^i(1 - S\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big) - \frac{I_t^{flex}}{I_{t-1}^{flex}} S'\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big)\right] = \beta_t \xi_{t+1}^i \mu_{t+1}^{flex} \lambda_{t+1}^{flex} \Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big)^2 S'\Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big) \tag{62}$$

$$\mu_t^{flex}\lambda_t^{flex} = \beta_t(1-\delta)\mu_{t+1}^{flex}\lambda_{t+1}^{flex} + \beta_t \lambda_{t+1}^{flex}\Big(\Phi'(u_{t+1}^{flex})u_{t+1}^{flex} - \Phi(u_{t+1}^{flex})\Big) \tag{63}$$

$$\Phi'(u_t^{flex}) = (1-\tau^k) r_t^{k,flex} \tag{64}$$

$$y_t^{flex} = (u_t^{flex} k_{t-1}^{flex})^\alpha n_t^{flex(1-\alpha)} - \Omega \tag{65}$$

$$y_t^{flex} = c^{flex} + I_t^{flex} + g_t + \Phi(u_t^{flex}) k_{t-1}^{flex} \tag{66}$$

$$(1+\tau^c) c_t^{h,flex} = (1-\tau_t^n)\theta_t^h w_t^{flex} n_t^{h,flex} + tr_t^h \tag{67}$$

$$\chi (n_t^{h,flex})^\phi (c_t^{h,flex} - h c_{t-1}^{h,flex}) = (1-\tau_t^n)\theta_t^h w_t^{flex} \tag{68}$$

$$n^{flex} = \lambda \theta_t^h n_t^{h,flex} + (1-\lambda) n_t^{s,flex} \tag{69}$$

$$c_t^{flex} = \lambda c_t^{h,flex} + (1-\lambda) c_t^{s,flex} \tag{70}$$

Functional forms:

$$S\Big(\frac{I_t}{I_{t-1}}\Big) = \frac{\kappa}{2}\Big(\frac{I_t}{I_{t-1}} - e^{\gamma}\Big)^2 \tag{71}$$

$$\Phi(u_t) = \frac{r^k(1-\tau^k)}{\varphi_u}(e^{\varphi_u(u_t-1)} - 1) \tag{72}$$

B.1.1 Detrending

Technology $\xi_t^a \equiv \frac{a_t}{a_{t-1}}$ evolves as:

$$\log \xi_t^a = (1-\rho_a)\gamma + \rho_a \log \xi_{t-1}^a + \epsilon_t^a \tag{73}$$

Detrend y_t, c_t, c_t^h, c_t^s, w_t, b_t, tr_t, g_t, k_t, I_t, $F_{1,t}^w$, $F_{2,t}^w$, $F_{1,t}^p$, $F_{2,t}^p$, λ_t

Non-savers:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + \frac{tr_t}{\lambda} \tag{74}$$

$$(1+\tau^c)\chi(n_t^h)^{\phi_h}(c_t^h - hc_{t-1}^{h,a}(\xi_t^a)^{-1}) = (1-\tau_t^n)\theta_t^h w_t \tag{75}$$

Savers:

$$\lambda_t = \frac{\xi_t^b}{1+\tau^c}\frac{1}{c_t^s - hc_{t-1}^{s,a}(\xi_t^a)^{-1}} \tag{76}$$

$$\lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}}(\xi_{t+1}^a)^{-1} \tag{77}$$

$$k_t = (1-\delta)k_{t-1}(\xi_t^a)^{-1} + \xi_t^i\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big)\Big]I_t \tag{78}$$

$$1 - \xi_t^i\mu_t\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big) - \frac{I_t}{I_{t-1}}\xi_t^a S'\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t \xi_{t+1}^a}\Big(\frac{I_{t+1}}{I_t}\xi_{t+1}^a\Big)^2 S'\Big(\frac{I_{t+1}}{I_t}\xi_{t+1}^a\Big) \tag{79}$$

$$\mu_t = \beta(1-\delta)E_t\mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t\xi_{t+1}^a} + \beta E_t\frac{\lambda_{t+1}}{\lambda_t\xi_{t+1}^a}\Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{80}$$

$$\Phi'(u_t) = (1-\tau^k)r_t^k \tag{81}$$

Wage setting:

$$(w_t^*)^{1+\eta_w\phi_s} = \frac{\eta_w \chi}{\eta_w - 1}\frac{f_{1,t}^w}{f_{2,t}^w} \tag{82}$$

$$f_{1,t}^w = \xi_t^b w_t^{\eta_w(1+\phi_s)}(n_t^s)^{1+\phi_s}(\xi_t^w)^{\frac{1}{\Theta_2}} + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{-\eta_w(1+\phi_s)}E_t(\xi_{t+1}^a)^{\eta_w(1+\phi_s)}\Pi_{t+1}^{\eta_w(1+\phi_s)}f_{1,t+1}^w \tag{83}$$

$$f_{2,t}^w = \lambda_t(1-\tau_t^n)w_t^{\eta_w}n_t^s + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{1-\eta_w}E_t(\xi_{t+1}^a)^{\eta_w-1}\Pi_{t+1}^{\eta_w-1}f_{2,t+1}^w \tag{84}$$

$$w_t^{1-\eta_w} = (1-\theta_w)(w_t^*)^{1-\eta_w} + \theta_w(\xi_t^a)^{\eta_w-1}(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{1-\eta_w}\Pi_t^{\eta_w-1}w_{t-1}^{1-\eta_w} \tag{85}$$

$$v_t^w = (1-\theta_w)\Big(\frac{w_t^*}{w_t}\Big)^{-\eta_w(1+\phi_s} + \theta_w\Big(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^{\gamma}\Big)^{-\eta_w(1+\phi_s)}\Pi_t^{\eta_w(1+\phi_s)}\Big(\xi_t^a\frac{w_t}{w_{t-1}}\Big)^{\eta_w(1+\phi_s)}v_{t-1}^w \tag{86}$$

Price setting:

$$p_t^* = \frac{\eta_p}{\eta_p - 1}\frac{f_{1,t}^p}{f_{2,t}^p} \tag{87}$$

$$f_{1,t}^p = mc_t y_t (\xi_t^p)^{\frac{\theta_p(1+\beta\nu_p)}{(1-\beta\theta_p)(1-\theta_p)}} + \beta\theta_p \Pi_t^{-\eta_p\nu_p}\Pi^{-\eta_p(1-\nu_p)} E_t \frac{\lambda_{t+1}}{\lambda_t}\Pi_{t+1}^{\eta_p} f_{1,t+1}^p \tag{88}$$

$$f_{2,t}^p = y_t + \beta\theta_p \Pi_t^{(1-\eta_p)\nu_p}\Pi^{(1-\eta_p)(1-\nu_p)} E_t \Pi_{t+1}^{\eta_p-1}\frac{\lambda_{t+1}}{\lambda_t} f_{2,t+1}^p \tag{89}$$

$$1 = (1-\theta_p)(p_t^*)^{1-\eta_p} + \theta_p \Pi_{t-1}^{\nu_p(1-\eta_p)}\Pi^{(1-\nu_p)(1-\eta_p)}\Pi_t^{\eta_p-1} \tag{90}$$

Government:

$$\frac{b_{t-1}}{\xi_t^a \Pi_t} = -g_t - tr_t + \tau_t^n w_t n_t + \tau^k(y_t - w_t n_t) + \tau^c c_t + q_t b_t \tag{91}$$

Equilibrium/aggregation

$$y_t v_t^p = (\xi_t^a)^{-\alpha}(u_t k_{t-1})^{\alpha} n_t^{1-\alpha} - \Omega \tag{92}$$

$$v_t^p = (1-\theta_p)(p_t^*)^{-\eta_p} + \theta_p \Pi_{t-1}^{-\eta_p\nu_p}\Pi^{-\eta_p(1-\nu_p)}\Pi_t^{\eta_p} v_{t-1}^p \tag{93}$$

$$c_t + I_t + g_t + \Phi(u_t)k_{t-1}(\xi_t^a)^{-1} = y_t \tag{94}$$

$$mc_t = \frac{1}{1-\alpha} w_t \Big(\frac{u_t k_{t-1}}{\xi_t^a n_t}\Big)^{-\alpha} \tag{95}$$

$$\frac{w_t}{r_t^k} = \frac{1-\alpha}{\alpha}\frac{u_t k_{t-1}}{n_t}(\xi_t^a)^{-1} \tag{96}$$

$$n_t = \lambda\theta_t^h n_t^h + (1-\lambda)n_t^s \tag{97}$$

$$c_t = \lambda c_t^h + (1-\lambda)c_t^s \tag{98}$$

B.1.2 Steady-state

Given the normalized value of n:

$$u = 1$$

$$p^* = 1$$

$$v^p = 1$$

$$q = \frac{e^{-\gamma}\beta}{\Pi}$$

$$mc = \frac{\eta_p - 1}{\eta_p}$$

$$\mu = 1$$

$$r^k = \frac{1-\beta(1-\delta)e^{-\gamma}}{\beta e^{-\gamma}(1-\tau^k)}$$

$$k = ne^{\gamma}\Big(\frac{\alpha mc}{r^k}\Big)^{\frac{1}{1-\alpha}}$$

$$w = e^{-\gamma}\frac{1-\alpha}{\alpha}\frac{k}{n}r^k$$

$$I = (1-(1-\delta)e^{-\gamma})k$$

$$\Omega = e^{-\alpha\gamma}k^{\alpha}n^{1-\alpha} - r^k k - wn$$

$$y = e^{-\alpha\gamma}k^{\alpha}n^{1-\alpha} - \Omega$$

$$c = y - I - g$$

B.1.3 Log-linear equations

Savers:

$$\hat{\lambda}_t = \hat{\xi}_t^b - \frac{1}{1-he^{-\gamma}}(\hat{c}_t^s - he^{-\gamma}\hat{c}_{t-1}^s + he^{-\gamma}\hat{\xi}_t^a) \tag{99}$$

$$\hat{\lambda}_t + \hat{q}_t = E_t\hat{\lambda}_{t+1} - E_t\hat{\pi}_{t+1} - E_t\hat{\xi}_{t+1}^a \tag{100}$$

$$\hat{k}_t = (1-\delta)e^{-\gamma}(\hat{k}_{t-1} - \hat{\xi}_t^a) + (1-(1-\delta)e^{-\gamma})(\hat{I}_t + \hat{\xi}_t^i) \tag{101}$$

$$\hat{I}_t = \frac{1}{1+\beta}(\hat{I}_{t-1} + \beta E_t\hat{I}_{t+1}) - \frac{1}{1+\beta}(\hat{\xi}_t^a - \beta E_t\hat{\xi}_{t+1}^a) + \frac{e^{-2\gamma}}{(1+\beta)\kappa}(\hat{\mu}_t + \hat{\xi}_t^i) \tag{102}$$

$$\hat{\mu}_t = \beta(1-\delta)e^{-\gamma}E_t\mu_{t+1} + E_t\hat{\lambda}_{t+1} - \hat{\lambda}_t - E_t\hat{\xi}_{t+1}^a + (1-\beta(1-\delta)e^{-\gamma})E_t\hat{r}_{t+1}^k \tag{103}$$

$$\hat{r}_t^k = \varphi_u\hat{u}_t \tag{104}$$

Price and wage setting:

$$\hat{\pi}_t = \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p(1+\beta\nu_p)}\hat{m}c_t + \frac{\nu_p}{1+\beta\nu_p}\hat{\pi}_{t-1} + \frac{\beta}{1+\beta\nu_p}E_t\hat{\pi}_{t+1} + \hat{\xi}_t^p \tag{105}$$

$$\hat{w}_t = \tilde{\Theta}_2\Big(\phi_s\hat{n}_t^s - \hat{\lambda}_t + \xi_t^b + \frac{\tau^n}{1-\tau^n}\hat{\tau}_t^n\Big) + \tilde{\Theta}_1\Big(\hat{w}_{t-1} + \beta E_t\hat{w}_{t+1} + \nu_w\hat{\pi}_{t-1} - (1+\beta\nu_w)\hat{\pi}_t + \beta E_t\hat{\pi}_{t+1} - \hat{\xi}_t^a + \beta E_t\hat{\xi}_{t+1}^a\Big) + \hat{\xi}_t^w \tag{106}$$

with $\tilde{\Theta}_1 \equiv \frac{\theta_w(1+\eta_w\phi_s)}{(1+\eta_w\phi_s)(1+\beta\theta_w^2)-\eta_w\phi_s(1-\theta_w)(1-\beta\theta_w)}$ and $\tilde{\Theta}_2 \equiv \frac{(1-\beta\theta_w)(1-\theta_w)}{\theta_w(1+\eta_w\phi_s)}\tilde{\Theta}_1$.

Government, equilibrium and aggregation:

$$\frac{b}{\Pi}e^{-\gamma}(\hat{b}_{t-1} - \hat{\xi}_t^a - \hat{\pi}_t) = -g\hat{g}_t - tr\hat{tr}_t + \tau^n wn(\hat{\tau}_t^n + \hat{w}_t + \hat{n}_t) + \tau^k(y\hat{y}_t - wn(\hat{w}_t + \hat{n}_t)) + \tau^c c\hat{c}_t + qb(\hat{q}_t + \hat{b}_t) \tag{107}$$

$$y\hat{y}_t = e^{-\alpha\gamma}k^\alpha n^{1-\alpha}[\alpha(\hat{u}_t + \hat{k}_{t-1} - \hat{\xi}_t^a) + (1-\alpha)\hat{n}_t] \tag{108}$$

$$c\hat{c}_t + I\hat{I}_t + g\hat{g}_t + e^{-\gamma}r^k(1-\tau^k)k\hat{u}_t = y\hat{y}_t \tag{109}$$

$$n\hat{n}_t = \lambda\theta^h n^h(\hat{\theta}_t^h + \hat{n}_t^h) + (1-\lambda)n^s\hat{n}_t^s \tag{110}$$

$$c\hat{c}_t = \lambda c^h\hat{c}_t^h + (1-\lambda)c^s\hat{c}_t^s \tag{111}$$

$$\hat{m}c_t = \hat{w}_t + \alpha(\hat{u}_t + \hat{k}_{t-1} - \hat{n}_t - \hat{\xi}_t^a) \tag{112}$$

$$\hat{w}_t - \hat{r}_t^k = \hat{u}_t + \hat{k}_{t-1} - \hat{n}_t - \hat{\xi}_t^a \tag{113}$$

Non-savers:

$$(1+\tau^c)c^h\hat{c}_t^h = (1-\tau^n)\theta^h wn^h(\hat{\theta}_t^h + \hat{w}_t + \hat{n}_t^h) - \tau^n\theta^h wn^h\hat{\tau}_t^n + \frac{tr}{\lambda}\hat{tr}_t \tag{114}$$

$$\phi_h n_t^h + \frac{1}{1-he^{-\gamma}}(\hat{c}_t^h - he^{-\gamma}\hat{c}_{t-1}^h + he^{-\gamma}\hat{\xi}_t^a) = \hat{\theta}_t^h + \hat{w}_t - \frac{\tau^n}{1-\tau^n}\hat{\tau}_t^n \tag{115}$$

B.1.4 Mixed frequency estimation

A critical issue of the estimation is the matching of the model constructed at quarterly frequency with data that are only available at yearly frequency, as our CPS earnings data. To do so, we must define an observed equation that defines the theoretical relation between the relatively high-frequency model with the low-frequency observed variables. The observation equations needed are the ones linking the observed annual earnings of hand-to-mouth and Ricardian households, $Earn_{ann,t}^{data,i}$, to their quarterly concepts counterpart and the trend growth.

In every quarter, we can define the annual earnings of hand-to-mouth households, $Earn_{ann,t}^{HtM}$, as the sum of their earnings in the previous four quarters:

$$Earn_{ann,t}^{HtM} = \theta_t^h W_t n_t^h + \theta_{t-1}^h W_{t-1} n_{t-1}^h + \theta_{t-2}^h W_{t-2} n_{t-2}^h + \theta_{t-3}^h W_{t-3} n_{t-3}^h \tag{116}$$

where $E_{ann,t}^{HtM}$ can be decomposed into a stationary components, $e_{ann,t}^{HtM}$, and the trend a_t :

$$Earn_{ann,t}^{HtM} = earn_{ann,t}^{HtM} a_t$$

In the data, we observe the sum of the quarterly earnings of hand-to-mouth households, $Earn_{ann,t}^{data,HtM}$, only every fourth quarter. The growth rate of earnings is given by the log difference between today's measurement of annual earnings (comprising the quarters t, t-1, t-2, t-3) and the annual earnings from time $t-4$ (comprising t-4, t-5, t-6, t-7). Hence, the earnings growth rate can be linked to the model variables as:

$$\begin{aligned} \Delta Earn_{ann,t}^{obs,HtM} &= logEarn_{ann,t}^{data,HtM} - logEarn_{ann,t-4}^{data,HtM} \\ &= logEarn_{ann,t}^{HtM} - logEarn_{ann,t-4}^{HtM} \\ &= e\hat{arn}_{ann,t}^{HtM} - e\hat{arn}_{ann,t-4}^{HtM} + log\Big(\frac{a_t}{a_{t-4}}\Big) \\ &= e\hat{arn}_{ann,t}^{HtM} - e\hat{arn}_{ann,t-4}^{HtM} + \xi_t^a + \xi_{t-1}^a + \xi_{t-2}^a + \xi_{t-3}^a \end{aligned} \tag{117}$$

The third line make use of the fact that earnings the year before inherits trend a_{t-4} and uses the definition of percentage deviation from the trend. Equation 117 is our desired observation equation. To make it operational, we need to define $e\hat{arn}_{ann,t}^{HtM}$. To do so, we use equation 116 we divide by a_t and log-linearize it around the following steady state:

$$earn_{ann}^{HtM} = \theta^h w n^h \Big(1 + \frac{1}{e^\gamma} + \frac{1}{(e^\gamma)^2} + \frac{1}{(e^\gamma)^3}\Big)$$

This leads to:

$$\begin{aligned} e\hat{arn}_{ann,t}^{HtM} = & \Big(\frac{1}{1+e^\gamma+(e^\gamma)^2+(e^\gamma)^3}\Big)^{-1} \Big[\big(\hat{\theta}_t^h + \hat{w}_t + \hat{n}_t^h\big) + \frac{1}{e^\gamma}\big(\hat{\theta}_{t-1}^h + \hat{w}_{t-1} + \hat{n}_{t-1}^h - \hat{\xi}_t^a\big) \\ & + \frac{1}{(e^\gamma)^2}\big(\hat{\theta}_{t-2}^h + \hat{w}_{t-2} + \hat{n}_{t-2}^h - \hat{\xi}_{t-1}^a\big) + \frac{1}{(e^\gamma)^3}\big(\hat{\theta}_{t-3}^h + \hat{w}_{t-3} + \hat{n}_{t-3}^h - \hat{\xi}_{t-2}^a\big)\Big] \end{aligned}$$

This last equation completes the implementation of equation 117.

B.2 The optimal policy

B.2.1 The Ramsey program

$$
\begin{aligned}
\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \quad & \lambda \xi_t^b \Big(\log(c_t^h - h\bar{c}_{t-1}^h) - \chi \frac{(n_t^h) n^{1+\phi}}{1+\phi} \Big) + (1-\lambda) \Big(\log(c_t^s - h\bar{c}_{t-1}^h) - \chi \frac{(n_t^s)^{1+\phi}}{1+\phi} \Big) \\
& + \lambda_t^1 \Big[-\frac{b_{t-1}}{\Pi_t} - g_t - T_t + \tau_t^n w_t N_t + \tau^k (r_t^k u_t k_{t-1} + d_t) + \tau^c c_t + q_t b_t \Big] \\
& + \lambda_t^2 \Big[-\frac{R_t}{R} + \Big(\frac{R_{t-1}}{R}\Big)^{\rho_r} \Big[\Big(\frac{\Pi_t}{\Pi}\Big)^{\phi_\pi} \Big(\frac{y_t}{y_t^p}\Big)^{\phi_y} \Big]^{1-\rho_r} \Big] \\
& + \lambda_t^3 \Big[-(1+\tau^c) c_t^h + (1-\tau_t^n) \theta_t^h w_t n_t^h + tr_t^h \Big] \\
& + \lambda_t^4 \Big[-\chi (n_t^h)^{\phi_h} (c_t^h - h c_{t-1}^{h,a}) + (1-\tau_t^n) \theta_t^h w_t \Big] \\
& + \lambda_t^5 \Big[-k_t + (1-\delta) k_{t-1} + \xi_t^i \Big[1 - S\Big(\frac{I_t}{I_{t-1}}\Big) \Big] I_t \Big] \\
& + \lambda_t^6 \Big[-\lambda_t + \xi_t^b \frac{u_c^s (c_t^s - h c_{t-1}^{s,a})}{1+\tau^c} \Big] \\
& + \lambda_t^7 \Big[-\lambda_t q_t + \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} \Big] \\
& + \lambda_t^8 \Big[1 - \xi_t^i \mu_t \Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big) - \frac{I_t^s}{I_{t-1}^s} S'\Big(\frac{I_t^s}{I_{t-1}^s}\Big) \Big] - \beta E_t \xi_{t+1}^i \mu_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \Big(\frac{I_{t+1}^s}{I_t^s}\Big)^2 S'\Big(\frac{I_{t+1}^s}{I_t^s}\Big) \Big] \\
& + \lambda_t^9 \Big[-\mu_t + \beta(1-\delta) E_t \mu_{t+1} \frac{\lambda_{t+1}}{\lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \Big[\Phi'(u_{t+1}) u_{t+1} - \Phi(u_{t+1}) \Big] \Big] \\
& + \lambda_t^{10} \Big[-\Phi'(u_t) + (1-\tau^k) r_t^k \Big] \\
& + \lambda_t^{11} \Big[-(w_t^*)^{1+\eta_w \phi_s} + \frac{\eta_w \chi}{\eta_w - 1} \frac{F_{1,t}^w}{F_{2,t}^w} \Big] \\
& + \lambda_t^{12} \Big[-F_{1,t}^w + \xi_t^b w_t^{\eta_w (1+\phi_s)} (n_t^s)^{1+\phi_s} + \beta \theta_w (\Pi_t^{\nu_w} \Pi^{1-\nu_w} e^{\gamma})^{-\eta_w (1+\phi_s)} E_t \Pi_{t+1}^{\eta_w (1+\phi_s)} F_{1,t+1}^w \Big] \\
& + \lambda_t^{13} \Big[-F_{2,t}^w + \lambda_t (1-\tau_t^n) w_t^{\eta_w} n_t^s + \beta \theta_w (\Pi_t^{\nu_w} \Pi^{1-\nu_w} e^{\gamma})^{1-\eta_w} E_t \Pi_{t+1}^{\eta_w - 1} F_{2,t+1}^w \Big] \\
& + \lambda_t^{14} \Big[-w_t^{1-\eta_w} + (1-\theta_w)(w_t^*)^{1-\eta_w} + \theta_w (\Pi_{t-1}^{\nu_w} \Pi^{1-\nu_w} e^{\gamma})^{1-\eta_w} \Pi_t^{\eta_w - 1} w_{t-1}^{1-\eta_w} \Big] \\
& + \lambda_t^{15} \Big[-v_t^w + (1-\theta_w) \Big(\frac{w_t^*}{w_t}\Big)^{-\eta_w (1+\phi_s} + \theta_w \Big(\Pi_{t-1}^{\nu_w} \Pi^{1-\nu_w} e^{\gamma} \Big)^{-\eta_w (1+\phi_s)} \Pi_t^{\eta_w (1+\phi_s)} \Big(\frac{w_t}{w_{t-1}}\Big)^{\eta_w (1+\phi_s)} v_{t-1}^w \Big] \\
& + \lambda_t^{16} \Big[-p_t^* + \frac{\eta_p}{\eta_p - 1} \frac{F_{1,t}^p}{F_{2,t}^p} \Big] \\
& + \lambda_t^{17} \Big[-F_{1,t}^p + mc_t y_t + \beta \theta_p \Pi^{-\eta_p \nu_p} \Pi^{-\eta_p (1-\nu_p)} E_t \Pi_{t+1}^{\eta_p} \frac{\lambda_{t+1}}{\lambda_t} F_{1,t+1}^p \Big] \\
& + \lambda_t^{18} \Big[-F_{2,t}^p + y_t + \beta \theta_p \Pi_t^{(1-\eta_p)\nu_p} \Pi^{(1-\eta_p)(1-\nu_p)} E_t \Pi_{t+1}^{\eta_p - 1} \frac{\lambda_{t+1}}{\lambda_t} F_{2,t+1}^p \Big] \\
& + \lambda_t^{19} \Big[-1 + (1-\theta_p)(p_t^*)^{1-\eta_p} + \theta_p \Pi_{t-1}^{\nu_p (1-\eta_p)} \Pi^{(1-\nu_p)(1-\eta_p)} \Pi_t^{\eta_p - 1} \Big] \\
& + \lambda_t^{20} \Big[-y_t v_t^p + (u_t k_{t-1})^{\alpha} (a_t N_t)^{1-\alpha} - \Omega a_t \Big] \\
& + \lambda_t^{21} \Big[-v_t^p + (1-\theta_p)(p_t^*)^{-\eta_p} + \theta_p \Pi_{t-1}^{-\eta_p \nu_p} \Pi^{-\eta_p (1-\nu_p)} \Pi_t^{\eta_p} v_{t-1}^p \Big] \\
& + \lambda_t^{22} \Big[-y_t + c_t + I_t + g_t + \Phi(u_t) k_{t-1} \Big] \\
& + \lambda_t^{23} \Big[-N_t + \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s \Big] \\
& + \lambda_t^{24} \Big[-c_t + \lambda c_t^h + (1-\lambda) c_t^s \Big] \\
& + \lambda_t^{25} \Big[-mc_t + \frac{1}{1-\alpha} \frac{w_t}{a_t} \Big(\frac{u_t k_{t-1}}{a_t n_t}\Big)^{-\alpha} \Big] \\
& [\ldots]
\end{aligned}
$$

$$
\begin{aligned}
&+\lambda_t^{26}\Big[-w/rk+\frac{(1-\alpha)}{\alpha}\frac{u_t k_{t-1}}{n_t a_t}\Big]\\
&+\lambda_t^{27}\Big[-R+1/q\Big]\\
&+\lambda_t^{28}\Big[-\lambda_t^{flex}+\frac{\xi_t^b}{(1+\tau^c)(c_t^{s,flex}-hc_{t-1}^{s,flex})}\Big]\\
&+\lambda_t^{29}\Big[-\lambda_t^{flex}+\beta r^{flex}\lambda_{t+1}^{flex}\Big]\\
&+\lambda_t^{30}\Big[-w^{flex}(1-\tau_t^n)+\frac{\xi_t^b\chi(n_t^{s,flex})^\phi}{\lambda_t^{flex}}\frac{\eta^w}{\eta^w-1}\Big]\\
&+\lambda_t^{31}\Big[-w_t^{flex}+\frac{(\eta^p-1)}{\eta^p}(1-\alpha)\big(\frac{u_t^{flex}k_{t-1}^{flex}}{n_t^{flex}}\big)^\alpha\Big]\\
&+\lambda_t^{32}\Big[-r_t^{k,flex}+\frac{(\eta^p-1)}{\eta^p}\alpha\big(\frac{u_t^{flex}k_{t-1}^{flex}}{n_t^{flex}}\big)^{(\alpha-1)}\Big]\\
&+\lambda_t^{33}\Big[-k_t^{flex}+(1-\delta)k_{t-1}^{flex}+\xi_t^i(1-S\big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\big)I_t^{flex}\Big]\\
&+\lambda_t^{34}\Big[-\lambda_t^{flex}\Bigg[1-\mu_t^{flex}\xi_t^i(1-S\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big)-\frac{I_t^{flex}}{I_{t-1}^{flex}}S'\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big)\Bigg]+\beta_t\xi_{t+1}^i\mu_{t+1}^{flex}\lambda_{t+1}^{flex}\Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big)^2S'\Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big)\Big]\\
&+\lambda_t^{35}\Big[-\mu_t^{flex}\lambda_t^{flex}+\beta_t(1-\delta)\mu_{t+1}^{flex}\lambda_{t+1}^{flex}+\beta_t\lambda_{t+1}^{flex}\Big(\Phi'(u_{t+1}^{flex})u_{t+1}^{flex}-\Phi(u_{t+1}^{flex})\Big)\Big]\\
&+\lambda_t^{36}\Big[-\Phi'(u_t^{flex})+(1-\tau^k)r_t^{k,flex}\Big]\\
&+\lambda_t^{37}\Big[-y_t^{flex}+(u_t^{flex}k_{t-1}^{flex})^\alpha n_t^{flex(1-\alpha)}-\Omega\Big]\\
&+\lambda_t^{38}\Big[-y_t^{flex}+c^{flex}+I_t^{flex}+g_t+\Phi(u_t^{flex})k_{t-1}^{flex}\Big]\\
&+\lambda_t^{39}\Big[-(1+\tau^c)c_t^{h,flex}+(1-\tau_t^n)\theta_t^h w_t^{flex}n_t^{h,flex}+tr_t^h\Big]\\
&+\lambda_t^{40}\Big[-\chi(n_t^{h,flex})^\phi(c_t^{h,flex}-hc_{t-1}^{h,flex})+(1-\tau_t^n)\theta_t^h w_t^{flex}\Big]\\
&+\lambda_t^{41}\Big[-n^{flex}+\lambda\theta_t^h n_t^{h,flex}+(1-\lambda)n_t^{s,flex}\Big]\\
&+\lambda_t^{42}\Big[-c_t^{flex}+\lambda c_t^{h,flex}+(1-\lambda)c_t^{s,flex}\Bigg\}
\end{aligned}
$$

C Data

In this section we provide precise definitions of the estimated series we use in the paper, both for aggregate-level and households-level data. Then, we dispense a detail account of the components of the US federal budget and its relation with the US business cycle, with a particular focus on the behaviour of transfers.

C.1 NIPA Data

The dataset we use to estimate our structural model contains series on consumption, investment, inflation, interest rates, hours worked, wages, government spending, transfers, labor tax revenues and the market value of government debt. All the data are for the U.S and are observed at a quarterly frequency for the period 1980Q1-2008Q4.

Unless stated otherwise, all data are computed based on National Income and Products Account (NIPA) collected by the Bureau of Economic Analysis. Real values are obtained using the GDP deflator, as reported by the BEA. The construction of fiscal data series follows Leeper et al. (2010, 2015).

The observed variable X is defined making the following transformation to variable x, for $x = (CONS, INV, HOURS, LTAX, TRANSF, GOV, MVDEBT)$:

$$X = \ln(\frac{x}{PopIndex}) * 100$$

where $Popindex$ is an index of Population, constructed so that 2009:3=1 using the "Pop Civilian noninstitutional population aged 16 years and over, seasonally adjusted" series from the US Bureau of Labor Statistics.

Consumption $(CONS_t)$**:** Consumption is computed as the sum of personal consumption expenditure on nondurable goods (Table 1.1.5 line 5) and on services (Table 1.1.5 line 6).

Investment (INV_t)**:** Investment is defined as the sum of personal consumption expenditure on durable goods (Table 1.1.5 line 4) and gross private domestic investment (Table 1.1.5 line 7).

Inflation $(INFL_t)$**:** The quarterly inflation rate is defined as the growth rate of the GDP deflator (Table 1.1.4 Line 1).

Nominal interest rate (FFR_t)**:** The quarterly nominal interest rate used for estimation is the Fed Funds rate, retrieved from the FRED database.

Hours worked $(HOURS_t)$**:** Data on hours worked are constructed based on statistics collected by The US Department of Labor. We compute total hours worked as follows. Let H be the average weekly hours duration in non-agricultural establishments (PRS85006023) and Emp the civilian employment (LNS12000000). Both are defined as indices with 2009:3 = 100. Hours worked are then defined as $N = \frac{N \times Emp}{100}$.

Wages $(WAGE_t)$**:** The wage rate is taken from the U.S Bureau of Labor Statistics, and is defined as the index for hourly compensation for non-farm business, all persons. We use a seasonally adjusted index with 2009 as base year.

Government spending (GOV_t)**:** Government spending is defined as the sum of consumption expenditure (Table 3.2 Line 25), gross government investment (Table 3.2 Line 45), net purchases of non-produced assets (Table 3.2 Line 47), minus consumption of fixed capital (Table 3.2 Line 48).

Transfers: Total transfers are usually defined as the sum of current transfer payments (Table 3.2 Line 26), subsidies (Table 3.2 Line 36), capital transfer payments (Table 3.2 Line 46), minus current transfer receipts(Table 3.2 Line 19) and capital transfer receipts (Table 3.2 Line 42).

Section 2 of the NIPA provides information on households' personal income (Table 2.1). Personal current transfer receipts (Table 2.1 Line 16) corresponds to total transfers received by all households. It is the sum of government social benefits to persons (Table 2.1 Line 17) and other current transfer receipts from business (net) (Table 2.1 Line 24) minus the domestic contributions for government social insurance (Table 2.1 Line 25). Government social benefits to persons is itself composed of: social security benefits[28] (Table 2.1 Line 18) Medicare[29] and Medicaid benefits (Table 2.1 Line 19 and 20, respectively), unemployment insurance (Table 2.1 Line 21), veterans' benefits[30] (Table 2.1 Line 22) and other benefits[31] (Table 2.1 Line 23).

In this model, we focus on transfers that insure households against transitory shocks to their earnings. Therefore we define **Transfers** $(TRANSF_t)$ as unemployment insurance + other benefits.

Labor tax revenues $(LTAX_t)$**:** First we compute the average personal income tax as follows:

$$\tau^p = \frac{IT}{W + PRI/2 + CI}$$

where IT is personal income tax revenues (Table 3.2 line 3), W is wage and salary accruals (Table 1.12 line 3 plus Table 3.3 line 4), PRI is proprietors' income (Table 1.12 line 9) and CI is capital income. This last is computed as rental income (Table 1.12 line 12), plus corporate profits (Table 1.12 line 13), plus interest income (Table 1.12 line 18) plus PRI/2. Here we follow the arbitrary decision of Jones (2002) and Leeper et al. (2015) of dividing proprietors' income into capital and labor income.

[28]Social security benefits include old-age, survivors, and disability insurance benefits that are distributed from the federal old-age and survivors insurance trust fund and the disability insurance trust fund.

[29]Medicare benefits include hospital and supplementary medical insurance benefits that are distributed from the federal hospital insurance trust fund and the supplementary medical insurance trust fund.

[30]Veterans' benefits include pension and disability benefits, mustering-out pay, terminal leave pay, and adjusted compensation benefits.

[31]Other benefits include the main income assistance programs such as Supplemental Nutrition Assistance Program, Black lung benefits, Supplemental security income, and Direct relief. They also include housing subsidies and some education and childcare assistance programs.

Then labor tax revenues are computed as:

$$LTAX = \tau^p(W + PRI/2) + CSI$$

And the average labor income tax rate is computed as:

$$\tau_l = \frac{\tau_p(W + PRI/2) + CSI}{EC + PRI/2}$$

where CSI stands for contribution for government social insurance (Table 3.2 line 11) and EC stands for compensation of employees (Table 1.12 line 2). It includes contributions to pension and social insurance, untaxed benefits and wages and salaries.

Capital tax revenues $(KTAX_t)$**:** Capital tax revenues are computed as:

$$KTAX = \tau^p CI + CT$$

Then, the average capital income tax is computed as:

$$\tau_k = \frac{\tau^p CI + CT}{CI + PT}$$

where CT is taxes on corporate income (Table 3.2 line 7) and PT is property taxes (Table 3.3 line 8).

Consumption tax revenues $(CTAX_t)$ Consumption tax revenues include excise taxes and custom duties (Table 3.2 lines 5 and 6).

And the consumption tax rates is computed as:

$$\tau_c = \frac{CTAX_t}{C - CTAX_t - CTAX_t^l}$$

where $CTAX_t^l$ is state and local sales taxes (Table 3.3 line 7).

Market-value of debt-to-GDP $(MVDEBT_t)$**:** The series for the market value of U.S government debt is taken from the Dallas Fed. We use series on the market value of marketable treasury debt. To construct quarterly series we use the stock of debt in the first month of each quarter.

C.2 CPS Data

We used the ASEC Supplement of the CPS, as reported by IPUMS, to construct Figures 1, 2 and 3.

The Current Population Survey (CPS) is a monthly U.S. household survey conducted jointly by the U.S. Census Bureau and the Bureau of Labor Statistics that is designed to develop official US government statistics on employment and unemployment. It is designed to be representative of the civilian non-institutional population. The CPS is administered monthly by the U.S. Census Bureau, it is designed as a rotating panel: households are interviewed for four consecutive months, are not in the sample for the next eight months, and then are interviewed for four more consecutive months. These surveys gather information on education, labor force status, demographics, and other aspects of the U.S. population. The monthly output is known as the "basic monthly survey" and these data are available from 1976 to present. Over time, supplemental inquiries on special topics have been added. We concentrate our attention on the Annual Social and Economic Supplement (ASEC) which collects data on work experience, several sources of income, migration, household composition, health insurance coverage, and receipt of non-cash benefits. We use the ASEC to study the evolution of households earnings.

Sample selection: Our sample includes all years from 1962 to 2020 (which reports figures for the years 1961-2019). For each year, we follow Heathcote et al. (2020) by selecting the sample of all men who are between the ages of 25 and 55. We also drop the following observations: men in the armed forces (as they do not report weeks worked before 1989), men with a 0 ASEC weight, men who report 0 weeks worked during the year but positive earnings, men for whom information on weeks or earnings is missing.

We define **total earnings last year** as the sum of total pre-tax wage and salary income (variable INCWAGE), net pre-income-tax non-farm business and/or professional practice income (variable INCBUS) and net pre-income-tax earnings as a tenant farmer, sharecropper, or operator of his or her own farm (variable INCFARM).

No information on wealth is available. Hence, we define hand-to-mouth agents as the 30% households with the lowest earned income.

We used the variable **weeks worked last year**. It is an intervalled variable (the non intervalled variable is only available starting in 1976) which we replaced by mid point intervals: 0, 6, 20, 33, 43, 48.5, 51.

All statistics reported in the paper and in this appendix are computed using the ASEC person weights.

As for aggregate variables, nominal values are deflated using GDP deflator.

C.3 CEX Data

In order to construct our data on consumption and income of hand-to-mouth agents, we make use of the Consumer Expenditure Survey (CEX).

The CEX consists of two separate surveys collected for the Bureau of Labor Statistics by the Census Bureau that provide detailed information about household consumption expenditures. The Diary Survey focuses only on expenditures on small, frequently purchased items (such as food, beverages, and personal care items). It operates as a product-oriented diary that last for two consecutive 1-week periods. The Interview Survey is a quarterly survey that aims at providing information on up to 95% of the typical household's consumption expenditures. In this paper we focus on the Interview survey. It is a rotating panel of households that are selected to be representative of the US population every quarter. Each household is interviewed for a maximum of four consecutive quarters. However, we treat each wave as cross sectional.

The interview quarter refers to the calendar quarter corresponding to the month in which the interview occurred. The survey provides data on the demographic characteristics for all household members, on the consumption expenditures of each household and on the total income, hours worked, and taxes paid by the household.

Sample selection: We dropped households if we have no information on age for either the head or spouse, and if the household is flagged as "incomplete income reporters". Since we are interested in the working age population we restricted the sample to households with at least one member aged between 25 and 60.

Imputation: Until 2004 the CEX did not use income imputation methods to compensate for non-responses. Since then, income imputation is used. For 2004 and 2005, it is not possible to select observations with non-imputed measures. Hence, for consistency, when possible, we use only observations with non-imputed measures.

Income Each household reports information on income, hours worked and taxes paid over the twelve-month period preceding the interview. Households' money income includes the sum of wages, salaries, business and farm income earned by each member plus household financial income (including interest, dividends and rents) plus private transfers (including private pensions, alimony and child support) plus public transfers (including social security, unemployment compensation, welfare and food stamps).

Consumption: Each household reports consumption for the three-month period preceding the interview. Henceforth, a household interviewed in June will report consumption for March, April and May. Although the reported consumption covers two quarters, the information is stored as a second quarter occurrence. In order to calculate our quarterly data on expenditure, we adapted the methodology proposed by the US Bureau of Labor Statistics to compute weighted calendar year estimates. For each quarter, we adjust the weights associated to each household for the months in scope. In the above example, what matters for the second quarter is the consumption reported for April and May. Hence, only the part in scope is used for the representative population weights.

We focus on non-durable consumption expenditure, which includes food and beverages (including food away from home and alcoholic beverages), tobacco, apparel and services, personal care, gasoline, public transportation, household operation, medical care, entertainment, reading material and education. As for the CPS, no information on wealth is available. Hence, we compute the **consumption share of hand-to-mouth households** ($CONS_t^{30}$) as the consumption of the 30% households with the lowest earned income (wages and salaries plus two third of business and farm income) over total consumption.

Transfers The CEX provides information about the following categories of private and public transfers received by the households:

1. **SSI**: Supplemental Security Income.
2. **WLF**: Amount received from public assistance or welfare including money received from job training grants such as Job Corps.
3. **UNEMP**: Amount received from unemployment compensation.
4. **FDSTMP**: Annual value of food stamps.
5. **OTHR**: Amount of income received from any other source such as Veteran's Administration (VA) payments, unemployment compensation, child support, or alimony.

These categories cover the amounts perceived in past 12 months. In the paper, we restrict our attention on transfers that are particularly fluctuating over the business cycle. Hence we define transfers as the sum of UNEMP and FDSTMP. Other income also fluctuates a lot over the business-cycle. However, as it gathers both public and personal income assistance, we did not include them in our restricted definition of transfers.

As for aggregate variables, real values are obtained using the GDP deflator.

C.4 Additional statistics on transfers, earnings, and consumption inequality

In this section, we first use aggregate data to draw some well-known facts on trends and cyclical behaviour affecting transfers and their components. Then, using CEX data, we provide some insights on the role of transfers in reducing and smoothing inequalities across the business cycle in the US.

Federal government expenditures have continuously increased over the last decades and their share of US GDP in 2017 was almost double of what it was in 1947. At the same time we saw a compositional shift in expenditures, from government spending towards transfers. While government spending accounted for 68% of total expenditure in 1947, they accounted for 23% of the total expenditure in 2017. Transfers accounted for 34% of total expenditure in 1947 but 64% in 2017.[32] Among all transfers, social benefits to persons are the largest federal expenditures, they account for 70% to 80% of total transfers.

Generally, social benefits are designed to ensure that the basic needs of the American population are met. As such, it is the main tool for the government to reduce poverty. It is also its main instruments to ensure the population against temporary losses of income. Consequently, as it is shown in Table 8, the total amount of social benefits is affected by the business cycle and transfers have a counter-cyclical profile. However, not all transfers are subject to the same fluctuations. Indeed, unemployment insurance benefits and other income assistance programs explain more than 60% of the variance of total social benefits to person over the period 1960Q1-2007Q4[33].

[32] We do not account for subsidies and capital transfers. Total expenditure is equal to government spending, gross government investment, transfers (with subsidies and capital transfers) less consumption of fixed capital. In 1947, consumption of fixed capital was large. Hence consumption and transfers account for more than total expenditure.

[33] All social benefits are measured as log of real values in per capita terms, and are de-trended with a HP filter.

Table 8: **Corr. matrix of social benefits with GDP in the US**

	GDP	SSI	Health Ins.	Unemp. Ins.	Veterans	Others
GDP	1	-	-	-	-	-
SSI	-0.26	1	-	-	-	-
Health Ins.	-0.24	0.21	1	-	-	-
Unemp. Ins.	-0.75	0.33	0.37	1	-	-
Veterans	-0.26	0.14	0.09	0.27	1	-
Others	-0.09	0.06	0.23	0.22	0.05	1

Using CEX data, we study the US cross-sectional inequality and the role played by transfers over the business cycle. Although income variables in the CEX are reported on a quarterly frequency, they account for the amount perceived (or paid) over the 12 preceding months. Hence, the survey does not allow us to study the dynamics of earnings and income inequality in details. However, it is sufficient to get a broad overview.

In the following paragraphs, we first study the dynamics of the earning distribution between two main groups: the first group contains households at the bottom 30% of the *earned* income distribution (wages and salaries plus two third of business and farm income), the other group contains the remaining 70% of households. Then we study how transfers are distributed among these two groups and how the business cycle affects this distribution.

Earnings of hand-to-mouth households appear to be slightly more pro-cyclical than the earnings of Riccardian households. Indeed, as shown in Table 9 the correlation between *hand to mouth* households' earned income and GDP amounts to 0.34, while it amounts to 0.13 for Ricardian households. Moreover, the volatility of the (log-)earnings of hand-to-mouth households appears to be four times higher than the one associated with the earnings of Riccardian households.

Table 9: **Correlation between Earnings and GDP**

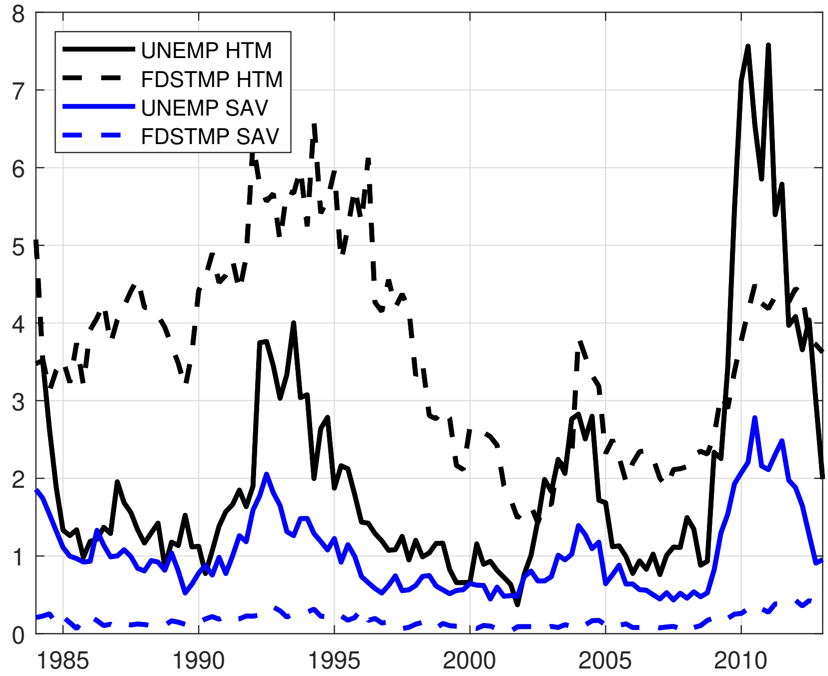
x	Corr(x,GDP)	Std(x)
Earned Income HTM	0.34	0.05
Earned Income Savers	0.13	0.01

Notes: The table displays the correlation between the cyclical components of households log-earnings and GDP for hand-to-mouth and Riccardian households. The table also displays the standard deviation of households earnings for both groups. Data on GDP are from the NIPA database. Data on Earned Income come from the CEX. Since income data are accounted as the amount perceived over the twelve-month period preceding the interview in the CEX, GDP is computed as a moving average over 4 consecutive quarters. All variables are logged, and de-trended with the HP-Filter.

Another indication of the larger volatility of the earnings of hand-to-mouth households with respect to Ricardian households would have been the volatility of their respective unemployment rate. Unfortunately, we cannot derive directly these indicators from the CEX data. Instead, we can compute the share of households receiving unemployment and food stamps among hand-to-mouth households and among Ricardian households. This is done in Figure 23. It shows that, following a recession, the *share* of low income households receiving unemployment benefits increases generally more than the share of high income households receiving unemployment benefits. Figure 23 displays the share of low income households receiving unemployment and food stamps.

After the Great Recession, the share increased from approximately 1% up to 7% , while for high income households, it raised from 1% to 3% only. This observations is an additional evidence of the results highlighted by Heathcote et al. (2010b) and in Section 2 of this paper: households earnings at lower percentiles of the income distribution decline very rapidly in recessions and these declines are mostly explained by large fluctuations in the labor supply. [34]

FIGURE 23: **Share of Households receiving Unemployment Benefits and Food Stamps**



Notes: The figure plots the share of hand-to-mouth households receiving unemployment benefits (solid black line) and food stamps (dashed black line), as well as the share of Riccardian households receiving unemployment benefits (solid blue line) and food stamps (dashed blue line). Data is from the CEX database.

Turning to the study of the distribution of transfers among the different groups of households, we show in Table 10 that transfers are mainly directed toward low income households. Indeed, over the period 1984Q1 - 2013Q1, these households received a larger share of total transfers, going from 44% of overall employment benefits to 92% of the total amount of the benefits linked to public assistance and other welfare programs. Hence, by raising disposable income for households with low earned income, transfers reduce inequality.

TABLE 10: **Average share of transfers perceived by HtM households by category - CEX**

SSI	WLF	UNEMP	FDSTP	OTHR	ALL TSF
84.1%	91.9%	43.6%	90.2%	58.2%	67.9%

Finally, Table 11 confirms that transfers are mostly counter-cyclical and that unemployment benefits are the main instruments to ensure households against temporary losses of income. Food

[34] If the unemployment rate fluctuates more among hand-to-mouth households than among Ricardian households, it does not mean that the total amount of the benefits that directed towards hand-to-mouth households fluctuates more than the total amount of the benefits that directed towards Ricardian households. Indeed, because the average amount of unemployment benefits received per hand-to-mouth household is smaller than the average amount receive per Ricardian household, the *share of the total amount of benefits* that is directed toward hand-to-mouth households remains relatively constant over the business cycle.

stamps and other assistance programs are also negatively correlated with GDP[35] but the correlation is not significant.

Table 11: **Corr. matrix of transfers in the US - CEX, All Households**

	GDP	SSI	WLF	UNEMP	FDSTP	OTHR
GDP	1.00	-	-	-	-	-
SSI	-0.19	1.00	-	-	-	-
WLF	0.13	-0.02	1.00	-	-	-
UNEMP	-0.54	0.12	0.34	1.00	-	-
FDSTP	-0.21	0.02	0.64	0.62	1.00	-
OTHR	-0.21	0.08	0.23	0.65	0.46	1.00

D Robustness check

In this section, we provides the estimated and simulated under the alternative calibration that the share of hand-to-mouth households in the economy is equal to 20% (i.e. $\lambda = .2$).

[35]Data are log of real values (2012$) in per capita terms and de-trended with a HP filter. Since transfers are accounted as the amount perceived over the twelve-month period preceding the interview, GDP is computed as a moving average over 4 consecutive quarters.

TABLE 12: **Estimated parameters - $\lambda = .2$**

Parameter		**Posterior TANK**		**Posterior TANK***		**Prior**		
		mean	90 % interval	mean	90 % interval	distrib	par A	par B
100γ	description	0.479	[0.408 ; 0.55]	0.492	[0.422 ; 0.563]	G	0.5	0.05
$100(\beta^{-1}-1)$	description	0.267	[0.144 ; 0.378]	0.177	[0.086 ; 0.265]	G	0.25	0.1
$100\log\pi$	description	0.531	[0.453 ; 0.608]	0.517	[0.442 ; 0.59]	G	0.5	0.05
ϕ	inv. Frish elasticity	2.534	[1.862 ; 3.172]	2.825	[2.164 ; 3.489]	N	1.5	0.5
h	habit formation	0.817	[0.755 ; 0.876]	0.621	[0.552 ; 0.696]	B	0.5	0.1
Production								
ϕ_u	utilization cost	2.616	[1.775 ; 3.433]	3.364	[2.414 ; 4.287]	G	2	0.5
κ	adjustment cost	4.895	[3.633 ; 6.075]	3.935	[2.735 ; 5.037]	G	4	0.75
Nominal Rigidities								
θ_w	wage rigidity	0.769	[0.698 ; 0.841]	0.395	[0.246 ; 0.638]	B	0.5	0.1
θ_p	price rigidity	0.909	[0.872 ; 0.947]	0.856	[0.818 ; 0.898]	B	0.5	0.1
Monetary Policy								
ρ_r	interest rate smoothing	0.823	[0.784 ; 0.862]	0.769	[0.719 ; 0.817]	B	0.8	0.1
ϕ_π	response to inflation	1.784	[1.622 ; 1.947]	1.926	[1.763 ; 2.105]	G	1.75	0.1
ϕ_y	response to output	0.076	[0.036 ; 0.116]	0.038	[0.013 ; 0.063]	G	0.12	0.05
Labor tax rule								
ρ_τ	lab tax rate smoothing	0.764	[0.642 ; 0.895]	0.736	[0.615 ; 0.854]	B	0.5	0.2
$\phi_{\tau,b}$	response to debt	0.131	[0.079 ; 0.182]	0.132	[0.083 ; 0.182]	G	0.15	0.05
$\phi_{\tau,y}$	response to output	0.748	[0.375 ; 1.131]	0.581	[0.313 ; 0.866]	N	0	0.5
Transfer rule								
ρ_T	tsf smoothing	0.959	[0.931 ; 0.988]	0.959	[0.931 ; 0.988]	B	0.5	0.2
$\phi_{T,y}$	response to output	-0.47	[-0.727 ; -0.228]	-0.473	[-0.716 ; -0.232]	N	-0.5	0.15
HtM productivity rule								
ρ_θ	HtM prod. smoothing	0.41	[0.068 ; 0.679]	0.955	[0.923 ; 0.99]	B	0.5	0.2
$\phi_{\theta,y}$	response to output	0.487	[-0.209 ; 1.171]	1.085	[0.245 ; 1.864]	N	0.5	0.15

To be continued

Parameter		Posterior TANK		Posterior TANK*		Prior		
		mean	90 % interval	mean	90 % interval	distrib	par A	par B
Shocks, AR								
ρ_g	gov.spending	0.978	[0.963 ; 0.994]	0.975	[0.958 ; 0.993]	B	0.5	0.2
ρ_w	wage mark-up, sav	0.379	[0.18 ; 0.571]	0.858	[0.583 ; 0.984]	B	0.5	0.2
ρ_p	price mark-up	0.769	[0.633 ; 0.91]	0.933	[0.881 ; 0.988]	B	0.5	0.2
ρ_a	technology	0.205	[0.063 ; 0.332]	0.379	[0.24 ; 0.512]	B	0.5	0.2
ρ_i	investment	0.814	[0.727 ; 0.907]	0.762	[0.658 ; 0.868]	B	0.5	0.2
ρ_b	preference, sav.	0.801	[0.72 ; 0.881]	0.87	[0.816 ; 0.929]	B	0.5	0.2
ρ_m	monetary policy	0.452	[0.335 ; 0.569]	0.448	[0.337 ; 0.561]	B	0.5	0.2
ρ_{gbc}	gov. budget const.	0.157	[0.041 ; 0.267]	0.139	[0.034 ; 0.242]	B	0.5	0.2
$\rho_{c_{30}}$	relative cons.			0.889	[0.815 ; 0.963]	B	0.5	0.2
$\rho_{inc^{Ric}}$	relative inc.			0.524	[0.229 ; 0.8]	B	0.5	0.2
Shocks, Std								
σ_g	gov. spending	2.377	[2.096 ; 2.658]	2.605	[2.291 ; 2.949]	IG	0.1	2
σ_w	wage mark-up, sav	0.279	[0.21 ; 0.344]	0.269	[0.196 ; 0.341]	IG	0.1	2
σ_p	price mark-up	0.058	[0.039 ; 0.077]	0.063	[0.041 ; 0.082]	IG	0.1	2
σ_a	technology	1.041	[0.871 ; 1.223]	1.339	[1.056 ; 1.607]	IG	0.1	2
σ_i	investment	3.549	[2.508 ; 4.511]	3.255	[2.248 ; 4.251]	IG	0.1	2
σ_b	preference, sav.	3.609	[2.607 ; 4.573]	2.028	[1.541 ; 2.517]	IG	0.1	2
σ_m	monetary policy	0.12	[0.103 ; 0.135]	0.126	[0.108 ; 0.144]	IG	0.1	2
σ_τ	lab tax rate	1.947	[1.706 ; 2.187]	1.887	[1.655 ; 2.105]	IG	0.1	2
σ_T	tsf cyclical comp.	1.438	[1.271 ; 1.603]	1.45	[1.27 ; 1.624]	IG	0.1	2
σ_θ	relative productivity	0.539	[0.133 ; 1.054]	5.27	[4.608 ; 5.905]	IG	0.1	2
Measurement errors								
σ_{rc}	output	0.275	[0.242 ; 0.307]	0.281	[0.247 ; 0.313]	IG	0.1	2
σ_{gbc}	gov. budget const.	4.277	[3.734 ; 4.782]	4.239	[3.688 ; 4.744]	IG	0.1	2
$\sigma_{c_{30}}$	relative cons.			5.854	[4.21 ; 7.431]	IG	0.1	2
$\sigma_{inc^{Ric}}$	relative cons.			2.213	[1.547 ; 2.822]	IG	0.1	2

Notes: TANK [TANK*] denote posterior estimates for the model [with households heterogeneity data].

Table 13: **Simulated Moments -** $\lambda = .2$

Moments	Estim. w/o cross-sect. data		Estim. w cross-sect. data	
	HtM=.2	**HtM=.3**	**HtM=.2**	**HtM=.3**
corr(def,y)	-0.16	-0.28	-0.42	-0.63
corr(def,tr)	0.35	0.49	0.73	0.82
corr(tr,y)	0.07	-0.08	-0.21	-0.53

Notes: The table provides the simulated fiscal moments of interest – namely, the correlation between deficits and output, between deficits and transfers and between transfers and output – for our two sets of parameters in the model with fiscal rules.

Table 14: **Ramsey steady-state -** $\lambda = .2$

	Data	**Ramsey w/o cross-sect. data**		**Ramsey w cross-sect. data**	
		HtM=.2	**HtM=.3**	**HtM=.2**	**HtM=.3**
Labor tax rate	0.21	0.41	0.37	0.31	0.34
Transfers-to-GDP	0.03	0.17	0.15	0.11	0.12
Consumption heterogeneity	0.63	0.84	0.78	0.71	0.75

Notes: The table provides the steady state values of the labor tax rate, of the transfers-to-GDP ratio and the level of consumption heterogeneity, measured as the ratio of hand-to-mouth households consumption over aggregate consumption, for the model of optimal fiscal policy, when evaluated with the parameters with (column 2) and without (column 3) data on earnings and consumption inequality. The table also provides the values observed in the data in the first column.

Table 15: **Ramsey simulated moments -** $\lambda = .2$

	Data	**Ramsey w/o cross-sect. data**		**Ramsey w cross-sect. data**	
		HtM=.2	**HtM=.3**	**HtM=.2**	**HtM=.3**
Corr(T,Y)	-0.45	-0.40	-0.29	-0.39	-0.53
Corr(def,T)	0.68	-0.92	-0.09	0.11	0.22
Corr(def,Y)	-0.79	0.24	-0.24	-0.21	-0.53

Notes: The table provides the simulated fiscal moments of interest – namely, the correlation between deficits and output, between deficits and transfers and between transfers and output – for our two sets of parameters in the optimal fiscal policy model.

INSTITUT DE RECHERCHE
ÉCONOMIQUES ET SOCIALES

Place Montesquieu 3

1348 Louvain-la-Neuve

ISSN 1379-244X D/2022/3082/09

IRES | Louvain Institute of Data Analysis and Modeling in economics and statistics