# Essays on Macroeconomic Theory
# Optimal Fiscal Policy and History of Macroeconomics

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**Composition du Jury:**

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|---|---|
| Rigas Oikonomou | (*UCLouvain*, Promoteur) |
| Vincent Bodart | (*UCLouvain*) |
| Jochen Mankart | (*Deutsche Bundesbank*) |
| Goulven Rubin | (*Université Paris 1 Panthéon-Sorbonne*) |
| Gonzague Vannoorenberghe | (*UCLouvain*) |

**Président du Jury:**

Gonzague Vannoorenberghe (*UCLouvain*)

*Marshall took the world as it is;*
*he sought to construct an "engine" to analyze it,*
*not a photographic reproduction of it.*

[Friedman 1959: 167]

# Acknowledgements

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# Chapter 1

# General Introduction

> *We are indeed living historic moments. The kind of occasion where the crisis calls in to question all certainties and minds are more open to change. These are very special moments and they are not happening everyday. We have to understand that it's really one of those moments where there is some higher plasticity and then where we can make a real change.*

[José Manuel Barroso, 21st of Octobre 2008, European Parliament]

In his address, the President of the European Commission, José Manuel Barroso, recognized in the 2008 Global Financial Crisis a moment of great uncertainties, but also of great opportunities. Everything had to be questioned, and in particular the organisation of our societies. Actually, his speech was an invitation for the European parliament and European leaders to dare making the changes the Commission was praying for. From a more personal point of view, it was also an invitation to start a reflection on the kind of macroeconomic policies that must be implemented. This summarizes the spirit in which I started my training in economics.

Since then, we got to know many of these historic moments. The last decade has been characterized by a succession of crises. The Global Financial Crisis and the ensuing Great Recession hit the global economy over the period 2008-2010. In Europe, the Sovereign Debt crisis directly followed. And, whereas the European economy was still slowly recovering from these tumultuous periods, the Covid-19 pandemic crisis hit in 2020. Obviously, these developments have shaped my research interest, giving it a greater focus on debt sustainability and economic inequality.

In particular, two important yet simple considerations have motivated this dissertation.

First, households differ in many dimensions which influence their respective exposure to major disturbances. For instance, and not exclusively, households differ in terms of skills, employment status, income and wealth. More often than not, these characteristics are correlated. While low skilled workers earn lower wages, they are also the more exposed to greater unemployment risks during recession periods. Moreover, as they have lower income, these households usually have more difficulties to accumulate enough wealth to self-insure against temporary income losses.

Second, the government pursues two (potentially) conflicting goals. On one side, the government aims at stabilizing the economy in the most efficient way. In face of large negative macroeconomic shocks, government deficits worsen such that macroeconomic fluctuations are smoothed across the business cycle. In turn, the fiscal authority needs to generate additional surpluses to finance the increase in the stock of debt and, therefore, guarantee the solvency of government budgets. Some fiscal adjustments must take place. However, when the fiscal authority has little margin to adjust government spending, the financing of the deficit requires to increase sufficiently taxes. And, as the buoying discussions on debt sustainability testify, this is costly. In other words, the first goal of the government is to minimize the fiscal cost of the smoothing of aggregate output. On the other side, the government aims at providing some degree of social insurance throughout its fiscal policy. Along the business cycles, the government uses transfers, such as unemployment benefits and other income assistance programs, to redistribute wealth across households. This way, transfers mitigate the heterogeneous impact of aggregate shocks but worsen the government needs to increase taxes.

Until recently, macroeconomic theory was barely studying at once (i) the implications of the presence of household heterogeneity for the transmission of aggregate shocks and (ii) their impacts on the financing of government debt. Indeed, the literature on optimal fiscal policy relied heavily on the so called representative agent framework. In this thesis, I investigate in the first two chapters the properties of optimal taxes and transfers in a framework where household heterogeneity is accounted for. I contribute to the literature by providing new insights on the role of income inequality, and its dynamics, for the optimal design of the fiscal policy.[1] In the third and last chapter of the thesis, I take a step back and reflect on the macroeconomic theory used in the first two chapters.

In the DSGE literature, models often represent an economy inhabited by an infinitively-lived representative household. This assumption is obviously unrealistic but one might

[1]Note that the approach to optimal fiscal policy taken in this thesis is in direct line with Lucas and Stokey (1989), Chari and Kehoe (1999), etc. The Ramsey planner chooses (distortionary) taxes and transfers as to maximize aggregate welfare of the agents of the economy, therefore taking an utilitarian perspective. An interesting avenue to optimal fiscal policy would be to compare the recommended policies under alternative welfare criterion.

need simplifying assumptions to study aggregate fluctuations and their interactions with macroeconomic policies in a compact and tractable manner. Simplifications of this sort are of few importance if they do not abide on the way policies are to be conducted. Of course, the representative household assumption might not be innocuous as it rules out the presence of borrowers and savers. In presence of financial frictions, household heterogeneity, in particular income and wealth inequality, might have non-trivial implications for economic fluctuations and, therefore, for the design of monetary and fiscal policies.

Three elements are key when integrating heterogeneous agent. First, households must have different income paths. Usually, the literature introduces idiosyncratic shocks to households' labor productivity. Second, households cannot perfectly insure themselves against these shocks. In other words, there are exogenous borrowing constraints. Third, these lasts are binding for a fraction of households, making their consumption responds strongly to fluctuations in their current income. Therefore, households, that are similar otherwise (since they hold similar preferences), appear to have different marginal propensities to consume (MPC) at any point in time. Households with low income and wealth tend to have relatively high MPC. Consequently, aggregate fluctuations, resulting from aggregate or policy shocks, will depend on how the distribution of income and wealth across households will be affected.

In this thesis, I integrate some of these three features to investigate the properties of optimal fiscal policy models when heterogeneity between households is accounted for. This is done 'à minima'. Indeed, my models are constituted of only two types of agents, a 'saver' and a 'hand-to-mouth agent' (a household that neither borrow nor save) and I assume that the share of financially constrained households is constant. Therefore, the credit-constrained agents always have a MPC equal to one, while, in models accounting for more heterogeneity, households have usually a MPC below one, especially when facing a positive shock, to constitute what we call 'precautionary savings'.[2] Bearing in mind these considerations, I studied the design of optimal fiscal policies in two steps, which correspond to the first two chapters of this thesis.

Chapter 1, co-authored with Boris Chafwehé, explores how the introduction of household heterogeneity alters the prescriptions of the standard optimal fiscal policy framework that only accounts for a representative agent. We focus in particular on the optimal volatility of labor taxes and transfers. Traditionally, the literature has found that the government acting as a benevolent planer (i.e. that maximizes aggregate welfare) chooses to finance

[2]In other words, I ignore the impact of agents' current decisions on their likelihood of being financially constrained in the future.
I made these hypotheses for two reasons. In the first chapter, these assumptions allow me to keep on with analytical solution when studying the cyclical properties of the optimal fiscal policy. In the second, these assumptions eased the estimation of the model as I did not need to keep track of changes in the wealth distribution.

deficits and debt throughout negative and highly fluctuating transfers while keeping the labor tax rate constant and as close as possible to 0. Instead, we show that the presence of heterogeneity between households induces the government to use taxation and the transfer system as a redistributing device that partially reduces income inequality. Then, we show that the behavior of taxes and transfers over the business cycle depends (i) on the way transfer receipts are distributed among households, (ii) on the type of shocks hitting the economy, and (iii) on the structure of the government bond market. We also prove that financial market incompleteness is the main force driving the fluctuations of the optimal taxes and transfers.

Chapter 2 builds on the *qualitative* results provided in the first chapter to assess whether the presence of income inequality matters *quantitatively* for the design of the optimal fiscal policy. To this end, I construct a two agent New-Keynesian (TANK) model that enlarges the set of shocks and frictions in Smets and Wouters (2007). In particular, I allow for households specific income shocks and I introduce a larger fiscal bloc that includes distortionary taxes and transfers. This way, I construct a model that is able to reproduce the main moments that are characterizing the US economy. When estimating the model, I find that adding data on income and consumption inequality has limited influence on the parameters of the model. It identifies, however, that shocks to the income income of constrained households have significantly contributed to the business fluctuations affecting the US economy. Turning to the normative analysis, I show that the variations in households earnings are key for optimal fiscal variables, including transfers, to reproduce the behavior of their counterparts in the US data.

There is an evident closeness between chapter 1 and chapter 2, yet they look at different things. Chapter 1 builds on a simple RBC model.It aims at studying, in few alternative theoretical settings, the cyclical properties of the optimal tax schedule. Therefore, we are able to characterize two main components affecting labor tax rate fluctuations – household heterogeneity and financial market incompleteness – and to discuss in details the trade-offs faced by the government. This first chapter develops what I identify as a theoretical model. It is quite simple and aims at discussing the core mechanisms that are underpinning the decision of the Ramsey planner when choosing the optimal fiscal policy. The model does not aim at reproducing the economy but rather at exploring the implications of some well chosen assumptions.

In contrast, Chapter 2 builds up a much larger model which is directly confronted to the data. This difference in terms of modelization explains the different focus of the two chapters. While the first chapter focuses on two specific mechanisms, the second chapter blends many more ingredients and possible mechanisms affecting the design of the overall fiscal policy. This renders the model more realistic and provides an accurate measure of the (actual and optimal) fluctuations of the labor tax rate and transfers in response to aggregate and idiosyncratic shocks that are effectively affecting the US economy. However, the complexity of the model also leaves the observer myopic on the actual trade-offs faced by the government.[3] In this sense, while the first chapter addresses a qualitative question – i.e. what are the trade-off faced by the government when setting its fiscal policy? – the second chapters aims at answering a quantitative question – i.e. are fluctuations in households income inequality (observed in the US) quantitatively relevant for the optimal design of the fiscal policy?.

Together, the findings of these first two chapters suggest that household heterogeneity matters and and points out that future research on optimal fiscal policy should take the dynamics of income inequality into account. Further research should include assessing whether the source of earnings inequality matters for the conduct of optimal fiscal policy. As such, including stronger micro-foundations for earnings dynamics (as for example by introducing search and matching in the labor market) and introducing a larger set of assets (which price fluctuations would lead to additional income dynamics) is of first order-importance.

The last chapter of this thesis distinguishes itself from the previous two. It does not address the questions of household heterogeneity or even of fiscal policy. It is rather the result of a reflection on the kind of models used in the first chapters, and in macroeconomics in general.

During the time I spent working on the first two chapters of the thesis I often had the feeling that many of the things I was doing resulted from choices I was not entirely making on my own. While constructing my models, I simply reproduced the choices the literature had judged to be the most relevant. But to me, taking a step back and thinking on the requirements to provide 'good' macroeconomic theory was at least as important as studying the optimal design of the fiscal policy. This is what I undertook while working on the last chapter of the thesis.

When I started the PhD, I was aware (as most economists are) of the role played by Lucas and his Critique in the matter. I knew that he had set new standards in the way to do macroeconomics: it ought to be microfounded, concerned with general equilibrium analysis and set into mathematical modelling. I also knew that Lucas wanted macroeconomic theory to be concerned with policy conclusions, to answer practical questions and to be quantitatively assessed.

Over my training in economics, I followed many courses that prepared me to catch up with these standards. The vast majority of them were concerned either with the topical issues

[3] Of course, chapter 2 cannot proceed without discussing the mechanisms at work. However, this theoretical discussion is rather short and based on the existing literature (which includes the first chapter of the thesis).

addressed by economists or with the techniques used in economics. I followed courses on business fluctuations, unemployment, inflation, trade, monetary and fiscal policies. I attended courses in mathematics, statistics and other quantitative methods used in economics. A new vocabulary entered my daily talks: equilibrium, steady state and saddle path; joint, marginal and conditional distributions; deterministic or stochastic dynamic optimization; discrete and continuous time; global and local approximation; bellman equation; value function iteration...

The technical training was intense and very challenging. It was necessary for my research to abide to the standards of top-of-the-art macroeconomic theory. But at some point, I felt the need to go beyond technicalities. I needed to return to the origin of the kind of modeling I was pursuing. I needed a deeper understanding of the conceptual and methodological choices that are underpinning macroeconomic theory. Only then, I though, I would better appreciate the implications of the theory developed and I would be able to use its policy conclusions in a right way.

Unfortunately, as only few courses of the master in economics were actually discussing the questions raised by the Lucas' Critique,[4] I did not have many occasions to reflect on of these choices. Hence, I was eager to devote some time during my PhD to develop a broader understanding of the models used to study macroeconomic policy. It is with this spirit that I followed the *Advanced course in History of Macroeconomics* given by Michel De Vroey. With Michel and other PhD students, we ended up discussing the differences between the IS-LM model as it is taught nowadays in undergraduate macroeconomics courses and the IS-LM model as it was first developed. This gave the impetus for a research project which aim is to understand the theoretical and methodological roots of the teaching of macroeconomics. The third chapter of this thesis, co-authored with Michel De Vroey and Riccardo Turati, is the first paper that resulted from this reflection. It stems that the teaching of macroeconomics at the undergraduate level is different than at the graduate level.

To convey our claim, we start by providing an up-to-date description of the diffusion and usage of macroeconomics textbooks. To that matter, we rely on two sources of information: the world's largest network of library content and services, the WorldCat database, and a survey of the textbooks used for teaching in leading universities across the world. Then, we analyze the theoretical core of each textbook. We do so by constructing a taxonomy allowing a comparison between two baseline models: the IS-LM/AS-AD model, an heir of Keynesian macroeconomics, and the RBC model, which further developments led to dynamic general equilibrium (DSGE) modeling strategies. We identify four basic methodological nodes: (a) the specific equilibrium concept adopted in the two baseline

[4] There is one elective course in the Master program in Economics in UCLouvain that is covering this issue: History of Economic Though. For some reasons, I did not follow it.

models (static/state of rest equilibrium or dynamic equilibrium à la Arrow-Debreu); (b) whether they assume 'implicit' (i.e., like Marshall) or 'explicit' (i.e., like Walras) micro-foundations; (c) whether they comprise a labor market; and (d) whether they assume adaptive or rational expectations. This analysis led us to the conclusion that there is a deep methodological discrepancy between the theories taught in undergraduate and graduate macroeconomics courses. On the one hand, the theoretical core of undergraduate textbooks is the IS-LM/AS-AD model, on the other hand, graduate textbooks are based on dynamic general equilibrium macroeconomics.

Two remarks are called for regarding the last chapter of the thesis. First, this chapter presents a succinct but deep synthesis of a large theoretical and methodological background which is necessary to construct the benchmarks against which we evaluate the content of the textbooks. Actually, we are currently setting up additional pieces that would provide a more exhaustive and detailed description of the methodological divide sketched in this third chapter. This said, the text intends to be self contained and should fit well to economists who, like us, want to acquire a broader perspective on the teaching of macroeconomics.[5] Second, towards the end of the chapter, we also provide some perspectives and our own views on what could explain the difference in the teaching of macroeconomics at the undergraduate and graduate levels. In particular, we ponder that one key element is the priority given to external validity over internal consistency at the undergraduate level. Despite its theoretical flaws, the IS-LM/AS-AD model has proved itself to be very intuitive and empirically relevant, making it a powerful instrument for introductory courses and for policy advice.

Finally, before closing this introduction and letting the reader navigate throughout this thesis, I want to get back to the question of the relationship between the chapters of the thesis.

At first sight, this last chapter might be seen as disconnected from the first two. The questions addressed are unrelated. The methods used are different. Yet, I believe that the third chapter adds a great value to the other two.

Recently, I was discussing the content of this thesis with a friend who is not familiar with the way macroeconomists do research. I presented him the main assumptions of the model in chapter 2, explaining him that I was summarizing the US economy. Of course, he was troubled. How could a two-agent type economy with households holding perfect foresight and rational expectations be a 'correct' representation of the world we live in? To his questioning, I answered as I always do: I made those assumptions for "tractability" reasons. I received a puzzled gaze again.[6] I explained. Unfortunately,

[5]For inquiring minds, we also provide, in an addendum at the end of chapter 3, an overview of the larger project on textbooks.

[6]Actually, you also might have winced upon this word in the text above.

economists do not always make modeling choices because they believe these are key to imitate the world or even needed to produce useful policy recommendations. They often make these assumptions because otherwise they cannot manipulate, estimate or even use their models. No economist thinks that the two-agent structure is a characteristic of actual economies. Neither does postulating linearity or normality reflects the way they see the world. These choices are simply made for convenience, for economists to be able to reach solutions, to simplify their work. Unfortunately, I said, there is always a trade-off between tractability and realism in economics.

My friend diligently accepted the explanation. But then came the next questions: how do you know that you are not simplifying too much? What are the necessary assumptions? And what can you do with such a model? To the first two questions, I simply answered that I was following the "standards". This time, I could see an unsatisfied look in his eyes. I suddenly realised that this answer might sound empty. It indirectly implies that I am undertaking these modeling choices without specific attention, because they are spread around, some would even say they are mundane. Of course, this is not the case. Actually, one of the core values of the third chapter is that it led me to make a deep reflexive endorsement of these assumptions. Through it, I had the opportunity to review, discuss and accept the basic methodological choices that characterize current macroeconomic theory and on which the first two chapters of this thesis rely heavily. More than that, the third chapter helps me answering my friend's doubt on the usefulness of these models. Indeed, through it, I was forced to take a closer look at the relationship between theory and reality. It forced me to reconsider seriously the meaning of the policy conclusions derived in the first two chapters. In the concluding part of the thesis, I share my thoughts with the reader. I expand the discussion started in the last chapter with the aim to briefly explain how the relationship between theory and reality embedded in macroeconomic models affect the making of policy recommendations.

# Chapter 2

# Optimal Taxes and Transfers with Household Heterogeneity

Co-authored with Boris Chafwehé (JRC).

**Abstract**

We investigate the properties of optimal fiscal policy in a framework where household heterogeneity is accounted for. The Ramsey planner chooses (distortionary) labor taxes and transfers to maximize aggregate welfare in a two-agent economy. We contrast the properties of optimal labor taxes in our model to the ones obtained in the representative agent counterpart. We first show that the presence of household heterogeneity introduces an additional source of fluctuations in the optimal tax rate, as varying taxes allows the planner to use transfers for redistributive purposes. We then show that, depending on the assumptions that are made on how transfer receipts are distributed among households, and the type of shocks hitting the economy, the structure of government bond markets becomes more or less important in shaping the dynamics of the Ramsey allocation. In some cases, the presence of transfers brings the incomplete markets allocation close to the one in which the planner has access to state-contingent claims. We finally show that the presence of heterogeneity and optimal transfers helps bring the behaviour of fiscal variables in the Ramsey model closer to their counterpart in US data.

## 2.1 Introduction

The importance of heterogeneity at the household level in shaping economic fluctuations is the focus of a flourishing literature in macroeconomics. While many authors have studied the positive aspects of heterogeneity to analyze its impact on the cyclical properties of key macroeconomic aggregates, little work has been done that combines the cycle with the normative aspects of policy. This paper intents to fill this gap, by providing an analysis of optimal fiscal policies in models where households are heterogeneous in terms of labor productivity and holdings of financial assets.

The fiscal tools available to governments can broadly be seen as serving two main goals. First, deficit financing can be used along the business cycle to stabilize macroeconomic fluctuations; second, governments can use fiscal instruments to redistribute resources between economic agents and provide social insurance. While many papers in the optimal fiscal policy (OFP) literature have studied these two components in isolation, few authors have considered them at the same time. Indeed, broadly speaking, the OFP literature can be divided in two parts. On the one hand, several papers develop representative agent models in which fiscal instruments are used to mitigate the impact of aggregate shocks on macroeconomic variables[1]. These papers are therefore mostly concerned with the stabilization role of fiscal policy. On the other hand, numerous works have developed frameworks featuring household heterogeneity and in which the fiscal authority sets policy variables so as to redistribute resources between agents[2]. This line of work is therefore mostly concerned with the redistribution component of policy, and it usually relies on models where aggregate shocks are absent. In this paper, we consider a framework that weds these two approaches. We introduce a business cycle model which relies on a mild degree of heterogeneity, and consider fiscal instruments that allow the planner to redistribute resources across agents.[3] This implies a potential conflict between the stabilization of aggregate variables and the redistribution of market resources, and we are interested in looking at the trade-offs facing the fiscal authority.

The set of questions we want to address in this paper are the following. First, we intend to understand the properties of the optimal tax schedule when heterogeneity is accounted for. In particular, we want to investigate how the volatility of optimal labor taxes is impacted by the presence of household heterogeneity and the availability of transfers

[1]Two seminal papers in this literature are the work of Lucas and Stokey (1983) and Aiyagari, Marcet, Sargent, and Seppälä (2002).

[2]See, for instance, Conesa and Krueger (2006); Conesa, Kitao, and Krueger (2009) and Heathcote, Storesletten, and Violante (2017).

[3]In this way our paper relates to the consequent literature using the so-called TANK model to study the impact of household heteorogeneity on the macroeconomy (following the work of Galí, López-Salido, and Vallés, 2007 and Bilbiie, 2008). Note, however, that most of the work that has been done using this type of models has focused on monetary policy, while we are interested in the role of fiscal policy.

as a fiscal instrument for the Ramsey planner. We study to which extent variations in transfers rather than distortionary taxes are used to finance deficits, when it comes at the cost of increasing inequality in consumption and hours worked between households. In order to assess whether heterogeneity matters for the design of the optimal policy, we contrast our results to the ones obtained in the representative agent framework typically used in the literature. Later in the paper, we investigate whether our simple model can reproduce key stylized facts related to the conduct of fiscal policy in the US. In particular, we assess whether the cyclical properties of output, deficits, transfers, and government debt, are better matched by our two-agent framework than by its representative agent counterpart, when we calibrate the model parameters plausibly.

In our model, *savers*, or *Ricardian* households, have access to financial markets and save by accumulating government bonds. *Non-savers*, or *hand-to-mouth* households, do not have access to financial assets and consume their entire disposable income in every period. Households also differ in terms of their labor productivity, and we allow these differences to move over the business cycle (in other words, we allow for non-trivial interactions between aggregate and 'household-specific' shocks). Using this framework, we study the properties of optimal fiscal policy under commitment, where a benevolent government sets distortionary labor taxes and issues debt to finance government spending and transfers, so as to maximize aggregate welfare in the economy. Transfers are restricted to follow an empirically-motivated targeting rule which specifies their repartition between agents, and implies a co-movement between the transfers received by each household. The level of transfers is also set optimally by the planner, and we do not impose restrictions on their value. Therefore a government that prioritizes to smooth the burden from distortionary taxation can set transfers negative, thus relying on lump-sum taxes to finance deficits.

We first analyze the steady-state properties of the model, in which the planner chooses labor taxes and transfers to maximize aggregate welfare, for given levels of government expenditures and government debt. We provide a condition for the optimal long-run tax rate on labor to be positive, and show that it is not always optimal to set the labor tax rate to zero and finance the entire deficit in lump-sum. The optimal labor tax is positive when heterogeneity between households is sufficiently high, and when the design of transfers allows for sufficient redistribution between agents. In this case, increasing the tax rate and letting transfers be positive, allows the planner to redistribute across agents.

We then study the properties of optimal taxes and transfers in the presence of shocks, and look at the cyclical properties of the Ramsey allocation. We thus extend the analysis of Lucas and Stokey (1983) and Aiyagari et al. (2002, AMSS) to a two-agent setting. We derive an analytical expression for the optimal labor tax schedule, showing that tax volatility can be attributed to two components/sources. The first is related to market incompleteness, since as in AMSS we assume that debt is not state contingent. We show that transfers enable the planner to reduce tax volatility through (for example) lowering transfers when the deficit is high. This tends to bring the economy closer to a complete market outcome (e.g. Lucas and Stokey, 1983). The second component of tax volatility derives from heterogeneity in consumption and hours worked between households. Tax volatility is shown to be a function of the cyclical behavior of variables that summarize consumption and hours inequality. Using our simplistic model we investigate the relative importance of these two sources of volatility. We show that the quantitative impact of heterogeneity is much weaker than the impact arising from incomplete markets.

In the last part of the paper, we investigate the potential of an optimal fiscal policy model with heterogeneity to match the US data. We do so mainly to gain insights on the relative importance of heterogeneity and incomplete markets in shaping the behavior of fiscal variables and on the necessity of explictly modeling heterogeneity in models of optimal fiscal policy. We use a simulated method of moments (SMM) estimator to choose the parameter values that minimize the distance between moments generated by the model and those observed in the data. We find that the estimated model does a good job in matching the empirical properties of fiscal variables and for plausible parameter values. Our estimates suggest that a key driver of fluctuations in model variables are the shocks affecting the relative labor productivity of hand-to-mouth agents. In response to these shocks, the planner implements a policy which implies co-movement between transfers, deficits and GDP that is very similar to the analogous moments in the data. At the estimated parameters values, we find that the optimal allocation features less tax volatility than in a representative agent, incomplete markets model.

**Related Literature** Our paper contributes to the literature in several ways. First, we consider a model where household heterogeneity is accounted for using a two-agent setup, along the lines of Campbell and Mankiw (1989), Galí et al. (2007) and Bilbiie (2008).[4] This class of models has widely been used to look at the positive aspects of monetary and fiscal policies;[5] we take a normative stance and study the properties of optimal fiscal policy implemented by a planner that operates under full commitment and has access to two types of instruments: distortionary labor taxes and transfers.

Our model also builds on the seminal contributions of Lucas and Stokey (1983) and

[4]A growing literature studies the impact of household heterogeneity on macroeconomic outcomes in models where agents face idiosyncratic risks. The seminal contribution of Kaplan, Moll, and Violante (2018) studies monetary policy in their so-called HANK model. Other examples of papers this literature include Krueger, Mitman, and Perri (2016), Auclert (2019), McKay and Reis (2016b), Werning (2015). Debortoli and Galí (2017) provide a useful comparison between the predictions obtained from TANK versus HANK models.

[5]Bilbiie and Ragot (2017),Challe et al. (2017b) and Bilbiie (2018) use this framework to study optimal monetary policies.

Aiyagari et al. (2002). These two papers study the cyclical properties of Ramsey policies when, respectively, the planner has access to a full set of contingent securities (financial markets are complete), and when the planner can only issue one-period risk free bonds, such that markets are incomplete.[6] Scott (2007) and Marcet and Scott (2009) show that the co-movement between deficits and government debt is negative under complete markets, while it is positive under incomplete markets. Moreover, they show that Ramsey models with complete markets imply no persistence in government debt while incomplete markets models imply very persistent levels.[7] Empirically, the behaviour of fiscal variables seems to favor incomplete markets, as the observed correlation between deficits and the market value of debt is positive. However, the persistence of government debt under incomplete markets that is derived in these models overshoots the data counterpart (see Marcet and Scott (2009)). In this paper, we show that, when household heterogeneity is accounted for, and transfers are introduced, the obtained persistence of government debt gets closer to what is observed in the data.

While models featuring household heterogeneity have been widely used to study the long-run properties of the optimal tax schedule (see Aiyagari (1995), Conesa et al. (2009), Heathcote et al. (2017) and references therein), little work has been done on Ramsey policies in frameworks that integrate both heterogeneous agents and aggregate shocks. Notable exceptions are Werning (2007), Bassetto (2014), Bhandari, Evans, Golosov, and Sargent (2017, 2018), and Le Grand and Ragot (2017). Le Grand and Ragot (2017) and Bhandari et al. (2018) develop numerical algorithms that approximate Ramsey allocations in economies with heterogeneous agents, uninsurable idiosyncratic risks, and aggregate shocks. They apply their novel methods to study, respectively, optimal capital taxation, and jointly optimal monetary and fiscal policies. Compared to these papers, ours adopts a simpler 2-agent structure, and focuses on the optimal use of labor taxes and transfers under complete and incomplete government bond markets, in a model without capital and nominal rigidities. Our simpler setup enables us to derive analytical formulae that shed light on the trade-offs facing the government. Bassetto (2014), Werning (2007) and Bhandari et al. (2017) study optimal policies in settings closely related to ours. The novelty in our paper lies in its focus on the role that transfers and market (in)completeness play for the conduct of optimal fiscal policy.

Finally, given the emphasis we give to transfers and their role for social insurance along the business cycle, our paper is also related to Oh and Reis (2012), who study the stabilizing

[6] The implications of the maturity of the government debt, i.e. the existence of both short and/or long term bonds, on the properties of optimal fiscal policy are well understood. See, for instance, Angeletos (2002), Buera, Nicolini et al. (2004), and Faraglia, Marcet, Oikonomou, and Scott (2019a,b).

[7] The literature has also explored the role of monetary policy in stabilizing government debt. It has been shown that, in the presence of nominal rigidities, inflation volatility has too big welfare costs to become an appropriate margin to stabilize debt. See e.g. Schmitt-Grohé and Uribe (2004b) and Faraglia, Marcet, Oikonomou, and Scott (2013).

role of transfers in the Great Recession in a model with heterogeneous households and idiosyncratic risk; McKay and Reis (2016a,b) use a similar framework to look at the role of automatic stabilizers in the business cycle. Transfers in our model can also be used by the planner as a social insurance tool which has a role in mitigating the impact of aggregate shocks. However, contrarily to these papers, we focus on the joint use of transfers and other fiscal instruments such as debt and labor taxes and the implied trade-offs between providing insurance and minimizing labor tax distortions.

The remainder of the paper is organized as follows. In Section 2.2, we provide key stylized facts regarding the behaviour of fiscal variables in the US, using both macro and micro data sources. Section 2.3 describes the building blocks of the model that we use in the subsequent analysis. Section 2.4 and 2.5 contain the results obtained from the model, with a focus on the steady-state properties and the dynamics implied by the Ramsey allocation. Section 2.6 concludes.

## 2.2 Fiscal policy in the United States

In this section we present facts on the cyclical and distributional properties of fiscal variables in the US, focusing on the behaviour of transfers. The objective is twofold. First, we want to provide a clear definition of the notion of transfers that we will use throughout the paper. Second, we want to shed light on the data properties of transfers that we will use to justify the way we design transfers in the theoretical model presented in the next section. We first use aggregate data to describe the main cyclical properties of transfers. Then, we make use of household-level data to analyze the redistributive aspects of policy.

We use data from the NIPA tables to look at the aggregate properties of transfers. In this paper, we will focus on the components of transfers which are targeted towards households. We therefore construct our aggregate series accordingly, and define transfers as the sum of unemployment insurance payments, and other social benefits such as food stamps and income assistance programs. A complete description of our data series is provided in Appendix 3.6.3.[8] We now study the cyclical properties of our transfer series, and its relation with other components of the US federal budget. We summarize the observed properties with the following :

**Fact 1:** *Transfers are counter-cyclical, and are strongly correlated with primary deficits.*

[8] Oh and Reis (2012) show that the fiscal expansion during the Great Recession was also mostly driven by increases in social transfers. While unemployment benefits and income assistance programs explain a large share of the increase in transfers, social security and Medicare expenditures also increased significantly during the period 2007-2009.

In Table 2.1 we provide the correlation matrix of the cyclical components of transfers, primary deficits, and GDP. From this table we can observe that transfers and GDP have a negative correlation (-0.45). This observed counter-cyclicality of transfers can be attributed to the fact that, in recessions, governments use social insurance schemes to alleviate the drop in income that households suffer, and therefore (partially) insure them against fluctuations. We will further investigate this insurance component while analysing transfers using micro data sources.

[Table 2.1 approximately here]

Another noteworthy feature is the strong positive correlation between transfers and deficits observed from the table. It suggests that transfers are an important component of deficits, or at least that the government is not reducing transfers when deficits are high.

Figure 2.1 illustrates the negative correlation between GDP and transfers and the positive correlation between transfers and deficits. It shows that transfers are not used by the government to stabilize deficits. On the contrary, they are one of the most important components enabling public finances to fulfil their automatic stabilization role.

[Figure 2.1 approximately here]

We now provide empirical evidence on the behaviour of transfers in the cross-section. We use data from the Consumer Expenditure Survey (CEX), a quarterly survey of consumption expenditure by US households conducted by the Bureau of Labor Statistics. Besides detailed consumption data, the survey provides information on labor earnings and transfers received by households that are interviewed. We make use of these records to construct data series that summarize the behaviour of these variables across different household groups. Details on the construction of our series are provided in Appendix 3.6.3.

To perform our analysis, we proceed as follows. We first classify households according to the value of their yearly earnings, in order to divide them in two groups. The first group contains households at the bottom 30% of the income distribution, while the other group contains the remaining 70%.[9] Then, we aggregate data series across households in each

[9]In the theoretical framework developed in the next section, we distinguish between *hand-to-mouth* and *Ricardian households*. The first group is defined as households which do not have access to a savings technology and therefore consume their entire disposable income in every period. As the data we use do not contain information on wealth and asset holdings, we use labor earnings as a proxy for these variables, and assign households to subgroups according to this criterion.

group to look at how the empirical properties of income and transfers vary across income groups.[10]

We define individual transfers in a similar way as for the aggregate series described above. The aggregate transfer series obtained from the micro database shares the same cyclical properties as the macro data series used previously.

Let us now turn to the second stylized fact:

**Fact 2:** *Transfers are unevenly targeted towards low-income households.*

In Figures 2.2 and 2.3 we plot, respectively, the evolution over time of the value of per capita transfers for each of the two household groups defined above, and the total share of transfers received by households in the low-income group.[11] We can observe from these figures that on average, the value of transfers directed towards households at the bottom 30% of the income distribution is greater than the one received by households in the high income group. Indeed, as depicted in Figure 2.3, while hand-to-mouth agents represents 30% of the population, they receive about two third of total transfers: the average value for this share is 67% for our sample period. This confirms that transfers have a redistributive aspect, and that low-income individuals are more likely to benefit from them.

[Figures 2.2 and 2.3 approximately here]

**Fact 3:** *Transfers directed towards low and high income groups are strongly correlated.*

To finish this section, we want to emphasize the strong correlation between the cyclical component of transfers across groups. The correlation coefficient between the two series plotted in Figure 2.2 is equal to 0.79, implying a huge co-movement of the transfer series across the two considered income groups. This observation will be used in the next section to justify the assumption made in our theoretical model of a unique transfer that is split between households, rather than separate transfer processes targeting individual households independently.

[10] While CEX data are collected at a quarterly frequency, households only report the values of earnings and transfers received over the preceding 12 months. Hence, the quarterly series we get for these variables have some inertia, and are not as volatile as they should be, which does not allow us to study the dynamics of earnings and income inequality in greater detail. However, it is sufficient to get a broad overview of the dynamics of transfers at the micro level.

[11] In Appendix 3.6.3, we provide the transfer series by income quintile and show that the relation between income and transfer receipts described here is similar using this level of aggregation.

## 2.3 A simple two-agent model

In this section, we consider a simple two-agent model to outline the key features of optimal fiscal policy when household heterogeneity is accounted for. We first lay out a model where the government can only issue one period risk-free debt, and markets are incomplete. Then, we set up a model in which the planner issues state-contingent claims and markets are complete. Contrasting these two cases will allow us to study the implications of the market structure on the optimal behaviour of taxes and transfers, and characterize its interplay with heterogeneity.

Two types of households populate the economy: a fraction $1-\lambda$ of agents are Ricardian, or *savers*, and have access to financial markets: they can accumulate government bonds to smooth consumption over time. The remaining fraction $\lambda$ of agents are hand-to-mouth, or *non-savers*; they do not have access to the savings technology and consume their entire disposable income every period. Labor supply is chosen optimally by each household. There is no capital, and production is linear in total labor effort. We consider uncertainty deriving from three sources: shocks to government spending, to aggregate productivity, and individual productivity shocks relevant only for hand-to-mouth agents.

In what follows, we describe in detail the main building blocks of the model.

### 2.3.1 Model description

**Government:** The government has to finance an exogenous stream of spending denoted $g_t$, and transfers $T_t$, which are chosen optimally. Transfers are allowed to be negative, in which case they are essentially lump-sum taxes. To generate revenues, the government also taxes labor at the rate $0 \leqslant \tau_t \leqslant 1$. The latter is also chosen optimally by the Ramsey planner. Finally, the government issues debt, which takes the form of one-period discount government bonds. Current bond issuances are denoted $b_t$, and their price is $q_t$. The intertemporal government budget constraint is written as:

$$b_{t-1} = \tau_t a_t n_t - g_t - T_t + q_t b_t \tag{2.1}$$

where $a_t$ and $n_t$ denote respectively aggregate productivity and total labor supply. These objects are described below.

**Modelling transfers:** One of the goals of this paper is to explore the effect of transfers and their design on the properties of optimal fiscal policy. As we will show, the assumptions we make on the transfer schedule have important implications for the outcomes of the Ramsey allocation. It is therefore crucial to model transfers in an appropriate and empirically-relevant way. For instance, we could allow for household-specific transfers, that could be denoted $T_t^i$, for agent $i = h, s$, where $h$ and $s$ denote respectively hand-to-mouth and Ricardian households. The government would choose their optimal value and total transfers would simply equal their weighted sum: $T_t = \lambda T_t^h + (1-\lambda)T_t^s$. However, such an assumption is unappealing for two reasons. First, letting the planner choose household-specific transfer levels would allow her to reach the first-best allocation, thereby leading to trivial results. In such allocation, labor taxes would be set to zero and, as is shown below, the planner would choose transfers to equate marginal utilities of consumption across households.

Second, household-specific transfers, which imply that individual transfers can potentially evolve very differently across households, are not a good approximation of the behaviour of transfers observed in the data. This would violate the last stylized fact of the previous section, according to which individual transfers are strongly correlated across households.

For the above reasons, we choose to model transfers as a unique process $T_t$. However, to make it consistent with our second stylized fact (according to which transfers are unevenly targeted towards a subset of households), we introduce a targeting rule, which specifies the share of transfers going towards each of the two households populating the economy. More precisely, we assume that a share $\omega \in [0, 1]$ of total tranfers is targeted towards hand-to-mouth agents. 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 $T_t^s = \frac{1-\omega}{1-\lambda}T_t$. Therefore, when $\omega = \lambda$, transfers are equally distributed among the population ($T_t^h = T_t^s = T_t$), and whenever $\omega > \lambda$ transfers are targeted towards hand-to-mouth agents ($T_t^h > T_t^s$).[12] Although our targeting rule is simple and abstracts from many elements characterizing the design of transfers in the US, we believe that our assumptions enable us to develop a workable approximation of the actual transfer schedule.

**Ricardian agents:** Ricardian households choose consumption, labor supply, and holdings of government bonds to maximize their expected lifetime utility, which is expressed as:

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big( u(c_t^s) - v(n_t^s) \Big) \tag{2.2}$$

where $c_t^s$ and $n_t^s$ denote respectively the consumption and the labor effort exerted by the agent at time $t$. Period utility is assumed to be separable between consumption and labor. We make common assumptions on the functions $u(\cdot)$ and $v(\cdot)$, namely $u' > 0$,

[12] Throughout the paper, we assume that $\omega$ is exogenous, and constant over time. While we believe that allowing the planner to optimally choose $\omega$ is an interesting exercise, we abstract from this in our model.

$u'' < 0$, and $v' > 0$, $v'' > 0$.

The budget constraint of savers, which has to be satisfied in every time period $t$, can be expressed as:

$$c_t^s + q_t b_t^s = (1 - \tau_t) a_t n_t^s + b_{t-1}^s + \frac{1-\omega}{1-\lambda} T_t \tag{2.3}$$

This constraint states that to finance consumption and the accumulation of newly issued government bonds ($b_t^s$ denotes the quantity of bonds held by savers), the household uses its labor income net of taxes, transfers, and the payoff on government bonds issued in $t-1$. Note that the coefficient $\frac{1-\omega}{1-\lambda}$ appearing in front of aggregate transfers $T_t$ is consistent with our targeting rule described above.

First order conditions for Ricardian agents give:

$$\frac{v_{n,t}^s}{u_{c,t}^s} = a_t(1 - \tau_t) \tag{2.4}$$

$$q_t = \beta \frac{E_t u_{c,t+1}^s}{u_{c,t}^s} \tag{2.5}$$

where $u_c \equiv \frac{\partial u}{\partial c}$ and $v_n \equiv \frac{\partial v}{\partial n}$ denote, respectively, the marginal utility of consumption, and the marginal disutility of work. The first equation is a standard labor supply condition, equating the marginal rate of substitution between leisure and consumption to (net) labor income. The second equation is the usual Euler equation, which also constitutes the pricing condition for government bonds and has to be accounted for by the social planner.

**Hand-to-mouth agents:** Non-savers do not have access to financial markets and are therefore constrained in each period to consume their entire disposable income. They choose labor supply optimally to maximize their period utility $u(c_t^h) - v(n_t^h)$, subject to the budget constraint:

$$c_t^h = (1 - \tau_t) \theta_t^h a_t n_t^h + \frac{\omega}{\lambda} T_t \tag{2.6}$$

Variable $\theta_t^h$ denotes an exogenous shock to the relative productivity of hand-to-mouth agents. If $\theta_t^h < 1$, hand-to-mouth agents are less productive than Ricardian Households; this might provide incentives to the planner to tilt transfers towards hand-to-mouth agents.

The introduction of shocks to the relative productivity of hand-to-mouth households is useful to capture the following properties. First, on average the revenue of hand-to-mouth households is lower than the revenue of savers in the data. Second, the cyclical properties of their income are also likely to differ from the ones of savers. In the Appendix, we show that in our data, the earnings of households at the bottom of the distribution are more volatile than the ones of richer agents.[13]

Utility maximization by hand-to-mouth agents gives the labor supply condition:

$$\frac{v^h_{n,t}}{u^h_{c,t}} = \theta^h_t a_t (1-\tau_t) \tag{2.7}$$

**Equilibrium** We define aggregate consumption and hours worked, respectively, as follows:

$$\begin{aligned} c_t &= \lambda c^h_t + (1-\lambda) c^s_t \\ n_t &= \lambda \theta^h_t n^h_t + (1-\lambda) n^s_t \end{aligned}$$

Equilibrium in the market for government debt implies $b^s_t = \frac{1}{1-\lambda} b_t$.

We can use the government budget constraint, and the individual budget constraints of both households to obtain the economy-wide resource constraint:

$$c_t + g_t = a_t n_t \tag{2.8}$$

### 2.3.2 Optimal policy

#### The Ramsey problem

The Ramsey planner maximizes aggregate welfare, which we define as the weighted sum of individual expected lifetime utility functions:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \Big[ \lambda \Big( u(c^h_t) - v(n^h_t) \Big) + (1-\lambda) \Big( u(c^s_t) - v(n^s_t) \Big) \Big] \tag{2.9}$$

The Ramsey planner maximizes (2.9) subject to her inter-temporal budget constraint (2.1), households optimality conditions (2.4), (2.5) and (2.7), the resource constraint (2.8), and the budget constraint of hand-to-mouth agents (2.6).

[13] We also show in the Appendix that the correlation between the revenues of low-income households and GDP is higher than the one obtained for high-income households: in other words, the revenues of low-income agents is more pro-cyclical. While we believe that the implications of this property for optimal fiscal policy is an interesting issue, we abstract from this in the current version of the paper.

The Lagrangian associated to the planner's optimization program is:

$$
\begin{aligned}
\mathcal{L} \;=\; & E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \lambda \Big[ u(c_t^h) - v(n_t^h) \Big] + (1-\lambda) \Big[ u(c_t^s) - v(n_t^s) \Big] \qquad (2.10) \\
& + \Psi_t^{IM} \Big[ - u_{c,t}^s b_{t-1} + (u_{c,t}^s a_t - v_{n,t}^s)(\lambda \theta_t^h n_t^h + (1-\lambda) n_t^s) - u_{c,t}^s (g_t + T_t) + \beta u_{c,t+1}^s b_t \Big] \\
& + \Psi_t^1 \Big[ a_t \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s a_t - \lambda c_t^h - (1-\lambda) c_t^s - g_t \Big] + \Psi_t^2 \Big[ \frac{v_{n,t}^s}{u_{c,t}^s} - \frac{1}{\theta^h} \frac{v_{n,t}^h}{u_{c,t}^h} \Big] \\
& + \Psi_t^3 \Big[ - u_{c,t}^s c_t^h + v_{n,t}^s \theta_t^h n_t^h + \frac{\omega}{\lambda} u_{c,t}^s T_t \Big]
\end{aligned}
$$

where we made use of Ricardian agents' Euler equation and labor supply condition to substitute away the bond price $q_t$ and the labor tax rate $\tau_t$, thereby making use of the primal approach to solve for optimal policies (see Lucas and Stokey, 1983). The optimality conditions associated to the planner's problem are the following:

$$
\begin{aligned}
c_t^h \;&:\; \lambda u_{c,t}^h - \lambda \Psi_t^1 + \frac{\Psi_t^2}{\theta_t^h} \frac{v_{n,t}^h}{(u_{c,t}^h)^2} u_{cc,t}^h - \Psi_t^3 u_{c,t}^s = 0 \\
c_t^s \;&:\; (1-\lambda) u_{c,t}^s + \Psi_t^{IM} \Big[ u_{cc,t}^s a_t n_t - u_{cc,t}^s (g_t + T_t) \Big] + (\Psi_{t-1}^{IM} - \Psi_t^{IM}) u_{cc,t}^s b_{t-1} \\
& \quad - \Psi_t^1 (1-\lambda) - \Psi_t^2 \frac{v_{n,t}^s}{(u_{c,t}^s)^2} u_{cc,t}^s + \Psi_t^3 (-u_{cc,t}^s c_t^h + \frac{\omega}{\lambda} T_t u_{cc,t}^s) = 0 \\
n_t^h \;&:\; -\lambda v_{n,t}^h + \Psi_t^{IM} (u_{c,t}^s a_t - v_{n,t}^s) \lambda \theta_t^h + \Psi_t^1 a_t \lambda \theta_t^h - \frac{\Psi_t^2}{\theta_t^h} \frac{v_{nn,t}^h}{u_{c,t}^h} + \Psi_t^3 v_{n,t}^s \theta_t^h = 0 \\
n_t^s \;&:\; -(1-\lambda) v_{n,t}^s + \Psi_t^{IM} \Big[ (1-\lambda)(u_{c,t}^s a_t - v_{n,t}^s) - v_{nn,t}^s n_t \Big] + \Psi_t^1 (1-\lambda) a_t + \\
& \quad \Psi_t^2 \frac{v_{nn,t}^s}{u_{c,t}^s} + \Psi_t^3 v_{nn,t}^s \theta_t^h n_t^h = 0 \\
T_t \;&:\; -\Psi_t^{IM} u_{c,t}^s + \Psi_t^3 \frac{\omega}{\lambda} u_{c,t}^s = 0 \\
b_t \;&:\; -E_t \Psi_{t+1}^{IM} u_{c,t+1}^s + \Psi_t^{IM} E_t u_{c,t+1}^s = 0
\end{aligned}
$$

### The first-best allocation as a useful benchmark

In Appendix 2.7.2 we show that the first-best allocation in our two-agent model can be characterized by the following conditions:

$$
\frac{v_{n,t}^h}{\theta_t^h u_{c,t}^h} = \frac{v_{n,t}^s}{u_{c,t}^s} = a_t
$$
$$
u_{c,t}^h = u_{c,t}^s
$$

The first equalities provide a well-known optimality condition which can also be derived from representative agent models: it states that the marginal rate of substitution between consumption and leisure must be equal to the marginal product of labor, which is equal to $a_t$ for Ricardian households, and $\theta_t^h a_t$ for hand-to-mouth households. This allocation can be attained by the planner if it is possible for her to set $\tau_t = 0$ for all $t$ (which is the case if, for instance, she only makes use of variations in transfers to finance fiscal deficits), and therefore eliminate tax distortions.

The second condition equates marginal utilities of consumption across agents. It therefore states that the first-best allocation features complete consumption equality, given the assumptions made on the function $u(\cdot)$. In the framework considered here, it is in some cases possible for the planner to make this condition hold by using transfers to redistribute resources across agents. However, as such a policy often comes at the cost of increasing the level and volatility of labor taxes, this in turn prevents the planner from getting close to the first set of conditions mentioned above. This therefore creates a trade-off between efficiency and redistribution; one of the goals of this paper is to investigate the nature and the resolution of such a trade-off by the Ramsey planner.

### 2.3.3 Complete vs. incomplete markets

In this section, we briefly outline how the complete markets version of the model looks like. The Ramsey problem under complete markets is similar to the one which has been described above for the incomplete market case; the main difference lies in the government budget constraint.

In the model presented in the previous section, the state of the economy at time $t$ can be represented by the object $s^t = \{s_0, s_1, ..., s_t\} = \{s^{t-1}, s_t\}$, where $s_t$ denotes the state vector at time $t$. We assume that shocks are Markovian, implying that the evolution of exogenous processes can be represented by a density function of the form $f(s^t|s_{t-1})$.[14]

For the sake of exposition, in this section we rewrite model variables as $x_t = x(s^t)$ for any variable $x$. This way, we explicitly acknowledge the mapping between the state object $s^t$ and the value taken by any variable $x$ at time $t$. Using this notation, we can rewrite the government budget constraint under incomplete markets, specified in (2.1), as:

$$b(s^{t-1}) = \overline{S}(s^t) + q(s^t)b(s^t) \tag{2.11}$$

where $\overline{S}_t \equiv \tau_t a_t n_t - g_t - T_t$ is the primary surplus at time $t$. Using Ricardian agents' Euler equation (2.5) and iterating equation (2.11) forward, we can express the inter-temporal

[14] As stated above, we consider three types of shocks in this model version: shocks to government spending, to aggregate productivity, and to the relative productivity of hand-to-mouth households.

budget constraint as follows:

$$u_c^s(s^t)b(s^{t-1}) = E_0 \sum_{j=0}^{\infty} \beta^j \overline{S}(s^{t+j}) u_c^s(s^{t+j}) \tag{2.12}$$

This equation has to hold for any $t$ (acknowledging that $b(s^{-1}) = b_{-1}$: the initial value of government debt is taken as given by the government); this expression is very standard: it states that the inherited value of government debt (in units of marginal utility) has to be equal to the discounted sum of future primary surpluses.

When financial markets are complete, the government issues in each period $t$, a portfolio of state-contingent bonds $b^{CM}(s^{t+1})$ at prices $q^{CM}(s^{t+1})$. The dependence of $b^{CM}$ on the state vector in $t+1$ makes it clear that the payoff on government debt depends on the state of the economy when bond payments are due. In this scenario, the government budget constraint can be written as follows:

$$b^{CM}(s^t) = \overline{S}^{CM}(s^t) + \int_{s^{t+1}} q^{CM}(s^{t+1}) b^{CM}(s^{t+1})\, ds^{t+1} \tag{2.13}$$

From savers' first order conditions (see Appendix 2.7.2), we obtain the pricing equation:

$$u_c^{s,CM}(s^t) q^{CM}(s^{t+1}) = \beta f(s^{t+1}|s_t) u_c^{s,CM}(s^{t+1}) \tag{2.14}$$

This equation has to hold for any $s^{t+1}$. Combining equations (2.13) and (2.14), and iterating forward, we get:

$$u_c^{s,CM}(s^t)b(s^t) = E_t \sum_{j=0}^{\infty} \beta^j \overline{S}^{CM}(s^{t+j}) u_c^{s,CM}(s^{t+j}) \quad \text{for } t \geqslant 1 \tag{2.15}$$

$$u_{c,0}^{s,CM} b_{-1} = E_0 \sum_{t=0}^{\infty} \beta^t \overline{S}^{CM}(s^t) u_c^{s,CM}(s^t) \quad \text{for } t = 0 \tag{2.16}$$

where $E_t x(s^{t+j}) \equiv \int_{s^{t+j}} x(s^{t+j}) f(s^{t+j}|s_t)\, ds^{t+j}$ is the conditional expectation of variable $x$ at time $t+j$ based on the information set at time $t$. As mentioned earlier, in any period $t \geqslant 1$, the state-contingent nature of government debt makes debt payments $b^{CM}$ a function of the current state vector $s^t$. It follows that the constraint (2.15) is slack (and therefore irrelevant for the Ramsey planner) for $t \geqslant 1$, as the government can freely choose the value of $b(s^t)$ which makes the constraint non-binding. In period 0, however, the inherited the level of government debt is $b_{-1}$ is given; the planner has no influence on this value. This makes equation (2.16) the only binding constraint that has to be part of the planner's constraint set.

It follows from the above discussion that when markets are complete, only the intertemporal budget constraint in the initial period $t = 0$ needs to hold; this is a standard property of optimal fiscal policy models with complete financial markets (see Lucas and Stokey, 1983). The full set of constraints that have to hold in this model version is therefore constituted of equations (2.4), (2.6), (2.7), (2.8) and (2.16). A full description of the Ramsey program under complete markets and the associated first order conditions are provided in Appendix 2.7.2.

### 2.3.4 Calibration and functional forms

We describe here the parameter values and functional forms that will be used in the subsequent analysis and numerical simulations. The period utility function is separable between consumption and leisure, and takes the form:

$$u(c) - v(n) = \log(c) - \frac{n^{1+\phi}}{1+\phi} \tag{2.17}$$

The three shock processes are all assumed to follow AR(1) process in logs:

$$\log\left(\frac{x_t}{x}\right) = \rho_x \log\left(\frac{x_{t-1}}{x}\right) + \epsilon_{x,t} \tag{2.18}$$

for $x = g, a, \theta^h$. Shocks $\epsilon_{x,t}$ are iid with mean zero and standard deviations $\sigma_x$.

[Table 2.2 approximately here]

The parameter values are summarized in Table 2.2. The model horizon is annual, and we set the discount factor to $\beta = 0.95$. The inverse Frisch elasticity $\phi$ is set to unity. The share of hand-to-mouth agents is $\lambda = 0.3$, a value which is standard in the literature.[15]

We assume a steady-state debt-to-gdp ratio of 60%, and set the steady-state value of government expenditures to 15% of output.

Given the crucial role played by the individual productivity of constrained agents $\theta^h$ and the share of transfers going to these agents $\omega$, we will allow for different values of these parameters in the next section. This will allow us to study how these parameters affect the properties of the Ramsey allocation. However, when not stated otherwise, we consider the benchmark case of $\theta^h = 1$, i.e. the scenario under which the two agents are equally productive in the steady-state. As for $\omega$, there are two cases that we focus on: the case where $\omega = \lambda$ (transfers are evenly distributed among households, and can therefore be

[15] This is also consistent with the empirical evidence provided in Kaplan and Violante (2014), according to which around 30% of US households can be considered as being hand-to-mouth.

considered as purely lump-sum); and the case where $\omega = 1$ (all the transfers are targeted towards hand-to-mouth agents). We will present results for these two cases throughout the rest of the paper.

## 2.4 Steady-state analysis

In this section we study the steady-state properties of the model. We first analyze the set of equilibrium outcomes that are attainable to the planner for the combinations of taxes and transfers satisfying the budget constraint; this gives us a sense of the objective of the planner. We then solve for the optimal long-run allocation, and study how taxes and transfers vary as a function of key model parameters.

### 2.4.1 Long-run tradeoffs

We assume that the government inherits a long-run level of government debt $b_{-1}$; the steady-state level of government spending is given and equal to $g$. In the steady-state, the government budget constraint is:[16]

$$(1-\beta)b_{-1} = \tau n - g - T \tag{2.19}$$

where dropping time subscripts from the variables denotes the steady-state. When choosing taxes and transfers, the planner faces a trade-off between efficiency and redistribution. On the increasing side of the Laffer curve, a higher labor tax rate $\tau$ increases tax revenues, thereby allowing the government to raise transfers $T$, which potentially has a redistributive role. However, this comes at the cost of distorting labor supply, and therefore reducing aggregate output. In standard models featuring a representative agent, the planner will always choose to set the distortionary tax on labor to zero, and to finance the entire deficit through lump-sum taxes (negative transfers). We study here whether the same property holds when agents are heterogeneous.

Figure 2.4 displays steady-state consumption inequality, measured as the ratio of hand-to-mouth to Ricardian households' consumption ($\frac{c^h}{c^s}$), as a function of the labor tax rate ($\tau$). The first best allocation (which, as mentioned before, is the allocation which sets the labor tax rate to 0 and the consumption ratio to 1), is depicted in the figure by a red cross.

[16]Note that the steady-state allocations under complete and incomplete markets, for a given level of inherited government debt, are the same. It implies, among others, that the steady-state multipliers on the government budget constraint are equal ($\psi^{IM} = \psi^{CM} = \psi$), and so are the optimal labor tax rate and transfers.

[Figure 2.4 approximately here]

We can see from the left panel of the figure (which assumes $\theta^h = 1$) that increases in the labor tax rate have almost no effect on consumption inequality if $\omega = \lambda$. In such a scenario transfers are evenly targeted between households, and as a result, a tax-financed increase in transfers does not allow for redistribution. However, when $\omega = 1$, an increase in transfers financed by an increase in the labor tax rate has a strong impact on the consumption ratio $\frac{c^h}{c^s}$, and such a policy allows the planner to reduce consumption inequality. Note that, as there is little ex-ante heterogeneity between households (the two agents are equally productive), the first-best is almost attainable by the planner when $\omega = \lambda$. Moreover, in such a case, increases in the tax rate *increase* consumption inequality, so there is no trade-off between efficiency and redistribution and under this parameterization (as will be shown below), the optimal allocation features a zero labor tax rate.

When hand-to-mouth households are less productive than Ricardian households (as in the right panel of Figure 2.4, for which we assume $\theta^h = 0.7$), a similar picture arises: increases in the labor tax rate affect consumption inequality only if transfers are unevenly distributed among households (which is the case when $\omega = 1$). However, the first best solution is now unreachable at any value of $\omega$. Under an evenly distributed transfer rule, the planner never achieves to equalize consumption between households, while it requires a large labor tax rate to ensure consumption equality between households when transfers are targeted towards hand-to-mouth households.

Figure 2.4 shows that in some cases, increases in transfers (financed by positive labor taxes) allow the planner to reduce the consumption gap between households. Nevertheless, because such a policy implies efficiency losses (as higher labor taxes distort labor supply), we might wonder whether such a policy can be welfare improving. In the following section, we show under which conditions it is indeed optimal for the planner to set a positive labor tax rate.

### 2.4.2 Optimal taxes and transfers

The following proposition provides the condition under which it is optimal for the planner to set a positive labor tax.

**Proposition 1:** Given an inherited level of government debt $b_{-1}$ and in the absence of stochastic shocks, the optimal long-run tax rate of labor is strictly positive if:

$$\frac{c^*}{c^{s*}} + \omega\Big(c^* - (1-\beta)b_{-1}\Big)\Big(\frac{1}{c^{h*}} - \frac{1}{c^{s*}}\frac{\theta^h(1+\phi\frac{c^{h*}}{n^{h*}})}{\theta^h + \phi\frac{c^{h*}}{n^{h*}}}\Big) > 1 \tag{2.20}$$

where variables with a "$*$" are evaluated at the allocation implied by setting $\tau = 0$: for any $x$, $x^* = x|_{\tau=0}$ .

***Proof:*** The above proposition essentially provides the condition under which, in the steady-state allocation, aggregate welfare is increasing in $\tau$, when $\tau = 0$. More formally, it provides an expression for $\frac{dU}{d\tau}|_{\tau=0} > 0$, which is obtained by totally differentiating the system of steady-state model equations.

In the steady-state allocation, the competitive equilibrium can be represented by:

$$
\begin{gathered}
(1-\beta)b_{-1} = \tau(\lambda n^h + (1-\lambda)n^s) - g - T \\
c^h = (1-\tau)\theta^h n^h + \frac{\omega}{\lambda}T \\
c^s = (1-\beta)b_{-1} + (1-\tau)n^s + \frac{1-\omega}{1-\lambda}T \\
(n^h)^\phi c^h = \theta^h(1-\tau) \\
(n^s)^\phi c^s = 1-\tau
\end{gathered}
$$

This gives us a system of 5 equations in $(c^h, c^s, n^h, n^s, T, \tau)$. Totally differentiating the equations, we obtain a system in $(dc^h, dc^s, dn^h, dn^s, dT, d\tau)$, that we can rearrange to get:

$$
\begin{aligned}
dn^h &= \left(\tau\lambda\theta^h + \phi\frac{\lambda}{\omega}\frac{c^h}{n^h} + \frac{\lambda}{\omega}(1-\tau)\theta^h - \tau\frac{\lambda\theta^h(1+\frac{c^h}{n^h}\phi)}{1+\phi\frac{c^s}{n^s}}\right)^{-1} \\
&\quad \left(\frac{\lambda}{\omega}\theta^h n^h - n + \frac{\tau}{1-\tau}\frac{c}{1+\phi\frac{c^s}{n^s}} - \frac{\lambda}{\omega}\frac{c^h}{1-\lambda}\right)d\tau \\
dn^s &= \left((1-\lambda)(1+\phi\frac{c^s}{n^s})\right)^{-1}\left(-\lambda\theta^h(1+\phi\frac{c^h}{n^h})dn^h - \frac{c}{1-\tau}d\tau\right) \\
dc^h &= -\frac{c^h}{1-\tau}d\tau - \phi\frac{c^h}{n^h}dn^h \\
dc^s &= -\frac{c^s}{1-\tau}d\tau - \phi\frac{c^s}{n^s}dn^s
\end{aligned}
\tag{2.21}
$$

Totally differentiating aggregate welfare gives:

$$
dU = \lambda(u_c^h\, dc^h - v_n^h\, dn^h) + (1-\lambda)(u_c^s\, dc^s - v_n^s\, dn^s) \tag{2.22}
$$

Making use of the system (2.21) in (2.22) , setting $\tau = 0$ and rearranging, we get the result stated in expression (2.20). ■

Proposition 1 gives us the condition under which setting positive labor taxes is welfare improving. In the next paragraphs, we describe three specific cases which help interpreting this result. Then, we study the effect of two specific parameters, the individual productivity of constrained agents ($\theta^h$) and the share of transfers going to these agents ($\omega$), on the optimal tax rate.

**Representative agent:** The first special case we consider is the representative agent version of the model, under which both distortionary taxes and lump-sum transfers (or taxes) are available. In such a setting, it is well-known that Ricardian equivalence holds and the planner chooses to entirely finance deficits at any time using lump-sum taxes, therefore setting $\tau = 0$. This can be seen by setting, $c^{s*} = c^{h*} = c^*$, and $\theta^h = 1$ in the above expression. In this case, the left-hand size of the condition is equal to one, and it is therefore sub-optimal to set $\tau > 0$.

**Two-agent, evenly distributed transfers:** Turning to the two-agent case, we assume first that $\omega = \lambda$ , $\theta^h = 1$ , $b_{-1} = 0$ and $g > 0$. In such a case, the two households have the same amount of resources available in the steady-state, as (i) they are equally productive, (ii) no agent holds assets, and (iii) transfers affect each agent in the same way. The assumption of positive government spending implies a need for the government to generate resources by taxation to satisfy its budget constraint. In such a scenario, we can show that, as in the representative agent case, the LHS of the expression stated in Proposition is equal to 1, and therefore the optimal labor tax is zero. It reflects the fact that, when the two households have similar characteristics, it is optimal to finance fiscal deficits with lump-sum taxes, if such an instrument is available to the planner. Because the two agents have similar characteristics, the optimal allocation is the one that maximizes aggregate consumption and output; this allocation is obtained by setting $\tau = 0$ and financing the entire deficit lump-sum.

**Two-agent, transfers directed towards HTM households:** As a third example, we still assume that $\theta^h = 1$ , $b_{-1} = 0$ and $g > 0$, but we now set $\omega = 1$, such that transfers are fully targeted towards hand-to-mouth households. In this case, the LHS of the above condition boils down to $\frac{c^*}{c^{h*}}$. We can easily show from the steady-state model equations that, in such a scenario, $c^{s*} > c^{h*}$, and then $\frac{c^*}{c^{h*}} > 1$. Then, according to Proposition 1 the optimal long-run tax is positive. This is the case because, when the labor tax rate is zero, government expenditures are entirely financed by a lump-sum tax on hand-to-mouth agents, which reduces their consumption level, while Ricardian households are not impacted by such a tax. The planner thus finds it optimal to spread the tax burden across households by setting a positive labor tax rate. However, the optimal allocation does not equalize consumption/hours and welfare levels across household types: the efficiency costs associated with higher distortionary taxes imply that it is not optimal for the planner to fully wipe out any level of cross-sectional inequality.

[Figure 2.5 approximately here]

In Figure 2.5, we display aggregate steady-state welfare as a function of the labor tax, for the parametrization just described. We can see from the Figure that the tax rate which maximizes welfare (as shown by the red circle) is approximately 15%. At this value, the transfer is still negative, but is such that the costs associated to government spending are more equally shared between households.

**Effect of key parameters**

We now solve for the steady-state of the Ramsey allocation, and look at the properties of the optimal tax schedule. We are primarily interested in identifying the effect of key model parameters on the behaviour of fiscal variables. We set the parameters to their baseline values, as described in Section 2.3 and summarized in Table 2.2, and then look at the impact of changing one parameter at a time on the behaviour of the steady-state labor tax. The results of this exercise are displayed in Figure 2.6.

[Figure 2.6 approximately here]

Panel (a) shows the effect of $\omega$, the parameter targeting the share of transfers going to hand-to-mouth households, on the long-run optimal tax rate. As we can see from the Figure, the effect of $\omega$ on the optimal tax rate is non-monotonic: at low values of $\omega$ (when most of the transfer is directed towards Ricardian agents), the optimal tax rate is decreasing with $\omega$, and reaches zero for values which are close to $\lambda$. Then, as $\omega$ starts increasing again, the tax rate becomes higher. This result emerges because, when transfers are evenly distributed among households ($\omega$ is close to $\lambda$), increasing them do not allow for much redistribution across households. Therefore, it is optimal to finance the deficit by decreasing transfers, which allows the planner to reduce the labor tax rate and thereby minimize its distortionary effects.[17]

In Panel (b) of the figure we look at the effects of the relative productivity of constrained agents ($\theta^h$). The solid blue line provides results for the case where $\omega = \lambda$ (evenly distributed transfers), while the dashed black line is for the case where $\omega = 1$ (transfers targeted towards HTM agents). In this case too, the optimal labor tax is non-monotonic. At low values of $\theta^h$, 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

[17] As it has been showed formally above, when the transfer is entirely lump-sum ($\omega = \lambda$), lump-sum taxes finance spending needs and the optimal labor tax is zero.

hand-to-mouth agents closer to the one of Ricardian households, even if it comes with an efficiency cost. At high levels of $\theta^h$, the optimal labor tax is increasing when $\omega = \lambda$, while it stays at zero when $\omega = 1$. In the former case, the relative productivity of hand-to-mouth agents becomes so high that it is optimal to redistribute resources towards Ricardian households by increasing labor taxes and transfers. In the latter case, redistribution towards savers is impossible, hence there is no tax response when $\omega = 1$ (dashed line).

Panels (c) and (d) display the results of changes in steady-state debt levels and government spending. Unsurprisingly, we observe that, when spending needs increase (higher values of $b$ and $g$), the optimal labor tax increases.

We have seen throughout this section that, in the long-run allocation, when heterogeneity is sufficiently high, it is optimal to redistribute across households through setting $\tau > 0$, even though this comes at the cost of higher tax distortions. In the next section we introduce dynamics and study the properties of the Ramsey allocation out of the steady-state.

## 2.5 Optimal responses to shocks

In the previous section, we showed how the Ramsey allocation departs from the first-best in the long-run. We now analyze the cyclical properties of the model when the economy is hit by random shocks. We first present theoretical results which allow us to discuss the properties of the optimal labor tax schedule. In particular, we study the link between fluctuations in consumption/hours heterogeneity between households, market (in)completeness, and the volatility of labor taxes in the Ramsey allocation. Then, we rely on numerical simulations to study the response of key variables to the stochastic shocks present in the model.[18]

### 2.5.1 Heterogeneity, market (in)completeness, and optimal labor taxes

We first analyze the properties of the optimal labor tax schedule.[19] We start with the following proposition, which characterizes the optimal labor tax rate in the two-agent model presented above:

[18]Throughout the paper, we solve the model using linear perturbation techniques around the initial steady-state.

[19]We focus on taxes and not transfers, as it allows us to directly compare our results to the ones obtained in representative agent models that are common in the Ramsey literature, and in which the planner is usually not allowed to choose transfers optimally.

**Proposition 2:** When the planner has access to distortionary taxes and transfers, and financial markets are incomplete, the optimal labor tax rate can be expressed as:

$$\tau_t = 1 - \frac{(H_t^c)^{-1}\Big[1 + (\Psi_t^{IM} - \Psi_{t-1}^{IM})\frac{b_{t-1}}{c_t^s}\Big]}{H_t + (1+\phi)\Big[1 - \frac{\lambda}{\omega}\theta_t^h \frac{h_t^n}{H_t^n}\Big]\Psi_t^{IM}} \tag{2.23}$$

where $h_t^c \equiv \frac{c_t^h}{c_t^s}$; $h_t^n \equiv \frac{n_t^h}{n_t^s}$; $H_t^c \equiv \lambda h_t^c + 1 - \lambda$; $H_t^n \equiv \lambda\theta_t^h h_t^n + 1 - \lambda$; $H_t \equiv (\lambda\theta_t^h \frac{h_t^n}{h_t^c} + 1 - \lambda)/H_t^n$.

When markets are complete, the multiplier associated with the budget constraint is constant ($\Psi_t^{IM} = \Psi \; \forall \; t$), and the expression becomes:

$$\tau_t = 1 - \frac{(H_t^c)^{-1}}{H_t + (1+\phi)\Big[1 - \frac{\lambda}{\omega}\theta_t^h \frac{h_t^n}{H_t^n}\Big]\Psi}$$

***Proof:*** We can rewrite the first order conditions given in section 2.3.1 (rearranging and using $\frac{v_{n,t}^s}{u_{c,t}^s} = \frac{v_{n,t}^h}{\theta_h u_{c,t}^h} = a_t(1\breve{}\tau))$ as follows:

$$\begin{aligned}
\Psi_t^2 a_t(1\breve{}\tau_t)\frac{u_{cc,t}^h}{u_{c,t}^h} &= -\lambda u_{c,t}^h + \lambda\Psi_t^1 + \Psi_t^3 u_{c,t}^s \\
\Psi_t^2 a_t(1\breve{}\tau_t)\frac{u_{cc,t}^s}{u_{c,t}^s} &= (1-\lambda)u_{c,t}^s - \Psi_t^1(1-\lambda) - u_{cc,t}^s\Psi_t^3(c_t^h - \frac{\omega}{\lambda}T_t) \\
&\quad + \Psi_t^{IM}u_{cc,t}^s(a_t n_t - g_t - T_t) - u_{cc,t}^s b_{t-1}\Big[\Psi_t^{IM} - \Psi_{t-1}^{IM}\Big] \\
\Psi_t^2 a_t(1\breve{}\tau_t)\frac{v_{nn,t}^h}{v_{n,t}^h} &= -\lambda v_{n,t}^h + \Psi_t^{IM}(u_{c,t}^s a_t - v_{n,t}^s)\lambda\theta_t^h + \Psi_t^1 a_t\lambda\theta_t^h + \Psi_t^3 v_{n,t}^s\theta_t^h \\
\Psi_t^2 a_t(1\breve{}\tau_t)\frac{v_{nn,t}^s}{v_{n,t}^s} &= (1-\lambda)v_{n,t}^s - \Psi_t^{IM}\Big[(1-\lambda)(u_{c,t}^s a_t - v_{n,t}^s) + v_{nn,t}^s n_t\Big] \\
&\quad - \Psi_t^1(1-\lambda)a_t - \Psi_t^3 v_{nn,t}^s\theta_t^h n_t^h
\end{aligned} \tag{2.24}$$

Merging the expressions of the system (2.24), and using functional forms given in (2.17), we get:

$$\begin{aligned}
&\Big[\frac{c_t^h}{c_t^s}\lambda + 1 - \lambda\Big]\Big[\frac{n_t^h}{n_t^s}\Big(\lambda\frac{v_{n,t}^h}{u_{c,t}^h}u_{c,t}^h - \Psi_t^{IM}\lambda\theta_t^h a_t\tau_t u_{c,t}^s - u_{c,t}^s\Psi_t^3\frac{v_{n,t}^s}{u_{c,t}^s}\theta_t^h a_t\Big) + (1-\lambda)\frac{v_{n,t}^s}{u_{c,t}^s}u_{c,t}^s \\
&\qquad - \Psi_t^{IM}\Big((1-\lambda)a_t\tau_t u_{c,t}^s - \frac{v_{n,t}^s v_{nn,t}^s}{n_t^s v_{n,t}^s}n_t n_t^s\Big) - \Psi_t^3 n_t^s\frac{v_{nn,t}^s}{v_{n,t}^s}\theta_t^h a_t\frac{n_t^h}{n_t^s}v_{n,t}^s\Big] = \\
&\Big[\frac{n_t^h}{n_t^s}a_t\theta_t^h\lambda + (1-\lambda)a_t\Big]\Big[\frac{c_t^h}{c_t^s}(\lambda u_{c,t}^h - \Psi^3 u_{c,t}^s) + (1-\lambda)u_{c,t}^s + \Psi_t^{IM}u_{cc,t}^s(c_t - T_t) \\
&\qquad - \Big(\Psi_t^{IM} - \Psi_{t-1}^{IM}\Big)u_{cc,t}^s b_{t-1} - \Psi_t^3 u_{cc,t}^s(1-\tau_t)a_t\theta_t^h n_t^h\Big]
\end{aligned}$$

Dividing both sides by $u^s_{c,t}$ and $a_t$, we get:

$$\begin{aligned}
&\Big[\frac{c^h_t}{c^s_t}\lambda + 1 - \lambda\Big]\Big[\frac{n^h_t}{n^s_t}\Big(\lambda\theta^h_t(1\breve{}\,\tau)\frac{u^h_{c,t}}{u^s_{c,t}} - \Psi^{IM}_t\lambda\theta^h_t\tau_t - \Psi^3_t\theta^h_t(1-\tau_t)\Big) + (1-\lambda)(1\breve{}\,\tau_t) \\
&\qquad -\Psi^{IM}_t\Big((1-\lambda)\tau_t - \phi(1-\tau_t)(\lambda\frac{n^h_t}{n^s_t}\theta^h_t + 1 - \lambda)\Big) - \Psi^3_t\phi\theta^h_t\frac{n^h_t}{n^s_t}(1-\tau_t)\Big] \quad = \\
&\Big[\frac{n^h_t}{n^s_t}\theta^h_t\lambda + 1 - \lambda\Big]\Big[\frac{c^h_t}{c^s_t}(\lambda\frac{u^h_{c,t}}{u^s_{c,t}} - \Psi^3_t) + (1-\lambda) - \Psi^{IM}_t(\lambda\frac{c^h_t}{c^s_t} + 1 - \lambda - \frac{T_t}{c^s_t}) \\
&\qquad + \Big(\Psi^{IM}_t - \Psi^{IM}_{t-1}\Big)\frac{b_{t-1}}{c^s_t} + \Psi^3_t\Big(\frac{c^h_t}{c^s_t} - \frac{\omega}{\lambda}\frac{T_t}{c^s_t}\Big)\Big]
\end{aligned} \tag{2.25}$$

Rearranging (2.25) and using $\Psi^3_t = \frac{\lambda}{\omega}\Psi^{IM}_t$, we get the tax expression given in (2.23). ■

As we can see from equation (2.23), when markets are incomplete changes in the optimal tax rate reflect changes in two types of variables: $\Psi^{IM}_t$, which denotes the multiplier on the government budget constraint (2.1) in the Lagrangian associated with the Ramsey problem, and variables related to household heterogeneity $(h^c_t, h^n_t, H^c_t, H^n_t, H_t)$. Notice that in the absence of heterogeneity these elements are all equal to one. In contrast, under complete markets, $\Psi$ is constant and only $h^c_t, h^n_t, H^c_t, H^n_t, H_t$ affect the optimal allocation.[20]

In order to study the effects of heterogeneity on the optimal tax schedule, we provide the counterpart of equation (2.23) in the representative agent case, where only distortionary taxes are available to the planner.[21] In the Appendix, we show that in this case the labor tax expression is:

$$\tau^R_t = 1 - \frac{1 + (\Psi^R_t - \Psi^R_{t-1})\frac{b_{t-1}}{c_t}}{1 + (1+\phi)\Psi^R_t} \tag{2.26}$$

under incomplete markets, and $\tau^R = 1 - \frac{1}{1+(1+\phi)\Psi^R}$ when markets are complete.[22] Therefore, it turns out that the tax rate in the representative agent model is a special case of our two-agent economy, in which the calibration is such that all agents are Ricardian and there is no more heterogeneity in the model.[23]

[20]Note that, as mentioned above, the steady-state allocation is the same under complete and incomplete markets. Under incomplete markets, the multiplier $\Psi$ is time-varying. When markets are complete, this multiplier is constantly equal to its steady-state value (see Aiyagari et al., 2002).

[21]Introducing lump-sum transfers/taxes in such a framework would imply a trivial response of fiscal variables: labor taxes would be constant at zero, and lump-sum taxes would finance the inter-temporal budget of the government, thereby allowing the government to complete the market.

[22]The constant optimal tax rate on labor is a well-known property of this class of model when the elasticity of labor supply is constant, as is the case under the functional form for individual preferences stated in (2.17).

[23]The tax rate in the representative agent model can be obtained from equation (2.23) by setting $\lambda = 0$, $h^c_t = h^n_t = H^c_t = H^n_t = H_t = 1$, and $c^s_t = c_t$.

The above property is useful to decompose the effect of heterogeneity and incomplete markets on the optimal labor tax. To simplify the exposition, we log-linearize expressions (2.23) and (2.26), to obtain:

$$\hat{\tau}_t^R = \tau \hat{\Psi}_t^R - \hat{\psi}_t^R \tag{2.27}$$

for the representative agent case, and

$$\begin{aligned}\hat{\tau}_t = \; & \underbrace{\tau \hat{\Psi}_t - \hat{\psi}_t}_{\text{(a) IM}} + \underbrace{(1-\tau)(1-H^c H)\hat{\Psi}_t}_{\text{(b) IM + Heterogeneity}} + \\ & \underbrace{\hat{H}_t^c + (1-\tau)H^c H \hat{H}_t + \Big[1 - H^c\Big(1-\tau\Big)\Big(H + (1+\phi)\Psi\Big)\Big]\Big(\hat{\theta}_t^h + \hat{h}_t^n - \hat{H}_t^n\Big)}_{\text{(c) Heterogeneity}}\end{aligned} \tag{2.28}$$

for the two-agent version. Variables with hats denote log-deviations from steady state ($\hat{x}_t = \log(\frac{x_t}{x})$)[24], and variables without time subscripts denote steady-state values. We also define $\psi_t \equiv 1 + (\Psi_t - \Psi_{t-1})\frac{b_{t-1}}{c_t^s}$, and similarly for $\psi_t^R$ in the representative agent case.

We can distinguish two main components in the characterization of labor tax fluctuations given by equation (2.28).[25] The first component (elements $a$ and $b$) is related to market incompleteness, and summarizes the co-movement between the labor tax and the multiplier on the government budget constraint $\Psi_t$. Note that, when comparing the equation with its representative agent version in (2.27), we can see that the introduction of heterogeneity implies an additional term related to market incompleteness (the component $b$). It implies that heterogeneity can amplify/dampen the effects of market incompleteness on tax volatility, depending on the sign of $1 - H^c H$. However, for plausible parameter values, this effect is likely to be small.

The second component, summarized in the term $c$, shows that the tax rate in the Ramsey allocation is also affected by variables related to household heterogeneity. It means that consumption and hours dispersion between households introduces an additional source of tax volatility in the two-agent model, compared to the representative agent counterpart.

Together, these two forces (market incompleteness and heterogeneity) imply that, for labor taxes to have low volatility, two conditions must be met. First, it is required that shocks affecting government deficits can be financed in a non-distorting way, i.e. through changes in lump-sum taxes, or through the accumulation of state-contingent claims when markets are complete. These two policies allow the government to finance its deficit while having little impact on households' welfare. Therefore, the volatility of the multiplier on

[24]With the exception of $\hat{\tau}_t \equiv -\log\left(\frac{1-\tau_t}{1-\tau}\right)$. This way, $\hat{\tau}_t$ represents the approximated change in the tax rate in percentage points, rather the percentage change from its steady-state value. This makes results easier to interpret and facilitates the comparison between the representative agent and two-agent versions of the model, because these models do not feature the same steady-state tax rate.

[25]We should stress here that expressions (2.23) and (2.28) do not constitute optimal tax reaction functions for the fiscal authority. Instead, they describe relationship between taxes and other model variables which are satisfied along the Ramsey equilibrium path, and in this sense only they help to shed light of the mechanisms at play in the model.

the government budget constraint ($\Psi_t$) is low and little variations in labor taxes arise from elements (a) and (b) of expression (2.28).

Second, it must be that shocks can be financed through a policy that limits variations in consumption and hours dispersion between households. In our model, the impact of fiscal policy on heterogeneity is influenced by the design of the sharing rule for transfers (the value of the parameter $\omega$): if $\omega \approx \lambda$, variations in transfers imply little redistribution between households. In this case, variations in transfers are an efficient way to finance deficits in response to shocks that have little impact on heterogeneity, as they do not distort labor supply and do not exacerbate fluctuations in heterogeneity terms. For this reason, variations in transfers provide a good hedge against the aggregate shocks present in the model (government spending and TFP shocks). For values of $\omega$ away from $\lambda$, transfers imply redistribution and can therefore not be used in such a way. However, in this case they are efficient in bringing down fluctuations in heterogeneity arising from shocks that affect households unequally, such as the shocks to the productivity of hand-to-mouth households ($\theta^h$). To shed light on these properties, the next section studies the response of taxes to shocks under different model specifications.

### 2.5.2 Impulse responses

**Aggregate shocks** Figure 2.7 displays the response of taxes to the two aggregate shocks present in the model (government spending, and TFP shocks), for the parametrization in which $\omega = \lambda$, i.e. where transfers are evenly distributed between the two households. We also provide in this figure the decomposition of the tax rate following equation (2.28). The main insight emerging from the figure is the following. Comparing the representative agent model (dashed black line) to the two-agent model (solid blue line), we observe that the tax response to any aggregate shock is stronger in the model featuring a representative agent. As explained above, fluctuations in the tax rate can be decomposed in two parts: a component related to market incompleteness, and a component related to heterogeneity. For each shock, we display the contributions of these two elements in the middle and bottom panels of Figure 2.7. As can be seen from the figure, the main difference between the representative agent model and the two-agent model lies in the weaker variation in the component related to market incompleteness. This result comes from the fact that, in the two-agent setting, the planner can use variations in transfers to finance her inter-temporal budget, and thus does not have to rely entirely on labor tax fluctuations. Because the use of transfers does not generate distortions, the shocks have a smaller effect on the $\Psi$ multiplier, and we observe in the middle panels of the figure that the tax component linked to market incompleteness responds less strongly to shocks in the two-agent framework. This implies that the planner is able to rely on fluctuations in transfers to bring the economy closer to the complete market allocation. Indeed, the solid blue lines (depicting the response of variables in the incomplete markets version of the two-agent framework), are close to the dotted cyan lines, which provide the response of variables in the complete markets version. Moreover, the planner can implement this transfer policy at low costs because, as can be seen from the bottom panels of the figure, the policy response is also associated with weak responses in the component associated with heterogeneity. Therefore, the policy implemented by the planner allows her to contain fluctuations in heterogeneity, while financing the deficit in a non-distorting way.

[Figure 2.7 approximately here]

The case of government spending shocks is a good illustration of this result. Following such a shock, the response of labor taxes is mute when $\omega = \lambda$, because financing the impact of the shock with transfers only allows the planner to spread the implied fiscal costs equally between households, in such a way that the dispersion in consumption and hours worked between them is left unaffected. Financing government spending shocks with transfers (or, in this case, lump-sum taxes) therefore implies that there is no variation in the multiplier $\Psi$ (because transfers are non-distortive), and no variations in the variables summarizing heterogeneity. Both of these forces translate into no change in the tax rate following the shock.

To shed light on the mechanisms outlined in the previous paragraphs, we also provide in Figure 2.7 the tax response for a version of the two-agent model where only distortionary taxes are available.[26] The results are depicted in the dotted red lines. We can see that, in this setup, the tax response to shocks is similar to the one obtained in the representative agent model. This shows that, when transfers are not available and the labor tax is the main instrument allowing the government to finance the government budget, the resulting tax volatility implied by market incompleteness is stronger.

[Figure 2.8 approximately here]

In Figure 2.8 we consider the case where transfers are fully targeted towards hand-to-mouth households ($\omega = 1$). We can see from the figure that in this model version, the tax response is stronger than in the case where $\omega = \lambda$, which was displayed in the previous figure. This result arises from the fact that, under the present calibration, fluctuations

[26] In this case, the tax expression, as stated in Proposition 2 and equation (2.28) is slightly altered. We provide the tax expression in this model version in Appendix 2.7.2.

in transfers cannot be used to finance the government budget without impacting heterogeneity between households. As a result, the planner is not able to use transfers to bring the economy closer to the complete markets allocation, while keeping consumption and hours dispersion close to constant. This can be seen from comparing the solid blue lines with the dotted cyan lines which depict the response under complete markets: contrarily to the case where transfers are evenly distributed across households, when $\omega = 1$ the response of taxes under incomplete markets is much stronger than in the complete markets counterpart. Unevenly targeted transfers makes the policy of absorbing the shocks solely through variations in transfers sub-optimal. As a result, a bigger share of the intertemporal budget is financed through changes in the labor tax rate, which becomes more volatile. We can see from Figure 2.8 that, following government spending and technology shocks, the policy response implies little changes in variables describing heterogeneity, and makes fluctuations in the second component of taxes (bottom panels) very low. Indeed, most of the tax volatility implied by the shocks comes from the impact of market incompleteness (middle panels).

**Shocks to hand-to-mouth productivity** In Figure 2.9 we study the response of key variables to a positive shock to the individual productivity of hand-to-mouth households ($\theta^h$). The top panels display the case where $\omega = \lambda$, while the bottom panels are obtained setting $\omega = 1$. The key takeaway from this figure is the following. We observe that in the two cases, and both under complete and incomplete financial markets, transfers drop following the shock. 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. We observe that the fall in transfers is higher when $\omega = \lambda$: because in this case transfers are evenly distributed between agents, the planner needs to engineer a bigger reduction to produce the desired effect on hand-to-mouth agents' budget constraint.

[Figure 2.9 approximately here]

Turning to the response of the labor tax rate, we can see from the figure that, as was the case for aggregate shocks, the component related to market incompleteness is still the one explaining most of the tax change. Indeed, under complete markets (dotted cyan lines), the response of the labor tax is much weaker than under incomplete markets (solid blue lines), and the response of the incomplete markets component of the tax rate is much stronger than the one summarizing the effect of heterogeneity. Therefore, even though the shock considered here affects heterogeneity in a non-negligible way (even after accounting for the optimal transfer response), this effect does not have much influence on the volatility of labor taxes. This brings us to the conclusion that, in the model presented here, market incompleteness is the main component influencing the volatility of labor taxes, no matter which shock is considered.

Comparing the case where $\omega = \lambda$ to the one where $\omega = 1$, it can be observed that, under incomplete markets, the sign of the labor tax response is opposite: it increases in the first case, and decreases in the second. This is the case because, when variations in transfers affects the two households equally ($\omega = \lambda$), the total drop in transfers for HTM agents is weaker. This implies a lower negative wealth effect on these households, which then decide to increase their labor supply by a lesser amount. All in all, the aggregate labor supply drops, and so do labor tax revenues. This has the effect of tightening the government budget constraint (the multiplier $\Psi$ increases), and calls for an increase in the labor tax rate. When transfers are fully targeted towards HTM households ($\omega = 1$), the drop in transfers is big enough to induce a labor supply response which has the effect of increasing total labor effort, and tax revenues. It loosens the government budget constraint, and implies a fall in the labor tax.

Let us also stress that, in the two cases considered in Figure 2.9, when markets are incomplete, the initial tax response when the shock occurs overshoots its response in the subsequent periods. This property is known in the optimal fiscal policy literature under the name of *interest rate twisting* (see e.g. Faraglia et al., 2019a): the Ramsey planner uses fluctuations in the tax rate to influence households' consumption path and therefore manipulate bond prices to influence borrowing conditions and use government debt as an active fiscal policy tool. In our model, because the bond is priced by Ricardian households, the planner seeks to influence this price through changing the consumption path of these agents only. Following a shock, she therefore uses the proper combination of labor taxes and transfers to induce a kink in the consumption process of Ricardian agents, while keeping the consumption path of hand-to-mouth households as smooth as possible.

**Discussion** To end this section, we want to stress the importance of the transfer sharing rule, summarized by the parameter $\omega$, in shaping the optimal behavior of the labor tax rate. This parameter specifies the share of total transfers going towards hand-to-mouth households. As discussed above, the impact of $\omega$ on optimal policy depends on the type of shocks hitting the economy. When shocks affect individual households in a similar way (which is the case for government spending and productivity shocks in our model), the labor tax rate remains constant only when $\omega$ is close to $\lambda$. In this case, the planner uses transfers to finance its deficit, and such a policy does not impact consumption and hours heterogeneity. In contrast, when $\omega$ gets away from $\lambda$, as in our example assuming $\omega = 1$, transfers are redistributive and financing deficits using them can be welfare detrimental, as such a policy exacerbates consumption and hours heterogeneity. In this case the optimal policy features more tax volatility.

When the economy is hit by household-specific shocks (such as a shock to $\theta^h$ in our model), labor taxes are also less volatile when $\omega \approx \lambda$. However, in this case consumption heterogeneity between household is greater, as fiscal instruments do not allow the planner to reduce household heterogeneity.

### 2.5.3 Matching the empirical properties of transfers

In this section we assess whether our optimal fiscal policy model is able to match some of the key moments that summarize the business cyclical properties of macroeconomic and fiscal variables in the US. In particular, we study the co-movement between transfers, deficits, output and the market value of debt.

We are particularly interested in the ability of our model to match the following data properties. First, the negative correlation between transfers and GDP, and the positive correlation between transfers and the primary deficit, which have been described in Section 2.2. Being able to generate counter-cyclical transfers with our model will be possible (i) if there is less need for redistribution in expansions, meaning that transfers can be decreased without negatively impacting households' welfare; and (ii) if the government is willing to consolidate its budget in an expansion, and thereby decides to decrease transfers to generate fiscal surpluses. To generate the positive correlation between transfers and deficits, it is key that variations in transfers are not used to compensate for rising deficits implied, for instance, by a rise in government spending. Transfers should, on the contrary, be one of the main drivers behind changes in primary deficits.

Second, we are interested in the co-movement between deficits and the market value of debt (positive in the US data). Marcet and Scott (2009, MS) analyze the ability of simple optimal fiscal policy models to reproduce key facts related to the behaviour of government debt. They show that, in representative agent models, when markets are complete, the market value of debt falls in response to shocks that force the deficit to increase. Moreover, the optimal portfolio pays out more than the actual income shock to compensate for higher future deficits when shocks are persistent. This is what MS call the "over-insurance" effect. Hence, the co-movement between deficits and debt is negative when the government can issue state-contingent securities, which is at odds with what is observed empirically. In the incomplete markets case, the market value of debt cannot decrease when deficits rise, and the government issues more debt to absorb the shock. Therefore, there is a positive correlation between deficits and debt in the representative agent, incomplete markets benchmark.

Third, we are interested in the persistence of the market value of government debt. Throughout this section, we follow MS and use the *k-variance* to measure the persistence of government debt. The k-variance of a random variable $x$ at horizon $k$ is defined as:

$$Var_k(x) = \frac{Var(x_t - x_{t-k})}{kVar(x_t - x_{t-1})} \quad \text{for} \quad k = 1, 2, ...$$

This object is a measure of the persistence of a random variable: when a process reverts to its mean, its k-variance converges to zero; otherwise it takes a higher value. MS show that Ramsey models with complete markets imply no persistence of debt (the k-variance quickly converges to zero, which is at odds with the actual behaviour of US government debt), while incomplete markets models imply very persistent levels of debt, such that the k-variances obtained from these models usually overshoot their data counterpart.

In the previous sections, we have already seen that, in our two-agent, incomplete markets setting, the use of transfers to finance the government budget allows the planner to reduce tax distortions and brings the optimal allocation close to its complete markets counterpart. Such a property is both a threat and an opportunity for the ability of our model to reproduce the moments of interest. On the one hand, it might prevent the model to generate the desired co-movements between deficits, output and the market value of debt that are usually generated in a representative agent framework with incomplete markets. However, on the other hand, it might help the incomplete markets model to generate a lower persistence of debt, thereby overcoming the overshooting feature outlined by MS. The object of this section is therefore to study whether our two-agent model can help bringing the persistence of debt closer to its empirical counterpart while also doing a good job matching the other properties mentioned above.

The next subsection makes use of the impulse response functions of key fiscal variables to each of the shocks present in the model, under the calibration described in Table 2.2, to shed light on the ability of the model to match the moments described above. We then make use of the simulated method of moments to choose the model parameters in order to match a broad vector of moments computed from US data.

### Impact of shocks on the cyclical properties of fiscal variables

Figure 2.10 depicts the impulse response of the main fiscal variables, consumption and output for each of the three shocks present in the model, in the incomplete markets version of the framework with $\omega = \lambda$ (top panels), and $\omega = 1$ (bottom panels). This allows us to analyze the impact of shocks on the co-movement between variables, as described above.

**Government spending shocks:** The solid blue lines in Figure 2.10 depict the responses to a positive government spending shock. As described in the previous section, when the shock hits, households work more and the planner reduces transfers to finance the shock. When transfers are evenly distributed between households ($\omega = \lambda$), the combined effect of increased hours and decreased transfers enables the deficit to remain constant. Hence, while the co-movement between transfers and output is negative following a $g$ shock, the co-movement between deficit and output is almost null.

When transfers are directed towards hand-to-mouth households only ($\omega = 1$), the deficit cannot be insulated from the shock. Indeed because of their effect on heterogeneity, the planner is not willing to use transfers to absorb the shock entirely. Therefore, it is sub-optimal to use variations in transfers to bring the economy close to the complete markets allocation. As such, government spending shocks imply positive co-movements between deficits and output and between deficits and the market value of government debt, the former being at odds with what we see in the data.

[Figure 2.10 approximately here]

**TFP shocks:** Dashed red lines of Figure 2.10 describe the response of variables to a positive TFP shock. When $\omega = \lambda$, transfers, deficits and output increase on impact. Then, as the shock fades away, transfers and deficits continue to increase, while output decreases to return to its steady-state value. Hence, the co-movement between these variables is positive.

When $\omega = 1$, transfers remain approximately constant. Then, there is no co-movement between transfers and output, and between transfers and deficits. Note that, in this case, the market value of debt and deficits have a positive co-movement, which is not the case when $\omega = \lambda$.

**Shocks to the productivity of HTM agents:** Dotted black lines of Figure 2.10 depict the response of variables to an increase in the productivity of hand-to-mouth households. Following the shock, we observe a big drop in transfers and an important increase in output. This is true for the two values of $\omega$ that are considered. Overall, output and transfers co-move negatively, and output and deficits too. We can also see from the graph that the response of deficits and the market value of debt is negative, implying a positive co-movement between the two variables, as is the case in the US data.

From this analysis of the impulse responses of fiscal variables to various shocks, we can draw two important conclusions. First, when transfers are unevenly targeted towards hand-to-mouth households ($\omega > \lambda$), our model produces moments that are getting closer to their empirical counterpart. Second, it appears that the only shock that enables the model to jointly match the empirical moments discussed in the preceding sections is the shock to the productivity of hand-to-mouth households $\theta^h$. Hence, the values of $\omega$ and the properties of the $\theta^h$ shock are likely to be key to allow the model to match the behaviour of US data moments, a task that we undertake in the following section.

**Choosing model parameters to target empirical moments**

To investigate the ability of our simple model to produce moments which are close to their empirical counterpart, we estimate some of the parameters using the simulated method of moments (SMM). In particular, we choose the share of transfers going to HTM households ($\omega$), the inverse Frisch elasticity ($\phi$), the steady-state productivity of hand-to-mouth agents ($\theta^h$), as well as the AR coefficients and standard deviations of our three shock processes, to minimize the quadratic distance between the moments generated by the model and those observed in US data. We make use of quarterly US data for the period 1960Q1-2017Q3 to compute our moments.[27] We target 15 moments related to the cyclical properties of fiscal variables and heterogeneity between households (see Table 2.3 for the full list of moments). Our estimation methodology is explained in more detail in Appendix 2.7.2.

As the data moments are computed at a quarterly frequency, we assume a model period of one quarter. We set the discount factor to $\beta = 0.995$ (this implies a 2% steady-state annual real interest rate) and $\lambda = 0.3$, as was the case before. We set the steady-state levels of government spending-to-gdp and the market value of annual government debt-to-GDP to their empirical average of respectively 7.36% and 35.08%.

[Table 2.3 approximately here]

Our results are presented in Table 2.3. The upper part of the table displays the estimated values of model parameters. One result is worth mentioning here. The value we obtain for the parameter targeting the share of transfers going to HTM households is $\omega = 0.82$. This is higher than $\lambda$, which was calibrated to 0.3, which implies that most of the transfers are targeted towards hand-to-mouth households. We also observe that in steady-state

[27] The sample period is reduced to 1984Q1-2017Q3 for the cross-sectional data, as the dataset we use only covers this timespan. The datasets we use are the ones described in Section 2.2: we make use of NIPA tables to compute aggregate statistics, and the CEX to get cross-sectional moments.

transfers are positive (transfers-to-gdp are equal to 15.6%), which means that under the obtained parametrization, the planner chooses to redistribute resources towards HTM agents, which helps reducing consumption inequality. The value of $\omega$ is not far from its data counterpart (the average value of transfers targeted to households at the bottom 30% of the income distribution) which, as we mentioned in Section 2.2, is equal to 0.67. No data on the cross-sectional distribution of transfers were used to compute the targeted moments, so we see this as a way to stress the ability of our simple model to match key empirical facts.

In the lower part of Table 2.3, we compare the moments obtained from our model to the ones observed in the US data. We observe that our simple model does surprisingly well in matching the targeted moments. Indeed, each of the simulated correlation has the appropriate sign, with the exception of the correlation between the market value of debt and deficits, which is almost zero in the model. The absolute deviations of most of the model moments to their data counterpart are very small. Of particular interest are the aggregate fiscal moments described in Section 2.2: the correlation between transfers, deficits and GDP, which are displayed in the first three lines of the table. We see that, for these moments, the fit is particularly good. To understand this result, we provide in Figure 2.11 the variance decomposition of some of the key variables when the parameters are set to their estimated values. We can see from the figure that more than 90% of the variation in the labor tax rate, transfers, and consumption heterogeneity, is explained by the shocks to hand-to-mouth agents' productivity ($\theta_t^h$). These shocks account for about 50% of variations in output, while TFP shocks account for about 46% of the fluctuations in this variable. The importance of shocks to the productivity of hand-to-mouth households in the estimated model explain why the model does so well in generating a co-movement of fiscal variables which is very close to the one observed in the US. Indeed, we have seen in the previous section that such a shock generates the desired co-movement between deficits, transfers, and GDP; then, given the prevalence of fiscal variables in the moments that we target, it is with little surprise that the estimated process for this shock is such that it plays an important role.

[Figures 2.11 and 2.12 approximately here]

In Figure 2.12 we display the k-variance of the market value of government debt in our model and in the data, up to an horizon of 40 quarters. The solid blue line depicts the k-variance for the baseline 2-agent, incomplete markets model, using our estimated parameters; the dotted black line provides the empirical counterpart, computed using US data.[28] We observe from the figure that the model generates a k-variance which implies

[28]To compute the k-variance of US government debt, we use data for the period 1960Q1-2007Q4. This

too little persistence in the debt process compared to its empirical counterpart. This is in contrast with representative agents models, which typically overshoot this statistics, as reported in Marcet and Scott (2009). The k-variance obtained in the representative agent version of the model is depicted by the dashed-dotted green lines in the figure.[29] These results confirm the fact that in our 2-agent framework, the use of transfers allow the planner to bring the economy closer to the complete markets allocation, thereby implying a lower persistence of government debt. Note that there is still a stark contrast between the baseline results, and the ones obtained assuming complete financial markets, which are displayed in the dashed red line of Figure2.12, and in which we observed that the k-variance of debt is below one at all horizons, and quickly reaches zero.

## 2.6 Conclusions

In this paper we extend some results of the optimal fiscal policy literature by considering a model which introduces a small degree of heterogeneity between households, and an additional instrument to the Ramsey planner: (un)targeted transfers. We make the following contributions.

First, we provide the condition under which the optimal labor tax is strictly positive in the steady-state allocation. We show that, when heterogeneity in consumption and hours between households is sufficiently high, and/or when transfers are targeted towards a given type of agent, it might be optimal for the planner to set positive labor taxes in order to free up resources and increase the value of transfers. Such a policy partially removes inequality between households, which, as we show, can be optimal even though it comes at the cost of reducing aggregate consumption and output.

Second, we derive analytical expressions for the optimal dynamic response of labor taxes under complete and incomplete financial markets. We find that the main driver of labor tax fluctuations comes from the incomplete markets assumption rather than household heterogeneity. When markets are incomplete, fluctuations in transfers are used by the planner to bring the economy closer to the complete markets allocation, featuring a very low tax volatility. The allocation gets closer to complete markets when the transfer rule is not targeted towards an agent type, and shocks are aggregate. When transfers are directed towards a given type of households, the planner faces a trade-off between minimizing labor

way, our sample period resembles the one used by Marcet and Scott (2009), which helps us comparing our results to the ones described in their paper.

[29]We use the same model parameters as in our two-agent model to compute the statistics in the representative agent framework. Note that there are only two shocks (government spending and TFP) in this model version. We simply ignore the $\theta^h$ shock, and do not reestimate the variance of the shock processes to obtain our results.

tax distortions and reducing consumption and hours heterogeneity. Hence, it becomes less optimal to keep the labor tax close to constant.

Finally, in order to investigate the ability of our simple model to reproduce empirical moments, we study the joint behaviour of key macro and fiscal variables and estimate some of the model parameters using the simulated method of moments (SMM). We show that heterogeneity, and more specifically shocks to the productivity of hand-to-mouth agents, is key for the model to be able to reproduce the cyclical behaviour of transfers, deficits, and output.

# 2.7 Appendix

## 2.7.1 Tables and figures

TABLE 2.1: **Corr. matrix of fiscal variables in the US**

| | **GDP** | **Deficit** | **Transfers** |
|---|---|---|---|
| **GDP** | 1 | - | - |
| **Deficit** | -0.7961 | 1 | - |
| **Transfers** | -0.4462 | 0.6841 | 1 |

**Notes:** Data are from the NIPA database and cover the period 1984Q1-2013Q1. The frequency is quarterly. All variables are expressed in per-capita terms and are de-trended using the HP-Filter (Smoothing parameter: 1,600). Transfers correspond to our restricted definition, which covers unemployment benefits and other income assistance programs (see Section 2.2). Taking a broader definition of transfers - that is, government social benefits to persons - leads to even more counter-cyclical transfers. In this case, the correlation between GDP and transfers amounts to -0.7592.

TABLE 2.2: **Calibrated parameter values**

| **Parameter** | **Description** | **Value** |
|---|---|---|
| $\beta$ | Discount factor | 0.95 |
| $\lambda$ | Share of hand-to-mouth households | 0.30 |
| $\phi$ | Inverse Frisch elasticity | 1 |
| $g/y$ | Steady-state government spending to gdp | 0.15 |
| $b/y$ | Steady-state government debt to gdp | 0.6 |
| $\theta^h$ | Steady-state productivity of HTM agents | 1 |
| $\omega$ | Share of transfers targeted to HTM agents | $\{\lambda;1\}$ |

**Notes:** The table provides the assumed parameter values in the baseline specification of the model presented in Section 2.3.

TABLE 2.3: **Estimated parameters and implied moments**

*Estimated parameters:*

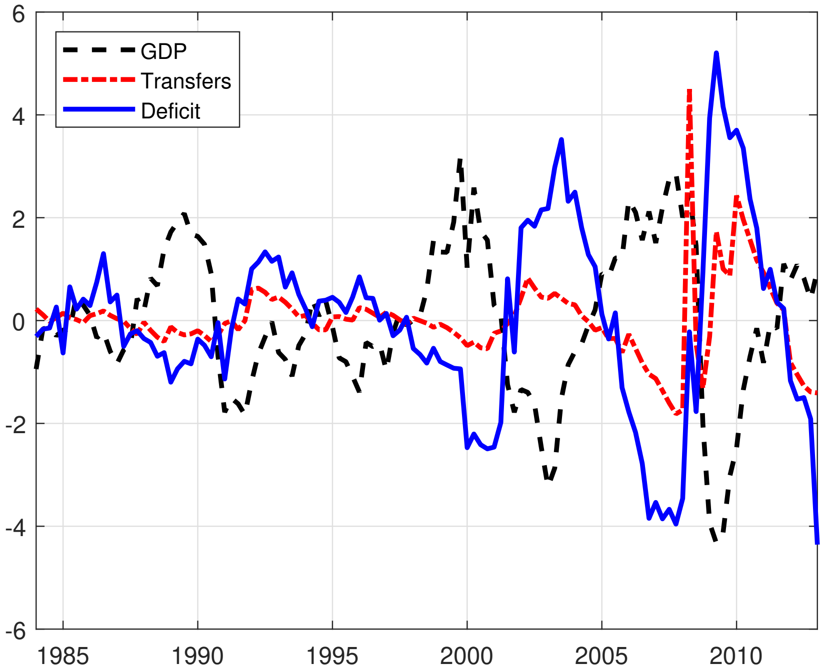
| Parameter | Description | Value |
|---|---|---|
| $\omega$ | Share of transfers targeted to HTM agents | 0.82043 |
| $\phi$ | Inverse Frisch elasticity | 1.9004 |
| $\theta^h$ | Steady-state productivity of HTM agents | 0.57591 |
| **Shocks** | | |
| $\rho_g$ | AR coeff. gov. spending | 0.7139 |
| $\rho_a$ | AR coeff. total factor productivity | 0.93072 |
| $\rho_\theta$ | AR coeff. relative productivity of HTM agents | 0.60146 |
| $\sigma_g$ | Std, gov. spending | 0.074173 |
| $\sigma_a$ | Std, total factor productivity | 0.0052298 |
| $\sigma_\theta$ | Std, relative productivity of HTM agents | 0.052671 |

*Implied moments:*

| | Data | Model |
|---|---|---|
| $corr(T, y)$ | -0.6323 | -0.59263 |
| $corr(def, y)$ | -0.631 | -0.60137 |
| $corr(T, def)$ | 0.7329 | 0.82561 |
| $std(y)$ | 0.0146 | 0.016852 |
| $std(g/y)$ | 0.0379 | 0.10109 |
| $corr(mv/y, def)$ | 0.5065 | -0.08311 |
| $corr(g_t, g_{t-1})$ | 0.6836 | 0.68526 |
| $corr(y_t, y_{t-1})$ | 0.8623 | 0.72385 |
| $cor(mv_t, mv_{t-1})$ | 0.8752 | 0.98709 |
| $mean(\theta^h n^h/n^s)$ | 0.2089 | 0.46055 |
| $std(\theta^h n^h/n^s)$ | 0.0724 | 0.10122 |
| $corr(\theta^h_t n^h_t/n^s_t, \theta^h_{t-1} n^h_{t-1}/n^s_{t-1})$ | 0.5085 | 0.57832 |
| $mean(h^c)$ | 0.5582 | 0.88074 |
| $std(h^c)$ | 0.0331 | 0.0045294 |
| $corr(h^c_t, h^c_{t-1})$ | 0.5044 | 0.61323 |

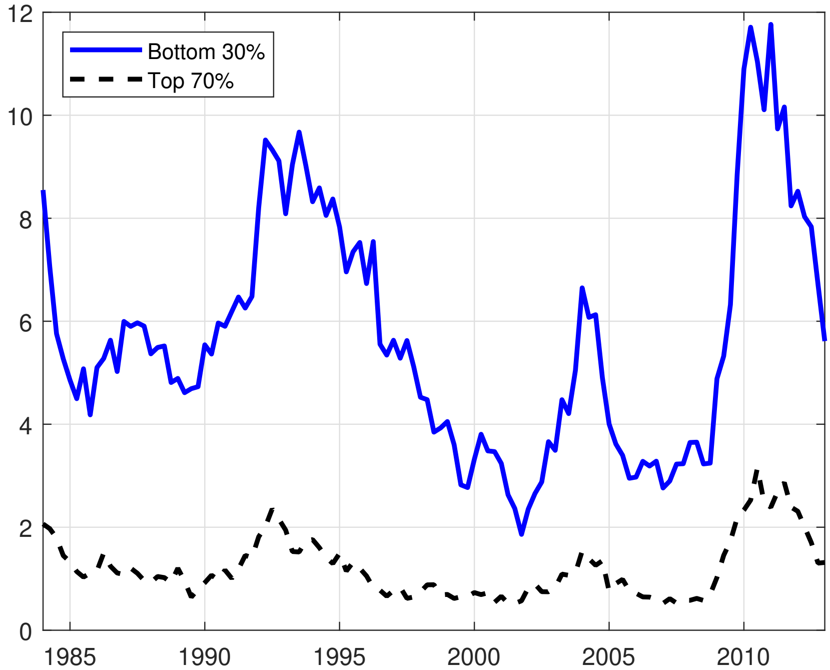
**Notes:** The table presents the results obtained in our Simulated Method of Moments (SMM) exercise. We choose the model parameters to match the set of moments presented in the bottom part of the table (the left column displays the values obtained from the US data for the period 1960Q1-20017Q3), while the right columns presents the values obtained from the model). The top part of the displays the values of estimated parameters. The remaining parameters are set to the value displayed in Table 2.2.

Figure 2.1: **Cyclical behaviour of fiscal data in the US**



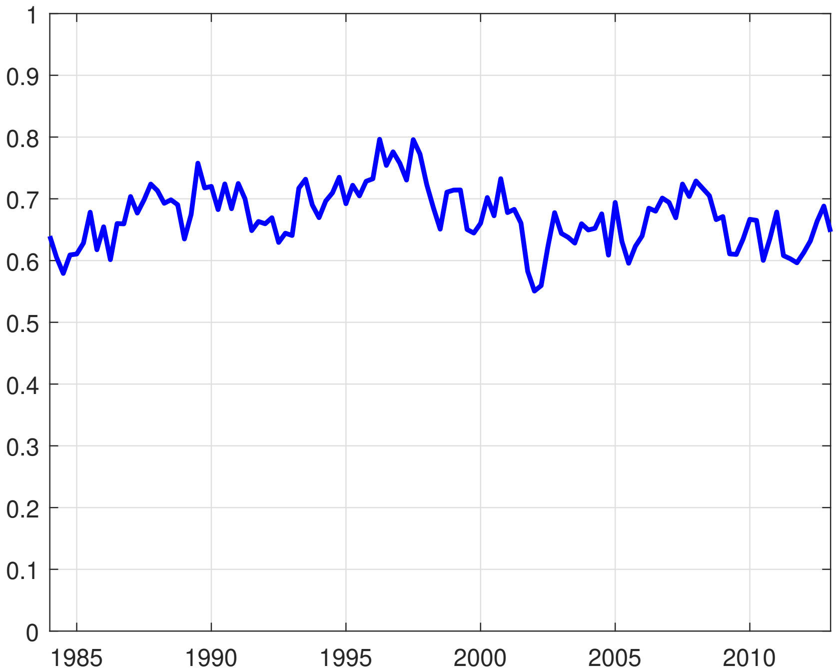

**Notes:** The figure plots the cyclical behaviour of real GDP (dashed black line), real deficit (solid blue line), and real transfers (dashed red line), at the quarterly frequency. Data are from the NIPA database. Variables are in per-capita terms and de-trended with HP-Filter.

FIGURE 2.2: **Transfers towards household income groups**



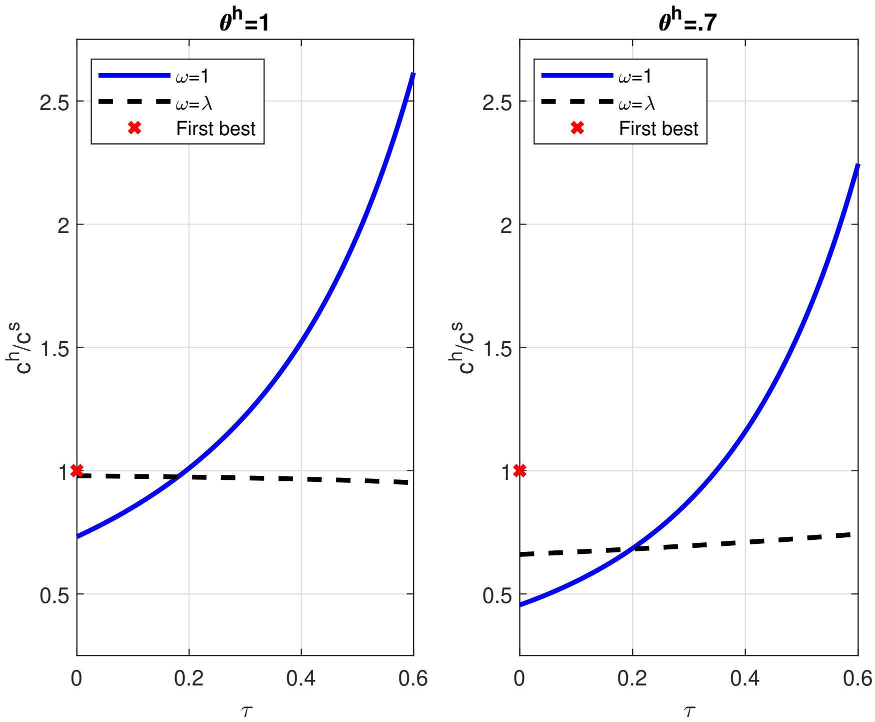

**Notes:** The figure plots the behaviour of transfers per capita for households at the bottom 30% of the income distribution (solid blue line), and the top 70% (dashed black line), at the quarterly frequency. Household-level data is aggregated from the CEX database.

FIGURE 2.3: **Share of transfers targeted towards low-income households**



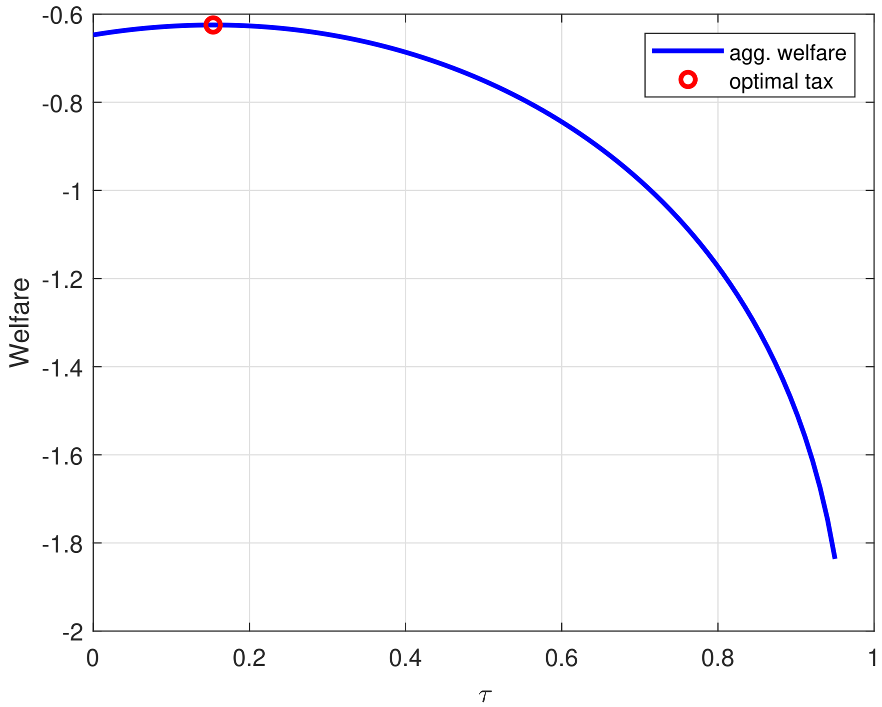

**Notes:** The figure plots the evolution of the share of total transfers targeted towards households at the bottom 30% of the income distribution (solid blue line), at the quarterly frequency. The series was constructed using household-level data from the CEX.

FIGURE 2.4: **Steady-state consumption inequality**



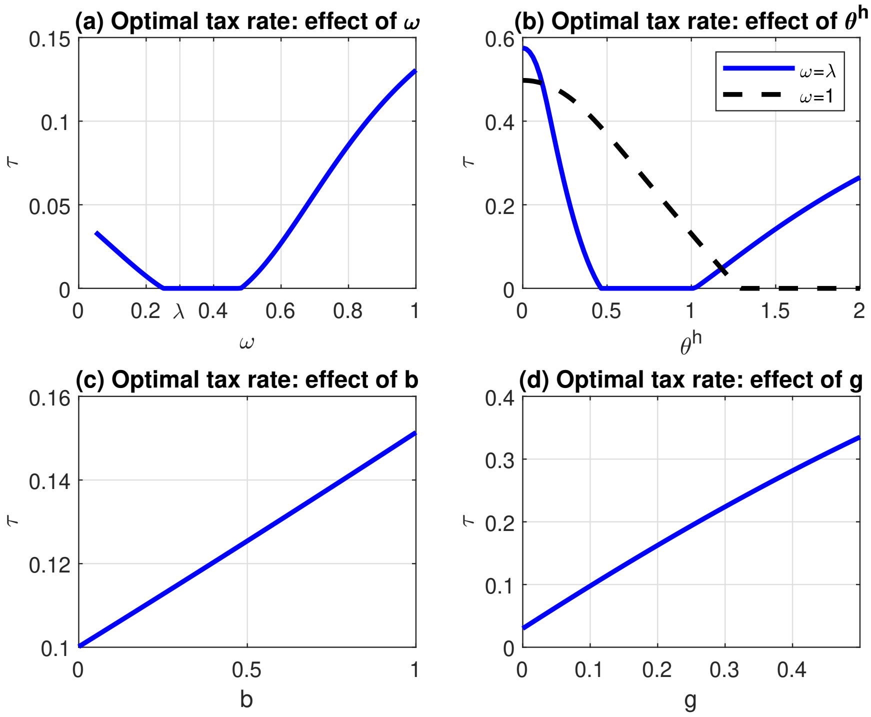

**Notes:** The figure depicts the steady-state consumption inequality, measured as the ratio of hand-to-mouth over Ricardian households' per capita consumption levels ($c^h/c^s$), as a function of the labor tax rate. The red cross depicts the first-best allocation. The dashed black line plots consumption inequality for the case of evenly targeted transfers ($\omega = \lambda$). The solid blue line presents consumption inequality for the case of transfers fully targeted towards hand-to-mouth households ($\omega = 1$).

FIGURE 2.5: **Steady-state welfare**




**Notes:** The solid blue line plots the value of aggregate welfare $U$ in the steady-state of the model presented in Section 2.3, as a function of the labor tax rate. The red circle depicts the optimal the tax rate and associated welfare level. To produce this figure, we set $\theta^h = 1$, $\omega = 1$, and $b_{-1} = 0$. The remaining parameters are set to the baseline values provided in Table 2.2.

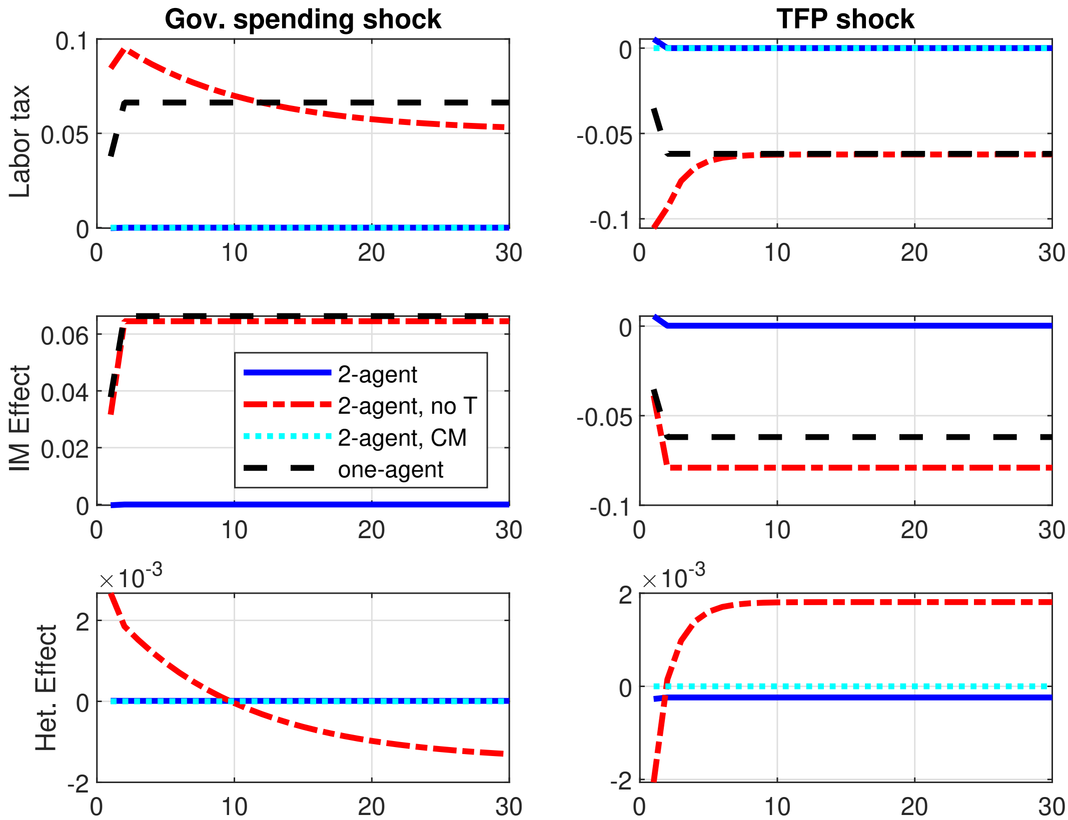
FIGURE 2.6: **Optimal long-run taxes: effect of key parameters**




**Notes:** The figure analyses the effect of key model parameters on the optimal labor tax rate in the steady-state of the baseline model. Panel (a) displays the effect of $\omega$, the share of transfers targeted towards hand-to-mouth agents. Panel (b) depicts the effect of $\theta^h$, the long-run value of the relative productivity of hand-to-mouth agents. Panel (c) and (d) present, respectively, the effect of the long-run levels of the debt-to-gdp and government spending-to-gdp ratios. The remaining parameters are set to their baseline values, as presented in Table 2.2.

FIGURE 2.7: **Labor tax response under incomplete markets: one vs. two-agent models (1)**

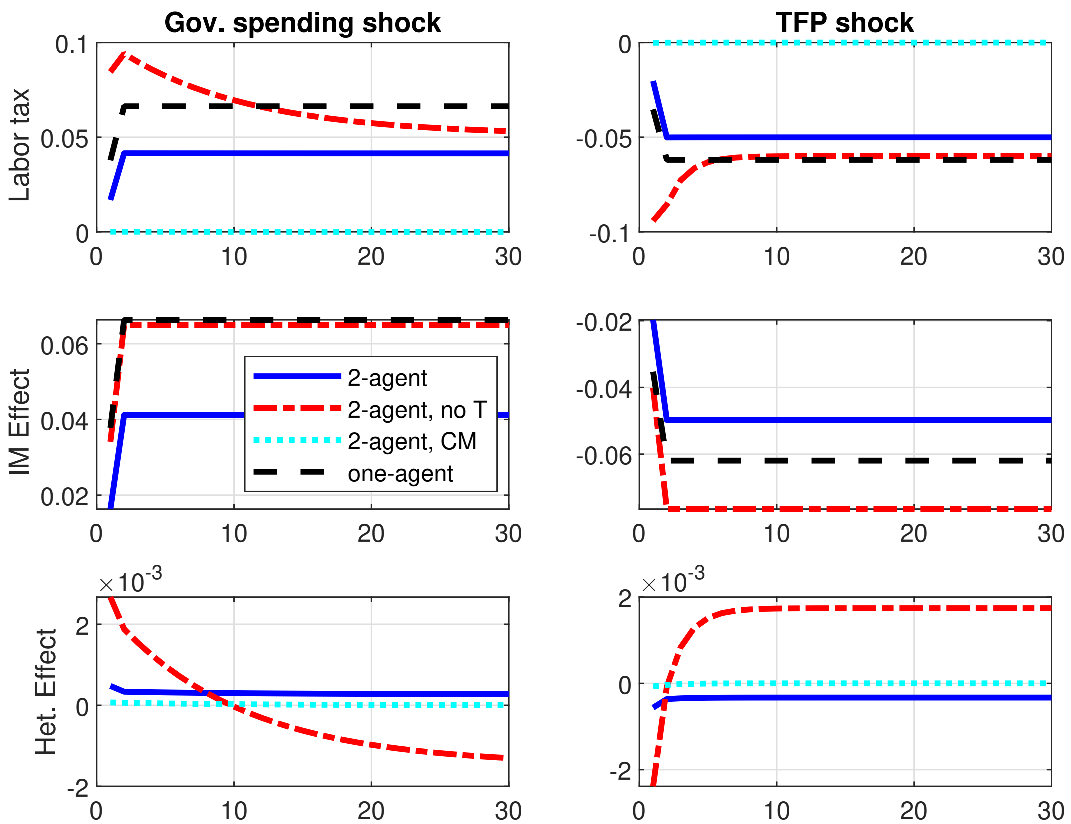
**Case 1:** $\omega = \lambda$




**Notes:** Response of the labor income tax to government spending (left panels) and TFP shocks (right panels), for the case of evenly targeted transfers ($\omega = \lambda$). The value of each shock is normalized to one. The top panels present the response of the optimal labor tax (in deviation from steady-state). The middle and bottom panels depict, respectively, the component of taxes related to market incompleteness and heterogeneity, following the decomposition presented in equation (2.28). The solid blue lines are for the baseline two-agent model under incomplete markets, and the dotted cyan lines for the complete markets counterpart. The dashed red lines display the responses for a 2-agent model version where only labor taxes are available to the planner. Finally, the dashed black lines present the results for a standard representative agent model without transfers.

FIGURE 2.8: **Labor tax response under incomplete markets: one vs. two-agent models (2)**

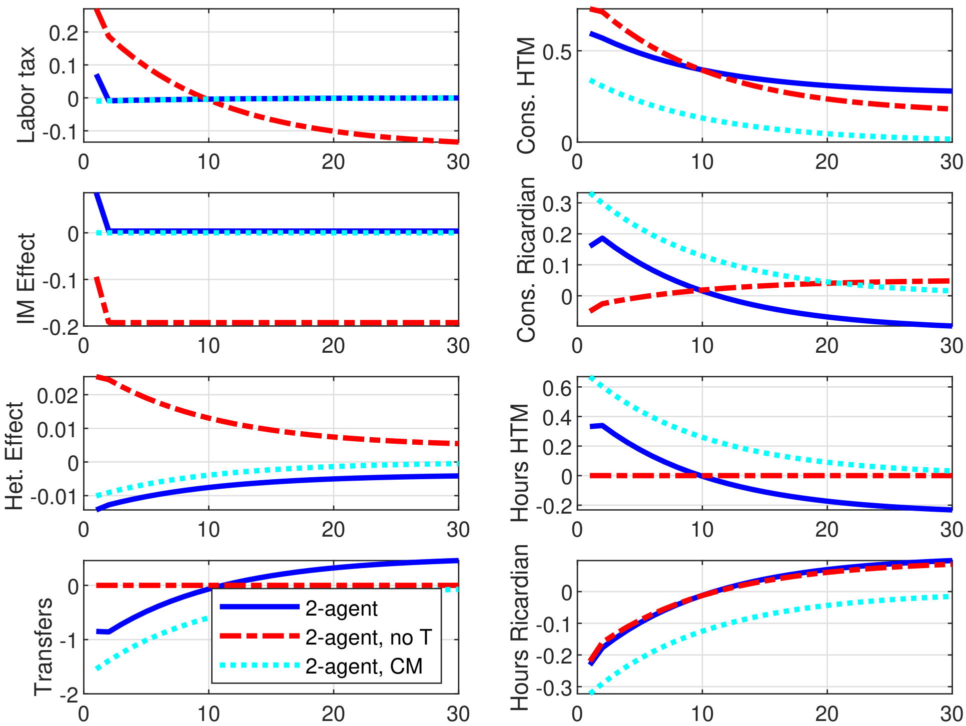
**Case 2:** $\omega = 1$



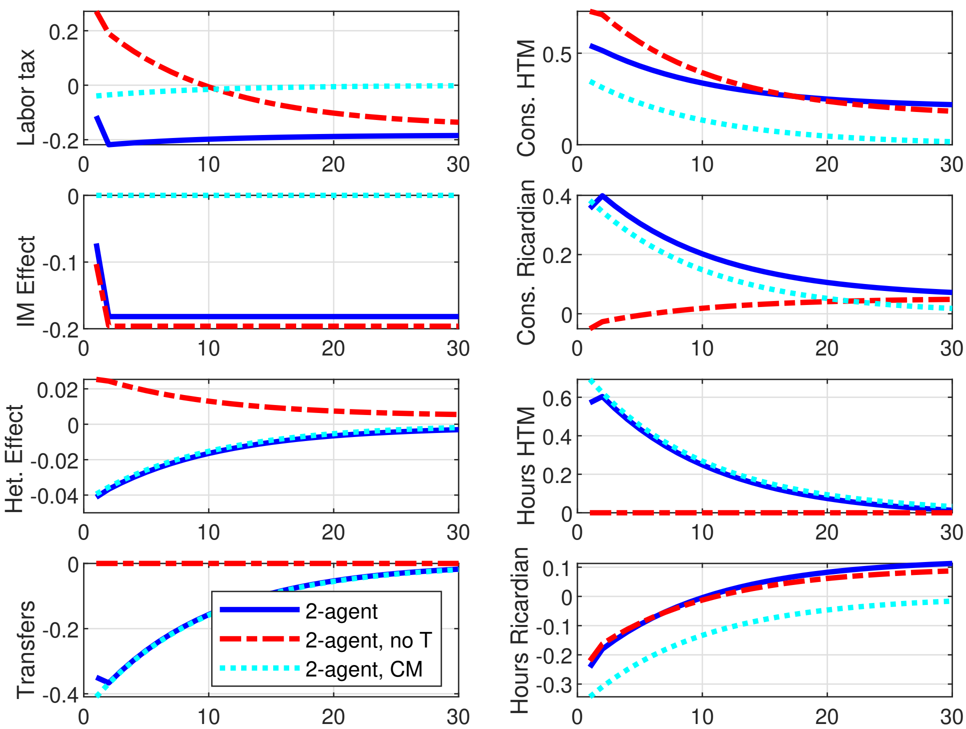

**Notes:** Response of the labor income tax to government spending (left panels) and TFP shocks (right panels), for the case where transfers are targeted towards hand-to-mouth agents ($\omega = 1$). The value of each shock is normalized to one. The top panels present the response of the optimal labor tax (in deviation from steady-state). The middle and bottom panels depict, respectively, the component of taxes related to market incompleteness and heterogeneity, following the decomposition presented in equation (2.28). The solid blue lines are for the baseline two-agent model under incomplete markets, and the dotted cyan lines for the complete markets counterpart. The dashed red lines display the responses for a 2-agent model version where only labor taxes are available to the planner. Finally, the dashed black lines present the results for a standard representative agent model without transfers.

FIGURE 2.9: **IRFs under incomplete markets: Shock to HTM productivity**

**Case 1:** $\omega = \lambda$



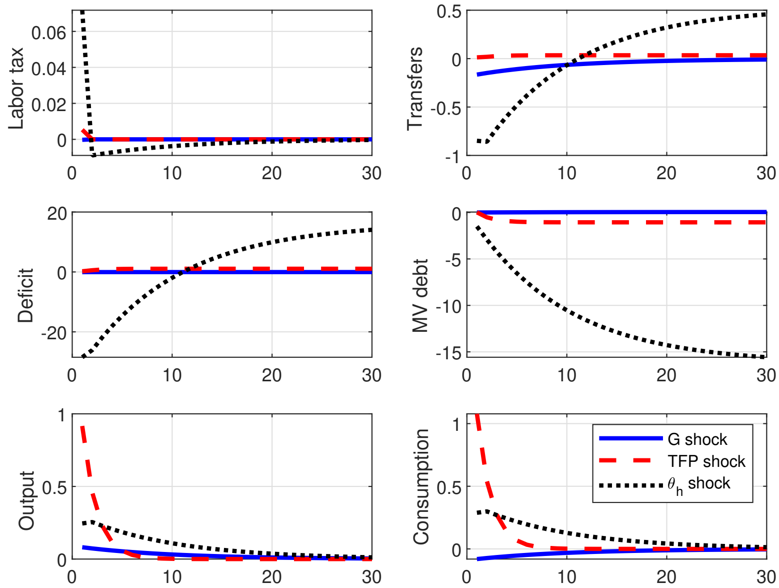

**Case 2:** $\omega = 1$



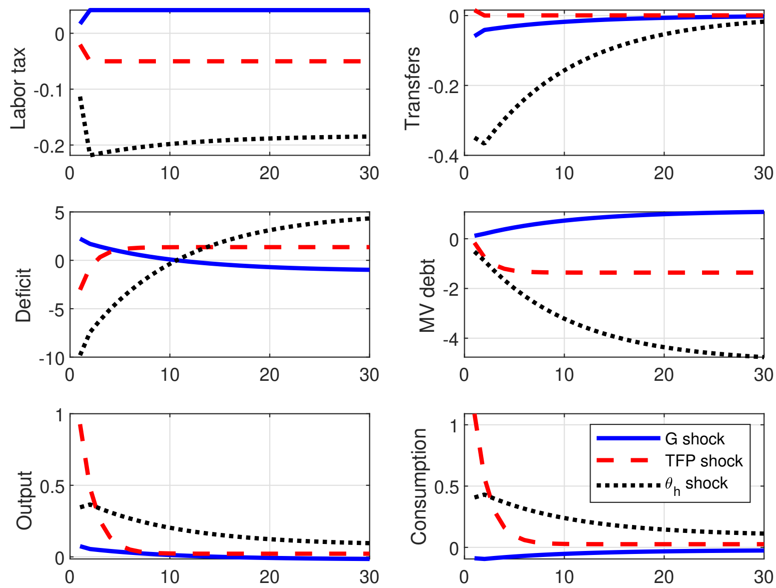

**Notes:** Response of key model variables to a $\theta^h$ shock, for the case of evenly targeted transfers ($\omega = \lambda$, top graphs) and transfers towards hand-to-mouth agents only ($\omega = 1$, bottom graphs). The value of the shock is normalized to one. The solid blue lines are for the baseline two-agent model under incomplete markets, and the dotted cyan lines for the complete markets counterpart. The dashed red lines display the responses for a 2-agent model version where only labor taxes are available to the planner.

FIGURE 2.10: **IRFs under incomplete markets: fiscal variables**

(a) **Case 1:** $\omega = \lambda$

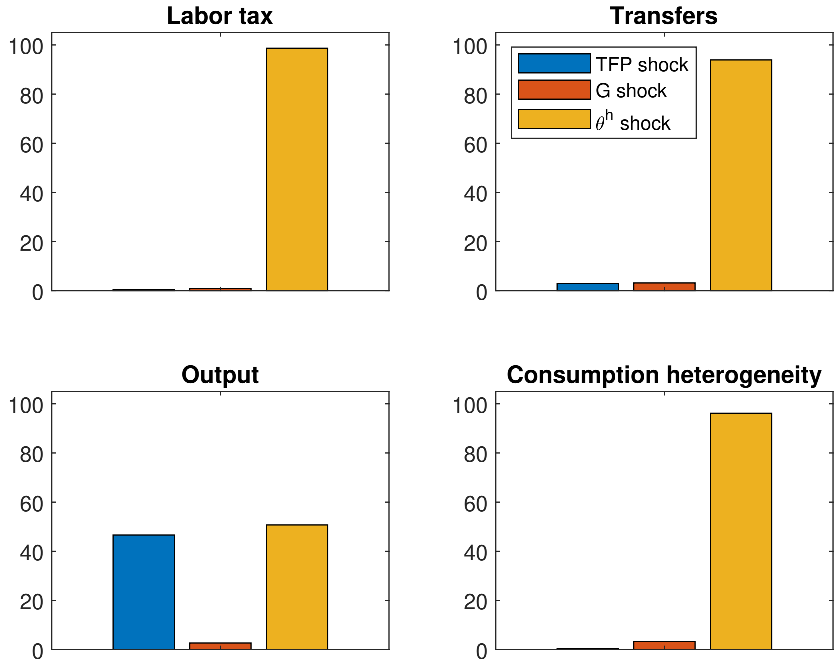



(b) **Case 2:** $\omega = 1$



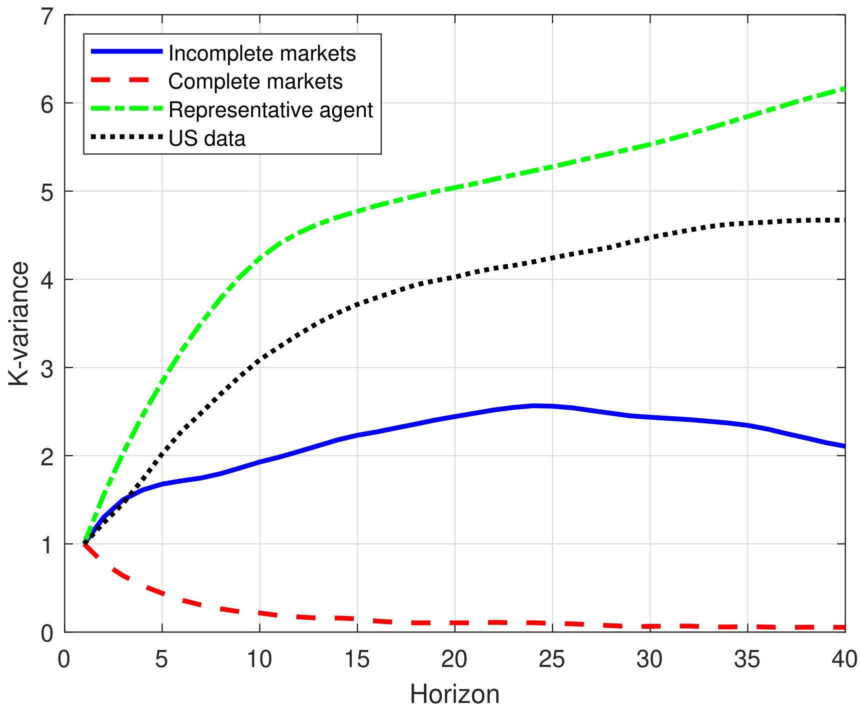

**Notes:** The figure presents the impulse response functions of key variables to the three shocks present in the model. The top panels display results for the case where $\omega = \lambda$, while the bottom panels set $\omega = 1$. The value of the remaining model parameters are displayed in Table 2.2. The solid blue lines display the responses to a government spending shock, the dashed red lines to the TFP shock, and the dotted black lines present results to a $\theta^h$ shock. The values taken by the shock is normalized to one in the three cases.

FIGURE 2.11: **SMM results: Variance decomposition**




**Notes:** The figure displays the variance decomposition of labor taxes, transfers, output and consumption heterogeneity, for the model estimated with the SMM (the parameter values are displayed in Table 2.3).

FIGURE 2.12: **SMM results: k-Variance of debt**




**Notes:** The figure displays the behaviour of the k-variance for the market value of debt in our estimated model. The solid blue line depicts the obtained values for our baseline 2-agent model with incomplete markets. The dashed red line provides the analogous result when we assume complete markets, and the dashed-dotted green line displays the representative agent counterpart, where only distortionary taxes are available. The dotted black line shows the series obtained from the US data in the period 1960Q1-2007Q4.

### 2.7.2 Model appendix

#### Complete markets

In this section we provide additional details on the complete markets model studied in the main text and presented in Section 2.3.3. In this model version the Ricardian households' budget constraint can be written as:

$$c_t^s + \int_{s^{t+1}} q^{CM}(s^{t+1}) b^{s,CM}(s^{t+1})\, ds^{t+1} = (1-\tau_t) a_t n_t^s + b^{s,CM}(s^t) + T_t^s \tag{2.29}$$

The first order conditions give:

$$\frac{v_{n,t}^s}{u_{c,t}^s} = 1 - \tau_t \tag{2.30}$$

$$u_c^s(s^t) q^{CM}(s^{t+1}) = \beta f(s^{t+1}|s_t) u_c^s(s^{t+1}) \tag{2.31}$$

The second equation gives the pricing condition for each state contingent security $b^{CM}(s^{t+1})$. This equation can be aggregated over states $s^{t+1}$ to obtain the usual Euler equation:

$$q_t^{CM} = \beta \int_{s^{t+1}} \frac{u_{c,t+1}^s}{u_{c,t}^s} f(s^{t+1}|s_t) ds^{t+1}$$

The Lagrangian associated to the Ramsey program (the complete markets equivalent of equation (2.10)) can be written as:

$$\begin{aligned}
\mathcal{L}^{CM} \;=\; & E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \lambda \Big[ u(c_t^h) - v(n_t^h) \Big] + (1-\lambda) \Big[ u(c_t^s) - v(n_t^s) \Big] \\
& + \Psi^{CM} \Big[ -u_{c,0}^s b_{-1} + (u_{c,t}^s a_t - v_{n,t}^s)(\lambda \theta_t^h n_t^h + (1-\lambda) n_t^s) - u_{c,t}^s (g_t + T_t) \Big] \\
& + \Psi_t^1 \Big[ a_t \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s a_t - \lambda c_t^h - (1-\lambda) c_t^s - g_t \Big] + \Psi_t^2 \Big[ \frac{v_{n,t}^s}{u_{c,t}^s} - \frac{1}{\theta^h} \frac{v_{n,t}^h}{u_{c,t}^h} \Big] \\
& + \Psi_t^3 \Big[ -u_{c,t}^s c_t^h + v_{n,t}^s \theta_t^h n_t^h + \frac{\omega}{\lambda} u_{c,t}^s T_t \Big]
\end{aligned}$$

The associated first order conditions are:

$$
\begin{aligned}
c_t^h &: \lambda u_{c,t}^h - \lambda \Psi_t^1 + \frac{\Psi_t^2}{\theta_t^h} \frac{v_{n,t}^h}{(u_{c,t}^h)^2} u_{cc,t}^h - \Psi_t^3 u_{c,t}^s = 0 \\
c_t^s &: (1-\lambda) u_{c,t}^s + \Psi^{CM} \Big[ u_{cc,t}^s a_t n_t - u_{cc,t}^s (g_t + T_t) \Big] \\
&\quad - \Psi_t^1 (1-\lambda) - \Psi_t^2 \frac{v_{n,t}^s}{(u_{c,t}^s)^2} u_{cc,t}^s + \Psi_t^3 (-u_{cc,t}^s c_t^h + \frac{\omega}{\lambda} T_t u_{cc,t}^s) = 0 \\
n_t^h &: -\lambda v_{n,t}^h + \Psi^{CM} (u_{c,t}^s a_t - v_{n,t}^s) \lambda \theta_t^h + \Psi_t^1 a_t \lambda \theta_t^h - \frac{\Psi_t^2}{\theta_t^h} \frac{v_{nn,t}^h}{u_{c,t}^h} + \Psi_t^3 v_{n,t}^s \theta_t^h = 0 \\
n_t^s &: -(1-\lambda) v_{n,t}^s + \Psi^{CM} \Big[ (1-\lambda)(u_{c,t}^s a_t - v_{n,t}^s) - v_{nn,t}^s n_t \Big] + \Psi_t^1 (1-\lambda) a_t + \\
&\quad \Psi_t^2 \frac{v_{nn,t}^s}{u_{c,t}^s} + \Psi_t^3 v_{nn,t}^s \theta_t^h n_t^h = 0 \\
T_t &: -\Psi^{CM} u_{c,t}^s + \Psi_t^3 \frac{\omega}{\lambda} u_{c,t}^s = 0
\end{aligned}
$$

**Representative agent**

The representative agent model is a specific case of our two agent model where $\lambda = 0$. As such, the Lagrangian associated to the planner's optimization program in the incomplete markets setting is:

$$
\begin{aligned}
\mathcal{L} &= E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ u(c_t) - v(n_t) + \Psi_t^{IM} \Big[ -u_{c,t} b_{t-1} + (u_{c,t} a_t - v_{n,t}) n_t) - u_{c,t} g_t + \beta u_{c,t+1} b_t \Big] \\
&\quad + \Psi_t^1 \Big[ a_t n_t - c_t - g_t \Big] \Big\}
\end{aligned}
$$

where we make use of the representative agents' Euler equation $q_t = \beta \frac{E_t u_{c,t+1}}{u_{c,t}}$ and labor supply condition $(1-\tau_t) a_t = \frac{v_{n,t}}{u_{c,t}}$ to substitute away the bond price $q_t$ and the labor tax rate $\tau_t$.

The optimality conditions associated to the planner's problem are the following:

$$
\begin{aligned}
c_t &: u_{c,t} + \Psi_t^{IM} u_{cc,t} \Big[ -b_{t-1} + a_t n_t - g_t \Big] + \Psi_{t-1}^{IM} u_{cc,t} b_{t-1} - \Psi_t^1 = 0 \\
n_t &: -v_{n,t} + \Psi_t^{IM} \Big[ (u_{c,t} a_t - v_{n,t}) - v_{nn,t} n_t \Big] + \Psi_t^1 a_t = 0 \\
b_t &: -E_t \Psi_{t+1}^{IM} u_{c,t+1} + \Psi_t^{IM} E_t u_{c,t+1} = 0
\end{aligned}
$$

Eq. (2.26) is derived as follows. First, divide the above two first FOC by $u_{c,t}$ and make use of the labor supply condition to get:

$$\begin{aligned}
1-\Psi_t^{IM}-\left(\Psi_t^{IM}-\Psi_{t-1}^{IM}\right)\frac{u_{cc,t}}{u_{c,t}}b_{t-1}-\frac{\Psi_t^1}{u_{c,t}} &= 0\\
\tau_t-1+\Psi_t^{IM}\left[\tau_t-\frac{v_{nn,t}}{v_{n,t}}n_t(1-\tau_t)\right]+\frac{\Psi_t^1}{u_{c,t}} &= 0
\end{aligned}$$

Then, using the functional form described in Eq. (2.17) and substituting away $\Psi_t^1$ using the above equations leads to Eq. (2.26).

### Two-agent framework: first-best allocation

The first best allocation in a two-agent framework is defined as the result of the maximization process of aggregate welfare subject to the feasibility constraint of the economy, i.e. the resource constraint. As such, the Lagrangian associated to the planner's optimization program is:

$$\begin{aligned}
\mathcal{L} &= E_0\sum_{t=0}^{\infty}\beta^t\Big\{\lambda\Big(u(c_t^s)-v(n_t^s)\Big)+(1-\lambda)\Big(\big(u(c_t^h)-v(n_t^h)\Big)\\
&\quad -\Psi_t^{RC}\Big[\lambda c_t^h+(1-\lambda)c_t^s+g_t-\lambda a_t\theta_t^h n_t^h-(1-\lambda)a_t n_t^s\Big]\Big\}
\end{aligned}$$

The first order conditions associated to the planner's problem are the following:

$$\begin{aligned}
c_t^s &: u_{c,t}^s=\Psi_t^{RC} & \qquad n_t &: v_{n,t}^s=\Psi_t^{RC}a_t\\
c_t^h &: u_{c,t}^h=\Psi_t^{RC} & \qquad n_t &: v_{n,t}^h=\Psi_t^{RC}\theta_t^h a_t
\end{aligned}$$

They imply that:

$$u_{c,t}^s = u_{c,t}^h \tag{2.32}$$

$$\frac{v_{n,t}^s}{u_{c,t}^s} = a_t \tag{2.33}$$

$$\frac{v_{n,t}^h}{u_{c,t}^h} = \theta_t^h a_t \tag{2.34}$$

In a decentralized economy, Eq (2.32) implies that hand-to-mouth households' consumption is equal to Ricardian households' consumption in the case of separable utility, as is assumed throughout the paper. Eq (2.33) and (2.34) indicate that the planner prefers to set labor taxes to zero. It also states that $\theta_t^h v_{n,t}^s = v_{n,t}^h$. Therefore, when $\theta_t^h < 1$, hand-to-mouth households work less than Ricardian households.

### Additional results

**Proposition 2B:** When the planner has access to distortionary taxes only and markets are incomplete, the optimal labor tax rate satisfies:

$$\tau_t = 1 - \frac{(H_t^c)^{-1}\Big[1 + (\Psi_t^{IM} - \Psi_{t-1}^{IM})\frac{b_{t-1}}{c_t^s}\Big](1-\lambda)}{\Big[H_t H_t^n + (1-\lambda)(1+\phi)\Psi_t^{IM}\Big] - (H_t^n - (1-\lambda))\Big[(1+\phi)(h_t^c)^{-1} - \frac{\phi}{H_t^c}\Big(1 + (\Psi_t^{IM} - \Psi_{t-1}^{IM})\frac{b_{t-1}}{c_t^s}\Big)\Big]} \tag{2.35}$$

where $h_t^c \equiv \frac{c_t^h}{c_t^s}$; $h_t^n \equiv \frac{n_t^h}{n_t^s}$; $H_t^c \equiv \lambda h_t^c + 1 - \lambda$; $H_t^n \equiv \lambda \theta_t^h h_t^n + 1 - \lambda$; $H_t \equiv (\lambda \frac{h_t^n}{h_t^c} + 1 - \lambda)/H_t^n$.

When markets are complete, the multiplier $\Psi_t^{IM}$ is constant ($\Psi_t^{IM} = \Psi \ \forall\ t$), and the expression becomes:

$$\tau_t = 1 - \frac{(H_t^c)^{-1}(1-\lambda)}{\Big[H_t H_t^n + (1-\lambda)(1+\phi)\Psi\Big] - (H_t^n - (1-\lambda))\Big[(1+\phi)(h_t^c)^{-1} + \frac{\phi}{H_t^c}\Big]}$$

*Proof:* Using the equations of the system (2.24) and the functional forms given in (2.17), while setting $T_t = 0\ \forall t$, we can define $\Psi^3$ as follows:

$$\Psi^3 = \frac{1}{(1+\phi)\theta^h h_t^n}\Big[H_t^n\Big(H_t - \frac{1}{H^c(1-\tau_t)}\Big) + \Psi_t^{IM}\Big(\frac{H_t^n \tau_t}{1-\tau_t} + \psi\frac{n}{n^s}\Big) - \frac{b_{t-1}}{c_t^s}(\Psi_t^{IM} - \Psi_{t-1}^{IM})\frac{1}{H_t^c(1-\tau_t)}\Big]$$

Replacing $\Psi^3$ by this expression in equation (2.25) leads to the tax expression given in equation (2.35).

Log-linearizing the equation for the incomplete market case leads to:

$$\begin{aligned}\hat{\tau}_t \quad = \quad & \Big[\frac{(1-\tau)}{(1-\lambda)}\Big(H^n - (1-\lambda)\Big)\phi - 1\Big]\hat{\psi}_t + (1-\tau)(1+\phi)H^c\Psi\hat{\Psi}_t \\ & + \hat{H}_t^c + \frac{(1-\tau)}{(1-\lambda)}H^n H^c H(\hat{H}_t + \hat{H}_t^n) - \frac{(1-\tau)}{(1-\lambda)}H^n\Big((1+\phi)\frac{H^c}{h^c} - \phi\Big)\hat{H}_t^n + \frac{(1-\tau)}{(1-\lambda)}\Big(H^n - (1-\lambda)\Big)\Big((1+\phi)\frac{H^c}{h^c}\hat{h}_t^c - \phi\hat{H}_t^c\Big)\end{aligned}$$

.

### Simulated method of moments

In Section 2.5.3 of the paper, we choose the model parameters to target empirical moments. In particular, we make use of the simulated method of moments (SMM), in which the structural model parameters are chosen to minimize the distance between the moments computed from numerical simulations of the model, and those observed in the data. More formally, we choose the vector of parameters which minimizes a quadratic loss function, thereby obtaining the estimator $\hat{\theta}$ that satisfies:

$$\hat{\theta} = \underset{\theta \in \Theta}{\operatorname{argmin}}\ \Big(m(\theta) - m_{\text{us}}\Big)'\mathbf{W}\Big(m(\theta) - m_{\text{us}}\Big)$$

where $\mathbf{W}$ is a weighting matrix, which we set to the identity matrix in our estimation routine. $m_{\text{us}}$ is the vector of moments computed from the US data, and $m(\theta)$ is a function mapping model parameters $\theta$ to a vector of simulated moments. We make use of a non-linear optimization routine to solve for the above problem.

### 2.7.3 Data Appendix

In this section we provide details on the construction of the data series used in Section 2.2, when we provide stylized facts for the US economy, and in Section 2.4 and 2.5 when we target empirical moments with our theoretical model.

#### Macro data

All aggregate data, i.e. government spending, transfers, deficits and the market value of government debt, are for the U.S and are observed at a quarterly frequency. They 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.

All variables are in per capita terms. Each variable is divided by an index of the US population, constructed from the 'Pop Civilian noninstitutional population aged 16 years and over' series from the US Bureau of Labor Statistics.

**Output** is measured as real output per capita. We deflate nominal GDP (Table 1.1.5, Line 1) with the GDP deflator, and divide it with the population index.

**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).

**Tranfers:** In this paper, we adopt a narrow definition of transfers. We are mainly interested in the components of transfers targeted towards households, and reflecting social insurance. We therefore define transfers as a subset of government social benefits to persons[30] (provided in section 2 of the NIPA): we compute them as the sum of unemployment insurance (Table 2.1 Line 21) and other benefits [31] (Table 2.1 Line 23).

**Deficits** are defined as government expenditures (Table 3.2 Line 42) minus government receipts (Table 3.2 Line 39) and interest payments (Table 3.2 Line 32).

**The market-value of debt-to-GDP** 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.

[30] Government social benefits to persons are composed of: social security benefits (Table 2.1 Line 18) Medicare and Medicaid benefits (Table 2.1 Line 19 and 20, respectively), unemployment insurance (Table 2.1 Line 21), veterans' benefits (Table 2.1 Line 22) and other benefits (Table 2.1 Line 23).

[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.

### Cross-sectional data

In order to construct our series on consumption, income and transfer receipts across household types, 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. It consists of 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.

**Income:** Each household reports information on income, hours worked and taxes paid over the twelve-month period preceding the interview. We compute the **earnings** of each household as the sum of wages and salaries plus two thirds of business and farm income earned by that household. **Income before taxes** (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). **Income after taxes** (disposable income) is computed as money income minus personal taxes (including federal, states and local income taxes), property taxes and other taxes such as vehicle personal property taxes.

**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 the past 12 months.

To comply with the narrow definition of transfers adopted in this paper, we define the individual transfer series as the sum of UNEMP and FDSTMP.

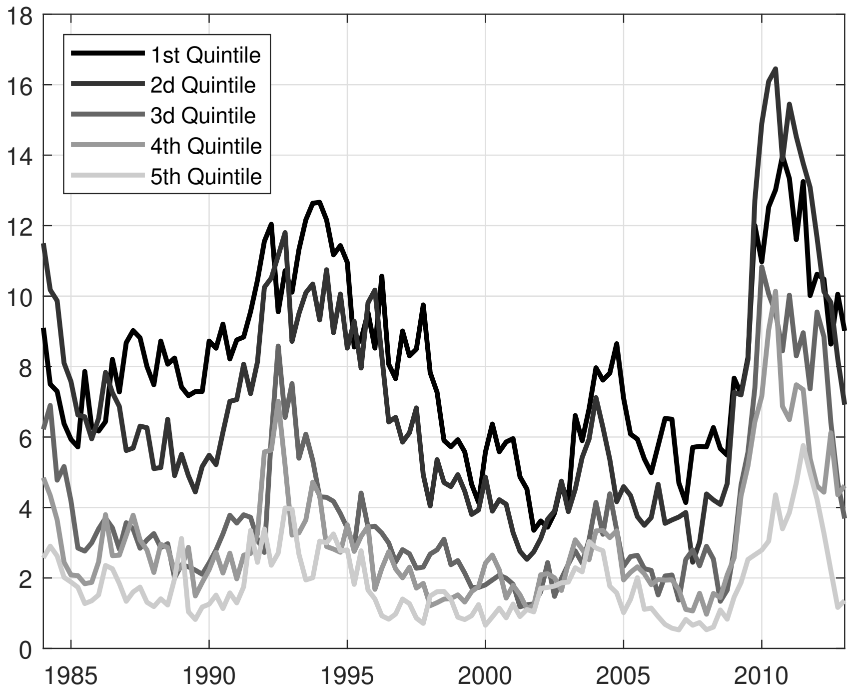
**Real values:** As is the case for aggregate variables, real values are obtained using the GDP deflator.

### Transfers along income quintiles

To complement the results displayed in Figure 2.3 (plotting the share of transfers towards housheolds at the bottom 30% and top 70% of the income distribution), we show in Figure 2.13 the same figure along income quintiles. We can see from the figure that the per capita amount of transfers received is decreasing along income quintile, thereby confirming the results displayed in the main text.

Indeed, most of the transfers are directed towards low income households. In particular, hand-to-mouth households receive on average more than 90% of Food Stamps benefits and around 40% of unemployment benefits [32].

FIGURE 2.13: **Average transfers per household along the income distribution**




**Notes:** The figure plots the behaviour of transfers per capita for households belonging to each quintile of the income distribution at the quarterly frequency. Transfers to households of the first quintile of the income distribution (that is the bottom 20%) are drawn with the darker black line, while transfers to households of the fifth quintile of the income distribution (that is the top 20%) are drawn in the lightest gray line. Data is from the CEX database.

[32]Moreover, hand-to-mouth households received in average more than 90% of the total amount of the public assistance and welfare programs benefits, more than 80% of the total amount of SSI benefits and around 60% of other transfers

**Inequality and the business cycle:**

We provide here more details on how inequality evolves over the business cycle according to CEX data.

Earnings of hand-to-mouth households appear to be slightly more pro-cyclical than the earnings of Riccardian households. Indeed, as shown in Table 3.9 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 2.4: **Correlation between Earnings and GDP**

| x | **Corr(x,GDP)** | **Std(x)** |
|---|---|---|
| Earned Income, bottom 30% | 0.34 | 0.05 |
| Earned Income, top 70% | 0.13 | 0.01 |

**Notes:** The table displays the correlation between the cyclical components of households log-earnings and GDP for low and high income 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.

# Chapter 3

# When Household Heterogeneity Matters: Optimal Fiscal Policy in a TANK Model

**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.

## 3.1 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

[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.

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 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

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

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.

**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 DS-

[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

GEs.[5] For example Galí et al. (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 et al. (2002) and Faraglia et al. (2019b). 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 et al. (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 3.2, we provide key stylized facts regarding the behaviour of fiscal variables in the US, using both macro and micro data sources. Section 3.3 describes the building blocks of the model and discusses the value of the estimated parameters. Section 3.4 delineates the optimal fiscal policy. Finally, Section 3.5 concludes.

## 3.2 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

[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 (2016b); Kaplan et al. (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.

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 3.3 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 3.6.3. 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 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 3.1 traces the evolution of earnings inequality over the past 58 years. The three

[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

[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.

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 3.1 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, 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 3.1 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 3.1 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 3.1 approximately here]

To inspect the sources of income fluctuations of households at the bottom of the distribution, Panel (a) of Figure 3.2, 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

[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.

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 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 3.2 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 3.4 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 3.4 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 3.4 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.

[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 3.3 in the Appendix.

## 3.3 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.

### 3.3.1 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.

#### 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 $\lambda$ 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:

$$U^{s,i} = E_0 \sum_{t=0}^{\infty} \beta^t \xi_t^b \Big( u(c_t^s - h\bar{c}_{t-1}^s) - v(n_t^s(i)) \Big) \tag{3.1}$$

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 (3.1) subject to:

$$(1+\tau^c)P_t c_t^s + P_t I_t^s + q_t B_t^s + P_t \Phi(u_t) K_{t-1}^s = (1-\tau_t^n) W_t(i) n_t^s(i) + \Xi_t(i) + (1-\tau^k)(R_t^k u_t K_{t-1}^s + D_t^s) + B_{t-1}^s + T_t^s \tag{3.2}$$

$$K_t^s = (1-\delta)K_{t-1}^s + \xi_t^i \Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big)\Big] I_t^s \tag{3.3}$$

The first equation is the budget constraint of the Ricardian household $i$. $\tau^c$ and $\tau^k$ 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. $\tau_t^n$ 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 (3.3) is the law of motion of private capital. Investment adjustment costs are determined by the function $S(\cdot)$, and $\xi_t^i$ denote investment-specific shocks, which follow an AR(1) process.

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

$$c_t: \quad \lambda_t = \xi_t^b \frac{u_c(c_t^s - hc_{t-1}^{s,a})}{1+\tau^c} \tag{3.4}$$

$$B_t^s: \quad \lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} \tag{3.5}$$

$$I_t^s: \quad 1 - \xi_t^i \mu_t \Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big) - \frac{I_t^s}{I_{t-1}^s} S'\Big(\frac{I_t^s}{I_{t-1}^s}\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \Big(\frac{I_{t+1}^s}{I_t^s}\Big)^2 S'\Big(\frac{I_{t+1}^s}{I_t^s}\Big) \tag{3.6}$$

$$K_t^s: \quad \mu_t = \beta(1-\delta) E_t \mu_{t+1} \frac{\lambda_{t+1}}{\lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{3.7}$$

$$u_t: \quad \Phi'(u_t) = (1-\tau^k) r_t^k \tag{3.8}$$

where $\mu_t \equiv \frac{\psi_t}{\lambda_t}$, and $\lambda_t$ and $\psi_t$ denote respectively the Lagrange multipliers on constraints (3.2) and (3.3).

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:

$$n_t^s = \Big(\int n_t^s(i)^{\frac{\eta_w - 1}{\eta_w}} di\Big)^{\frac{\eta_w}{\eta_w - 1}} \tag{3.9}$$

Cost-minimization leads to the demand for individual labor:

$$n_t^s(i) = \Big(\frac{W_t(i)}{W_t}\Big)^{-\eta_w} n_t^s \tag{3.10}$$

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:

$$W_t(i) = \begin{cases} W_t^* & \text{with prob. } 1-\theta_w \\ \Pi e^{\gamma} W_{t-1}(i) & \text{with prob. } \theta_w \end{cases} \tag{3.11}$$

where $W_t^*$, which expression is given in the appendix, is the wage rate which maximizes (3.1) subject to (3.10) and the budget constraint (3.2). We assume that wages that are not re-optimized in the current period are indexed by the steady-state inflation rate $\Pi$.

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

$$U^h = u(c_t^h - h\bar{c}_{t-1}^h) - v(n_t^h) \tag{3.12}$$

subject to their budget constraint:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + t_t^h \tag{3.13}$$

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.

$\theta_t^h$ 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:

$$\frac{\theta_t^h}{\theta^h} = \Big(\frac{\theta_{t-1}^h}{\theta^h}\Big)^{\rho_\theta} \Big(\frac{y_t}{y_t^p}\Big)^{\phi_{\theta,y}(1-\rho_\theta)} \exp(\epsilon_{\theta,t}) \tag{3.14}$$

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

$$\frac{v_n(n_t^h)}{u_c(c_t^h - h\bar{c}_{t-1}^h)} = (1-\tau_t^n)\theta_t^h w_t \tag{3.15}$$

**Firms and price setting**

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

$$y_t = \Big(\int y_t(j)^{\frac{\eta_p-1}{\eta_p}} dj\Big)^{\frac{\eta_p}{\eta_p-1}} \tag{3.16}$$

Cost minimization gives the following demand for intermediate goods:

$$y_t(j) = \Big(\frac{P_t(j)}{P_t}\Big)^{-\eta_p} y_t \tag{3.17}$$

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 $j$:

$$P_t(j) = \begin{cases} P_t^* & \text{with prob. } 1-\theta_p \\ \Pi e^{\gamma} P_{t-1}(j) & \text{with prob. } \theta_p \end{cases} \tag{3.18}$$

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:

$$y_t(j) = K_t(j)^\alpha \Big(a_t n_t(j)\Big)^{1-\alpha} - \Omega a_t \tag{3.19}$$

where $\Omega$ 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:

$$\xi_t^a \equiv \frac{a_t}{a_{t-1}} = \exp(\gamma)^{1-\rho_a}[\xi_{t-1}^a]^{\rho_a}\exp(\epsilon_{a,t}) \tag{3.20}$$

where $\gamma$ 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:

$$\frac{w_t}{r_t^k} = \frac{1-\alpha}{\alpha}\frac{K_t(j)}{n_t(j)} \tag{3.21}$$

**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:

$$\frac{R_t}{R} = \Big(\frac{R_{t-1}}{R}\Big)^{\rho_r}\Big[\Big(\frac{\Pi_t}{\Pi}\Big)^{\phi_\pi}\Big(\frac{y_t}{y_t^p}\Big)^{\phi_y}\Big]^{1-\rho_r}\xi_t^m \tag{3.22}$$

where $R$ denotes the steady state level of the nominal interest rate associated with the long-run inflation target $\Pi$. The variable $y_t^p$ represents potential output, and is derived in the Appendix. The variable $\xi_t^m$ is an exogenous monetary policy shock which follows an AR(1) process in logs. The parameters $\rho_r$, $\phi_\pi$ and $\phi_y$ 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:

$$\frac{b_{t-1}}{\Pi_t} = -(g_t + T_t + \xi_t^{gb}) + \tau_t^n w_t n_t + \tau^k(r_t^k u_t k_{t-1} + d_t) + \tau^c c_t + q_t b_t \tag{3.23}$$

Government spending $g_t$ evolves exogenously as an AR(1) process in logs and $\xi_t^{gb}$ 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:

$$\frac{\tau_t}{\tau} = \left(\frac{\tau_{t-1}}{\tau}\right)^{\rho_\tau} \left[\left(\frac{b_{t-1}}{b}\right)^{\phi_{\tau,b}} \left(\frac{y_t}{y_t^p}\right)^{\phi_{\tau,y}}\right]^{1-\rho_\tau} \exp(\epsilon_{\tau,t}) \tag{3.24}$$

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:

$$\frac{T_t}{Y_t} = \left(\frac{T_{t-1}}{Y_{t-1}}\right)^{\rho_T} \left[\left(\frac{y_t}{y_t^p}\right)^{\phi_{T,y}}\right]^{1-\rho_T} \exp(\epsilon_{T,t}) \tag{3.25}$$

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 $\omega$ to be larger than $\lambda$ 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 (3.24) and (3.25) are removed from the system, and taxes and transfers are set optimally by a Ramsey planner operating under full commitment.

### 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:

$$n_t = \lambda \theta_t^h n_t^h + (1-\lambda) n_t^s \tag{3.26}$$

$$c_t = \lambda c_t^h + (1-\lambda) c_t^s \tag{3.27}$$

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

$$c_t + I_t + g_t + \Phi(u_t)k_{t-1} = y_t \tag{3.28}$$

**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 $\lambda_t$.

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.

### 3.3.2 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.

**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 ($CONS_t$), GDP ($GDP_t$), investment ($INV_t$), inflation ($INFL_t$), the federal funds rate ($FFR_t$), hours worked ($HOURS_t$) and the aggregate wage rate ($WAGE_t$). On the fiscal side, we use data on government spending ($GOV_t$), labor tax revenues ($LTAX_t$), transfers ($TRANSF_t$), and the market value of government debt ($MVDEBT_t$). We used micro data from the Current Population Survey (CPS) to construct series of annual earnings of both hand-to-mouth ($EARN_t^{HtM}$) and Ricardian ($EARN_t^{Ric}$) households. In Appendix 3.6.2, 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 ($C30_t$).

A complete description of the methodology used to construct the series is provided in Appendix 3.6.3.

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:

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

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

[10] Among others, Garner, Janini, Paszkiewicz, and Vendemia (2006); Heathcote et al. (2010b) and

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).

**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 3.6.2.

The values given to calibrated parameters are summarized in Table 3.3.

[Table 3.3 approximately here]

We choose the labor disutility parameter $\chi$ 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 $\Omega$ 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.

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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.

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 3.3.

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 ($\lambda$) is equal to 20%, while the share of transfers that is directed to them ($\omega$) 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.

**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) for the most standard parameters, and Traum and Yang (2011) for an estimated model with a fiscal block similar to ours). Table 3.4 displays the prior distributions of the estimated parameters, and we refer the reader to this table for more details.

Table 3.4 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

[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%.

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 $\theta_t^h$, 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 household 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 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

[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 $t$.

one obtained in the literature and are robust to the introduction of data on earnings and consumption heterogeneity.[13]

The introduction of data on household 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 3.4 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 3.6.4, 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 3.6.4).

### 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 3.5 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 3.5. The variance decomposition obtained from the estimation with data on heterogeneity (TANK*) is provided on the right part of each panel.

[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%.

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 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 3.5. 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 household 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 3.5.

[Figure 3.5 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 3.8 and 3.9.

[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.

Lets us first concentrate on Figures 3.8 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 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 3.8 approximately here]

As a matter of comparison, we provide in Figure 3.9 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 3.9 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.

### Earnings and Consumption Inequality

To understand further the evolution of households' earnings and consumption over the course of 1984-2007, Figure 3.10 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 3.10 approximately here]

Figure 3.11 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.

[15]Figure 3.6 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 3.7 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.

[Figure 3.11 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 3.2, using cross-sectional data leads the model to view fiscal policy even more pro-cyclical.

[Table 3.2 approximately here]

## 3.4 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 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.

### 3.4.1 The Ramsey program

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

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \Big[ \lambda \xi_t^b \Big( u(c_t^h - h\bar{c}_{t-1}^h) - v(n_t^h) \Big) + (1-\lambda) \Big( u(c_t^s - h\bar{c}_{t-1}^s) - v(n_t^s) \Big) \Big] \quad (3.29)$$

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 (3.23) and the monetary authority's reaction function (3.22). The full set of equations constituting the constraints accounted for by the planner is described in Appendix 3.6.2.

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.

### 3.4.2 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 $\xi_t^b$ can influence the government's intertemporal budget. Finally, we describe the trade-off faced by planner when, in face of a household heterogeneity, she has to choose between decreasing transfers or increasing labor tax rates to finance expenditure shocks.

[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.

**Fiscal Hedging through inflation**

Iterating forward on the government budget constraint we have:

$$\xi_t^b u_{c,t} \frac{b_{t-1}}{\Pi_t} = E_t \sum_{j=0}^{\infty} \beta^j \xi_{t+j}^b u_{c,t+j} s_{t+j} \tag{3.30}$$

which equates the present value of the surplus of the government, $s_t$, to the initial liability (LHS of 3.30). According to 3.30 (which needs to hold in every state) there are several ways to finance a rise in $g_t$. First, through a rise in $\Pi_t$ 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 (3.30) is slack for all $t > 0$. This would be the case if $\Pi_t$ 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 $\Pi_t$ so that (3.30) 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.

**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

[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 et al. (2004); Faraglia et al. (2019b)).

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 $h = 0$. 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 et al. (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 $\lambda^{bc}$ denotes the multiplier on the government budget constraint, $\lambda^{rc}_t$ is the analogous multiplier on the resource constraint of the economy and $\lambda^R$ 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), $\lambda^{bc}_t$ 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 $\lambda^{bc}_t$ 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 (3.22). In the above equation, this is summarized through the term $\left(\lambda^R_t - \frac{\lambda^R_{t-1}}{\Pi_t}\right)$.[21]

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

[20]Faraglia et al. (2019b) 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

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.

**household 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 household 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:

$$\frac{v^h_{n,t}}{\theta^h_t u^h_{c,t}} = \frac{v^s_{n,t}}{u^s_{c,t}} = a_t \qquad\qquad u^h_{c,t} = u^s_{c,t} \tag{3.31}$$

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

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 (3.22). Thus interest rate manipulation is not mute but maybe difficult to implement in the presence of constraint (3.22).

[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.

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 $\omega$) 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 ($\theta_t^h$).

### 3.4.3 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 3.4). Then, we study further the impact of some key parameters on the steady state level of taxes and transfers.

#### The steady-sate allocation

Table 3.6 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.

[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.

[Table 3.6 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 $\omega$, 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-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 3.14 in Appendix 3.6.4 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 3.14.

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

[25] Table 3.6 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 3.3.2 and Table 3.4), this does not come as a surprise.

**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 $\lambda$, 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 $\theta^h$, and the parameters determining the share of transfers going to hand-to-mouth households, $\omega$. Figure 3.12 depicts the impact of these parameters on the optimal tax rate, leaving all the other model parameters at their posterior mean.

[Figure 3.12 approximately here]

We start by studying the effects of the relative productivity of constrained agents ($\theta^h$) in the top right panel of Figure 3.12. At low values of $\theta^h$, 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 $\theta^h$, 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 3.12 plots the impact of $\omega$ on the optimal tax rate. We see that the influence of this parameter on the labor tax is non-monotonic: at low values of $\omega$, an increase in 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 $\omega$ approaches one, the optimal long-run tax rate starts to decrease. At high values of $\omega$, 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 ($\theta_w$) 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.

### 3.4.4 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 3.3.2.

**Impulse responses**

In Figures 3.13 and 3.14 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 3.15 and 3.16 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 3.13 to 3.16 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 household heterogeneity only marginally, the planner can use variations in transfers to finance her inter-temporal 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**, $\theta_t^h$, 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 $\theta_t^h$. 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 3.14, 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,

[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.

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 inter-temporal 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. 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]

### Matching moments

In this section, we are particularly interested in the ability of our model to match the data properties already mentioned in Section 3.3.2, namely, the negative correlation between transfers and GDP, and the positive correlation between transfers and the primary deficit.

[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 3.19 and 3.20 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 ($\theta^h$) 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 3.4), which implies larger and long-lasting effects on inflation, the interest rate, Ricardian households' consumption and aggregate output.

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 ($\theta^h$). 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 3.7 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 3.7 approximately here]

For comparison purposes, Table 3.7 also provides the simulated moments when we use the parameters obtained from the estimation without data on household heterogeneity. In this case, the 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 3.15 in Appendix 3.6.4 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.

## 3.5 Conclusion

In this paper, we investigate the role of household 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 household 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.

## 3.6 Appendix

### 3.6.1 Tables and Figures

TABLE 3.1: **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 3.2: **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 3.3: **TANK model: Calibrated parameters**

| **Parameter** | **Description** | **Value** |
|---|---|---|
| $n$ | Steady-state hours | 1 |
| $d$ | Steady-state profits | 0 |
| $\lambda$ | Share of hand-to-mouth households | 0.30 |
| $\alpha$ | Capital share in production | 0.30 |
| $\delta$ | 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 |
| $\omega$ | Share of transfers going to HTM agents | 0.673 |
| $\tau^c$ | Consumption tax rate | 0.030 |
| $\tau^k$ | Capital tax rate | 0.198 |
| $\tau^n$ | 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 3.3.

TABLE 3.4: **Estimated parameters**

| **Parameter** | | **Posterior TANK** | | **Posterior TANK*** | | **Prior** | | |
|---|---|---|---|---|---|---|---|---|
| | | mean | 90 % interval | mean | 90 % interval | distrib | par A | par B |
| $100\gamma$ | 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 |
| $\phi$ | 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** | | | | | | | | |
| $\phi_u$ | utilization cost | 2.639 | [1.811 ; 3.456] | 3.068 | [2.167 ; 3.911] | G | 2 | 0.5 |
| $\kappa$ | adjustment cost | 4.384 | [2.887 ; 5.806] | 3.545 | [2.579 ; 4.494] | G | 4 | 0.75 |
| **Nominal Rigidities** | | | | | | | | |
| $\theta_w$ | wage rigidity | 0.562 | [0.298 ; 0.795] | 0.341 | [0.25 ; 0.42] | B | 0.5 | 0.1 |
| $\theta_p$ | price rigidity | 0.888 | [0.828 ; 0.943] | 0.836 | [0.804 ; 0.867] | B | 0.5 | 0.1 |
| **Monetary Policy** | | | | | | | | |
| $\rho_r$ | interest rate smoothing | 0.803 | [0.75 ; 0.854] | 0.763 | [0.72 ; 0.81] | B | 0.8 | 0.1 |
| $\phi_\pi$ | response to inflation | 1.871 | [1.666 ; 2.069] | 1.961 | [1.797 ; 2.121] | G | 1.75 | 0.1 |
| $\phi_y$ | response to output | 0.051 | [0.013 ; 0.09] | 0.031 | [0.015 ; 0.047] | G | 0.12 | 0.05 |
| **Labor tax rule** | | | | | | | | |
| $\rho_\tau$ | 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** | | | | | | | | |
| $\rho_T$ | 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** | | | | | | | | |
| $\rho_\theta$ | 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** | | | | | | | | |
| $\rho_g$ | gov.spending | 0.979 | [0.963 ; 0.995] | 0.975 | [0.959 ; 0.994] | B | 0.5 | 0.2 |
| $\rho_w$ | wage mark-up, sav | 0.338 | [0.156 ; 0.514] | 0.953 | [0.922 ; 0.991] | B | 0.5 | 0.2 |
| $\rho_p$ | price mark-up | 0.772 | [0.644 ; 0.895] | 0.938 | [0.897 ; 0.981] | B | 0.5 | 0.2 |
| $\rho_a$ | technology | 0.173 | [0.058 ; 0.283] | 0.4 | [0.256 ; 0.547] | B | 0.5 | 0.2 |
| $\rho_i$ | investment | 0.841 | [0.76 ; 0.925] | 0.779 | [0.677 ; 0.882] | B | 0.5 | 0.2 |
| $\rho_b$ | preference, sav. | 0.766 | [0.668 ; 0.866] | 0.859 | [0.801 ; 0.922] | B | 0.5 | 0.2 |
| $\rho_m$ | monetary policy | 0.454 | [0.337 ; 0.575] | 0.447 | [0.342 ; 0.558] | B | 0.5 | 0.2 |
| $\rho_{gbc}$ | 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** | | | | | | | | |
| $\sigma_g$ | gov. spending | 2.402 | [2.104 ; 2.678] | 2.537 | [2.211 ; 2.86] | IG | 0.1 | 2 |
| $\sigma_w$ | wage mark-up, sav | 0.249 | [0.161 ; 0.341] | 0.29 | [0.205 ; 0.371] | IG | 0.1 | 2 |
| $\sigma_p$ | price mark-up | 0.065 | [0.045 ; 0.084] | 0.071 | [0.053 ; 0.088] | IG | 0.1 | 2 |
| $\sigma_a$ | technology | 1.12 | [0.977 ; 1.268] | 1.105 | [0.854 ; 1.339] | IG | 0.1 | 2 |
| $\sigma_i$ | investment | 3.34 | [2.181 ; 4.397] | 2.898 | [2.067 ; 3.696] | IG | 0.1 | 2 |
| $\sigma_b$ | preference, sav. | 2.881 | [1.594 ; 4.133] | 1.959 | [1.545 ; 2.36] | IG | 0.1 | 2 |
| $\sigma_m$ | monetary policy | 0.123 | [0.104 ; 0.14] | 0.129 | [0.11 ; 0.147] | IG | 0.1 | 2 |
| $\sigma_\tau$ | lab tax rate | 1.947 | [1.712 ; 2.187] | 1.885 | [1.649 ; 2.118] | IG | 0.1 | 2 |
| $\sigma_T$ | tsf cyclical comp. | 2.288 | [2.015 ; 2.564] | 2.291 | [2.018 ; 2.552] | IG | 0.1 | 2 |
| $\sigma_\theta$ | relative productivity | 0.112 | [0.023 ; 0.21] | 2.518 | [2.197 ; 2.85] | IG | 0.1 | 2 |
| **Measurement errors** | | | | | | | | |
| $\sigma_{rc}$ | output | 0.275 | [0.243 ; 0.305] | 0.28 | [0.246 ; 0.312] | IG | 0.1 | 2 |
| $\sigma_{gbc}$ | 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 |

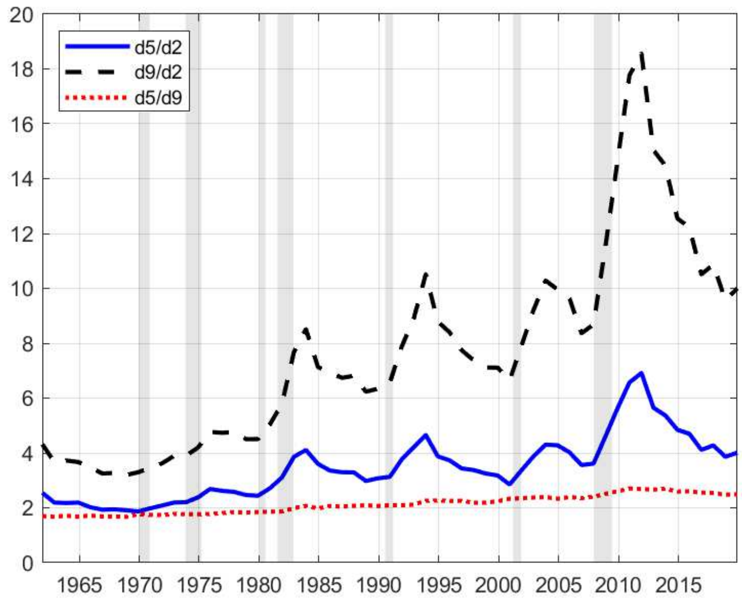
**Notes:** TANK [TANK*] denote posterior estimates for the model [with household heterogeneity data].

TABLE 3.5: **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 |
| $eps_\theta$ | 2.34 | 2.33 | -0.11 | 0.45 | 1.52 |
| **Fiscal shocks** | | | | | |
| $eps_\tau$ | -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.

FIGURE 3.1: **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.

Table 3.6: **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 3.7: **Ramsey simulated moments**

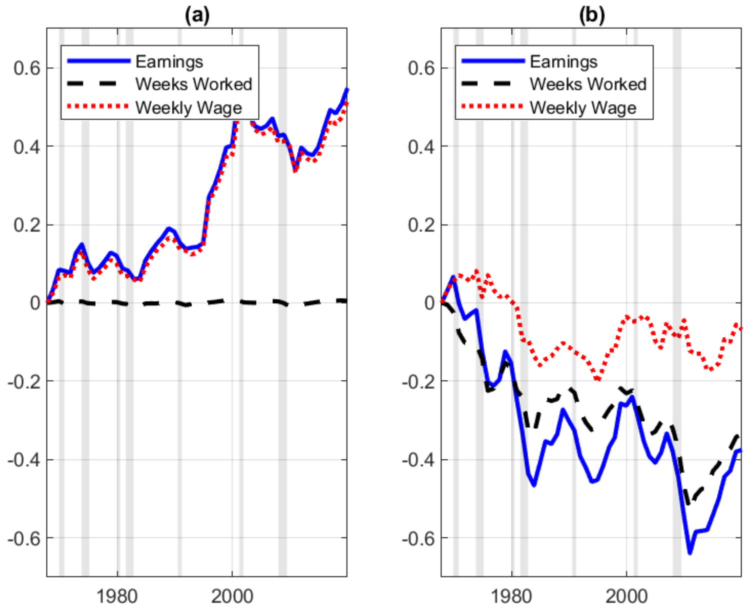
| | **Ramsey w/o cross-sect. data** | **Ramsey w cross-sect. data** |
|---|---|---|
| Corr(T,Y) | -0.29 | -0.53 |
| Corr(def,T) | -0.09 | 0.22 |
| Corr(def,Y) | -0.24 | -0.53 |

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

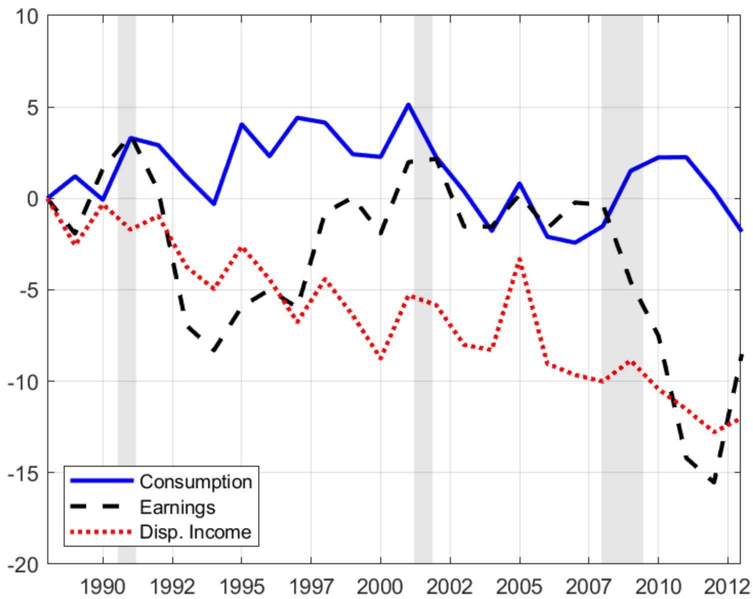

**Notes**: Panel (a) plots the evolution of average weekly wages (dashed black line), yearly earnings (solid blue line) and the average number of weeks worked (dotted red line) at the bottom 30% of the earnings distribution. Panel (b) decomposes the average weeks worked (solid blue line) in two terms: 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 3.3: **The evolution of wages, earnings and weeks worked at the top and the bottom of the earnings distribution**



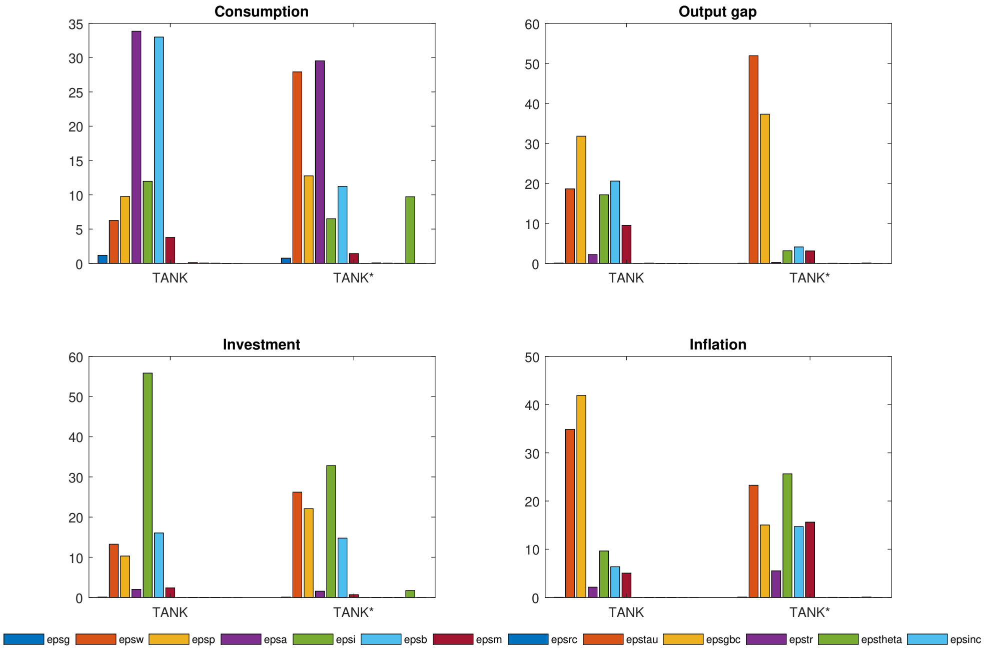

**Notes**: Panel (a) plots the evolution of average weekly wages(dashed black line), yearly earnings (solid blue line) and the average number of weeks worked (dotted red line) at the bottom 30% of the earnings distribution. Panel (b) reproduces the same exercise for the top 70% of the earnings distribution.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

FIGURE 3.4: **The evolution of earnings, disposable income and consumption inequality**



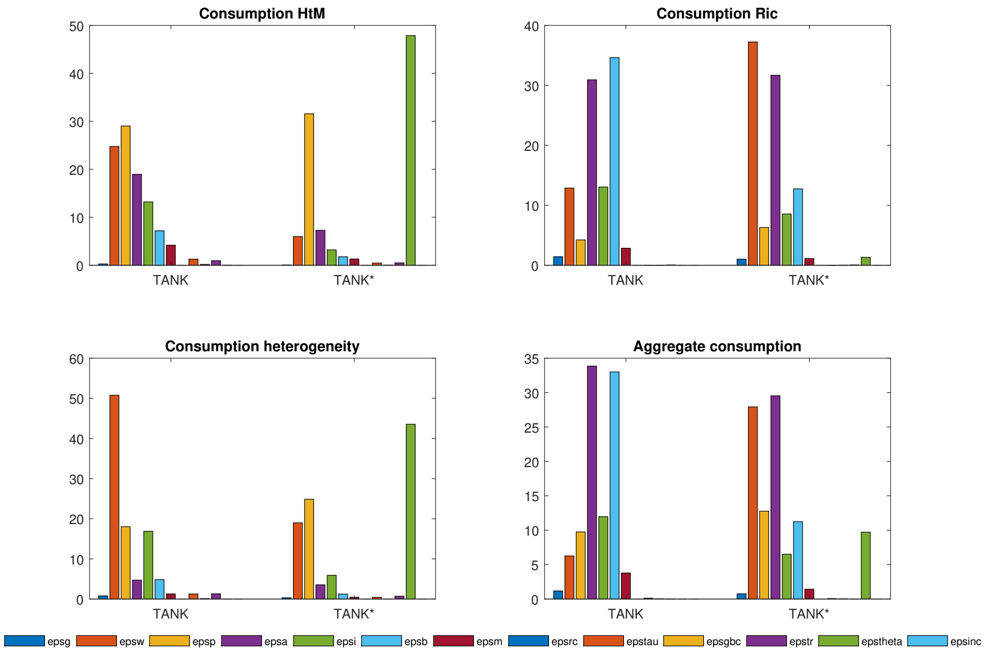

**Notes**: The figure plots the evolution of households' non-durable consumption expenditures (solid blue line), earnings (dashed black line) and disposable income (dotted red line) inequality. Consumption inequality is measured as the ratio of consumption expenditures at the bottom 30% of the earnings 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 3.5: **Variance decomposition of the main aggregate variables**



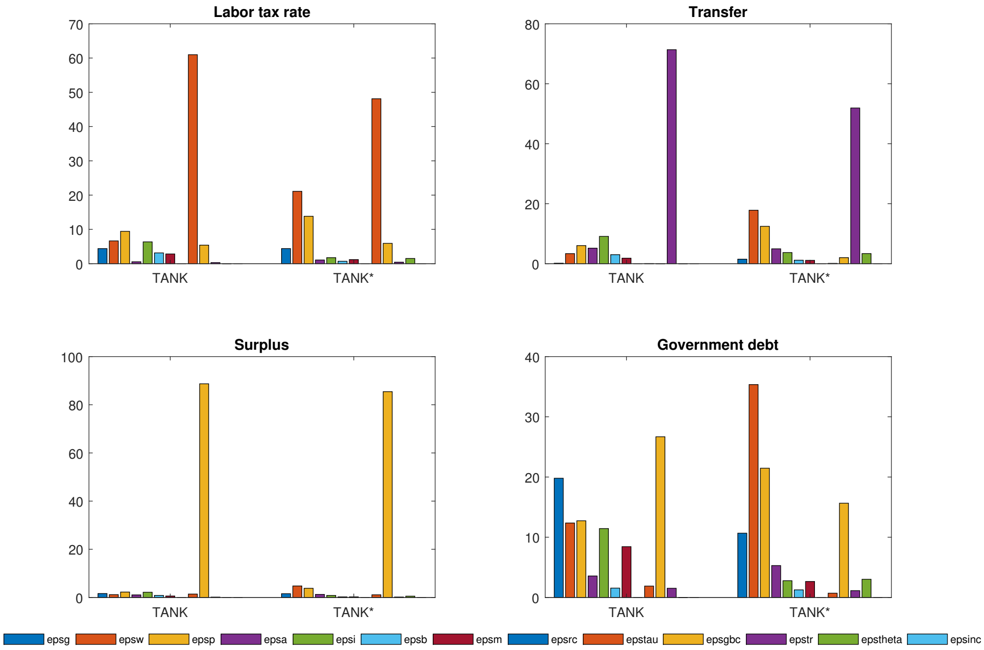

**Notes**: The Figure plots the variance decomposition of aggregate consumption (top-left), output (top-right), investment (bottom left) and inflation (bottom right) obtained from our two alternative estimations. TANK [TANK*] corresponds to the estimation of the TANK model without data on household heterogeneity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

FIGURE 3.6: **Variance decomposition of the variables measuring consumption**



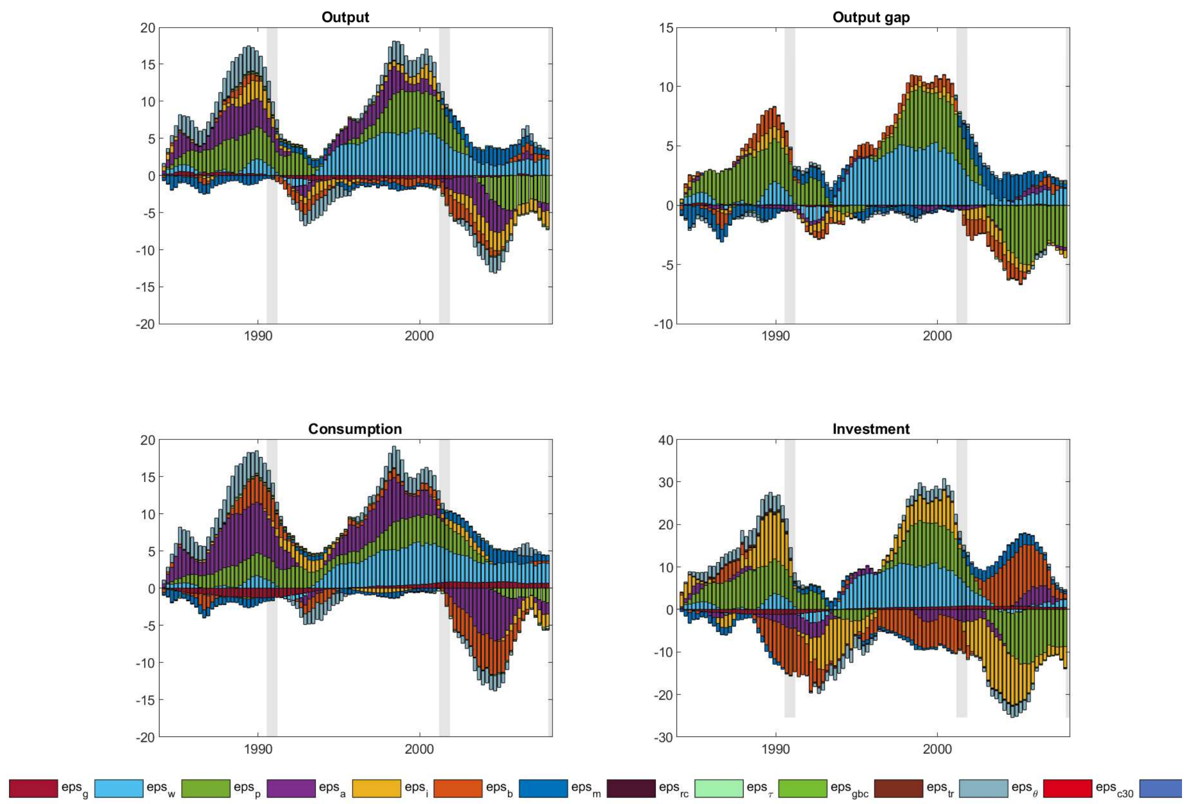

**Notes**: The Figure plots the variance decomposition of hand-to-mouth households' consumption (top-left), Ricardian households' consumption (top-right), consumption heterogeneity (bottom-left) and aggregate consumption (bottom-right) obtained from our two alternative estimations. TANK [TANK*] corresponds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

FIGURE 3.7: **Variance decomposition of fiscal variables**



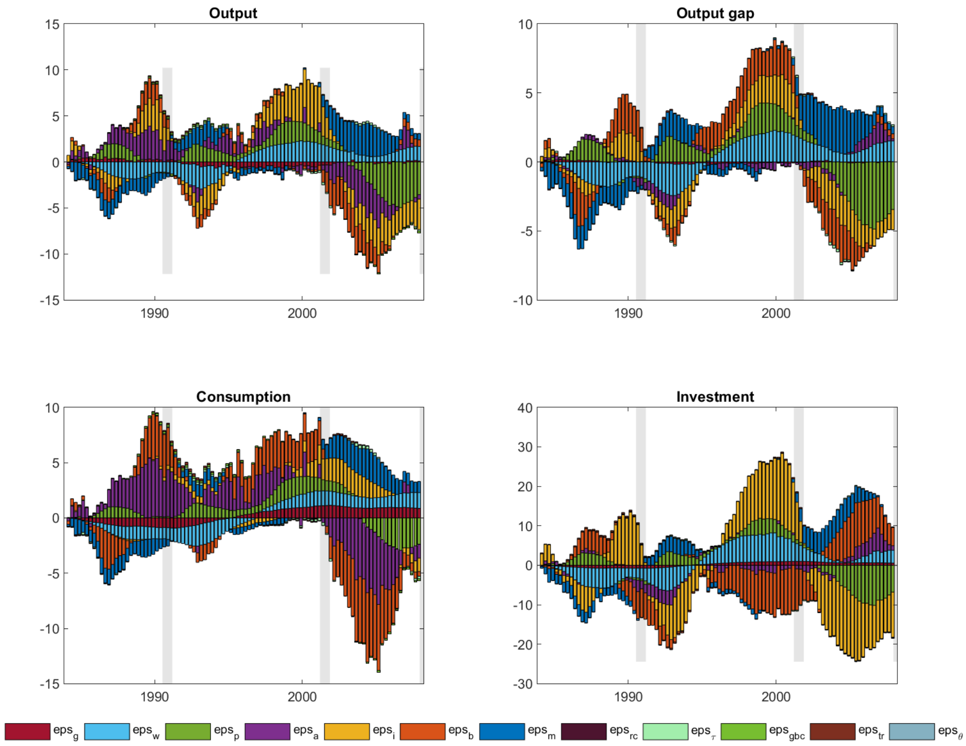

**Notes**: The Figure plots the variance decomposition of the labor tax rate (top-left), transfers (top-right), the government surplus (bottom-left) and government debt (bottom-right) obtained from our two alternative estimations. TANK [TANK*] corresponds to the estimation of the TANK model without data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

FIGURE 3.8: **Historical decomposition of aggregate variables in TANK***



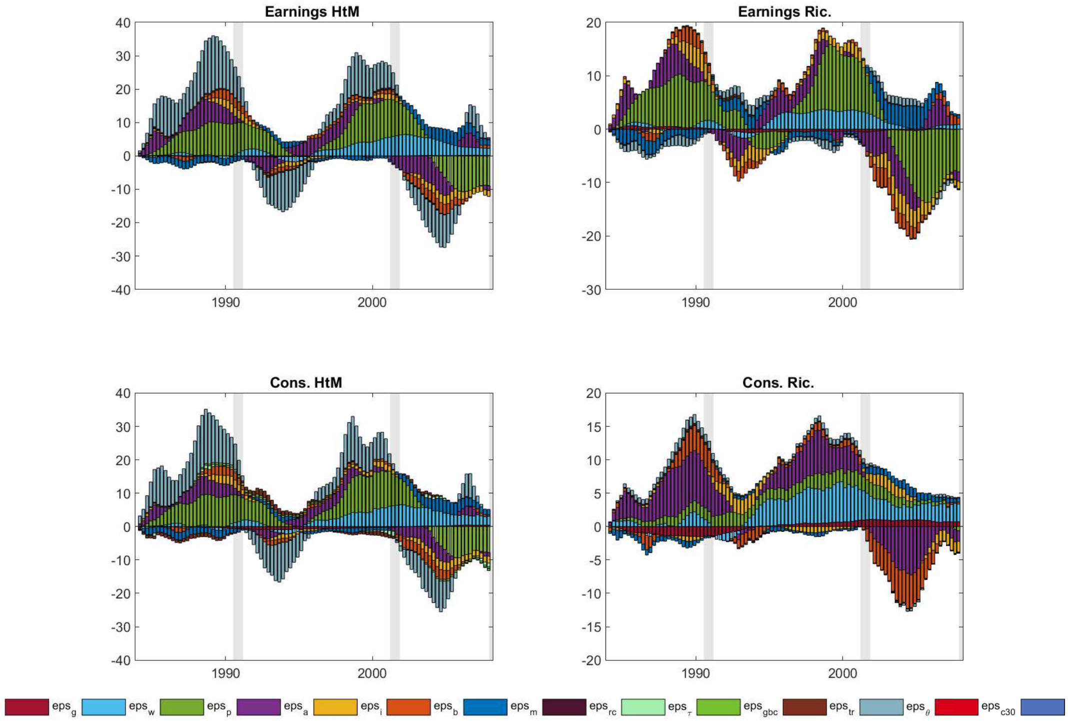

**Notes**: The figure plots the historical decomposition of the log-deviations of output (top-left panel), the output-gap (top-right), aggregate consumption (bottom-left) and investment (bottom-right) from the estimation of the model with data on earnings and consumption inequality (TANK*). Shaded areas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

FIGURE 3.9: **Historical decomposition of aggregate variables in TANK**



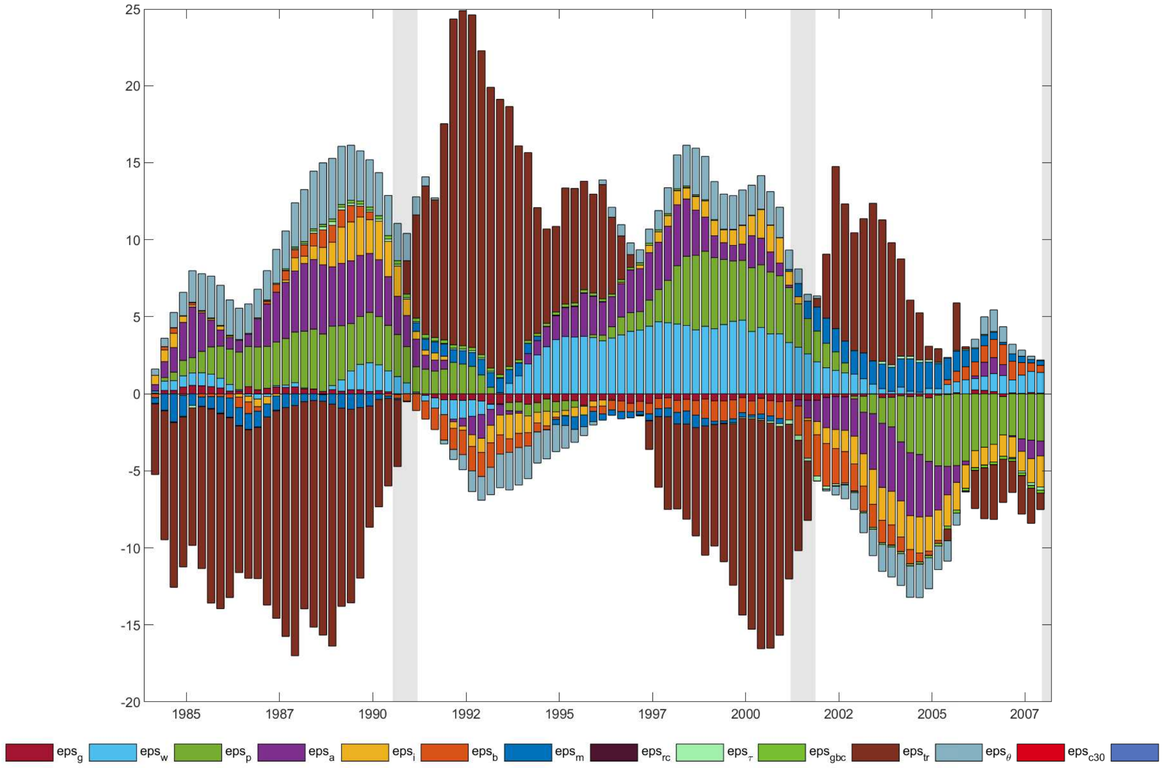

**Notes**: The figure plots the historical decomposition of the log-deviations of output (top-left panel), the output-gap (top-right), aggregate consumption (bottom-left) and investment (bottom-right) from the estimation of the model without data on earnings and consumption inequality (TANK). Shaded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

FIGURE 3.10: **Historical decomposition of households' earnings and consumption**



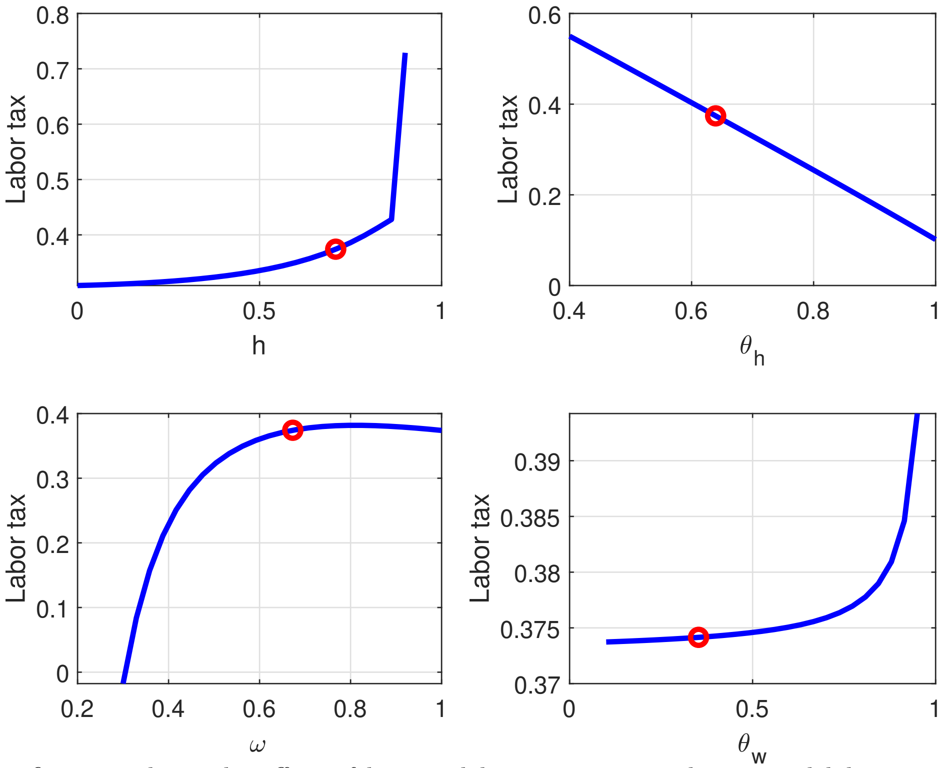

**Notes**: The figure plots the historical decomposition of the log-deviations of hand-to-mouth households' earnings (top-left panel) and consumption (bottom-left), and Ricardian households' earnings (top-right) and consumption (bottom-right) from the estimation of the model with data on earnings and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

FIGURE 3.11: **Historical decomposition of transfers**



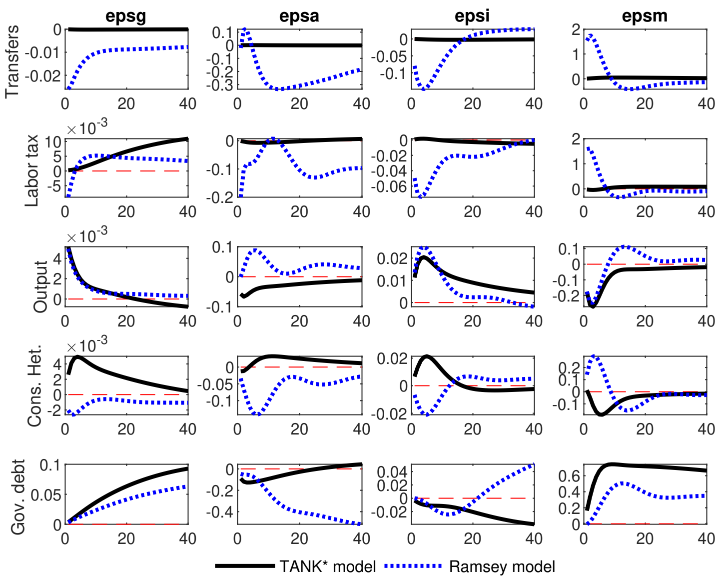

**Notes**: The figure plots the historical decomposition of the log-deviations of transfers from the estimation of the model with data on earnings and consumption inequality (TANK*). Shaded areas correspond to NBER dated recessions.

FIGURE 3.12: **Steady-state in the Ramsey model**



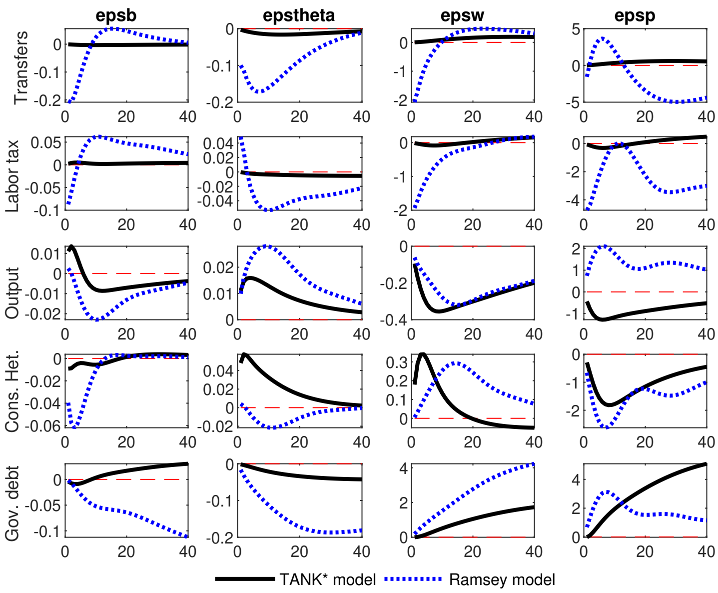

**Notes:** The figure analyses the effect of key model parameters on the optimal labor tax rate in the steady-state of the baseline model (i.e. based on the parameters obtained from the estimation without data on heterogeneity). Panel (a) displays the effect of $h$, the parameters measuring households' habits in consumption, panel (b) depicts the effect of $\theta^h$, the long-run value of the relative productivity of hand-to-mouth agents. Panel (b) Panel (c) and (d) present, respectively, the effect of $\omega$, the share of transfers targeted towards hand-to-mouth agents, and $\theta_w$, the wage rigidity parameter. The remaining parameters are set to their baseline values, as presented in Table 3.3. A close figure can be reproduced with the parameters obtained from the estimation with data on heterogeneity.

FIGURE 3.13: **IRFs in the medium-scale model - fiscal rules vs. Ramsey (a)**



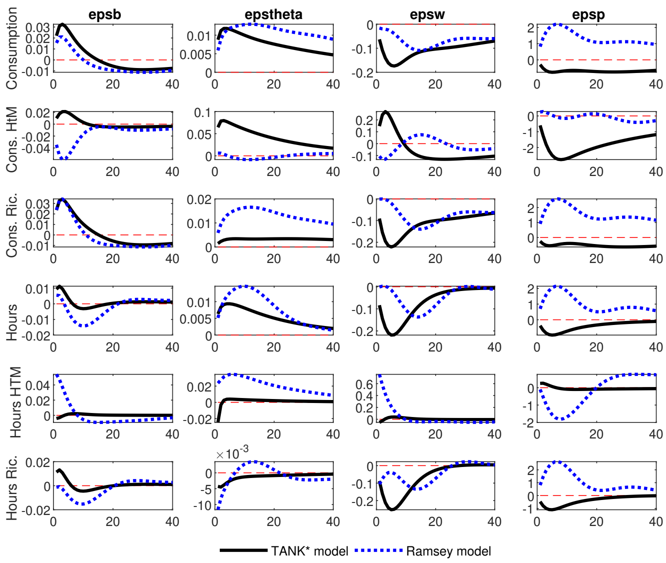

**Notes**: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black lines 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 household heterogeneity.

FIGURE 3.14: **IRFs in the medium-scale model - fiscal rules vs. Ramsey (b)**



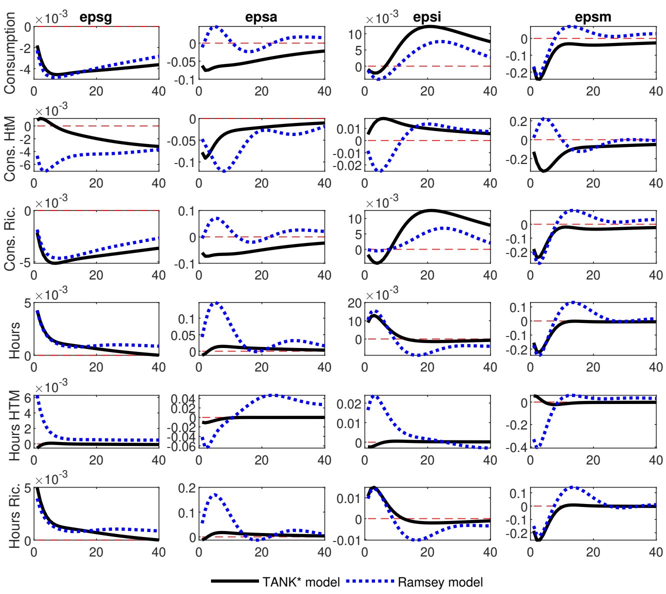

**Notes**: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and 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 household heterogeneity.

FIGURE 3.15: **IRFs in the medium-scale model - fiscal rules vs. Ramsey (c)**



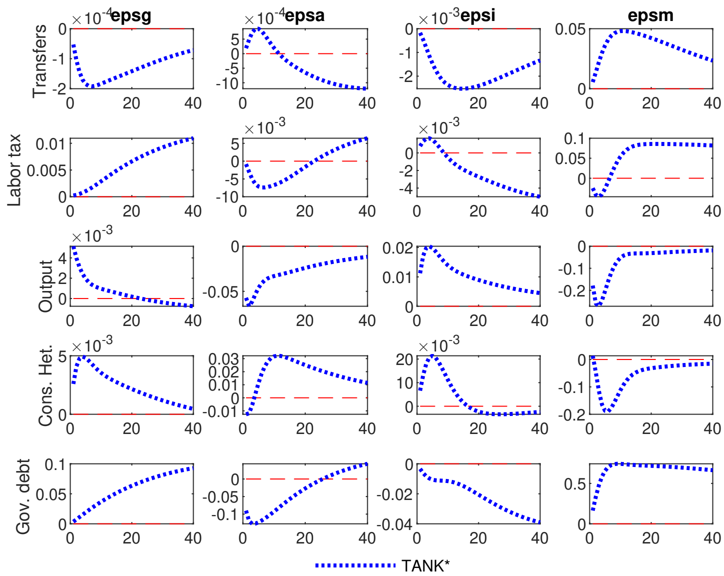

**Notes**: The figure plots the IRFs of households-specific variables – hours worked and consumption – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black lines display the responses obtained from the TANK model with fiscal rule, the dotted blue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

FIGURE 3.16: **IRFs in the medium-scale model - fiscal rules vs. Ramsey (d)**



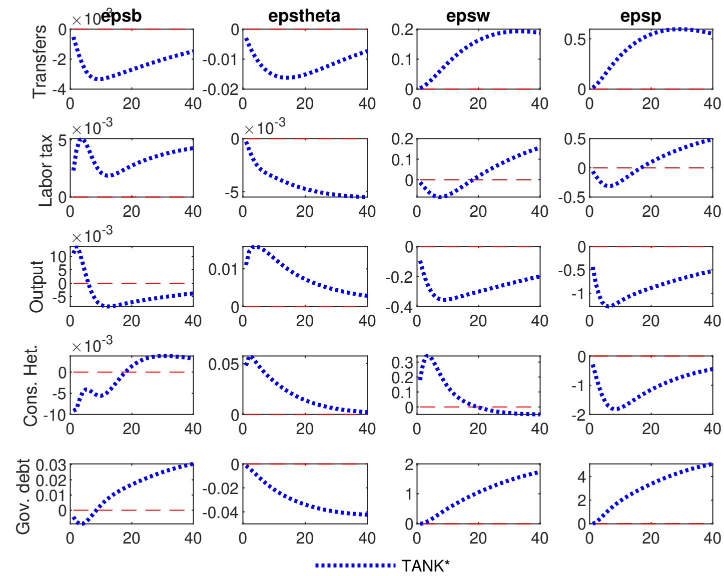

**Notes**: The figure plots the IRFs of households-specific variables – hours worked and consumption – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups. The solid black lines display the responses obtained from 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 household heterogeneity.

FIGURE 3.17: **IRFs in the medium-scale model with fiscal rules (a)**



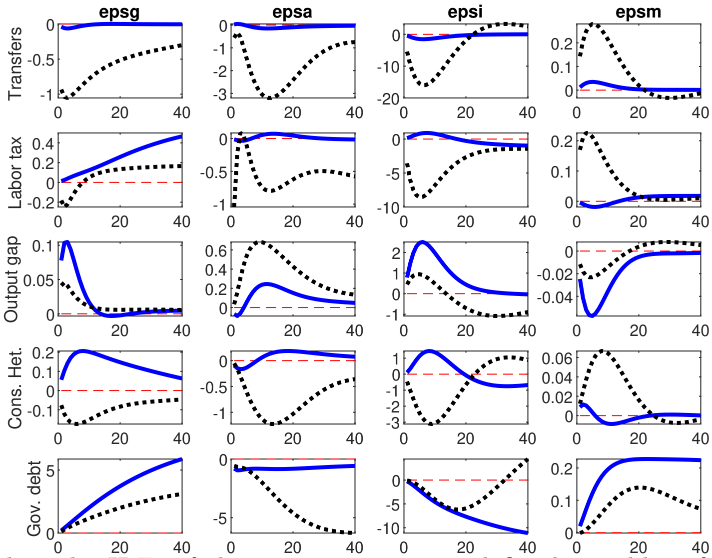

**Notes**: The figure plots the IRFs obtained from the TANK model with fiscal rule for the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and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

FIGURE 3.18: **IRFs in the medium-scale model with fiscal rules (b)**



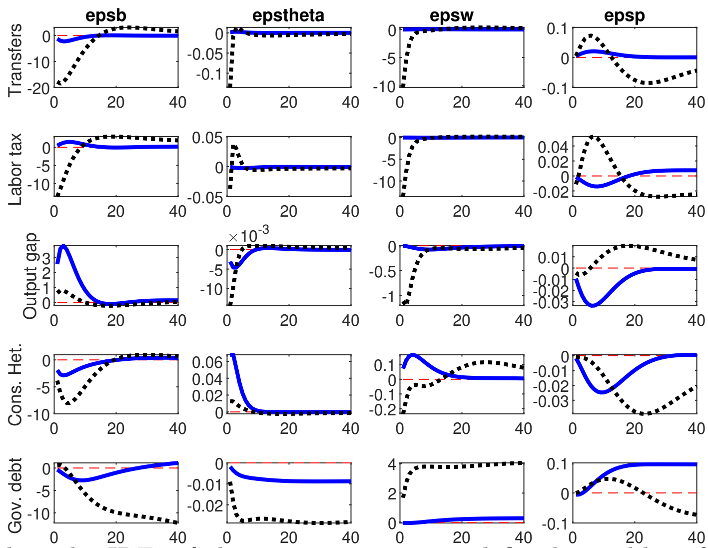

**Notes**: The figure plots the IRFs of obtained from the TANK model with fiscal rule for the main aggregate and fiscal variables of the model – output, consumption heterogeneity, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative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

FIGURE 3.19: **Optimal IRFs in the medium-scale model (a)**



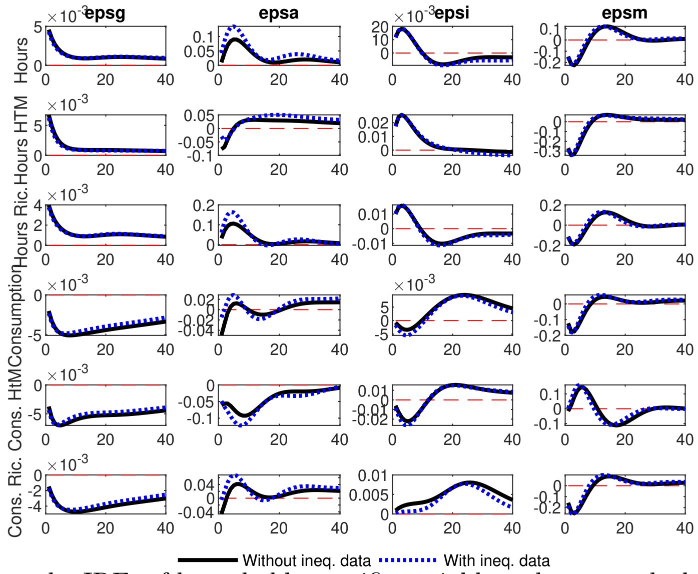

**Notes**: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption, transfers, the labor tax rate and the government debt – to government expenditure shocks, TFP shocks, investment specific and monetary policy shocks. The solid black (dotted blue) line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

FIGURE 3.20: **Optimal IRFs in the medium-scale model (b)**



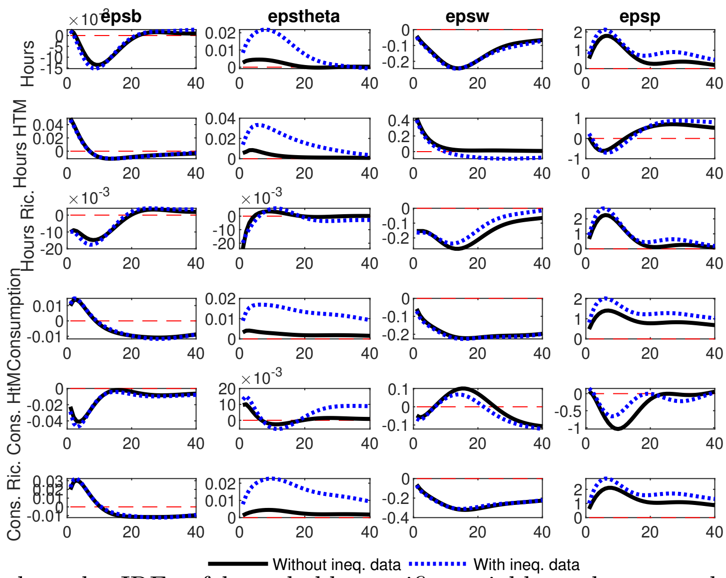

**Notes**: The figure plots the IRFs of the main aggregate and fiscal variables of the model – output, consumption, transfers, the labor tax rate and the government debt – to shocks to the preferences of Ricardian households, to the relative productivity of hand-to-mouth households and to wage- and price-markups.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

FIGURE 3.21: **Optimal IRFs in the medium-scale model (c)**




**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 household heterogeneity.

FIGURE 3.22: **Optimal IRFs in the medium-scale model (d)**




**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 household heterogeneity.

### 3.6.2 The medium-scale DSGE model

**The competitive equilibrium**

Non savers:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + tr_t^h \tag{3.32}$$

$$\chi(n_t^h)^{\phi_h}(c_t^h - hc_{t-1}^{h,a}) = (1-\tau_t^n)\theta_t^h w_t \tag{3.33}$$

Savers' first order conditions:

$$k_t = (1-\delta)k_{t-1} + \xi_t^i\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\Big)\Big]I_t \tag{3.34}$$

$$\lambda_t = \xi_t^b \frac{u_c^s(c_t^s - hc_{t-1}^{s,a})}{1+\tau^c} \tag{3.35}$$

$$\lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}} \tag{3.36}$$

$$1 - \xi_t^i \mu_t\Big[1 - S\Big(\frac{I_t^s}{I_{t-1}^s}\Big) - \frac{I_t^s}{I_{t-1}^s}S'\Big(\frac{I_t^s}{I_{t-1}^s}\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t}\Big(\frac{I_{t+1}^s}{I_t^s}\Big)^2 S'\Big(\frac{I_{t+1}^s}{I_t^s}\Big) \tag{3.37}$$

$$\mu_t = \beta(1-\delta)E_t\mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t} + \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{3.38}$$

$$\Phi'(u_t) = (1-\tau^k)r_t^k \tag{3.39}$$

Wage setting (by savers):

$$(w_t^*)^{1+\eta_w\phi_s} = \frac{\eta_w\chi}{\eta_w - 1}\frac{F_{1,t}^w}{F_{2,t}^w} \tag{3.40}$$

$$F_{1,t}^w = \xi_t^b w_t^{\eta_w(1+\phi_s)}(n_t^s)^{1+\phi_s} + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{-\eta_w(1+\phi_s)}E_t\Pi_{t+1}^{\eta_w(1+\phi_s)}F_{1,t+1}^w \tag{3.41}$$

$$F_{2,t}^w = \lambda_t(1-\tau_t^n)w_t^{\eta_w}n_t^s + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{1-\eta_w}E_t\Pi_{t+1}^{\eta_w-1}F_{2,t+1}^w \tag{3.42}$$

$$w_t^{1-\eta_w} = (1-\theta_w)(w_t^*)^{1-\eta_w} + \theta_w(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^{\gamma})^{1-\eta_w}\Pi_t^{\eta_w-1}w_{t-1}^{1-\eta_w} \tag{3.43}$$

$$v_t^w = (1-\theta_w)\Big(\frac{w_t^*}{w_t}\Big)^{-\eta_w(1+\phi_s}+\theta_w\Big(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^{\gamma}\Big)^{-\eta_w(1+\phi_s)}\Pi_t^{\eta_w(1+\phi_s)}\Big(\frac{w_t}{w_{t-1}}\Big)^{\eta_w(1+\phi_s)}v_{t-1}^w \tag{3.44}$$

Price setting:

$$p_t^* = \frac{\eta_p}{\eta_p - 1}\frac{F_{1,t}^p}{F_{2,t}^p} \tag{3.45}$$

$$F_{1,t}^p = mc_t y_t + \beta\theta_p \Pi^{-\eta_p \nu_p}\Pi^{-\eta_p(1-\nu_p)} E_t \Pi_{t+1}^{\eta_p}\frac{\lambda_{t+1}}{\lambda_t}F_{1,t+1}^p \tag{3.46}$$

$$F_{2,t}^p = y_t + \beta\theta_p \Pi_t^{(1-\eta_p)\nu_p}\Pi^{(1-\eta_p)(1-\nu_p)} E_t \Pi_{t+1}^{\eta_p - 1}\frac{\lambda_{t+1}}{\lambda_t}F_{2,t+1}^p \tag{3.47}$$

$$1 = (1-\theta_p)(p_t^*)^{1-\eta_p} + \theta_p \Pi_{t-1}^{\nu_p(1-\eta_p)}\Pi^{(1-\nu_p)(1-\eta_p)}\Pi_t^{\eta_p - 1} \tag{3.48}$$

Government budget:

$$\frac{b_{t-1}}{\Pi_t} = -g_t - tr_t + \tau_t^n w_t N_t + \tau^k(r_t^k u_t k_{t-1} + d_t) + \tau^c c_t + q_t b_t \tag{3.49}$$

Equilibrium and aggregation:

$$y_t v_t^p = (u_t k_{t-1})^\alpha (a_t N_t)^{1-\alpha} - \Omega a_t \tag{3.50}$$

$$v_t^p = (1-\theta_p)(p_t^*)^{-\eta_p} + \theta_p \Pi_{t-1}^{-\eta_p \nu_p}\Pi^{-\eta_p(1-\nu_p)}\Pi_t^{\eta_p} v_{t-1}^p \tag{3.51}$$

$$c_t + I_t + g_t + \Phi(u_t)k_{t-1} = y_t \tag{3.52}$$

$$N_t = \lambda\theta_t^h n_t^h + (1-\lambda)n_t^s \tag{3.53}$$

$$c_t = \lambda c_t^h + (1-\lambda)c_t^s \tag{3.54}$$

$$mc_t = \frac{1}{1-\alpha}\frac{w_t}{a_t}\left(\frac{u_t k_{t-1}}{a_t n_t}\right)^{-\alpha} \tag{3.55}$$

Potential output (flexible price block) to determine ($c_t^{flex}$, $c_t^{h,flex}$, $c_t^{s,flex}$, $n_t^{flex}$, $n_t^{h,flex}$, $n_t^{s,flex}$,

$\lambda_t^{flex}, k_t^{flex}, I_t^{flex}, \mu_t^{flex}, r_t^{k,flex}, r_t^{flex}, u_t^{flex}, w_t^{flex}, y_t^{flex})$.

$$\lambda_t^{flex} = \frac{\xi_t^b}{(1+\tau^c)(c_t^{s,flex} - hc_{t-1}^{s,flex})} \tag{3.56}$$

$$\lambda_t^{flex} = \beta r^{flex} \lambda_{t+1}^{flex} \tag{3.57}$$

$$w^{flex}(1-\tau_t^n) = \frac{\xi_t^b \chi (n_t^{s,flex})^\phi}{\lambda_t^{flex}} \frac{\eta^w}{\eta^w - 1} \tag{3.58}$$

$$w_t^{flex} = \frac{(\eta^p - 1)}{\eta^p}(1-\alpha)\big(\frac{u_t^{flex} k_{t-1}^{flex}}{n_t^{flex}}\big)^\alpha \tag{3.59}$$

$$r_t^{k,flex} = \frac{(\eta^p - 1)}{\eta^p}\alpha\big(\frac{u_t^{flex} k_{t-1}^{flex}}{n_t^{flex}}\big)^{(\alpha-1)} \tag{3.60}$$

$$k_t^{flex} = (1-\delta)k_{t-1}^{flex} + \xi_t^i(1 - S\big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\big)I_t^{flex} \tag{3.61}$$

$$\lambda_t^{flex}\left[1 - \mu_t^{flex}\xi_t^i(1 - S\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big) - \frac{I_t^{flex}}{I_{t-1}^{flex}}S'\Big(\frac{I_t^{flex}}{I_{t-1}^{flex}}\Big)\right] = \beta_t \xi_{t+1}^i \mu_{t+1}^{flex}\lambda_{t+1}^{flex}\Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big)^2 S'\Big(\frac{I_{t+1}^{flex}}{I_t^{flex}}\Big) \tag{3.62}$$

$$\mu_t^{flex}\lambda_t^{flex} = \beta_t(1-\delta)\mu_{t+1}^{flex}\lambda_{t+1}^{flex} + \beta_t\lambda_{t+1}^{flex}\Big(\Phi'(u_{t+1}^{flex})u_{t+1}^{flex} - \Phi(u_{t+1}^{flex})\Big) \tag{3.63}$$

$$\Phi'(u_t^{flex}) = (1-\tau^k)r_t^{k,flex} \tag{3.64}$$

$$y_t^{flex} = (u_t^{flex}k_{t-1}^{flex})^\alpha (n_t^{flex})^{(1-\alpha)} - \Omega \tag{3.65}$$

$$y_t^{flex} = c^{flex} + I_t^{flex} + g_t + \Phi(u_t^{flex})k_{t-1}^{flex} \tag{3.66}$$

$$(1+\tau^c)c_t^{h,flex} = (1-\tau_t^n)\theta_t^h w_t^{flex} n_t^{h,flex} + tr_t^h \tag{3.67}$$

$$\chi(n_t^{h,flex})^\phi (c_t^{h,flex} - hc_{t-1}^{h,flex}) = (1-\tau_t^n)\theta_t^h w_t^{flex} \tag{3.68}$$

$$n^{flex} = \lambda\theta_t^h n_t^{h,flex} + (1-\lambda)n_t^{s,flex} \tag{3.69}$$

$$c_t^{flex} = \lambda c_t^{h,flex} + (1-\lambda)c_t^{s,flex} \tag{3.70}$$

Functional forms:

$$S\Big(\frac{I_t}{I_{t-1}}\Big) = \frac{\kappa}{2}\Big(\frac{I_t}{I_{t-1}} - e^\gamma\Big)^2 \tag{3.71}$$

$$\Phi(u_t) = \frac{r^k(1-\tau^k)}{\varphi_u}(e^{\varphi_u(u_t - 1)} - 1) \tag{3.72}$$

**Detrending**

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

$$\log \xi_t^a = (1-\rho_a)\gamma + \rho_a \log \xi_{t-1}^a + \epsilon_t^a \tag{3.73}$$

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

Non-savers:

$$(1+\tau^c)c_t^h = (1-\tau_t^n)\theta_t^h w_t n_t^h + \frac{tr_t}{\lambda} \tag{3.74}$$

$$(1+\tau^c)\chi(n_t^h)^{\phi_h}(c_t^h - hc_{t-1}^{h,a}(\xi_t^a)^{-1}) = (1-\tau_t^n)\theta_t^h w_t \tag{3.75}$$

Savers:

$$\lambda_t = \frac{\xi_t^b}{1+\tau^c}\frac{1}{c_t^s - hc_{t-1}^{s,a}(\xi_t^a)^{-1}} \tag{3.76}$$

$$\lambda_t q_t = \beta E_t \frac{\lambda_{t+1}}{\Pi_{t+1}}(\xi_{t+1}^a)^{-1} \tag{3.77}$$

$$k_t = (1-\delta)k_{t-1}(\xi_t^a)^{-1} + \xi_t^i\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big)\Big]I_t \tag{3.78}$$

$$1 - \xi_t^i\mu_t\Big[1 - S\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big) - \frac{I_t}{I_{t-1}}\xi_t^a S'\Big(\frac{I_t}{I_{t-1}}\xi_t^a\Big)\Big] = \beta E_t \xi_{t+1}^i \mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t \xi_{t+1}^a}\Big(\frac{I_{t+1}}{I_t}\xi_{t+1}^a\Big)^2 S'\Big(\frac{I_{t+1}}{I_t}\xi_{t+1}^a\Big) \tag{3.79}$$

$$\mu_t = \beta(1-\delta)E_t\mu_{t+1}\frac{\lambda_{t+1}}{\lambda_t\xi_{t+1}^a} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t \xi_{t+1}^a}\Big[\Phi'(u_{t+1})u_{t+1} - \Phi(u_{t+1})\Big] \tag{3.80}$$

$$\Phi'(u_t) = (1-\tau^k)r_t^k \tag{3.81}$$

Wage setting:

$$(w_t^*)^{1+\eta_w\phi_s} = \frac{\eta_w \chi}{\eta_w - 1}\frac{f_{1,t}^w}{f_{2,t}^w} \tag{3.82}$$

$$f_{1,t}^w = \xi_t^b w_t^{\eta_w(1+\phi_s)}(n_t^s)^{1+\phi_s}(\xi_t^w)^{\frac{1}{\Theta_2}} + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{-\eta_w(1+\phi_s)}E_t(\xi_{t+1}^a)^{\eta_w(1+\phi_s)}\Pi_{t+1}^{\eta_w(1+\phi_s)}f_{1,t+1}^w \tag{3.83}$$

$$f_{2,t}^w = \lambda_t(1-\tau_t^n)w_t^{\eta_w}n_t^s + \beta\theta_w(\Pi_t^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{1-\eta_w}E_t(\xi_{t+1}^a)^{\eta_w-1}\Pi_{t+1}^{\eta_w-1}f_{2,t+1}^w \tag{3.84}$$

$$w_t^{1-\eta_w} = (1-\theta_w)(w_t^*)^{1-\eta_w} + \theta_w(\xi_t^a)^{\eta_w-1}(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^\gamma)^{1-\eta_w}\Pi_t^{\eta_w-1}w_{t-1}^{1-\eta_w} \tag{3.85}$$

$$v_t^w = (1-\theta_w)\Big(\frac{w_t^*}{w_t}\Big)^{-\eta_w(1+\phi_s} + \theta_w\Big(\Pi_{t-1}^{\nu_w}\Pi^{1-\nu_w}e^\gamma\Big)^{-\eta_w(1+\phi_s)}\Pi_t^{\eta_w(1+\phi_s)}\Big(\xi_t^a\frac{w_t}{w_{t-1}}\Big)^{\eta_w(1+\phi_s)}v_{t-1}^w \tag{3.86}$$

Price setting:

$$p_t^* = \frac{\eta_p}{\eta_p - 1}\frac{f_{1,t}^p}{f_{2,t}^p} \tag{3.87}$$

$$f_{1,t}^p = mc_t y_t (\xi_t^p)^{\frac{\theta_p(1+\beta\nu_p)}{(1-\beta\theta_p)(1-\theta_p)}} + \beta\theta_p \Pi_t^{-\eta_p\nu_p}\Pi^{-\eta_p(1-\nu_p)} E_t \frac{\lambda_{t+1}}{\lambda_t}\Pi_{t+1}^{\eta_p} f_{1,t+1}^p \tag{3.88}$$

$$f_{2,t}^p = y_t + \beta\theta_p \Pi_t^{(1-\eta_p)\nu_p}\Pi^{(1-\eta_p)(1-\nu_p)} E_t \Pi_{t+1}^{\eta_p-1}\frac{\lambda_{t+1}}{\lambda_t} f_{2,t+1}^p \tag{3.89}$$

$$1 = (1-\theta_p)(p_t^*)^{1-\eta_p} + \theta_p \Pi_{t-1}^{\nu_p(1-\eta_p)}\Pi^{(1-\nu_p)(1-\eta_p)}\Pi_t^{\eta_p-1} \tag{3.90}$$

Government:

$$\frac{b_{t-1}}{\xi_t^a \Pi_t} = -g_t - tr_t + \tau_t^n w_t n_t + \tau^k(y_t - w_t n_t) + \tau^c c_t + q_t b_t \tag{3.91}$$

Equilibrium/aggregation

$$y_t v_t^p = (\xi_t^a)^{-\alpha}(u_t k_{t-1})^\alpha n_t^{1-\alpha} - \Omega \tag{3.92}$$

$$v_t^p = (1-\theta_p)(p_t^*)^{-\eta_p} + \theta_p \Pi_{t-1}^{-\eta_p\nu_p}\Pi^{-\eta_p(1-\nu_p)}\Pi_t^{\eta_p} v_{t-1}^p \tag{3.93}$$

$$c_t + I_t + g_t + \Phi(u_t)k_{t-1}(\xi_t^a)^{-1} = y_t \tag{3.94}$$

$$mc_t = \frac{1}{1-\alpha} w_t \left(\frac{u_t k_{t-1}}{\xi_t^a n_t}\right)^{-\alpha} \tag{3.95}$$

$$\frac{w_t}{r_t^k} = \frac{1-\alpha}{\alpha}\frac{u_t k_{t-1}}{n_t}(\xi_t^a)^{-1} \tag{3.96}$$

$$n_t = \lambda\theta_t^h n_t^h + (1-\lambda)n_t^s \tag{3.97}$$

$$c_t = \lambda c_t^h + (1-\lambda)c_t^s \tag{3.98}$$

**Steady-state**

Given the normalized value of $n$:

$$u = 1$$
$$p^* = 1$$
$$v^p = 1$$
$$q = \frac{e^{-\gamma}\beta}{\Pi}$$
$$mc = \frac{\eta_p - 1}{\eta_p}$$
$$\mu = 1$$
$$r^k = \frac{1-\beta(1-\delta)e^{-\gamma}}{\beta e^{-\gamma}(1-\tau^k)}$$

$$k = ne^\gamma\left(\frac{\alpha mc}{r^k}\right)^{\frac{1}{1-\alpha}}$$
$$w = e^{-\gamma}\frac{1-\alpha}{\alpha}\frac{k}{n}r^k$$
$$I = (1-(1-\delta)e^{-\gamma})k$$
$$\Omega = e^{-\alpha\gamma}k^\alpha n^{1-\alpha} - r^k k - wn$$
$$y = e^{-\alpha\gamma}k^\alpha n^{1-\alpha} - \Omega$$
$$c = y - I - g$$

**Log-linear equations**

Savers:

$$\hat{\lambda}_t = \hat{\xi}_t^b - \frac{1}{1-he^{-\gamma}}(\hat{c}_t^s - he^{-\gamma}\hat{c}_{t-1}^s + he^{-\gamma}\hat{\xi}_t^a) \tag{3.99}$$

$$\hat{\lambda}_t + \hat{q}_t = E_t\hat{\lambda}_{t+1} - E_t\hat{\pi}_{t+1} - E_t\hat{\xi}_{t+1}^a \tag{3.100}$$

$$\hat{k}_t = (1-\delta)e^{-\gamma}(\hat{k}_{t-1} - \hat{\xi}_t^a) + (1-(1-\delta)e^{-\gamma})(\hat{I}_t + \hat{\xi}_t^i) \tag{3.101}$$

$$\hat{I}_t = \frac{1}{1+\beta}(\hat{I}_{t-1} + \beta E_t\hat{I}_{t+1}) - \frac{1}{1+\beta}(\hat{\xi}_t^a - \beta E_t\hat{\xi}_{t+1}^a) + \frac{e^{-2\gamma}}{(1+\beta)\kappa}(\hat{\mu}_t + \hat{\xi}_t^i) \tag{3.102}$$

$$\hat{\mu}_t = \beta(1-\delta)e^{-\gamma}E_t\mu_{t+1} + E_t\hat{\lambda}_{t+1} - \hat{\lambda}_t - E_t\hat{\xi}_{t+1}^a + (1-\beta(1-\delta)e^{-\gamma})E_t\hat{r}_{t+1}^k \tag{3.103}$$

$$\hat{r}_t^k = \varphi_u\hat{u}_t \tag{3.104}$$

Price and wage setting:

$$\hat{\pi}_t = \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p(1+\beta\nu_p)}\hat{mc}_t + \frac{\nu_p}{1+\beta\nu_p}\hat{\pi}_{t-1} + \frac{\beta}{1+\beta\nu_p}E_t\hat{\pi}_{t+1} + \hat{\xi}_t^p \tag{3.105}$$

$$\begin{aligned}\hat{w}_t = \tilde{\Theta}_2\Big(\phi_s\hat{n}_t^s - \hat{\lambda}_t + \xi_t^b + \frac{\tau^n}{1-\tau^n}\hat{\tau}_t^n\Big) + \tilde{\Theta}_1\Big(\hat{w}_{t-1} + \beta E_t\hat{w}_{t+1} + \nu_w\hat{\pi}_{t-1}\\ -(1+\beta\nu_w)\hat{\pi}_t + \beta E_t\hat{\pi}_{t+1} - \hat{\xi}_t^a + \beta E_t\hat{\xi}_{t+1}^a\Big) + \hat{\xi}_t^w\end{aligned} \tag{3.106}$$

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:

$$\frac{b}{\Pi}e^{-\gamma}(\hat{b}_{t-1} - \hat{\xi}_t^a - \hat{\pi}_t) = -g\hat{g}_t - tr\hat{tr}_t + \tau^n wn(\hat{\tau}_t^n + \hat{w}_t + \hat{n}_t) + \tau^k(y\hat{y}_t - wn(\hat{w}_t + \hat{n}_t)) + \tau^c c\hat{c}_t + qb(\hat{q}_t + \hat{b}_t) \tag{3.107}$$

$$y\hat{y}_t = e^{-\alpha\gamma}k^\alpha n^{1-\alpha}[\alpha(\hat{u}_t + \hat{k}_{t-1} - \hat{\xi}_t^a) + (1-\alpha)\hat{n}_t] \tag{3.108}$$

$$c\hat{c}_t + I\hat{I}_t + g\hat{g}_t + e^{-\gamma}r^k(1-\tau^k)k\hat{u}_t = y\hat{y}_t \tag{3.109}$$

$$n\hat{n}_t = \lambda\theta^h n^h(\hat{\theta}_t^h + \hat{n}_t^h) + (1-\lambda)n^s\hat{n}_t^s \tag{3.110}$$

$$c\hat{c}_t = \lambda c^h\hat{c}_t^h + (1-\lambda)c^s\hat{c}_t^s \tag{3.111}$$

$$\hat{mc}_t = \hat{w}_t + \alpha(\hat{u}_t + \hat{k}_{t-1} - \hat{n}_t - \hat{\xi}_t^a) \tag{3.112}$$

$$\hat{w}_t - \hat{r}_t^k = \hat{u}_t + \hat{k}_{t-1} - \hat{n}_t - \hat{\xi}_t^a \tag{3.113}$$

Non-savers:

$$(1+\tau^c)c^h\hat{c}_t^h = (1-\tau^n)\theta^h wn^h(\hat{\theta}_t^h + \hat{w}_t + \hat{n}_t^h) - \tau^n\theta^h wn^h\hat{\tau}_t^n + \frac{tr}{\lambda}\hat{tr}_t \tag{3.114}$$

$$\phi_h n_t^h + \frac{1}{1-he^{-\gamma}}(\hat{c}_t^h - he^{-\gamma}\hat{c}_{t-1}^h + he^{-\gamma}\hat{\xi}_t^a) = \hat{\theta}_t^h + \hat{w}_t - \frac{\tau^n}{1-\tau^n}\hat{\tau}_t^n \tag{3.115}$$

**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, $Earn^{data,i}_{ann,t}$, to their quarterly concepts counterpart and the trend growth.

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

$$Earn^{HtM}_{ann,t} = \theta^h_t W_t n^h_t + \theta^h_{t-1} W_{t-1} n^h_{t-1} + \theta^h_{t-2} W_{t-2} n^h_{t-2} + \theta^h_{t-3} W_{t-3} n^h_{t-3} \tag{3.116}$$

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

$$Earn^{HtM}_{ann,t} = earn^{HtM}_{ann,t} a_t$$

In the data, we observe the sum of the quarterly earnings of hand-to-mouth households, $Earn^{data,HtM}_{ann,t}$, 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:

$$\begin{aligned}
\Delta Earn^{obs,HtM}_{ann,t} &= logEarn^{data,HtM}_{ann,t} - logEarn^{data,HtM}_{ann,t-4} \\
&= logEarn^{HtM}_{ann,t} - logEarn^{HtM}_{ann,t-4} \\
&= e\hat{arn}^{HtM}_{ann,t} - e\hat{arn}^{HtM}_{ann,t-4} + log\Big(\frac{a_t}{a_{t-4}}\Big) \\
&= e\hat{arn}^{HtM}_{ann,t} - e\hat{arn}^{HtM}_{ann,t-4} + \xi^a_t + \xi^a_{t-1} + \xi^a_{t-2} + \xi^a_{t-3} \qquad (3.117)
\end{aligned}$$

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 3.117 is our desired observation equation. To make it operational, we need to define $e\hat{arn}^{HtM}_{ann,t}$. To do so, we use equation 3.116 we divide by $a_t$ and log-linearize it around the following steady state:

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

This leads to:

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

This last equation completes the implementation of equation 3.117.

**The optimal policy**

**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] \\
& [...]
\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}
$$

### 3.6.3 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.

#### 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).

[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.

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.

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.

**CPS Data**

We used the ASEC Supplement of the CPS, as reported by IPUMS, to construct Figures 3.1, 3.2 and 3.3.

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.

### 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.

**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 3.8, the total amount of social benefits is affected by the business cycle and transfers have a counter-cyclical profile. However, not all transfers

[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.

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].

Table 3.8: **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 3.9 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.

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.

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

Table 3.9: **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.

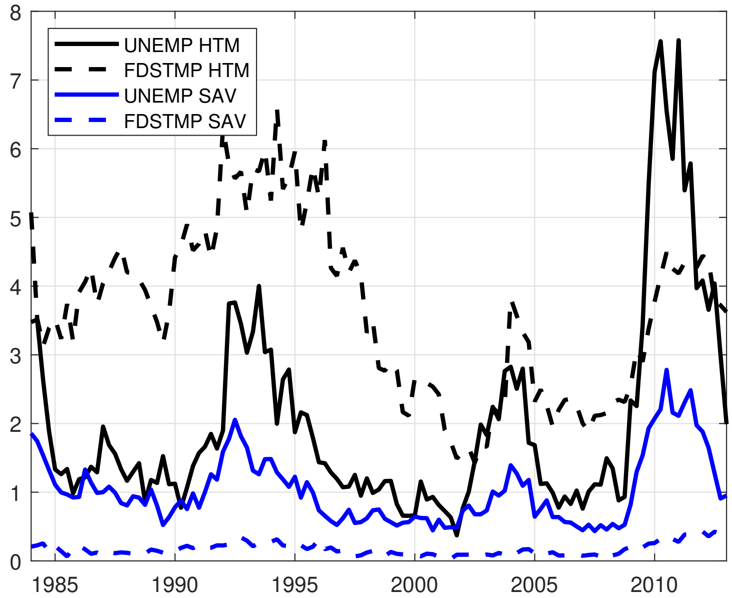
This is done in Figure 3.23. It shows that, following a recession, the *share* of low income households receiving unemployment benefits increases generally more than the share of high income households receiving unemployment benefits. Figure 3.23 displays the share of low income households receiving 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 3.2 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]

Turning to the study of the distribution of transfers among the different groups of households, we show in Table 3.10 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.

Finally, Table 3.11 confirms that transfers are mostly counter-cyclical and that unemployment benefits are the main instruments to ensure households against temporary losses of income. Food stamps and other assistance programs are also negatively correlated with GDP[35] but the correlation is not significant.

[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

FIGURE 3.23: **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.

TABLE 3.10: **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% |

### 3.6.4 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. $\lambda = .2$).

the business cycle.

[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 3.11: **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 |

TABLE 3.12: **Estimated parameters - $\lambda = .2$**

| **Parameter** | | **Posterior TANK** | | **Posterior TANK*** | | **Prior** | | |
|---|---|---|---|---|---|---|---|---|
| | | mean | 90 % interval | mean | 90 % interval | distrib | par A | par B |
| $100\gamma$ | 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 |
| $\phi$ | 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** | | | | | | | | |
| $\phi_u$ | utilization cost | 2.616 | [1.775 ; 3.433] | 3.364 | [2.414 ; 4.287] | G | 2 | 0.5 |
| $\kappa$ | adjustment cost | 4.895 | [3.633 ; 6.075] | 3.935 | [2.735 ; 5.037] | G | 4 | 0.75 |
| **Nominal Rigidities** | | | | | | | | |
| $\theta_w$ | wage rigidity | 0.769 | [0.698 ; 0.841] | 0.395 | [0.246 ; 0.638] | B | 0.5 | 0.1 |
| $\theta_p$ | price rigidity | 0.909 | [0.872 ; 0.947] | 0.856 | [0.818 ; 0.898] | B | 0.5 | 0.1 |
| **Monetary Policy** | | | | | | | | |
| $\rho_r$ | interest rate smoothing | 0.823 | [0.784 ; 0.862] | 0.769 | [0.719 ; 0.817] | B | 0.8 | 0.1 |
| $\phi_\pi$ | response to inflation | 1.784 | [1.622 ; 1.947] | 1.926 | [1.763 ; 2.105] | G | 1.75 | 0.1 |
| $\phi_y$ | response to output | 0.076 | [0.036 ; 0.116] | 0.038 | [0.013 ; 0.063] | G | 0.12 | 0.05 |
| **Labor tax rule** | | | | | | | | |
| $\rho_\tau$ | 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** | | | | | | | | |
| $\rho_T$ | 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** | | | | | | | | |
| $\rho_\theta$ | 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** | | | | | | | | |
| $\rho_g$ | gov.spending | 0.978 | [0.963 ; 0.994] | 0.975 | [0.958 ; 0.993] | B | 0.5 | 0.2 |
| $\rho_w$ | wage mark-up, sav | 0.379 | [0.18 ; 0.571] | 0.858 | [0.583 ; 0.984] | B | 0.5 | 0.2 |
| $\rho_p$ | price mark-up | 0.769 | [0.633 ; 0.91] | 0.933 | [0.881 ; 0.988] | B | 0.5 | 0.2 |
| $\rho_a$ | technology | 0.205 | [0.063 ; 0.332] | 0.379 | [0.24 ; 0.512] | B | 0.5 | 0.2 |
| $\rho_i$ | investment | 0.814 | [0.727 ; 0.907] | 0.762 | [0.658 ; 0.868] | B | 0.5 | 0.2 |
| $\rho_b$ | preference, sav. | 0.801 | [0.72 ; 0.881] | 0.87 | [0.816 ; 0.929] | B | 0.5 | 0.2 |
| $\rho_m$ | monetary policy | 0.452 | [0.335 ; 0.569] | 0.448 | [0.337 ; 0.561] | B | 0.5 | 0.2 |
| $\rho_{gbc}$ | 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** | | | | | | | | |
| $\sigma_g$ | gov. spending | 2.377 | [2.096 ; 2.658] | 2.605 | [2.291 ; 2.949] | IG | 0.1 | 2 |
| $\sigma_w$ | wage mark-up, sav | 0.279 | [0.21 ; 0.344] | 0.269 | [0.196 ; 0.341] | IG | 0.1 | 2 |
| $\sigma_p$ | price mark-up | 0.058 | [0.039 ; 0.077] | 0.063 | [0.041 ; 0.082] | IG | 0.1 | 2 |
| $\sigma_a$ | technology | 1.041 | [0.871 ; 1.223] | 1.339 | [1.056 ; 1.607] | IG | 0.1 | 2 |
| $\sigma_i$ | investment | 3.549 | [2.508 ; 4.511] | 3.255 | [2.248 ; 4.251] | IG | 0.1 | 2 |
| $\sigma_b$ | preference, sav. | 3.609 | [2.607 ; 4.573] | 2.028 | [1.541 ; 2.517] | IG | 0.1 | 2 |
| $\sigma_m$ | monetary policy | 0.12 | [0.103 ; 0.135] | 0.126 | [0.108 ; 0.144] | IG | 0.1 | 2 |
| $\sigma_\tau$ | lab tax rate | 1.947 | [1.706 ; 2.187] | 1.887 | [1.655 ; 2.105] | IG | 0.1 | 2 |
| $\sigma_T$ | tsf cyclical comp. | 1.438 | [1.271 ; 1.603] | 1.45 | [1.27 ; 1.624] | IG | 0.1 | 2 |
| $\sigma_\theta$ | relative productivity | 0.539 | [0.133 ; 1.054] | 5.27 | [4.608 ; 5.905] | IG | 0.1 | 2 |
| **Measurement errors** | | | | | | | | |
| $\sigma_{rc}$ | output | 0.275 | [0.242 ; 0.307] | 0.281 | [0.247 ; 0.313] | IG | 0.1 | 2 |
| $\sigma_{gbc}$ | 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 household heterogeneity data].

Table 3.13: **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 3.14: **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 3.15: **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.

# Chapter 4

# What do we teach in Macroeconomics? Evidence of a theoretical divide

Co-authored with Michel De Vroey (UCLouvain) and Riccardo Turati (UAB).

**Abstract**

This paper studies the way in which macroeconomics is taught at the undergraduate and graduate levels. Based on two sources of information, the world's largest network of library content and services, the WorldCat data base, and a survey of the textbooks used for teaching at leading universities across the world, the paper provides an up-to-date description of macroeconomics teaching. Our results show a clear methodological divide: whereas IS-LM/AS-AD modeling is the theoretical core of undergraduate textbooks, graduate ones have the RBC model as their baseline model.

## 4.1 Introduction

In every area of knowledge, textbooks are the main vehicle for acquainting students with the content of a given field or sub-field. When it comes to undergraduate macroeconomics textbooks – our object of study in this paper - authors face two challenges. The first is to meet the aspiration of students to decipher the workings of real-world present-day economies, which implies addressing issues such as the existence of business cycles, unemployment, inflation, and the role of government. The second, pertaining to the fraction of students who consider specializing in macroeconomics, is to acquaint them with its distinct way of reasoning and present practice.

Over the last decades, shocks, like the 2008 financial crisis and the 2020 Covid pandemic, and other issues, such as rising concerns regarding the environment and inequalities, have elicited a new reflexive thinking on what good textbooks might consist of. In this respect, most of the attention has been given to the teaching of Econ 101 or Principles of Economics (Allgood, Walstad, and Siegfried, 2015; Mankiw, 2021, 2020; Bowles and Carlin, 2020) with the *Core Econ Project* playing a leading role. Macroeconomics textbooks have received less attention.[1] The few studies available consider a small set of textbooks, usually four or five. They focus on certain topics – e.g. the financial sector, liquidity traps, etc. – rather than on the theoretical content and methodological approach adopted in these textbooks. Finally, as they center on undergraduate textbooks, they fail to address the issue of the congruence, or lack thereof, between undergraduate and graduate teaching.

Investigating this issue is the aim we pursue in this paper. To this end, we proceed in two steps. First, we engage in an empirical examination of the diffusion and use of textbooks using two pieces of evidence. The first is the WorldCat data base, a unique catalogue of more than 72,000 libraries around the world. Its existence allows us to get a picture of the whole range of undergraduate macroeconomics textbooks available to students. The second, the 'teaching sample', is a data base of our own construction. It strives to document the actual teaching of macroeconomics at the undergraduate and graduate levels in a sample of economics departments. *Mutatis mutandum*, the relationship between the two sets of data can be regarded as one of supply and demand.

In the second step, we study the theoretical core upon which the teaching of macroeconomics is based. Broadly described, the history of macroeconomics has undergone two phases. In the first, Keynesian macroeconomics, the IS-LM/AS-AD model was the dominating conceptual apparatus; in the second – the era of dynamic general equilibrium macroeconomics – RBC modeling took over. Congruence between undergraduate

[1]See, however, De Araujo, O'Sullivan, and Simpson (2013); Gärtner, Griesbach, and Jung (2013); Bowles, Carlin, Halliday, and Subramanyam (2019)

and graduate teaching implies that this transformation percolated into the content of textbooks.

The results of our query are as follows. As for our empirical examination, we find that, although several undergraduate textbooks are widely available across libraries, only two are predominant in teaching, one by Olivier Blanchard and the other by Gregory Mankiw. As far as our theoretical analysis is concerned, we conclude that there is a deep discrepancy between the undergraduate and the graduate teaching of macroeconomics: the theoretical core of undergraduate textbooks is the IS-LM/AS-AD model, while that of graduate textbooks is the RBC model. This is a cleavage that many graduate students have experienced yet which has hardly been explored.

The paper is structured as follows. In Section 4.2, we present findings drawn from the WorldCat data base. In Section 4.3, we identify the textbooks used in undergraduate teaching in a representative sample of economics departments. Section 4.4 compares the results of the two sets of data. Section 4.5 describes how macroeconomics is taught at the graduate level. In Section 4.6, we classify undergraduate textbooks according to the theoretical framework upon which they are based. Section 4.7 concludes.

## 4.2 The diffusion of macroeconomics textbooks across libraries

Our first source of information is the WorldCat data base. Introduced in 1971, it itemizes the collections of more than 72,000 libraries belonging to the Online Computer Library Center (OCLC) in 170 countries, containing over 412 million records with 2.6 billion cataloged items. Moreover, the catalog contains records from 491 different languages, 39% of which are in English. It allows us to identify the available macroeconomics textbooks published between 1960 and 2018.[2] To instruct our query, we adopt two selection criteria. First, the title of the textbook has to include the word "macroeconomics." Second, we retain only those textbooks whose last edition was published after 2009. Forty textbooks satisfy these criteria. With the exception of David Romer's *Advanced Macroeconomic*, they are undergraduate textbooks. As we need to separate undergraduate from graduate textbooks, we eliminate Romer's book from our sample.[3] They are listed in Table **??**.

In the left panel, from column (1) to (3), textbooks are ranked by the number of libraries holding at least one copy of them. This number is a proxy of the diffusion and relevance

[2]The available information for each of them consists of the authors, title, number of editions, year of the first and last edition, translations, and number of libraries holding a (digital or hardcover) copy of it.

[3]As will be seen, Romer's book is the only graduate textbook having the macroeconomics' word in its title.

TABLE 4.1: **Ranking of macroeconomics textbooks indexed in WorldCat (2021)**

| *Absolute Availability* | | | *Relative Availability* | | |
|---|---|---|---|---|---|
| (1) Author(s) ( $1^{st}$ Ed. ) | (2) Ranking ($AA_b$) | (3) $AA_b$ | (4) Author(s) ( Last Ed. - $1^{st}$ Ed. ) | (5) Ranking ($RA_b$) | (6) $RA_b$ |
| Dornbusch R. *et al.* ( 1978 ) | 1 | 3722 | Krugman P. & Wells R. ( 2021 - 2006 ) | 1 | 141.73 |
| Blanchard O. ( 1996 ) | 2 | 3003 | Blanchard O. ( 2021 - 1996 ) | 2 | 120.12 |
| Barro R. J. ( 1984 ) | 3 | 2737 | Kennedy P. ( 2019 - 2000 ) | 3 | 93.24 |
| Mankiw G. ( 1991 ) | 4 | 2694 | Mankiw G. ( 2020 - 1991 ) | 4 | 89.80 |
| Krugman P. & Wells R. ( 2006 ) | 5 | 2126 | Dornbusch R. *et al.* ( 2018 - 1978 ) | 5 | 86.56 |
| Gordon R. J. ( 1971 ) | 6 | 2056 | Barro R. J. ( 2010 - 1984 ) | 6 | 73.97 |
| Parkin M. ( 1984 ) | 7 | 2055 | Rossana R. J. ( 2011 - 2011 ) | 7 | 63.30 |
| Kennedy P. E. & Prag J. ( 2000 ) | 8 | 1958 | Abel A. *et al.* ( 2021 - 1991 ) | 8 | 63.27 |
| Abel A. *et al.* ( 1991 ) | 9 | 1898 | Parkin M. ( 2019 - 1984 ) | 9 | 55.54 |
| Colander D. ( 1986 ) | 10 | 1531 | Popescu G. ( 2018 - 2006 ) | 10 | 54.93 |
| Burda M. & Wyplosz C. ( 1993 ) | 11 | 1363 | Williamson S. D. ( 2019 - 2002 ) | 11 | 50.16 |
| Froyen R. T. ( 1983 ) | 12 | 1280 | Burda M. & Wyplosz C. ( 2017 - 1993 ) | 12 | 48.68 |
| McEachern W. ( 1988 ) | 13 | 996 | Richards D. *et al.* ( 2017 - 2016 ) | 13 | 44.40 |
| Hall R.E. & Taylor J.B. ( 1986 ) | 14 | 983 | Colander D. ( 2020 - 1986 ) | 14 | 43.74 |
| Williamson S. D. ( 2002 ) | 15 | 953 | Jones C. ( 2021 - 2008 ) | 15 | 41.31 |
| McConnell C. *et al.* ( 1990 ) | 16 | 914 | Gordon R. J. ( 2014 - 1971 ) | 16 | 41.12 |
| Gwartney J. D. ( 1976 ) | 17 | 883 | Hubbard G. & O'Brian P. ( 2021 - 2006 ) | 17 | 37.73 |
| Lindauer J. ( 1968 ) | 18 | 828 | Froyen R. T. ( 2014 - 1983 ) | 18 | 33.68 |
| Popescu G. ( 2006 ) | 19 | 824 | McEachern W. ( 2017 - 1988 ) | 19 | 30.18 |
| Rossana R. J. ( 2011 ) | 20 | 633 | McConnell C. *et al.* ( 2018 - 1990 ) | 20 | 29.48 |
| Hubbard G. & O'Brian P. ( 2006 ) | 21 | 566 | Hall R.E. & Taylor J.B. ( 2012 - 1986 ) | 21 | 28.09 |
| Jones C. ( 2008 ) | 22 | 537 | Chakraborty S. ( 2020 - 2009 ) | 22 | 26.92 |
| Gartner M. ( 1997 ) | 23 | 510 | Carlin W. & Soskice D. ( 2017 - 2014 ) | 23 | 26.71 |
| Samuelson P. & Nordhaus W. ( 1988 ) | 24 | 502 | Mishkin F. ( 2020 - 2011 ) | 24 | 24.40 |
| Bradford DeLong J. & Olney M. ( 1994 ) | 25 | 405 | Acemoglu D. *et al.* ( 2019 - 2014 ) | 25 | 22.29 |
| Boyes W. & Melvin M. ( 1991 ) | 26 | 348 | Gartner M. ( 2016 - 1997 ) | 26 | 21.25 |
| Slavin S. ( 1994 ) | 27 | 329 | Gwartney J. D. ( 2021 - 1976 ) | 27 | 19.62 |
| Chakraborty S. ( 2009 ) | 28 | 323 | O' Sullivan A. *et al.* ( 2020 - 2007 ) | 28 | 17.71 |
| O' Sullivan A. *et al.* ( 2007 ) | 29 | 248 | Chugh S. ( 2015 - 2015 ) | 29 | 17.33 |

| *Absolute Availability* | | | *Relative Availability* | | |
|---|---|---|---|---|---|
| (1) Author(s) ( $1^{st}$ Ed. ) | (2) Ranking ($AA_b$) | (3) $AA_b$ | (4) Author(s) ( Last Ed. - $1^{st}$ Ed. ) | (5) Ranking ($RA_b$) | (6) $RA_b$ |
| Mishkin F. ( 2011 ) | 30 | 244 | Lindauer J. ( 2012 - 1968 ) | 30 | 15.62 |
| Richards D. *et al.* ( 2016 ) | 31 | 222 | Samuelson P. & Nordhaus W. ( 2011 - 1988 ) | 31 | 15.21 |
| Carlin W. & Soskice D. ( 2014 ) | 32 | 187 | Bradford DeLong J. & Olney M. ( 2017 - 1994 ) | 32 | 15.00 |
| Acemoglu D. *et al.* ( 2014 ) | 33 | 156 | Gottfries N. ( 2013 - 2012 ) | 33 | 12.22 |
| Gottfries N. ( 2012 ) | 34 | 110 | Slavin S. ( 2019 - 1994 ) | 34 | 12.19 |
| Chugh S. ( 2015 ) | 35 | 104 | Boyes W. & Melvin M. ( 2016 - 1991 ) | 35 | 11.60 |
| Brooman F.S & Jacoby F. D. ( 2008 ) | 36 | 95 | Brooman F.S & Jacoby F. D. ( 2017 - 2008 ) | 36 | 7.31 |
| Handa J. ( 2010 ) | 37 | 61 | Karlan D.S. & Morduch J. ( 2021 - 2014 ) | 37 | 7.00 |
| Karlan D.S. & Morduch J. ( 2014 ) | 38 | 49 | Handa J. ( 2011 - 2010 ) | 38 | 5.55 |
| James E. M. *et al.* ( 2008 ) | 39 | 9 | James E. M. *et al.* ( 2012 - 2008 ) | 39 | 0.69 |

Note: The list above is related to a WorldCat exploration made in March 2021. Columns (1) and (4) present the name(s) of the author(s), the year of the first edition and last edition of the textbook. Columns (2) and (5) show the ranking of the textbook, based on a measure of absolute availability, which captures the number of libraries that hold a copy of the book ($AA_b$), and on a relative availability, which is measured as the number of libraries that hold a copy divided by the number of years on the market ($RA_b$), presented respectively in columns (3) and (6).

of the textbook in the market. We call this number absolute availability ($AA_b$) for each textbook $b$. The right panel, columns (4) to (6), provides a second measure – their relative availability. By taking into account the lifetime of textbooks, it allows us to cope with the over-representation in the sample of textbooks published earlier on. The measure of relative availability ($RA_b$) for each textbook $b$ is the ratio between the number of libraries that hold a copy of it over the years since its first edition:

$$RA_b = \frac{AA_b}{2021 - Year\ 1^{st}_b}. \tag{4.1}$$

Starting with the left-panel, the first textbook ranked in terms of absolute availability is *Macroeconomics* initially authored by Rudy Dornbusch and Stanley Fischer with Richard Startz becoming an additional author from the seventh edition onwards (in 1999). Its first edition dates from 1978 and it is available in almost 3,700 libraries. The other textbooks available in more than 2,500 libraries are Robert Barro's, Blanchard's, and Mankiw's. The broad diffusion of these four textbooks can be related to their lasting presence in the market, since their first editions were published more than 25 years ago. Unsurprisingly, more recent textbooks rank lower. On exception is Paul Krugman and Robin Wells' *Macroeconomics* which ranks fifth although its first edition dates from 2006.

Turning to the right panel, we observe that, Krugman and Wells's book now occupies the first place. Blanchard's, Mankiw's, and Barro's books roughly keep their rank. By contrast, Dornbusch et al. (1978) and Robert Gordon (1971) fall in the ranking, respectively by four and ten places. Krugman and Wells's textbook is not the only one that jumps in the ranking as compared to the $AA_b$-based ranking. Some notable mentions are: Gheorghe Popescu's *Macroeconomics* (from $19^{th}$ to $10^{th}$ place), Peter Kennedy's *Macroeconomic Essentials: Understanding Economics in the News* (from $8^{th}$ to $3^{rd}$ place), Robert J. Rossana's *Macroeconomics* (from $20^{th}$ to $7^{th}$ place) and Stephen Williamson's *Macroeconomics* (from $15^{th}$ to $11^{th}$ place). Also some poorly-ranked textbooks according to the absolute availability measure get a better score when the relative availiabity measure is used. This is the case of Daron Acemoglu, David Laibson and John A. List's *Macroeconomics* (moving from the $33^{rd}$ to the $25^{th}$ place), David Soskice and Wendy Carlin's *Macroeconomics: Institutions, Instability, and the Financial System* (moving from the $32^{nd}$ to the $23^{rd}$ place) and Dan Richards, Manzur Rashid, and Peter Antonioni's *Macroeconomics For Dummies* (moving from the $31^{st}$ to the $13^{th}$ place).

The evidence presented hitherto provides a snapshot of the availability of undergraduate macroeconomics textbooks in a given period (in this case March 2021). To get a slightly more dynamic view, we focus on the eleven textbooks whose first edition is posterior to 2008 and compute the growth rate of the number of libraries holding a copy of the textbooks (i.e. our absolute availability measure) between January 2019 and March 2021.

TABLE 4.2: **Ranking of recent textbooks based on the growth rate in absolute availability**

| (1) Author(s) ( $1^{st}$ Ed. ) | (2) Ranking ($Gr_{AA_b}$) | (3) $Gr_{AA_b}$ (%) | (4) $AA_b$ (2021) | (5) $AA_b$ (2019) |
|---|---|---|---|---|
| Jones C. ( 2008 ) | 1 | 366.9 | 537 | 115 |
| Rossana R. J. ( 2011 ) | 2 | 257.6 | 633 | 177 |
| Karlan D.S. & Morduch J. ( 2014 ) | 3 | 53.1 | 49 | 32 |
| Acemoglu D. *et al.* ( 2014 ) | 4 | 44.4 | 156 | 108 |
| Chugh S. ( 2015 ) | 5 | 22.3 | 104 | 85 |
| Chakraborty S. ( 2009 ) | 6 | 16.7 | 323 | 277 |
| Richards D. *et al.* ( 2016 ) | 7 | 14.4 | 222 | 194 |
| Gottfries N. ( 2012 ) | 8 | 13.4 | 110 | 97 |
| Mishkin F. ( 2011 ) | 9 | 10.4 | 244 | 221 |
| Carlin W. & Soskice D. ( 2014 ) | 10 | 8.1 | 187 | 173 |
| Handa J. ( 2010 ) | 11 | 5.2 | 61 | 58 |

Note: The list above is related to a WorldCat extraction made in January 2019 and March 2021, and it shows the results for textbooks whose first edition dates from 2008 onwards. Column (1) presents the name(s) of the author(s) and the year of the first edition. Column (2) shows the ranking of the textbook, based on the growth rate (in percentage points) of the number of libraries that hold the textbook between 2019 and 2021, which is presented in column (3). The number of libraries that hold a textbook is available in column (4) (March 2021 extraction) and column (5) (January 2019 extraction)

Table 4.2 displays the results of this little exercise. It comes as no surprise that recent textbooks display a high growth rate.[4] This is particularly true for Charles Jones's, Rossana's, and Acemoglu *et al.*'s books.

## 4.3 The use of macroeconomics textbooks in undergraduate teaching

In this section, we document the current use of textbooks in undergraduate macroeconomics teaching. To this end, we created a dataset of undergraduate macroeconomics textbooks used in a sample of Economics Departments drawn from the Tilburg University Economics Ranking. The latter ranks departments on the basis of the number of publications in seventy-four leading peer-reviewed economics journals since 2004. Although the whole ranking covers one thousand one hundred and seventy-nine universities, we focused on the four hundred and eleven departments with a publication index at least equal to ten. From this subset, we randomly picked eight departments in each decile. Twenty seven of the eighty departments selected are located in the U.S. and Canada, forty-four

[4]Two forces can explain the eventual growth rate of the diffusion of textbooks: (i) the inclusion in the OCLC system of new libraries which already held a copy of the textbook, and (ii) the higher diffusion of textbooks across libraries that already belonged to the OCLC. With our data, we cannot disentangle these two potential forces.

in Europe, and the remaining nine universities are spread around the world.[5] To proceed, we contacted the heads of the Economics Departments or the teachers of macroeconomics courses directly when they were easily identifiable on the university websites, and asked them two simple questions: (i) “What is the current sequence of macroeconomics courses in both undergraduate and graduate programs in your department?" and (ii) “What are the textbooks used in these courses for the 2020-2021 academic year?" Among the 80 universities of our sample, 65 answered our query.[6]

Leaving aside 101-type courses with half of the course devoted to microeconomics and the other half to macroeconomics, the teaching of macroeconomics at the undergraduate level can take two forms: (a) it can consist in a single course as often the case in three-year long programs; (b) it can consist of a sequence of macroeconomic courses, with either two of them – an introductory course followed by an intermediate one – or three of them, the additional one being an advanced course; this is especially the case in four-year programs. We faced these different configurations in our survey. To get a homogeneous set-up, we gathered the textbooks used in type (a) courses with those used in intermediate courses of the type (b) sequence. Together, these textbooks form our main object of attention.

Table 4.3 displays the results of our inquiry. For each textbook, column (3) indicates the number of times a textbook is cited as the reference text for the course. To account for the fact that sometimes we received more than one answer (for example, when the course is given by several teachers with different preferences), we constructed a weighted indicator. When just one book is cited by a department, it receives a weight equal to 1; when two books are cited, they are registered as 0.5, etc. These data are displayed in column 4.

Table 4.3 shows the existence of a leading trio composed of Blanchard’s, Mankiw’s, and Steven Williamson’s books, with Blanchard being the indisputable champion. Looking at the share in total weighted use, the first two represent 52.4%, while the first three represent the 62.9% of the total. Noticeably, Michael Burda and Charles Wyplosz’s book fares quite well. By contrast, Dornbusch, Fisher, and Startz’s book has lost its leading position.

Two additional results are worth mentioning. The first relates to the geographical distribution of textbooks. Table 4.9 in the Appendix displays the result of splitting the sample

[5]We consider all universities located within one of the 48 countries that are part of the European Higher Education Area (EHEA) as belonging to the same broad geographical area labelled as Europe. The EHEA is a group of countries that follow the directives of the so-called Bologna Process and that cooperate to achieve comparable and compatible higher education systems throughout Europe. It consists of the 27 EU Members plus Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Iceland, Kazakhstan, Liechtenstein, Moldova, Montenegro, North Macedonia, Norway, The Russian Federation, San Marino, Serbia, Switzerland, Turkey, Ukraine, and the United Kingdom. The remaining universities are located in Australia, Brazil, China, Israel, New-Zealand and Singapore.

[6]Table 4.8 in the Appendix gives the list of the departments selected.

TABLE 4.3: **Ranking of textbooks used in intermediate macroeconomics courses**

| (1) Author(s) | (2) Title | (3) # of citations | (4) Weighted use |
|---|---|---|---|
| Blanchard O. | Macroeconomics | 30 | 22.8 |
| Mankiw G. | Macroeconomics | 20 | 11.3 |
| Williamson S. D. | Macroeconomics | 13 | 6.8 |
| Burda M. & Wyplosz C. | Macroeconomics | 7 | 6.3 |
| Jones C. | Macroeconomics | 5 | 4 |
| Abel A. & Bernanke B. | Macroeconomics | 4 | 2.5 |
| Carlin S. & Soskice D. | Macroeconomics: Institutions, Instability and the Fin. Sys. | 3 | 1.5 |
| Dornbusch R. *et al.* | Macroeconomics | 2 | 1.5 |
| Gaertner M. | Macroeconomics | 1 | 1 |
| Gottfries N. | Macroeconomics | 1 | 1 |
| Flaschel et al. | Keynesianische Makroökonomik | 1 | 1 |
| Sachs J. & Larrain F. | Macroeconomics in the Global Economy | 1 | 1 |
| Hubbard G. R. & A. P. O'Brien | Macroeconomics | 2 | 0.8 |
| Mishkin F. | Macroeconomics | 1 | 0.5 |
| | The Economics of Money, Banking and Financial Markets | 1 | 0.5 |
| No reference text | | 3 | 2.5 |
| Total | | 95 | 65 |

Note: The table shows the sample of textbooks used in the economics departments considered in the academic year 2020-2021. Column (1) presents the name(s) of the author(s). Column (2) shows the title of the textbook. Column (3) provides the number of departments using the textbook in their intermediate macroeconomics course. Column (4) displays the sum over economics departments of the probability for each textbook to be used as a reference textbook in the department's intermediate macroeconomics course. Probabilities are proxied by the actual use of the textbook: 0 if not used, 1 if it is the only reference textbook, 0.5 if two textbooks are used, etc. We label this indicator 'Weighted use.'

of universities into three regions: North America (U.S. and Canada), Europe, and the rest of the world. Williamson's and Mankiw's stand out as the most taught textbooks in the U.S. and Canada, whilst Blanchard's is by far the most used in Europe. Notice also the fine ranking of Burda and Wyplosz's textbook and the underperformance of Williamson's in Europe.

Another interesting question is whether the use of textbooks is similar in the best ranked departments of the Tilburg ranking and the others. To answer it, we divide our sample into two sub-samples: (a) the top-ranked departments, defined as belonging to Tilburg ranking's first decile (London School of Economics, University of Munich, Texas A&M University, MIT, University of Toronto, Boston University, Stanford University, and Tilburg University) and the others (the remaining departments provided in Table 4.8 in the Appendix). Table 4.10 in the Appendix summarizes the results. As far as the first two positions are concerned, there is no difference between the two groups: Blanchard's and Mankiw's textbooks are ranked first. Surprisingly, Williamson's textbook is used in none of the eight top-ranked departments, whilst it fares well in the second sub-group.[7]

[7] These results are robust to alternative definitions of top-ranked universities (e.g. two or three deciles).

## 4.4 Comparing the two rankings

In this section, we compare the WorldCat and teaching rankings. More precisely, we compare the ten most diffused textbooks in the WorldCat catalogue (using our relative availability measure) with the ten most used textbooks in the teaching sample. To make the two rankings comparable, we eliminate introductory textbooks from the WorldCat data base.[8] The result of this comparison is displayed in Table 4.4.

TABLE 4.4: **Comparison of rankings of textbooks in WorldCat and in the teaching sample**

| | **WorldCat** | | **Teaching Sample** |
|---|---|---|---|
| 1. | Blanchard O. | 1. | Blanchard O. |
| 2. | Mankiw G. | 2. | Mankiw G. |
| 3. | Dornbusch R. et al. | 3. | Williamson S.D. |
| 4. | Barro R. J. | 4. | Burda M. & Wyplosz C. |
| 5. | Rossana R. J. | 5. | Jones C. |
| 6. | Abel A. & Bernanke B. | 6. | Abel A. & Bernanke B. |
| 7. | Williamson S.D. | 7. | Carlin S. & Soskice D. |
| 8. | Burda M. & Wyplosz C. | 8. | Dornbusch R. et al. |
| 9. | Jones C. | 9. | Gaertner M. |
| 10. | Gordon R. J. | 10. | Gottfries N. |

Note: The first column of the table lists the authors of the 10 highest ranked textbooks according to the relative availability index and based on our WorldCat exploration in March 2021. The ranking has been adjusted to keep only intermediate macroeconomics textbooks (footnote 8 lists the textbooks that have been removed from the ranking). The second column gives the ranking of the textbooks in our representative sample of universities selected in the Tilburg University Economics ranking.

Seven textbooks are common to the two rankings. Among them, three hold the same place, Blanchard (first), Mankiw (second), and Andrew Abel, Ben Bernanke, and Dean Croushore (sixth). Williamson's, Burda and Wyplosz's, and Jones's books perform better in the teaching than in the WorldCat ranking. Again, Dornbusch et al.'s book undergoes a sharp drop. Absent from the WorldCat top-ranking, yet present in the teaching sample top ranking are Carlin and Soskice's, Manfred Gartner's and Nils Gottfries's books. By contrast, three books present in the WorldCat ranking – Gordon's, Barro's, and Rossana's – do not make it in the teaching ranking. Each of these 'excess supply' cases has a specific

[8] We eliminated six introductory textbooks from the WorldCat data base: *Macroeconomics* by Krugman and Wells, *Macroeconomics Essentials: Understanding Economics in the News* by Kennedy, *Macroeconomics* by Parkin, *Macroeconomics for Dummies* by Richards et al., and *Macroeconomics* by Colander. Among them, only Krugman and Wells and Parkin were mentioned in the teaching sample. We also deleted Popescu's book, *Macroeconomics*, because it has little analytical content.

explanation. Gordon's was a pioneering textbook, whose first edition was published in the late seventies. Therefore, it is little surprise that it has become somewhat outdated. The case of Barro's book, the pioneering anti-Keynesian textbook, is more surprising. It turns out that it has been dethroned by Williamson's textbook.[9] Rossana's is still another story. It is a rather recent book. Its author's was already emeritus at the time of its publication and died since. Hence, its impact will probably fade away.

Finally, the absence Krugman and Well's *Macroeconomics* from the two rankings despite its first place in the relative availability ranking of the WorldCat data base is worth noticing. This absence is normal since Table 4.4 is limited to intermediate textbooks, whilst theirs must be regarded as an introductory textbook. Still, it is worth asking how it fares among textbooks of this category. A partial answer to this question can be found in the paper's Appendix (see Table 4.11). It can then be observed that it is only used in introductory macroeconomics courses and it accounts for 5% of the total (weighted) use. This suggests a discrepancy between the presence of Krugman and Wells's book in libraries and its use in teaching.

## 4.5 Macroeconomic textbooks in graduate teaching

The terms “graduate program" covers different realities. Subsequently to the Bologna Process, higher education systems across the European Higher Education Area have converged to a two-step teaching sequence beginning with a bachelor's degree (3 to 4 years) often followed by a master's degree (1 to 2 years). Two types of master's degrees are available: *professional masters* – targeting students interested in pursuing a professional career and offering a large set of subjects in economics – and *research masters* - providing advanced training in core subjects of economics and preparing students for Ph.D. programs. In the U.S., undergraduate programs take four years to be completed, Master's programs are the exception and graduate programs are about getting a Ph.D. In this section we examine the European research master's program and the first year of the U.S. Ph.D. program together.

As seen, as far as undergraduate programs are concerned, textbooks are the almost exclusive teaching device. This is less the case for graduate programs. Advanced textbooks do exist yet most of the teachers we contacted declared that their teaching mixes chapters from different textbooks, seminal papers, and their own lecture notes. Therefore, our data no longer refer to textbooks *used* but rather to textbooks *cited* in syllabi.

[9]As shown in Table 4.9, Williamson's book is more used in the U.S. than in Europe. It can be surmised that Barro became aware of this situation. Indeed, in 2017, he published a new version of his book – this time entitled *Intermediate Macroeconomics* – and co-signed by Angus Chu and Guido Cozzi. The oddity is that the theoretical part is quasi-identical to that of the 2008 version, but the empirical part is original. It is based on Eurozone rather than US data as in the 2008 version.

TABLE 4.5: **Advanced textbooks referred to in graduate teaching**

| (1) Author(s) | (2) Title | (3) Overall | (4) *Professional* Master's | (5) PhD & *Research* Master's |
|---|---|---|---|---|
| Romer D. | Advanced Macroeconomics | 32 | 23 | 9 |
| Ljungqvist L. & Sargent T. | Recursive Macroeconomic Theory | 21 | 1 | 20 |
| Stokey N. Lucas R. & Prescott E. | Recursive Methods in Economic Dynamics | 12 | 1 | 11 |
| Gali J. | Monetary Policy, Inflation and the Business Cycle | 10 | / | 10 |
| Acemoglu D. | Introduction to Modern Economic Growth | 7 | 1 | 6 |
| Blanchard O. & Fischer S. | Lectures on Macroeconomics | 5 | 2 | 3 |
| Barro R. & Sala-i-Martin X. | Economic Growth | 5 | 2 | 3 |
| Walsh C. | Monetary Theory and Policy | 5 | 1 | 4 |
| Woodford M. | Interest and Prices: Foundations of a Theory of Monetary Policy | 4 | / | 4 |
| Cooley T. | Frontiers of Business Cycle Research | 4 | 1 | 3 |
| Wickens M. | Macroeconomic Theory. A Dynamic General Equilibrium Approach | 4 | 2 | 2 |
| Obstfeld M. & Rogoff K. | Foundations of International Macroeconomics | 3 | 2 | 1 |
| Adda J. & Cooper R. | Dynamic Economics: Quantitative Methods and Applications | 2 | 1 | 1 |
| Alogoskoufis G. | Dynamic Macroeconomics | 2 | 2 | / |
| Azariadis C. | Intertemporal Macroeconomics | 2 | 1 | 1 |
| McCandless G. | The ABCs of RBCs: An Introduction to Dynamic Macroeconomic Mod. | 2 | 1 | 1 |

Notes: The table shows the sample of textbooks used in the economics departments considered in the academic year 2020-2021. Column (1) presents the names of the authors and column (2) displays the titles of the textbooks. Column (3) shows the number of institutions using the textbook in their graduate macroeconomics courses either as reference text or as a recommended readings, and columns (4) and (5) make the distinction between (i) *professional* master's and (ii) *research* master's/PhD courses. Only textbooks that are used in at least two universities appear in the table.

Table 4.5 displays the textbooks used or referred to.[10] Four prevail: *Recursive Macroeconomic Theory* by Lars Ljungqvist and Thomas Sargent; *Recursive Methods in Economic Dynamics* by Nancy Stokey, Robert Lucas, and Edward Prescott; *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications* by Jordi Gali; and *Advanced Macroeconomics* by David Romer. They all have the RBC model as their baseline model.[11] A quick glance at them makes it clear that quantitative methods dominate graduate-level macroeconomics. As for substance, growth theory and business cycle (with a specific focus on monetary policy) are the dominant objects of study. Whilst labor economics and international macroeconomics receive pride of place in undergraduate macroeconomics textbooks, it is no longer the case in graduate ones. These topics are outsourced to dedicated courses.

## 4.6 Typology of theoretical approaches

Now that we have a clearer picture of the textbooks used in macroeconomics, we can focus on the anomaly which lies at the center of this paper, the existence of a discrepancy between the teaching of macroeconomics at the undergraduate and graduate levels. The question at stake is whether undergraduate textbooks are based on the same methodologi-

[10]The table presents textbooks that are used in at least two universities.

[11]As argued by Moreira and Wren-Lewis (2016), uniformity in graduate teaching emerged in the late 1980s. This is confirmed in our data, as shown in Table 4.13 in the Appendix: it displays no substantial differences in references between highly ranked departments and the rest.

cal core as graduate ones, it being understood that the latter are in tune with cutting-edge research. This matter can be further narrowed by realizing that the issue bears only on one of the two specializations forming macroeconomics, the study of business cycles. Indeed, as far as growth theory is concerned, no basic discrepancy is present. The Solow model is regarded as the base-camp of growth theory in both graduate and undergraduate textbooks. In the early editions of undergraduate textbooks, the topic of growth received scant attention; it was studied in the last chapters as a sort of appendix. This is no longer so in present days. It often constitutes the first part of textbooks, and several chapters are devoted to it. However, their content is rudimentary with respect to the developments that have taken place both at graduate level and in cutting-edge research.[12] Moreover, no attempt is made at piecing together the growth and the business fluctuations topics.

Two stages can be distinguished in the development of the business fluctuations sub-specialization of macroeconomics. Its birth as a discipline can be associated with the rise of the IS-LM model, itself an offspring of Keynes's *General Theory*. In the 1970s, macroeconomists enriched the IS-LM model by the addition of the AS-AD apparatus thereby giving it a monetarist twist. It gradually appeared that the AS-AD apparatus constitutes the core of the model, the IS-LM model serving as a steppingstone in its construction. The transformation that occurred in textbooks from the turn of the century onwards, in particular the disappearance of the LM curve, confirms the decisive role of the AS-AD model.[13] However, this addition hardly sufficed for its survival in research. Indeed, it came to be dethroned in the 1980s, the result of the 'rational expectations revolution' initiated by Lucas and stabilized by RBC modeling. The latter subsequently evolved into 'new Keynesian' or DSGE macroeconomics – an offshoot rather than a break from RBC modeling.[14]

Hence, the question we must ask ourselves is whether the central theoretical apparatus of undergraduate textbooks is the IS-LM/AS-AD or the RBC baseline model. To answer it, we characterize each of these approaches by using four basic methodological bifurcations: (a) their main object of analysis, (b) their equilibrium concept adopted, (c) their attitude

[12] Current economic growth theory is based on an endogenous formation of technology and ideas. On this, see Jones (2021)

[13] See Romer (2000).

[14] Alternative labels are DSGE, dynamic stochastic general equilibrium, or DGE, dynamic general equilibrium, modeling. The 'new Keynesian terminology is ambiguous because it overlooks the fact that two generations of new Keynesian economists must be distinguished. The first was composed of a loose group of economists many of whom were microeconomists rather than macroeconomists like e.g. Stiglitz or Akerlof. Whilst accepting Lucas's microfoundations requirement, they were stern defenders of the involuntary unemployment and sticky prices notions. They were radically opposed to RBC modeling without however being keen on using the IS-LM model. By contrast, second-generation new Keynesian economists, such as Gali or Woodford, accept the RBC model as their baseline model. The aim they pursue is to superimpose Keynesian elements on it, such as price stickiness, imperfect competition, and the presence of money. Henceforth, whenever we use the 'RBC modeling' wording, we mean the extended RBC modeling – that is, including second-generation new Keynesian models.

toward the microfoundations requirement, and (d) their overriding purpose governing the construction and usage of the theoretical model. Their respective choices are summarized in Table 4.6.

We begin with IS-LM/AS-AD modeling:[15]
(a) *Main object of analysis* - The main object of inquiry of IS-LM/AS-AD models is the trade-off between unemployment and inflation. As far as labor is concerned, the focus is on the extensive rather than the intensive margin. To explain unemployment, these models resort to wage sluggishness or rigidity.
(b) *Equilibrium* - IS-LM/AS-AD economists tread the footsteps of classical political economists by adopting the state of rest equilibrium notion, a single standstill equilibrium position acting as a center of gravity. As described by Frisch (1950), this notion is reminiscent of a pendulum. When it is observed that the pendulum moves, the conclusion to be drawn is that the economy experiences a state of disequilibrium what in turn triggers a re-equilibration process. A distinctive feature of the IS-LM/AS-AD approach is that unemployment exists in equilibrium – the natural rate of unemployment.
(c) *Microfoundations* - In IS-LM/AS-AD modeling the optimizing behavior of the agents, i.e. their decision-making process, is evoked but not substantiated. That is, microeconomic foundations are present only implicitly.
(d) *Overarching methodological rule* - The overriding methodological purpose is to provide a framework to interpret and act on real-world economic events. Hence, external validity prevails; it comes at the expense of a serious consideration for the internal consistency of the theory developed.

TABLE 4.6: **Basic methodological differences between IS-LM/AS-AD and RBC modelling**

| | **IS-LM/AS-AD** | **RBC** |
|---|---|---|
| (a) *Main object of analysis* | Unemployment & inflation | Business fluctuations |
| (b) *Equilibrium concept* | State of rest equilibrium | Intertemporal equilibrium |
| (c) *Microfoundations* | Evoked but not substantiated | Required |
| (d) *Overriding methodological rule* | External validity | Internal consistency |

[15]For the sake of keeping track of the origin of AS/AD modeling, we have kept the IS-LM/AS-AD label.

Turning to RBC modeling, the picture is as follows:

(a) *Main object of analysis* - The purpose of RBC modeling is to construct an equilibrium model of business fluctuations, having for object variations in output, consumption, investment, labor, etc. When it comes to labor, the total hours worked is the main – and for long, has been the only – variable taken into consideration. In other words, it is assumed that unemployment can be studied separately from business fluctuations.

(b) *Equilibrium* - The equilibrium notion is the neo-Walrasian notion of intertemporal equilibrium. Equilibrium is defined as generalized individual equilibrium; it being understood that agents engage in intertemporal substitution – hence the concern is optimizing paths. The existence of equilibrium is postulated; no room is left for disequilibrium occurrences.

(c) *Microfoundations* - Explicit microfoundations is a *sine qua non*.

(d) *Overarching methodological rule* - A theory and a model (understood as a mathematical model) are one and the same thing. This implies giving priority to internal over external consistency, which makes their model strongly unrealistic. The validity of this counter-intuitive research strategy, RBC economists argue, must be judged on its ability to fit the data and to display a strong cumulative development rather than on the plausibility of the model itself.

One point of contrast deserving an additional comment is the implication of the two equilibrium concepts adopted. Central to the AS-AD model is that equilibrium acts as a center of gravity, which in turn implies that the basic data of the economy remain fixed during the adjustment process – only temporary shocks are possible. This is what the term dynamics means in reference to the AS-AD model – a poor notion of dynamics since it implies a static environment. By contrast, whenever the intertemporal equilibrium is adopted, irreversible changes in the data can enter the scene.

In 1978, when Dornbusch and Fischer, the pioneers of the IS-LM/AS-AD-based textbooks, published their first edition, the IS-LM/AS-AD model still prevailed in advanced teaching. A situation of congruence between the two levels of teaching thus existed.[16] The fact that in the 1980s, the decade during which RBC modeling grew to dominance, the content of undergraduate textbooks hardly changed could be regarded as a mere delay in adjustment. However, the fact that most present-day textbooks belong to the IS-LM/AS-AD approach signifies a case of lack of congruence. That is, the transformations that occurred in cutting-edge research has scarcely percolated into undergraduate textbooks. Table 4.7 shows that this is the prevailing situation currently.

The left panel of Table 4.7 displays how the thirty-nine textbooks from the WorldCat catalogue fare with respect to the divide between IS-LM/AS-AD and RBC modeling.

[16] It can be argued that Dornbusch and Fischer's first edition lies between the undergraduate and graduate teaching levels.

Table 4.7: **Distribution of undergraduate textbooks according to their methodological lines**

| *WorldCat Sample* | | | *Teaching Sample* | | |
|---|---|---|---|---|---|
| (1) Author(s) | (2) Typology | (3) Ranking ($RA_b$) | (4) Author(s) | (5) Typology | (6) Ranking (Weighted Use) |
| Krugman P. & Wells R. | IS-LM/AS-AD | 1 | Blanchard O. | IS-LM/AS-AD | 1 |
| Blanchard O. | IS-LM/AS-AD | 2 | Mankiw G. | IS-LM/AS-AD | 2 |
| Kennedy P. | IS-LM/AS-AD | 3 | Williamson S. D. | RBC | 3 |
| Mankiw G. | IS-LM/AS-AD | 4 | Burda M. & Wyplosz C. | IS-LM/AS-AD | 4 |
| Dornbusch R. | IS-LM/AS-AD | 5 | Jones C. | IS-LM/AS-AD | 5 |
| Barro R. J. | RBC | 6 | Abel A. *et al.* | Other | 6 |
| Rossana R. J. | IS-LM/AS-AD | 7 | Carlin W. & Soskice D. | IS-LM/AS-AD | 7 |
| Abel A. *et al.* | Other | 8 | Dornbusch R. | IS-LM/AS-AD | 8 |
| Parkin M. | IS-LM/AS-AD | 9 | Gartner M. | IS-LM/AS-AD | 9 |
| Popescu G. | Other | 10 | Gottfries N. | IS-LM/AS-AD | 10 |
| Williamson S. D. | RBC | 11 | Hubbard G. & O'Brian P. | IS-LM/AS-AD | 11 |
| Burda M. & Wyplosz C. | IS-LM/AS-AD | 12 | Mishkin F. | IS-LM/AS-AD | 12 |
| Richards D. *et al.* | IS-LM/AS-AD | 13 | | | |
| Colander D. | IS-LM/AS-AD | 14 | | | |
| Jones C. | IS-LM/AS-AD | 15 | | | |
| Gordon R. J. | IS-LM/AS-AD | 16 | | | |
| Hubbard G. & O'Brian P. | IS-LM/AS-AD | 17 | | | |
| Froyen R. T. | Other | 18 | | | |
| McEachern W. | IS-LM/AS-AD | 19 | | | |
| Campbell R. McConnell *et al.* | IS-LM/AS-AD | 20 | | | |
| Hall R.E. & Taylor J.B. | IS-LM/AS-AD | 21 | | | |
| Chakraborty S. | IS-LM/AS-AD | 22 | | | |
| Carlin W. & Soskice D. | IS-LM/AS-AD | 23 | | | |
| Mishkin F. | IS-LM/AS-AD | 24 | | | |
| Acemoglu D. *et al.* | IS-LM/AS-AD | 25 | | | |
| Gartner M. | IS-LM/AS-AD | 26 | | | |
| Gwartney J. D. | IS-LM/AS-AD | 27 | | | |
| O' Sullivan A. *et al.* | IS-LM/AS-AD | 28 | | | |
| Chugh S. | RBC | 29 | | | |
| Lindauer J. | IS-LM/AS-AD | 30 | | | |
| Samuelson P. & Nordhaus W. | IS-LM/AS-AD | 31 | | | |
| Bradford DeLong J. & Olney M. | IS-LM/AS-AD | 32 | | | |
| Gottfries N. | IS-LM/AS-AD | 33 | | | |
| Slavin S. | IS-LM/AS-AD | 34 | | | |
| Boyes W. & Melvin M. | IS-LM/AS-AD | 35 | | | |
| Brooman H.D. & Jacoby F. D. | IS-LM/AS-AD | 36 | | | |
| Karlan D.S. & Morduch J. | IS-LM/AS-AD | 37 | | | |
| Handa J. | IS-LM/AS-AD | 38 | | | |
| James E. M. | IS-LM/AS-AD | 39 | | | |

Note: The list above is related to a WorldCat exploration made in March 2021 (col. (1) to (3)) and to the economic departments considered in the academic year 2020-2021 (col. (4) to (6)). Columns (1) and (4) present the names of the authors. Columns (2) and (5) show the broad methodological category associated with each macroeconomics textbook. Columns (3) and (6) present the ranking of textbooks based either on the relative availability measure (see Table **??**) or on the number of departments using the textbook in their intermediate economics course (see Table 4.3).

Thirty-two out of them are based on the IS-LM/AS-AD apparatus. Only three of them – Barro's, Williamson's and Sanjay Chugh's – are grounded on the RBC methodological principles. As for the three remaining ones, the situation is as follows. Abel, Bernanke, and Croushore's book aims to provide a synthesis of the two approaches – for sure, an appealing project yet also a thorny one in view of the opposed features of the two approaches. Richard Froyen adopts a historical approach to macroeconomics, going through the historical evolution of the methodology and of macroeconomic thought rather than dwelling on one of the two lines. Popescu's book fits neither of the two approaches because of the socio-economic line it takes.

The right panel of Table 4.7 displays the result of the same exercise for the teaching sample. Eleven of the twelve textbooks used adopt the IS-LM/AS-AD framework. Only one of them, Williamson's, belongs to RBC modeling.[17]

These results confirm the claim that a methodological discrepancy between undergraduate and graduate teaching is present in macroeconomics. Admittedly, several textbooks which we classified as IS-LM/AS-AD – for example, Burda and Wyplosz or Nils Gottfries – comprise one or a few chapters on intertemporal substitution. However, in as far as the AS-AD model remains the core of the conceptual apparatus, and if it is accepted that this apparatus and the state of rest equilibrium concept are part and parcel of each other, it must be concluded that these chapters are a mere adornment or *pro forma* modification with respect to the central theoretical core of the textbook. When these authors move to the analysis of the workings of their model economy, intertemporal substitution vanishes from the scene.

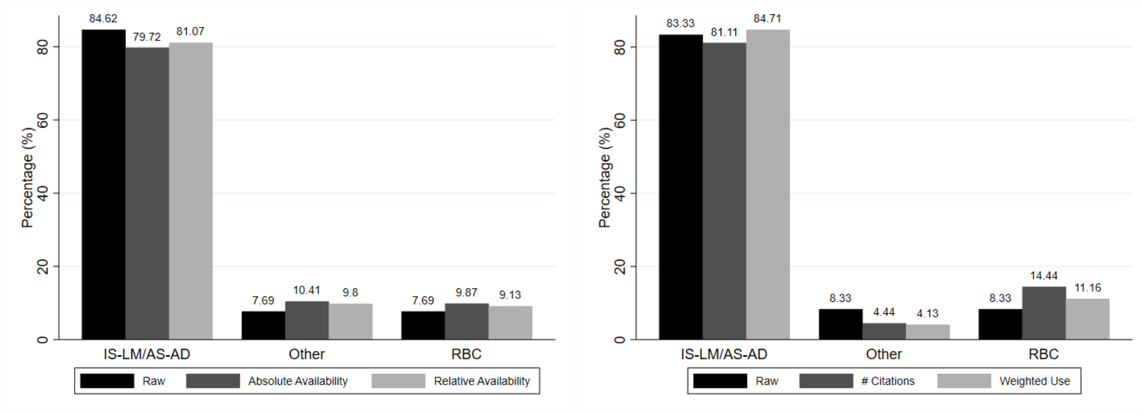
The geographical discrepancy of the use of macroeconomics textbooks is also worth considering. It turns out that Williamson's textbook is mostly used in the U.S. and Canada, while Blanchard's textbook is predominant in Europe, so that we can conclude that North American universities are more inclined to teach macroeconomics based on the RBC paradigm than their European peers. As displayed in Table 4.10 in the Appendix, this difference does not seem to be explained by the higher ranking of economics departments in the Tilburg ranking, which would have suggested that the use of RBC textbooks reflects a stronger research orientation.

Until now, we have only considered the rankings of the textbooks. Nonetheless, it may be the case that the importance of RBC textbooks is underestimated because the share of libraries distributing these textbooks and/or the number of departments using them in their teaching are relatively important. This is not the case. As can be seen in Figure 4.1, our above results hold even when indexing each textbook by their respective weights.[18] RBC textbooks account for less than 10% of the available (panel (a)) or used (panel (b)) textbooks. Hence, the discrepancy between undergraduate and graduate textbooks cannot be ruled out by the relevance of a few outliers, like Williamson in our teaching sample, or the weights associated with each textbook.

[17] The other two present into the WorldCat data base, Barro's and Chugh's, have not found a way in the departments in our sample.

[18] For the WorldCat sample, textbooks are weighted by the number of libraries holding a copy (i.e. absolute availability) and the indicator of relative availability ($RA_b$). For the teaching sample, textbooks are weighted by the number of departments using the textbooks and the weighted use index.

FIGURE 4.1: **Distribution of textbooks according to their methodological lines**




(a) WorldCat Sample (b) Teaching Sample

Notes: Authors' calculations on WorldCat data and teaching sample. Figure (a) shows the distribution by category, giving each textbook the same weight (Raw) or weighting each textbooks by the number of libraries which hold a copy ($AA_b$) or by the index of relative availability ($RA_b$). Figure (b) shows the distribution of the sample of textbooks used in intermediate courses by category, using the same weight (Raw) or weighting them using the # of citations or the weighted use displayed in Table 4.3.

## 4.7 Concluding Remarks

Our aim in this paper was to establish evidence about the teaching of macroeconomics at the undergraduate and graduate levels. After having identified the main undergraduate macroeconomics textbooks used in teaching and having confronted them with the teaching material used in graduate courses, we have concluded that they are based on distinct theoretical cores. Hence, the discrepancy claim is confirmed.

This conclusion calls for an explanation. A full one is beyond the scope of this paper. However, it is worth sketching out our view on the matter. Two factors evoked in the paper can serve as benchmarks for our judgment. The first relates to a remark made in the introduction about the tension between two objectives faced by the authors of undergraduate textbooks – shedding light on prevalent macroeconomics issues and acquainting students with the present-day practice of macroeconomics. The predominance of IS-LM/AS-AD textbooks can be explained by the fact that they give a priority to the first objective. By contrast, Barro's textbook is an emblematic example of the opposite standpoint. As for Williamson, it also bends towards the second objective yet in a more mitigated way.

The second factor, which is a consequence of the former, is the methodological bifurcations exposed above, and the priority given to internal or external consistency.[19] The IS-

[19]This bifurcation is underpinned by an even deeper one, the Marshall-Walras divide. On this, see Hoover (1984); De Vroey (2016a, 2018).

LM/AS-AD line privileges the second, the RBC line the first. The question to be asked then is whether methodologically principles that are compulsory for advanced research must also be so for introductory works. That is, we must go beyond acknowledging the existence of a lack of congruence between the undergraduate/graduate teaching of macroeconomics and ponder whether its existence must be deplored or justified.

For our part, we lean toward the second standpoint. The IS-LM model is certainly sloppy, but it is intuitively relevant. It has also revealed a high rebounding ability. Fischer aptly pointed this out:

> The versatility of the (IS-LM) model is responsible for its survival: it can be used to analyze both monetary and fiscal policy, in both full employment and unemployment modes; it can generate quantity theory or pure Keynesian results with only minor modifications. The model is capable of accommodating monetarist and Keynesian views, as Friedman's (1970) theoretical framework shows. In my view, it can also accommodate a basic rational expectations-market clearing view, though I am not sure adherents of that approach would agree. Fischer 1986 (Note 7).

The above remark was made at a conference honoring Franco Modigliani, and it would have been inappropriate for Fischer to take this opportunity to defend his own textbook. However, the authors of the two most used textbooks currently have taken the plunge. In 1990, Mankiw published a paper entitled "A Quick Refresher Course in Macroeconomics" in which he discusses the discrepancy between the theoretical developments of macroeconomics and applied macroeconomics by drawing an analogy between Ptolemy's and Copernicus's astronomic theories. The latter was more elegant and, ultimately, more useful. However, Mankiw claimed that for some purposes it was appropriate to content oneself with Ptolemy's theory:

> If you had been an academic astronomer, you would have devoted your research to improving the Copernican system. [...] Yet if you had been an applied astronomer, you would have continued to use the Ptolemaic system. (Mankiw, 1990).

Replace 'academic astronomer' by 'graduate teacher' and 'applied astronomer' by 'undergraduate teacher' and you have a justification of IS-LM/AD-AS textbooks. Blanchard makes a similar point in an article entitled "On the Future of Macroeconomic Models." (Blanchard, 2018). According to him, economists face different types of tasks, each requiring a specific approach. In his words:

> (a) Foundational models. The purpose of these models is to make a deep theoretical point, likely of relevance to nearly any macro model, but not pretending to capture reality closely.
> (b) DSGE models. The purpose of these models is to explore the macro implications of distortions or sets of distortions.
> (c) Policy models. The purpose of these models is to help policy, to study the dynamic effects of specific shocks, to allow for the exploration of alternative policies.
> (d) Forecasting models. The purpose of these models is straightforward: give the best forecasts.
> (e) Toy models. Here, I have in mind models such as the many variations of the IS–LM model; (52-53)

IS-LM/AS-AD textbooks are thus justified as toy models. When it comes to introducing students to the field, such models are appropriate despite their defects.

Our study paves the way for several developments aiming to provide a more exhaustive answer on the reasons behind the methodological divide sketched out in Section VI. First, it would be worth the while to study the present state status of the IS-LM/AS-AD approach by accounting for its evolution from its pioneering textbook (Donrbusch and Fischer) to its current most popular expression (Blanchard's last edition). Second, as far as the RBC line is concerned, it would be interesting to delve deeper into the methodological differences between Barro's and Williamson's textbooks and investigate their internal consistency. A third possible quest is to appraise the attempts at making a synthesis between the IS-LM/AS-AD and the RBC lines, such as Abel and Bernanke's textbook. A fourth and last quest is to zero in on more recent textbooks in the RBC line, written after of the rise of new Keynesian macroeconomics, such as Chugh's. All these elements would certainly allow getting a sharper answer on the rationale behind the riddle exposed in the paper and a better evaluation on whether the present state of affair is acceptable or must be changed.

## 4.8 Appendix

### 4.8.1 List of Textbooks

**Undergraduate textbooks**

1. Abel, A. B., Bernanke, B. S. & Croushore, D. (2016), *Macroeconomics*, Pearson 9th Edition
2. Acemoglu, D., Laibson, D. & List, J. A. (2017), *Macroeconomic (Global Edition)*, Pearson
3. Barro, R. J. (2007), *Macroeconomics: A Modern Approach*, Thomsosn South-Western
4. Blanchard, O. (2017), *Macroeconomics*, Pearson Higher Ed. 7th Edition
5. Boyes, W. & Melvin, M. (2015), *Macroeconomics*, Cengage Learning 10th Edition
6. Bradford DeLong, J. & Olney, M. (2005), *Macroeconomics*, McGraw-Hill/Irwin. 2nd Edition
7. Brooman, F. S. & Jacoby, H.D. (2017), *Foundations of macroeconomics: Its theory and policy*, Routledge
8. Burda, M. & Wyplosz, C. (2017), *Macroeconomics: a European text*, Oxford University Press
9. Carlin, W. & Soskice, D. W. (2014), *Macroeconomics: Institutions, instability, and the financial system*, Oxford University Press, USA
10. Chakraborty, S. K. (2010), *Macroeconomics*, Himalaya Pub. House
11. Chugh, S. K. (2015), *Modern macroeconomics*, MIT Press
12. Colander, D. (2016), *Macroeconomics*, McGraw-Hill Education. 10th Edition
13. Dornbusch, R., Fischer, S. & Startz, R. (2018), *Macroeconomics*, McGraw-Hill Education. 13th Edition
14. Flaschel, P., Groh, G. & Proano, C. (2007), *Keynesianische Makroökonomik: Unterbeschäftigung, Inflation und Wachstum*, Springer-Verlag
15. Froyen, R. T. (2012), *Macroeconomics: Theories and policies*, Pearson Series in Economics, 10th Ed.
16. Gartner, M. (2016), *Macroeconomics*, Trans-Atlantic Publications, Inc. 5th Edition.
17. Gordon, R. J. (2011), *Macroeconomics*, Perason Series in Economics 12th Edition
18. Gottfries, N., (2013), *Macroeconomic*, Red Globe Press 2013 Edition

19. Gwartney, J. D., Stroup, R.L., Sobel, R.S. & Macpheron, D.A. (2017), *Macroeconomics: Private and Public Choice*, Cengage Learning. 16th Edition.

20. Hall, Robert E. & Taylor, J. B. (1997), *Macroeconomics*, W W Norton & Co Inc. 5th Edition.

21. Handa, J. (2010), *Macroeconomics (With Study Guide Cd-rom)*, World Scientific Publishing Company

22. Hubbard, G. & O'Brien, P. (2018), *Macroeconomics*, Pearson 7th Edition

23. James, E., Wellman, S.& Aberra, W. (2011), *Macroeconomics*, Pearson Education Canada. 2nd Edition

24. Jones, C. I. (2017), *Macroeconomics*, W. W. Norton & Company. 4th Edition

25. Karlan, D. & Morduch, J. (2017), *Macroeconomics*, McGraw-Hill Education. 2nd Edition.

26. Kennedy, P. E. & Prag, J. (2017), *Macroeconomic essentials: Understanding economics in the news*, MIT Press

27. Krugman, P. & Wells, R. (2015), *Macroeconomics*, Worth Publisher 4th Edition

28. Lindauer, J.L. (2012), *Macroeconomics*, iUniverse. 4th Edition.

29. Mankiw, N. G. (2018), *Macroeconomics*, Worth Publishers

30. McConnell, C., Brue, S. & Flynn, S. (2014), *Macroeconomics: Principles, Problems, & Policies*, McGraw-Hill Education. 20th Edition

31. McEachern, W. A. (2016). *Macroeconomics: A contemporary introduction.* Cengage Learning.

32. Mishkin, F. S. (2014), *Macroeconomics: Policy and practice*, Pearson Education

33. O'Sullivan, A., Sheffrin, S. & Perez, S. (2016), *Macroeconomics: principles, applications, and tools*, Pearson Higher Ed. 9th Edition

34. Parkin, M. (2015), *Macroeconomics*, Pearson Series in Economics 12th Edition

35. Popescu, G. H. (2013), *Macroeconomics*, Addleton Academic Publishers. 1st Edition. Kindle Version

36. Richards, D. and Rashid, M. & Antonioni, P. (2015), *Macroeconomics For Dummies*, John Wiley & Sons

37. Rossana, R. J. (2011), *Macroeconomics*, *Routledge. 1st Edition*

38. Sachs, J. D. & Larrain, B. F. (1993), *Macroeconomics in the global economy*, Prentice Hall

39. Samuelson, P. & Nordhaus, W. (2009), *Macroeconomics*, McGraw-Hill/Irwin. 19th Edition

40. Slavin, S. (2013), *Macroeconomics*, McGraw-Hill Series Economics 11th Edition

41. Williamson, S.D (2018), *Macroeconomics*, Pearson 6th Edition


**Graduate teaching**


1. Acemoglu, D. (2009), *An Introduction to Modern Economic Growth*, Princeton University Press

2. Adda, J. & Cooper, R. (2003), *Dynamic economics: quantitative methods and applications*, MIT press

3. Alogoskoufis, G. (2019), *Dynamic Macroeconomics*, MIT Press

4. Azariadis, C. (1993), *Intertemporal macroeconomics*, Blackwell Publishing Company

5. Barro, R. & Sala-i-Martin, X. (1998), *Economic Growth*, MIT Press

6. Blanchard, O. J. & Fischer, S. (1989), *Lectures on macroeconomics*, MIT Press

7. Cooley, T. F. (1995), *Frontiers of business cycle research*, Princeton University Press

8. Galí, J. (2015), *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*, Princeton University Press

9. Ljungqvist, L. & Sargent, T. J. (2018), *Recursive macroeconomic theory*, MIT press

10. McCandless, G. (2008), *The ABCs of RBCs: An Introduction to Dynamic Macroeconomic Models*, Harvard University Press

11. Obstfeld, M. & Rogoff, K. (1996), *Foundations of international macroeconomics*, MIT press

12. Romer, D. (2012), *Advanced macroeconomics*, *Mcgraw-Hill*

13. Stokey, N., Lucas, R. & Prescott, E. (1989), *Recursive methods in economic dynamics*, Harvard University Press

14. Walsh, C. E. (2017), *Monetary theory and policy*, MIT press

15. Wickens, M. (2012), *Macroeconomic theory: a dynamic general equilibrium approach*, Princeton University Press

16. Woodford, M. (2011), *Interest and prices: Foundations of a theory of monetary policy*, Princeton University Press

### 4.8.2 Additional Tables

TABLE 4.8: **University Sample**

| Respondent | $1^{st}$ *Dec. (8/8)* | $2^{nd}$ *Dec. (4/8)* | $3^{rd}$ *Dec. (7/8)* | $4^{th}$ *Dec. (8/8)* | $5^{th}$ *Dec. (5/8)* |
|---|---|---|---|---|---|
| 1 | London School of Economics | University of New South Wales | Hebrew University of Jerusalem | University of Hamburg | University of Georgia |
| 2 | University of Munich | University of Bologna | Georgia State University | Florida State University | North Carolina State University |
| 3 | Texas A&M University | Michigan State University | University of Technology Sydney | University of Innsbruck | University of Arkansas |
| 4 | MIT | University of Vienna | Humboldt University of Berlin | Vienna University of Econ&Buss. | University of Wisconsin |
| 5 | University of Toronto | | University of St. Gallen | University of Montreal | University of Rome, Tor Vergata |
| 6 | Boston University | | Uppsala University | University of Konstanz | |
| 7 | Stanford University | | University of Bristol | Lund University | |
| 8 | Tilburg University | | | University of Leicester | |
| Respondent | $6^{th}$ *Dec. (8/8)* | $7^{th}$ *Dec. (7/8)* | $8^{th}$ *Dec. (6/8)* | $9^{th}$ *Dec. (5/8)* | $10^{th}$ *Dec. (7/8)* |
| 1 | Free University of Berlin | Ryerson University | Kansas State University | University of Augsburg | University of Canterbury |
| 2 | York University | Montana State University | University of Paris II | University of Lugano | Radboud University Nijmegen |
| 3 | University of Kent | Bielefeld University | University of Namur | Newcastle University | Umea University |
| 4 | University of Tennessee, Knoxville | University of Fribourg | Catholic University of Rio de Janeiro | Norwegian Business School | University of Modena |
| 5 | University of Padua | University of Lyon | University of Naples Federico II | University of Rennes I | University of Delaware |
| 6 | University of Adelaide | Sabanci University | Pablo Olavide University | | Catholic University of Portugal |
| 7 | The New Economic School | Concordia University | | | University of Potsdam |
| 8 | University of Guelph | | | | |

Note: The table shows the random sample of universities considered by decile of Tilburg Ranking. In the parenthesis we report the number of departments that answer to our query with respect to the total number of departments in each decile (8).

TABLE 4.9: **Geographical distribution of the use of intermediate textbooks**

| *US-Canada* | | | *Europe (EHEA)* | | | *Rest of the World* | | |
|---|---|---|---|---|---|---|---|---|
| (1) Author(s) | (2) # of citations | (3) Weighted use | (4) Author(s) | (5) # of citations | (6) Weighted use | (7) Author(s) | (8) # of citations | (9) Weighted use |
| Mankiw G. | 10 | 5.93 | Blanchard O. | 22 | 18.83 | Dornbusch D. *et al.* | 2 | 1.5 |
| Williamson S.D. | 8 | 4.5 | Burda M. & Wyplosz C. | 7 | 6.33 | Mankiw G. | 2 | 1 |
| Blanchard O. | 6 | 3.23 | Mankiw G. | 8 | 4.33 | Jones C. | 1 | 1 |
| Jones C. | 4 | 3 | Williamson S.D. | 4 | 2 | Sachs J. & Larrain F. | 1 | 1 |
| Abel A.& Bernanke B. | 2 | 1 | Carlin S. & Soskice D. | 3 | 1,5 | Blanchard O. | 2 | 0.75 |
| Hubbard G.R. & O'Brien A.P. | 2 | 0.83 | Abel A.& Bernanke B. | 2 | 1.5 | Mishkin F. | 1 | 0.5 |
| Mishkin F. | 1 | 0.5 | Flaschel et al. | 1 | 1 | Williamson S.D. | 1 | 0.25 |
| | | | Gaertner M. | 1 | 1 | | | |
| | | | Gottfries N. | 1 | 1 | | | |
| No reference textbook | 1 | 1 | No reference textbook | 2 | 1.5 | | | |
| Total | 34 | 20 | | 51 | 39 | | 10 | 6 |

Note: The table shows the sample of textbooks used in the economics departments considered in the academic year 2020-2021 by broad geographical area. Columns (1), (2) and (3) respectively present the name(s) of the author(s) of the textbook, the number of U.S. and Canadian departments using the textbook in an intermediate course, and the weighted use of the textbook. Columns (4), (5) and (6) reproduce the same exercise for economics department in the European Higher Education Area (EHEA), while columns (7), (8) and (9) reproduce it for departments that are located outside the US or Canada and do not belong to the EHEA.

TABLE 4.10: **Distribution of intermediate textbooks across top- and lower ranked departments in the Tilburg ranking**

| *Top decile* | | | *Other deciles* | | |
|---|---|---|---|---|---|
| (1) Author(s) | (2) # of citations | (3) Weighted use | (4) Author(s) | (5) # of citations | (6) Weighted use |
| Mankiw G. | 6 | 3.1 | Blanchard O. | 25 | 19.91 |
| Blanchard O. | 5 | 2.9 | Mankiw G. | 14 | 8.16 |
| Jones C. | 2 | 1 | Williamson S.D. | 13 | 6.75 |
| Gaertner M. | 1 | 1 | Burda M. & Wyplosz C. | 7 | 6.33 |
| | | | Jones C. | 3 | 3 |
| | | | Abel A. & Bernanke B. | 4 | 2.5 |
| | | | Carlin W. & Soskice D. | 3 | 1.5 |
| | | | Dornbusch R. *et al.* | 2 | 1.5 |
| | | | Mishkin F. | 2 | 1 |
| | | | Flaschel *et al.* | 1 | 1 |
| | | | Gottfries N. | 1 | 1 |
| | | | Sachs J. & Larrain B. | 1 | 1 |
| | | | Hubbard G.R. & O'Brien P. | 2 | 0.83 |
| | | | No reference textbook | 3 | 2.5 |
| Total | 14 | 8 | | 81 | 57 |

Note: The table shows the sample of textbooks used in the departments considered according to their rank in the Tilburg Ranking. Columns (1) and (4) display the names of the authors. Column (2) shows the number of institutions belonging to the first decile of the Tilburg Ranking (top-ranked departments) that use the textbook in their intermediate macroeconomics courses. Column (3) weights textbooks according at their actual use in these universities. Columns (5) and (6) reproduce columns (2) and (3), respectively, but only considering lower ranked departments.

Table 4.11: **Ranking of undergraduate textbooks according to their use in introductory and intermediate courses**

| *Introductory classes* | | | | *Intermediate classes* | | | |
|---|---|---|---|---|---|---|---|
| (1) Author(s) | (2) Title | (3) # citations | (4) Weighted use | (5) Author(s) | (6) Title | (7) # citations | (8) Weighted use |
| Mankiw G. | Principles of Macroeconomics | 4 | 2.25 | Mankiw G. | Macroeconomics | 8 | 5.83 |
| Fregert K. & Jonung L. | Makroekonomi | 2 | 2 | Blanchard O. | Macroeconomics | 7 | 4.58 |
| Krugman P. & Wells R. | Macroeconomics | 3 | 1.75 | Williamson S.D. | Macroeconomics | 8 | 3.75 |
| Parkin M. | Macroeconomics | 3 | 1.75 | Jones C. | Macroeconomics | 4 | 3.5 |
| Hubbard G. R. & O'Brian A. P | Macroeconomics | 3 | 1.5 | Burda M. & Wyplosz C. | Macroeconomics: a European text | 3 | 3 |
| Asarta C. & Butters R. | Principles of Economics | 2 | 1.5 | Abel A.B. *et al.* | Macroeconomics | 3 | 1.5 |
| Mankiw G. | Macroeconomics | 3 | 1.08 | Dornbusch R. *et al.* | Macroeconomics | 2 | 1.5 |
| Baumol W. & Blinder A. | Macroeconomics: Principles and Policy | 1 | 1 | Carlin W. & Soskice D.W. | Macroeconomics: Institutions. instability and the financial system | 2 | 1 |
| Bernanke B. *et al.* | Principles of Macroeconomics | 1 | 1 | Gaertner M. | Macroeconomics | 1 | 1 |
| Blanchard O. | Macroeconomics | 1 | 1 | Gottfries N. | Macroeconomics | 1 | 1 |
| Burda M. & Wyplosz C. | Macroeconomics | 1 | 1 | Sachs J.D. & Larrain B.F. | Macroeconomics | 1 | 1 |
| Curtis D. & Irvine I. | Principles of Macroeconomics | 1 | 1 | Hubbard G. & O'Brien P. | Macroeconomics | 2 | 0.83 |
| Dobrescu I. & Motta A. | Playconomics: Principles of Economics | 1 | 1 | Mishkin F.S. | Macroeconomics | 1 | 0.5 |
| Gwartney J. *et al.* | Macroeconomics: Private and Public Choice | 1 | 1 | | | | |
| Mayshar J. | The Macroeconomics of Israel | 1 | 1 | | | | |
| Otto G. | Introduction to Macroeconomics | 1 | 1 | | | | |
| Steigum E. | Moderne makroøkonomi | 1 | 1 | | | | |
| Chiang E. | Economics Principles for a Changing World | 2 | 0.58 | | | | |
| Hickson S. | The New Zealand macroeconomy : what we measure and what it means | 1 | 0.5 | | | | |
| Karlan D. & Morduch J. | Macroeconomics | 1 | 0.5 | | | | |
| Krugman P. & Obstfeld M. | International Macroeconomics | 1 | 0.5 | | | | |
| McConnel C. *et al.* | Macroeconomics | 1 | 0.5 | | | | |
| Acemoglu D. *et al.* | Macroeocnomics | 1 | 0.33 | | | | |
| Feijo C.A. & Ramos R. O. | Contabilidade Social: A nova referência das contas nacionais do Brasil | 1 | 0.33 | | | | |
| Paulani L.& Braga M. | A Nova Contabilidade Social: uma introdução à macroeconomia | 1 | 0.33 | | | | |
| Tucker I. | Survey of Economics | 1 | 0.33 | | | | |
| Coppock L. & Mateer D. | Principles of Macroeconomics | 1 | 0.25 | | | | |
| CORE-ECON | | 1 | 1 | | | | |
| No reference textbook | | 3 | 3 | No reference textbook | | 2 | 2 |
| Total | | 46 | 31 | Total | | 45 | 31 |

Note: We only consider departments offering a sequence of courses in macroeconomics starting with an introductory course to macroeconomics. Columns (1) (2) (3) and (4) provide the names of the author(s) of each textbook. its title. the number of departments using the textbook in the 2020-2021 academic year. as well as its weighted use. Columns (5) to (8) provide the same information for intermediate courses.

TABLE 4.12: **Ranking of graduate textbooks according to the number of citations**

| (1) Author(s) | (2) Title | (3) Overall | (4) *Professional* Master's | (5) PhD & *Research* Master's |
|---|---|---|---|---|
| Romer D. | Advanced Macroeconomics | 32 | 23 | 9 |
| Ljungqvist L. & Sargent T. | Recursive Macroeconomic Theory | 21 | 1 | 20 |
| Stokey N. Lucas R. & Prescott E. | Recursive Methods in Economic Dynamics | 12 | 1 | 11 |
| Gali J. | Monetary Policy, Inflation and the Business Cycle | 10 | / | 10 |
| Acemoglu D. | Introduction to Modern Economic Growth | 7 | 1 | 6 |
| Blanchard O. & Fischer S. | Lectures on Macroeconomics | 5 | 2 | 3 |
| Barro R. & Sala-i-Martin X. | Economic Growth | 5 | 2 | 3 |
| Walsh C. | Monetary Theory and Policy | 5 | 1 | 4 |
| Woodford M. | Interest and Prices: Foundations of a Theory of Monetary Policy | 4 | / | 4 |
| Cooley T. | Frontiers of Business Cycle Research | 4 | 1 | 3 |
| Wickens M. | Macroeconomic Theory. A Dynamic General Equilibrium Approach | 4 | 2 | 2 |
| Obstfeld M. & Rogoff K. | Foundations of International Macroeconomics | 3 | 2 | 1 |
| Adda J. & Cooper R. | Dynamic Economics: Quantitative Methods and Applications | 2 | 1 | 1 |
| Alogoskoufis G. | Dynamic Macroeconomics | 2 | 2 | / |
| Azariadis C. | Intertemporal Macroeconomics | 2 | 1 | 1 |
| McCandless G. | The ABCs of RBCs: An Introduction to Dynamic Macroeconomic Models | 2 | 1 | 1 |
| Agenor P-R. & Montiel P. | Development Macroeconomics | 1 | 1 | / |
| Aghion P. &Howitt P. | The economics of growth | 1 | / | 1 |
| Athreya K. | Big Ideas in Macroeconomics: A Nontechnical View | 1 | 1 | / |
| Bagliano F. & Bertola G. | Models for Dynamic Macroeconomics | 1 | 1 | / |
| Bertocchi G. | Strutture Finanziarie Dinamiche | 1 | / | 1 |
| Champ B. *et al.* | Modeling monetary economics | 1 | 1 | / |
| Chiang A. & Wainwright K. | Fundamental Methods of Mathematical Economics | 1 | / | 1 |
| Chugh S. | Modern Macroeconomics | 1 | 1 | / |
| de la Croix D. & Michel P. | A theory of economic growth : Dynamics and policy in Overlapping generations | 1 | 1 | / |
| Enders W. | Applied Econometric Time Series | 1 | / | 1 |
| Froyen R. & Guender A. | Optimal Monetary Policy under Uncertainty | 1 | 1 | / |
| Galor O. | Discrete Dynamical Systems | 1 | / | 1 |
| Heijdra B. | Foundations of Modern Macroeconomics | 1 | / | 1 |
| Jappelli T. & Pistaferri L. | The economics of consumption | 1 | / | 1 |
| Kurlat P. | A Course in Modern Macroeconomics | 1 | 1 | / |
| Mankiw G. | Macroeconomics | 1 | 1 | / |
| Miao J. | Economic Dynamics in Discrete Time | 1 | / | 1 |
| Mishkin F. | The economics of money, banking, and financial markets | 1 | 1 | / |
| Niepelt D. | Macroeconomic Analysis | 1 | / | 1 |
| Pissarides C. | Equilibrium unemployment theory | 1 | / | 1 |
| Sargent T. | Rational Expectations and Inflation | 1 | 1 | / |
| Weil D. | Economic Growth | 2 | 1 | 1 |
| Williamson S. D. | Macroeconomics | 1 | 1 | / |
| No reference textbook | | 10 | 2 | 8 |

Notes The table shows the sample of textbooks used in the 2020-2021 academic year in graduate macroeconomics courses in the economics departments considered. Column (1) presents the names of the author(s), while column (2) shows the title of the textbooks. Column (3) shows the number of institutions using the textbook either as a reference text or as a recommended readings, columns (4) and (5) make the distinction between (i) *professional* master's and (ii) *research* master's/PhD courses. Only textbooks that are used in at least two universities appear in the table.

Table 4.13: **Distribution of graduate textbooks used in research masters or PhD programs across top- and lower ranked departments in the Tilburg ranking**

| *Top-2 deciles* | | *Other deciles* | |
|---|---|---|---|
| (1) Author(s) | (2) # of citations | (3) Author(s) | (4) # of citations |
| Ljungqvist L. & Sargent T. | 5 | Ljungqvist L. & Sargent T. | 16 |
| Stockey N. Lucas R. & Prescott E. | 4 | Stokey N. Lucas R. & Prescott E. | 8 |
| Acemoglu D. | 2 | Romer D. | 8 |
| Gali J. | 2 | Gali J. | 7 |
| Cooley T. | 2 | Acemoglu D. | 3 |
| Woodford M. | 2 | Barro R. & Sala-i-Martin . | 3 |
| Adda J & Cooper R. | 1 | Blanchard O. & Fischer S. | 3 |
| Obstfeld M & Rogoff K. | 1 | Walsh | 3 |
| Walsh C. | 1 | Wickens | 2 |
| | | Woodford M. | 2 |
| | | Aghion P. & Howitt P. | 1 |
| | | Azariadis C. | 1 |
| | | Bertocchi G. | 1 |
| | | Chiang A. & Wainwright K. | 1 |
| | | Cooley C. | 1 |
| | | Enders W. | 1 |
| | | Galor O. | 1 |
| | | Heijdra B. | 1 |
| | | Jappelli T. & Pistaferri L. | 1 |
| | | McCandless G. | 1 |
| | | Miao J. | 1 |
| | | Niepelt D. | 1 |
| | | Pissarides C. | 1 |
| | | Weil D. | 1 |
| No reference textbook | 2 | No reference textbook | 7 |

Notes: The table shows the sample of textbooks used in the 2020-2021 academic year in graduate macroeconomics courses in the economics departments considered. Only textbooks used in a research master's or a PhD course are considered. Column (1) and (3) display the names of the author(s). Columns (2) and (4) shows the number of institutions using the textbook either as a reference text or as a recommended reading in top-ranked universities (2) and other universities (4). Top-ranked universities are the ones that belong to the first decile of the Tilburg Ranking.

# Addendum to Chapter 3

## *The theoretical background behind our typology*

The aim pursued in this addendum is threefold. First, we want to provide additional information on the context in which the project on macroeconomics textbooks emerged. This way, we will be able to clear out the broader research question that we aim at tackling. Second, we want to develop further the theoretical background that underpins the typology exposed in the third chapter of the thesis. We do so by focusing on one particular, but fundamental, methodological bifurcation – the equilibrium conception followed. Finally, we aim at regarding from a broader historical perspective the evolution of undergraduate macroeconomics textbooks. We separate our analysis in two, focusing first on what we identify as AS-AD textbooks, and then on RBC textbooks.

## 4.9 Addendum Chapitre 3

Before heading through this addendum, we have to warn the reader. This text is quite arid and dense. Its aim is to present succinctly the ideas that have been discussed over the course of an already five years-long project. It may sometimes resemble a collection of (very) strong statements that call for more details and longer discussions. Actually, each section here presents the core ideas of an embryonic paper that is still under construction. Be it as it may, this addendum provides a much more precise idea of the constituting elements of the typology presented in Chapter 3. It also nourishes the typology with reflections on, and assessments of, the theory presented in the different macroeconomics textbooks surveyed in Chapter 3.

The remainder of this addendum goes as follow. Section 1 summarizes the origin and the main goal of the broader project on macroeconomics textbooks. Section 2 distinguishes two phases in the development of macroeconomics and discusses their characteristics based on well selected methodological criteria. Section 3 takes a particular criteria, the equilibrium concept followed, to confront the two main macroeconomic theories as presented in macroeconomics textbooks. Section 4 details further the evolution of AS/AD macroeconomics textbooks. Section 5 discusses the relationship between three undergraduate RBC textbooks. Section 6 provides a synthesized but comprehensive picture of the evolution of macroeconomics textbooks. Finally, section 7 adds a reflection on the place of the labor market in macroeconomics textbooks and, more generally, in macroeconomic theory.

### 4.9.1 The origin of the project

This project is an offspring of the discussions Riccardo Turati and I – then PhD students and teaching assistants in undergraduate macroeconomics courses – had with Michel De Vroey when following his *Advanced course in History of Macroeconomics* in 2017. Our main questioning came from the observation that what we were teaching to our students – i.e. some relatively standard IS-LM/AS-AD model which we deemed to be Keynesian macroeconomics – was neither close to early Keynesian macroeconomics nor related to nowadays top-of-the art New-Keynesian macroeconomics. From this observation came two questions:

1. What was this IS-LM/AS-AD model that we used to teach?

2. Where there other ways to teach macroeconomics at the undergraduate level, maybe more in-line with cutting-edge macroeconomic theory?

We gave ourselves the task of answering these by documenting in a systematic way how macroeconomics is (and has been) taught at the undergraduate level. We did so while taking the advantage that one of us is a historian of economics. This was key at two levels. First, it enabled us to relate macroeconomics textbooks to the seminal contributions that transformed the field of macroeconomics. Second, it helped us to narrow down our discussion to the main methodological choices that may be used to characterize macroeconomic theory. Doing so, we actually followed A. Leijonhufvud's suggestion to regard the development of economic theory as a decision-tree (Leijonhufvud, 1994), which nodes mark the methodological choices that have to be made in the initial stage of the theory-construction process. These nodes may be compared to forks or bifurcations on a road. Choosing one rather than another puts the theory on different tracks. Basic or first-rank choices come first. Second-, third rank, etc. choices come next. For this project, we only considered first-rank choices, such as the equilibrium concept adopted or the degree of formalisation of microfoundations.[20]

The next sections will be clearer on what we consider to be a first-rank methodological choice. But, at this stage, to get a better view of what the project aims at, it is also important to clarify what it does not plan to do.

First, we want to make a distinction between (i) methodological choices regarding the theory-building process, and (ii) ideology or policy conclusions. Concerns such as "RBC models emphasize the neutrality of money whereas New Keynesian models posit money can have real effects on the economy" or "New Keynesian models assert that the economy's response to shocks is generally inefficient, while RBC theory states that the economy's responses are always efficient." relate to the economists' ideology or to her model policy conclusions. They do not relate to core modeling choices. Particularly, they do not prevent New-keynesian models to abide to the same standards as RBC models in terms of core model-building choices (i.e. intertemporal equilibrium, explicit microfoundations, etc.).

Second, we do not dispute that the degree of rigor matters, especially when studying the differences between undergraduate and graduate textbooks, and between AS-AD textbooks and RBC textbooks. This is probably one of the reasons why, in Chapter 3, we find that the vast majority of undergraduate textbooks are based on the theory that is the least demanding in terms of investment in mathematical modeling (AS-AD textbooks). This has certainly played a role. But intellectual honesty must recognize that it is not a sufficient criterion to discard the dominant theory in macroeconomics research (for more than 40 years of development!) from the teaching of macroeconomics at the undergraduate level. What we argue instead is that there are also conceptual differences

[20] Are microfoundations 'implicit' as in the Marshallian supply-demand apparatus or 'explicit' as in Walrasian theory?

between the two main theories which probably also matter, and make the teaching of AS-AD theory more appealing. We intend to uncover them throughout this project.

### 4.9.2 The two phases of macroeconomics

We started this project by reviewing the history of macroeconomic theory, focusing on the methodological choices taken up regarding the theory-building process. This helped us to identify the two main phases of macroeconomics. This section aims at summarizing our reflections.

What came to be called 'macroeconomics' is an offshoot of Keynes's "General Theory" (Keynes, 1936). This seminal work is a kaleidoscope book that mixes several research claims in a somewhat lose way. It defends a single vision of the market system, a balance between being pro-market and pro-government. Keynes' main contention is that the stability of market economy, the basic hypothesis of the 'classical project', can fail. The economy can be stuck is a sub-optimal state that is characterized by the existence of 'involuntary unemployment'. To him, the economy is plagued by some malfunctioning, which, in contrast to the classical vision, it is not self-healing. Instead, the economy needs the government to remedy upon it.

Though its interpretation generated fierce interpretative disputes, the message of Keynes's General Theory was rapidly transformed into a body of knowledge centered on the IS-LM model.[21] Along the theoretical developments, Keynesian economists transformed Keynes' ideas into quantitative economics. Indeed, from pure theory macroeconomics turned to econometric testing, a path opened by Klein and Goldberger (1955).[22]

For the few decades after the General Theory had been released, there were no other macroeconomics than Keynesian. Yet, its hegemony came to be questioned by the monetarists, whose leading figure was Milton Friedman. At the 1967 Meeting of the American Economic Association, Friedman presented a Presidential Address entitled "The Role of Monetary Policy" (Friedman et al., 1968). His Address is a mixture of theoretical analysis and policy pleading. It is a direct attack on Keynesian theory and the vision of the market system that underpins it.[23]

[21]From a theoretical point of view, Keynesian macroeconomics was less unified than what it seems. For sure, Keynesian economists shared the same vision of the market system. Yet, this unanimity masked significant methodological differences, which are rooted in four alternative influential interpretations of the General Theory by Hicks (1937); Modigliani (1944); Klein (1947); Patinkin (1956). More on this in De Vroey (2016b).

[22]The Klein-Goldberger model is a system of time-recursive difference equations, most of which are linear approximations of the structural theoretical relations. They estimated the model as a system using limited-information maximum-likelihood techniques.

[23]Friedman's aim was to offer an alternative to Keynesian theory by demonstrating that, how well-intended expansionary policies might have been, they are themselves the source of a malfunctioning. His

Friedman's Presidential Address marked a decisive turning point in the ideological vision underpinning macroeconomics. From a mitigated economic liberalism, which assumes that government interventions may result in welfare improvements, it turned to absolute economic liberalism, which assumes that government interventions do more harm than good. However, despite its tremendous impact on the ideology conveyed into macroeconomics, Friedman did not argue for profound methodological changes. Actually, the theoretical body of macroeconomics barely evolved. The IS-LM model was simply enriched by the addition of the AS-AD apparatus.[24]

Friedman's influence on macroeconomics was rather short-lived. Indeed, even though Lucas's motivations in its "Expectations and the Neutrality of Money" paper (Lucas Jr, 1972) was to recast Friedman's arguments in a more systematic way, it also paved the way to the 'rational expectations revolution'. The result of which was to sweep away the cornerstone of Friedman's model: the adaptive expectations assumption. Later on, Lucas' paper "Methods and Problems in Business Cycle Theory" (Lucas, 1980) spelt out new methodological standards for the practice of macroeconomics and succeeded in convincing the majority of the profession to adopt them. Lucas contention was both theoretical and empirical. On the theoretical part, he wanted macroeconomics to be microfounded, concerned with general equilibrium analysis and set into mathematical modelling. On the empirical part, he wanted macroeconomic theory to be quantitatively assessed.

In this (r-)evolution, Kydland and Prescott's "Time to Build and Aggregate Fluctuations" article (Kydland and Prescott, 1982), played a similar role as Klein and Goldberger's 1955 paper. They took Lucas principles and brought an already existing theory to the data. Soon, these new insights came to be encapsulated in a baseline model, the RBC baseline model (see King, Plosser, and Rebelo (1988); Plosser (1989)) and, from this stage on, the evolution of macroeconomic theory consisted in the introduction of 'frictions' within the RBC baseline model. This process has led to continuous and cumulated changes that resulted in what is called nowadays 'new Keynesian macroeconomics'[25] or 'DSGE

plea was cast in the trade-off between inflation and unemployment, the so-called Philips Curve that was 'owned' by Keynesians. To him, there was not such a thing. Central to his claim was the hypothesis that, because workers were holding adaptive expectations, they were misperceiving the impact of monetary shocks. The profession quickly adopted his point and the expectations-augmented Phillips curve became a sine qua non in macroeconomic theory.

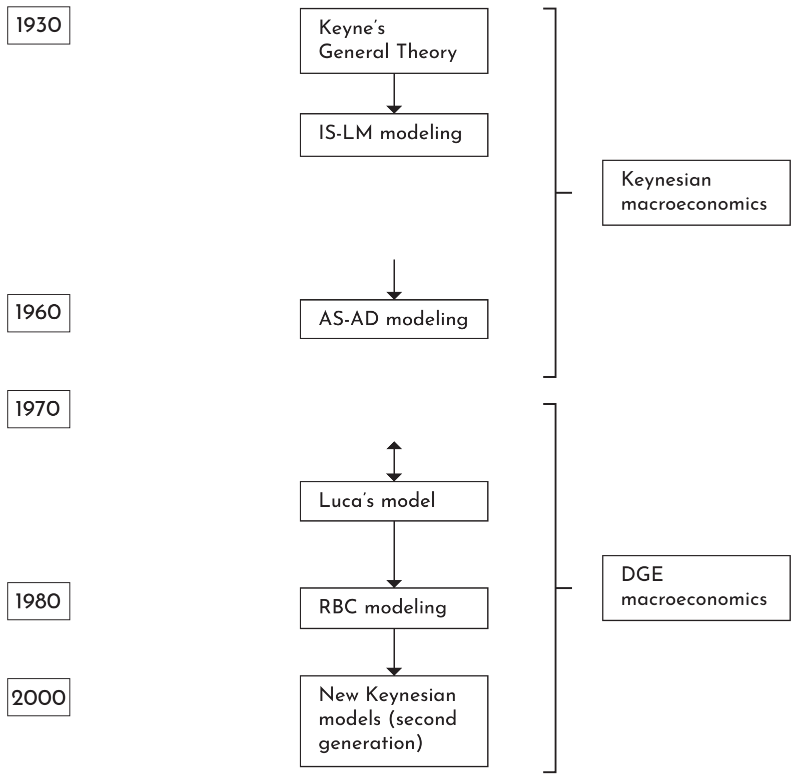
[24]The IS-LM part now received an instrumental role, serving the purpose of construct the Aggregate Demand curve.

[25]The 'new Keynesian' terminology is ambiguous. The 'new' term is useful because 'old' and 'new' Keynesian theories must be differentiated, but then a further distinction must be drawn between two generations of new Keynesian economics. The first is composed of a group of economists, many of them with a microeconomics background, like J. Stiglitz or G. Akerlof. Whilst accepting Lucas's microfoundations requirement, they were stern defenders of the involuntary unemployment and sticky prices notions. They were also radically opposed to RBC modeling without however being keen on using the IS-LM model. By contrast, second-generation new Keynesian economists accept the RBC model as their base-

models'.

The previous paragraphs deal with the evolution of macroeconomics in a very succinct way. Yet, they provide the big picture we need. What can be drawn from it is that macroeconomics has been evolving in two phases: the first one is Keynesian macroeconomics (in which we include monetarism), the second one is Dynamic General Equilibrium (henceforth DGE) macroeconomics. Though sketchy, Figure 4.2 summaries our views.

FIGURE 4.2: **The evolution of macroeconomics over time**




**Notes**: Arrows indicate a relationship of lineage, double-edged arrows a relationship of opposition.

### The methodological bifurcations

There are important similarities between the two broad approaches to macroeconomics. They are worth being underlined. Both theory are based on the subjective theory of value. They both belong to the neoclassical approach and hence to the methodological individualism perspective. They are general equilibrium models and assume a perfect

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line model. They purport to superimpose supposedly Keynesian elements on it, such as price stickiness, imperfect competition, and the presence of money. Practitioners of the first or the second-generation of new Keynesian economics may well share a broader Keynesian affiliation, bearing on the existence of market failures and the role of government, but, as far as theory is concerned, they cannot be amalgamated. So, whenever henceforth we will use the 'RBC modeling' wording, we mean the extended RBC modeling – that is, including second-generation new Keynesian models.

competition framework. And, both AS-AD and RBC economists adhere to the positivistic viewpoint that the validity of theoretical propositions hinges on their empirical confirmation.

But for our purpose we must zero in on their differences – and for that matter, on their basic differences. After having given much thought on the issue, we have selected the following four criteria in chapter 3: (a) the main object of analysis (Unemployment & inflation VS Business fluctuations); (b) the equilibrium concept used (State of rest equilibrium VS Intertemporal equilibrium); (c) the degree of formalisation of microfoundations (Implicit VS Explicit microfoundations); and (d) the overarching methodological rule adopted (External validity VS Internal consistency). We chose these ones rather than possible others — like for example the barter/monetary, the external forward/backward expectations, the price formation technology, the information set available to workers, the role given to the labor market, the congruence between growth and business cycle, etc. – because we believe they are more suited to answer the practical questions raised in that chapter, i.e. "Is there a divide between macroeconomic theory taught at the undergraduate and graduate level, and if so, why ?"

But, actually, all these criteria matter. They are linked and form a single general perspective. For the sake of completeness and because each of them highlights a different aspect of this general perspective, it would be useful to present them all separately. Yet, one of them, the equilibrium concept, plays a pivotal role in explaining the methodological divide between the two programs. In the next section, we expose in a (relative) detailed way the two main equilibrium concepts used: the state of rest equilibrium and the intertemporal equilibrium. At the end of the section, we also aim at presenting their implications for macroeconomics textbooks.

### 4.9.3 Two main equilibrium concepts used in macroeconomic theory

In a nutshell, we identified three equilibrium concepts: the state of rest equilibrium, the intertemporal equilibrium and the multiple equilibria framework. The latter exists in research but has hardly percolated in textbooks. So, we do not discuss it further here. The state-of-rest equilibrium is close to the common-sense understanding of the word equilibrium, it bears a sense of a gravitation. It is assume that disturbances may well affect the working of markets yet, at the end of the day, normality is re-established. The economy always returns to a static equilibrium, the state-of-rest. To describe this concepts, economists usually refer to the rocking chair or pendulum analogy. It is the equilibrium concept used in keynesian macroeconomics (and AS-AD textbooks). The intertemporal equilibrium instead, is defined as generalized optimizing behavior, meaning choosing an optimizing intertemporal path. It has been set out by Lucas and is one of the main ingredients of DGE economics. Therefore, it is also the core equilibrium concept to be found in RBC textbooks. In the following, we further discuss these two equilibrium concepts.

**Three milestones in the history of gravitation theory: : A. Smith, A. Marshal and M. Friedman**

The static equilibrium notion can already be found in the writings of classical economists. Its origin can be traced back to Book I, Chapter 8 of A. Smith's Wealth of Nations, entitled "Of the Natural and Market Price of Commodities". "The natural price, therefore, is, as it were, the central price, to which the prices of all commodities tend to gravitate" (: 74).

Neo-classical economists, such as Marshall, pursued with the static state-of-rest equilibrium concept. Actually, one of the earliest systematic exposition of it is to be found in Marshall's fish industry example in Book V, Chapter V of his "Principles of Economics". The latter is more than a mere example. It encapsulates the basic reasoning that, still today, economists make when presenting the Law of Supply and Demand. As such, it can also be regarded as a condensation of his theory of value.

Marshall's object of analysis in the fish market example is producers' reactions to a positive shock on the demand for fish. It is a a canonical exposé of the basic functioning of good markets and aims at assessing the effects of demand or supply shocks on output and prices in a given market. Marshall's reasoning rested on a few conceptual arrangements which need to be spelled out to fully grasps what the state-of-rest equilibrium is. We draft here few key elements:

- Production takes place in advance of trade. Marshall's organization of time and its division between production and trade has been encapsulated in the Week device by Hicks in "Value and Capital". It consists in representing time as a succession of weeks with trade occurring exclusively on Mondays. The other days of the week are devoted to production, leisure and consumption (Hicks (1946): 122-3).
- Equilibrium price and quantity on a given market-day (on a given Monday) results from the matching of supply and demand (in other words, market clearing). This is ensured as far as agents share a correct perception of market conditions, i.e. they are able to make a mental reconstruction of the market supply and demand function up to the point of rightly conjecture the equilibrium price/quantity (Marshall (1922): 337)
- The state-of-rest equilibrium concept is a multiple-layer notion: there is the *normal equilibrium* (the gravitation point) and the *period-of-the-market equilibrium* (the

matching of demand and supply on a given trading day). Whenever these two equilibria do not correspond, it is said that the market is in disequilibrium (hence the qualifier of disequilibrium economics). Consequently, market clearing coexists with disequilibrium, understood as a departure from normal equilibrium.

- The normal equilibrium is supposed to exist at the beginning **and** at the end of the *period-of-analysis*, which notion delineates the time span over which the normal equilibrium acts as a center of gravity. Therefore, it is necessary that during this period" ... the general circumstances of the market remain unchanged; that there is, for instance, no change in fashion or taste, no new substitute which might affect the demand, no new intervention to disturb the supply "(Marshall 1920: 342). This is key. It means that Marshall analysis holds only for short-run issues.

Friedman's Presidential Address "The Role of Monetary Policy" (Friedman et al., 1968)[26] can be seen as a transformation of Marshall's fish market analysis into a general equilibrium analysis. Indeed, Friedman's aim is to study the impact of a positive demand shock on labor and output market outcomes.[27] With the difference that the shock is monetary and that the model includes a labor market, this the exact same aim Marshall pursued. Actually, Friedman adopted Marshall's conceptual toolbox and enriched it by introducing two key elements:

- As in Marshall's fish market, production takes place in advance of trade. But in Friedman's setting, this translates into the assumption that the labor market starts and comes to a close before the opening of the goods market. More precisely, the labor market trade taking place on $t_i$ determines the supply of goods that will be traded in the good market on $t_{i+1}$. Hence, supply of and the demand for labor are parametrized with firms' and workers'expectations held about the price that will prevail in the good's market.

- The basic mechanism for achieving market clearing is the same as in Marshall but one friction impedes this mechanism to function perfectly. When bargaining in the labor market on $t_i$, workers and firm have different views about the equilibrium price that will emerge in good market at its closure a $t_{i+1}$. Workers have adaptive expectations, while firms have perfect foresight. Hence in case of a demand shock[28]

[26] As in Marshall, there is no explicit model in Friedman's address. Yet, an implicit one is definitely present. Friedman worked it out in his Price Theory textbook (Friedman, Company, and Medema (1976): 221 seq.).

[27] To all intents, the good market is composed of a single good, yet the latter is supposedly composite, a proxy for the typical consumption basket. Hence the story told by Friedman runs in terms of the 'price level' rather than of the good's price.

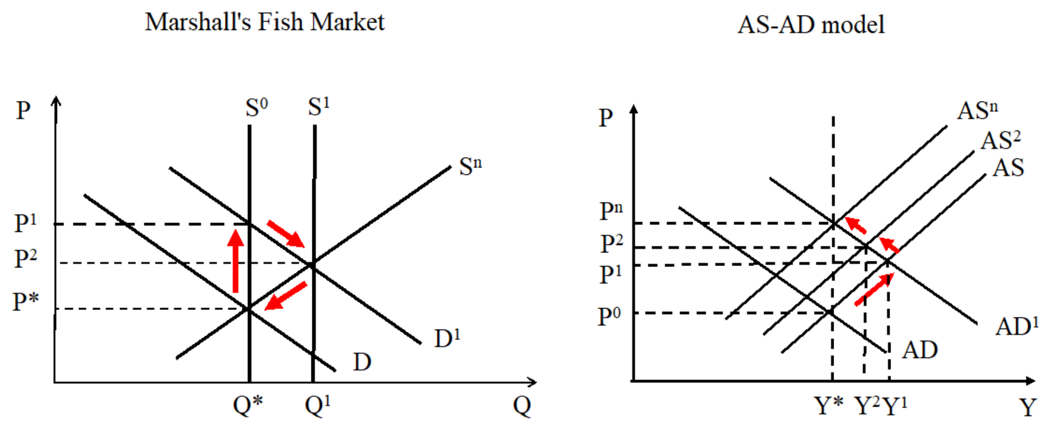
[28] That the shock is actually a monetary shock is of secondary issue here. The question of the central bank policy is dealt with in the next section.

they are able to anticipate its effect on prices. Moreover, it is assumed that firms know how workers behave while the contrary is untrue.

This asymmetry of perception, more than the existence of the labor market, makes the difference between Marshall's and Friedman's models. It is the only elements justifying that there is a lengthy (over several market-periods) adjustment to shocks while, in the case of Marshall's fish market, adjustment to shocks take at most two periods after the shock disappear. This marks also the crucial element on which any AS-AD model is based.

Figure 4.3 provides, in the left panel, Marshall's fish market, and in the right panel, the AS/AD model of an entire economy as it is displayed in Dornbusch and Fischer (1979). They are both in equilibrium to begin with. A shock strikes them generating disequilibrium allocations. Market forces set in and the initial equilibrium is restored. In other words, they adhere to the same equilibrium concept: a state of rest that acts as a center of gravity.

FIGURE 4.3: **Marshall Fish's Market and AS-AD model in Dornbusch and Fischer (1979)**




**Notes**: $D, S, S^n$ stand, respectively, for *period-of-the-market* fish demand, *period-of-the-market* fish supply, and *normal* fish supply. $Q^*$ and $P^*$ indicate *normal* equilibrium quantities and prices, i.e. the gravity point in Marshall's fish market. AS and AD stand for aggregate supply and aggregate demand. $AS^n$ last *period-of-the-market* aggregate supply. $Y^*$ corresponds to the natural level of output, i.e. the gravity point in the AS-AD model.

### Lucas's all-out attack on the static equilibrium approach

Compared to today's standards of doing research, Marshall's fish market analysis and Friedman's workers' misperception model are rather rudimentary. They are flawed in few aspects. But one aspect is important: their analysis is worthy only for what concerns short-run issues. Long run issues, such as changes in capital investment affecting productivity, cannot be dealt with.

This defect has been well perceived by Robert Lucas. It is one of the reasons that motivated him to start his fierce attack against Keynesian macroeconomics. Lucas's best known offensive is his celebrated 'Lucas critique' article (Lucas, 1976), where he criticized the practice of using estimated macroeconometric models à la Klein-Goldberger to compare alternative economic policies.[29] But Lucas' critique of Keynesian macroeconomics was multi-dimensional. In his paper, "Methods and Problems in Business Cycle Theory" (Lucas, 1980), Lucas attacks the state-of-rest conception of equilibrium used in Keynesian macroeconomic theory. To him, it is wanting on two aspects. On the one hand, because, by definition, the gravitational analysis is about reaching a predefined equilibrium position, it cannot come to grips with irreversible changes in the data of the economy (affecting households' preferences or firm's technology). Such changes generate a new equilibrium position that makes the earlier equilibrium allocation obsolete before ever being reached. On the other hand, the speed of adjustment – i.e. the return to the normal equilibrium – is a free parameter. The economist can give as much (or as little) importance to the disequilibrium state. To Lucas, this cannot be in macroeconomics since, to him, any parameters of the model must be structural, i.e. rooted in agents optimizing plans.

Instead, Lucas praised the intertemporal equilibrium concept. This last was firstly introduced by Hicks in his Value and Capital (Hicks, 1939), but only became front and center in neo-Walrasian modeling à la Arrow-Debreu-McKenzie. The intertemporal equilibrium concept is characterized by the following elements:

- It is defined as generalized optimizing behavior, meaning that the equilibrium is the result of the choices of the agents of the economy that are optimizing over several (more often, an infinite number of) periods in order to define their intertemporal consumption/investment path.

- Unlike what is the case in gravitational models, it is not assumed in neo-Walrasian theory that equilibrium exists at the beginning of the analysis. Instead, it starts with the description of the economy, i.e., a series of propositions about commodities, consumers– their preferences, their endowment, their share of ownership shares of the firms – the firms – the production function. The logical existence of equilibrium is demonstrated using these elements.[30]

- Trade takes place ahead of production. As shocks hit the economy, the agents make their decisions instantaneously and the process through which their optimizing plan

[29]His main contention being that agents behave differently under distinct regimes and, that macroeconometric models failed to be 'deeply structural', i.e. to describe the microeconomic behavior of individual agents.

[30]But the issue of coordination (tâtonnement) is swept under the rug using the auctioneer artefact.

> are made compatible is also supposed to occur instantaneously. In a neo-Walrasian economy everything is produced on order. As a result, the duality of equilibrium concepts proper to the static equilibrium vision is dispensed with and no room exists for the disequilibrium notion.

Here, time is cast as a succession of dated points of exchanges with the possibility of engaging in intertemporal substitution. Few consequences ensue. First, the assumption that irreversible changes must be excluded no longer holds. Hence, the need for two separate theories bearing respectively on the short- and the long- period vanished. Second, there is no more need to build a synthesis between Keynesian macroeconomics and classical economics[31] since the latter, when adjunct with the intertemporal equilibrium concept, can take on board what was previously assigned to Keynesian theory.

Lucas argued that it is understandable that earlier macroeconomists, like Samuelson and Patinkin, adhered to the state of rest equilibrium concept, because they lacked the tools for doing serious dynamic analysis.[32] However, he argued, that reasoning in terms of a stationary conception of equilibrium, once new concepts and tools - in particular dynamic programming – became available is a non-sense. He was right, the static equilibrium concept quickly became obsolescent and disappeared completely in further developments of macroeconomic theory.[33]

**The implications for textbooks**

Of course, Lucas's remark bears on cutting-edge macro and it can be argued that, for a reason of teachability, the matter is different for textbooks. So, we will find many textbook authors admitting that advanced research must be DGE but arguing that teaching must be AS/AD.

What is the drawback of this approach? The adoption of the state-of-rest equilibrium was OK when the mission of macroeconomics was deemed to serve the purpose of explaining lapses from full employment (as was the case with Keynesian macro for which the adoption of a fundamentally static framework was a non-issue). Yet it is ill sited when the mission is to study business fluctuations– the existence of cycles with peaks and through, time series, typical movement of variables across the cycle, their co-movements, etc. — all

[31] AS-AD textbooks make the hypothesis that Keynesian macroeconomics holds the 'short-term,' while Classical economics owns the 'long-term'.

[32] "To ask why the monetary theorists of the 1940s did not make use of the contingent-claim view of equilibrium is, it seems to me, like asking why Hannibal did not use tanks against the Romans instead of elephants" (Lucas [1980] 1981, 286).

[33] But the adoption of the intertemporal equilibrium is not a free lunch either. Adopting it amounts to sweeping the idea of duration of adjustment under the rug. Hence the return of Keynesian ideas in DGE models at the turn of the century.

things for which the state of rest equilibrium framework is ill suited. Hence, AS-AS models are unable to come to grips with the functioning of the economy over long spans of time for which changes in both capital and labor must be taken on board, and for that matter irreversible changes. That is, business fluctuations and growth are beyond their purview.

To compound the matter, most AS/AD textbooks have simplified Marshall's time apparatus. The short-long period came to replace the period-of-the-market/normal equilibrium distinction, while the period-of-analysis notion disappeared. If these changes had been only semantic it would not have mattered. Yet, nothing but confusion is gained from shifting to the long-run terminology. If our above remarks are admitted, this means that they should banish the long-run term from all their theoretical analysis. Manifestly, they do not do this. Moreover, they tend to associate their 'short-run analysis' with the Keynesian model and the 'long-run analysis' with the classical. For all its wide acceptance, this views makes little sense in the light of our above analysis. There is no justification for associating the classical model with the long period.

To critical minds what AS-AD defenders call a powerful operation amounts rather to sweeping a difficult epistemological issue under the rug. Anyway, at this point, we do not want to take a normative standpoint and stating that it is better to take the DGE textbook line than the AS-AD. We simply want to make their difference clear because we cannot accept that textbooks disguise it by suggesting that there is a continuity between AS/AD and DGE (as Jones (2008) does).

### 4.9.4 Unfolding the evolution of AS/AD textbooks

Bearing in mind the discussion above, we now turn to the analysis of the evolution of the textbooks that are base on Keynesian macroeconomics. We identified three generations of AS/AD textbooks:

1. **First-Generation**: IS-LM in Allen (1969); Ackley, R, ACKLEY, Ackley, Company, and Press (1961)

2. **Second-Generation**: IS-LM/AS-AD as in Dornbusch and Fischer (1979)

3. **Third-Generation**: AS-AD-MR the 3-equations model as in Jones (2008)

The aim of this section is to discuss the changes operated between these three generations of AS-AD textbooks.

### The transition from first- to second-generation

Dornbusch and Fischer's (1979, henceforth DF) textbook inaugurated a second generation IS-LM macroeconomics textbooks different from those of the first generation such as Acleky's (1961). The context has changed. Ackley wrote his book at the heyday of Keynesian macroeconomics when no macroeconomics other than the Keynesian one existed. Things changed in the 1970s as Keynesian macroeconomic came under a fierce attack led by M. Friedman. Initially regarded as a maverick, Friedman proved able to rally the profession on several of his ideas – that inflation is always a monetary phenomenon, that money is neutral in the long run,[34] that the early Phillips curve must be augmented with expectations, and, finally, that the validity of theoretical propositions depends on their empirical validation. Reading DF's book makes it clear that taking stock of Friedman's insights was the main challenge they felt the need to address.[35]

As a result, expectations and the Aggregate Supply/Aggregate Demand (AS/AD) mechanism became front and center; the IS-LM model being relegated to a stepping-stone model for the construction of the Aggregate Demand curve. This marks the abandonment of the fixed-price level assumption but also a change in perspective. The aim of first-generation IS-LM model was to follow Keynes by demonstrating the possibility of involuntary unemployment on a given market period. DF pursues another aim, of a dynamic nature, which studies the impact of shocks and the return-to-equilibrium path. It does so by giving importance to the full-employment notion and lack-thereof.[36] Hence, if both the first- and the second-generation of macroeconomics textbooks are centered on a dysfunction of the labor market, its nature and the policy conclusions that are to be derived from its analysis are poles apart. From a mitigated economic liberalism, which assumes that government interventions may result in welfare improvements, it turned to absolute economic liberalism, which assumes that government interventions do more harm than good.

Another second important difference with earlier Keynesian macroeconomics as reflected in textbook like Ackley's relates to the two sub-systems of the IS-LM model. First generation Keynesian economists regarded its Keynesian variant as the good one – that is, the realistic one – and the classical variant as stepping stone for it. For their part, DF also drew a distinction between a Keynesian and a classical model yet deemed them both valid,

[34]Friedman's 1967 Presidential Address was a fierce blow against the earlier held view that policy makers could exploit a tradeoff between inflation and unemployment. The stagflation episode of the 1970s came timely allowing the critics of Keynesian to present it as a real-world laboratory experiment of Friedman's 'predictions'.

[35]When DF were working on the first edition of their book, Lucas had already launched his new vision of macroeconomics, which was more antagonistic to traditional macroeconomics than Friedman's. Yet at the time its future attack its impact on the evolution of macroeconomics was hardly perceived.

[36]Although we did no counting, our surmise is that it might well be the most frequent word used in their book.

their respective relevance depending on the prevailing economic circumstances. Thereby, DF treaded Hicks's footsteps when writing that Keynesian theory was the Economics of recession.

The final difference, which has been discussed in the previous sections is the pivotal role played by the short-/long run distinction. A notion that was absent in first-generation textbooks.

Note that, more recent second-generation AS-AD textbooks have taking up the path opened by Dornbusch and Fisher (1979), while refining their core model. For instance, Blanchard (1996) adds a more comprehensive model of the labor market (WS-PS model) and Mankiw (1991) provides alternative justifications for the shape of the Aggregate Supply.[37]

### The transition from second- to third-generation

The evolution of AS-AD textbooks through the last decades is twofold. First, while first- and second-generation textbooks were giving little attention to growth theory, current macroeconomics textbooks give it a much bigger attention. Nowadays, most textbooks aim at providing with a balanced discussion of both business fluctuations and growth. This change is not clear cut, it has been looming in the back for quite a long time now. Second, textbooks move from a monetarist AS/AD to the a 3-equations AS/AD modeling. This change is more recent and more consequential, up to the point that it marks the advent of a third-generation of AS-AD textbooks.

The basic change is that the Aggregate Demand curve now describes the behavior of the central bank. The AD curve is still determined but is now defined as deviation from equilibrium arising when the nominal interest rate differs from the equilibrium one. These differences are rooted in seminal papers, such asRomer (2000); Taylor (2000).

Looking at the AS and AD curve in second-generation textbooks (DF 1979) and in third-generation textbooks (Jones 2008), they have totally different meanings. Their constructions are clearly different. But it is the same graph and the same reasoning pointing to the mechanism of return to equilibrium understood as a state of rest equilibrium. They use alternative concepts geared at explaining the same idea that shocks to the economy generate temporary departures form the equilibrium output/inflation rate of the economy.

[37] A more formal comparison of these textbooks, along with Krugman and Wells (2006); Burda and Wyplosz (1993), does not lead to the identification of substantial differences.

#### A unified methodological framework

The transition from first- to second-generation textbooks testifies of the effect of Friedman's and monetarists' ideas on Keynesian macroeconomics. Likewise, the transition from second- to third-generation textbooks testifies of the changing perception of the role of central banking among economists: from a disruptive object that has only negative effects on the economy, it turns out to be the accelerator/key element ensuring the return to equilibrium. These innovations correspond to changes in ideology, not in methodology.

Moreover, if we recognise that there is an important degree of heterogeneity among AS-AD textbooks, the differences relates to secondary methodological choices. Instead, in this project, we care at identifying the deeply rooted criteria, that is first-order methodological choices, that form the contrast between core models. When asking ourselves whether the changes observed in new textbooks moved the framework away from the bifurcations we have ascribed to the AS/AD model? We cannot find a different answer than a clear 'No'. The transformation that occurred remains well within the bounds of the AS/AD modeling strategy.

### 4.9.5 The issue with RBC textbooks

The preceding sections suggest that, because IS-LM/AS-AD textbooks build on an equilibrium concept that is unfit for the study of business cycle, they should be discarded from the teaching of macroeconomics and be replaced by RBC textbooks which build on a more suitable equilibrium concept. As discussed in Chapter 3, only three textbooks were identified as RBC textbooks – i.e. the ones of R. Barro, S. Williamson and S. Chugh. All together, they represent only a small fraction of the textbooks that are available on the market and that are actually used in the teaching of undergraduate macroeconomics. We explain this state of affairs by the tension between two goals: internal consistency and external validity. In the case of RBC textbooks, the balance is strongly skewed towards internal consistency, therefore making the story behind these textbooks very unrealistic. This section aims at deepening the discussion.

#### The constituting elements of the RBC baseline model

We characterize RBC modeling in a twofold way:

1. Its object of analysis is business fluctuations regarded as departures from the growth path caused by exogenous shocks. The study of growth and business fluctuations are grounded on a single model, the Solow model.

2. Its baseline model has for object an array of self-employed agent living in autarchy.

Only point 2 needs to be expatiated.

**Definition of an economy** Economists hardly bother defining the concept of economy. For the purpose of the present discussion, it is worth clarifying it. The first step to be taken is to regard the economy as a characterization of the production/allocation dimension of a society. This is the viewpoint taken by classical economists. The society and the economy are supposed to cover the same scope. Against this background, we propose the following definition: an economy is an institutional set-up allowing the members of a given society to consume goods and services that they have not directly produced. Thus, an economy is a set-up in which exchanges take place, what it turns implies that it is composed of heterogeneous agents and/or heterogenous goods and services. The study of an economy is the purview of general equilibrium analysis and of macroeconomics since the latter is a simplified way of doing it.

General equilibrium analysis can be led in different ways according to the methodological choices that are made. They concern, for instance, the choice between (a) a centralized or a decentralized allocation of activities, resources and goods;[38] (b) a single market-period analysis or an intertemporal analysis; (c) a barter or a monetary economy; (d) an exchange or a production economy etc. At this stage, it is not the ambition to go through all these choices, we rather make few remarks that allows us to better characterize the baseline choices made by the founders of the RBC modeling.

The ambition sets out by Lucas in its famous Critique of Keynesian macroeconomics was to start the analysis of an economy by the study of individual decision-making, this being a stepping-stone for the further study of interactions across agents. Patinkin captures this idea by making a distinction between the 'individual experiment', pertaining to the agents defining their optimizing plan, and the 'market experiment' dealing with their plans being made compatible (Patinkin 1965: 11-12; 387-392). This conception is to be confronted to an alternative: the possibility to study the decision-making process of agents supposedly living in autarchy – the Robinson Crusoe character being invoked[39] – in which the individual experiment has no longer a reason to be the preamble of a market experiment.

[38]This amounts at studying a planning or a market economy. Walras's baseline model in his *Elements* and Lucas' model in his 1972 article study a competitive economy. In comparison, Kydland and Prescott put forward, in their 1982 paper, the idea that it would be advantageous to pursue the study of a planning economy. In the end, this will be the path followed by the entire DGE program.

[39]A better analogy is to think of hermits – individuals, who have decided to drop out from social life to live forever in confinement. In this thought experiment, these hermits are assumed to be rational, to be able to plan their consumption/leisure equilibrium path, and to have a good grasp of the technology constraint and states of nature they face.

Altogether, studying Robinson Crusoe's economic behavior is just a *curiosum*. It hardly fits our definition of an economy. Yet, it turns out to be relevant for our inquiry.

**The RBC baseline model** Many expositions of the RBC baseline models are available. King, Plosser and Rebelo (1988) was an early one, and we will refer to it. However, rather than exposing the entire model (which entreprise would require a long exposé), we point out and comment few key elements of it.

King et al. (1988) write, "We consider an economy populated by many identical infinitely-lived individuals with preferences over goods and leisure ..." (1988: 198). The fact that many agents populate the model is not a sufficient condition for it being concerned with an economy. What is needed is that they trade different goods. A route that they decided not to follow.[40]

Later, they also state that their model "focuses on the optimal quantities chosen by a social planner or representative agent directly operating the technology of the economy" (1988: 200). This statement is ambiguous for two reasons. First, King's et al. (1988) reference to the representative agent is misplaced. This notion was introduced by Marshall in order to deal with the fact that firms are heterogenous. Yet, in the RBC baseline model, agents are identical. Hence there is no need for averaging them. Theorists may pick any agent as their object of study, the result obtained will be valid for the whole set of them. By Occam's razor, there must be only one agent in the economy! Second, in a planning economy, the planner dictates to the participants in the economy what they must produce and consume, which implies that the planner and the agents are different actors. In the RBC baseline model, the planner and the agent are one and the same person!

In the end, this model studies an hermits who, on top of enjoying leisure, consumes only what she has produced and produces only what she consumes.[41] In other words, the RBC baseline model is nothing more than a 'disguised' Robinson Crusoe's story. And despite of all the efforts to wrap it up with a sense of reality, the model cannot hide the fact that there is no trade,[42] and hence that it does not depict a fully-fetched economy.

At first sight, taking such a model as starting for a theory aiming at explaining business fluctuations on real-world economies cannot but look preposterous.[43] In order to render the model more realistic, new features were added to the baseline RBC model. These

[40]Notice that the RBC baseline model contains a single physical good contrary to what King et al. (1988) write in the above quotation. We all understand that this single good is a proxy for a large bundle of goods, yet, when writing what they do, they depart from a literally description of the model.

[41]Declaring that people barter with themselves is playing with words. It amounts to confusing allocation of time and exchange.

[42]Hence the off-made criticism that RBC modeling is off the mark because resting on a representative agent is misdirected. Properly stated, it should bear on the absence of trade!

[43]However, this state of affairs was not a sufficient reason for dismissing RBC modeling if we accept that research line must assessed on the validation standards defined by its founders: its ability (a)

improvements consisted in integrating new stylized facts, adding new shocks (as for ex. government spending shocks) and new relations and variables (adjustment costs in investment, variable capital utilization, etc.). More recently, New-Keynesian models emerged following the integration of two key Keynesian ingredients: imperfect competition with the Dixit-Stiglitz aggregator and sluggishness with Calvo-Pricing.At this point, and because these two elements introduced inertia in inflation and output, macroeconomists could switch their attention back to the real effect of monetary shocks and the central bank could reentered the picture.

It remains that what is described in DSGE models is in the end a world of simile. The introduction of the elements just described make the model resemble more to real-world economies. Yet, leaving aside cutting-edge research on heterogeneity, no change has occurred as far as decision-making is concerned. The decision-maker remains a single household. The condition for equilibrium is still capsulated in an Euler equation acting as a decision-rule for a so-called representative agent. The parsimony of the RBC baseline model is now lost but the ambiguity in the narrative accompanying the model remains present in cutting hedge DSGE models.[44]

### The three RBC textbooks

These preliminary remarks established, we continue with the study of our three RBC textbooks, starting with Williamson's and Chugh's and finishing with Barro's.

**Williamson's and Chugh's textbooks - the necessity to adopt a second-degree narrative** The drawback of general equilibrium analysis is that it requires a high level of abstraction. Stripping away as much as possible most features of real-world economies notwithstanding their central importance is *sine qua non* for succeeding in constructing a general equilibrium model (in the same way as climbers must limit what they carry to the strict minimum). Thus, what impedes general equilibrium to any claim at realism is that it is general equilibrium analysis!

To circumvent the issue, the DGE program started from a (very) simple framework – The Robinson Crusoe's model – on which they apposed an interpretation that goes beyond

to replicate and predict real-time data and (b) to give rise to subsequent development. The further transformation of the RBC model into an entire research program which is still, 40 years later, at the headway of macroeconomics research testifies that they were not wrong.

[44]We thus witness a kind of disordered growth. The obstacle that logically should be sold from the start – the absence of heterogeneity – has been left untouched with the attention focused on developments that, strictly speaking, make sense only after heterogeneity has been established (i.e. the main role justifying the existence of money is that it is a mean of exchange. Hence, the need of differentiated goods! Why are we introducing a Central Bank and sticky prices if we do not introduce any reason for them to exist in the first place?!...).

what the model is able to capture. What we claim here is that there are two levels of interpretations: a literal one, which we call the first-degree narrative, and a more liberal one, the second-degree narrative, that aims at relating the model to the basic ingredients that form an economy.

In general, there is no reason for making a fuss about this narrative drift, especially when concerning research. But the matter is different when it comes to the subject of our inquiry, textbooks. The second-degree narrative would be innocuous were it not that it renders the distinction between the model and reality blurry, hiding the assumptions pertaining to the theoretical model and creating overlaps with reality which barely hold.

Hence, the second-degree narrative line may give a wrong image of the priorities of RBC modeling. It emphasizes the hours worked/consumption trade-off, the firm/worker relationship, and hence may evolve giving it a central place in the theoretical discussion. This picture hardly fits the practice of RBC modeling, especially in the first decades of its existence. In RBC models, the labor market is conspicuous for its absence. It is all about self-employed agents. Whenever the 'employment' word is to be found in these models, it means total hours worked, no reference being made to the employed/unemployment split.

Therefore, it does not appear incongruent that RBC textbooks, such as Williamson's and Chugh's, prefers to hide the incongruities of their model behind the second-degree narrative. Nevertheless, this disconnection between the model and the reality, between the first- and second-degree narrative is usually well perceived by undergraduate students who are not keen to adopt harsh methodological choices, even when they proved to be powerful research instruments. Therefore, these textbooks can only be seen as falling short in meeting students' aspiration to decipher the workings of real-world present-day economies, which implies addressing issues such as the existence of business cycles, unemployment, inflation, and the role of government.

**Barro's textbook - an alternative to the baseline RBC model** In an attempt to provide foundations for the existence of trade in his baseline model, Barro follows closely Peter Diamond when devising his coconut model (Diamond, 1982). Therein, Diamond assumes that a taboo existed forbidding agents to consume the coconuts they picked.[45] As a result, trade is present in spite of the fact that agents are self-employed and produce

[45]It is common in theoretical economics to use a tropical island metaphor to describe the workings of a model. The island described here has many individuals, not one. When unemployed they stroll along the beaches examining palm trees. Some trees have cocoanuts. All bunches have the same number of nuts, but differ in their heights above the ground. Having spotted a bunch the individual decides whether to climb the tree. There is a taboo against eating nuts one has picked oneself. Having climbed a tree, the worker goes searching for a trade - nuts for nuts - which will result in consumption. This represents, artificially, the realistic aspect of the small extent of consumption of one's own production in modem economies. (P. Diamond 1982: 17).

the same good. Despite its high degree of abstractness, Diamond's idea is simple and easy to reproduce. Hence, Barro decided to introduce the same taboo as early as in the first edition of the first version of his textbook. He writes:

> In the theoretical model, we want to capture the feature that individuals consume little of what they produce. To keep things workable it is convenient to go to the extreme and assume that producers sell their entire output on a market where people buy and sell commodities. Then sellers use their proceeds to buy other goods for consumption purposes." (Barro 1987: 58)

Similar statements can be find in Barro's 2008 and 2017 versions of his textbook, where Barro extends the taboo notion to labor and capital service markets.[46]

If this modelling choice enables Barro to introduce trade and therefore markets in his modelled economy, it also makes clear that models are parables that should not be understood in any realistic way. Somebody like Lucas might have been ready to accept such a standpoint but undergraduate students would probably have some difficulties to appreciate the modelling choices. Indeed, by introducing trade as a result of the assumption that households cannot consume their own production, use their own labor or their own capital, Barro makes a 'coup de force'. His attempt at justifying these assumptions as extreme representations of what exist in reality cannot hide that they are utterly *ad hoc*. In the end, Barro's economy is nothing more than an artefact, and most of the students understand it.

### 4.9.6 To sum up

Figure 4.4 below provides a general picture of the evolution of macroeconomics textbooks since the advent of macroeconomic theory in the 1930s. It summaries the discussion above and points out to three key elements.

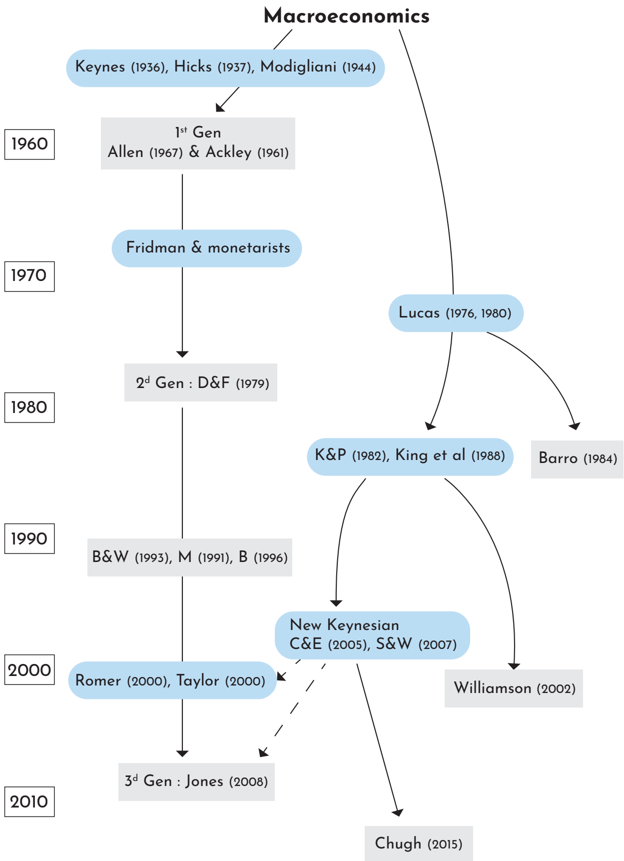
1. Macroeconomics history can be divided in two phases: Keynesian macroeconomics and DGE macroeconomics. The separation of which is based on a methodological revolution kicked off by Lucas. These two phases also led to the development of two separated groups of undergraduate intermediate macroeconomics textbooks.
2. The AS-AD model survived its disappearance from academic research through Keynesian textbooks, the evolution of which pursued by incorporating the change in

[46]"We shall find it convenient to assume that each household rents out all of the capital that it owns on a rental market. [...] the important assumption in our model is that households do not allow any of their capital to sit idle and, rather, provide all of it for use on the rental market." (Barro et al. 2017: 108)

the vision of the role and purposed of monetary policy gained from New-Keynesian macroeconomics.

3. In comparison to AS-AD textbooks, the development of RBC/DGE textbooks has been very limited. Only three undergraduate textbooks can be related to DGE macroeconomics, one of which being very recent (Chugh 2015). The necessary degree of abstraction, inherent to DGE theory, makes the writing of an undergraduate textbook based on this theory very difficult.

FIGURE 4.4: **The evolution of macroeconomics textbooks**




**Notes**: Arrows indicate a relationship of methodological (and ideological) lineage, dotted arrows additional ideological relationships. Boxes indicate macroeconomics textbooks. Ovals indicate research papers and contributions that lead to new developments in macroeconomic theory.

### 4.9.7 A last reflexive point: the labor market in macroeconomics

Over our study of macroeconomics textbooks, two recurrent questions kept on emerging: (a) what is the role of the labor market? and (b) how are these macroeconomics textbooks taking count of the issue of unemployment? In this section, we review the account of the labor market in the two main groups of macroeconomics textbooks and we end up providing a personal assessment of the identified state of affairs.

#### Keynesian textbooks

As explained, macroeconomics saw the day of light in the aftermath of Keynes's General Theory. His motivation when writing it was to make involuntary unemployment an acceptable notion in Marshallian economics. It remained the overarching aim of Keynesian macroeconomics, to the point that many regarded involuntary unemployment as the very object of inquiry of macroeconomics. Surprisingly, implementing this aim has proven to be a fiendish task. De Vroey (2007, 2016b) argues that the failure of Keynes and Keynesian macroeconomics to produce a robust theoretical explanation of involuntary unemployment was that, except for the trivial assumption of a wage floor, the Marshallian trade technology, based on supply and demand analysis, is bound to generate market clearing results.

As for monetarists and AS-AD textbooks, this feature led to an even more paradoxical state of affairs. Indeed, full employment and the lack thereof are declared to be their main concern.[47] Yet, they hardly enter into the study of the working of the labor market and the nature and causes of unemployment. This can be seen at two levels. First, their definition of the natural rate of unemployment is far fetched and has little theoretical content. Second, the deviations from the natural level and the return to it do not provide any justification for variations in unemployment level (at least in its joblessness sense). Let us explain.

Usually, the definition of the natural rate of unemployment is two-legged. Its first part points to institutional and structural factors.[48] In this line, any reduction of the natural rate of unemployment is deemed a good thing. It operates through labor market policies. The second refers to theory and expresses an equilibrium condition – i.e. when expectations of firms and workers as regard the behavior of prices and wages are correct – with the implication that any departure from the natural rate will generate feed-back effects.

[47]"The unemployment rate is widely watched as an indicator of the performance of the economy and as matter of concern on its own right" (DF 1978: 10).

[48]The factors explaining duration are the organization of the labor market, the demographic makeup, the ability and desire to search for a job, the availability and type of jobs. Frequency depends of the variability of the demand across firms and the rate of entry into the labor force.

This definition of the natural rate can be plugged into theoretical reasoning, yet only as an exogenous variable. This is what they do, the natural level of unemployment is empirical determined (usually as the average unemployment level over many periods) and the figure obtained is forcefully plugged into the model. It then turns that that their central notion, the equilibrium level of employment (or its symmetrical notion the natural rate of unemployment) receives no theoretical grounding. In our view, the transformation of a center of gravity into a statistical average is hardly benign.

When turning to the analysis of the business cycle – or more precisely the deviation from and the return to the natural rate of unemployment –, they discuss heavily the wage and price formations. They write about 'workers' and 'firms'. This suggests that the discussion proceeds in term of a representative agent and a representative firm. This route taken, no unemployment, strictly defined, is possible. Unemployment implies heterogeneity. The employed and the unemployed are in a different position. The question of why some agents are employed and others not must be addressed and modeled. None of the AS-AD textbooks provides a decent explanation. Thus, the adjustment must be occurring exclusively on the intensive margin; so that labor market disequilibrium takes the form of under- or over-employment. In other words, in AS-AD models, unemployment is supposedly existing but the unemployed people are absent from the model.

**RBC textbooks**

With the rational expectations revolution and the ensuing rise of RBC modeling, the scene changed even more dramatically. Not only did the involuntary unemployment and the natural rate of employment notions disappear from the radar but unemployment tout court - and by the same taken the labor market – disappeared. [49] RBC models are all about optimizing self-employed agents. Whenever the 'employment' word is to be found in this literature, it means total hours worked rather than the number of jobs. Since there is no labor market, there is definitely no room for unemployment. This move has hardly been hidden. In his Models of Business Cycles book (Lucas, 1987), Lucas openly vindicated it on the ground of tractability and parsimony. To him, cyclical fluctuations and variations of hours worked were issues that could and should be analyzed assuming market clearing whilst, at least temporarily, being dissociated from the issue of unemployment. He writes:

> "For many other economists, explaining business cycles is taken to mean accounting for recurrent episodes of widespread unemployment. From this alternative viewpoint, a model with cleared markets seems necessarily to miss the

[49] From the beginning, the labor market has been conspicuous for its absence from it. Its later integration was motivated by a desire to explain sluggishness rather than unemployment.

> main point, however successful it may be at accounting for other phenomena, and the work of 'equilibrium' macroeconomists is often criticized as though it were a failed attempt to explain unemployment (which it surely does fail to do) instead of an attempt to explain something else" (Lucas 1987, p. 48).

To all intents and purposes, a majority of macroeconomists accepted his standpoint. Notice worthy, in his 1987 book, Lucas devoted a chapter on the subject of unemployment arguing that the right line to tackle it is the search approach. There is not much going for this judgment, yet it amounts to admitting a methodological disconnection between the study of unemployment and that of business fluctuations.[50]

The above remarks pertain to methodological issues among academics. Yet, an attitude like Lucas's is hard to defend when it comes to public discussions. In the latter, unemployment lies at the center of debates on business fluctuations. Hence authors of textbooks, even if they adopt the RBC line, cannot leave it untouched. Williamson's solution, as well as Barro's, is treading the Lucas's footsteps by addressing unemployment in a separate chapter exposing the search model and/or the efficiency wage model. Therein unemployment is described in realistic terms as joblessness. The questions of the flows in and out of unemployment, the breakdown of unemployment between job losers and job leavers and new entrants, the distribution of unemployment across ages and ethnic groups, the cost of unemployment as compared to that of inflation, are addressed.

**An assessment**

In our understanding, one of the main reasons why macroeconomists have been studying business cycles is that they are costly. Recessions, in particular, are costly as they imply that there are production capacities that are left unexploited, and, from an efficiency perspective, this makes no sense. In this view, unemployment is just a measure, an indicator of the degree of inefficiency of the economy. Hence, if indeed this was there the sole reason to be concerned with unemployment, there would be no reason to make a fuss of the difference between unemployment and underemployment: knowing who is employed and who is not would not matter.

However, in our view, the unemployment rate should be a matter of concern on its own right. Experiencing unemployment is traumatic, as such it bears a cost to the society. But the issue goes way beyond that. As discussed in the introduction, not everyone is facing the same unemployment risks. Especially, we emphasized that low skilled workers are the more exposed. Moreover, we stressed that, since they earn lower wages, these low

[50] Danthine and De Vroey (2017) is a study of earlier attempts at integrating search into RBC modeling.

income earners usually have more difficulties to accumulate enough wealth to self-insure against temporary income losses. Therefore, they see their consumption level varying as much as their income. As discussed in the first two chapters of this thesis, the existence of these households, who hold high marginal propensities to consume, lead to meaningful and costly fluctuations in output. We also emphasized that, because global shocks have distributive impacts, the overall degree of inequality in the economy varies over time and with the business cycle, and we concluded that this matters from a policy point of view.

Hence, it is necessary to model unemployment from the beginning. To that aim, one must introduce some degree of heterogeneity between agents in the model economy. This is surely not an easy task. In this thesis, our analysis bears on the fluctuation in labor income, which are very much linked to the experience of unemployment. Yet, as most macroeconomic theory, we did not formally model the labor market. Doing so would require much more investment in dynamic programming and in tools that are still developing. Be it as it may, we strongly believe that the way forward in research is to introduce sufficient degree of heterogeneity in macroeconomic theory. The kind of heterogeneity that would allow the modeler to introduce both unemployment and trade in genuinely different goods; two essential elements for a thorough study of any economy.

# Chapter 5

# General Conclusion

Arrived at the end of the process of writing this thesis, it seemed important to me to take a step back and put in perspective the three chapters that compose it. At first glance, the first two may seen irremediably different from the last one. Yet, I believe that the latter can shed some interesting light on the former. In this conclusion, I undertake to briefly explain how.

Michel De Vroey (2016) identifies three levels at which 'conversations' about macroeconomics may evolve: 'peer controlled conversations', 'public intellectual conversations' and 'armchair conversations'. In the first type, all 'conversations' are theoretical. They are 'peer-controlled' because they take place in scientific journal, conferences, seminars, etc. whose audience is composed essentially by professional economists. In comparison, the other two levels are not addressed to a professional audience and, therefore, do not undergo any professional control.

He further divides the 'peer-controlled conversations' in three subgroups:

1. The 'production-of-theory conversations' which aim at producing new scientific knowledge
2. The 'meta-theoretical conversations' which aim at commenting on the production of theory. It does not aim at making theory progress but at providing some interesting light on how the theory or the economy has evolved.
3. The 'art-of-policy making conversations' which does not aim at producing theory but at operating the transition from theory to concrete policy decision making.

Because they are concerned with the production of new scientific knowledge, the first two chapters of this thesis are standard pieces for a PhD in economics. To put it briefly, I study how the presence of income and wealth inequality between groups of households affects the way the government should design its fiscal policy. As often in the scientific literature they carry on with policy conclusions – i.e. the government should provide some degree of redistribution and insurance over the business cycle, – which can serve as stepping-stones for an 'art-of-policy making conversation'. They may be used by professional macroeconomists (as forecasters and central bankers) who are seen as experts and whose advice are particularly valued in difficult times. As flattering as this role might be, it should be undertaken cautiously. Indeed, in order to be able to make the transition from top-of-the-art theory to concrete decision making, one should understand the roots and limitations of the theory. In particular, one should understand the nature of the connections between theory and reality the economist had in mind while producing the new theory.

This is exactly the kind of issues that 'meta-theoretical conversations' papers aim at tackling. It is also the main concern of the third chapter of the thesis, which convey that the relationship between theory and reality is actually one of the key methodological traits that trace the distinction between two main classes of models in macroeconomics: IS-LM/AS-AD models and RBC/DSGE models. In the former, external validity prevails and comes at the expense of a serious consideration for internal consistency. That is, the main concern of IS-LM/AS-AD models is to provide a framework to interpret and act on real-world economic events. In contrast, RBC type of models give priority to internal consistency over external validity, which makes them somewhat unrealistic.

Building on these meta-theoretical discussions, this conclusion aims (i) at deepening slightly the discussion on the connections between theory and reality, (ii) at showing how these connections affect policy recommendations, and (iii) at putting the results of the first two chapters into perspective.

*The theory-reality relationship*[1]

It can be pondered on but most economists adhere to the methodological principles spelled out by Friedman in his famous article entitled "Methodology of Positive Economics" (1953). Basically, in this paper, Friedman states that the construction and the validation of theoretical propositions must be grounded on empirical analysis.

In a nutshell, this conception of the theory-reality relationship assumes that there exits a systematic structure underlying the economic reality, and that theory is just a set of

[1] This section and the following one are summarises of a larger reflection that aims at comparing the different visions of Marshall, Walras and Lucas regarding the relationship between theory and reality and their consequent implications for the use in reality of theoretically constructed policy conclusions.

beliefs about this structure.[2] Models, on their side, are formal demonstrations of the theory. Therefore, they are seen as a structure of similarities, idealizations (or close fictions) of reality. That is, models aim at representing the world. However, because the world is too complex to be represented completely, models cannot but integrate some features that seem to misrepresent the world.[3] Yet, these misrepresentations should be as small as possible.

Theory – and by extension a model – is about reality. Therefore, there must be a direct correspondence between what the model is concerned about and what can be measured. Hence, the outcome of the model can, and actually must, be confronted to the data. This is a crucial feature since this confrontation serves as a validation, a confirmation of the theory. Taking this stance, economists simply consider models as *approximations* of the reality.

*Policy recommendations in economics*

Adopting this vision of the relationship between theory and reality entails some consequences. One of them relates to the ability to use theory/models to produce policy recommendations. Actually, when a model is deemed to be a valid approximation of the reality – that is when they accurately capture the relevant features of the data up to a level of precision that has been set in advance, – it could be argued that there is a good probability that the alternative and better policy in theory would also be better off in reality. Indeed, because there is, by assumption, a close correspondence between the model and the reality, theoretical propositions that pertain to the modelled economy must also hold for the reality. Hence, taken literally, the idea that models are approximations implies that their policy conclusions can be extended to the reality.

However, at least two arguments pledge against the simple applications of models recommendations. First, no model can come close enough to the complexity of the economy.[4] Second, the economy changes over time and models cannot catch up closely enough with these changes. Consequently, the transition from theory to concrete policy decision making is (and will remain) an art which should be handled cautiously.

[2] Because, by nature, the theoretical understanding of the economy is uncertain, the beliefs the economist holds about the reality can be modified and adapted as new facts accumulate.

[3] The models used in this thesis make many simplification assumptions. The main ones concern the number of households groups, the functioning of the labor market and the number of assets to which households have access. These assumptions are made for tractability reasons.

[4] This claim has been particularly vigorous since the 2008-2009 financial crisis, when some leading figures in macroeconomic policy debates – among others, Krugman (2016), Romer (2013, 2016), Blanchard (2018), Stiglitz (2018) – started to raise questions about the state of macroeconomic theory. Broadly speaking their criticisms can be summarized as follows: the rational expectations, perfect information and infinitively-lived agent assumptions cannot be valid microfoundations because of their lack of realism. The answers to these criticisms consisted, in most cases, in providing 'stronger' microfoundations and in enlarging models (i) by adding a detailed financial block, (ii) by introducing learning and limited-information, or (iii) by bringing in household heterogeneity.

Nevertheless, macroeconomic models are indeed used in the policy-making process. This is because any policy conclusion necessarily rests on the prediction of the consequences of doing something instead of another. In this sense, models, like the ones developed in this thesis, are very helpful. However, these models cannot be the sole – not even the main – instrument on which policymakers found their decision. The only way to do policy-making is to carefully study the functioning of the economy, both from a positive and a normative perspective, while keeping in mind that model conclusions are always embedded in the hypothesis on which the theory rests. Therefore, macroeconomic policies (be they fiscal or monetary policies) must rest on the understanding of (the limits of) the mechanisms that underpin the policy conclusions of a model rather than on the conclusion themselves.

*The policy conclusions of the first two chapters*

My work in the first two chapters has been a mixture of both positive and normative analysis. By digging in US fiscal data and in consumption and population surveys, by estimating a model that has been constructed to match the US economy, I have been trying to understand further how the US economy is actually working. Then, based on these findings, I have been studying the design of the optimal fiscal policy. That is, I aimed at finding the behaviour of the labor tax rate and transfers that would maximize the welfare of an economy.

When presenting this work in seminars and conferences, one of the main questions raised was: According to your model, what should the US government do? From chapters 1 and 2, it could be said that:

1. The US government should institutionalize wealth redistribution across household groups. In other words, it should implement a policy that aims at minimizing the average level of income inequality.
2. Over the business cycle, the US government should set taxes and transfers as to counterbalance increases and decreases in income inequality and as to follow closely changes in relative productivity.
3. Moreover, it should do so in a way that minimizes the financing costs, i.e. by minimizing the fluctuations of the labor tax rate.

These conclusions rest on basic assumptions and modeling choices regarding the labor market, the available fiscal instruments for the government, the type of assets to which all agents (households and the government) have access to, the social welfare function under which the government derives its policy, etc. Many of these modeling decisions were made as to render the models tractable. They are meant to be lifted as theory, mathematics and technology (hardware and software) ‘progress’. Hence, these briefly summarized conclusions may evolve with time, as knowledge and technical advancement accumulates. That is why, despite their consistency across different theoretical settings, they cannot be simply taken up by policy makers. Yet, this does not mean that these models and these conclusions are useless in practice. Economists who understand the limitations of the models and the implications of the assumptions made may see some relevance in them, and might therefore produce policy recommendations that are making sense. This is my ambition for the way forward.

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