Essays on Financial Economics and Policy Modeling

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Essays on Financial Economics & Policy Modeling

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General Introduction

0.1 Overview and Objectives

Any macroeconomic impact is a result of trade-offs between forces in the economy. Examples of trade-offs are: Does wage flexibility in crises increase employment and help mitigate recessions or does it decrease demands and increase the severity of recessions? Is the higher oil price good or bad for the world economy? These questions and similar dilemmas could be answered only by considering the specifications of each economy [1]. A good macroeconomic model not only considers the significant forces and characteristics of an economy, but also is able to draw a clear forecast for the future of the economy.

By giving special attention to economic policy making, this thesis in 5 chapters studies, theoretically and empirically, the propagation mechanisms governing business cycles, in particular the role of financial sector, housing and credit markets. To do so, DSGE framework remains a core to modeling, estimating, simulating and analyzing in this thesis. This study concerns different types of agents and focuses on the implications of various policies on price fluctuations, housing, the behavior of non-financial firms, households, governments and in turn, their impacts on real macroeconomic performance. The aim is twofold. First, contributing to the literature for enhancing our ability to define, measure, and manage activities that pose risks to the macroeconomy as a whole. Second, defining financial and public policies which mitigate the volatility of the system and insulate individual well-being. In addition, models are calibrated to correspond with various examples of advanced and developing economies. These examples help diagnose the problems and assess the functionality of the models.

The first three chapters of this thesis focus on advanced economies with the example of

1. These specifications includes defining interconnections between agents and calibrations. In the language of DSGE, the calibration is delineated by giving value to parameters related to deeper structural parameters describing household preferences, technological and institutional constraints, etc.

the US economy in three periods, respectively: the economic climate before the Great Recession, the systemic collapse on 2008, and the recovery time after the crisis. The two last chapters of this thesis answer policy questions about developing economies with examples of Iran and Morocco. The key questions of each chapter are as follows;

i) The key question of the first chapter is a policy question related to the origin of the recent crisis: What are macroeconomic consequences, if in the presence of the housing and credit markets, borrowers default on their obligations to financial intermediary agents i.e. if banks accumulate Non Performing Loans (NPLs)?

ii) The main question of the second chapter is how the housing and credit markets can exacerbate disasters on shadow financial institutions in times of recession, in which situation the financial institution can collapse and how this collapse impacts on recovery?

iii) The third chapter's core question is about finding the proper housing and mortgage fiscal policies. These policies should have lower fiscal multipliers and welfare losses. This chapter also studies the tax revenue neutral reforms.

iv) The fourth chapter's key question is how does the financial sector of oil-exporting developing countries react against oil price fluctuations. The relationship between macroeconomic aggregates and the financial sector as well as channels through which the business cycle and the financial cycle in oil economies interacts are the subject of this study.

v) The last chapter of the thesis answers a policy question about the optimal fiscal reform in non-oil developing countries with a big informal sector [2].

Purely empirical models quantitatively discover statistical characterizations of the data. This would be useful only if the model is well designed to account for economic structures that conduct data processes. On the order hand, stylized theoretical models

2. This research is contributed to the IMF's Article IV consultation of Morocco 2017. See IMF Country Report No. 18/76 https://www.tralac.org/images/docs/12847/morocco-selected-issues-paper-imf-country-report-no-18-76-march-2018.pdf

might provide a rich theoretical structure but they are usually silent in accommodating observed behavior. A policy maker requires tools which has both strengths: the conformation to the data and the ability to discover the causal relations behind the data. To do so, DSGE models follow the complexity of the modern economy and have become more adaptable with a variety of variables. This "complexity to accuracy" is imperative from the modern socio-economic perspective: any business cycle has fallouts by changing GDP, unemployment and growth. So policy makers are responsible for choosing the best models for insulating well-being of people.

Imposing any complexity to an economic model cannot be preformed only in an ad-hoc manner [3], without referring to the reality and microfoundations. In this view, another favorable characteristic of DSGE framework is its attempt to build a macro model based on microfoundations. This means that micro and macro-economics cooperate to achieve the results. The attempt for building macro models taking microfoundations has two periods in the recent economic history. The first attempt was real business cycle (RBC) theory [4]. The second attempt tries to meet micro and macro-economics by defining market imperfections in different forms, principally by introducing imperfect competition in goods, labor, asset, financial and credit [5] markets, as well as by nominal or real rigidities. Two good examples of this new neoclassical approach with Keynesian elements are Smets and Wouters (2003) and

3. For the discussion about why the models only based on microeconomic fundamentals are not enough for economic analyses, please see Chumacero and Schmidt-Hebbel (2004):"*A major disadvantage of many empirical structural models based only on microeconomic fundamentals – reflected in a sparse specification that avoids ad hoc variable inclusion – is their poor tracking of short-run dynamics and unsatisfactory short-term predictive ability. This (and Sims 1980 critique of large-scale macroeconometric models) has led to the development of non- (and semi-) structural vector autoregression models (VARs), based on statistically observed dynamic relations among a small number of key macroeconomic variables. VARs are popularly used for generating impulse responses to temporary shocks, variance decompositions, and short-term projections, but because they lack behavioral structure, they are not useful for understanding structural relations, generating long-term projections, or simulating permanent changes in predetermined variables. Hence, VARs are empirically useful but not more than complementary tools to structural general equilibrium models for empirical analysis*".

4. Competitive equilibrium models and their microfoundations has the crucial rule in framing RBC models. See Dosi et al. (2009). On RBC, also see the seminal work Kydland and Prescott (1982). The older examples of general equilibrium models are Lucas Jr (1972), Lucas and Lucas (1987) and Lucas Jr (1978).

5. Theses models allow for borrowing and lending in equilibrium. For example, see Rotemberg (1987), Benanke and Gertler (1989) and Carlstrom and Fuerst (1997).

Laxton and Pesenti (2003).

Both RBC and New Keynesian models are studied in this thesis. Financial sector and rigidities are as core in these analyses. The findings of the thesis illustrate that DSGE models which are enriched by financial factors better match the data, therefore they are more reliable for forecasting and policy making.

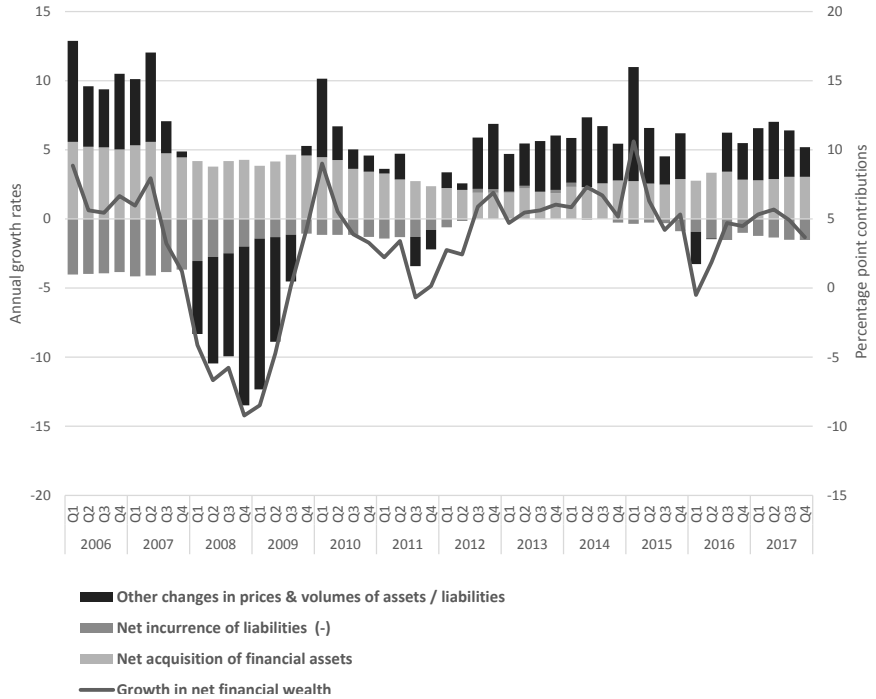

Figure 1 – Changes in household financial assets, liabilities and net financial wealth in the euro area. Source: ECB

The financial sector- which we can call financial intermediary or bank- is at the center of the modern economy. For example, the theory of credit rationing is tied to the banking theory [6] or the existence of central banks without financial sector cannot be assumed. Figure 1 depicts the decomposition of wealth in the Euro area between 2006-2017. The figure clearly indicates the importance of financial assets and financial activities, especially in the time of the recent crisis. The 2008 crisis massively changed

6. There is an expansive literature on the connection between credit and the macroeconomy. For example, Gilchrist et al. (2009),Nolan and Thoenissen (2009), Faust et al. (2013), and Gilchrist and Zakrajšek (2012).

the modeling of financial sector and frictions in the literature.

Chapter one and three of this thesis adopt the banking model of the seminal work of Iacoviello (2015). This kind of financial modeling belongs to an expansive literature which deals with a bank as an agent who performs financial intermediary activities between savers and borrowers. For a brief list of this literature, one can refer to Brunnermeier and Sannikov (2014), Kollmann et al. (2011) and Meh and Moran (2010). The banking modeling of chapter one and three differs in two parts. First, their bank's balance sheet are different. In chapter one the bank asset side is composed of two assets: mortgage and government bonds. While in chapter three mortgages are the only assets of banks. Second, the capital adequacy constraints differs in the two chapters. In chapter three, the banking system must satisfy banking regulations every period i.e. the bank equity must exceed a fraction of bank assets in any moment of the simulation. This constraint is modified in chapter one to allow for a partial adjustment in bank capital. This partial adjustment gives a degree of freedom to the banking sector to modestly recapitalize and meet banking regulations. This freedom is close to the microfoundations of banks' activities.

Chapter two focuses on shadow banks [7]. The model of chapter two improves a very recent model of shadow banking sector built and developed [8] by the influential work of Gertler and Kiyotaki (2015). In the model, shadow banks issue short-term debt to finance mortgage and loan demands by households and firms, respectively. As a result, the bank's assets are long-term assets while the liabilities are short-term (one-period). The different maturity time between assets and liabilities makes banks vulnerable to shocks.

Chapter four focuses on the impact of oil price fluctuations on interconnections of the financial sector. The model of chapter four sets up a New-Keynesian model that

7. "*Shadow banks are financial entities other than regulated depository institutions (commercial banks, thrifts, and credit unions) that serve as intermediaries to channel savings into investment. Securitization vehicles, ABCP vehicles, money market funds, investment banks, mortgage companies, and a variety of other entities are part of the shadow banking system. Before the crisis, the shadow banking system had come to play a major role in global finance; with hindsight, we can see that shadow banking was also the source of some key vulnerabilities*",Bair (2010).

8. See Gertler et al. (2016a) and Gertler et al. (2016b).

features a heterogenous financial sector with the presence of the central bank. The financial agents are either a borrowing (deposit) bank or a lending bank. These two types interact on an inter-bank market. Borrowing banks collect deposit from households and lend it to the lending banks at the interbank rate. Lending banks, then, mix up inter-bank loans with their own net worth and liquidity from the central bank to finance loans to firms and buy government bonds. This kind of modeling financial sector is standard and vastly used in the literature e.g. Dib (2010), De Walque et al. (2010), Gerali et al. (2010).

The fifth chapter, in its empirical section, emphasizes that an efficient financial sector remarkably helps economic development. A well designed banking system stimulates saving and investments by mobilizing savings and assigns them to productive enterprises. This removes the deficiency of capital in the economy and results in a progressive distribution, effective investments, decreasing informality and consequently, a direct positive impact on growth.

Before the crisis, most efforts had been made to study the dynamics of the main macroeconomic variables and not the relation between financial and credit markets, and the real economy. For example, Stiglitz and Greenwald (2003) build a model in which financial sector- i.e. banks- acts as a firm. Banks combine their own net worth with capital from other sectors to issue loans. So banks are subject to equity and regulatory constraints. Nevertheless financial frictions are the missing points in such paper. On the other hand, seminal works such as Bernanke et al. (1999), Bernanke and Gertler (2000), Gilchrist and Leahy (2002) and Iacoviello (2005) introduce financial frictions and credit transactions in economic models through the market but they ignored an independent financial sector.

The absence of financial intermediaries causes that credit-supply effects are ignored. As a result, financial frictions are considered only on the borrowers' side of credit markets. The absence of financial mechanisms in pre-crisis models has a rational reason; there was a public belief at that moment about the financial sector: financial

shocks cannot have a major effects on aggregate economic activity. This opinion was driven from the economic history and pre-crisis literature in which, the financial sector does not significantly modify the responding mechanism to the shock [9]. In addition, economists were sure about the stability of financial systems for the reason of deposit insurance; conventional wisdom had it that deposit insurance makes the financial system impossible to run [10].

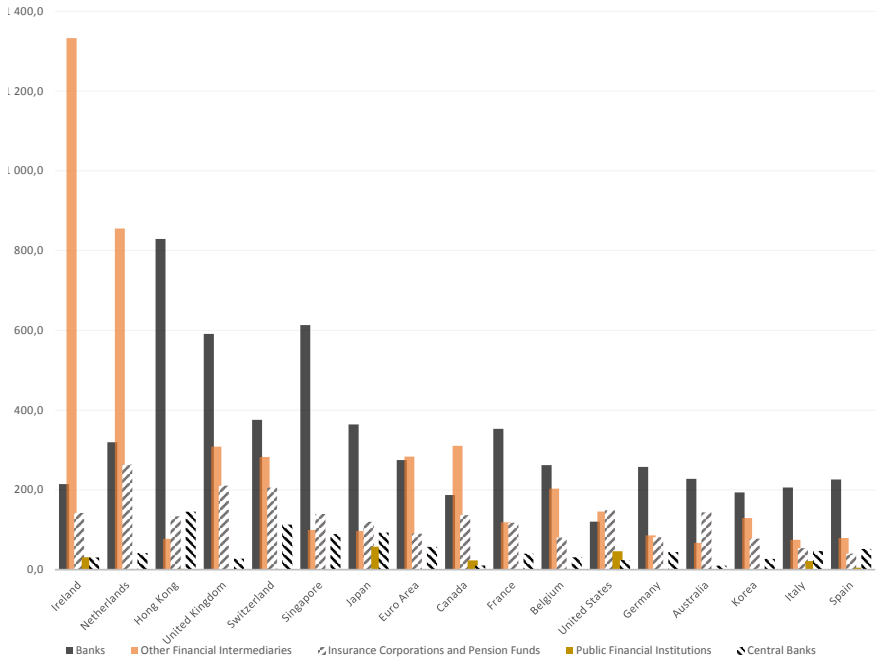

Figure 2 – Composition of financial systems per GDP (%), Advanced economies (End of 2016). Source: FSB Global Shadow Banking Monitoring Report 2016.

Figure 2 presents the composition of financial systems per GDP at the end of 2016 for Advanced economies [11]. The figure depicts that the size of the financial sector in advanced economies stood at above twice GDP. For example, the total financial sector for France and Euro area are about 6.29 and 7.06 times of GDP, respectively. This confirms the crucial role of the financial sector in economic modeling. By

9. For example see Lindé et al. (2016)

10. See Diamond and Dybvig (2000) and Cooper and Ross (2002). Even at that time there were some research which indicates different opinion. For instance, Demirgüç-Kunt and Detragiache (2002) show that deposit insurance cannot fully save the financial system from banking crises and somehow it might increase the probability of a crisis.

11. To keep the figure clear, Luxembourg and Cayman Islands are excluded from the figure. The volume of banks and OFIs for Cayman Islands are 34171% and 211,844% of GDP, respectively. These are 1414% and 24674% of GDP for Luxembourg.

neglecting the financial sector, models miss crucial channels. Ignoring financial sector as a failure, was revealed and resolved in the aftermath of the financial crisis. In this tiem, many empirical researches emphasized the role of shifts in credit supply in amplifying the business cycle and macroeconomic fluctuations [12]. As a result, theoretical papers have included financial intermediaries in economic models. This links financial factors to macroconomic fluctuations. Here, I mention a non-exhaustive list of a few influential studies such as Gertler et al. (2010), Curdia and Woodford (2010), Del Negro et al. (2010), Dib (2010), Angeloni and Faia (2013), Christiano et al. (2014), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014) and Christiano et al. (2016).

Financial frictions are another important subject of this thesis and recent DSGE models. Critics e.g. Stiglitz (2018) argues that the pre-crisis DSGE models were not equipped with essential elements of a complex economy such as financial frictions, liquidity constrained consumers and credit rationing. As a result, the models were not able to predict the crisis or to provide accurate policy recommendation to resolve related issues. The critics, then, doubt the ability of the DSGE model to predict and recommend an efficient policy in the context of other deep downturns. The answer to this critique is what has been already mentioned in the paragraph above and also partly mentioned in the critics' arguments: the absence of a financial sector with proper financial frictions made pre-crisis DSGE models unable to predict the crisis which was based on housing bubble and financial issues. Pre-crisis DSGE models did not fail to predict the 2008 crisis because of their approach, they failed because of the crucial elements missing from their models. As an example, Christiano et al. (2017) indicate that the failure of DSGE models to forecast the 2008 crisis was a consequence of a mistake in modeling the financial sector by missing shadow banking system which is not subject to deposit insurance [13].

Another important objective of this thesis is to illuminate the fundamental

12. See Adrian and Shin (2010), Ciccarelli et al. (2015) and Gilchrist et al. (2009).

13. The significant role of shadow banking sector in the recent crisis is generally confirmed by the economics community, for instance see Bernanke (2010), Gertler (2017) and Pozsar (2008).

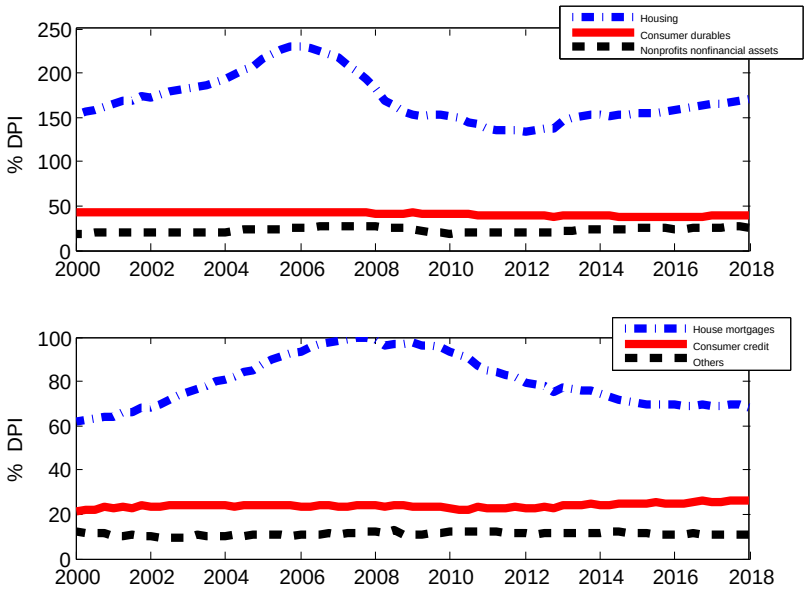

Figure 3 – Non-financial Assets for the US (top), Liabilities (Below). Source: Balance Sheet of Households and Nonprofit Organizations, Board of governors of the federal reserve system

involvement of housing market in supply and demand, housing behavior, housing wealth effect and finally, the role of housing on triggering business cycles. As discussed earlier, all chapters of this thesis allow DSGE models for some sort of financial factors including financial frictions, financial liquidity constraints, capital constraints and collateral constraints which are attached to housing market. The interest of macroeconomic models in housing market, as a field out of real estate economics, is new. The literature on housing starts by Iacoviello (2005), years before 2008 housing crisis, when economists underestimated housing market contributions in economics and considered it to have no impact on the real economy. The recent housing turmoil, which nobody had expected, showed that there are mechanisms in housing market which are crucial in macroeconomic fluctuations. Figure 3 presents the components of non-financial assets as well as that of liabilities in the balance sheet of households and non-profitable organizations of the US. Both charts clearly indicate that housing has the main share in both sides of the balance sheet. As a result, housing has become an important key in designing policy decisions and many researches ratify the

association of housing market and the real economy [14].

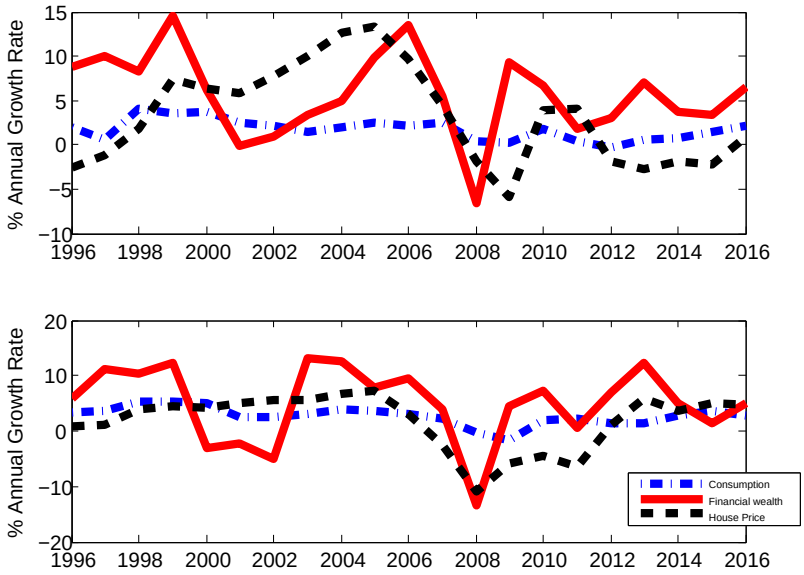

Figure 4 – Annual growth rates of consumption, housing price and financial assets for France (top) and United States (below). The figure shows that consumption growth is strongly correlated with housing wealth growth. Source: OECD

Housing and financial sector are connected through mortgage market. As a result, any disruption in mortgage market, as it happened in the US, affects both sectors. Housing is, in addition, linked to households' wealth through corrections in house prices. Any change in households' wealth directly influences consumption and saving decisions. This, as a consequence, impact both the financial and real sector. Figure 4 compares the annual growth rate of private consumption, real housing price and financial wealth in France and the US. The positive correlation between house prices and consumption is evident in both charts, however the intensity of the correlation is mostly related to household borrowings against housing wealth to finance consumption in both countries. New studies on Europe such as Skudelny (2009), January (2009), Cho (2011) confirm the claim of figure 4 and indicate a positive and significant housing and financial wealth effect on consumption.

Housing also addresses overall employment by its impact on the construction sector.

14. To shed light on the importance of housin, see de Bandt et al. (2010).

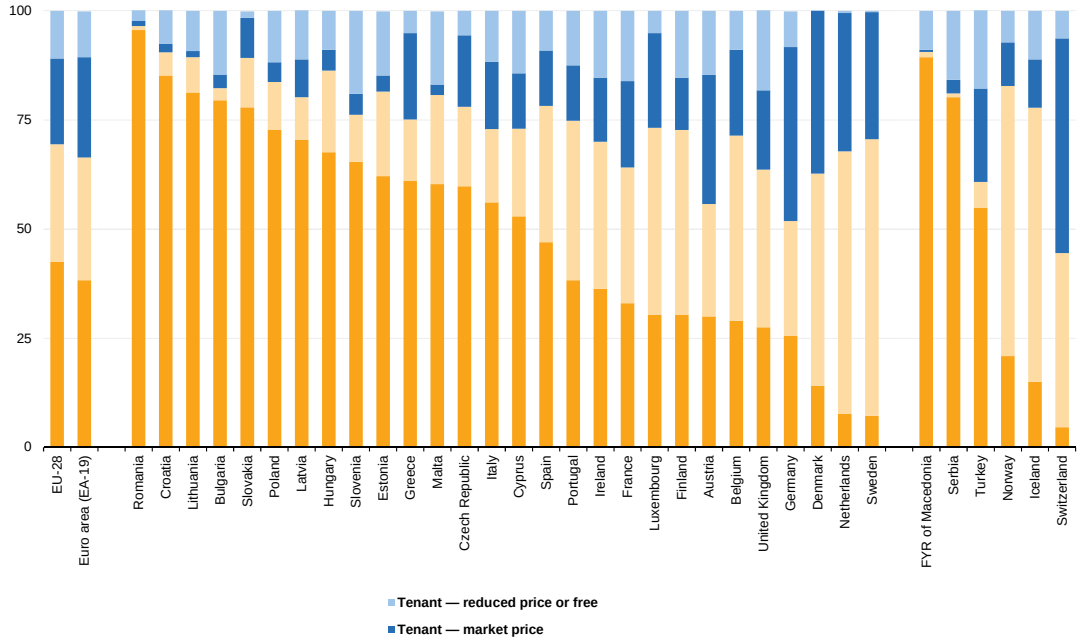

Figure 5 – Distribution of population by dwelling type, Euro area 2015. Source: Eurostat

This impacts are more tense in the countries with a higher share of debtors. Figure 5 presents the distribution of population by dwelling type in 2015 for Euro area. The figure illustrates that over 70% of the population in Western Europe are strongly linked to the housing and credit market. This linkage is less in less-developed European country such as those in the east.

0.2 Chapters

0.2.1 Chapter One

Chapter one estimates a DSGE model using Bayesian methods to simulate an economy which features excessively loose monetary policy, irresponsible mortgage lending and lax regulation (similar to the situation before the Great Recession). In this environment, banks granted loans to borrowers who did not have a clear credit history

and sometimes struggled to repay the loans [15]. As a result, some borrowers did not repay their obligations to the financial sector. This default, in general, imposes reductions in the financial sector's net worth. Since financial intermediaries are subject to capital constraints, they cannot absorb the losses by raising more deposit. As a result, banks are forced to deleverage. Deleveraging impacts the bank balance sheet. This, accordingly, affects the real sector through credit, housing and deposit channels. This climate is well explained in Iacoviello (2015).

What is ignored in the literature is the role of treasury bond market and the fact that before the crisis, mortgages and deposits showed an increasing manner. However banks were faced by defaults. The banking sector could tolerate the default because there was a positive spread between the return on loans and that of deposits. As a result, banks increased their net worth by making profit on their credit activities and, in turn, reducing their bond holdings. The principal contribution of this chapter to the literature is giving freedom to the financial sector to choose between borrowers. To do so, chapter one uses the banking sector and the definition of financial default in the form of Iacoviello (2015) into a model with government i.e. Alpanda and Zubairy (2016). In addition, chapter one employs its model in a policy experiment. To do so, two types of macroprudential policy are proposed. First, introducing the debt-to-income (DTI) ratio on the the collateral constraint of the borrower which caps credit growth. Second, controlling liabilities-to-assets ratio (LTA) on the capital constraint of the banker.

The main finding of this chapter is that the bond market plays an important role in the portfolio decision of the banking sector: the lack of regulations allows the intermediary agents to ignore the defaults and increase mortgages by liquidating the sovereign bond holdings and increasing the liabilities. In addition, this chapter reveals that the house price expectation and friction in the housing sector, which can be a reason for the Paradox of Thrift, are the major delay factors in recovery. The model gives prominence

15. " *These risky mortgages were passed on to financial engineers at the big banks, who turned them into supposedly low-risk securities by putting large numbers of them together in pools. The pooled mortgages were used to back securities known as collateralised debt obligations (CDOs), which were sliced into tranches by degree of exposure to default.*" the Economist (2013).

to the important features of the recent crisis such as the home price downward spiral and the lengthy recovery period. For the application of macroprudential policy tools, the main finding is that macroprudential policy tools help the economy safeguard against adverse shocks but they should be timely, targeted and temporary, otherwise they can slow down recovery.

0.2.2 Chapter Two

Chapter two studies the impact of housing and credit market on financial stability. Ten years after the Great Recession, there is still an ongoing discussion about the reason of the financial collapse. This chapter reflects this view that the financial collapse was a collaboration among various factors: the mismatch between banks' assets and liabilities, the deposit roll over crisis and accelerated shocks through macro-financial and macro-housing channels. This chapter improves Gertler and Kiyotaki (2015) by adding the housing and credit markets into the basic definition of market-based financing institutions i.e. shadow financial system. This contribution shifts attentions to the asset side of bank's balance sheet as the origin of frictions in normal times. The model is calibrated using data pertaining to the US to simulate the economy, before, during and after 2008 collapse when big shadow financial institutions such as Lehman Brothers failed.

The main finding of the chapter is that the banking sector, housing and credit markets are at the core of main consequences of the recent crisis such as house price double-dip, output downward spiral and lengthy recovery period. This chapter reveals different mechanisms for these features which pass through three channels including household balance sheets, bank balance sheets and asset liquidity channels.

Furthermore, chapter two studies the supervision of both the bank and borrower balance sheets by introducing Capital Adequacy Ratio and caps on Loan-To-Value ratio. The chapter illustrates that the macroprudential policies ensure the stability by cushioning asset prices in the time of disasters. As a result, macroprudential tools

can exclude the bank-run equilibrium from the economy. Hence, they mitigate the insolvency risk, boost output and increase investment.

0.2.3 Chapter Three

Chapter three studies the effects on macroeconomic aggregates of permanent changes in housing taxes and tax deductions through the lens of a multi-agent DSGE model with financial intermediaries. Specifically, the housing taxes that are examined consist in the property tax, and the tax deductions are the ones that are attached to the mortgage interest rate and imputed rental income. The primary contribution to the literature is adding a well-defined financial intermediation sector and realistic financial frictions into the models which have ignored the financial sector.

The main result is that borrowing-constrained bankers play an important role for housing dynamics and for welfare improvements. While in the model without a financial sector [16] the long-run multipliers are around -2, this chapter illustrates that the introduction of a banking sector lowers the housing tax multipliers more than twice: close and below unity, the range from -1.02 to -0.6. On the contrary with tax deductions, policies that change property tax and banking requirements so that tax revenues are raised lead to a greater GDP. All policies are welfare-improving for homeowners, but welfare-diminishing for renters and bankers.

Chapter three also looks at the effects of tax revenue neutral policies for which the government uses its additional revenues to lower labor income taxes. The chapter finds that the repeal of mortgage interest deductions is the only policy that generates significant gains in GDP. In light of the tax plan recently proposed by the US government [17] that encompasses, among others, changes in mortgage interest deductibility, these results are particularly interesting for policymakers.

16. See Alpanda and Zubairy (2016).
17. See https://home.treasury.gov/policy-issues/top-priorities/tax-reform

0.2.4 Chapter Four

The human society gradually gets more and more complex. Building new institutions and agencies are an answer to these new complexities. Each new institution (does not matter monetary, financial, fiscal, regulatory etc) individually can impact the economy. As a result, it is important for policy makers to know and model the modern economy as it really is. There is a big difference between a theoretical model, the goal of which is to help better understand the basics of economics, and a model which is applied to make economic policies for a country [18]. Following this view, chapter five builds a new model to studies the economy of oil-exporting countries.

Chapter four builds a New-Keynesian DSGE model to analyse the macro-financial linkages through which the exogenous oil price affects *quasi-modern oil economies*. These economies have tried to analogize themselves to the modern economies by creating modern institutions i.g. central bank, commercial banks and chamber of commerce etc, but not by practicing the rules of open free market. As a result, they are still highly dependent on oil revenues [19]. These economies, apparently, work well when there is a high oil price. Problems become visible when their economy is hit by a negative oil shock [20]. This shock not only has a simple negative effect on GDP, but also affects the economy through those so-called modern institutions. The goal of this chapter is to study the role of modern economic institutions in accelerating the propagation of commodity shocks to the rest of the economy in an oil-exporting country [21]. These modern institutions composed of: a heterogeneous financial sector

18. However adding new complexities (even if there are microfundation evidences behind it) is usually considered as vain, but the modern economy and recent financial crisis shows us that the economic studies (and in social perspective, polciymaking) need complex models to better understand the new channels and mechanisms which tremendously affect an economy. Even before the crisis 2007, many economists believed that financial and housing sectors are vain and these sectors do not add anything to the literature. The time showed them that there is nothing vain in economics. See Iacoviello (2010).

19. For Saudi Arabia: the share of oil revenues in budget revenues is 87%, in GDP is 42%, and in export earnings is 90% (IndexMundi 2018). For Venezuela: oil sales accounts for 50% of GDP and 95% of export revenue (The World Bank). For Iran: oil sales accounts for 25% of GDP and 70% of export revenue (The World Bank).

20. IMF forecasts: *"We are projecting a surge in inflation to 1,000,000 percent by end-2018 to signal that the situation in Venezuela is similar to that in Germany in 1923 or Zimbabwe in the late 2000's."* https://blogs.imf.org/2018/07/23/outlook-for-the-americas-a-tougher-recovery/.

21. The analysis of such countries are different than modern economies, not only because of a

i.e. deposit and lending banks, oil reserve fund (sovereign wealth fun) and central bank. In this regard, the impact of an interbank market and different monetary policy on the economy is on interest.

The findings of this chapter are as follows. *i*) The labor market has a crucial role in propagating shock in such economies. The shocks force labor supply moves between oil and non-oil sectors with different productivity. This affects GDP, oil and non-oil outputs. *ii*) Because in such economies government transfers depends on oil revenues, government transfers become an essential channel in propagating oil shocks. *iii*) Financial sector has an important role in amplifying oil shocks. The interests rate changes, i.e. deposit return rate, loan rate and inter-bank, during the shocks affects other sectors. This deepens the effect of shocks.

0.2.5 Chapter Five

Chapter five builds a dynamic general equilibrium model to assesses the macroeconomic and welfare effects of structural and fiscal reforms in non-oil developing countries. This chapter aims to provide a better understanding of tax reforms in non-oil developing economies by quantifying the potential effects of various reform scenarios, especially on inequality and growth. The optimal reform aims three goals at the same time: creating fiscal space by enhancing tax revenues for improving investment and social spending, boosting GDP by recommending tax incentives to entrepreneurship, and increasing the progressivity of the tax system to improve fairness and welfare.

Chapter five shows that a single reform cannot address the 3-dimension goal and the reform should be comprehensive and in different sectors. Such an approach should consider the combined impact of various tax measures in several dimensions, including growth, revenue, and fairness, as well as parallel efforts to improve the targeting and impact of public social spending. In the absence of comprehensive strategy, the

different economic structure, but also because of huge differences between economic parameters. For example, while the Central bank discount rate in the western economies are close to 0, in Venezuela it is 30% and in Iran it is close to 20% (IndexMundi 2018).

risks are that isolated reforms are not sequenced properly, that they either introduce inconsistencies or distortions, or that they be perceived as unfair, and in the end counter-productive from the perspective of improving the quality, efficiency, fairness, and acceptance of the tax system. The chapter draws the impact of fiscal policies from a holistic viewpoint; It provides useful guidance on the relationship between taxation and economic growth, how taxation can help reduce inequality, and the importance of strengthening social safety key to mitigate the effects of tax reform.

The model of this chapter is calibrated using data pertaining to Morocco (and applicable to similar developing and emerging market countries). In addition, this chapter looks at the impact of tax reforms in developing economies on the housing market i.e. house and rent prices. The results of the simulation illustrate that Morocco would benefit from a comprehensive tax reform strategy. At the same time, the targeting of social programs should be strengthened. Such a reform approach would protect the most vulnerable and help broaden the tax base, remove tax distortions, and better share the tax burden.

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Chapter 1

Macroeconomic Consequences of Bank's Assets Reallocation After Mortgage Defaults

Abstract

This paper proposes a DSGE model which uses Bayesian estimations to assess an economy under the strain of borrower's default on its obligation to intermediary agents, similar to the climate of the Great Recession. The paper finds that the treasury bond market plays an important role in such economy: the default increases the spread between the return on mortgages and deposits, as a result banks prefer to compensate their losses by making profit in the mortgage market and in turn, decreasing their treasury bond holdings. These changes transfer the shock to the real side of the economy through housing, credit, deposit and government loan channels and thereby instigate a business cycle. The model proposed in this paper accurately portrays the behaviour of key economic variables before the Great Recession; in particular housing prices, mortgages, deposits and treasury bond holdings by banks. Significantly, this model illustrates the home price downward spiral which succeeded the recession. This paper demonstrates that the specification of credit constraints relying on house price expectations as well as frictions in housing and capital investments, which can give rise to the Paradox of Thrift, are the major delay factors in recovery. In addition, the findings argue that macroprudential policies help mitigate financial risks and reduce common exposures across markets. Such policies, however, may be inadequate for the post-crisis restoration of the economy.

JEL classification:E32, E44, E62 .

Keywords: Private default, Financial business cycle, Macroprudential policy, Home-price downward spiral.

1.1 Introduction

This paper outlines a DSGE model for the purpose of assessing the impacts of default on bank loans, in the presence of government, housing and credit markets. The key questions addressed by the paper are: *i*) What is the role of housing and credits in accelerating financial shocks? *ii*) what is the impact of frictions and expectations on recovery time? and *iii*) do *macroprudential regulation tools* always provide mechanisms to mitigate the adverse impact of shocks? To answer these questions, I build a model which incorporates a real sector, financially constrained intermediaries, government, housing and credit markets. The paper uses Bayesian methods to estimate and simulate the behaviour of the economy before and after the Great Recession. The model captures the important features of the recent crisis such as the home price downward spiral and the lengthy recovery period.

This paper is designed to incorporate the basic features of Iacoviello (2015). The banking structure, the context of default and the financial shock, as presented in this model, are closely comparable to Iacoviello (2015). In both models, the household default causes a wealth transfer from the banking system to borrower households. While Iacoviello (2015) successfully identifies the origin of the Great Recession [1], his simulation does not correctly match the data on house prices, mortgages or deposits. Iacoviello (2015)' simulation indicates that mortgages and deposits decrease in times of default, while the data from 2005 to 2008 indicates [2] an upswing in both variables. This upswing happened due to an increase in the return spread (between return on assets and liabilities) and the demand in the mortgage market. As a result, the intermediary agents ignored the defaults and heated the mortgage market by liquidating the sovereign bond holdings and increasing the liabilities [3].

Iacoviello (2015) neither incorporates unconstrained borrower [4] nor fluctuations in

1. Interestingly, it shows that "financial shocks account for two-thirds of the decline in private GDP during the 2007–2009 recession"
2. Source: The World bank 2017 and European Mortgage Federation (EMF) 2014.
3. The process of reducing Sovereign Bond Holdings by bank from 2005 to 2008 is pointed in Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012).
4. The unconstrained borrower points at government. Banks participate in general trading

the total housing supply. Both borrows, entrepreneurs and households, are financially constrained: their loans are constrained by their assets. When a default happens, due to the raise in the asset price and the impact of the fixed housing supply, the entrepreneur's credit constraint is relaxed. This increases the entrepreneur's ability to borrow from the financial sector. As a result, the mortgage supply reduces.

To deal with this problem, I improve on a rich macrofounded general equilibrium model which has been widely implemented in previous literature. This paper develops Alpanda and Zubairy (2016)'s model by introducing intermediary agents to the lender-borrower relationship. The model features lender, borrower and renter households, elastic housing supply, a financial intermediary sector, house producers and a government. Government collects taxes, distributes lump-sum transfers and issues bonds. Both borrower households and government are debtors of the financial sector. There is no friction in the bond market so the intermediary agents can freely hold or sell government bonds. On the other hand, there is a friction in the mortgage market in the form of collateral constraint. The main result of incorporating government, the bond market and an elastic housing supply is that the model of this paper accurately simulates the behaviour path of key economic variables especially deposits, mortgages and housing prices. The existence of both constrained and unconstrained borrowers provides a freedom for the financial sector to answer mortgage demands by adjusting its bond holdings. However, this liquidity-risk change [5] exposes the financial sector to shock [6].

This paper finds the crucial role of house price expectation in lengthy recovery [7]. The collateral constraint in this paper is based on the expectation of house value and not on the current price. House producers also take the house price and adjustment costs into account to produce houses. With these features, the model captures the role

operations (open market) to buy and sell securities. The government securities mostly offer risk free returns and are generally the most liquid instrument a bank holds. Using these liquid assets, banks are able to immediately react to shocks. See Gennaioli et al. (2014).

5. I used this term because in my model bonds act as a liquid asset which is traded without any friction and their return is risk-free.While in the mortgage market there is a constraint which should be satisfied, and borrower households can default.

6. See Angeloni and Wolff (2012).

7. See Case and Shiller (2003) and Case et al. (2003).

of the price expectation on the credit and investment growth: the mortgage market and housing investments move in the same direction of the house price expectation. The paper illustrates that the expectation of the economy for a lower house price as well as frictions in investments cause a gradual decline in house prices, even after the default is ended. This *home price downward spiral* is an economic setback which delays recovery.

Finally, the paper presents the application of macroprudential tools and their impact on recovery. These tools are applied to debt-to-income ratio on the borrower side and liabilities-to-assets ratio on the bank asset side. The paper reveals that by introducing a cap on debt-to-income ratio to the mortgage market, the economy is safeguarded against extreme drops but recovers more slowly. In addition, the paper shows that the application of a countercyclical liabilities-to-assets ratio policy helps reduce house price volatilities.

There is an expansive body of literature which studies banking sector, intermediary agents and capital constraints which incorporate banks in the analysis. Gorton and Metrick (2010), Brunnermeier and Sannikov (2014) and Gersbach et al. (2015) use simple non-stochastic intermediary capital constraints to show the major role of financial intermediaries. Tchana (2012) presents a banking regulation in an overlapping-generations model and analyses its effect on welfare. Mimir (2016) studies the role of financial shocks and credit frictions in a quantitative analysis à la Gertler and Karadi (2011) with the addition of a stochastic banking sector. Banks in these two models either act as zero profit organizations or accumulate net worth every period and consume all their net worth at the final period of their life. The model of this paper is more realistic as following Iacoviello (2015), it uses a stochastic representative banking sector which consumes every period. Households do not have the expertise required for direct investment and so they rely on bankers to invest under behalf. In other words, the banking sector facilitates transfers of assets between agents. In addition, the banking sector in this paper faces a capital adequacy constraint which is dynamically dependent on banker's expectations for future assets, defaults and

liabilities-to-assets ratio set by an authority as a macroprudential policy tool.

Macroprudential policy tools [8] aim to provide a global model for the protection of banks and households against financial and real shocks. Following the recession, attention turned to the study of the effects of these tools i.e. Lim et al. (2011) and Igan and Kang (2011). This paper provides a theoretical background which sustains known empirical results on the procyclicality on macroprudential policies. By simulating the behaviour of the economy after the default shock, the paper confirms Claessens et al. (2013)'s empirical assertion that macroprudential tools are time inconsistent. The stylized facts, e.g. Gordy and Howells (2006), show that an efficient tool in boom periods could slow down the recovery of the economy during a recession. This procyclicality is evidenced in this paper for a cap on borrower credit which is based on debt-to-income ratio à la Gelain et al. (2013).

Macroprudential tools are all protecting, but should be carefully selected. Some policies are designed to mitigate the vulnerabilities and others are better suited to building up buffers. The liabilities-to-assets ratio pertains to the latter [9]. Both countrcyclical capital buffers and the prudential policies for mitigating vulnerabilities (especially in the form proposed by the Basel committee) are corroborated by an expansive body of empirical and theoretical evidence. For instance, Angelini et al. (2014) and Angelini et al. (2015) build a DSGE model à la Gerali et al. (2010) to show the functionality of Basel and countercyclical capital buffers. The impact of these buffers after the shock on recovery is neglected in the literature . This paper finds that a countercyclical liabilities-to-assets ratio reduces the volatility of house prices and protects the economy without slowing it down. The model used here highlights the supporting role of the macroprudential policy tools in mitigating

8. Macroprudential policy tools are proposed by regulators including the SEC, Federal Reserve, Basel Committee on Banking Supervision (BCBS), Financial Standards Board (FSB), Prudential Regulatory Authority (PRA) and the European Commission.

9. The liabilities-to-assets ratio is controversial because it has the same context as the capital requirement ratio (CRR). The required total CRR in Basel I and II was 8%. A mandatory capital conservation buffer in the form of dynamic macroprudential is presented in Basel III (2010) which adds 2.5% to the previous CRR. The required total capital increases up to 10.5% Supervision (2011).

financial system vulnerabilities. These policies address both the cross-sectional and temporal dimension of systemic risk and may assist monetary policy by counteracting financial imbalances.

This paper is organized as follows: Section 2 presents the model. Section 3 calibrates and estimates the parameters used as per the US data. Section 4 simulates the Great Recession using the estimated parameters and compares the accuracy of the model with previous literature. Section 5 outlines the effectiveness of different macroprudential policies and their protective mechanism. Section 6 offers a conclusion on the findings of this paper.

1.2 Model

The model is composed of four heterogeneous households: lenders (patient), borrowers (impatient), renters (hand to mouth) and bankers. Lenders are capital owners. Firms borrow this capital to produce non-housing goods. Lenders are, in addition, active in the housing market. They accumulate housing which are either for personal use or for rent to renter households. Lenders issue bank deposits. Bankers are expert investors and the owners of the banking sector. Bankers create credits for borrowers in the form of mortgages and trade government securities. Borrowers accumulate housing and because of their impatience, do not save. Stochastic financial frictions are applied on impatient households and bankers in the form of collateral and capital constraints, respectively. The government collects income and housing taxes and combines them with governmental liabilities to cover its expenditure and lump-sum transfers to patient, impatient and renter households.

1.2.1 Household

Superscribes P, I, R, B stand for Patient, Impatient, Renter households and Bankers, respectively. There is a unit measure of every type of infinitely lived household.

Patient households

The patient households' problem is

$$\begin{aligned} &\max E_t \sum_{\tau=t_0}^{\infty} \beta_P^{\tau-t_0} \{\log c_\tau^P + \varphi_h \log h_{\tau-1}^P - \varphi_l \frac{(l_\tau^P)^{1+\iota}}{1+\iota}\} \\ &s.t. \\ &(1+\tau_c)c_t^P + p_t^h h_t^{Ph} + i_t^k + d_t \leq \omega_t^P - \tau_t^P - AC_t^P \end{aligned} \tag{1.2.1}$$

where t presents time. $\beta_P < 1$ is the discount factor that is greater than the discount factor of other households. φ_h and φ_l present the relative importance of housing and labor in the utility function respectively, and ι is the inverse of the Frisch-elasticity of labor supply. τ_c is the tax on consumption.

A representative patient household consumes c_t^P, accumulates housing h_t^{Ph} at relative price p_t^h. There are two types of houses: residential houses h^P, and rental houses h^R. l_t^P is the labor supply of patient households. The patient household is the owner of capital which is borrowed by firms in order to produce non-housing goods. The patient housing variation h_t^{Ph}, and capital investments i_t^k respectively are

$$h_t^{Ph} = [h_t^P - (1-\delta_h)h_{t-1}^P] + [h_t^R - (1-\delta_h)h_{t-1}^R] \tag{1.2.2}$$

$$i_t^k = k_t - (1-\delta_k)k_{t-1} \tag{1.2.3}$$

The depreciation rates on housing and capital are δ_h and δ_k, respectively. Deposit d_t is the saving of the patient household in the banking sector. In summary, the patient household has three saving tools, housing, capital and deposit. Total income ω_t^P is composed of wage w_t^P, rent from renters at price p_t^R , return on deposit and capital

with interest rate r_t and r_t^k respectively and the government transfer Γ_t^P,

$$\omega_t^P = w_t^P l_t^P + p_t^R h_{t-1}^R + (1 + r_t) d_{t-1} + r_t^k k_{t-1} + \Gamma_t^P \tag{1.2.4}$$

Total tax paid by the patient household τ_t^P is composed of taxing on wage, rent, property, return on deposit and capital,

$$\begin{aligned}\tau_t^P = {} & \tau_w [w_t^P l_t^P + p_t^R h_{t-1}^R - \delta_h h_{t-1}^R - \tau_p p_t^h (h_{t-1}^R + h_{t-1}^P)] + \tau_p p_t^h (h_{t-1}^P + h_{t-1}^R) \\ & + \tau_d r_t d_{t-1} + \tau_k (r_t^k - \delta_k) k_{t-1}\end{aligned} \tag{1.2.5}$$

τ_w stands for the income tax rate , τ_p for property tax rate, τ_d and τ_k for tax rate on deposit and capital return, respectively. In addition, to remain consistent with the US tax code, home owners profit from a tax break [10] on property taxes and depreciation allowances for housing. The last term in the budget constraint is the adjustment cost AC^P consistent with the literature [11].

The FOC with respect to residential and rental houses respectively are

$$p_t^h = \beta_P \mathbf{E}_t [\frac{\varphi_h}{\lambda_t^P h_t^p} + \frac{\lambda_{t+1}^P}{\lambda_t^P} ((1 - \delta_h - \tau_p (1 - \tau_w)) p_{t+1}^h] \tag{1.2.6}$$

$$p_t^h = \beta_P \mathbf{E}_t [\frac{\lambda_{t+1}^P}{\lambda_t^P} ((1 - \delta_h - \tau_p (1 - \tau_w) p_{t+1}^h + (1 - \tau_w) p_{t+1}^R + \tau_w \delta_h] \tag{1.2.7}$$

where λ_t^P is the Lagrange multiplier of the budget constraint at time t. The FOCs

10. https://www.irs.gov/publications/p530/ar02.html

11. Patients' adjustment cost is $AC_t^P = AC_t^{Pk} + AC_t^{Pd}$ where $AC_t^{Pk} = \frac{\psi_k}{2} \frac{(k_t - k_{t-1})^2}{\bar{k}}, AC_t^{Pd} = \frac{\psi_{dh}}{2} \frac{(d_t - d_{t-1})^2}{\bar{d}}$ and it is adopted from Iacoviello (2015).

with respect to deposit, capital and labor respectively are [12],

$$1 = \beta_P \mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}(1 + (1 - \tau_d)r_{t+1})] \tag{1.2.8}$$

$$1 = \beta_P \mathbf{E}_t[\frac{\lambda_{t+1}^P}{\lambda_t^P}(1 - \delta_k + (1 - \tau_k)r_{t+1}^k + \tau_k\delta_k)] \tag{1.2.9}$$

$$\varphi_l(l_t^P)^\iota = \lambda_t^P(1 - \tau_w)w_t^P \tag{1.2.10}$$

Impatient households

The utility function of the representative impatient household is the same as the patient one but with a different discount factor. Thus, the problem of impatient household is

$$\begin{aligned} &\max E_t \sum_{\tau=t_0}^{\infty} \beta_I^{\tau-t_0}\{\log c_\tau^I + \varphi_h \log h_{\tau-1}^I - \varphi_l \frac{(l_\tau^I)^{1+\iota}}{1+\iota}\} \\ &s.t. \\ &(1 + \tau_c)c_t^I + p_t^h h_t^{Ih} + (1 + r_t^b)M_{t-1} - \varsigma_t^I \leq \omega_t^I + M_t - \tau_t^I - AC_t^I \end{aligned} \tag{1.2.11}$$

in order to have the impatient household as a net borrower and the patient one as a net saver in equilibrium, it is assumed that $\beta_I < \beta_P$. Impatient households consume c_t^I. h_t^{Ih} is impatient housing variation

$$h_t^{Ih} = h_t^I - (1 - \delta_h)h_{t-1}^I \tag{1.2.12}$$

where h_t^I is impatient houses. M_t is mortgages from the banking sector. ω_t^I is total impatient income at time t

$$\omega_t^I = w_t^I l_t^I + \Gamma_t^I \tag{1.2.13}$$

where w_t represents wage and Γ_t^I is the transfer from the government. ς_t^I is the focal point of the paper. It stands for a default shock. Since it is positive, it induces wealth transfers from the bank to the impatient household. It is a redistribution shock.

12. For simplicity in reading, the derivatives of adjustment costs are not written in the equations. They are, of course, considered in the coding.

This is consistent with the fact that during The Great Recession most of the damage incurred by the banking system was due to household defaults [13]. Repayments to the banking system are $[(1 + r_t^b)M_{t-1} - \varsigma_t^b]$. Total tax paid by the borrower is composed of income and property taxes,

$$\tau_t^I = \tau_w[w_t^I l_t^I - r_t^b M_{t-1} - \tau_p p_t^h h_{t-1}^I] + \tau_p p_t^h h_{t-1}^I \tag{1.2.14}$$

To remain consistent with the current US tax code, there is a tax exemption on the mortgage return, with the interest rate r^b, and on the property tax. AC^I is the adjustment cost on changing houses [14].

Collateral constraint restricts the impatient household mortgage to a fraction of the expected value of his house,

$$M_t \leq \rho_m M_{t-1} + (1 - \rho_m)\theta[\mathbf{E}_t(\frac{p_{t+1}^h}{1 + r_{t+1}^b} h_t^I)] \tag{1.2.15}$$

where θ is the loan-to-value ratio in housing and ρ_m captures the fact that only a fraction of borrowers change their loan every period. Collateralized houses are valued by the expectation of their future real value and not their current value. This structure captures the role of the price expectation in the credit market. This friction is one of the channels which connects the real and financial side of the economy.

The first order conditions with respect to impatient houses, mortgage [15] and labor

13. See Gabriel et al. (2016).
"The packaging of increasingly risky subprime loans, extended to people with poor credit by banks and other mortgage lenders, undermined the market, which was deeply interconnected through complex financial transactions. Increased demand for housing soon spurred a bubble, based on the widely shared assumption that housing prices would continue to go up. When they instead began to fall, borrowers began defaulting and lenders began foreclosing on mortgages at higher rates, which in turn shook the financial markets, mortgage giants Fannie Mae and Freddie Mac and the complex securities dependent on those underlying assets". Source: http://businessresearcher.sagepub.com/sbr-1863-101611-2765611/20170102/shadow-banking

14. $AC_t^I = \frac{\psi_m}{2} \frac{(M_t - M_{t-1})^2}{M}$

15. To keep the simplicity of reading, the derivations of the adjustment cost is not written in the equations.

respectively are

$$p_t^h - \frac{\lambda_t^m}{\lambda_t^I}(1-\rho_m)\theta \mathbf{E}_t \frac{p_{t+1}^h}{1+r_{t+1}^b} = \beta_I \mathbf{E}_t[\frac{\varphi_h}{\lambda_t^I h_t^I} + \frac{\lambda_{t+1}^I}{\lambda_t^I}((1-\delta_h-\tau_p(1-\tau_w))p_{t+1}^h)] \tag{1.2.16}$$

$$1 - \frac{\lambda_t^m}{\lambda_t^I} = \beta_I \mathbf{E}_t[\frac{\lambda_{t+1}^I}{\lambda_t^I}(1+(1-\tau_w))r_{t+1}^b - \frac{\lambda_{t+1}^m}{\lambda_t^I}\rho_m] \tag{1.2.17}$$

$$\varphi_l (l_t^I)^\iota = \lambda_t^I (1-\tau_w) w_t^I \tag{1.2.18}$$

where λ_t^I is the Lagrange multiplier of the budget constraint and λ_t^m is the Lagrange multiplier of the collateral constraint at time t.

Renter households

Renter households are hand-to-mouth and consume what they earn. The renters' problem is

$$\begin{aligned} &\max E_t \sum_{\tau=t_0}^{\infty} \beta_I^{\tau-t_0}\{\log c_\tau^R + \varphi_h \log h_{\tau-1}^R - \varphi_l \frac{(l_\tau^R)^{1+\iota}}{1+\iota}\} \\ &s.t. \\ &(1+\tau_c)c_t^R + p_t^R h_{t-1}^R \leq (1-\tau_{wr}) w_t^R l_t^R + \Gamma_t^R \end{aligned} \tag{1.2.19}$$

where the discount factor of renters is the same as impatient one. The Renter consumes c_t^R and rents rental houses from the patient household. They are are so poor so that they cannot borrow and lend. The renter provides the labor supply l_t^R to the economy and earns wage w_t^R. Because their income level is low, the government drives a lower tax on their wages, $\tau_{wr} < \tau_w$ (based on the US tax codes). Their income is composed of the wage and government transfer Γ_t^R. The existence of three types of households is a convenient approximation to mimic the stylized fact of the presence of lenders, borrowers and renters without making it an endogenous decision. The first

order conditions with respect to rental housings is

$$p_t^R = \frac{\varphi_h}{\lambda_t^R h_{t-1}^R} \tag{1.2.20}$$

where λ_t^R is the Lagrange multiplier of the budget constraint at time t.

Bankers

A representative banker is a type of household which consumes and intermediates between other agents. The banker issues liabilities d_t and buys assets a_t. The borrowers are either households (who borrow in the form of mortgages M_t) or government [16] (the borrowings of which are termed government bonds b_t^g). Banker's utility function and budget constraint are,

$$\begin{aligned} &\max E_t \sum_{\tau=t_0}^{\infty} \beta_B^{\tau-t_0} \log c_\tau^B \\ &(1+\tau_c)c_t^B + (1+r_t)d_{t-1} + a_t + AC_t^B = d_t + (1+r_t^b)a_{t-1} - \varsigma_t^I \\ &a_t = b_t^g + M_t \end{aligned} \tag{1.2.21}$$

r^b is the interest rate on loans. It is the same for impatient households and the government. The banker receives new deposits and the return on last period loans. ς_t^I is the default shock to the banker's assets. ς_t^I is the shock which makes the banker's asset side smaller and forces the banker to recapitalize (i.e. change banker's portfolio) in order to meet its budget constraint. AC^B is the adjustment cost of issuing liabilities and assets [17].

The financial friction on the banking sector is [18]

$$a_t - d_t - \mathbf{E}_t\varsigma_{t-1}^I \geq \rho_b(a_{t-1} - d_{t-1} - \mathbf{E}_{t-1}\varsigma_t^I) + (1-\phi)(1-\rho_b)(a_t - \mathbf{E}_t\varsigma_{t+1}^I) \tag{1.2.22}$$

16. See Ogawa and Imai (2014) and https://www.bloomberg.com/news/articles/2016-10-30/banks-amass-2-4-trillion-hoard-of-bonds-as-bofa-leads-stampede.

17. $AC_t^B = \frac{\psi_a}{2}\frac{(a_t - a_{t-1})^2}{\bar{a}} + \frac{\psi_{db}}{2}\frac{(d_t - d_{t-1})^2}{\bar{d}}$

18. This type of friction modeling is standard and used in Iacoviello (2015).

Parameter ϕ is the Liabilities-to-assets ratio (hence the capital-to-asset ratio is $1-\phi$). Basel I, II and III are based on this ratio. Similar to the real regulation patterns, with this constraint, the bank has the ability to deviate from its liabilities-to-assets ratio in the short run. In the long run bank should set its leverage ratio to ϕ. The constraint is derived from the fact that in every period the banker should be able to provide a fraction of bank assets. With the first term in the right hand side the bank has the option of partial adjustment in bank capital beyond one period. The first order conditions with respect to liabilities,d_t, and assets, a_t, are

$$1 = \frac{\lambda_t^\phi}{\lambda_t^B} + \beta_B \mathbf{E}_t \frac{\lambda_{t+1}^B}{\lambda_t^B}(1 + r_{t+1} - \rho_b \frac{\lambda_{t+1}^\phi}{\lambda_{t+1}^B}) \tag{1.2.23}$$

$$1 = (\phi(1-\rho_b) + \rho_b)\frac{\lambda_t^\phi}{\lambda_t^B} + \beta_B \mathbf{E}_t \frac{\lambda_{t+1}^B}{\lambda_t^B}(1 + r_{t+1}^b - \rho_b \frac{\lambda_{t+1}^\phi}{\lambda_{t+1}^B}) \tag{1.2.24}$$

where $\lambda_t^B, \lambda_t^\phi$ are the Lagrange multiplier of the budget constraint and the collateral constraint at time t, respectively.

1.2.2 Firms and Housing producers

Patient, impatient and renter households work for the representative firm and receive wages depending on different labor elasticity, $\iota_P, \iota_I, \iota_R$. It is assumed that $\iota_P + \iota_I + \iota_R = 1$. There is a continuum of identical firms of measure one. The firm produces a homogeneous good using a Cobb-Douglas technology

$$Y_t^f = A_t k_{t-1}^\alpha ((l_t^P)^{\iota_P} (l_t^I)^{\iota_I} (l_t^R)^{\iota_R})^{1-\alpha} \tag{1.2.25}$$

and maximizes its profit

$$\max Y_t^f - w_t^P l_t^P - w_t^I l_t^I - w_t^R l_t^R - r_t^k k_{t-1} \tag{1.2.26}$$

Since markets are perfectly competitive, the market prices are the usual terms

$$\alpha \frac{Y_t^f}{k_{t-1}} = r_t^k \tag{1.2.27}$$

$$(1-\alpha)\iota_i \frac{Y_t^f}{l_t^i} = w_t^i, \quad i = P, I, R \tag{1.2.28}$$

In the economy, there is a continuum of measure one and perfectly competitive housing producers which provide housing to households [19]. At every period, housing producers buy undepreciated part of houses from households at a relative price p_t^h, then invest then i_t^h to produce new houses h_t. Hence, they maximize the benefit as

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} [p_\tau^h (h_\tau - (1-\delta_h) h_{\tau-1}) - i_\tau^h] \tag{1.2.29}$$

where $h_t = h_t^P + h_t^I + h_t^R$ is total housing. The patient households' stochastic discount factor is used to discount future profits [20]. The production is subject to an adjustment cost defined as a fraction of investment. As a result, the housing production follows the law of motion

$$[1 - \frac{\psi_{hp}}{2}(\frac{i_t^h}{i_{t-1}^h} - 1)^2] i_t^h = h_t - (1-\delta_h) h_{t-1} \tag{1.2.30}$$

The FOC with respect to housing reveals the house price,

$$p_t^h [1 - \psi_{hp}(\frac{i_t^h}{i_{t-1}^h} - 1)\frac{i_t^h}{i_{t-1}^h} - \frac{\psi_{hp}}{2}(\frac{i_t^h}{i_{t-1}^h} - 1)^2] + \beta_P \mathbf{E}_t p_{t+1}^h [\frac{\lambda_{t+1}^P}{\lambda_t^P} \psi_{hp} (\frac{i_{t+1}^h}{i_t^h} - 1)(\frac{i_{t+1}^h}{i_t^h})^2] = 1 \tag{1.2.31}$$

19. Similar to Roi et al. (2007)
20. See Smets and Wouters (2007) and Alpanda and Zubairy (2016).

1.2.3 Government

The government collects all taxes from all households

$$T_t = \tau_c C_t + \tau_w[w_t^P l_t^P + (p_t^R - \delta_h)h_{t-1}^R - \tau_p(h_{t-1}^P + h_{t-1}^R)] + \tau_d r_t d_{t-1} + \tau_p(h_{t-1}^P + h_{t-1}^R) + \tau_k(r_t^k - \delta_k)k_{t-1} + \tau_w[w_t^I l_t^I - r_{t-1}^m M_{t-1} - \tau_p h_{t-1}^I] + \tau_p h_{t-1}^I + \tau_{wr} w_t^R l_t^R \tag{1.2.32}$$

where $C_t = c_t^P + c_t^I + c_t^R + c_t^B$ is total households' consumption. In each period, the government has access to funds from the banker in the form of bonds, b_t^g and total tax, T_t, to pay its liabilities to the banker, lump-sum transfers and the government spending, g_t. Hence, the government's budget constraint is

$$(1 + r_t^b)b_{t-1}^g + g_t + \Gamma_t = b_t^g + T_t \tag{1.2.33}$$

where Γ_t is total transfers to each household, depending on level parameters specific to the type of household $\vartheta_P, \vartheta_I, \vartheta_R$

$$\Gamma_t = \Gamma_t^P + \Gamma_t^I + \Gamma_t^R \tag{1.2.34}$$

$$\Gamma_t^i = \vartheta_i Y_t^f - \rho_g b_{t-1}^g, \quad i = I, P, R. \tag{1.2.35}$$

ρ_g determines the response of transfers to government debt to adjust transfers to government loans in order to avoid Ponzi game by government [21].

1.2.4 Market clearing

The non-housing good firms produce goods to cover total consumption, total housing investment, capital investment and government spending. Good market clearing is

$$Y_t^f = C_t + i_t^h + i_t^k + g_t \tag{1.2.36}$$

21. Making the adjustment through transfers is standard, for example see Alpanda and Zubairy (2016) and Alpanda and Zubairy (2017). The evidence could be find in Leeper et al. (2010).

In this paper total GDP is defined as [22]

$$Y_t = Y_t^f + \tau_c C_t + p_t^R h_{t-1} \tag{1.2.37}$$

An equilibrium defines a set of prices (p^h, p^R, r, r^b, r^k) and allocations $(c^P, c^I, c^R, c^B, h^P, h^I, h^R, d, k, b_g, g, \Gamma^P, \Gamma^i, \Gamma^R)$ so that all agents and firms maximize their objective functions subject to all constraints while all markets clear (markets for good, housing, labor, deposit, mortgage, capital and government bonds).

1.3 Estimation

1.3.1 Calibration

Table 1.1 – Calibrated parameters

Parameters	Symbol	Value
Discount factors	$\beta_P, \beta_I, \beta_B$	$0.9925, 0.94, 0.945$
Housing preference	φ_h	0.27
Labor Supply parameter	φ_l	0.8
Depreciation rates	δ_h, δ_k	$0.0096, 0.016$
Transfer share	$\vartheta_P, \vartheta_I, \vartheta_R$	$0.040, 0.036, 0.030$
Income taxes	τ_w, τ_{wr}	$0.32, 0.22$
loan-to-value ratio	θ	0.90
Liabilities-to-assets ratio	ϕ	0.90
Labor shares in production	$\iota_P, \iota_I, \iota_R$	$0.13, 0.67, 0.20$
Capital share in production	α, A	$0.2047, 1.805$
Inverse labor supply elasticity	ι	1
Inertia in collateral constraint	ρ_m	0.70
Inertia in capital constraint	ρ_b	0.24
Response of transfers to gov. debt	ρ_g	0.003
Taxes	$\tau_k, \tau_c, \tau_p, \tau_d$	$0.4, 0.05, 0.14/4, 0.15$
deposit and capital adj. for Pat.	ψ_{dh}, ψ_k	$0.10, 1.73$
deposit and loan adj. for Bank	ψ_{db}, ψ_a	$0.14, 0.54$
Mortgage adj. for Imp.	ψ_m	0.37
Housing investment adj. for Producer	ψ_h	2.48
Parameters of AR(1)	$\rho_{\varsigma^I}, \rho_{\varsigma^g}$	0.9

Table 5.1 presents the value of the parameters which are chosen to get the targets

22. To be is consistent with the National Income and Product Accounts (NIPA) data which is used for the calibration. NIPA is choosen because it is the only data that includes imputed rental income from owner-occupied housing. In NIPA data, VAT is included in the relative price of consumption and housing provides consumption services.

quarterly in the data and as initial values for the estimation of the model. The calibration here is closely based on the empirical estimation of Iacoviello (2015). In order to have binding borrowing constraint in the steady state the impatient discount factor should be set less than the weighted average of two others. Thus, discount factors of patient, impatient and banker are set to $0.9925, 0.94, 0.945$, respectively. With this setting the annual interest rate on deposits is 0.3 and the interest rate on loans is 0.5 according to Iacoviello (2015). Depreciation rates are set to 0.96% for housing and 1.6% for capital to target 5% housing, 10% non-housing investment and total investment equal to 15% and capital over GDP equal to 6 according to National Income and Product Accounts (NIPA,Bureau of Economic Analysis) and the Flow of Funds Accounts (FOF; Federal Reserve Board). With this setting, government loans over GDP is set to 80% consistent to the average loan of the US According to OECD 2016 for twenty years and government spending over GDP equal to 18% as Alpanda and Zubairy (2016). The inverse of the Frisch elasticity of labor supply is set to 1 according to Smets and Wouters (2007). $\vartheta_P, \vartheta_I, \vartheta_R$ are set to $0.04, 0.036, 0.030$, respectively, to target total transfer over GDP, $tr/Y = 0.08$ according to NIPA and based on their share of total income. τ_w, τ_{wr} are calibrated to $0.32, 0.22$ to get total income tax, $T/Y = 0.27$ as Zubairy (2014). loan-to-value ratio and Liabilities-to-assets ratio are both calibrated to 0.9, Inertia in collateral constraint and Inertia in capital constraint to 0.70 and 0.24 and parameters of AR(1) shock to 0.9 all according to the estimations of Iacoviello (2015). This calibration also addresses deposit and mortgage to GDP equal to 65% and 52%, respectively, roughly consistent with the wold bank data 1980-2015. According to the 2001 Residential Finance Survey (RFS; Census Bureau), $\iota_P, \iota_I, \iota_R$ are set to $0.13, 0.67, 0.20$ respectively to target $h_P/h = 0.37, h_I/h = 0.43, h_R/h = 0.20$. Response of transfers to government debts is calibrated to 0.003 to adjust transfers with government loans. Housing preference is set to 0.27 to have housing value over GDP equal to 5.44 according to Iacoviello and Neri (2010). Labor supply parameters calibrated in order to get total labor supply equal to one. Capital share in production α, is set to 0.2047 based on the optimal conditions and the relation between r_k, k and to insure $k/Y = 6$. All

coefficients for adjustment cost are chosen from the estimations of Iacoviello (2015), except adjustment cost for housing producer that is set as Roi et al. (2007). Capital, consumption, property and deposit taxes,$\tau_k, \tau_c, \tau_p, \tau_d$, are set to $0.4, 0.05, 0.14/4, 0.15$ respectively based on the US tax codes as Zubairy (2014). Total Consumption over GDP in this settings is $C/Y = 52\%$ and $c^P/C = 26\%, c^I/C = 53\%, c^R/C = 18\%, c^B/C = 3\%$.

Table 1.2 – Steady state of the benchmark model annually

Variable	symbol	Steady State/GDP
Consumption	c^P, c^I, c^R, c^B	$0.13, 0.28, 0.10, 0.01$
Housing	h^P, h^I, h^R	$0.50, 0.58, 0.27$
Tax	T	0.27
Bankers' asset	a	0.71
Mortgage	M	0.51
Government loan	b_g	0.80
Deposit	d	0.65
non-housing output	Y^f	0.84
wages	w^P, w^I, w^R	$0.38, 1.2, 0.36$
Government Exp.	g	0.18
Transfers	tr^P, tr^I, tr^R	$0.031, 0.027, 0.022$
Investments	i^k, i^h	$0.10, 0.05$

1.3.2 Estimation results

In order to estimate the model, Dynare [23] and Bayesian methods [24] are used. The model is estimated based on the borrower household default, consistence with the situation of the Great Recession. The shocks [25] follow autoregressive (AR1) process

$$\varsigma_t^I = \rho_{\varsigma^I} \varsigma_{t-1}^I + \epsilon_t^I \tag{1.3.1}$$

where $\epsilon^I \approx N(0, \sigma^2_{\varsigma^I})$. The optimizer for the mode computation is that introduced by Sims et al. (1999). There is one shock in the model so for estimating the parameters, there must only be one data set, otherwise, stochastic singularity arises [26]. On the

23. http://www.dynare.org/manual/index_27.html
24. SeeAn and Schorfheide (2007).
25. Note, another shock will be defined to the model in the government default section.
26. See Ruge-Murcia (2007).

other hand, estimating such a model on only one observable series is a bit of a stretch, hence I use measurement error technique [27] to estimate the model on 4 observable series. The applied series are U.S. quarterly data on real consumption, mortgage, losses from mortgage default and real house prices (all in the form of deviation from steady state) between $1985Q1$ and $2010Q4$ [28]. The 20 first observations are used as a training sample for the Kalman filter [29].

Number of replications for Metropolis-Hastings algorithm [30] (Markov chain Monte Carlo, MCMC) is set to 100000. Table 1.3 presents the estimated variables. Other variables are assumed to be fixed as Table 5.1, due to demeaned data and the fact that in the estimation procedure, when steady state is being updated for any draw, the non-estimated parameters are not able to conduct steady-state values in the procedure. Initial values for estimation are, in addition, set to the ones in the calibration (Table 5.1). Table 1.3 presents the comprehensive results of the estimation [31].

Table 1.3 – Estimation results

Parameter	symbol	Pri. mean	Post. mean	90% HPD interval		De.	Pri sd	Post. sd
St. Dev., default shock	σ_{ς^I}	0.0025	0.0015	0.0013	0.0016	I.G	0.025	0.0001
Autocor., default shock	ρ_{ς^I}	0.80	0.9037	0.8804	0.9294	Be.	0.100	0.0150
Inertia in collateral cons.	ρ_m	0.70	0.7069	0.6904	0.7238	Be.	0.100	0.0102
Inertia in capital cons.	ρ_b	0.25	0.4221	0.1380	0.7148	Be.	0.100	0.1769
Adj. cost,P Deposit	ψ_{dh}	0.25	0.2169	0.0567	0.3810	Ga.	0.125	0.1086
Adj. cost,P capital	ψ_k	1.00	1.1750	0.2905	2.0514	Ga.	0.500	0.5782
Adj. cost,B Deposit	ψ_{db}	0.25	0.2532	0.0599	0.4523	Ga.	0.125	0.1330
Adj. cost,I Mortgage	ψ_m	0.25	0.1864	0.0449	0.3184	Ga.	0.125	0.0900
Adj. cost,B assets	ψ_a	0.25	0.2528	0.0538	0.4342	Ga.	0.125	0.1275
Adj. cost,HP	ψ_h	1.00	1.2129	0.3883	2.0726	Ga.	0.500	0.5685

P:Patient household, I:Impatient, B:banker, HP:Housing producer, I.G:Inverse Gamma, Be:Beta, Ga:Gamma, HPD:highest posterior density interval

The 90% Highest Posterior Density interval shows the most probable interval of parameters. Posterior mean of inertia in collateral constraint is 0.71. This coefficient presents the fraction of impatient households which change mortgage every period.

27. See Pfeifer (2014)
28. As introduced in Iacoviello (2015)
29. See Kalman et al. (1960).
30. See Metropolis et al. (1953) and Chib and Greenberg (1995)
31. The optimal acceptance rate in a DSGE estimation with Bayesian method should be between one third and one quarter. The best value for the acceptance rate is approximately 23.4%. See Roberts et al. (1997). In the present estimation, the acceptance rate is 23.5%.

Inertia in bankers' capital constraint is estimated 0.42. This parameters shows how flexible a banker can be in deviating from the liabilities-to-loans ratio in short term after the shock. The autocorrolation of the default shock is 0.90, this constitutes a high persistent shock. It has the standard deviation of 0.0015. Prior and posterior estimated adjustment costs of deposits and loans for bankers are practically equal. This shows the observed data are not very informative about these parameters. Household deposit adjustment cost is estimated at 0.21. The difference between deposit adjustment cost of households and banks shows that changing deposits for households is cheaper and easier than for bankers. Capital and producer adjustment costs are both estimated around 1.2. This confirms the existence of a high inertia and show that deviating capital and housing from steady state is a costly activity.

1.4 The Great Recession

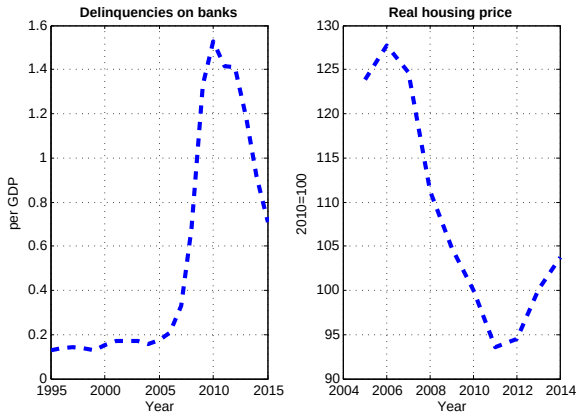

Figure 1.1 – Delinquencies on all loans and leases secured by real estate in all commercial banks (left) and real house price (right). Resource: (left) Federal Reserve bank of st. Louis, (right) OECD Data 2017

Household defaults, as explained before, were the primary cause of the Great Recession. This section demonstrates the impact of household default similar to the the real situation of the Great Recession within the estimated model. During the Great Recession, intermediary agents lost their assets. The loss was slowly recovered after the shock. The Great Recession officially happened in 2007-2009 with the

consequence of bankruptcies and bank runs. The most significant collapse was that of the Lehman Brothers. This was the largest bankruptcy filing in U.S. history, with holding over 613 billion in assets on September 2008. This crisis was the consequence of distortions in the economy accumulated from late 2000 [32]. Mortgage underwriting standards declined gradually during the boom period, particularly from 2004 to 2007 and mortgage fraud by lenders and borrowers increased enormously [33]. In 2004, an important credit risk of non-prime mortgage lending and an epidemic in mortgage fraud were foreseen by the Federal Bureau of Investigation [34]. Figure 1.1 (left) shows that the rate of default starts to increase from 2005 and it was almost doubled in 2006 [35].

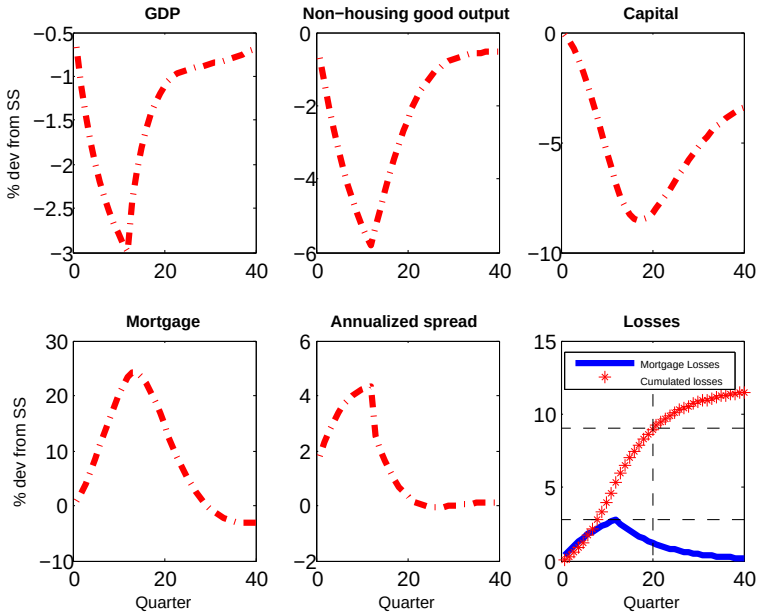

Figure 1.2 – Simulation of the Great Recession, Key variables, Spread is in level.

To simulate the situation of the Great Recession, the unexpected impatient shock is fed by 0.38% of annual GDP for 12 quarters (3 consecutive years). The maximum losses are set to equal 2.8% of GDP after three years and a cumulative losses are set to equal 9% of GDP after 5 years (20 quarters) [36]. This emulates the Great Recession

32. See Vos et al. (2011).
33. See Cowen (2008).
34. See Black (2009).
35. See Demyanyk and Van Hemert (2009) and an interesting discussion in Antoniades (2016).
36. To ensure the comparability of the model, I aim the same target as Iacoviello (2015). This

starting in 2005 and culminating with the bankruptcy of Lehman in 2008. After the shock, there is no shock so losses gradually return to zero.

The posterior mean values of estimated parameters in Table 1.3 and the value of non-estimated parameters in Table 5.1 are inputted to the model to simulate the Great Recession. Figure 1.2 shows the impact of the described shock on the model's key variables.

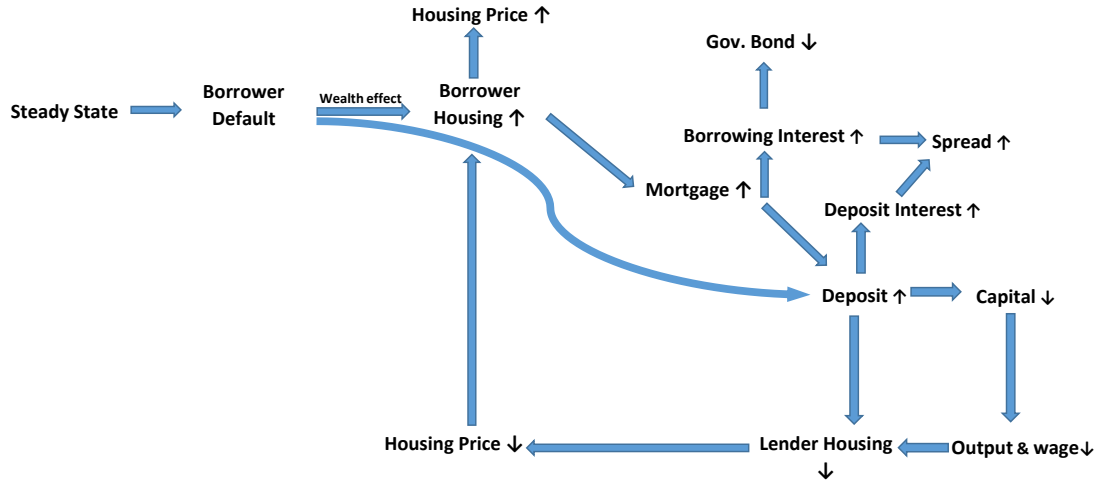

Figure 1.3 – The mechanisms of the model

The negative shock on bank's assets is a wealth transfer from bankers to impatient households for 12 periods, corresponding to the 2005-2008 period in the data. The effect of the transfers in these 12 periods is summarized in Figure 1.3. The mechanisms are fourfold. First, The transfer increases the housing demand by impatient households and consequently, the mortgage demand increases. This raises the return on mortgages. Impatient households can afford a high return due to the wealth effect. Second, bank which both suffers a loss in its assets and faces a high mortgage demand increases deposits. The deposit increase helps bank finance mortgage demands and payoff its liabilities. This effect raises the return on deposits. The mixed effect of the raise in deposit and mortgage interest rate on the spread [37],

setting is driven in order to meet and target the evidence and estimations found in IMF (2009).

37. Annualized spread is calculated as the annualized difference between the interest rate on

as seen in figure 1.2, is positive. Before the shock, the spread is about 2%. This raises to 4.2% by the end of the third year. Third, a higher interest rate on deposits changes the patient's portfolio. Patient households relocate their saving from capital and housing to deposits. The effect on the the housing market is further discussed below. The drop in capital investment gradually reduces GDP from -0.6% to -3% in 12 periods. Four, bank reduces its government bond holding in order to answer mortgage demands [38]. This mechanism reduces the size of the government's budget balance sheet and decreases the government expenditure. Figure 1.4 presents the data on government bond holdings of banking sector before 2009 and the simulation of the model.

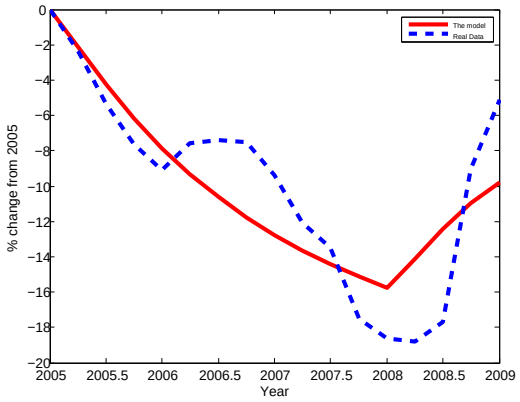

Figure 1.4 – Treasury bonds at all commercial banks per GDP. Index:2005. Sources: BEA, Board of Governors, FRED

The model imitated 2005-2008 economic behaviour and data. Figure 1.5 compares the data for deposit and mortgage to GDP alongside annualized spread between lending and borrowing rate in 2005-2010 with the path simulated by the model of this paper for the similar variables. The simulation demonstrates the same behaviour as the data.

After the shock (after period 12), the economy does not go back immidiately to the steady state. Capital and housing keep on falling for same periods before they recover. The explanation for this is as follows.

banker's loans and the interest rate on deposits.

38. Merler and Pisani-Ferry (2012) illustrate the reduction in Sovereign Bond Holdings by banks from 2005 to 2008.

The real housing price between 2005-2014 is presented in figure 1.1 (right). Following the beginning of the default in 2005, house prices increased. The increase picks in 2006 and then declines until early 2011. Noting the after crisis period, the figure 1.1 (right) evidences the *home price downward spiral* when, even after the crisis ends (in 2009) and recovery begins, housing price continue to fall. This continuous negative effect was a major contributing factor to the late recovery after the Great Recession. The data from FRED shows that it took almost 5 years for the the US economy to return to the 2007 level of output per capita. Normally for an economy like that of the US, it takes less time to return to the pre-recession peak [39].

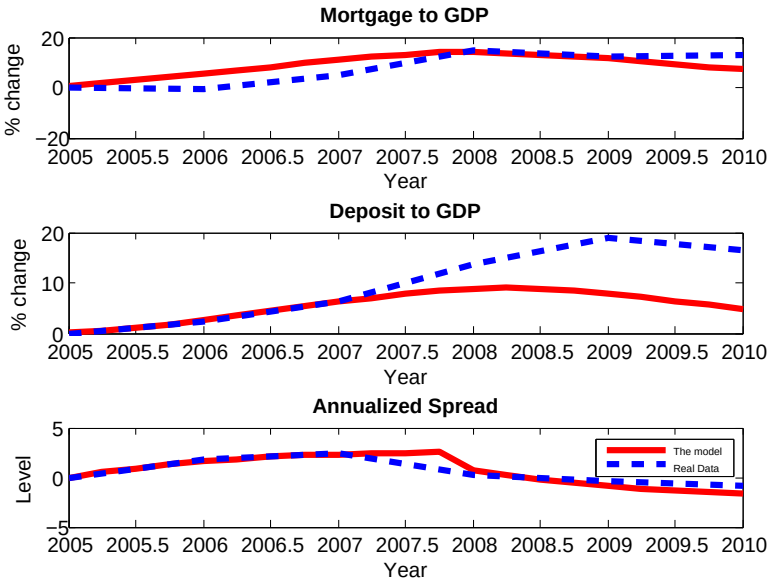

Figure 1.5 – Deposit and Mortgage to GDP, Annual Spread (lending-borrowing rate). Index:2005. Resource: The World Bank and European Mortgage Federation (EMF) 2015

Figure 1.6 presents the simulation of housing factors. The figure at the top left indicates that the home price downward spiral is captured by the model. The mechanisms effective in the behaviour house price are as follows. First, the wealth transfer has a positive impact on the impatient-house demand. This increase in housing demand is the reason of the initial house price increase, right after the shock. The increase in housing demand supports an increase in mortgages prevision. Note

39. For more details, see Christiano (2016).

that the amount of the current mortgage is contingent on the previous mortgage and the expectation of the future house value (equ 1.2.15), the latter of which is increasing. This clearly shows the crucial role of the expectation in mortgage fluctuations. Second, as discussed before, patient households prioritize deposits and decrease their housing investment. This, in turn, decreases the demand and consequently the housing price. Some period after the shock, this effect dominates the first mechanism. As a result, the house price decreases. Impatient households benefit from the impact on the housing price and expand their consumption and housing. When the shock comes to an end, so too do these expansions. Lastly, the rent price increases because lenders ask for a higher return rate on rental houses [40], so rental housing demands decreases.

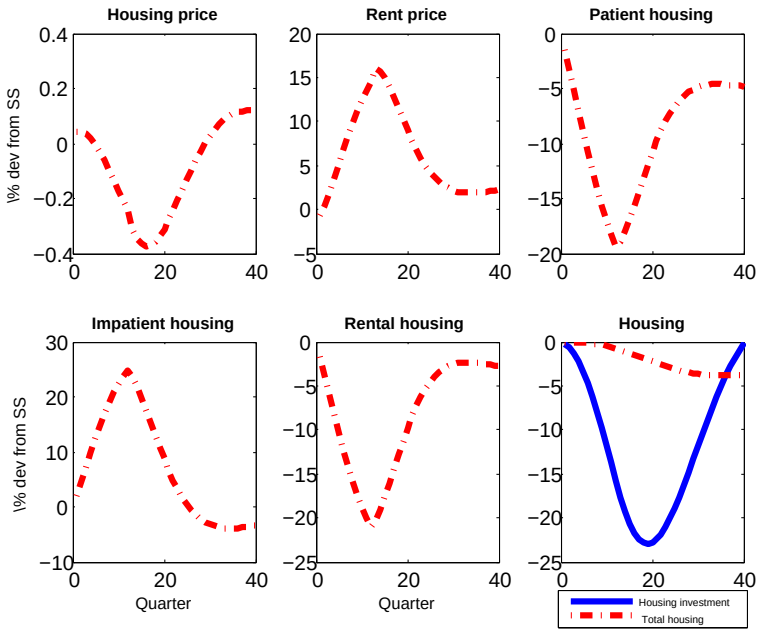

Figure 1.6 – Simulation of the Great Recession, Housing factors, (%) change from SS

In contrast, the drop in housing prices does not end at the same time as the shock. As recovery begins, house prices continue to fall. The explanation is as follows. At the end of the shock, the economy is still below the steady state and there is a large marginal utility of housing. So the immediate increase in the house price is not consistent with the all other returns on saving tools being equal. As a result, the house prices continue to decrease. For impatient households, the housing is large. So the return on housing

40. Because of the arbitrary condition. As seen before, the rate on deposits increases so the return on rental houses also increases.

is small. This is not a problem because impatient households make no arbitrage with deposits. For patient households, the rate on deposits remains above the steady state for a long time. So the return on housing for patient households remains above the steady state as long as the effect of the shock on housing has not disappeared.

The lower investment in housing and capital which makes the crisis so long-lasting is similar to the context of the Paradox of Thrift [41]. Investment frictions make saving more desirable than investing. Hence, personal savings role as a net drag on the economy during a recession.

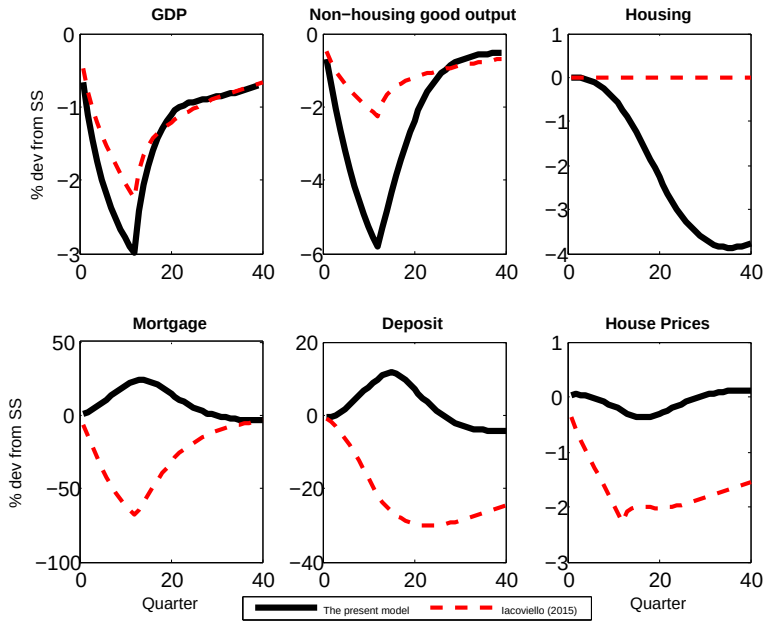

Figure 1.7 – Simulation of the Great Recession for two models Iacoviello (2015) and the model of this paper , (%) change from SS

Figure 1.7 compares the path of the key variables in the present model and in Iacoviello (2015)'s model. The economy was hit by the same shock in both models. The GDP response is almost the same. However, contrary to the data shown in figure 1.1, after the unset of the shock, key variables such as house price, mortgage and deposit decline in Iacoviello (2015)'s model. In addition, his model does not capture the downward

41. See Huo and Ríos-Rull (2013) and Christiano (2016).

spiral in the housing price.

1.5 Macroprudential regulation

In the aftermath of the global financial crisis, macroprudential policy tools have been proposed to ensure financial stability. In this section, two types of macroprudential policy are proposed; One on the the collateral constraint of the borrower and the other on the capital constraint of the banker. The debt-to-income (DTI) ratio caps credit growth for borrowers. Liabilities-to-assets ratio (LTA) restricts the liabilities of financial institutions to a fraction of their assets. In order to apply the DTI to the model, Equ 1.2.15 is changed to

$$M_t \leq \rho_m M_{t-1} + [\theta_m(w_t^I l_t^I) + (1-\theta_m)(1-\rho_m)\theta(\mathbf{E}_t(\frac{p_{t+1}^h}{1+r_{t+1}^b} h_t^I))] \tag{1.5.1}$$

where θ_m is the weight assigned by the banker to the borrower's wage income.

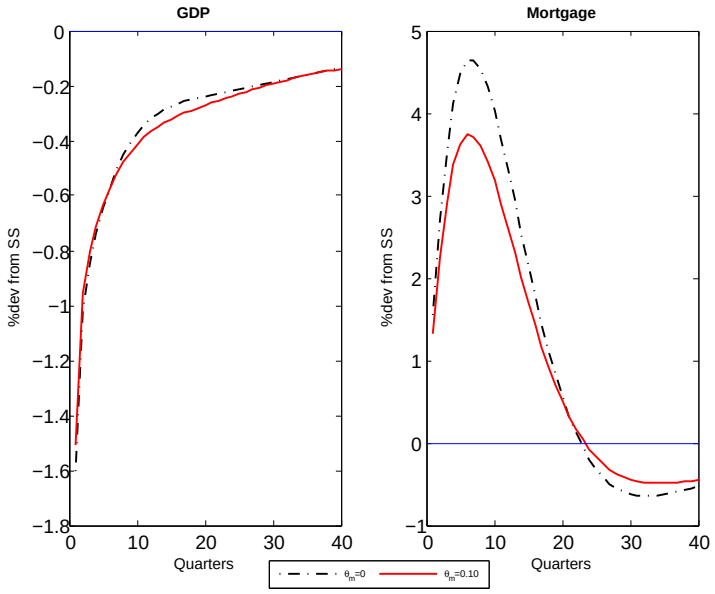

Figure 1.8 – The impact of applying debt-to-income (DTI) into the model.

Figure 1.8 presents the impulse response to a negative 1% shock to the banker's asset without a DTI and with DTI=0.10. The DTI ratio limits the borrower's debt to 10% of disposable income and 90% of the expected house value. Increasing the DTI by 10%

reduces the shock's negative impact on GDP by 0.1%. As explained in the previous section, GDP declines due to the higher demand of deposits by banks in response to the higher demand of mortgages. The DTI restricts mortgages. As a result, the patient household's portfolio change is moderated.

On the other hand, the DTI's effect on mortgages makes it difficult for the economy to recover. With such policy on the collateral constraint, the economy suffers less but recovers more slowly. The reasons are twofold. Firstly, GDP, capital and wages decline after the shock. The DTI restricts borrowers to their income so their accessibility to credits drops. Without the DTI, borrowers can raise more credit with lower income and buy more houses. This action ignites the economy and helps recovery. However, the strict regulation of a prudent debt-to-income ratio can regulate the housing boom and moderate the crisis. Secondly, a higher DTI and consequently a lower amount of mortgages result in less deposit issuance and credits. This reduces the amount of government loans and consequently government spending. The economy therefore slows down.

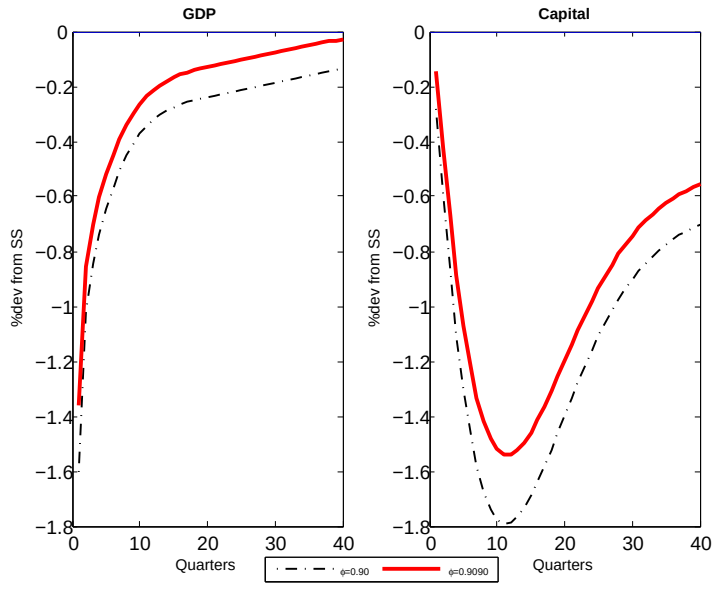

Figure 1.9 – IRFs to households defaults, different liabilities-to assets ratio

A higher liabilities-to-assets ratio (LTA) ϕ, influences the economy as follows. The rise gives the banker the ability to further increase deposits. Mortgages is regulated by

the household collateral constraint which binds the mortgage to the expectation of the house value. The mortgage, therefore, is not affected immediately. By raising more deposits, bankers can pay off the liabilities with new deposits and reduce the negative impact of a sudden shock. This is why the banker is no longer forced to sharply reduce government loans in the higher LTA. This helps the economy to recover more quickly. The impact of a 1% increase to the LTA is depicted in figures 1.9.

1.6 Conclusion

In this paper, I use a DSGE model to study the impact of defaults on the asset side of the bank balance sheet. The model features four types of heterogeneous households: lenders, borrowers, renters and bankers. In addition, the model incorporates government, firms and house producers as well as a tax system closed to the real tax code in the US. The key elements of the model are stochastic financial frictions: first, collateral constraints for borrower households based on the expected house value and second, capital constraints on intermediary agents. This paper examines the impact of a credit crunch on financial intermediaries similar to that of 2005-2008 on the aggregate key variables. The lack of regulations allows the intermediary agents to heat the housing market by liquidating the sovereign bond holdings, increasing the liabilities and financing more mortgages. The findings of this paper reveal that the role played by expectations and friction in housing and capital investments, which give rise to the Paradox of Thrift, are the major delay factors in recovery. In addition, the role of macroprudential policy tools in protecting financial stability is assessed.

A few essential points must be made regarding the role of intermediaries in financial shocks. These would be interesting departure points for future studies. In this model, banks are not able to run, though this is not the case in a real economy. In 2007, financial companies which could not meet their obligations were forced to run. This trend began with the bankruptcy of Lehman Brothers who had over 600 billion dollars in assets. The run was a result of having high volumes of subprime

and other lower-rated mortgage which were not sufficiently secured [42]. Other reasons outlined in literature are illiquid aspects of bank's assets and variations in the maturity time for the projects. As a result, banks are incapable of responding to all requests simultaneously. Different orientations such as those used by Uhlig (2010), Calvo (2012) and Gertler and Kiyotaki (2015) would make an interesting addition to the model. One could also study the impact of other shocks on the model such as technological shocks.

The presented DSGE model has the ability to explore the impacts of other scenarios of default e.g. government default [43]. The Government default may occur specifically in response to a government spending shock. One scenario could be government default in order to provide more transfers to households. This situation could happen in an exceptional social-political situation wherein governments might need political supports. This is the case of some third world countries which defaulted on their loans to increase public spending [44]. This model conducts the shocks in an exogenous manner but It would be favorable to examine the interaction of primitive economic elements.

42. Alan and Bialeck (2015)
43. See Roubini and Sachs (1989) and Ramey (2011). A famous example of this situation is 1998 Russian crisis in which the low productivity, a high fixed exchange rat, a chronic fiscal deficit and declines in demand and price of crude oil (following the Asian financial crisis) impacted Russian foreign exchange reserves and consequently leads the government to an internal default and as well the economy to collapse. The IMF sources, http://www.imf.org/external/np/sta/ir/IRProcessWeb/data/rus/eng/currus.htm/#I. The shock in the model is not directly comparable with the Russian crisis, but it has the potential to be extended to meet the parameters of the Russian default.
44. See Dinç (2005).

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Chapter 2

Shadow Bank run, Housing and Credit Market: The Story of a Recession

Abstract

This paper proposes a DSGE model with bank runs which improves Gertler and Kiyotaki (2015) to assess the impact of housing and credit markets in financial instability and shadow banking activities. This paper illustrates that a negative TFP shock is amplified by macro-financial and macro-housing channels through household's balance sheet, bank's balance sheet and liquidity channels. If the shock makes the shadow banking system insolvent, two equilibria, no-run and run equilibrium, coexist. In this view, run is a sunspot coordination failure; if households receive a negative signal from fundamentals and stop rolling over deposits to the financial sector, banks are not able to fund their losses by new deposits. So they are forced to liquidate their assets at an endogenous fire sale price. The main finding of this paper is that the model with housing comprehensively details the consequences of economic crises, namely home price double-dip, the output downward spiral and lengthy recovery period. In addition, the paper indicates that macroprudential policy tools in the form of capital adequacy buffers and loan-to-value ratios can be helpful for eliminating bank-run equilibrium. They safeguard the economy against extreme busts and help mitigate systemic risks by insulating asset prices.

JEL classification: E23, E32, E44, G21, G33 .

Keywords: Shadow banking, Bank run, Recession, Sunspot equilibrium, Double-dip.

2.1 Introduction

This paper outlines a DSGE model of financial instability for the purpose of assessing the impacts of housing on financial accelerator mechanisms and shadow financial institutions. The key questions addressed by this paper are: *i*) What is the role of the housing and credit markets in exacerbating financial distresses? *ii*) What are the significant channels through which shocks are amplified and propagated into the economy? and *iii*) does regulating shadow financial institutions provide mechanisms to mitigate the procyclicality and the amplitude of fluctuations? To answer these questions, this paper incorporates shadow financial intermediary agents, lender and borrower households, housing and credit markets, goods and capital producers. The model of this paper is calibrated using data pertaining to the US economy.

This paper is designed to improve Gertler and Kiyotaki (2015) (hereafter, GK). GK's model focuses on the liability side of bank's balance sheet and successfully identifies the sunspot phenomenon [1] of shadow bank runs. However, housing, mortgages and financial malfunctions, in the asset side of bank's balance sheet, were at the core of the recent recession [2]. This paper contributes to the literature by focusing on financial frictions between bankers and borrowers. This includes the role of housing frictions, house prices and the credit market. GK's model incorporates three agents: lender households, shadow banks and firms. These agents are connected through two types of goods: capital and non-durable goods. This paper improves GK's model by introducing a third asset, housing, and a fourth agent, borrower households, to the basic features of GK's shadow banking system [3]. In this manner, the financial agents' assets are composed of capital lent to the productive sectors, and credits demanded by households. Although simple models help to conceptualize the problem, they jeopardize the results by underestimating the impact of shocks and overlooking

1. See Diamond and Dybvig (1983), Benhabib and Farmer (1999) and Farmer (2015) and self-fulfilling debt crisis literature: Cole and Kehoe (1996), Jeanne and Masson (2000) and Cole and Kehoe (2000).
2. The asset side of bank's balance sheet is also the primary source of frictions in normal times, when marcoprudential in under control. See Christiano (2017).
3. Market-based financing as some authorities prefer to call it.

influential channels.

The main finding of this paper is that by introducing housing and credit market into the literature the model is able to capture the important features of crises such as the home price double-dip, output downward spiral [4], and lengthy recovery period. The explanation of these features are in following paragraphs.

This paper finds that the house price double-dip is an event which occur by banking recovery activities. Recession literature e.g. Giri et al. (2016), Koo (2014) and Marelli and Signorelli (2017) clarifies the concept of the economic double-dip, however the double-dip in house prices remains unexplored. The US data [5] shows the double-dip in the house price in 2010, two years after the crisis. This paper indicates that financial intermediary agents are primary in forming the house price double dip. The mechanism of double dip is as follows. The first shoot occurs during the crisis mainly due to a fall in mortgages and then a fall in borrowers housing demand. After the crisis, house prices are low so the demand by lender households is high. This increases the price i.e. the price start to recover. The higher house price relaxes collateral constraints and consequently, increases mortgage demands. Banks are in the recovery period so they need more deposits to answer the mortgage demands and accumulate more net worth. The high deposit demand by banks reduces lenders' housing demand and reduces the house prices one more time after the crisis.

This paper illustrates that the major factors in causing the shocks in output to persist (i.e. output downward spiral after the crisis) are financial frictions as well as frictions in capital investments. The mechanisms involved in this persistence are as follows. Two channels amplify a TFP shock into the economy: i) household balance sheets: a negative TFP shock shrinks the lender and borrower's wealth (firstly from a reduction in wage and the capital return, secondly from housing value). The contraction in the lender's wealth reduces deposit rollovers. This exacerbates banks' financing-ability and leads banks to distresses. In addition, the sagged borrower's wealth reduces the

4. The continues decrease in output even after the shock. See Eichengreen (2004).
5. See the S&P/Case-Shiller Home Price Index 2011, Harding (2011) and https://www.economist.com/blogs/dailychart/2010/12/house_prices

borrower's house demands, tightens collateral constraints and consequently reduces banks' assets. All theses affect capital investments and output. *ii*) bank balance sheets: a negative TFP shock affects the economy through both sides of bank's balance sheet and the asset liquidity. In the liability side, high leveraged banks cannot absorb more leverage due to financial constraints. This limits the ability of the bank to pay off its liabilities by new deposits. As a result, banks are forced to deleverage. In the asset side, by facing the deterioration of asset value, banks are obliged to decrease capital investment as well as credit. The cut back in investments causes a vicious circle in capital and output. This ignites an output downward spiral. The cut back in credit effects the borrower's house demand and has an adverse effect on house prices. This channel reinforces the the borrower balance sheet's impact which is explained above.

Finally, by comparing two equilibria i.e. no-bank run and bank run equilibrium, this paper finds that the financial collapse (or i.e. bank run) puts a major delay on recovery. The reasons are threefold. First, the financial collapse always comes with an asset fire sale. In other words, at the period of the run, banks liquidate all their assets. As a result, the excess capital supply remarkably reduces capital prices. The low asset prices, in addition, have impact on household wealth. All these effects put a delay on recovery. Second, the financial collapse negatively impacts the credit and housing markets. When the financial collapse occurs, the financial sector closes its door for one period. As a result, there is no credit market. This extremely impacts the housing market and delays recovery. Third, the financial collapse increases the cost of production. When the financial sector is shut down, households hold all capital. As they should pay management cost for holding capital, the production is more costly. This, in turn, affects output and recovery.

Considering the significance of the shadow banking system and its run-like behavior [6] during the recent recession, this paper models the financial agents in the form of market-based financing institutions. These shadow financial institutions do not adhere

6. See Christiano et al. (2017) and Adrian and Liang (2016).

to formal banking regulations. There is only an incentive compatibility constraint which limits the bank's ability to raise liabilities. This constraint is created by the rationality of lenders. This agency problem markedly differentiates between traditional and shadow banking systems. The traditional banks are supposed to the regulatory constraints which are suggested in international regulatory frameworks by committees such as the Basel. These regulations are extensively studied in the literature e.g. Elenev et al. (2017), Rampini and Viswanathan (2017),He and Krishnamurthy (2013), Iacoviello (2015) , Brunnermeier et al. (2012) and Perri and Quadrini (2014). The financial sector adopted by this paper is standard and widely investigated in the literature, in particular, Gertler et al. (2010), Gertler and Karadi (2011), Gertler et al. (2012), Occhino and Pescatori (2014), Quadrini (2017) and Gertler et al. (2016a). The banking sector modeled here correspond best to the shadow banking sector which was at the core of the instability of the 2008 financial crisis. To do so, following Gertler and Kiyotaki (2015), the other types of financial intermediaries are excluded from this modeling because the nature and the possibility of their run is extremely different with the shadow banking sector. For instance, commercial banks, due to tight regulations and bank reserves at the central bank, are not supposed to the same type of run as that of shadow banks.

This paper finds that a proper marcoprudential policy tool is able to remove bank-run equilibrium. to do so, this paper assesses the supervision of both the bank and borrower balance sheets by introducing Capital Adequacy Ratio (CAR) à la Ghilardi and Peiris (2016) and caps on the Loan-To-Value (LTV) ratio à la Claessens et al. (2013) on financial stability. The share of shadow banking in the U.S. mortgage market as a whole increased to 38% in 2015, compared to 14% in 2007 [7]. The debate on how to regulate these entities remains a controversial issue [8]. The impact of macroprudential

7. See Buchak et al. (2017).

8. To see the fragility of the shadow banking system before, during and after crisis please see https://www.federalreserve.gov/newsevents/speech/tarullo20120612a.htm at the conference on Challenges in Global Finance, Federal Reserve Bank of San Francisco. In addition, Collier (2017) describes the importance of shadow banking and the potential for systemic collapse in the current world economy especially in the biggest economies like the US and China.

policy tools in mitigating systemic distortions is wildly explored [9]. These policy tools control either bank balance sheets, borrower balance sheets or the liquidity of the banking sector [10].

This paper finds that the CAR increases the financial stability by insulating the bank's asset price. The CAR control carries out a countercyclical capital buffer. In this policy, shadow banks are obliged to withhold a certain ratio of their net worth over productive assets. This protects the economy by ensuring that the shadow banks have enough cushion to absorb temporary losses and pay off their obligations. This mitigates, as well, the insolvency risk. This helps banks facing a shock to modestly recapitalize without defaulting or causing panic [11]. Furthermore, the cap on the LTV reduces mortgage issuance and gives more leverage to banks for investing in capital. In this regard, the cap on the LTV performs the same role as CARs. This is empirically confirmed in the literature e.g. Moreno (2011) and Cerutti et al. (2015).

This paper is organized as follows: Section 2 presents the model. Section 3 calibrates the parameters used as per the US data. Section 4 simulates the recession with and without a bank run. Section 5 outlines the effectiveness of countercyclical macroprudential policies and their protective mechanisms. Section 6 offers a conclusion on the findings of this paper.

2.2 Model

The model incorporates households, the financial and the production sector. There is a continuum of measure unity of each type. Households are either lenders or borrowers. The lender households consume, accumulate housing and capital. They,

9. To have a comprehensive overview in theoretical and empirical researches on macroprudential policy tools, see Galati and Moessner (2017).

10. See Laeven et al. (2016), Brown et al. (2016) and Brunnermeier and Sannikov (2014).

11. Panics are one reason of bank runs. They act as an extrinsic random variable i.e. a sunspot which can firstly, make a bank run equilibrium feasible and secondly, shift the economy from the no-bank run equilibrium to the bank run equilibriumSee Diamond and Dybvig (1983) and Chen and Hasan (2008).

also, raise deposits in the financial sector. [12]. The borrowers consumes and accumulate housing by getting credits from the financial sector. Credits are subject to a collateral constraint. The financial sector is in the form of shadow banking. The financial sector issues credits and has its own capital. Finally, the firms use productive assets borrowed from the lender households and the bankers to produce non-durable goods.

2.2.1 Lender Households

The lender's problem [13] is

$$\begin{aligned}
\text{Max} \quad & E_t \sum_{\tau=t_0}^{\infty} \beta_P^{\tau-t_0} \{(1-\varphi_c)\log(C_\tau^P - \varphi_c C_{\tau-1}^P) + \varphi_h \log h_\tau^P + \varphi_l \log(1-l_t^P)\} \\
& s.t. \\
& C_t^P + D_t + p_t^h(h_t^P - h_{t-1}^P) + p_t^k(K_t^h - (1-\delta_k)K_{t-1}^h) + f(K_t^h) + (1-\sigma)N^n \leq \\
& w_t^P l_t^P + (1+r_{t-1})D_{t-1} + r_t^k K_{t-1}^h \qquad (2.2.1)
\end{aligned}$$

where t presents time. $\beta_P < 1$ is the discount factor , C_t^P is consumption, h_t^P is the housing asset of the lender household and l_t^P is the labor supply. φ_h and φ_l are the coefficients which represent the relative importance of housing and leisure in the utility function, respectively.

Every period, the lender engages in the following activities: consuming non-durable goods, depositing safe assets D_t to the banking sector, buying and selling housing at the house price p_t^h, investing in capital at the price p_t^k and working at the firms with wage w^P. r is the interest rate on the deposit and r^k is the one-period return on capital. K_t^h is capital held by the lender. The household bears a convex managing cost $f(K_t^h) = \frac{\alpha_k}{2}(K_t^h)^2$, $\alpha_k > 0$.

N^n is the donation of the household to perform new banks in the case of bank failure.

12. Cross sectional and over time analysis indicates the homogeneity of banks' liability structures: banks are almost financed by deposits. See Hanson et al. (2015). Shadow financial institutions are engaged with short-term debts and securitization.

13. This type of utility function is known in literature. See Iacoviello (2015).

The probability of a failure is $1-\sigma$, i.i.d. This case will be explained in the bank section.

The Lagrange multiplier of lenders is the result of the first order condition with respect to consumption,

$$\lambda_t^P = \frac{1-\varphi_c}{C_t^P - \varphi_c C_{t-1}^P} \tag{2.2.2}$$

The FOC with respect to the lenders' housing asset, deposit and capital, respectively, are

$$p_t^h = \frac{\varphi_h}{\lambda_t^P h_t^P} + \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P} p_{t+1}^h \tag{2.2.3}$$

$$1 = \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P}(1+r_t) \tag{2.2.4}$$

$$p_t^k + f'(K_t^h) = \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P}[p_{t+1}^k(1-\delta_k) + r_{t+1}^k] \tag{2.2.5}$$

2.2.2 Borrower Households

The borrower's problem is

$$\begin{aligned} \text{Max} \quad & E_t \sum_{\tau=t_0}^{\infty} \beta_I^{\tau-t_0}\{(1-\varphi_c)\log(C_\tau^I - \varphi_c C_{\tau-1}^I) + \varphi_h \log h_\tau^I + \varphi_l \log(1-l_t^I)\} \\ & s.t. \\ & C_t^I + p_t^h(h_t^I - h_{t-1}^I) + (1+r_t^b)M_{t-1} \le w_t^I l_t^I + M_t \\ & M_t \le \theta_m p_t^h h_t^I \end{aligned} \tag{2.2.6}$$

In order to make borrowing and lending possible for the agents, the borrower's discount factor is assumed to be less than that of the lender, $\beta_I < \beta_P$. At time t, the borrower consumes C_t^I, buys and sells housing assets h_t^I at the price p_t^h, receives mortgages M_t and pay the mortgage interest rate r_t^b. The borrower works for the firms at the wage, w_t^I and provides labor supply l_t^I. The borrower household does not accumulate physical capital nor hold any equity.

The collateral constraint restricts the mortgage to the fraction, θ_m, of the housing-asset value. θ_m is the loan-to-value (LTV) ratio. It is set by the regulatory as a macroprudential policy tool. The collateral constraint is one of the channels by which the financial sector is connected to the real economy. For instance, stricter regulation i.e. a smaller LTV lowers the consumption to income ratio [14].

The macroprudential constraint highlights the role of the house price in the borrower's portfolio decision. Higher house prices decrease house demands and affect consumption. On the other hand, the high house price relaxes the collateral constraint and increases available credit. This credit increase opens a new mechanism which increases spending capacity of constrained households [15]. In addition, higher house prices have a wealth effect on home owners which, again, increases the consumption capacity [16]. These contrary mechanisms impact the borrower at the same time, so the final effect is ambiguous prior to a calibration.
λ_t^I and λ_t^m are the Lagrange multipliers associated to the budget and collateral constraint, respectively. The FOC with respect to consumption is

$$\lambda_t^I = \frac{1-\varphi_c}{C_t^I - \varphi_c C_{t-1}^I} \tag{2.2.7}$$

the FOCs with respect to borrower's housing asset, mortgage and labor, respectively, are

$$(1 - \frac{\lambda_t^m}{\lambda_t^I}\theta_m)p_t^h = \frac{\varphi_h}{\lambda_t^I h_t^I} + \beta_I \mathbf{E}_t \frac{\lambda_{t+1}^I}{\lambda_t^I} p_{t+1}^h \tag{2.2.8}$$

$$1 - \frac{\lambda_t^m}{\lambda_t^I} = \beta_I \mathbf{E}_t \frac{\lambda_{t+1}^I}{\lambda_t^I}(1 + r_{t+1}^b) \tag{2.2.9}$$

$$\frac{\varphi_l}{1 - l_t^I} = \lambda_t^I w_t^I \tag{2.2.10}$$

14. See Jappelli and Pagano (1994) and Chen et al. (2010).
15. See Muellbauer and Lattimore (1995) and Cheng and Fung (2008). The housing wealth acts as buffer stock. Buffer stock is a supply of inputs held as a reserve to safeguard against unforeseen shortages or demands. See Carroll et al. (1992).
16. See Christelis et al. (2015) and Cooper and Dynan (2016).

2.2.3 Shadow Bankers

The bankers are responsible of shadow banking financial institutions [17]. The banker's problem is

$$
\begin{aligned}
\text{Max} \quad & V_t = \mathbf{E}_t \sum_{\tau=t_0+1}^{\infty} \beta_B^{\tau-t_0}(1-\sigma)\sigma^{\tau-t_0-1}c_\tau^b \\
& s.t \\
& \text{Pro}\simeq \sigma \begin{cases} n_t = n_t^l = (r_t^k + (1-\delta_k)p_t^k)k_{t-1}^b + (1+r_t^b)m_{t-1} - (1+r_{t-1})d_{t-1} \\ c_t^b = 0 \end{cases} \\
& \text{Pro}\simeq 1-\sigma \begin{cases} n_t = n^n \\ c_t^b = n_t^l \end{cases} \\
& p_t^k k_t^b + m_t = d_t + n_t \\
& \theta_b(p_t^k k_t^b + m_t) \leq V_t \quad \text{where } 0 < \theta_b < 1
\end{aligned} \tag{2.2.11}
$$

where V_t is the bank's value function, β_B is the bankers' discount factor, c_t^b is the banker consumption and n_t is the total net worth of the shadow banker. There are two possibilities at the beginning of each period. First, the bank is still alive (with the probability σ). In this case, the banker pays off its liabilities and manages its net worth, $n_t = n_t^l$. Then the banker combines its net worth with new deposits d_t to operate new investments $p_t^k k_t^b + m_t$. Second, the banker fails and should leave the market (with the probability $1-\sigma$). In this case, the banker pays the liabilities and consumes all its net worth. Then, a new banker enters into the financial sector by receiving the start-up fund n^n, from lender households [18]. Thus, the banking utility function is defined as the present discounted value of banker's consumption. In both cases the bank balance sheet equates the liabilities to the assets.

The significant contrast between shadow and traditional banks arises from regulations.

17. The banking model here extends Gertler and Kiyotaki (2015)'s banking model to a bank granting mortgages.

18. This structure guarantees the existence of the steady state. Otherwise bankers accumulate their net worth every period, so the net worth is increasing and the aggregate net worth is not stationary. For more details on proof, see Gertler and Kiyotaki (2015) and Gertler et al. (2016a).

The last equation in problem 2.2.11 indicates an incentive compatibility constraint posed by the rationality of lenders restricts the liabilities of shadow banking sector. This constraint can be described by a simple agency problem.

Every period, the banker decides between operating normally or scamming. If the bank operates normally, it holds its assets and pays back the liabilities at the end of the period. If the bank chooses to scam, it sells the fraction, θ_b, of its assets in the open market, then leaves the economy. The banker is not able to sell the whole asset due to the asset illiquidity. In addition, this large financial transaction cannot be done without attracting attention. The capital constraint restricts the banker's ability to issue liabilities so that the banker's utility of the normal case is greater than the utility of the scamming case. One can see θ_b as the index of banker trustworthiness. The higher the value of θ_b, the greater the trust in the shadow banking system.

The value function is the expected present value of the next-period net worth. It is more informative to show this maximization recursively as a Bellman equation

$$V_t = \mathbf{E}_t \beta_B [(1-\sigma) n^l_{t+1} + \sigma V_{t+1}] \tag{2.2.12}$$

Equ. 2.2.12 drives the banker's *Tobin's Q*. It is the banker's value function over its net worth. Using the tobin's Q, the banker's problem can be rewritten as

$$\begin{aligned} \text{Max} \quad & v_t = \mathbf{E}_t \beta_B [(1-\sigma) + \sigma v_{t+1}] \frac{n^l_{t+1}}{n_t} \\ & \theta_b (\phi^d_t + 1) \leq v_t \end{aligned} \tag{2.2.13}$$

where $v_t = \frac{V_t}{n_t}$ is Tobin's Q and $\phi^d_t = \frac{d_t}{n_t}$ is the leverage ratio.

There is an arbitrage between the return on the mortgage and capital for the banker which drives the relation between the prices,

$$\mathbf{E}_t (1 + r^b_{t+1}) = \mathbf{E}_t \left(\frac{r^k_{t+1} + (1-\delta_k) p^k_{t+1}}{p^k_t} \right) \tag{2.2.14}$$

Considering the balance sheet and the arbitrage condition 2.2.14, the evaluation of net worth is

$$\frac{n_{t+1}^l}{n_t} = \frac{(r_{t+1}^k + (1-\delta_k)p_{t+1}^k)k_t^b + (1+r_{t+1}^b)m_t - (1+r_t)d_t}{n_t} \tag{2.2.15}$$

$$= s_{t+1}\phi_t^d + (1+r_{t+1}^b) \tag{2.2.16}$$

where $s_t = r_t^b - r_{t-1}$ is the spread between lending and borrowing rates. The first term of equ. 2.2.16 is the marginal profit gained by raising the deposit by one unit and the second term is the pure benefit from one unit of the net worth. From equations 2.2.4,2.2.5 and 2.2.14, the spread is a function of the lender management cost and the asset price

$$\beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P} s_{t+1} = \frac{f'(K_t^h)}{p_t^k} \tag{2.2.17}$$

Assuming the capital constraint is binding, the Bellman equation 2.2.13 leads to

$$\theta_b(\phi_t^d + 1) = \beta_B \mathbf{E}_t[(1-\sigma) + \sigma\theta_b(\phi_{t+1}^d + 1)](s_{t+1}\phi_t^d + (1+r_{t+1}^b)) \tag{2.2.18}$$

Equ. 2.2.18 describes the dynamic of the leverage ratio. The equation equates the minimum value of the marginal bank's value to the discounted marginal benefit of future operations. $s_{t+1}\phi_t^d + (1+r_{t+1}^b)$ is the growth rate of the net worth.

Equ. 2.2.18 demonstrates the main difference between shadow financial institutions and regular banks. The leverage ratio of the regular banks is subject to regulations. The regular banks should set their activities in order to meet the regulations. The shadow financial institutions are not subject to the banking regulations. Their leverage ratio is set endogenously by the market. The equation 2.2.18 illustrates that the leverage ratio of a bank does not depend on its net worth or other individual characteristic. This property helps write the model in the aggregate form.

2.2.4 Firms

A perfectly competitive non-housing goods market is characterized by constant returns to scale. The identical firms of measure one are producing a homogeneous final good according to the Cobb-Douglas technology. The profit maximization determines factor prices. All households except bankers work for the firm with labor elasticity, ι_P, ι_I. It is assumed that $\iota_P + \iota_I = 1$. The firm rents the capital from patient households and bankers in order to produce goods

$$Y_t = Z_t K_{t-1}^{\alpha_f}((l_t^P)^{\iota_P}(l_t^I)^{\iota_I})^{1-\alpha_f} \tag{2.2.19}$$

$$\Pi_t^f = Y_t - w_t^P l_t^P - w_t^I l_t^I - r_t^k K_{t-1} \tag{2.2.20}$$

Y is output, , $K = K^h + K^b$ is total capital in the economy, Z is total factor productivity and α_f is the output elasticity of capital. Π^f stands for the firms' profit. Factor markets are competitive. Factor prices are the result of the first order condition with respect to capital and labor, respectively

$$\alpha_f \frac{Y_t}{K_{t-1}} = r_t^k \tag{2.2.21}$$

$$(1-\alpha)\iota_i \frac{Y_t}{l_t^i} = w_t^i, \quad i = P, I \tag{2.2.22}$$

Total factor productivity Z has a stochastic nature. In the next sections, an adverse shock on this variable reduces productivity and starts a business cycle.

2.2.5 Capital Producers

In the economy there are perfectly competitive capital producers who produce capital subject to an adjustment cost. The capital investment by producers is i^k. The law of motion of capital is

$$[1 - \frac{\psi_k}{2}(\frac{i_t^k}{i_{t-1}^k} - 1)^2]i_t^k = K_t - (1-\delta_k)K_{t-1} \tag{2.2.23}$$

Capital producers buy the undepreciated part of the last-period capital from households and bankers to produce new capital. This capital is offered at price p^k to capital holders. Consequently, a producer maximizes [19] his gains as

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P} [p_\tau^k (K_\tau - (1-\delta_k) K_{\tau-1}) - i_\tau^k] \tag{2.2.24}$$

the first order condition for capital production reveals the capital price,

$$p_t^k [1 - \psi_k (\frac{i_t^k}{i_{t-1}^k} - 1) \frac{i_t^k}{i_{t-1}^k} - \frac{\psi_k}{2} (\frac{i_t^k}{i_{t-1}^k} - 1)^2] + \beta_P \mathbf{E}_t p_{t+1}^k [\frac{\lambda_{t+1}^P}{\lambda_t^P} \psi_k (\frac{i_{t+1}^k}{i_t^k} - 1)(\frac{i_{t+1}^k}{i_t^k})^2] = 1 \tag{2.2.25}$$

2.2.6 Market clearing

The leverage ratio of the bankers does not depend on individual bank specifics. So at time t, all the bankers behave in the same way. By using this feature, it is possible to describe the economy in the aggregate form. The capital letters state the aggregate variables. In the aggregate, the asset-to-net worth ratio ϕ is defined by

$$A_t \equiv p_t^k K_t^b + M_t = D_t + N_t \tag{2.2.26}$$

$$\phi_t \equiv A_t / N_t = \phi_t^d + 1 \tag{2.2.27}$$

where A is the total financial-sector asset. The aggregate net worth N is defined by

$$N_t^l = (1 + r_t^b) A_{t-1} - (1 + r_{t-1}) D_{t-1} \tag{2.2.28}$$

$$N^n = \varpi \overline{Y} \tag{2.2.29}$$

$$N_t = \sigma N_t^l + (1 - \sigma) N^n \tag{2.2.30}$$

where N^l is the aggregate net worth of the banking system at the beginning of period t and $(1-\sigma)N^n$ is the aggregate household donation towards establishing new banks. To simplify the calibration and to fix the leverage ratio steady state to the target,

19. See Christiano et al. (2005) and Smets and Wouters (2007).

it is supposed that the aggregate start up fund is equal to the small fraction, ϖ, of the output steady state.The aggregate bankers' consumption and the market clearing equations are

$$C_t^B = (1-\sigma)N_t^l \tag{2.2.31}$$

$$H_t = h_t^P + h_t^I = 1 \tag{2.2.32}$$

$$K_t = K_t^b + K_t^h \tag{2.2.33}$$

$$Y_t = C_t + f(K_t^h) + \imath_t^k \tag{2.2.34}$$

where H_t is total housing which is normalized to one and $C_t = C_t^P + C_t^I + C_t^B$ is total consumption. Output is equal to total consumption, capital holding fees and capital investment.

A set of prices and allocations define an equilibrium so that households and banks maximize their utility functions subject to all constraints and all markets clears (markets for good, housing, labor, deposit, mortgage and capital).

2.3 Calibration

Table 2.1 − Calibrated parameters (quarterly)

Parameters	Symbol	Value
Discount factors	$\beta_P, \beta_I, \beta_B$	$0.9901, 0.9877, 0.9876$
Consumption preference	φ_c	0.50
Housing preference	φ_h	0.08
Leisure parameter	φ_l	2.18
Capital depreciation rate	δ_k	0.035
Probability of survive	σ	0.96
loan-to-value ratio	θ_m	0.80
Truth index to bankers	θ_b	0.27
Coef. of start-up funds	ϖ	0.05
Coef. of capital cost function	α_k	0.0014
Elasticity of capital	α_f	0.37
Elasticity of labor	ι_P, ι_I	$0.51, 0.49$
Factor productivity SS	$\overline{Z}$	0.88
AR parameter of the shock	ρ_z	0.95
Capital investment adj. for Producer	ψ_k	2
Policy parameters	ρ_Ω, ϱ	$0.5, 3.5$

Table 5.1 presents the value of the parameters which are chosen from the US data to calculate the quarterly targets. In adherence to standard practices and maintain the comparability, a subset of parameters are taken from Gertler and Kiyotaki (2015). In the case of absence, parameters are calibrated from the very standard related literature or they are conventional and are calibrated to match the long-run averages observed in the data. The calibration here is closely based on US data from 1985-2015. This information is sourced from the World Bank, the OECD, the Federal Reserve Bank, the Financial Flow Accounts and the 2011 American Housing Survey (Census Bureau).

In order to have a binding borrowing constraint in the steady state, the impatient discount factor should be set less than the weighted average of the two others. According to Gertler and Kiyotaki (2015), this setting of discount factors results in an annualized average real interest rate on deposits of 0.04 and an interest rate on loans of 0.05. The housing preference and loan-to-value ratio are calibrated to jointly match two long-run proportions: the total housing value over GDP equal to 1.3 on an annualized basis according to the Federal Reserve and the ratio of mortgage debt owed by households relative to their real estate holdings equal to 0.30 according to the 2011 American Housing Survey. The coefficient of leisure time in the utility function is calibrated to insure that the labor supply of households are approximately 30%. Consumption preference is set to 0.5 according to Iacoviello (2015). By the preference settings, the share of patient consumption on total consumption is $c^P/C = 56\%$, impatient $c^I/C = 41\%$ and banker $c^B/C = 3\%$. This is corroborated by the OECD data. In addition, consistent with the Financial Flow Accounts data and Roi et al. (2007), the ratio of quarterly consumption to housing is around 0.1. The coefficient of capital cost by lenders is set to 0.0014 in order to target the share of household capital over total capital which is equal to 30% based on Gertler and Kiyotaki (2015). The trustworthiness index to bankers, the coefficient of start-up funds to new bankers, and probability of survival are calibrated to jointly match the target of the asset-to-net worth ratio which equals 8.4 (and consequently the leverage ratio equals 7.4) according to the OECD data 1995-2015, and capital over GDP equal to 1.5 on an

annualized basis according to the Federal Reserve Economic Data. The coefficient for adjustment cost for capital producers is set as per Justiniano et al. (2015). The capital depreciation rate is set to 3.5% according to Iacoviello (2015). Considering the target of capital, the interest rates and market clearings, elasticity of capital in Cobb–Douglas production function and total factor productivity are set to 0.37 and 0.88, respectively. The policy parameters come from Ghilardi and Peiris (2016).

2.4 Run and Recession

In this paper, the recession has a real origin. The shock to TFP exacerbates the deterioration of financial and real market conditions [20] by financial accelerator mechanisms which will be explained later in this section.

If the net worth of the shadow bank is positive, the economy has only one equilibrium. If the banking net worth gets negative, two equilibria coexist: bank run or no-bank run equilibrium. When the net worth is negative, paying off liabilities requires rolling over deposits by lenders. The decision of lender households between "still rolling over" or "stopping rolling over" deposits into the financial sector determines what equilibrium is chosen.

Rolling over deposits helps banking system pay off the liabilities by new deposits and accumulate net worth. This is the equilibrium without bank run. In the equilibrium with bank run, stopping rolling over forces the banking system to sell all its assets at the fire sale price to pay off the liabilities. In this case the run occurs because the value of the bank's assets at the fire sale price is less than the liabilities. The fire sale price might be well below the assets' intrinsic value. The price cutback depends on various elements such as the nature of the shock, bank's financial stance etc.

The equilibrium is selected by macroeconomic fundamentals and sunspots. By definition a sunspot is a non-payoff relevant signal that generates coordination on a particular equilibrium among many. While two equilibria coexist, at the same time,

20. See Bernanke et al. (1999) and Gertler et al. (2016b).

it is the sunspot which forms the bank run or no-bank run equilibrium [21].

The depositor recovery rate X depicts the sufficient condition for the existence of a bank-run equilibrium,

$$X_t = \frac{(r_t^k + (1-\delta_k)p_t^{k*})K_{t-1}^b + (1+r_t^b)M_{t-1}}{(1+r_{t-1})D_{t-1}} < 1 \tag{2.4.1}$$

where p^{k*} is the fire sale price. Expression 2.4.1 is equivalent to a negative net worth. As a result, the return on deposits is outlined by,

$$\text{The deposit interest rate} = \begin{cases} (1+r_{t-1}) & \text{No-bank run equilibrium} \\ X_t(1+r_{t-1}) & \text{Bank run equilibrium} \end{cases} \tag{2.4.2}$$

The timing of the model is as follows: the economy starts at the steady state at $t = 0$. At $t = 1$ an adverse technological shock hits the economy. This affects production, and consequently wages and the borrowing return rate. Total factor productivity Z follows $AR(1)$ process, a white noise process with zero mean and constant variance. If the shock satisfies $X_t < 1$, a bank run equilibrium exists. The bank run may occur in any period before X_t becomes greater than one. At any time t, to determine if a run occurs, as in GK's model, a sunspot can appear with a given probability: if the sunspot appears, then the run occurs and the economy follows then the "bank run" equilibrium; if the sunspot does not appear, then there is no run at t and the economy keeps following the "no bank run" equilibrium.

Figure 2.1 (left) presents the path for the depositor recovery rate X_t after the 5% adverse technological shock [22]. The run can happen when the depositor recovery rate is less than one.

21. Agents can coordinate based on the observation of the signal. Sunspots are extrinsic random variables which influence expectations. The extrinsic uncertainty caused by market psychology, self-fulfilling prophecies and panics etc can alter equilibrium outcomes.

22. The shock should be big-enough to make banks insolvent. Here I chose 5% adverse shock as well as Gertler and Kiyotaki (2015) to keep the comparability of the model with the model without housing. In addition, the same methodology as Gertler and Kiyotaki (2015) is used to solve and simulate the model. Starting from the end of the simulation and working backwards, the program compute the path of the economy after a run happens back to steady state.

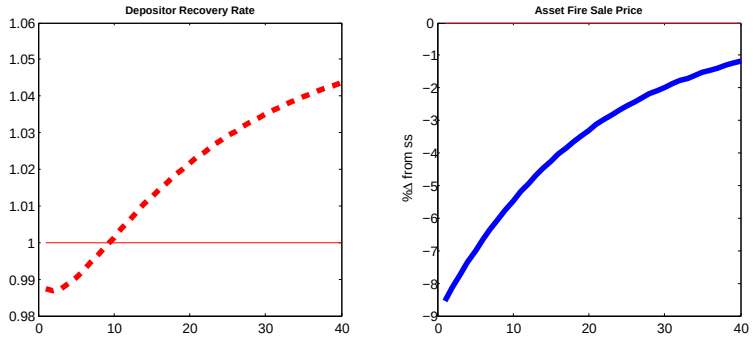

Figure 2.1 – Bank run may happen in periods in which the depositor recovery rate (left) is less than one.

The asset fire sale price, using equ. 2.2.5, is

$$p_t^{k*} = \mathbf{E}_t \left[\sum_{i=1}^{\infty} \beta_P^i \frac{\lambda_{t+i}^P}{\lambda_t^P} (1-\delta_k)^{i-1} [r_{t+i}^k - (1-\delta_k)\alpha_k K_{t+i}^h] \right] - \alpha_k K_t^h \tag{2.4.3}$$

The asset fire sale price is the discounted sum of the returns minus the managing cost and taking into account the depreciation rate. Figure 2.1 (right) presents the fire sale price after the 5% adverse technological shock. This price is the capital price at the period of the run. So figure 2.1 (right) is only meaningful for the periods in which bank run is possible i.e. the depositor recovery rate is less than one. The later the run, the higher the fire sale price. Equ. 2.4.3 indicates three important points; first, the price depends on the household's capital holdings. The higher the volume of household's capital, the higher the marginal management cost and the lower the fire sale price. Second, it takes time until household's and bank's capital return to the steady state. The longer this process, the lower the fire sale price. Third, the price depends on the size of the shock: the more severe the adverse shock, the lower total factor productivity and the lower the expected yield. This means a lower return on capital and consequently, a lower fire sale price.

Figure 2.2 and 2.3 (dashed lines) present the paths of the aggregate variables after the 5% adverse technological shock for no-bank-run equilibrium.

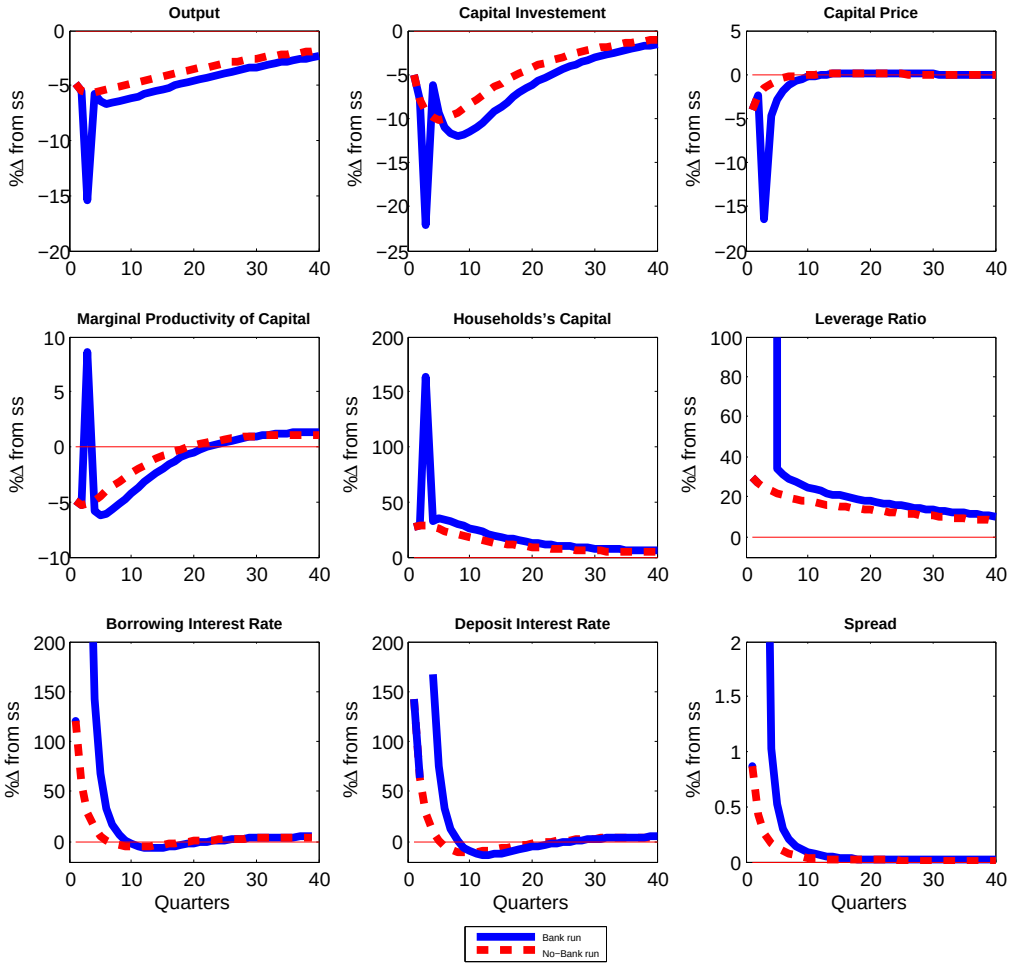

Figure 2.2 – % change from the SS for the key variables, 5% technological shock at t=1, bank run at t=3

The explanation of the economy after the shock and before the bank run is as follows (the summary of mechanisms is depicted in figure 2.4). After the shock, banks suffer losses, so their net worth declines. This leads to a reduction in investment and capital prices. The drop in the capital price feeds back into lower net worth and leads to an increase in bank leverage. The reason why banks are allowed to take on more leverage is the credit spread. This financial amplification (same as in GK's model) rests on the countercyclical behavior of credit spreads. Figure 2.2 shows that after a negative realization of TFP, both the leverage ratio and spread increase.

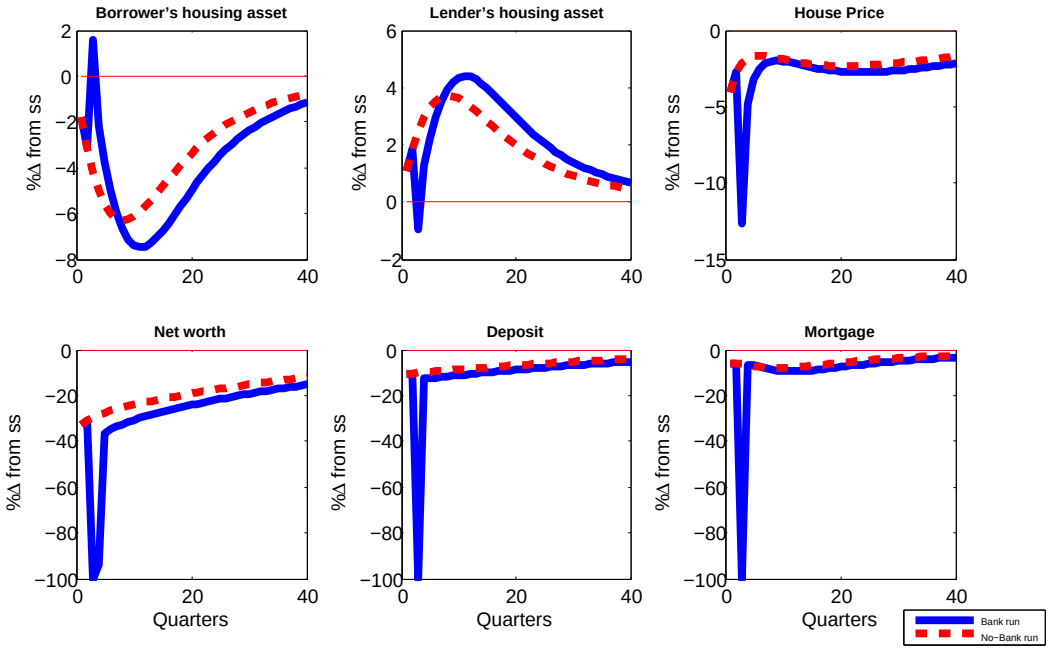

Figure 2.3 – % change from the SS for the household and financial variables, 5% technological shock at t=1, bank run at t=3

In addition to credit spreads, before the bank run, the adverse real shock propagates into the economy of this model through two channels: *i*) The household balance sheet channel: The adverse shock reduces output as well as wages and the return on capital. This reduces the household wealth. As a result, lender households decrease their deposit and capital. In addition, borrower households reduce their housing and mortgage demand. So the house price drops. It is why lenders increase their housing. The low-price housing asset tightens the collateral constraint and therefore, again, adversely effects mortgages.

ii) the bank balance sheet channel: the shock affects both asset and liability sides. 1- the asset side: the TFP shocks reduces the marginal productivity of capital. As a result, net worth drops. In this situation, the bank has to reduce issuing credits. There is a reduction in resources available for borrowing, so there is less capital for production and less available resources for mortgages. The former caused a vicious circle between capital and output. In addition, the reduction in mortgages causes the borrowers' house demand to decline. This, consequently, decreases the house price. 2-

the liability side: due to financial constraints, banks cannot pay off their liabilities by taking up more leverage. As a result, they are forced to deleverage. By deleveraging, banks sell their assets to pay off liabilities. This reduces bank's capital.

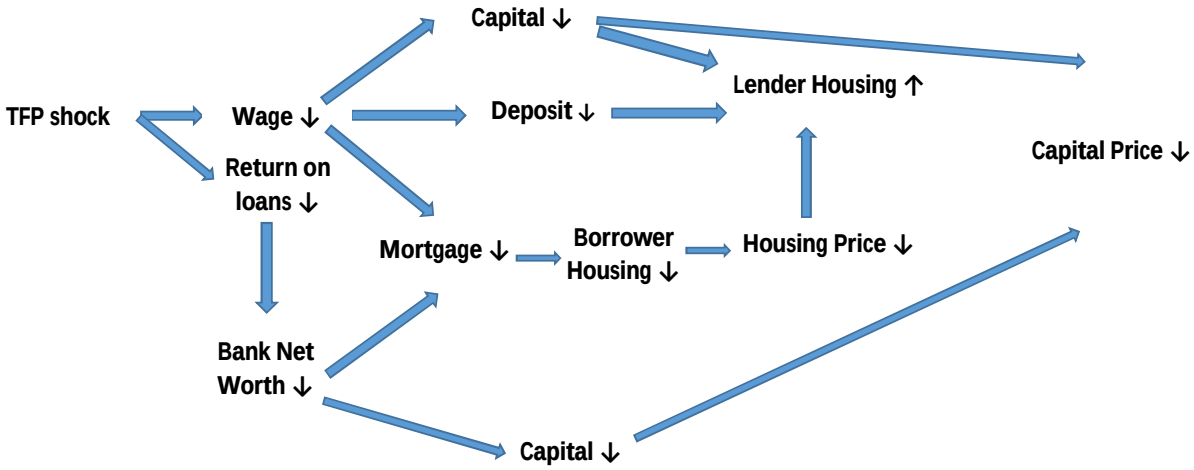

Figure 2.4 – Mechanism of the model, after the shock before the bank run.

The bank run equilibrium is as follows. The bank run is unexpected. Hence, the behavior of the economy before the run is the same as the no-bank run equilibrium. If the sunspot determines the bank run equilibrium at t^*, banks are forced to liquidate all their assets at t^*. During the period of the systemic bank run, the intermediary sector becomes inactive. Households continue their activities without bankers. It is assumed that only one bank run occurs and there are no other bank runs after the first one. This circumstance leads to the zero balance sheet for banks at t^*: $N_{t^*} = A_{t^*} = M_{t^*} = K^b_{t^*} = D_{t^*} = 0$.

During the period of the run, lender households collect capital and invest directly. The lender's budget constraint becomes:

$$C^P_{t^*} + p^h_{t^*}(h^P_{t^*} - h^P_{t^*-1}) + p^k_{t^*}K^h_{t^*} + f(K^h_{t^*}) \leq w^P_{t^*}l^P_{t^*} + (1 + r^b_{t^*})(A_{t^*-1} + p^k_{t^*-1}K^h_{t^*-1}) \tag{2.4.4}$$

where $K_{t^*} = K^h_{t^*}$ indicates the total capital. At this period, borrowers do not have access to credit so they smoothen their consumption using their assets and income.

The borrower's budget constraint is:

$$C^I_{t^*} + p^h_{t^*}(h^I_{t^*} - h^I_{t^*-1}) + (1 + r^b_{t^*})M_{t^*-1} \leq w^I_{t^*} l^I_{t^*} \tag{2.4.5}$$

At the period after the run, $t^* + 1$, the banking sector is revitalized. It uses the start-up fund provided by lender households to rebuild itself over time. In other words, the economy continues with the pre-run structure while all banks are newborn using start-up funds.

Figure 2.2 and 2.3 (solid lines) present the paths of the aggregate variables after the 5% adverse technological shock for bank run equilibrium. Here, it is assumed that the bank run occurs unexpectedly at $t^* = 3$ (the second period after the shock). No further bank runs occur after the first bank run.

The following is the interpretation of the time of bank run. When there is the run, households get all capital in the economy at the fire sale price. To do so, households reduce their housing. This, again, reduces housing prices. Note that there is no deposit for one period at t^*, because banks get inactive. Borrowers benefit the low house price and the excess supply of housing to increase their housing [23]. The summary of mechanisms at the bank run is depicted in figure 2.5.

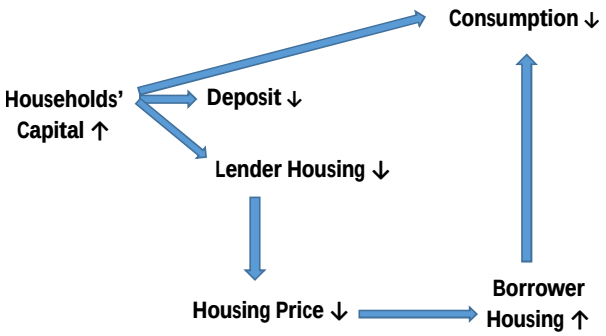

Figure 2.5 – Mechanism of the model at the bank run.

After the run, the TFP shock monotonically retrieves to the steady state. This is not the case for the other variables in the model e.g. capital, housing and output. Due to

23. It is also the effect of the normalization of total housing supply to one, equ. 2.2.32.

the quick price increase after the bottom point (at the run), there is a short period of a high capital return. This leads to an *overshooting* in capital investment. This investment boom leads capital to go above the no-run case and make a peak for GDP. In addition, banks try to get back a part of their previous capital but given that the bank net worth remains depleted, the financial frictions slow down this recovery.

Figure 2.3 indicates an interesting point about the behavior of the house price: *the home price double-dip*. The figure shows that the home price has sagged to another low after rebounding from the shock. The US data shows the double-dip in the house price in 2010, two years after the crisis. Two mechanisms take the home price double-dip into account. Lender's and bank's portfolio decision. The first drop in housing prices occurs during the run (explained in the previous paragraphs and figure 2.5). After the run, the banking system restarts its activities and retrieves capital. This gets lenders the opportunity to increase deposits and housing. As a result, the housing price increases. This relaxes collateral constraints and increases the mortgage demand. Bank is in the recovery period, so needs to issue more loans and accumulates more net worth. To do so, bank needs more deposit. The bank's deposit demand is constrained, so bank can raise the desired amount of deposit with the low interest rate. As a result, lenders issue more deposit and reduces their housing. For this process to be the optimal decision of lenders, the return on the housing must be low. This low return is made by housing price decreased. So the housing price reduces one more time after the crisis. Lastly, the price goes back monotonically to its steady state value.

The ways in which financial collapses contribute slow recovery can be determined by comparing the run and no run equilibrium paths in figure 2.3. The output's path of the run equilibrium is always below that of the no run equilibrium. This means that the financial collapse poses damage on recovery. This damage is mostly made in three ways. First, the financial collapse severely reduces asset prices through the process of asset fire sale. Second, the financial collapse exacerbates housing and credit markets.

Third, the financial collapse increase the production cost.

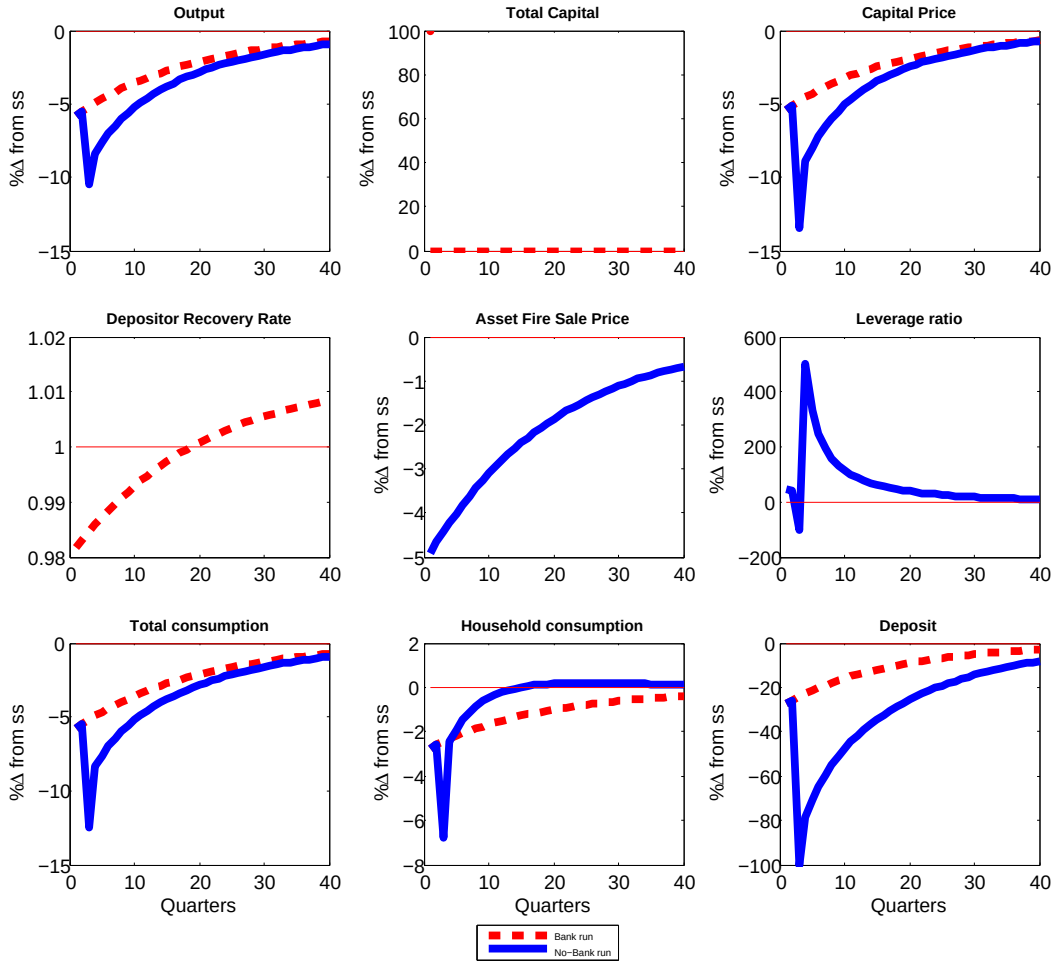

Figure 2.6 – Aggragate changes for a 5% real shock in the model without housing and credit markets

Figure 2.6 presents the response of aggregate variables of Gertler and Kiyotaki (2015) (the model which excludes the housing and credit markets) for the same size of TFP shock. There are four major differences between the results of this paper and GK. First, in this model, the economy exits faster from the bank runs-possible area than in the case of GK's economy. The period in which run can occur in GK's model is twice that of this paper. This is due to the absence of the credit market in the simple model. The borrowers' need to raise credit creates revenue for the banking sector which increases the bank's profitability. Second, GK's model is not able to capture the output downward spiral. This is due to its fixed total supply of capital

and the fact that capital cannot depreciate. In addition, in GK's model there is no rigidity in the form of capital adjustment costs. The adjustment cost makes the shock persistence. Third, this paper simulates a lower asset fire sale price than GK's model. Indeed, housing reduces the asset fire sale price. This is because of the expansion in the lender household choices for saving. The availability of cheap houses increases lenders' housing demands. As a result, the household does not forced to only buy capital, but he can changes its portfolio depending on the trad-off between return and costs. Fourth, the output downfall in this model is more severe than GK's model. The reason for this is a contraction in borrower consumption which is due to tightening in the collateral constraint.

2.5 Macroprudential Policy

This paper studies macroprudential policy on the bank balance sheet by introducing Capital Adequacy Ratio (CAR) and on the borrower balance sheet by the cap on the Loan-To-Value (LTV). Banks are obliged to pay a penalty if their CAR deviates from the regulatory target [24]. As a result, the bank aggregate net worth 2.2.30 changes to

$$N_t = \sigma N_t^l + (1-\sigma)N_t^n - \varrho(\frac{N_t}{p_t^k K_t^b} - \Omega_t)^2 \tag{2.5.1}$$

$$\Omega_t = (1-\rho_\Omega)\overline{\Omega} + \rho_\Omega \Omega_{t-1} + (1-\rho_\Omega)(\frac{Y_t - Y_{t-1}}{Y_{t-1}}) \tag{2.5.2}$$

where Ω_t is the macroprudential CAR target. This value considers only bank's capital asset and not other assets such as mortgages. This is in line with existing regulations. ϱ is the policy parameter, $\overline{\Omega}$ is the steady state value of $\frac{N}{p^k K^b}$ [25] and $0 < \rho_\Omega < 1$ is the parameter of the process. The growth value added to the CAR target corresponds to a countercyclical policy. It gives the flexibility to the policy to increase the target in booms and decrease it in recessions. This is in accordance with the current applied macroprudential policies recommended by Basel III.

24. This modeling is standard and applied by Ghilardi and Peiris (2016).
25. $\overline{\Omega}$ is such that the steady state of the model is not modified by different value of $\overline{\varrho}$.

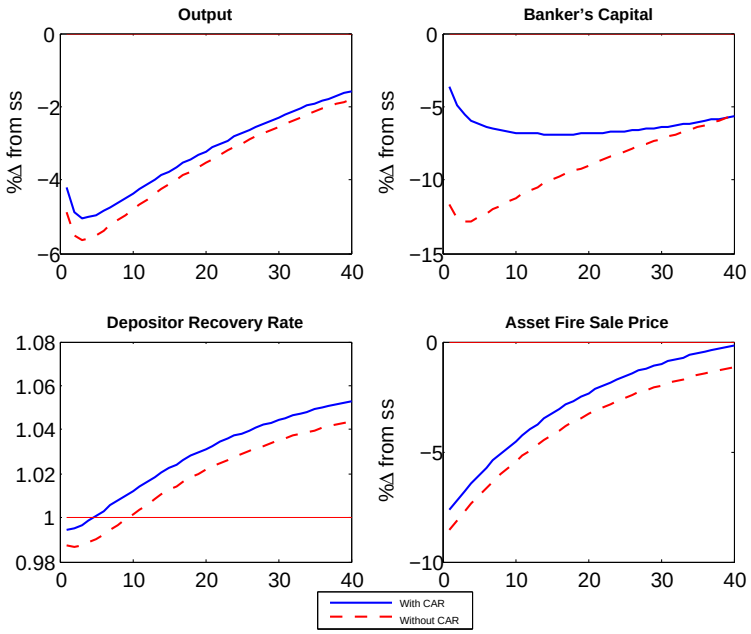

Figure 2.7 – Impact of introducing the CAR

Figures 2.7 and 2.8 present the impact of the 5% adverse real shock in the presence and absence of the macroprudential policies. Introducing the CAR target and cutting down the LTV by 1% insulates the banks' capital assets against extreme drops. These policies increase the resilience of the financial sector and have three impacts on the economy: *i*) increasing asset fire sale prices, *ii*) regulating credits and *iii*) reducing the volatility of the real economy.

The CAR regulating policy imply that banks recover faster. This happens because the capital fire sale price is higher in this case than that of no-regulation case. The CAR insulates the capital fire sale price because it obliges the banking sector to always keep a certain amount of capital. From equation 2.4.3, the lower the bank's capital holding, the lower the capital fire sale price. Hence, the drop of net worth (equivalently, X) at the shock is smaller. This is of course in the price of limiting mortgages and dampening the housing market.

The LTV has the same impact as the CAR. By reducing the LTV, banks issue less mortgage, and keep more capital. This has the same as the CAR on the capital fire sale price. All these effects mitigate fluctuations in the real economy. This may

impede boom-bust business cycles.

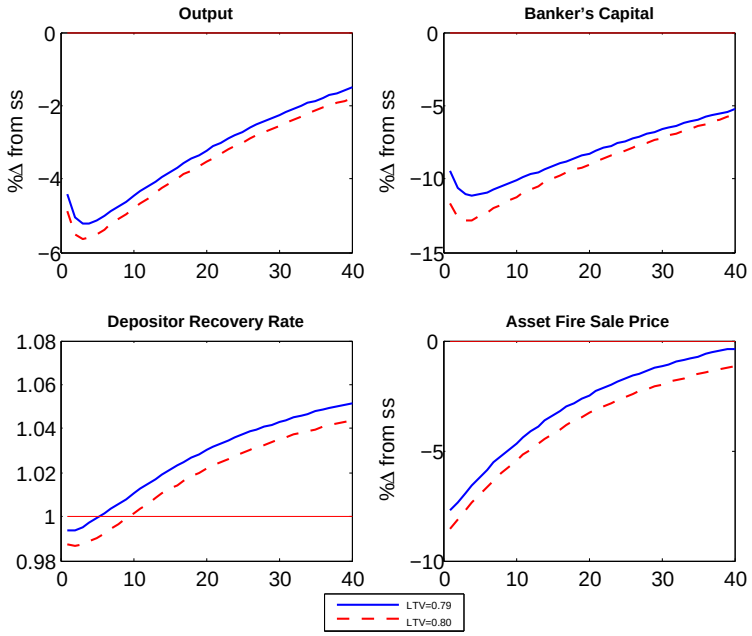

Figure 2.8 – Impact of cutting down the LTV

The main result of this section is that given a TFP shock, there is a proper value of policy parameters (θ_m and ϱ) which eliminate the bank run equilibrium. In other words, the depositor recover rate does not get less than one after the shock. As a result, the economy passes only in the no-bank run equilibrium path. The value of these parameters are critical for 2 reasons. First, the higher the value, the lower the mortgage supply and the lower the borrowers' housing demand. Second, the proper value is highly depends on the size of the expected shock. If the shock is not close to the expectation, the proper value is not any more a good value. As a result, a policy maker, before setting a value, should pay attention to the trade-off between protecting the financial sector and the impacts on the housing and credit markets. Then the parameters should be set carefully based on the economic situation and economic targets.

2.6 Conclusion

This paper improves the DSGE model of Gertler and Kiyotaki (2015) to study the impact of the housing and credit markets on the stability of the economy. The model is made representative of the real economy through the introduction of two types of heterogeneous households: lender and borrower. In addition, the model incorporates the financial sector in the form of shadow banking system, goods and capital producers. The key elements of the model are stochastic financial frictions in the form of collateral constraint for the borrowers and incentive compatibility constraint for the banking sector. This paper indicates how direct linkages and associated financial channels lead to the transmission of shocks from one sector to another, and how this can be intensified by feedback loops. In addition, an assessment is made of the amendatory role of macroprudential policy tools, in particular the CAR and LTV, in safeguarding financial stability.

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Chapter 3

Housing Taxation and Financial Intermediation

With

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Abstract

Through the lens of a multi-agent dynamic general equilibrium model, we examine the effects of four permanent changes in housing taxes and deductions on macroeconomic aggregates and welfare. We find that these changes have very small effects on economic activity in the short-run. The short-run tax multipliers that we find over a horizon of 20 quarters range from -0.02 to -0.13, while the long-run tax multipliers found range from -1.43 to -0.81. The presence of borrowing-constrained bankers dampen the negative consequences of housing taxation on output—especially in the short run. The reduction in the deduction of mortgage interest payments delivers the lowest long-run multiplier. We also implement revenue-neutral tax reforms and find that the repeal of mortgage deductibility is the only policy that generates gains in output.

JEL classification: E62, G28, H24, R38.

Keywords: Housing taxation, banking, dynamic general equilibrium.

3.1 Introduction

The importance of housing finance has grown substantially in the past decades in the United States. In 1970, mortgage debt corresponded to 26% of GDP; less than four decades later, in 2007, this ratio rose to 71%. Its weight on the commercial banks' balance sheets has also grown substantially. Specifically, mortgage lending as a fraction of total bank lending was 70% in 2007, up from 55% in 1970. [1] Throughout the same period, housing value as a proportion of GDP has almost doubled—moving up from 0.9 in 1970 to 1.7 in 2007. This build-up in mortgage debt and housing value is partially due to the favorable treatment of housing in the US tax code. In fact, mortgage interest payments are deductible from taxable income, and imputed rents on owner-occupied housing are exempted. Furthermore, owners of rental housing have access to a deduction for depreciation allowance. Making changes to the housing fiscal policies leads to greater tax revenues for the government, but at the expense of output losses. What are the effects of such changes in the short and long-run on aggregate variables and welfare? Alternatively, how would these variables react if the government decides to implement tax revenue neutral reforms?

In this paper, we pay special attention to the role of financial intermediaries in the transmission of permanent housing policy changes. Recent work that examine the role of banking on business cycles find that the presence of intermediaries amplify and propagate shocks [2]. Contrary to this strand of the literature, our results suggest that the presence of banks can dampen the effects of permanent housing tax policy changes.

Our model is closely based on Alpanda and Zubairy (2016). They incorporate to their framework the multi-agents structure and household borrowing constraints that are featured in iacoviello2005house work. [3] In addition to patient, impatient, and

1. See Jordà et al. (2016) for the evolution of bank loans over a long horizon for 17 advanced countries.

2. See *e.g.* Angeloni and Faia (2013), Brunnermeier and Sannikov (2014), Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Meh and Moran (2010).

3. Another paper that uses the structure of Iacoviello (2005) to examine housing tax policy is Ortega et al. (2011). However, they focus on the Spanish housing market, and their policy

renter households that are present in their framework, we introduce bankers to the economy in a similar fashion to Iacoviello (2015). The policy changes that we examine only affect the intensive margin of housing, since households cannot switch types. [4] Specifically, the housing tax policies that we examine are (i) the deduction of mortgage interest payments I_{mt} for impatient households, (ii) the deduction of imputed rents I_{rt}, (iii) the property tax τ_{pt}, and (iv) the depreciation allowance $\tilde{\delta}_{ht}$. Note that the policy change (i) is of particular interest, since the tax plan proposed by the Trump administration in November 2017 encompasses a repeal of mortgage interest deductibility for the portion of mortgages that exceed $ 500,000—down from one million dollars.

Housing tax policies are ranked according to the values of their long-run multipliers, which correspond to the ratio of the present value loss in output over the present value of tax revenues that are raised. We find long-run multipliers that range from -1.43 to -0.81. The size of these multipliers are not due to short-run transitions, since the multipliers that we find at a horizon of 20 quarters are much smaller—they range from -0.02 to -0.13. We also find that the new channels of propagation that arise with the introduction of a banking sector do not affect the ranking of long-run multipliers; however, as will be shown below, the presence of this sector dampens the adverse effects of changes in housing tax policies. Specifically, the less favorable policies are for impatient households, the more they are effective at limiting output losses. In fact, the distortion created by the deduction of interest mortgage payments is determinant. When this distortion is directly partially eliminated, *i.e.* in the case of policy (i), the output loss that ensues is the smallest (the long-run multiplier is -0.81). As for the mechanism, it works as follows. Since impatient households decrease their demand for housing, its price falls, which leads patient and renter households to consume more housing services.

instruments differ. Specifically, they examine the role of subsidies on house purchases and rentals.

4. As discussed by Alpanda and Zubairy (2016, pp. 508-510), this assumption is consistent with empirical evidence. Instituting partial taxation of imputed rents could even lead to an overestimation of output loss, as some impatient households would become renters. However, these changes are not large enough to modify the ranking of housing tax policies.

On the opposite side of the spectrum, the reduction of the depreciation allowances for rental income—*i.e.* policy (iv)— directly affects renters since the rental price of housing increases. There is a shift from rental to owner-occupied housing that takes place, which is beneficial for impatient households. This leads to an increase in mortgage payments for the latter that does not benefit the government, since these payments are fully deductible. Hence, depreciation allowances need to be further decreased in order for tax revenues to accrue. This reallocation of housing is detrimental in terms of output losses (the long-run multiplier is -1.43).

Even though the presence of banking does not modify the ranking of housing tax policies, it deflates the effects of these policies on output losses. [5] The causes of these smaller multipliers differ from one policy change to another. For the deduction of mortgage interest payments—policy (i)—the difference in multipliers is related to the interest rate spread incurred by the introduction of banking. In fact, the interest rate at which impatient households borrow is greater than the one that patient households receive on their deposits, as well as the equilibrium rate in a framework without banking. Therefore, the government does not need to reduce the deductibility of mortgages as much to increase its tax revenues, which results in smaller effects on housing. These effects are important to explain the dynamics of GDP, which includes a fraction of housing stock. Thus, smaller effects on housing implies smaller effects on output, and ultimately a smaller long-run multiplier.

For policies (ii) and (iii)—*i.e.* reduction in deduction of imputed rents and increases in property taxes—the lower output losses relative to the losses generated by the model without banking are also accounted by the smaller response of housing. Specifically, it is the housing stock held by impatient households that falls less. One important property of this fraction of housing is that it is used as collateral. Since they benefit from the spread between the deposit rate and the lending rate, bankers have some incentives to lend as much as possible. Following these policy changes, they absorb

5. The multipliers that we find are much smaller than the ones put forward by Alpanda and Zubairy (2016), for whom they range from -2.21 to -1.52. However, as we report in Ghiaie and Rouillard (2018), there is a coding error in their model that greatly affects the dynamics of business investment, and thereby the multipliers that they obtain.

some of the negative consequences by consuming less. In contrast, in the model without banking, the agents that lend are the patient households. Since they are able to redirect their lending into capital investment or rental housing, loans fall by a greater margin. Hence, the type of agents that lends matters for the response of housing and GDP.

As noted above, the reversal of depreciation allowances for rental housing—policy (iv)—is beneficial for impatient households who increase their housing loans and consumption services. By lending more, bankers increase their profits and consumption. Hence, by facilitating financial intermediation, this policy change has less detrimental effects in our baseline model than for the model without banking.

Finally, we implement three revenue-neutral tax experiments: the repeal of mortgage deductibility, the taxation of imputed rents at the same rate as labor income, and the repeal of the depreciation allowance for rental income. For each of these experiments, we lower the labor income taxes, so that the net present value of taxes is nil. Since lower taxes incentivize agents to work more hours, the rise in non-housing output is not large enough to overturn the effects of the fall in housing stock in the long-run. In fact, out of the three reforms, the repeal of mortgage deductibility generates the smallest losses in output in the long-run, which makes it the most appealing policy. However, in the short-run, we find increases in the present value of GDP for all experiments.

The rest of this paper is organized as follows. In section 3.2, we review the related literature. Sections 3.3 and 3.4 present the model and its calibration, respectively. Section 3.5 discusses the effects of permanent housing tax policy changes on the main aggregate variables and on welfare. Section 3.6 concludes.

3.2 Related literature

Our paper is related to the literature that examines the effects of changes in housing tax policy through the lens of theoretical models.[6] Gervais (2002) embeds the decisions of households to own or rent in a general equilibrium life-cycle model. His baseline model features the same properties of the US tax code for the housing sector, and financial institutions are embedded to simplify the exposition. These institutions are a veil, since they are zero-profit and unconstrained. In contrast, in our model, they play an active role in dampening the effects of policy changes. Gervais (2002) conducts two separate experiments: he introduces taxation for imputed rents, and a repeal of mortgage interest deductions. Both these experiments are tax revenue neutral, as the income tax rate is lowered simultaneously. By comparing steady state outcomes, he finds that both these changes are welfare-improving, since it allows households to better smooth their consumption. They result in significant shifts of resources from housing (-8.56%) to business capital (+6.4%) when imputed rents are taxed, whereas housing is unchanged and business capital increases (+4%) when mortgage interest deductions are repealed. Homeownership declines significantly following these housing tax policy changes.

In a similar type of framework, Chambers et al. (2009) examine the same two policy changes with special attention given to the supply of rental property and to the progressivity of the US tax system. They corroborate a crowding-out effect, as the stock of housing falls and capital increases, in response to the elimination of some asymmetries in housing taxation. Floetotto et al. (2016) emphasize the importance of considering transitional dynamics prior to undertaking housing tax policy changes. In fact, because in the short-run the fall in house prices overshoots its level in the terminal steady state, they find that taxing imputed rents is welfare-improving in the long-run for the economy, but not in the short-run. Similarly, for the repeal of mortgage interest deduction, the positive effects on welfare are greater in the long-run than in the short-run. There are also important distributional effects that result

6. For empirical contributions to the literature, see Glaeser and Shapiro (2003), Poterba (1992), Poterba and Sinai (2008), Rosen (1979).

from changes in these policies. Sommer and Sullivan (2013) underline the interaction between the progressivity of income taxation and the consequences of the repeal of mortgage interest deduction. In contrast, Floetotto et al. (2016) consider only a flat income tax. The decline in house prices in response to this tax policy change is welfare-improving for 58% of households and contributes to an increase in homeownership.

Chatterjee and Eyigungor (2015) simulate a model with shocks that reproduce the house price and foreclosure dynamics of the recent financial crisis. From their counterfactual experiment, they find that the rise in foreclosures would have been 10 percentage points lower—and the crisis much smaller—without a preferential tax treatment of mortgage interest payments. Alpanda and Zubairy (2017) compare the effectiveness of various policies that are aimed at reducing household indebtedness, since a high level of debt poses threats to financial stability. They find that a reduction in mortgage interest deduction—via its effects on home equity loans—is more effective and less costly than an increase in property taxes and a tightening of monetary policy. From the simulation of a housing search model that features geographical mobility and labor market frictions, Head and Lloyd-Ellis (2012) find that the elimination of mortgage interest deductibility leads to falls in house prices and in unemployment. BieSta:2018 New Keynesian model also features housing search frictions. They find that labor tax reductions financed by a rise in property taxes generates the highest level of welfare.

As we have mentioned above, we show that the banks' balance sheet channel is important in explaining the dynamics of macroeconomic aggregates following changes in housing tax policy. In our model, the banking sector is not a veil, in contrast to Gervais (2002), for example. Financial intermediation in the household mortgage market is present in other work; however, they focus on different objectives than our paper.[7] Iacoviello (2015) examines how the inclusion of a banking sector to a DSGE model amplifies and propagates financial shocks. Elenev et al. (2016) study the role of mortgage default insurance that is provided by the government on the amount of risk

7. For a review of the literature on the role of banking in dynamic general equilibrium models, see Galati and Moessner (2013).

exposure by the banks. Contrary to their work, we do not consider home foreclosures. Finally, Landvoigt (2016) puts forward the role of mortgage loans' securitization to explain the US housing boom in the 2000s.

3.3 Model

In this section, we present the optimization problems of the agents, the firms, and the capital and housing producers. We also show and discuss the tax instruments that the government possesses in the economy. We refer the reader to the Appendix for a complete derivation of the first order conditions.

All agents consume non-durable goods. Patient, impatient, and renter households also derive utility from housing services and leisure. Actions that are specific to each type of agents are as follows. Patient households rent a fraction of their housing stock to renters, accumulate housing and capital stocks, and earn interest on deposits made to bankers and on their holdings of government bonds. Impatient households finance their consumption and housing investment by contracting mortgage loans from bankers. Their loans are constrained by the value of their housing stock which is their collateral asset. We assume that renters are *hand-to-mouth*, so that their consumption of non-durable goods and houses corresponds to their after-tax labor income. Bankers act as a transmission belt between impatient and patient households. They are able to issue mortgages from the deposits made by patient households. However, they face a capital adequacy constraint so that deposits cannot exceed a fraction of mortgages issued. Finally, the government collects taxes from various sources, borrows from patient households, makes transfer payments to agents, and makes expenses.

3.3.1 Patient households

Patient households are savers, since they have a greater discount factor than other agents ($\beta_P > \beta_i$ where $i = I, R, B$). They maximize the following discounted sum of

period-utilities:

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \{\log c_t^P + \varphi_h \log h_{t-1}^P - \varphi_l \frac{(l_t^P)^{1+\iota}}{1+\iota}\} \tag{3.3.1}$$

where c_t^P corresponds to their consumption of non-durable goods, h_{t-1}^P to their housing stock chosen in period $t-1$, and l_t^P to their labor supply. The parameters φ_h and φ_l corresponds to the weights allocated to housing and leisure, and ι to the inverse of the Frisch elasticity of labor supply.

Their budget constraint is as follows:

$$\begin{aligned}
&(1+\tau_c)c_t^P + p_t^h[h_t^P - (1-\delta_h)h_{t-1}^P] + p_t^h[h_t^R - (1-\delta_h)h_{t-1}^R] \\
&+ p_t^k[k_t - (1-\delta_k)k_{t-1}] + d_t + b_t^g \leq w_t^P l_t^P + p_t^R h_{t-1}^R \\
&+ (1+r_{t-1}^d)(d_{t-1} + b_{t-1}^g) + r_t^k k_{t-1} + \Gamma_t^P - \tau_y[w_t^P l_t^P \\
&+ (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_{rt} h_{t-1}^P) - \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R)] \\
&- \tau_d r_{t-1}^d (d_{t-1} + b_{t-1}^g) - \tau_k (r_t^k - \delta_k) k_{t-1} - \tau_{pt} p_t^h (h_{t-1}^P + h_{t-1}^R) - AC_t^P
\end{aligned} \tag{3.3.2}$$

where h_{Rt} is the rental housing stock, k_t is the capital stock that they rent to firms at rate r_t^k. It depreciates at rate δ_k. The relative prices of housing and capital are p_t^h and p_t^k, respectively. Note that there are adjustment costs AC_t^P for choosing levels of housing that deviate from their steady states. [8] Every period, patient households also choose the amount of deposits that they make to bankers d_t, and the quantity of lending that they make to the government b_t^g. Interest accrue at rate r_{t-1}^d. Patient households are paid wages w_t^P for the hours that they work for firms. Their rental income corresponds to $p_t^R h_{t-1}^R$ where p_t^R is the rental price. There is a depreciation allowance for housing $\tilde{\delta}_{ht}$, which may differ from the depreciation rate of housing δ_h.

The government has many instruments to tax patient households: τ_c is the consumption tax rate, τ_y is the tax on labor and rental income, τ_d is the tax on interest income, τ_k is the tax on capital income, and τ_{pt} is the property tax rate on

8. We assume that these costs are quadratic: $AC_t^P = \frac{\psi_a}{2\bar{h}^P} p_t^h (h_t^P - h_{t-1}^P)^2 + \frac{\psi_a}{2\bar{h}^R} p_t^h (h_t^R - h_{t-1}^R)^2$.

housing. $0 < I_{rt} < 1$ is another policy instrument that is inversely proportional to the deduction of imputed rental income. Finally, the government transfers Γ_t^P to these households.

In order to examine the effects of tax policy changes, we present the first order conditions with respect to owner-occupied and rental housing. For the sake of simplification, we set the parameter that governs housing adjustment costs ψ_h to zero when presenting the first order conditions. The first order condition with respect to owner-occupied housing is

$$\lambda_t^P p_t^h = \beta_P \mathbf{E}_t[\frac{\varphi_h}{h_t^p} + \lambda_{t+1}^P \Big[(1 - \delta_h - \tau_{pt+1}(1 - \tau_y))p_{t+1}^h - I_{rt+1}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht+1})\Big] \tag{3.3.3}$$

where λ_t^P is the Lagrange multiplier of the budget constraint. In equilibrium, it is equal to the marginal utility of consumption. The left-hand side of equation (3.3.3) corresponds to the cost in terms of consumption that the patient households incur to purchase an additional unit of owner-occupied housing stock, while the right-hand side presents the benefits of that additional unit. Patient households derive utility from consuming housing services, and they also make capital gains that are taxed. One can see that the government distorts the decisions of investing in owner-occupied housing via its tax policy instruments. The government also distorts incentives for patient households to own rental housing. Specifically, the first order condition with respect to rental houses is

$$\lambda_t^P p_t^h = \beta_P \mathbf{E}_t[\lambda_{t+1}^P(1 - \delta_h - \tau_{pt+1}(1 - \tau_y)p_{t+1}^h + (1 - \tau_y)p_{t+1}^R + \tau_y\tilde{\delta}_{ht+1})]. \tag{3.3.4}$$

In a similar fashion to owner-occupied housing, the left-hand side shows the marginal costs of increasing rental houses, and the right-hand side the marginal benefits. Changes in tax policies can also affect the decisions of investing in rental housing.

3.3.2 Impatient households

As stated in the previous section, impatient households have a lower discount factor than patient households, and are also called borrowers. This is the only difference with regards to the function that they maximize. However, their budget constraint is different:

$$\begin{aligned}&(1+\tau_c)c_t^I + p_t^h(h_t^I - (1-\delta_h)h_{t-1}^I) + (1+r_{t-1}^b)M_{t-1} \leq w_t^I l_t^I + M_t \\ &+ \Gamma_t^I - \tau_y[w_t^I l_t^I - I_{mt} r_{t-1}^b M_{t-1} + I_{rt}(p_t^R - \tilde{\delta}_{ht})h_{t-1}^I - \tau_{pt} p_t^h h_{t-1}^I] \\ &- \tau_{pt} p_t^h h_{t-1}^I - \frac{\psi_a}{2\overline{h}^I} p_t^h (h_t^I - h_{t-1}^I)^2. \end{aligned} \tag{3.3.5}$$

Every period, they choose their consumption levels c_t^I, their housing stock h_t^I, their labor l_t^I, and their mortgage loans M_t. They face quadratic adjustment costs for changing their housing stock. They are paid at wage w_t^I, and they must repay their mortgage loan contracted the previous period in addition to the interest rate r_{t-1}^b due on these loans. They also receive transfers Γ_t^I from the government. Impatient households face four tax policy instruments. Three of them are similar to the ones faced by patient households. The fourth one is the deductibility of mortgage interest payments $0 \leq I_{mt} \leq 1$, where $I_{mt} = 1$ indicates that these payments are fully deductible. Their mortgage loans are constrained by their housing value as follows:

$$M_t \leq \rho_m M_{t-1} + (1-\rho_m)\theta p_t^h h_t^I \tag{3.3.6}$$

where θ corresponds to a loan-to-value, and ρ_m to the persistence in mortgage borrowing. Hence, if the value of their housing stock increases, impatient households are able to borrow more.

Setting housing investment adjustment cost to zero, the first order condition with respect to housing is

$$\lambda_t^I p_t^h = (1-\rho_m)\theta\lambda_t^m p_t^h + \beta_I \mathbf{E}_t[\frac{\varphi_h}{h_t^I} + \lambda_t^I((1-\delta_h - \tau_{pt+1}(1-\tau_y))p_{t+1}^h - I_{rt+1}\tau_y(p_{t+1}^R - \tilde{\delta}_{ht+1})] \tag{3.3.7}$$

where λ_t^I is the Lagrange multiplier of the budget constraint that is equal to the marginal utility of consumption in equilibrium. λ_t^m is the Lagrange multiplier of the borrowing constraint. The marginal costs and benefits of increasing housing resemble those of the patient owner-occupied housing. The only difference is the additional benefit that allows impatient households to borrow more when they invest in housing.

The first order condition with respect to mortgage loans is as follows:

$$\lambda_t^I = \lambda_t^M + \beta_I \mathbf{E}_t[\lambda_{t+1}^I(1 + (1 - I_{mt+1}\tau_y)r_t^b - \lambda_{t+1}^m \rho_m)]. \tag{3.3.8}$$

In a similar fashion to other first order conditions, the left-hand side consists of the marginal gain from borrowing, while the right-hand side shows the marginal costs. There are costs related to the tightening of the borrowing constraint and the repayment of the mortgage loan in the following period. Through the deduction of mortgage interest I_{mt}, the government can affect the effective interest rate at which impatient households repay their mortgage loans.

3.3.3 Renters

The renters' period-utility function is identical to those of patient and impatient households. We assume that they have a lower discount factor than the patient households. Their budget constraint is as follows:

$$(1 + \tau_c)c_t^R + p_t^R h_{t-1}^R \leq (1 - \tau_R)w_t^R l_t^R + \Gamma_t^R. \tag{3.3.9}$$

They consume non-durable goods c_t^R, rent houses h_{t-1}^R from patient households at price p_t^R, work l_t^R, and receive transfers from the government Γ_t^R. They earn w_t^R for their labor. Note that their labor income is taxed at a different rate (τ_R) than patient and impatient households. Since they are not able to borrow or invest, they are considered as *hand-to-mouth* agents. Finally, the housing tax policy changes do not affect these agents directly, but indirectly through the changes in rental housing

prices. The first order condition with respect to rental housing is as follows:

$$p_t^R = \frac{\varphi_h}{\lambda_t^R h_{t-1}^R} \tag{3.3.10}$$

where λ_t^R is equal to the marginal utility of consumption of renters.

3.3.4 Bankers

Bankers are the financial intermediaries in the economy. We assume that they are the only agents that have the technology to redirect funds between agents. Their assets are composed of mortgages contracted to impatient households and liabilities of deposits from patient households. They maximize the following problem:

$$\max E_0 \sum_{t=0}^{\infty} \beta_B^t \log c_t^B$$

subject to:

$$(1+\tau_c)c_t^B + (1+r_{t-1}^d)d_{t-1} + M_t = d_t + (1+r_{t-1}^b)M_{t-1} \tag{3.3.11}$$

where $\beta_B < \beta_P$. Since, in equilibrium the interest rate on mortgages r_t^b is greater than the interest rate on deposits r_t^d, they are able to make profits that they consume, *i.e.* c_t^B. In a similar fashion to Iacoviello (2015), bankers face a quadratic loan adjustment cost. Moreover, their issuance of liabilities is constrained by their asset holdings:

$$d_t \leq \phi M_t \tag{3.3.12}$$

where $0 < \phi < 1$ is a policy parameter typically set by regulatory agencies. [9]

9. See Appendix B of Iacoviello (2015) for the derivation of this constraint.

The first order conditions with respect to deposits and mortgage loans are as follows:

$$\lambda_t^B = \lambda_t^\phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^d) \tag{3.3.13}$$

$$\lambda_t^B = \lambda_t^\phi \phi + \beta_B \mathbf{E}_t \lambda_{t+1}^B (1 + r_t^b) \tag{3.3.14}$$

where λ_t^B and λ_t^ϕ are the Lagrange multipliers on the budget constraint and on the capital adequacy constraint, respectively. An additional unit of deposits implies more consumption in the present period; however, there are costs to do so. Specifically, the borrowing constraint is tightened, and bankers need to repay the principal of deposits and the interest r_t^d accrued the following period. As for the first order condition with respect to mortgage loans, the left-hand side of equation (3.3.14) represents the marginal costs of increasing mortgage loans, whereas the right-hand side shows the marginal benefits. Bankers gain from the repayment of the loans and the interest r_t^b thereon. An additional benefit of greater mortgage loans is that it relaxes the borrowing constraint.

3.3.5 Non-durable good producers

In a perfectly competitive environment, identical firms produce homogeneous non-durable goods. Their production functions feature constant returns to scale in capital and labor:

$$Y_t^f = k_{t-1}^\alpha \left((l_t^P)^{\iota_P} (l_t^I)^{\iota_I} (l_t^R)^{\iota_R} \right)^{1-\alpha} \tag{3.3.15}$$

where Y_t^f is the production of non-durable goods, α is the capital-elasticity of output, and ι_P, ι_I, and ι_R correspond to the labor shares of the households that work. These parameters are calibrated so that their sum is equal to one ($\iota_P + \iota_I + \iota_R = 1$). Every period, firms maximize their profits:

$$\Pi_t^f = Y_t^f - w_t^P l_t^P - w_t^I l_t^I - w_t^R l_t^R - r_t^k k_{t-1} \tag{3.3.16}$$

Non-durable good producers sell their production, and incur labor, and capital costs. From this profit maximization, wages and borrowing rates of capital are equal to their marginal products.

3.3.6 Capital and housing producers

We assume that capital and housing producers also operate in a perfectly competitive environment. Patient and impatient households sell to them the undepreciated part of the installed capital and housing at prices p_t^k and p_t^h, respectively. In the same period–once production is completed–these agents buy the new stocks of capital and housing at the same prices that they sold the undepreciated parts. The producers purchase capital and housing investment (i_t^k and i_t^h) from the non-durable goods firms at a unitary price. Hence, their maximization problem is as follows:

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \frac{\lambda_t^P}{\lambda_0^P} [\sum_{x=k,h} p_t^x (x_t - (1-\delta_x)x_{t-1}) - i_t^x]$$

subject to:

$$k_t = (1-\delta_k)k_{t-1} + [1 - \frac{\psi_k}{2}(\frac{i_t^k}{i_{t-1}^k} - 1)^2]i_t^k, \tag{3.3.17}$$

$$h_t = (1-\delta_h)h_{t-1} + [1 - \frac{\psi_h}{2}(\frac{i_t^h}{i_{t-1}^h} - 1)^2]i_t^h. \tag{3.3.18}$$

where $h_t = h_t^P + h_t^I + h_t^R$. We assume that capital and housing producers use the patient households' stochastic discount factor to discount future profits. Their profit maximization is subject to the laws of motion of capital and housing that are characterized by quadratic investment adjustment costs.

3.3.7 Government

The government collects taxes on consumption, income revenue, deposits, government bonds, capital, and housing properties. Total taxes tax_t correspond to the following

sum:

$$\begin{aligned} tax_t = {} & \tau_c C_t + \tau_y[w_t^P l_t^P + (p_t^R - \tilde{\delta}_{ht})(h_{t-1}^R + I_r h_{t-1}^P) - \tau_{pt}(h_{t-1}^P + h_{t-1}^R)] \\ & + \tau_d r_{t-1}^d (d_{t-1} + b_{t-1}^g) + \tau_{pt}(h_{t-1}^P + h_{t-1}^R) + \tau_k(r_t^k - \delta_k)k_{t-1} \\ & + \tau_y[w_t^I l_t^I - I_{mt} r_{t-1}^b M_{t-1} + I_r(p_t^R - \tilde{\delta}_h)h_{t-1}^I - \tau_{pt} h_{t-1}^I] + \tau_{pt} h_{t-1}^I + \tau_R w_t^R l_t^R \end{aligned} \tag{3.3.19}$$

where $C_t = c_t^P + c_t^I + c_t^R + c_t^B$ is the sum of consumption of all agents. The government's budget constraint is as follows:

$$b_t^g + tax_t = (1 + r_{t-1}^d) b_{t-1}^g + \overline{g} + \Gamma_t^P + \Gamma_t^I + \Gamma_t^R. \tag{3.3.20}$$

Every period, from taxes that they collect and the new borrowing that they contract from patient households, they make transfer payments (Γ_t^P, Γ_t^I, and Γ_t^R) to three types of agents. We assume that government expenditures $\overline{g}$ are fixed. Transfer payments are attributed according to the following rule:

$$\Gamma_t^i = \vartheta_i Y_t^f - \rho_b b_{t-1}^g, \quad i = P, I, R. \tag{3.3.21}$$

where ϑ_i are parameters specific to the type of households, and ρ_b denotes the response of transfer payments to government debt. This coefficient is necessary to ensure the stability of the model following policy changes.

3.3.8 Market clearing

In equilibrium, all non-durable goods are sold to the agents, the capital and housing producers, and the government, so that the market clearing condition is:

$$Y_t^f = C_t + i_t^h + i_t^k + \overline{g} \tag{3.3.22}$$

where $C_t = \sum_{i=P,I,R,B} c_t^i$. However, the production of non-durable goods is not consistent with the measure of GDP that is published by the Bureau of Economic

Analysis in the NIPA. Consumption needs to be adjusted to take into account the effects of consumption taxes, and the consumption services provided by housing. Therefore, NIPA-consistent GDP, Y_t, corresponds to

$$Y_t = (1+\tau_c)C_t + p^R h_{t-1} + i_t^h + i_t^k + \overline{g}. \tag{3.3.23}$$

3.4 Calibration

Table 3.1 – Endogenously calibrated parameters

	Symbol	Value	Steady state targets
Discount factors			
Patient households	β_P	0.9937	$\bar{r}^d$=0.03 (annualized)
Impatient households and renters	β_I, β_R	0.9852	250 basis points spread on $\bar{r}^d$ (annualized)
Bankers	β_B	0.9375	$\bar{r}^b$=0.05 (annualized)
Weights in the utility function			
Housing	φ_h	0.217	$\bar{h}/\overline{GDP} = 6$
Labor	φ_l	0.56	$\bar{l}^P = 1$
Factor shares in production			
Capital share	α	0.21	$\bar{k}/\overline{GDP} = 5.2$
Patient hhs labor share	ι_P	0.2	$\bar{h}^P/\bar{h} = 0.37$
Impatient hhs labor share	ι_I	0.56	$\bar{h}^I/\bar{h} = 0.43$
Renters labor share	ι_R	0.24	$\bar{h}^R/\bar{h} = 0.2$
Depreciation rates			
Housing	δ_h	0.0096	$\bar{i}^h/\overline{GDP} = 0.05$
Capital	δ_k	0.02	$\bar{i}^k/\overline{GDP} = 0.12$
Transfer shares			
Patient hhs	ϑ_P	0.038	**Total transfers**:
Impatient hhs	ϑ_I	0.035	$\left(\sum_{i=P,I,R} \bar{\Gamma}^i\right)/\overline{GDP} = 0.074$
Renters	ϑ_R	0.015	
Labor income tax rates			
Patient and impatient hhs	τ_y	0.3	**Average labor income tax rate**:
Renters	τ_R	0.2	$\frac{\tau_y(\bar{w}^P\bar{l}^P + \bar{w}^I\bar{l}^I) + \tau_R\bar{w}^R\bar{l}^R}{\sum_{i=P,I,R}\bar{w}^i\bar{l}^i} = 0.27$

The calibration of parameters is done at a quarterly frequency and is split into two parts. First, we show in Table 3.1 the calibrated values of parameters that are chosen by jointly matching steady state targets, *i.e.* endogenously calibrated parameters. Second, Table 3.2 presents the remaining set of parameters that are invariable to the

Table 3.2 – Exogenously calibrated parameters

	Symbol	Value
Inverse of Frisch elasticity of labor supply	ι	1
Loan-to-value ratio	θ	0.70
Persistence of mortgage	ρ_m	0.85
Liabilities to assets ratio for bankers	ϕ	0.9
Investment adjustment costs	ψ_k, ψ_h	$8, 30$
Responses of transfers to government debt	ρ_b	0.005
Tax rates	$\tau_k, \tau_c, \tau_p, \tau_d$	$0.4, 0.05, 0.0035, 0.15$
Tax deductions	$\overline{I}_m, \overline{I}_r$	$1, 0$

steady state, *i.e.* exogenously calibrated parameters. Most steady state targets and exogenously calibrated parameters take the same values than the ones reported by Alpanda and Zubairy (2016).

Discount factors slightly differ from their calibrated values, since we follow Iacoviello (2015) for these parameters. Specifically, we set β_P and β_B to match annualized steady-state deposit and lending rates of 3 and 5 percent, respectively. As for the transfer shares, they are chosen to match the relative shares of labor and capital income of each agent. We pick the labor income tax rates to reproduce the progressivity of the tax code. In the exogenously calibrated parameters category, we also follow Iacoviello (2015) and set $\phi = 0.9$, so that the liabilities-to-assets ratio in the bankers' capital adequacy constraint is consistent with historical data on banks' balance sheets. To avoid repetition of the discussion of the remaining steady state targets and exogenously calibrated parameters, we refer the reader to alpanda2016housing calibration section. The addition of a banking sector does not greatly alter these parameters.

3.5 Results

In this section, we present the effects of changing housing tax policies. First, the size of the changes are set so that all of them generate a present value of tax revenues

that corresponds to 50%.[10] The following four policies are considered: we (i) reduce the mortgage interest deductions I_{mt}, (ii) institute partial taxation of imputed rents I_{rt}, (iii) increase the property tax rate τ_{pt}, and (iv) reduce the depreciation allowances $\tilde{\delta}_{ht}$. Second, we present revenue neutral experiments that eliminate the distortions created by policies (i), (ii), and (iv). The additional tax revenues are used to lower the labor income tax rates of the households. For all these experiments, we discuss the mechanisms that generate the results, and pay particular attention to the role of banking.

3.5.1 Equivalent revenue generating experiments

Table 3.3 – Fiscal policy values

	Symbol	Initial	New	
			Baseline	**Model without banking**
Reduction of mortgage interest deductions	I_{mt}	1	0.85	0.72
Instituting partial taxation of imputed rents	I_{rt}	0	0.067	0.066
Property tax increase	τ_{pt}	0.014	0.015	0.015
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	0.0096	0.0065	0.0066

Table 3.4 – Short and long-run tax multipliers

		Baseline		**Model without banking**	
	Symbol	Short-run	Long-run	Short-run	Long-run
Reduction of mortgage interest deductions	I_{mt}	-0.13	-0.81	-0.22	-0.96
Instituting partial taxation of imputed rents	I_{rt}	-0.12	-1.14	-0.22	-1.26
Property tax increase	τ_{pt}	-0.1	-1.2	-0.2	-1.3
Reduction of depreciation allowance	$\tilde{\delta}_{ht}$	-0.02	-1.43	-0.12	-1.45

The tax policy changes that we implement are permanent. We assume that the economy is at its initial steady state in period 0. In period 1, the government surprises all the agents with new housing tax policies that last permanently. Agents have perfect information and foresight. We compute the transition of all variables from periods 0 to 1,000—as we consider that the economy attains its new steady state at this long horizon. Table 3.3 presents the changes in housing tax policies that are implemented

10. We use the discount factor of patient households to measure the present value of changes in tax revenues: $PV_{tax} = \frac{1}{tax_0} \sum_{t=0}^{T=20,\infty} \beta_P^t (tax_t - tax_0)$. $T = 20$ when we compute the short-run multipliers, and $T = \infty$ the long-run multipliers.

for the baseline model and the model without banking[11], so that the present value of tax revenues increases by 50%. Table 3.4 presents the corresponding short and long-run tax multipliers generated by both models. Specifically, these multipliers are measured as follows: $(PV_Y \cdot Y_0)/(PV_{tax} \cdot tax_0)$ where $PV_Y = \sum_{t=0}^{T=20,\infty} \beta_P^t (Y_t - Y_0)/Y_0$, Y_0, and tax_0 are the present value of changes in GDP, and the initial steady state values of GDP, and tax revenues, respectively. Over a horizon of 20 quarters, the multipliers that we obtain are very small, and even more so for the baseline model. Therefore, we can assert that changing housing tax policies is not very detrimental for economic activity in the short-run. This is not the case in the long-run, as multipliers are larger. We find that the order of desirability of policies is the same for the baseline model and the model without banking; however, the presence of banking contributes to lowering the multipliers. We discuss its role in the following sections.

Table 3.5 – Percent changes in the steady state

	Y	Y^f	C	i_k	i_h	M	p^R
Reduction of mortgage interest deductions	−0.11	−0.05	−0.01	−0.05	−0.63	−1.47	0
Instituting partial taxation of imputed rents	−0.15	−0.05	0	−0.05	−0.85	−0.89	0
Property tax increase	−0.15	−0.06	0.002	−0.05	−0.9	−0.67	1.13
Reduction of depreciation allowance	−0.17	−0.06	0.01	−0.06	−1.07	0.09	5.4

Table 3.6 – Welfare effects of housing tax policies

	Savers	Borrowers	Renters	Bankers
Reduction of mortgage interest deductions	0.10	−0.29	0.28	−0.64
Instituting partial taxation of imputed rents	−0.21	−0.11	0.33	−0.38
Property tax increase	−0.17	−0.05	0.11	−0.29
Reduction of depreciation allowance	−0.02	0.13	−0.7	0.05

We present the transitional dynamics of key variables to permanent policy changes for the first 100 quarters in Figure 3.1, while Table 3.5 shows the changes in the steady states of key variables. Finally, Table 3.6 displays the effects on welfare for all agents. Specifically, the amplitude of these effects is given by Λ_i, where $i = P, I, R, B$ which is

11. This model consists in the baseline model stripped out of its banking sector, which implies that patient households lend directly to impatient households. The calibration that we use is the same for both models.

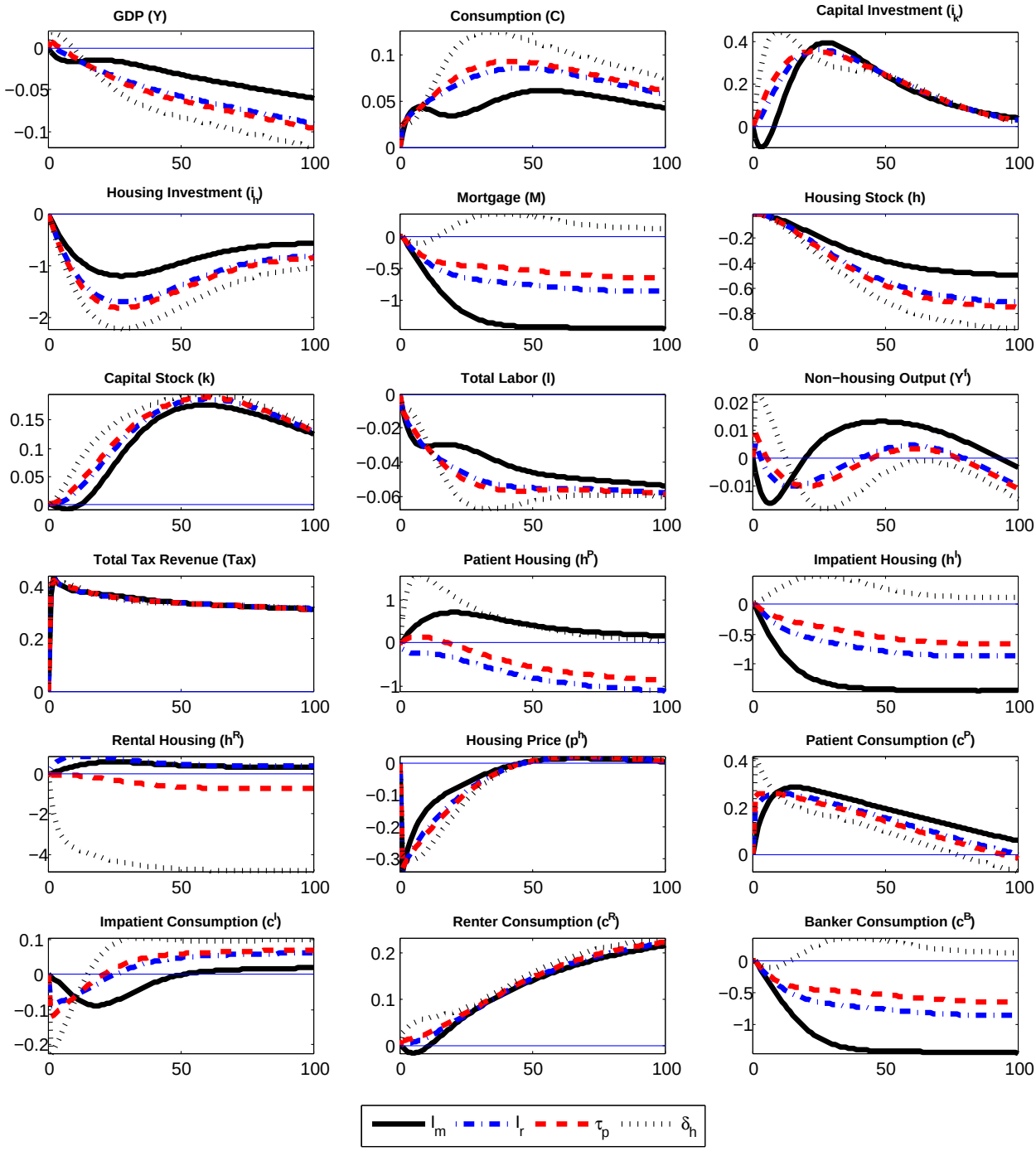

Figure 3.1 – Responses to four housing tax policy changes (I_{mt}, I_{rt}, τ_{pt}, and $\tilde{\delta}_{ht}$) measured in percent deviation from their initial steady states

a measure in annual consumption units that is calculated from the following equation:

$$\sum_{t=0}^{\infty} \beta_i^t U((1+\Lambda_i)c_0^i, h_0^i, l_0^i) = \sum_{t=0}^{\infty} \beta_i^t U(c_t^i, h_t^i, l_t^i) \tag{3.5.1}$$

where c_0^i, h_0^i, l_0^i are consumption, housing, and labor in the initial steady state. [12] A positive value of Λ_i implies that agents are better off following the policy change. All signs of the welfare changes are similar to Alpanda and Zubairy (2016), with the exception of the increase in property taxes for borrowers. The heterogeneity of these effects are important to appreciate the output losses. In fact, policy changes that lead to negative outcomes for the welfare of impatient households are inversely related with the size of the long-run multipliers for the economy.

Reducing the mortgage interest deduction

The reduction of the deduction of mortgage payments implies that the marginal cost of holding an additional unit of mortgage increases. Hence, this policy change directly targets the impatient households' mortgage decision, and, consequently, is the one that decreases their housing stock and welfare the most. As demand for housing from borrowers decreases, the equilibrium housing price falls in the short-run. As a consequence of lower prices, housing is reallocated to savers and renters, whose welfare increases. As for bankers, less mortgage implies less gains from financial intermediation, and thus lower consumption and welfare.

In the first ten quarters or so, non-housing output falls, partly as a result of lower capital investment. In fact, savers cut back their investment in order to smooth out their consumption. In the long-run, however, GDP is dragged down mainly by diminishing levels of housing stock. It appears that this policy change is the least distortionary on the housing market as the fall in total housing in the long-run is the smallest out of the four policy changes. Considering that output losses are the smallest, this makes it the most efficient one in accruing tax revenues.

12. Since we assume that bankers do not derive utility from housing services and do not work, housing and labor are set equal to zero.

Since bankers take advantage of financial intermediation, a wedge between the mortgage and deposit rates arises. In the steady state, the annualized mortgage rate is 5%, whereas the deposit rate is 3%. With a higher borrowing rate, the deduction from mortgage payments is even more important. Therefore, instead of reducing the mortgage deduction to 0.72 (as is the case for the model without banking), the government cuts it down almost halfway to 0.85. As a consequence, housing does not fall as much, and accounts for the smaller short and long-run multipliers.

Taxing imputed rental income

The second best policy change in terms of minimizing output losses is to institute partial taxation of imputed rents. This affects both the impatient and patient households who need to pay taxes on the consumption that they derive from housing services. Consequently, their housing demand and welfare fall. Savers substitute away from owner-occupied housing by investing in capital and by supplying more rental housing. This causes prices to fall, thereby making it beneficial for renters. This shift of housing towards renters also contributes to dampening the negative effects of a housing stock reduction on GDP. As for bankers, they lose out from this policy change as less housing demand from borrowers implies fewer originations of mortgages, and thus less revenues from financial intermediation.

The short and long-run multipliers attached to this policy change are also lower than the ones obtained from the model without banking. The smaller response of borrowers' housing accounts for the gap between the multipliers. Since housing enters GDP in two ways—through housing investment and consumption of housing services—the response of this variable is key. In fact, the lending process matters in its dynamics. In the baseline model, there is no substitute to lending for bankers. They have incentives to keep its value high, because it directly affects their consumption. In some ways, they absorb the losses incurred by additional taxation. In contrast, per the model without banking, lending is conducted by savers. Since they also invest in physical capital, more substitution between the types of investment takes place, which implies

that lending and housing fall by a greater margin.

Increasing the property tax rate

Contrary to other policies, property taxes affect owner-occupied and rental housing. When the government increases them, all agents reduce their housing stock. While impatient and patient households are hit directly, renters are impacted indirectly through a hike in rents. However, welfare does not fall for all these agents, as they substitute for more consumption. Specifically for borrowers and renters, the effects on consumption dominate those of declining housing consumption, and thus their change in welfare is positive. In contrast, the effects on patient households are negative. As for bankers, similar to the two previous policy changes, they suffer from less financial intermediation. Finally, since all agents reduce their demand for housing, its total stock further decreases, which accounts for a slightly lower long-run multiplier than for taxing imputed rental income.

In comparison to the multipliers generated by the model without banking, the baseline model generates short and long-run multipliers that are smaller. The mechanism at play is the same as for the previous tax policy change: more substitution towards capital investment arises—especially in the short-run—when patient households lend directly to impatient households.

Reducing the depreciation allowance

Another distortion introduced by the tax system in the US lies in the depreciation allowance of rental income that savers can deduct. In our experiment, this allowance was reduced to almost half—it drops from 0.0096 to 0.0065. Such a large policy change is necessary because it only affects rental housing, which is a small fraction of total housing. Since incentives to rent out housing shrink, its supply is reduced, leading to higher rental prices.

Consequently, renters are the big losers, while borrowers take advantage of a lower

housing price that ensue from a decrease in total housing. In the short-run, they reduce their consumption, since the value of their collateral falls as a result of lower house prices. However, in the long-run, the quantity effects dominate those of the price, and therefore the value of their collateral and consumption soar. Patient households' decisions also fluctuate throughout time. A lower house price makes them consume more non-durable goods and housing services in the short-run. However, once house prices revert to the steady state level, their total consumption falls so much that it leaves their welfare unchanged. They also invest more in non-durable goods than in reaction to the other policy changes, which implies that the multiplier is the lowest. As for bankers, their consumption evolves according to the dynamics of mortgages. Overall, the discounted sum of their period utilities rises.

The long-run multipliers attached to this tax policy change generated by the baseline model and the model are almost the same for the baseline model and the model without banking. However, the short-run multiplier generated by the baseline model (-0.02) is smaller. This result is also the consequence of a larger decrease in housing stock for the model without banking. Specifically, rental housing diminishes more for them, since savers reallocate their funds towards more lending. In our case, savers do not lend as much through deposits, since the presence of bankers creates a friction. In fact, by consuming a fraction of mortgages they compress lending, and thereby dampen the fall in housing, which leads to a greater multiplier than the model without banking.

3.5.2 Revenue neutral experiments

In the previous section, all policy changes deliver lower levels of GDP. Can these results be offset if the government uses its additional revenues to lower labor income taxes? To answer this question, we conduct three experiments that eliminate the asymmetric tax treatment of housing. Specifically, we consider (i) the repeal of mortgage interest deductions, (ii) the taxation of imputed rents at the same rate as labor income, and (iii) the repeal of depreciation allowance for rental income. The first two experiments

are similar to the ones that Chambers et al. (2009), Gervais (2002), and Sommer and Sullivan (2013) examine. In Table 3.7, we report the new labor income tax rates of patient and impatient households τ_y, and of renters τ_R. Since the experiments are revenue neutral, multipliers are nonexistent. Therefore, we present the present values of GDP and non-housing output. To obtain a better understanding of these present values, we display the transitional dynamics of key variables in Figure 3.2.

Table 3.7 – Effects of revenue neutral experiments

		New tax values		**Present value**			
				short-run		long-run	
	Symbol	τ_y	τ_R	Y	Y^f	Y	Y^f
Repeal of mortgage interest deductions	I_{mt}	0.288	0.192	0.033	0.042	-0.005	0.522
Taxing fully imputed rents	I_{rt}	0.277	0.185	0.063	0.083	-0.553	0.879
Repeal of depreciation allowance	$\tilde{\delta}_{ht}$	0.294	0.196	0.021	0.028	-0.226	0.2

For all three experiments, the responses of most variables are amplified compared to the equivalent revenue generating experiments, since the housing tax changes are much larger. The amplification is particularly more sizable for policy change (ii), because it directly affects patient and impatient households, whereas policy changes (i) and (iii) target only one type of household. The mechanisms at play are similar to the ones described in the previous section, except for the dynamics of labor. In fact, as a result of lower labor income tax rates, hours worked increase. This explains the positive responses of non-housing output and GDP in the short-run. In fact, the changes in the present value of both these aggregate variables are positive at a horizon of 20 quarters. However, since total housing falls gradually, the present values of GDP decrease in the long-run. This fall in housing is not compensated by the higher levels of non-housing output. Based on long-run present values of GDP, the repeal of mortgage interest deductions stands out as the superior policy change.

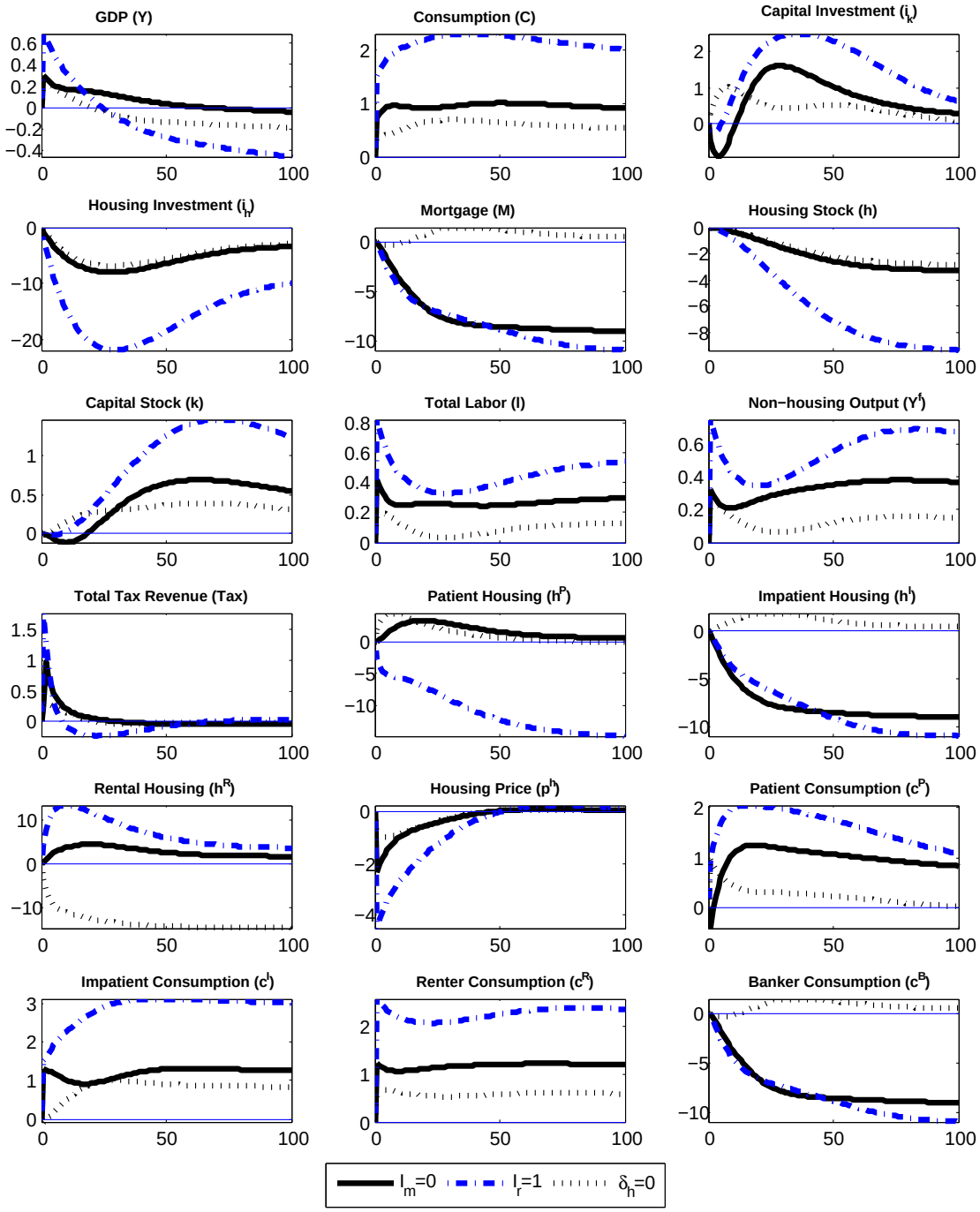

Figure 3.2 – Responses to three revenue neutral experiments (I_{mt}, I_{rt}, and $\tilde{\delta}_{ht}$) measured in percent deviation from their initial steady states

3.6 Conclusion

In the United States, housing receives a preferential tax treatment. We examine the effects of four policy changes that target this sector and increase the government's revenues. We employ a multi-agent general equilibrium model to simulate these policy changes. A fixed share of households are renters, and others are homeowners—either borrowers or savers. An important feature of our framework is the presence of financial intermediation, which is not a veil, since bankers face a capital adequacy constraint.

One key finding is that the economy substitutes residential investment for capital investment in response to the four experiments. The transitional effects on GDP are very small in the short-run for all the experiments. In the long-run, we find multipliers that are close and below unity for some of them. Banking plays a role in lowering these multipliers. The tax policy change that delivers the smallest long-run multiplier is the reduction of the deduction of mortgage payments. Furthermore, the welfare outcomes diverge significantly according to the types of households. We also consider the implementation of three revenue neutral experiments. We find substantial decreasing levels of housing, and only long-run output gains for the repeal of mortgage deductibility.

An extension to our work would be to embed the financing of the production of non-durable goods and housing. Firms would borrow from bankers and offer capital and land as collateral. Interesting dynamics may emerge, as bankers would redirect their funds towards firms in the event of a policy change. A financial accelerator mechanism, similar to the one put forward by Liu et al. (2013) would arise as the value of firms' land and capital are likely to increase.

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Chapter 4

Business Cycle in Oil-Exporting Countries with Bank Intermediation

With

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Abstract

The structural model in this paper proposes a micro-founded framework that incorporates an active banking sector with an oil-producing sector. The primary goal of adding a banking sector is to examine the role of an interbank market on shocks, introduce a national development fund and study its link to the banking sector and the government. The government and the national development fund directly play key roles in the propagation of the oil shock. In contrast, the banking sector and the labor market, through perfect substitution between the oil and non-oil sectors, have major indirect impacts in spreading shocks.

JEL classification: E44, E50, E58, G01, G21, G33 .

Keywords: Oil-Exporting countries, Banking, Oil-Reserve Fund DSGE.

4.1 Introduction

In November 2014 the Organization of the Petroleum Exporting Countries (OPEC) failed to reach an agreement on production curbs, despite a perceived global oil glut, sending prices skidding. However, about two years later OPEC reversed its path and reached a deal among all 14 member countries [1] on its first production cuts in eight years, sending crude oil prices soaring. Although OPEC is defying skeptics by going deeper than the pledged cuts, and extending them long enough to deplete oil inventories, U.S. production growth and other surging rivals like Brazil and Canada may leave little headroom for the cartel's expansion after its production curbs expire this year. According to the International Energy Agency (IEA), new U.S. supply will cover more than half of the world's oil demand growth in the medium term, partly thanks to the shale oil boom. With a slightly weaker global demand projection and the American surge, a supply cut is expected from the cartel to avoid another prolonged surplus.

This should be a concern for the majority of oil-exporting countries—and particularly for OPEC members. For Gulf countries, hydrocarbon exports represent about 70 percent of total exports (Fingure 4.1). Oil revenues account for 80 percent of total fiscal revenues, on average, and about 20 percent of GDP (Figure 4.2). In addition, fiscal breakeven prices fall below the projection prices for oil, in the medium-term for most countries (Figure 4.3). In many of oil-exporting countries, the financial sector has grown fairly large, and macro-financial linkages can exacerbate oil price shocks (Figure 4.4). The high volatility of oil prices could build systemic financial sector vulnerabilities, which in turn could adversely affect the real economy.

This study examines the relationship between macroeconomic aggregates, the financial sector, and the channels through which the business cycle and the financial cycle in oil economies interact. Unlike the growing body of literature assessing the effectiveness of policies and their underpinning theoretical models after the global crisis, the

1. Currently OPEC has 15 member countries after Equatorial Guinea became a member in 2017.

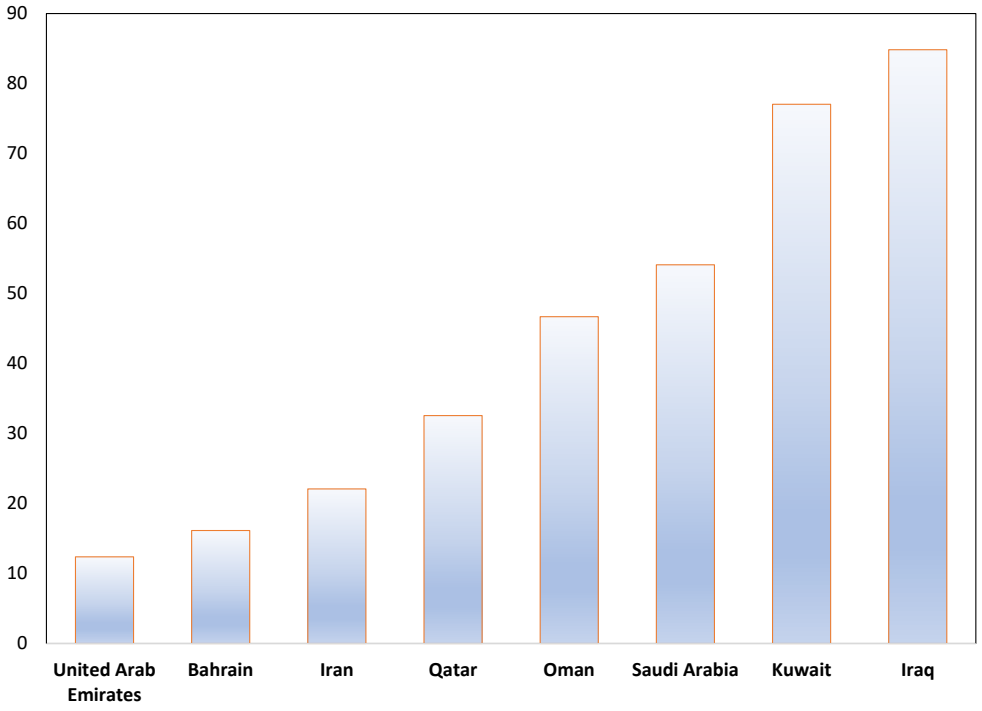

Figure 4.1 – Oil Revenue to export

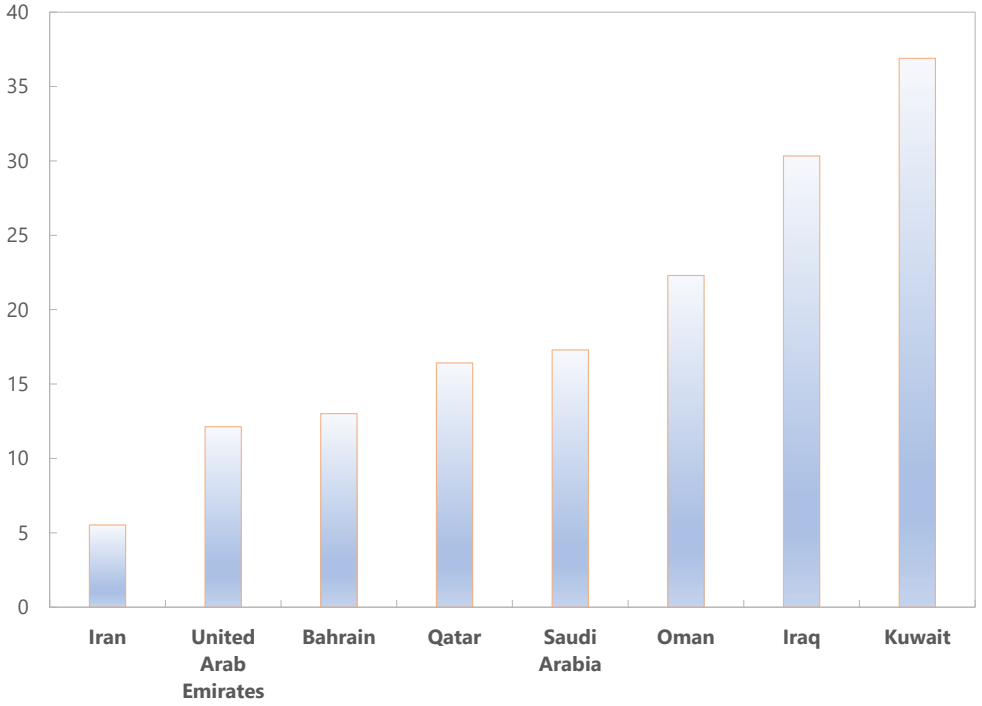

Figure 4.2 – Oil Revenue to GDP

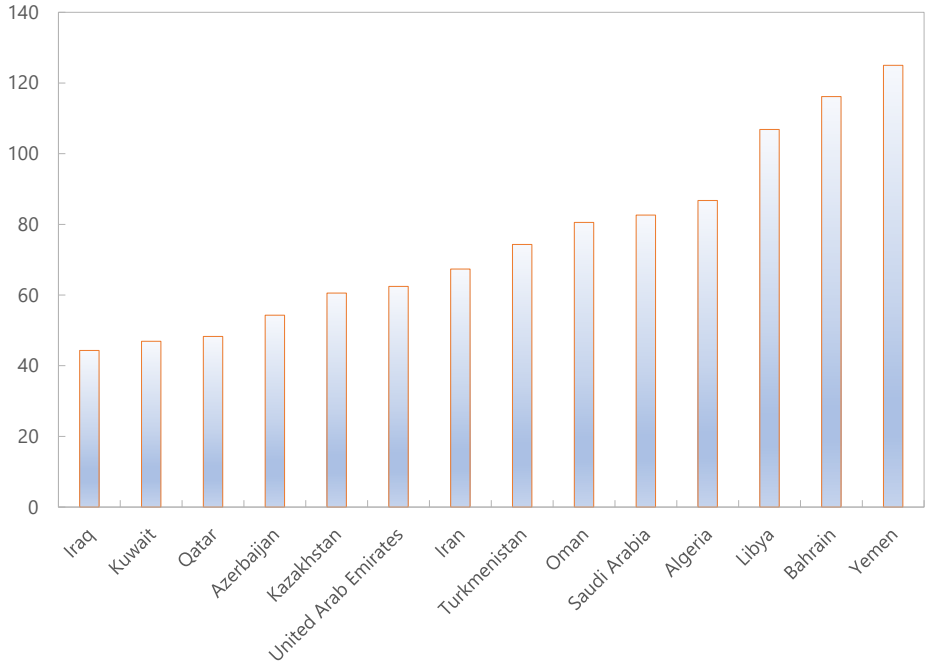

Figure 4.3 – IMF fiscal breakeven price

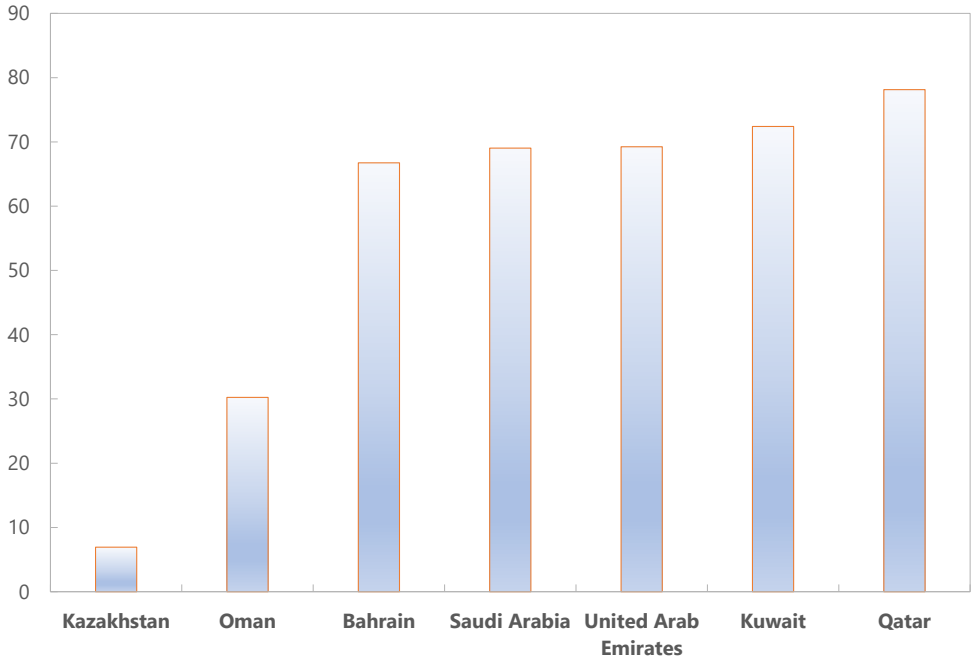

Figure 4.4 – Market capitalization to GDP

nexus between financial and oil price shocks has not been as fully explored. Most research in business cycle abstracts either from the role of commodities altogether or underestimates the role of the financial sector in commodity-exporting economies in accelerating the propagation of commodity shocks. Consequently, practitioners are left with limited knowledge on the macro-financial linkages for these economies.

Oil price fluctuations have a major impact on the public finances of developing, oil-exporting countries. The budget structure, the inability to smooth spending due to a lack of pertinent financial instruments, and limited access to credit markets combined with political and institutional constraints force governments to conduct procyclical fiscal policies (see for example Murphy et al. (2010) and Erbil (2011)), when facing an oil shock. Moreover, in most oil-dependent countries government investment expenditure and current spending drive non-oil GDP growth (Figures 4.5 and 4.6). As a result, oil price fluctuation determines the business cycle in the absence of a well-diversified economy.

The structural model in this paper proposes a micro-founded framework that incorporates an active banking sector, including an interbank market, into a DSGE model with an oil-producing sector. Although there is an oil revenue windfall, the economy is modeled as an autarky and it abstracts from exchange rate regimes. In addition to other traditional sectors in the real economy, the model includes a national oil fund collecting a share of oil revenue and a fiscal regime that depends on this fund in addition to oil revenues. This setting allows us to analyze the role of fiscal policy in transmission of the oil price volatility to the economy, as discussed in Tazhibayeva et al. (2008), Arezki and Ismail (2013) and Pieschacón (2012). The fiscal policy is guided by the public policy objective to increase capital expenditure, household incomes by transfers, and subsidies to firms as a means of sharing the oil revenue as suggested in Chemingui and Roe (2008). The result is a highly procyclical fiscal regime in line with previous studies (Tazhibayeva et al. (2008), Murphy et al. (2010)). The national development fund acts as a saving fund but also as a stabilization fund to hedge against the liquidity risk in the banking system. To capture government

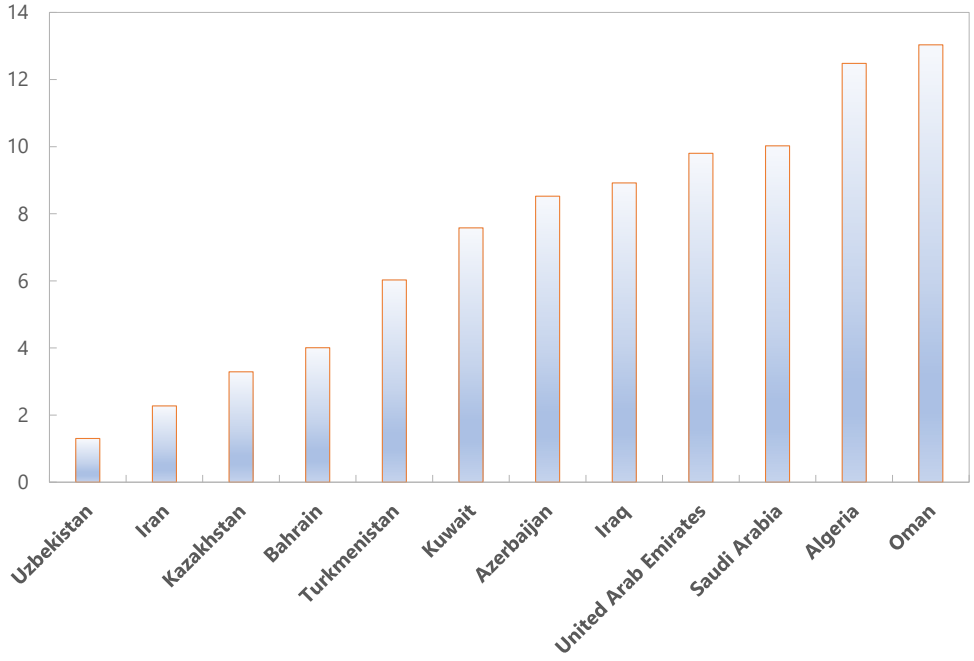

Figure 4.5 – Public investment to GDP

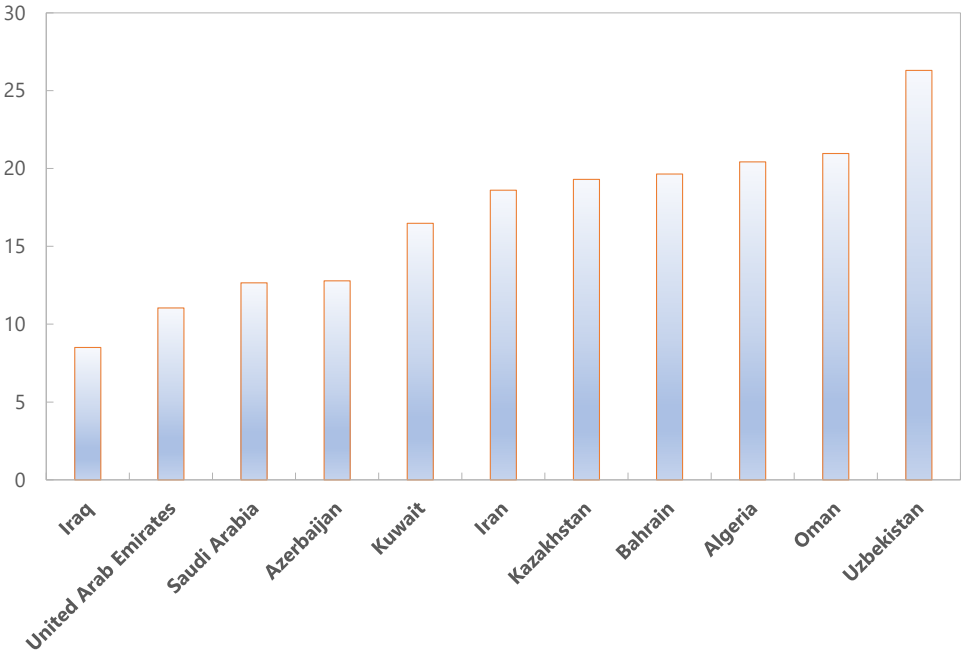

Figure 4.6 – Private investment to GDP

involvement in state-owned enterprises (SOEs), we assumed that the government provides productive capital to intermediate goods producers.

Although the government fiscal regime remains a major player in the transmission of shocks, banks in this model are key agents in spreading shocks across sectors of the economy. Banks give commercial loans to firms that produce goods, purchase government bonds, and finance their operation partly by borrowing through the interbank market from deposit collector banks and partly by the national development fund, which acts as a stabilizer. The endogenous interbank rate depends on the supply of deposits, which in turn is reliant upon government transfer to households. Also, banks are key in determining government bond rates and interest rates on loans to good-producing firms, thereby linking the real business cycle to the financial cycle.

Oil price shocks can affect the financial sector through multiple channels. First, with lower revenues, the government must adjust its capital expenditure. The government usually holds a large stake in SOEs and entities in a variety of sectors, and many of these SOEs remain dependent on the government's financial support through subsidies and transfers. Therefore, lower oil revenues and government spending reflects in the economic activities of SOEs, which in turn contract out big projects to private sector companies. As government investment falls, many of these subcontracts to private firms will halt, and many investment projects will fail. Therefore, banks' nonperforming loans (NPLs) can increase not only as a result of direct exposure to SOEs but also because of the private sector's failing projects. Higher NPLs diminish the credit availability in an economy, particularly to the private sector where access to finance is often a challenge in oil-exporting countries.

Second, governments remain the main employer in developing, oil-exporting countries. As oil revenues drop, efforts to contain the public wage bill increase, resulting in declines in household disposable income, consumption, and, importantly, bank deposits. Higher households' financial fragility and the possibility of falling into arrears raises nonperforming loans, making credit less available to borrowers who are dependent on bank financing. This development also affects banks' ability to

make new loans. Moreover, deposit volatility makes liquidity management difficult and costlier for banks, requiring them to borrow from the central bank (in absence of a developed interbank market) at a premium rate (see Choudhary and Limodio (2017)). Accordingly, because of the liquidity risk, the cost of supplying longer-term lending heightens.

Third, with a lower non-oil GDP growth rate due to an oil shock, the stock markets and housing market would stagnate. Because banks are highly exposed to these markets, higher credit risks emerge, which eventually feeds back into the real economy and leads to a lower credit to economy (Arouri et al. (2010), Fayyad and Daly (2011)). Other channels, such as lower international reserves accumulation and capital outflow, remain important in the long run.

For the sake of simplicity, not all of the aforementioned channels are modelled as just described. Nevertheless, several results prevail. First, the government role's in the propagation of shocks remains crucial. A positive oil shock boosts fiscal revenues and enlarges the fiscal space, which lets the government expand the social transfer to households and increase public capital expenditure. Wealthier households consume more, but their behavior on labor allocation also changes. Additionally, higher public investment raises non-oil output, which should result in a higher fiscal multiplier.

Second, due to complementarities between the oil and non-oil sectors in the model, the labor market becomes an important driver of shocks' diffusion. Because of fixed labor supply in the economy, this channel becomes important essentially for the oil-sector technology shock and the oil price shock. However, this hypothesis dampens the shock impacts on consumption and GDP and prevents the wage and prices from acting as automatic stabilizers to avoid large swings of production factors between sectors.

Finally, while banks do not have important roles in spreading the shocks, they have a critical role in amplifying them. This is because the oil sector is not directly exposed to the banking sector, the non-oil companies are not credit constrained, and the model abstracts from any credit default. However, the heterogenous banking

system, including deposit and lending banks, differentiate various market interest rates between households, government, non-oil firms, the national development fund, and the central bank.

The rest of the paper is organized as follows. Section 4.2 spells out a stylized but large-scale small open economy DSGE model of an oil-exporter with eight type of agents including explicit macro-financial links and demonstrate some of the channels that were discussed above. In section 4.3, discusses the calibration of structural and policy parameters of the model based on Iran's economy and the impact of an oil price shock on macroeconomic aggregates and financial sector variables. Also, we study the impact of monetary shock under an inflation- targeting regime. Finally, we offer some concluding remarks.

4.2 Model

In this section, we develop a DSGE model for a perfectly competitive small open economy consisting of a real private sector, a financial sector, a central bank, and a government. The real sector includes households, non-financial good producers, capital producers, intermediate good producers, and an oil sector. Additionally, a portion of oil export proceeds is saved in a national development fund, which intervenes in the financial market by providing funds to the lending bank. The representative household consumes the final good sold by retailers and supplies labor to intermediate good producers. The household also deposits her savings in the deposit bank and is the ultimate beneficiary of both financial and non-financial firms. Intermediate goods producers are monopolistically competitive and use private and public capital to produce goods. Retailers buy goods from final goods producers and mark up prices via monopolistic competition with nominal price rigidities à la Christiano et al. (2005), Fernández-Villaverde and Rubio-Ramírez (2009) and Smets and Wouters (2007).The oil sector uses capital and labor to extract oil to sell abroad at international prices.

The financial sector consists of a deposit bank and a lending bank forming an interbank market. The deposit banks offer a one-period financial instrument to households, namely de- posits, and lend to the lending banks at the interbank rate. The deposit contract is subject to a quadratic adjustment cost of deposit rates à la Gerali et al. (2010a) due to monopolistic power of deposit banks. Lending banks provide one-period loan contracts to goods producers and the government. In addition to the interbank market funding, lending banks use resources from the national development fund at the central bank policy rate. The government issues one-period bonds, collects taxes, and uses a fraction of oil revenues and the national development fund resources. The national development fund also receives a share of oil revenues and finances parts of government expenditure and the banking sector's needs. The central bank is independent from the government and follows an inflation targeting policy by using the Taylor rule.

4.2.1 Households

Households maximize their life-time utility function driven from consumption and leisure time. The representative household's intertemporal preference is

$$\max_{C_t, N_t, D_t} \mathbb{E}_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_s, N_s\right) \right\} \tag{4.2.1}$$

with $0 < \beta < 1$. C_t and N_t denote consumption and the number of hours worked. We assume the single period utility function as:

$$U\left(C_t, N_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi_N \frac{N_t^{1+\phi}}{1+\phi} \tag{4.2.2}$$

with $\chi_N, \phi > 0$. σ denotes households risk aversion and ϕ represents the inverse of the Frisch elasticity of labor supply. The disutility for work is weighted by χ_N. In each period, the household consumes C, raises a short debt D from banks and pay taxes T. Households supply labor N to the intermediate goods and oil producers, receive wages W and the previous period deposits return R^D, transfer Γ from the government, and

net payouts $\mathbb{P}$, from the ownership of both financial and non-financial firms. Therefore, households budget constraint is

$$C_t + D_{t+1} + T_t \leq W_t N_t + \frac{R_t^D D_t}{\Pi_{t+1}} + \Gamma_t + \mathbb{P} \tag{4.2.3}$$

The first order conditions in respect to consumption, deposit and labor are,

$$\lambda_t P_t^H = C_t^{-\sigma} \tag{4.2.4}$$

$$\frac{N_t^\phi}{C_t^{-\sigma}} = \frac{W_t}{\chi_N} \tag{4.2.5}$$

$$\frac{1}{R_{t+1}^D} = \beta \mathbb{E}_t \left(\frac{1}{\Pi_{t+1}} \frac{C_{t+1}}{C_t} \right)^{-\sigma} \tag{4.2.6}$$

where λ is the Lagrangian and Π_t is inflation. Households hold government debt indirectly through the financial sector [2].

4.2.2 The Final Good Producer

In a perfectly competitive market, a final good is produced by using intermediate goods. Taking as given all intermediate goods prices $P^H(i)$ and the final good price P^H, the final good producer's maximizes profit subject to its production function:

$$\max_{Y_t(i)} \quad P_t^H Y_t^H - \int_0^1 P_t^H(i) Y_t^n(i) di$$

$$s.t$$

$$Y_t^H = \left(\int_0^1 Y_t^n(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}} \tag{4.2.7}$$

where θ is the elasticity of substitution. By solving the problem, the input demand functions are

$$Y_t^n(i) = \left(\frac{P_t^H(i)}{P_t^H} \right)^{-\theta} Y_t^H \quad \forall i \tag{4.2.8}$$

2. Gertler and Karadi (2011) show that holding government debt directly or indirectly does not matter in such models.

where Y^H is the aggregate demand. The zero profit condition conducts

$$P_t^H = \left(\int_0^1 P_t^H(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}} \tag{4.2.9}$$

4.2.3 Intermediate Goods Producers

A continuum of intermediate goods producers use the Cobb-Douglas production technology to produce intermediate goods that are sold to final producers. These firms face a two-stage problem. In the first stage, an intermediate good producer maximizes her profit subject to her supply curve, taking wage, W, and capital rent, R^k, as given,

$$\begin{aligned} \max_{K_t, N_t} \quad & \Pi_t^n = P_t^H Y_t^n + (1-\delta_k) P_t^k K_t - (1-u) R_t^k P_{t-1}^k K_t - W_t N_t^n \\ s.t \\ & Y_t^n = A_t \left(K_t\right)^{\gamma_n} \left(K_{t-1}^G\right)^{\gamma_G} \left(N_t^n\right)^{1-\gamma_n} \end{aligned} \tag{4.2.10}$$

where K^G is the stock of public capital [3] raised by the government at the end of $t-1$ with $\gamma_n, \gamma_G > 0$. Every period, the intermediary good producer raises loan L in order to finance its required capital. The producer acquires capital K_{t+1} from the capital producer at price P_t^k in order to produce in the subsequent period,

$$L_t = P_t^k K_{t+1} \tag{4.2.11}$$

The producer will sell the undepreciated part of capital to capital producers on the open market at the proper price. The firm chooses labor and capital in a perfectly competitive factor market:

$$R_t^k = \frac{\gamma_n P_t^H Y_t^n + (1-\delta_k) P_t^k K_t}{L_{t-1}} \tag{4.2.12}$$

$$W_t = \frac{(1-\gamma_n) P_t^H Y_t^n}{N_t^n} \tag{4.2.13}$$

3. Leeper et al. (2010) and Berg et al. (2013) use the same structure.

To find the real marginal cost, mc, we set the level of labor and capital to produce one unit of good, $A_t \left(K_t\right)^{\gamma_n} \left(K_{t-1}^G\right)^{\gamma_G} \left(N_t^n\right)^{1-\gamma_n} = 1$. This equation, by using factor prices 4.2.12 and 4.2.13, implies

$$N_t^n = \frac{1}{A_t} \left(\frac{\gamma_n}{1-\gamma_n} \frac{W_t}{R_t} \right)^{-\gamma_n} \tag{4.2.14}$$

$$mc_t = (\frac{1}{1-\gamma_n})^{1-\gamma_n} (\frac{1}{\gamma_n})^{\gamma_n} \frac{W_t^{1-\gamma_n} R_t^{\gamma_n}}{A_t (K_{t-1}^G)^{\gamma_G}} \tag{4.2.15}$$

where $R_t = R_t^k P_{t-1}^k - (1-\delta_k) P_t^k$.

In the second stage, the intermediate good producer maximizes its discounted real profits. Following Fernández-Villaverde and Rubio-Ramírez (2009), a fraction $1-\alpha_p$ of producers might change their prices in each period to P_t^*. Other producers can only index their prices by past inflation. With the indexation parameter $\chi \in [0,1]$ [4], the price index, using Calvo pricing model, evolves as follow:

$$P_t^H = \left[\alpha_p \left(\Pi_{t-1}^{\chi} P_{t-1}^H \right)^{1-\theta} + (1-\alpha_p) \left(P_t^* \right)^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{4.2.16}$$

The dynamic pricing problem of the firm is to maximize the sum of discounted real profit subject to its supply curve:

$$\max_{P_t^H} \mathbb{E}_t \sum_{\tau=0}^{\infty} (\beta \alpha_p)^{\tau} \frac{\lambda_{t+\tau}}{\lambda_t} \left[\left(\prod_{s=1}^{\tau} \Pi_{t+s-1}^{\chi} \frac{P_t^H(i)}{P_{t+\tau}^H} - mc_{t+\tau} \right) Y_{t+\tau}^n(i) \right]$$

$$s.t$$

$$Y_{t+\tau}^n(i) = \left(\prod_{s=1}^{\tau} \Pi_{t+s-1}^{\chi} \frac{P_t^H(i)}{P_{t+\tau}^H} \right)^{-\theta} Y_{t+\tau}^H \tag{4.2.17}$$

where $\Pi_t = \frac{P_t^H}{P_{t-1}^H}$ is inflation. Since we have utility seperatable in consumption and the security market is complete, the stochastic discount factor (SDF) is similar across households. Also because firms are owned by households, the same SDF applies for the

4. where $\chi = 0$ is no indexation and $\chi = 1$ is total indexation

valuation of future profits of these firms. The solution P_t^* after simplication implies

$$X_t^1 = \lambda_t mc_t Y_t^H + \beta\alpha_p E_t(\frac{\Pi_t^\chi}{\Pi_{t+1}})^{-\theta} X_{t+1}^1 \tag{4.2.18}$$

$$X_t^2 = \lambda_t \Pi_t^* Y_t^H + \beta\alpha_p E_t(\frac{\Pi_t^\chi}{\Pi_{t+1}})^{1-\theta}(\frac{\Pi_t^*}{\Pi_{t+1}^*}) X_{t+1}^2 \tag{4.2.19}$$

where $\Pi_t^* = \frac{P_t^*}{P_t^H}$ and $\theta X_t^1 = (\theta - 1)X_t^2$.

4.2.4 Capital Producers

Competitive capital producing firms build new capital by using undepreciated part of capital from intermediate goods producers and new investment. The new capital is sold at price P_t^k at time t. The capital accumulation dynamic is

$$K_t = (1 - \delta_k)K_{t-1} + \Phi\left(\frac{i_t}{i_{t-1}}\right) i_t \tag{4.2.20}$$

$$\Phi\left(\frac{i_t}{i_{t-1}}\right) = 1 - \frac{\xi}{2}\frac{\left(\frac{i_t}{i_{t-1}} - 1\right)^2}{\frac{i_t}{i_{t-1}}} \tag{4.2.21}$$

where $\Phi(.)$ is the non-linear investment adjustment cost function following Christiano et al. (2010). parameter ξ measures the concavity of the technological constrains. The capital producer maximizes it profit

$$\max_{i_s} \quad \Pi_t^K = \mathbb{E}_t \sum_{s=t}^{\infty} M_{s,t}\left[P_s^k K_s - (1 - \delta_k)P_s^k K_{s-1} - i_s\right] \tag{4.2.22}$$

subject to the dynamic of capital accumulation, equation 4.2.20 where $M_{s,t}$ is the stochastic discount factor. P_t^k is the Tobin's Q which determines the relative cost of investment in units of consumption. The price of depreciated capital and the new capital is assumed to be the same. The maximization problem implies

$$P_t^k\left[\frac{i_t}{i_{t-1}}\Phi'\left(\frac{i_t}{i_{t-1}}\right) + \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] + \mathbb{E}_t\left[M_{t+1,t}\left(P_{t+1}^k\left(\frac{i_{t+1}}{i_t}\right)^2\Phi'\left(\frac{i_{t+1}}{i_t}\right)\right)\right] = 1 \tag{4.2.23}$$

The realized profit in each period is:

$$\Pi^K_{t+1} = P^k_t K_t - (1-\delta_k) P^k_t K_{t-1} - i_t \tag{4.2.24}$$

In the steady-state, the capital producer's profit is zero, whereas during the transition process around the steady-state, the adjustmnet cost cannot be set to its optimal level and the capital producers can realize a loss or profit because at time t, investment, i_t is pre-determined.

4.2.5 Oil Sector

The government owns the oil sector, which follows a Cobb-Douglas production function, using capital and labor to extract oil. The oil production Y^o, is sold in the international open market at price P^o without any friction. In each period, the government spends a fixed fraction α_o of the oil revenue as the new investment in the sector, partially to replace depreciated capital too.

$$K^o_t = (1-\delta_o)\, K^o_{t-1} + \alpha_o P^o_t Y^o_t \tag{4.2.25}$$

As a result, the oil sector maximizes its profit by choosing its required labor,

$$\begin{aligned} \max \quad & \Theta_t = (1-\alpha_o) P^o_t Y^o_t - W^o_t N^o_t \\ & s.t \\ & Y^o_t = A^o_t (K^o_{t-1})^{\gamma_o} (N^o_t)^{1-\gamma_o} \end{aligned} \tag{4.2.26}$$

the first order condition implies,

$$N^o_t = (1-\alpha_o)\,(1-\gamma_o)\,\frac{P^o_t Y^o_t}{W_t} \tag{4.2.27}$$

The oil sector is zero profit firm so it returns its profit to the government. We assume that the oil price follows an $AR(1)$ process,

$$P_t^o = \rho_o P_{t-1}^o + (1-\rho_o)\,\overline{P}^o + \epsilon_t^o \tag{4.2.28}$$

where $\epsilon_t^o \sim$ i.i.d $(0, \sigma_o^2)$

4.2.6 Financial sector

Deposit Banks

All net creditor financial intermediaries in the interbank market are referred to as deposit banks, which are price setters (that is monopolistically competitive). Each deposit bank $i \in (0,1)$ issues risk free deposit facilities for households and returns deposit interest $R_t^D(i)$ in the next period. These banks transfer the collected deposits to lending banks in the interbank market at the interbank rate R_t^{IB}. Given that deposits are imperfect substitution, and banks are monopolistically competitive, a deposit bank i faces a Dixit-Stiglitz loan demand curve [5].

$$D_t(i) = \left(\frac{R_t^D(i)}{R_t^D}\right)^{\varepsilon} D_t \tag{4.2.29}$$

where the demand is increasing in the relative deposit interest rate and $\varepsilon > 1$ is the elasticity of substitution between different types of deposits. $D_t(i)$ is deposit supplied to bank i at the offered interest rate $R_t^D(i)$. D_t and R_t^D are the aggregate deposit and deposit rate taken as given by bank i. For setting the interest rates, deposit banks face a quadratic adjustment cost à la Rotemberg (1982) when maximizing its profit,

$$\Pi_t^D = \max_{R_t^D(i)} \mathbb{E}_t \sum_{s=t}^{\infty} M_{s,t} \left\{ \left(R_t^{IB} - R_t^D(i)\right) D_t(i) - \frac{\kappa_D}{2} \left(\frac{R_t^D(i)}{R_{t-1}^D(i)} - 1\right)^2 D_t \right\} \tag{4.2.30}$$

5. As in Gerali et al. (2010b) and Dib (2010).

The first order condition is simplified to

$$\frac{1+\varepsilon}{\varepsilon}R_t^D = R_t^{IB} - \frac{\kappa_D}{\varepsilon}\left(\frac{R_t^D}{R_{t-1}^D}-1\right)\frac{R_t^D}{R_{t-1}^D} + \mathbf{E}_t\frac{M_{t+1,t}}{\varepsilon}\left(\frac{R_{t+1}^D}{R_t^D}-1\right)\frac{R_{t+1}^D}{R_t^D} \tag{4.2.31}$$

where symmetric equilibrium implies $R_t^D(i) = R_t^D$ for all $i \in (0,1)$. Equation 4.2.31 shows that the interbank rate includes the risk-free deposit rate, deposit bank's markup and adjustment costs. This spread between free-risk rate and the inter-bank rate varies over the business cycle.

Lending Banks

In contrast, all net debtor financial intermediaries in the interbank market are referred to as lending banks. In addition to deposit resources, the lending bank has access to the central bank's loan B_t^{CB} at rate R_t^{CB}. B_t^{CB} can be elucidated as quantitative monetary easing. Each bank adds this bundle to its last-period profit, ϖ, in order to finance lending to firms, L_t, and buying government bonds, B_t. Raising any loan is subject to a quadratic adjustment cost. So, a lending bank's balance sheet (which is the same for all lending banks and therefore we look at the aggregate) can be written as:

$$B_{t+1} + L_t = D_{t+1} + B_t^{CB} + \varpi_t \tag{4.2.32}$$

The bank maximizes its profit every period by

$$\max_{L_s^p, L_s, B_s^{CB}, B_s} \Pi_t^L = \mathbb{E}_t\left[\sum_{s=t+1}^{\infty} M_{s,t}\varpi_s\right]$$

$$s.t$$

$$\begin{aligned}\varpi_t = {} & R_t^k L_{t-1} + R_t^B B_t - R_t^{IB} D_t - R_{t-1}^{CB} B_{t-1}^{CB} \\ & - \frac{\eta_D}{2}\left(D_t - \overline{D}\right)^2 - \frac{\eta_B}{2}\left(B_t - \overline{B}\right)^2 - \frac{\eta_L}{2}\left(L_{t-1} - \overline{L}\right)^2\end{aligned} \tag{4.2.33}$$

where $\eta_B, \eta_D, \eta_L > 0$. The first order conditions imply,

$$R_t^{IB} = \frac{R_{t-1}^{CB}}{1 + \eta_D \left(D_t - \overline{D}\right)} \tag{4.2.34}$$

$$R_t^{B} = \frac{R_{t-1}^{CB}}{1 - \eta_B \left(B_t - \overline{B}\right)} \tag{4.2.35}$$

$$R_t^{k} = \frac{R_{t-1}^{CB}}{1 - \eta_L \left(L_{t-1} - \overline{L}\right)} \tag{4.2.36}$$

To close the model, we assume that lending banks have unlimited access to oil reserve fund resources at the policy rate R_t^{CB} after exhausting other resources. Therefore, in addition to the deposit rate in (4.2.31), all other rates in the financial system are pinned down by the policy rate in equations (4.2.34) to (4.2.36). Each of these rates can be a markup or a markdown to the policy rate depending on the resources on asset and liability sides. For instance, if there is an excess liquidity in the banking system due to high levels of deposits, the interbank rate falls below the policy rate. Conversely, in a liquidity shortage, the interbank rate is higher than the central bank rate.

4.2.7 Government

The government collects taxes, T_t , raises government domestic bonds, B_t, and has access to a fraction ν of the oil revenue Θ_t, a fraction ρ_g of the oil reserve fund F_t, and its return on international investment of the oil fund at interest rate R_t^* [6]. On the other side, the government spends G_t, remunarates bond holdings at R^B, distributes transfers Γ_t.The government budget constraint is

$$T_t + B_{t+1} + \nu\Theta_t + (\rho_g + R^*)F_{t-1} = G_t + R_t^B B_t + \Gamma_t \tag{4.2.37}$$

6. The best way to introduce R_t^* is by using the interest rate parity equation. However, for simplicity, we assume that the international interest rate is a markdown of the domestic policy rate.

The government has the following rules for transfer and public spending:

$$T_t = \tau_d(R_t^D - 1)D_t + \tau_c C_t + \tau_w W_t N_t + \tau_k \mathbb{P} \tag{4.2.38}$$

$$\Gamma_t = \rho_\Gamma \nu \Theta_t \tag{4.2.39}$$

$$G_t^c = \overline{G}^c \tag{4.2.40}$$

$$G_t^p = K_t^G - (1 - \sigma_G)K_{t-1}^G = \overline{G}^p \tag{4.2.41}$$

$$G_t = G_t^c + G_t^p \tag{4.2.42}$$

$\tau_d, \tau_c, \tau_w, \tau_k$ are tax rates on return on deposits, consumption, wage and profits, respectively. The government sets the transfer according to the oil revenue by parameter ρ_Γ. G_t^c is government current expenditure and G_t^p is government investment in building public capital. G_t is the total government expenditure.

4.2.8 Central Bank and Oil Reserve Fund

The central bank is a nonprofit institution. Every period, the central bank sets the policy rate by the Taylor rule as follows:

$$r_t^{CB} = \rho_{cb} r_{t-1}^{CB} + (1 - \rho_{cb})(\overline{r}^{CB} + \rho_\pi(\Pi_t - \overline{\Pi}) + \rho_y(Y_t - \overline{Y})) \tag{4.2.43}$$

where Y is GDP and $1 + r_t^{CB} = R_t^{CB}$. We assume that the central bank uses resources in the oil reserve fund to intervene in financial markets. The oil reserve fund dynamic evolves such that:

$$F_t = (1 - \rho_g)F_{t-1} + (1 - \nu)\Theta_t + R_{t-1}^{CB} B_{t-1}^{CB} - B_t^{CB} \tag{4.2.44}$$

which is a result of the oil reserve fund operation with the lending banks, receiving a share of oil revenues and a depreciation of the stock which can be due to many reasons.

4.2.9 Market clearing

By adding all budget constraints, market clearing conditions are:

$$GDP_t + R_t^* F_{t-1} = C_t + \Phi\left(\frac{i_t}{i_{t-1}}\right) i_t + \alpha^o P_t^o Y_t^o + G_t + (F_t - F_{t-1}) \tag{4.2.45}$$

$$N_t = N_t^o + N_t^n \tag{4.2.46}$$

$$\mathbb{P} = \Pi_t^K + \Pi_t^R + \Pi_t^D + \Pi_t^L \tag{4.2.47}$$

where $GDP_t = Y_t^H + P_t^o Y_t^o$. In equation 4.2.45, total output plus the return on foreign investments are equal to consumption, capital investments, government expenditure and net deposits in the oil reserve funds.

4.3 Results

Table 4.1 – Calibrated parameters (quarterly)

Parameters	Symbol	Value	source
Discount factors	β	0.9595	$R^D = 0.18(annually)$
Consumption elasticity	σ	1.5	Bhattacharjee et al. (2007)
Relative utility weight of labor	χ_N	0.52	$N = 1$
Inverse Frisch elasticity of labor supply	ϕ	2.17	Motevaseli et al. (2011)
Elasticity of private capital	γ_n	0.30	$K/GDP = 2$
Elasticity of public capital	γ_G	0.1	Berg et al. (2013)
Elasticity of private capital in oil	γ_o	0.80	$K^o/GDP = 0.30$
Coef. of intermediate producer	θ, χ, α_p	$9, 0.241, 0.50$	30% Mark up,Daliri and Mehrgan (2015)
Depreciation rates	$\delta_k, \delta_o, \delta_g$	$0.05, 0.007, 0.1$	Motevaseli et al. (2011)
Capital Pro. adj. cost	ξ	2	Daliri and Mehrgan (2015)
Coef. of deposit bank	ε, κ_D	$237, 1.5$	$R^{IB} = 0.20(annually)$
Taxes	$\tau_c, \tau_d, \tau_w, \tau_k$	$0.09, 0, 0.04, 0.15$	Average tax rates
Central bank	$\rho_{cb}, \rho_\pi, \rho_y$	$0.10, 1.5, 0.125$	Gertler and Karadi (2011)
Oil AR processes	ρ_o	0.80	Guerra-Salas (2014)
Other AR processes	$\rho_A, \rho_{A^o}, \rho_\xi$	$0.80, 0.90, 0.90$	
Gov. share of oil revenue	ν	0.70	
Gov usage of oil fund	ρ_g	0.05	
Share of Transfer in Oil Rev.	ρ_Γ	0.33	
Share of investment in oil revenue	α_o	0.01	
Adj. costs of lending bank	η_D, η_B, η_L	$2, 0.2, 2$	

The model is calibrated to the quarterly data for Iran's economy from 1985-2015. Table 5.1 presents the value of the parameters, which are chosen from Iran's data

based on the quarterly targets. In summary, a subset of parameters is taken from the literature or is calibrated to match the long-run averages observed in the data in table 4.2. The source of data is from the World Bank, the Central Bank of Iran and the budget law.

Table 4.2 – Steady state of the benchmark model(quarter)

Variable	symbol	Steady State/GDP
Consumption	C	0.64
Transfer	Γ	0.05
Private capital	K	2
Oil capital	K^o	0.36
Public capital	K^G	0.48
Non-oil output	$P^H Y^H$	0.75
Oil revenue	$P^o Y^o$	0.25
Gov. expenditure	G_c, G_p, G	$0.25, 0.046, 0.30$
Investment	X	0.10
Gov. loans	B	0.40
Tax	T	0.09
Total government's budget		0.78
Current expenditure/investment	G_c/G_p	5.5

This section discusses the main results of the paper. First, we look at the technology shocks on non-oil firms and on the oil sector and compare the impulse response functions to these shocks with well-established results in papers such as Christiano et al. (2010) and Smets and Wouters (2003). Then, upon the model's success in reproducing similar response for main fundamentals of the economy, we look into the oil price shock on P^o. Following Pieschacón (2012), we assume that the oil price and technology shocks are stationary and follow an AR(1) process as in (4.2.28):

$$P_t^o = (1-\rho_o)\overline{P}^o + \rho_o P_{t-1}^o + \epsilon_t^o$$
$$log(A_t) = \rho_i log(A_{t-1}) + \epsilon_t^a$$

where $\epsilon^i \approx N(0, \sigma_i^2) \quad i = P^o, A.$

4.3.1 Technology Shocks

Figure 4.7 and 4.8 show the impulse responses for the aggregate variables coming from the same set of models illustrated previously for a one-standard-deviation shock to the TFP level. A positive technology shock increases non-oil output, leading to an improvement in wages and the labor employed in the economy. With perfect labor mobility across sectors, and assuming no change in the oil price, the higher wage demand decreases the labor supply in the oil industry, leading to a decline in oil production and revenues. For this purpose, labor initially increases but then declines as the income effect from the oil sector starts to dominate the substitution effect from the non-oil sector. Due to higher wages and labor, transfers diminish for a few periods as the government receives lower oil revenues and households get wealthier. Following the productivity shock, the marginal cost falls on impact leading to a decline in inflation. The monetary policy follows the inflation path and with a decline in the central bank policy rate all market rates fall. The decline in rates reduces the net worth of the banking system accompanied by deposit and government bond supply. The only exception among the market rates is the return on capital which according to equation (4.2.12) follows the productivity shock. Moreover, a positive technology shock decreases firm's capital stock building and equivalently the loan demand.

Figure 4.7 compares the benchmark model with other scenarios including no price stickiness ($\alpha_p = 0$) and higher cost of capital replacement in the oil sector ($\alpha_o = 0.1$). In 4.8, the benchmark model is compared with models without Rotemberg adjustment cost in the deposit branch ($\kappa_D = 0$), no market power for deposit banks ($\varepsilon_D = \infty$) and finally with near perfect pass-through of rates through lending banks ($\eta_D, \eta_B, \eta_L \simeq 0$).

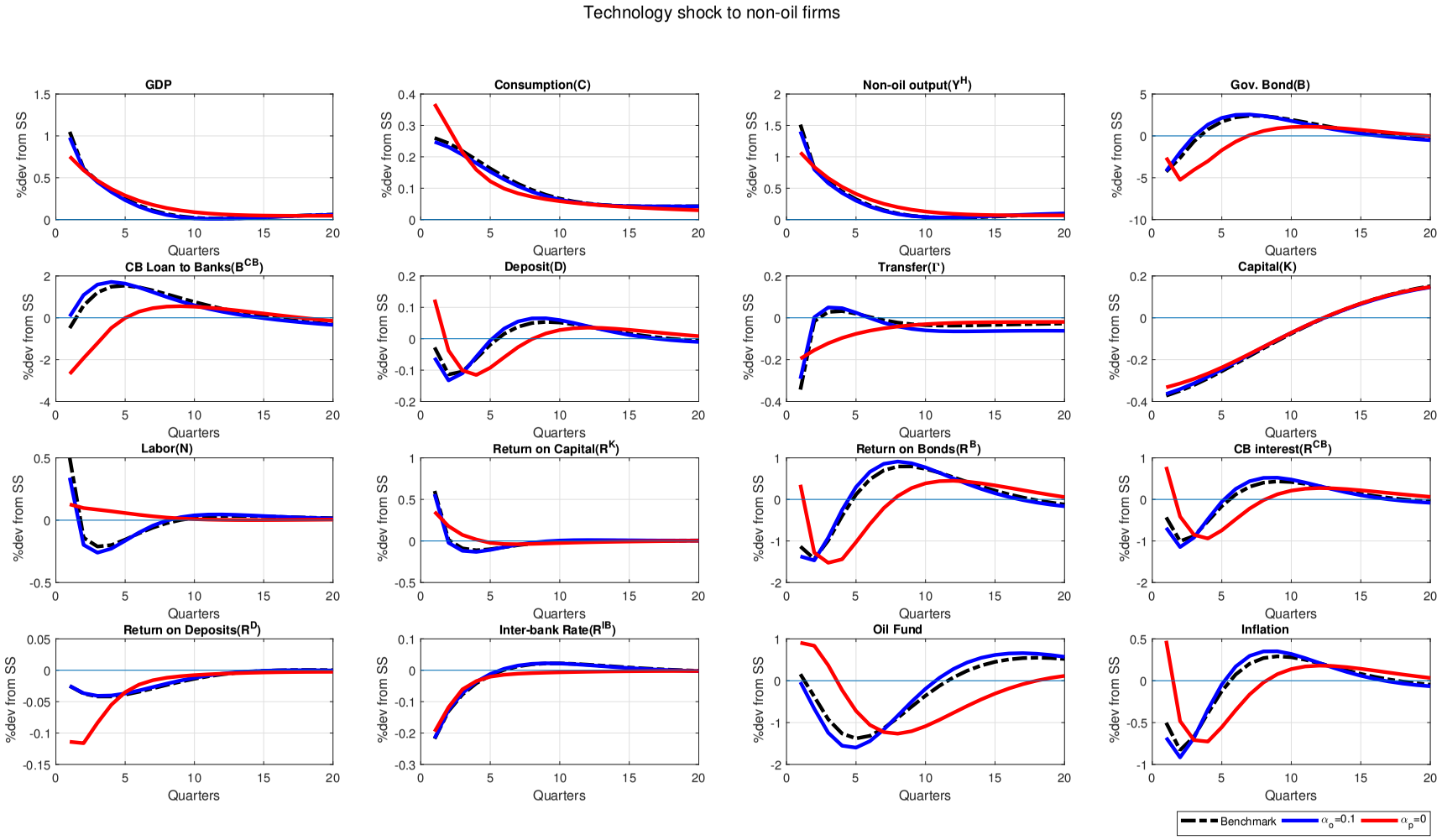

Figure 4.7 – % change from the SS for the key variables, 1% positive technological shocks

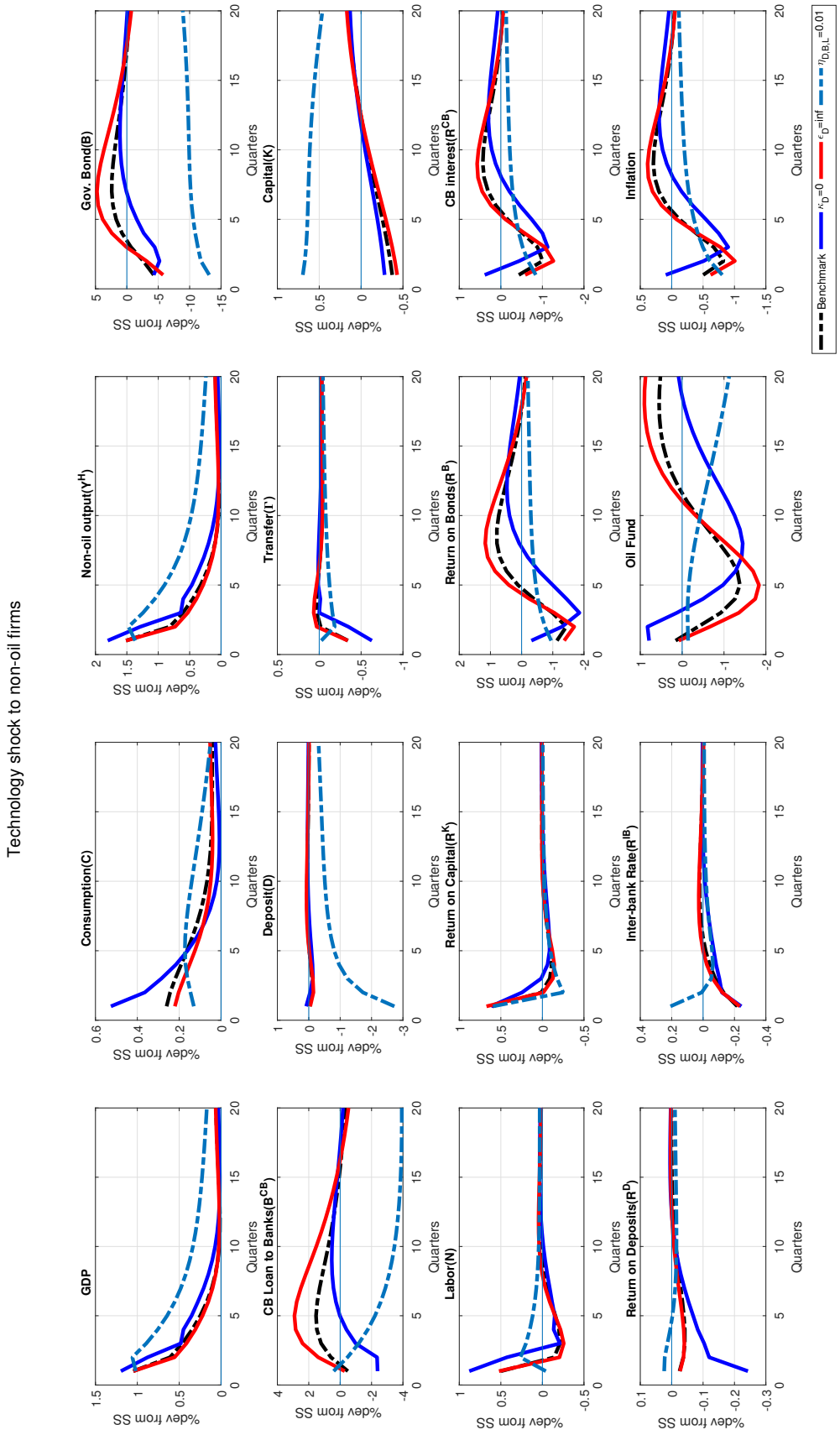

Figure 4.8 – % change from the SS for the key variables, 1% positive technological shocks

Higher cost of capital replacement in the oil sector only slightly dampens the technology shock impact on the economy. However, the absence of price stickiness affects the monetary policy behavior following an increase in inflation, since retailers can adjust their prices instantly. The absence of sticky rates and imperfectly competitive financial intermediation alter the picture only marginally. Nonetheless a quasi-perfect pass-through of rates through lending banks amplify the contribution to the expansion following a technology shock. The usual drop in inflation induces a policy rate cut, but without interest rate adjustment costs for lending banks, rates fall and converge to the steady state slowly against other scenarios in which the policy rate overshoots after five quarters. Nevertheless, an important difference is that the deposit rate and the interbank rate are still determined by deposit branches with monopolistic power.

A 1 percent technological shock on the oil industry has generally the same directional impact on the economy, but its impact remains more unattenuated. This shock increases oil revenues, and improves transfers as the government's receipt from oil enlarges and household consumption expands. The overall labor drops marginally in spite of higher hiring by the oil industry because households become wealthier and choose to work less. Nevertheless, labor in the oil sector constitutes only a small share of total labor, and modest variations in labor or wages cannot have an important impact on the real and financial sector. As a result, the government oil revenue remains the principal channel through which technological advances in the oil industry propagate into the economy. With higher revenues, government issues less bonds and carries out more public investment, which builds up public capital stock. On the impact, this would reduce the marginal cost and inflation, inducing the monetary policy reaction of reducing the policy rate.

4.3.2 Oil Price Shock

Figure 4.9 and 4.10 illustrate the impulse responses for the aggregate variables after a one-standard- deviation shock to the oil price. A positive oil price shock boosts oil

revenue, affecting the economy through different channels. First, due to the enhanced oil revenues, investment in the oil industry strengthens and boosts the capital stock in the sector, which further amplifies oil production and total output. Second, the rising oil revenue induces an increase in labor. This is interpreted for the non-oil sector as a labor supply shock, which inflates wages. To compensate for the loss, the non-oil sector responds by revising its prices upward. At the same time, the monetary policy reacts to the positive output gap and higher prices by increasing the policy rate momentarily. Nevertheless, the detrimental impact of higher oil prices on the non-oil sector pushes total labor below its steady state value, resulting in falling wages and prices, reversing the very short-term impact of higher oil prices. This shows the importance of structure within an economy and how the oil and non-oil sectors are linked. This development happened in our model, because the two sectors compete over labor. This effect could be strengthened, if the capital in the oil sector were of the same material as in the non-oil sector. Inversely, higher oil prices can have a positive impact on the non-oil sector, if for instance, government subsidies to firms were important, or government would use more of non-oil sector products in its public investment program.

As prices start to fall and the central bank cuts the policy rate, other rates start to decline. Following the drop in rates, deposit and bond supply plummet, partly because households move to smooth their consumption and the government receives higher revenues from oil. Naturally, with rising oil revenues, the government finances its expenses directly from oil revenues, leading to a shift from a modern state to an economy with reduced dependence on bonds and even taxes.

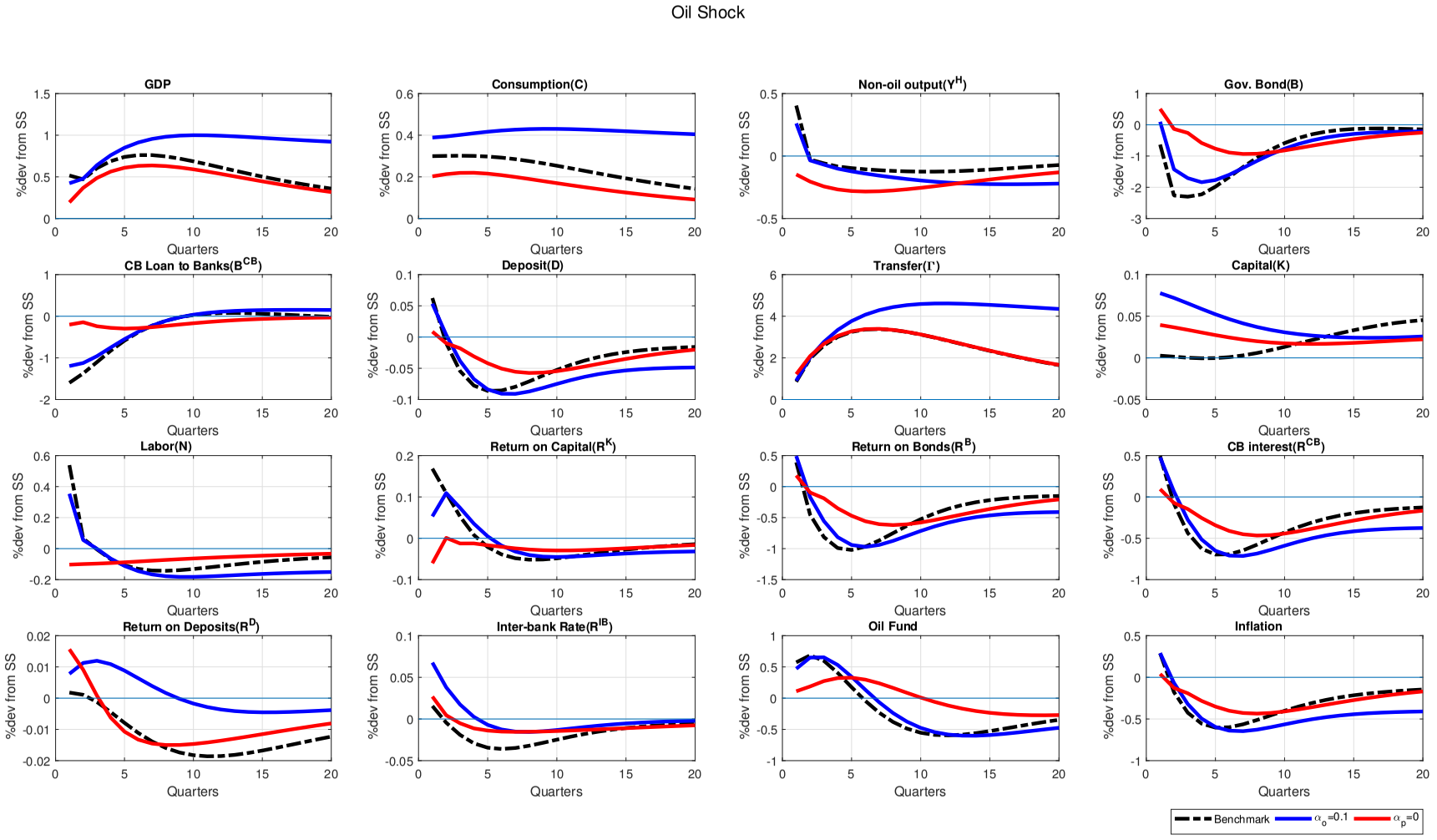

Figure 4.9 – % change from the SS for the key variables, 1% positive oil price shocks

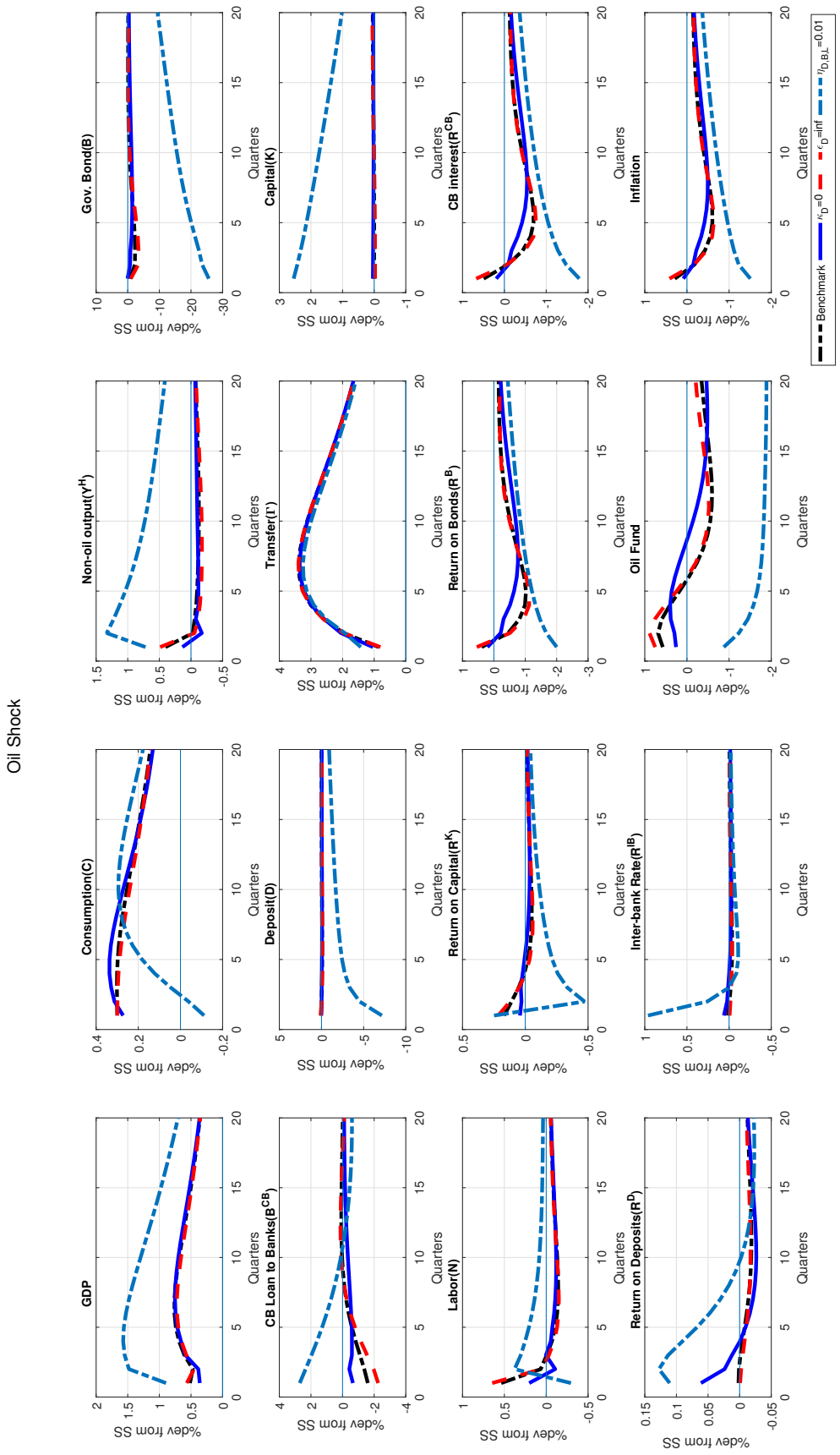

Figure 4.10 – % change from the SS for the key variables, 1% positive oil price shocks

Also, due to lower wages and a richer government, households choose to work less and receive more state transfers and therefore total consumptions grow. In the medium-term, non-oil firms will substitute lower labor with the capital accumulation by taking advantage of lower market rates for borrowing. For this reason, capital stock rises after the fall in interest rates and labor. The oil fund originally overshoots thanks to higher oil revenues, but because of lower deposits in the system and higher loan demand coming from non-oil firms, the oil fund must inject resources to the banking system. Eventually, resources go below the steady state. The oil fund resource injection is complemented by the central bank's lending to banks. Indeed, due to higher deposits at the beginning and lower bond supply, banks do not use the central bank's lending facilities. As soon as non-oil firms start to invest and their loan demand increases, central bank lending goes back to the steady state. Indeed, the central bank's rate, following the Taylor rule, rises at first based on output and inflation gaps. However, due to rigidities in adjusting the interbank rate, the increase in the interbank rate is smaller than that of the central bank. As a result, the lending branch has more incentive to borrow in the interbank market rather than directly from the central bank.

In this setup, the wage is determined only by non-oil firms. Although higher oil price makes it more efficient to reallocate resources from non-oil to the oil sector, this wage rigidity prevents a perfect substitution in the general equilibrium. The transmission mechanism could be reinforced if wage dispersion existed in the model and the wage was determined in a competitive labor market or even in monopolistic model à la Calvo for instance.

In addition to the benchmark model, figure 4.9 shows the oil shock under two alternative scenarios with no Calvo pricing and higher oil re-investment. The two models behave similarly to the benchmark model; however, they illustrate the role of each component in the propagation of shocks. With $\alpha_p = 0$ and no price stickiness, retailers can adjust the prices instantly, which dampens the impact of the shock on almost all variables. Since prices adjust immediately, the mechanism that happens with the full model at the beginning of the shock disappears. As in the benchmark

model, with positive oil price shock the oil industry absorbs more labor. The non-oil sector responds to the shock by increasing salaries and prices. However, this time retailers respond to the monetary policy reaction of a rate increase immediately, and, therefore, prices fall on impact. The non-oil sector's output falls as a result of losing labor and the inability to increase prices. With a shrinking labor force and cheaper capital acquirement, non-oil firms start accumulating capital. Households choose to work less, since the salaries have not increased and because transfers increase due to higher oil price. Nonetheless, consumption and transfers are weaker than in the benchmark model and the government initially issues higher bonds to support transfers and public investment.

The case of higher investment in the oil sector is more interesting. The response is very similar to the benchmark model; however, GDP and consumption expand more, and convergence to the steady state is slower. The reason is that as the oil output upsurges with the sector's investment intensification, production and labor demand also increase. The impact on the non-oil sector is as detrimental as in the benchmark, with a more protracted effect. The oil sector is greedier on labor, and the non-oil output declines faster while trying to compensate for labor losses with higher investment. This process is facilitated by suppressed market rates. Because of the prolonged impact on non-oil firms, the monetary reaction remains protracted, and rates remain low for a longer period.

4.3.3 Application

Once the model has been calibrated and its propagation mechanisms studied, we can use it to analyze the role of the financial sector and banks, raised in the introduction. We are not looking at the shocks originating within the banking sector, although they can be interesting, but are simply studying the role of banks in propagating an oil shock to the rest of the economy. In this model, agents are not a credit constraint, leading to the absence of a conventional financial accelerator mechanism. The goal of the model, therefore, is not to replicate a financial accelerator model, because

by construction it amplifies the impact of shocks. The goal of adding a financial sector was to 1) introduce an oil reserve fund and link it to the banking sector and the government; 2) to see the impact of an interbank market on shocks; and 3) to introduce different rates in the economy and later on intervention and exchange rate stability mandate for the central bank.

Figure 4.10 demonstrates the response function to the oil shock with different financial system component changes. We look at the responses with changes on the deposit branch where the deposit rate adjustment cost has been removed, $\kappa_D = 0$, and the case with no monopolization power for deposit branches, i.e. $\varepsilon_D = \text{inf}$. Then we analyze the impact of instantaneous rate changes at lending branches by removing all adjustment costs, i.e. $\eta_{B,D,L} = 0$.

The monopolization of the deposit branch or the deposit rate adjustment cost appear to have a mild impact on the model. In contrast, the response functions related to lending branches with no adjustment costs have a significant impact. Indeed, with instantaneous rate adjustments, non-oil firms replace the labor with capital. Therefore, the overall demand for labor falls at the beginning and investment soars. This process occurs at the same time as the central bank rate cut because this time firms do not see the necessity of increasing their price levels for paying higher salaries. Instead, the overall price index falls, and the central bank responds by cutting the policy rate, which in turn boosts investment. However, after two quarters, the non-oil output increases to the point that firms require hiring and therefore labor overshoots. Since labor declines right after the shock, consumption declines, but it increases as transfer and labor start to rise and the overall level remains higher than the benchmark and other scenarios. Government bond supplies also decline on account of lower bond rates and higher government revenues from oil. The major difference in this scenario is the positive spillover from the oil to the non-oil sector, because of the firms' labor-choosing behavior, falling prices, and the monetary policy reaction. As a result, the cumulative impact on GDP stands higher than in other scenarios. Nevertheless, this result remains very sensitive to the parameters' calibration. With different parameters for the households' utility function for labor and leisure and modified Taylor rule, the

results could be different and potentially closer to the benchmark model.

4.4 Concluding remarks

This paper studies an oil economy in a New-Keynesian framework with a heterogeneous banking sector. The main purpose is to analyze how different components of an oil economy from the oil sector, public financing from oil resources, and national development fund interact together and with a banking sector in propagating shocks in the economy.

Several results are provided. First, because of complementarities between the oil and non-oil sectors, the labor market becomes an important source of shocks spillover in this economy. This is seen especially in the oil sector technology shock and oil price shock. The main reason here is the fixed labor supply. In an economy with slack capacity of labor, the results can be different somewhat and a positive technology shock or oil price shock would have larger impact on GDP and consumption. Therefore, policies aimed at stabilizing wages and prices prevents these variables to play their role of automatic stabilizers to avoid large swings of production factors between sectors. The detrimental effect on the non-oil sector also results in a pro-cyclical behavior of the monetary policy to support price stability and stimulate the non-oil sector. Nevertheless, this setup can compensate for the lack of an exchange rate in the model to capture a similar Dutch disease kind of phenomena in oil economies.

Second, the government's role in propagating shocks is essential. When the oil revenues in- crease due to higher oil prices or a positive technological shock, the government magnifies the transfer to households and increases public capital expenditure. Higher transfer indeed improves consumption, but it also affects the households' decision of labor allocation. On the other hand, since public capital is used in the non-oil output, total output should increase proportionally, which would result in a higher fiscal multiplier.

Third, although banks do not play a key role in the propagation of oil shocks in

this model, they have a critical role in amplifying them. Because the oil sector is not directly exposed to the banking sector, and non-oil firms are neither credit constrained nor is a default allowed in the model, banks are not essentially driving the responses to the oil sector shocks. Instead banks in this model can differentiate between market rates. Various frictions in the banking sector affects the impulse response functions. But the deposit bank monopolistic power or deposit rate adjustment cost have insignificant impact compared to adjustment costs in lending banks. This is due to the fact, that lending banks are linked to the government, non-oil firms, national development fund and the central bank.

This model provides plausible explanations in a stylized manner that can help improve our understanding of how different sectors of an oil economy interact, but naturally it comes with many limitations. As mentioned before, the model remains very sensitive to the labor market. In reality, the oil sector is capital intensive. Additionally, the labor force is very specialized, and the degree of substitutability remain low. Furthermore, the model abstracts from the exchange rate and trade. Indeed, in oil economies the major export remains oil, and the revenue is accrued to the government and a sovereign wealth fund or a development fund. The negative spillover effect from the oil to the non-oil sector can be exacerbated by modeling a small open economy and introducing a real exchange rate. Moreover, by choosing credit-constrained firms and introducing collaterals, the banking system becomes part of the propagation mechanism, and the financial accelerator must function. Finally, the central banks of many oil-exporting countries have the implicit mandate of exchange rate stabilization. The model dynamic can be improved by choosing exchange rate stabilization as one of the objectives of the central bank. For this purpose, we have to introduce an intervention rule as well.

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Chapter 5

Distributional and Welfare Effects of Tax Reforms in Developing Countries

With

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Abstract

This paper assesses the macroeconomic and welfare effects of fundamental tax reforms in an emerging/developing economy. We develop a dynamic general equilibrium model with structural and institutional characteristics of non-oil emerging and developing economies and apply the model to Morocco. The model's simulations suggest that tax reforms imply complex trade-off between growth, government revenue, and equity. A comprehensive approach associated with better targeted social programs, broadens the tax base, removes tax distorsions, better distributes the tax burden, and mitigates adverse distributional effects (that is improves welfare) by making the tax system more progressive and reducing inequalities. For Morocco, a comprehensive tax reform package would involve *i*) reducing tax exemptions, *ii*) a broader-based property tax, *iii*) a lower corporate tax rate, *iv*) aligning the VAT rate on exempted goods and services to the standard rates, and *v*) a better targeted social safety net. The paper indicates that such a reform package is growth-friendly, broad-based, progressive and has implications for existing gender biases.

JEL classification:E62, H20, F41 .

Keywords: Tax reform, Macro-structural policies, Distributional effects, Dynamic general equilibrium, Welfare.

5.1 Introduction

This paper quantifies the potential effects of fundamental tax reforms on growth, government revenue, welfare, and inclusiveness. It aims to contribute to the design of tax reform strategies in emerging and developing economies using Morocco [1] as a case study. It builds a reliable model for policy makers to assess tax reforms and their distributional [2]/welfare effects by using a number of yardsticks. This includes: *i*) enhancing tax revenues which helps create fiscal space for investment and social spending; *ii*) boosting growth through tax incentives to entrepreneurship and investment; and *iii*) increasing fairness and welfare, by making the tax system progressive. The dynamic general equilibrium model is adapted to emerging and developing market economies' specifications and could capture all key dimensions mentioned above in the short, medium [3] and long run, as well as potential changes to social spending.

Our keys conclusions from the model simulation and welfare analysis are: first, tax reforms should be part of a comprehensive and well explained approach. Such an approach should consider the combined impact of various tax measures in several dimensions, including growth, revenue, and fairness, as well as parallel efforts to improve the targeting and impact of public social spending. In the absence of comprehensive strategy, the risks are that isolated reforms are not sequenced properly, that they either introduce inconsistencies or distortions, or that they be perceived as unfair, and in the end counter-productive from the perspective of improving the quality, efficiency, fairness, and acceptance of the tax system. Second, a comprehensive tax reform package for Morocco could include: removing tax exemptions on large agricultural firms, simplifying the value-added tax (VAT) regime and corporate taxation, better enforcing tax payments from self-employed and liberal professions,

1. Following the National Tax Conference in 2013. https://www.imf.org/external/pubs/ft/scr/2014/cr1465.pdf
2. For more studies on distributional effects of tax reform please see Aaron and Gale (2010) and Golladay and Haveman (2013).
3. Consistent with the medium term revenue strategy (MTRS) proposed by the IMF. See IMF et al. (2016).

applying property taxes and strengthening social safety net plans. This reform package helps broaden the tax base, remove tax distortions, and better distributes the tax burden [4]. The long-run multiplier for this reform is 0.55.

Our research is related to various papers that assess the macroeconomic and distributional effects of fundamental tax reforms e.g. Altig et al. (2001) and the impacts of major reforms in low-income developing economies e.g. Fabrizio et al. (2017) and Furceri et al. (2016). Our paper contributes to the literature by adding new features, specifically the real estate and rental market, property tax, the ability of assessing a mixed tax reform package, evaluating the impact of informality and the possibility of tracing different social aid plans. Our model draws from the neoclassical approach and is augmented by capital and housing frictions. The sectors which form the economy are households, firms and government. The household sector is heterogeneous by four agents: *i*) rural workers who work on land and produce food; *ii*) informal workers who produce services and rent houses; *iii*) formal workers who own a portion of housing market and produce goods and services using capital, and *iv*) entrepreneurs who rent houses to informal workers, manage the production of food, goods and services in firms where rural and formal workers are employed. The government collects taxes and carries out a re-distributive role through public spending and lump-sum transfers to households. It could finance its deficit by issuing interest-bearing bonds.

The application of the model to Morocco shows that a comprehensive tax reform implementation could help the government to achieve medium-term objectives such as lower public debt (below 60% of GDP) and higher and more inclusive growth. Implementing a comprehensive tax reform could yield about 1-2 percent of additional public revenues over the medium term, creating more fiscal space to support pro-

4. Tax burdens could also be alleviated by strengthening the social safety net and reducing corporate tax rate. This combination would minimize two major concerns surrounding high tax rates by: first, reorienting incentive toward value-added activities which would address the effects from high taxes rates on economic decisions and distortions; second, addressing income distribution effects of high tax rates by protecting the poor and most vulnerable tranches of the population from tax burdens.

growth and pro-poor spending. Moreover, the reform simplifies the tax system, improves fairness, and better targets transfers. It has a positive effect on output as investors direct resources to high-yield investments, as opposed to lower yield sector such as real estate. The paper simulates the behavior of key macroeconomic variables after applying simple or mix reforms in short and long-run. The short-run effect is mostly neglected in the literature, but in the context of developing economies, it might be as important as the long-term impacts [5].

The relationship between taxation and economic growth is mixed and differs across countries; in advanced economies, a tax rate increase may dampen growth, while in developing economies, the empirical relationship remains inconclusive. As to how taxation can help reduce inequality, the findings are also conflicting [6]; reducing inequality supports sustainable economic growth but redistributions through tax policy could significantly increase tax burdens. For developing economies, where the body of empirical evidence is smaller, the relationship between tax and growth seems inconclusive. These findings have in part been attributed to the role of other factors, such as weaker tax administration and enforcement (Acosta Ormaechea and Yoo, 2012). Our paper establishes that strengthening social safety nets is a key to mitigate the effects of tax reform on welfare and inequality. Alongside Emran and Stiglitz (2005), our paper shows that raising government revenue by increasing VATs without further reforms in social safety net plans results in welfare loss. Our paper features generalized and targeted transfers and suggests that designing a tax policy needs a balance between growth and redistribution objectives [7].

Our paper indicates that the tax mix has implications for existing gender biases and

5. Long-run effects tend to impact the steady equilibrium of the economy, while short-term effects only affect the cyclical components of macroeconomic variables. Effects that are positive over the long-run may have negative repercussions in the short-term. It could be difficult for a developing country (that may not have a stable political situation) to manage such a temporary slowdown for example in GDP or employment.

6. See October 2017 Fiscal Monitor for additional analysis on the relation between growth and inequality: the report takes the view that there is no systematic adverse trade-off between increasing growth and decreasing inequality.

7. For the poorest countries, a shift towards re-distributive tax policies happens only once a sufficient income per capita has been reached. See Ravallion (2010), Bird et al. (2014) and Lustig et al. (2013).

for the efficiency of tax administration. Income and consumption taxes can be gender-biased because of differences between men and women in employment and expenditure (Grown and Valodia, 2010). The aforementioned tax reform reduces unfair cost advantages enjoyed by the informal sector. This makes tax administration simpler and stronger (Fjeldstad, 2014), but has a gender dimension as men and women in the labor force are not equally employed across sectors. More women may participate in the agricultural and informal sectors for example.

We base our conceptualization of informal markets [8] on the standard informality literature. Ahmed et al. (2012) and Ahmed et al. (2013) develop and estimate a closed economy, using Pakistan data, in which informal sector uses labor to produce services. We include this structure in our model. The results indicate that the impact of decreasing the level of informality (by motivating informal sector to declare incomes) on growth and fiscal stance, considering related costs and difficulties, is not significant. Due to a big share of informal sector, tax on informal sector is sub-optimal for the economy and has a negligible distributional effects on wages.

Tax reform could address economic distortions thereby unlock additional growth. For Morocco, Karim and Mansouri (2015) shows that tax reform could decrease distortions in agriculture through an efficient allocation of investments. Verme and El-Massnaoui (2015) evaluates the 2014 subsidy reforms in Morocco by simulating the impact of reforms on household welfare, poverty, and the government budget. Our paper confirms the literature and shows appealing exemptions boost output by decreasing distortions and making the economy efficient [9].

Finally, the housing market and its impact on welfare in developing countries are mostly neglected in the literature (McBride, 2012 and Acosta Ormaechea and Yoo, 2012). However, for instance in Morocco, over 40% of the urban population lives in rental housing (2007 household survey, IMF.). This shows the significance of the housing market for both home owners and renters. To fill this gap, our paper evaluates

8. Informality has different definitions and sides. For more information, please see Perry et al. (2007).

9. Fiscal policy shocks affect output through wealth effects, intertemporal substitution, and distortions. See Ndela Ntsama et al. (2016).

the impact of taxes on the rental and property markets. This paper suggests that in the current situation [10] of Morocco, property taxes not only proceed the progressivity, but also boost output by making the tax system broad-based and growth-friendly.

The paper will rely on a few complementary analytical approaches, and is structured as follows: Section 2 presents key stylized features of Morocco's economy and tax system, including a cross-country perspective; section 3 develops a macrostructural dynamic general equilibrium model that incorporates developing countries' specific features. Section 4 calibrates the model based on Moroccan data. In section 5, results of permanent changes in various tax codes and different scenarios alongside policy issues are examined. Section 6 analyses the welfare effect of all analyzed scenarios and section 7 summarizes the keys conclusions.

10. Property taxes are an important revenue stream, particularly at the local and regional levels, but are still controversial in developing economies. See Slack and Bird (2014) and Bahl and Wallace (2008).

5.2 Stylized facts: Key features of morocco's tax system

5.2.1 Tax revenue and tax base

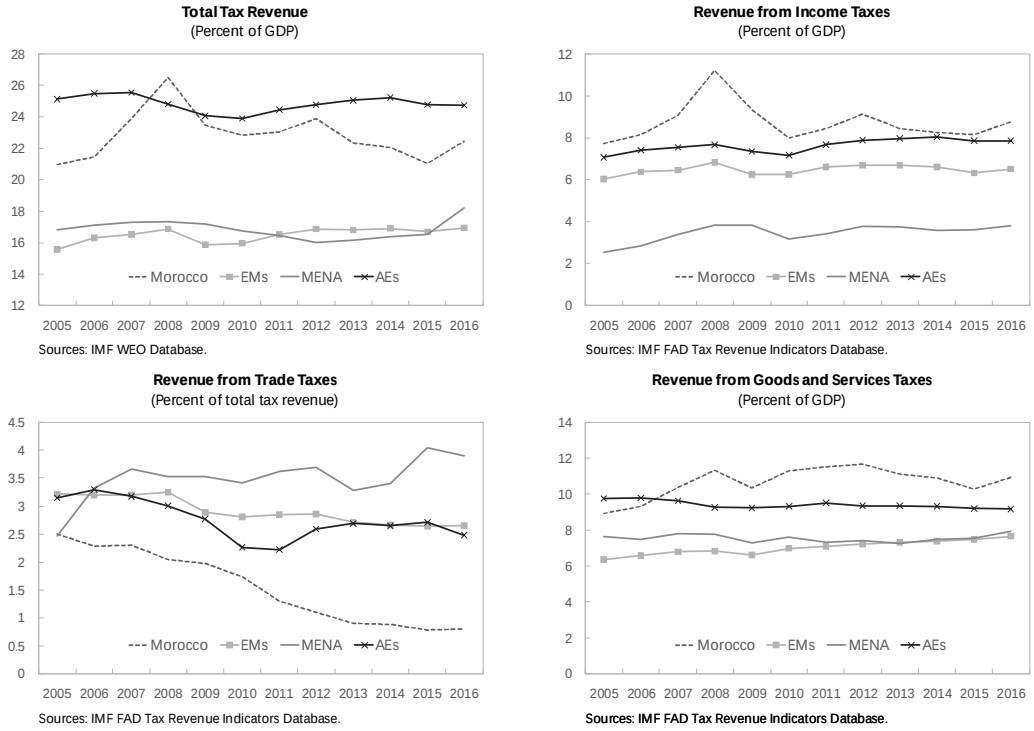

Figure 5.1 – Tax analysis, Morocco vs EMs, MENA and AEs regions

Morocco's tax to GDP ratio is on average at about 22% of GDP. It has declined in recent years from almost 24% in 2012 to 21.5% in 2016, but remains above the average for lower middle and upper middle income economies. Figure 5.1 compares the tax revenue in Morocco with the other EMs (Emerging Markets), AE (Advanced Economies), and the MENA (Middle East and North Africa) region.

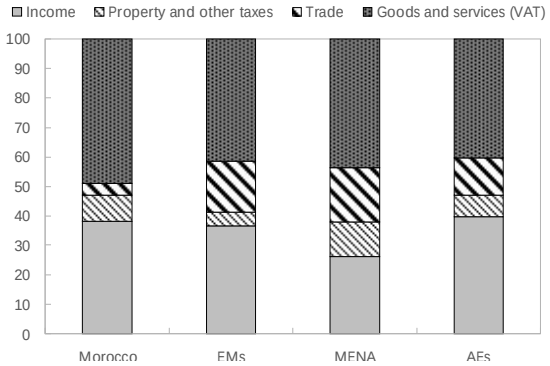

Figure 5.2 – Composition of tax revenues, 2012-16. Source: IMF FAD tax revenue Indicators Database.

Figure 5.2 depicts the share of each category in total tax revenue. Morocco's tax base is relatively narrow and skewed. There is an important gap between the potential tax base and actual tax collection. Significant contributors to this gap include tax exemptions, tax evasion and avoidance by certain sources of income. Moreover, the tax base is skewed towards (corporate and personal) income and goods and services taxes, with these two components accounting for about 80% of tax revenues. The VAT does not apply to all purchases of goods and services, since several items (e.g. some foods items, medicine) are exempted. Notably, the share of VAT in total taxes has risen over the past 10 years, while trade taxes have decreased as tariffs were reduced. Property taxes now supersede trade taxes as a revenue source, going from around 3% of total taxes in 2005 to almost 7% in 2016.

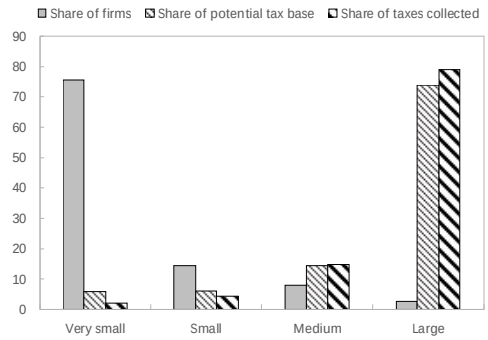

Figure 5.3 – Distribution of corporate tax burden in Morocco by firm size. Sources: IMF Fiscal Affairs Tax Revenue Indicators database.

Figure 5.3 shows that the corporate tax base is skewed towards a small number of large firms (5% of firms produce more than 80% of corporate tax). A significant number of firms (about 64% of total) do not pay corporate taxes as they tend to report losses. Tax bases for classes of taxes vary across the board. The VAT is a relatively broad-based tax as it levies a substantial share of its potential tax base. The income tax base is relatively narrow because many liberal and independent professions could manage to shelter their income from tax and only a few number of firms are subject to corporate tax. At current tax rate, a broad-based income tax could raise more revenue since more potential tax base would be levied.

5.2.2 Tax rate and tax burden

An analysis of the tax burden, drawing on cross country comparisons, shows that tax rates and income taxes in Morocco are relatively high compare to peers. Recent income tax reforms have focused on corporate tax, while personal income tax remained unchanged. Corporate tax brackets were introduced in the 2016 budget, departing from a unique 30 percent corporate income tax rate. The VAT regime has remained unchanged since 2012, with a standard rate of 20%, but a number of items have been subject to reduced rates [11], which has been at the sources of VAT refund issues. Personal income tax has been in place since January 2010, and its rate ranges between 0 to 38 percent across income brackets. Overall, the tax burden is not proportionally distributed in Morocco, and consumption tax, in particular, appears regressive.

11. Specifically: medicine and utilities (7%), essential food items (10%), and some processing food items and transportation equipment (14%).

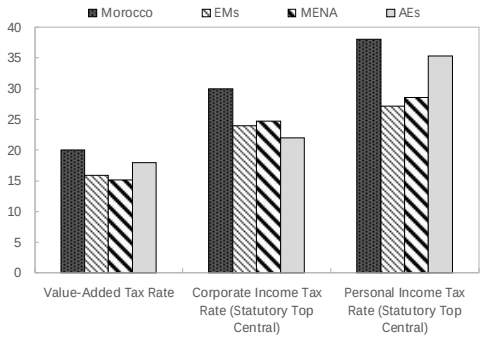

Figure 5.4 – Comparison of Tax Rates (Average by country group) . Morocco, EMD, MENA region and advanced countries. Sources: IMF Fiscal Affairs Tax Revenue Indicators database.

Rates applied to VAT and income tax are above regional average. Cross country experience in Figure 5.4 highlights some specific features of Morocco's tax system: *i*) average VAT statutory tax rates are very close among developing and advanced economies (14.7% versus 16.2%), *ii*) income tax rates can vary significantly across-country, *iii*) corporate tax rates are converging, and *iv*) multiple tax rates could introduce economic distortions, complicated administrative procedures, unfair revenue distribution, and revenue loss.

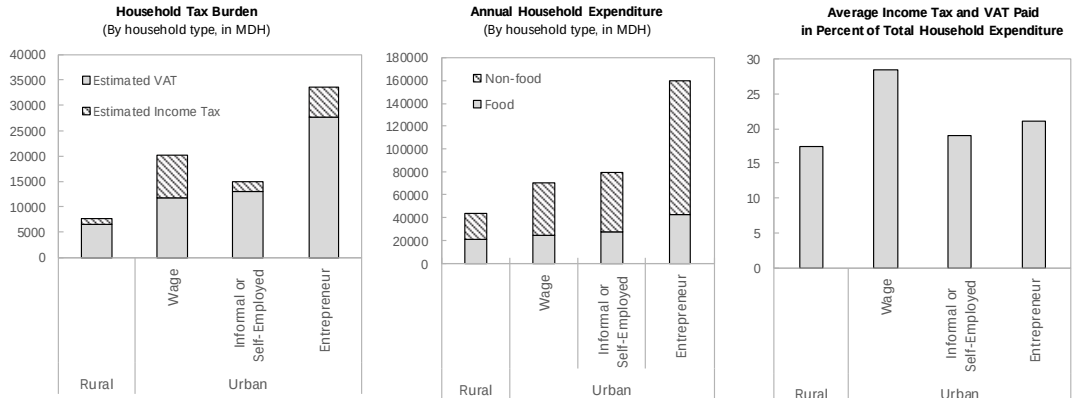

Figure 5.5 – Household Tax burden, transfer and expenditure. Sources: 2007 Morocco Household survey.

Within country analysis of tax burden suggests that it is not proportionally distributed and that consumption tax appear regressive. Figure 5.5 presents a micro distribution

and structural analysis using Morocco 2007 household survey data to determine whether (consumption and income) taxes are mostly regressive or progressive [12]. Tax burdens calculated as a percentage of both disposable income and pre-tax expenditure by household types show high proportion of tax levy on wage as opposed to profit.

5.2.3 Tax expenditures

While total tax expenditure in percentage of GDP is relatively low, exemptions are numerous and introduce distortions. Figure 5.6 presents revenue losses due to exemptions in Morocco. The number of identified exemptions went from 399 in 2015 to 407 in 2016, of which 30.7% of the total related to consumption tax, 45.5% to income tax, and the remaining to rights registration and stamp. For 2016, total tax expenditure was about 3.2% of the GDP (15.2% of tax revenue), compared to 3.1% in 2014. The largest fraction of tax expenditure is related to VAT (1.5% of GDP with 102 exemption measures), then administrative fee and corporate income tax, respectively 0.6 and 0.5 percent of the GDP.

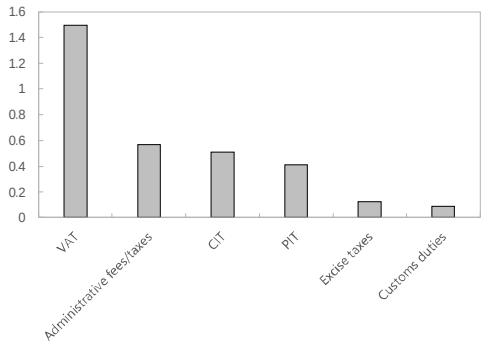

Figure 5.6 – Revenue losses due to exemptions (% GDP). Sources: IMF Fiscal Affairs Tax Revenue Indicators database.

While the objective of the exemptions was to provide incentives to certain economic

12. The computation uses a lifetime income approach – with expenditure as a proxy for lifetime income. It also estimates lifetime income using household panel income data (see Metcalf (1994)) to further assess household VAT burdens as a percentage of lifetime income.

activities, in many cases they are distorting [13].

5.2.4 Public transfers and social safety nets

The reform of public transfers system was motivated by the finding that public transfers were in general regressive (Figure 5.7, left). Public transfers system have been expanded in recent years but they are poorly targeted. Figure 5.7 (right) shows that the share of households receiving public transfers more than doubled between 2001 and 2014, going from 10.8 to 22.9 percent. However, the bulk of the increase was in urban areas while most of the poor reside in rural areas. In 2014, only 8.9% of households in the bottom quantile received public transfer as opposed to 40.2% in the top quintile. Moreover, 43.8% of the total amount transferred by public administrations during that same year benefited the top quantile households, which reflects significant disparities in public transfer. The average annual amount transferred to the poorest households in 2014 was about 6 times less than the top quantile household. Regressive transfers amplify inequality in the benefits between the poorest and upper quantile households.

13. Exemptions tend to differ widely, including in their duration (temporary, limited, or permanent), scope (limited versus full). While some exemptions are discretionary, many are stipulated (e.g. some sectors have total exclusion). Their implementation takes different forms, including reductions in rate, deductions, allowances, lump sum taxation, and liquidity facilities. In 2016, agriculture and fishing benefited from 65.4% of exemptions measures, while the real estate sector received about 23.6% of tax expenditures (about 0.7% of the GDP). Households are prime beneficiaries of income tax exemptions. Tax expenditures related to import duties amounted to 0.9% of the GDP and are mainly for capital goods from major investment projects and economic and commercial vehicles. Our analysis (see Section 6) suggests that the exemptions on food, for example, have affected allocated of resources and contributed to lower output growth.

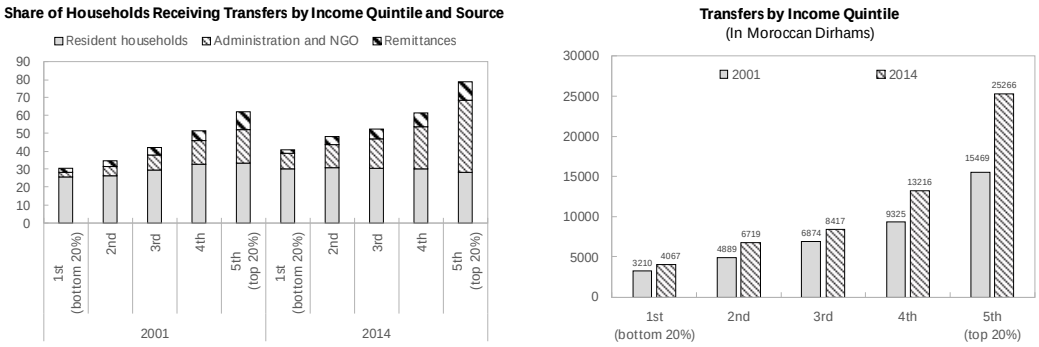

Figure 5.7 – (left) Share of households receiving transfers by quintile and source, (right) Share of households receiving transfers by quintile and source. Sources: Haut Commissariat au Plan.

5.2.5 Informality

A large segment of the economy is informal, which hinders equal application of tax collection. Self-employed individuals may be unlikely to report their earnings, as well as small informal businesses.

The informal sector is estimated, by National Statistics, , to about 15% of total economic activity. These estimations suffer from lack of data as informal activities are not surveyed and firms tend to underreport earnings. The estimations shows that about 22% of total employment (Figure 5.8)is the labor forces employed in the informal sector .

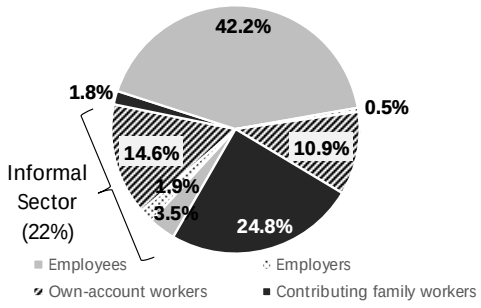

Figure 5.8 – Morocco Workforce, 2007. Sources: Haut Commissariat au Plan; ILO; and IMF staff estimates.

Taxing the informal sector in Morocco could offer ways to expand the tax base, if tax administration could achieve high efficiency collection at lower administrative costs. The primary disadvantages to taxing the informal sector are costs of administration and enforcement, and horizontal and vertical inequity. More progressive taxes need to be introduced in order to achieve vertical equity. This would improve the image of the tax system which would help lure informal workers into the formal sector.

5.3 Model

In this section, we develop a dynamic general equilibrium model to capture the main features of Moroccan tax system and economic structure (including the agrarian base) and to simulate the various impact of fundamental tax reforms. The model is a closed-economy [14] with four types of households: informal sector workers, formal manufacturing and service workers, rural workers, and entrepreneurs. The economy produces three goods: foods, manufacturing products, and informal services. The manufacturing sector includes structured service industries that require capital for production (e.g. communication, tourism, finance, tourism industries etc). The large number of households and products allows the model to capture the structure of Morocco tax system, specifically, multiple tax rates for VAT, income, and corportate tax. In addition, there is active housing market in urban areas to assess the benefits and impacts of a broad-based property taxation. The government collects taxes and receives bonds in order to cover its expenditure and lump-sum transfer to each agent. Informal services and food are non-tradable, while manufacturing goods are tradable, and also the numeraire.

14. Since most of the tax base rests on domestically produced goods, this rationalizes the choice of a closed economy. For Morocco, tax revenues from trade are less than 2% of GDP, as opposed to income taxes or VAT that are each about 10% of GDP.

5.3.1 Households

Households have utility for consumption, housing, and leisure. The consumption basket has three main goods: food c^f, manufacturing products(including formal services) c^m, and informal services c^s. Subscripts and superscripts f, m and s stand for food, manufacturing products and informal services, respectively. In addition, households profit from housing h, and leisure time $(1 - l)$. The population is normalized to unit, and we assume households live infinitely. The households utility function is given by

$$u_t^i = \varphi_f^i \ln c_t^{if} + \varphi_s^i \ln c_t^{is} + \varphi_m^i \ln c_t^{im} + \varphi_h^i \ln h_t^i + \varphi_l^i \ln(1 - l_t^i) \quad i = I, M, R, E \quad (5.3.1)$$

superscripts I, M, R, E stand for Informal service workers, formal Manufacturing workers (including formal service workers), Rural workers and Entrepreneurs, respectively. The share of each category of households in the population is given by $\mu_i, i = I, M, R, E$, (of one unit). The utility function is additively separable in consumption goods, housing, and leisure. The coefficients $\varphi_j, j = f, m, s, h, l$ reflect the relative importance of consumption goods, housing and leisure in the utility function.

Furthermore, the problem of each agent is to maximize its utility function over time,

$$\max \quad E_t \sum_{\tau=t}^{\infty} \beta_i^{\tau-t} u_t^i \quad i = I, M, R, E \quad (5.3.2)$$

where β is the specific discount factor for each agent.

Informal workers

Informal workers are self-employed who produce services in competitive markets. They live in urban areas where they rent houses owned by entrepreneurs. The budget

constraint for a representative informal household is given by,

$$(1+\tau_f)p_t^f c_t^{If} + (1+\tau_m)p_t^m c_t^{Im} + (1+\tau_s)p_t^s c_t^{Is} + p_t^r h_t^I = (1-\xi\tau_w^I)w_t^I l_t^I + \Gamma_t^I \quad (5.3.3)$$

where c^{Si} and $p^i, i = f, m, s$ are consumption and price for food, manufacturing goods and services, respectively. h^S is houses rent by informal workers and p^r is the rental price, determined in a competitive house renting market. At the equilibrium, the supply of rental houses by entrepreneurs equals the demand from informal workers. The production of services in the informal sector is labor intensive. $w_t^I = p_t^s z^I$ is the labor unit cost in the sector, and it depends on a constant productivity $z^I$and the service market price p^s. Production decisions in the informal sector are essentially on worked hours l^I to devote in the activity. So the total service (production function of the informal sector) is:

$$Y_t^s = \mu_S l_t^I z^I \quad (5.3.4)$$

Γ^S is a government lump-sum transfer to informal sector households.

Informal sector workers face the following tax regimes: i) VAT when they purchase goods and services; VAT rates are established by the tax code and are respectively τ_f , τ_m, τ_s and for food, manufacturing goods, and informal services that they consume; ii) personal income taxation to the extent that the tax administration is able to capture some of their activities. We assume that the tax administration has a collection efficiency rate $\xi \in [0, 1]$ for the informal sector, which reflects the fraction of the (informal sector) potential tax base $w_t^I l_t^I$ authorities could levy. High values of ξ implies a large actual tax base for the informal sector. We also assume that informal sector activities do not generate much income (as they typically operate on a lower scale, part to reduce likelihood of being taxed) and therefore are in the lower range personal income tax rate τ_w^I. We assess the effects of enforcing income tax (raising ξ) in the model simulation, where we compare the findings against those from the baseline model, where we assume $\xi = 0$, which implies that informal sector workers do not pay income tax. Since informal workers do not own houses, they are exempted

from property taxes. Finally, we assume that the informal sector workers spend all their income in consumption and housing, and have no savings to invest in government bonds [15].

The representative informal sector household maximizes his utility 5.3.2 subject to the budget constraint 5.3.3. The optimum conditions for consumption, housing and leisure are as follows:

$$p_t^r = \frac{\varphi_h^I}{\lambda_t^I h_t^I} \tag{5.3.5}$$

$$\frac{\varphi_l^I}{1 - l_t^I} = \lambda_t^I (1 - \xi \tau_w^I) w_t^I \tag{5.3.6}$$

where λ^I is the Lagrangian multiplier of the service worker's budget constraint [16]. The optimal allocations of consumption and labor by informal sector workers depend on the tax rates. Specifically, the marginal rate of substitution between labor and leisure in the informal sector will be shaped by the tax adminitration's ability to enforce tax collection, as reflected by the tax collection rate ξ. VAT rates also affect consumption at the equilibrium.

Formal manufacturing and service workers

Manufacturing and service sector households supply labor to productive units managed by entrepreneurs. They live in urban areas, buy and sell houses, and pay taxes, including VAT on the purchase of goods and services, personal income tax, and property tax at a rate τ_h. The representative household's budget constraint is given

15. According to HCP (2009), more than 78% of informal production and about 73% of informal labor force in Morocco, are concentrated in service sector. Industrial sector has only a small part of informal production unit. See Alami (2006). Hence, following literature, the assumption of including all informal workers in service sector simplifies the model and does not change the results. Informal service workers are urban and hand-to-mouth household. We have another hand-to-mouth agent who lives in rural area which will be explained later. They only consume what they earn and do not have access to bonds or savings mechanisms. According to HCP (2009) the share of bank loans in informal activities and products is barely 1%.

16. The full list of equations and optimum conditions are listed in the online Appendix.

by

$$(1+\tau_f)p_t^f c_t^{Mf} + (1+\tau_m)p_t^m c_t^{Mm} + (1+\tau_s)p_t^s c_t^{Ms} + p_t^h(h_t^M - (1-\tau_h)h_{t-1}^M) = (1-\tau_w^M)w_t^M l_t^M + \Gamma_t^M + AC_t^M \tag{5.3.7}$$

where $c^{Mi}, i = f, m, s$ are consumption of manufacturing workers for food, manufacturing goods and service, respectively. h^M is housing for manufacturing workers and p^h is the housing price, l^M is worked hours and Γ^M a lump-sum transfer received from the government. Manufacturing and service workers supply labor on competitive market at a wage w^M, subject to a personal income tax rate τ_w^M , which applies to their income backet. There are some adjustment costs attached to homeownership since acquiring a house could be a costly process due to administration fees and searching time. The adjustment costs add some frictions to the housing market and are defined by the quadratic function, $AC_t^M = (\psi_h/2)p_t^h(\frac{h_t^M - h_{t-1}^M}{\bar{h}^M})^2$.

The representative household maximizes his utility 5.3.2 subject to the budget constraint 5.3.7. His optimum conditions for consumption, housing and leisure are given by:

$$p_t^h = \frac{\varphi_{Mh}}{\lambda_t^M h_t^M} + \beta_M \mathbf{E}_t \frac{\lambda_{t+1}^M}{\lambda_t^M} p_{t+1}^h (1-\tau_h) \tag{5.3.8}$$

$$\frac{\varphi_l^M}{1-l_t^M} = \lambda_t^M (1-\tau_w^M) w_t^M \tag{5.3.9}$$

where λ^M is the Lagrangian multiplier for manufacturing and service sector worker's budget constraint.

Rural worker

Rural workers live in rural areas and work on lands which belong to entrepreneurs. Rural workers receive wages for working on lands and producing foods. We assume that frictions limit population movements across urban and rural areas, which eliminates migrations from wage differential, and renders the share of rural and

urban population relatively stable. Rural households are composed by individuals who spend all their income on consumption. Due to the high poverty in rural area, the government implements a generalized subsidy scheme to lower the price of food items and to help low-income households satisfy their food needs. We further assume that rural workers own their own houses; these are typically small dwellings of low value than urban houses, and for that reason they are exempted from property tax. Moreover, the housing market remains very shallow in rural areas, therefore the model assumes homeowners keep their houses infinitely.

The budget constraint for a representative rural worker is given by:

$$(1+\tau_f-\sigma_R)p_t^f c_t^{Rf}+(1+\tau_m)p_t^m c_t^{Rm}+(1+\tau_s)p_t^s c_t^{Rs}=(1-\tau_w^R)w_t^R l_t^R+\Gamma_t^R \quad (5.3.10)$$

where $c^{Ri}, i=f,m,s$ for food, manufacturing goods and services respectively. w_R is the wage paid in rural labor market, Γ^R is the government lump sum transfer to rural households, τ_w^R is the personal income tax rate for rural workers and is the lowest rate comparing with other payroll taxes. Parameter σ_R is the government subsidy (and policy parameter) to lower food price [17] in rural areas.

The representative rural household maximizes his utility 5.3.2 subject to the budget constraint 5.3.10. The optimal allocations of consumption and labor for rural workers are affected by tax rates. An increase in VAT rate for a consumption good or service would make certain items relatively more expensive than others, lowering its consumption and switching the structure of consumption basket. For example, the government could influence food consumption by adjusting food subsidies, changing effective food prices.

17. This subsidy presents indirect transfers to low-level income households, i.e., it is a generalized transfer in form of vouchers etc to aid low-income household and secure their essential needs, e.g foods . It facilitates food consumption for poor households and can be seen as a policy parameter.

Entrepreneurs

Entrepreneurs manage productive units of the economy. There are two type of firms: agricultural firms in rural areas and manufacturing and (formal) service firms in urban areas. The agricultural firms combine land and labor (by rural workers) to produce foods. The manufacturing and (formal) service firms use capital and the labor (by urban households) to produce goods. The technologies of production are given by a Cobb-Douglas functions in both sectors.

Food output Y_t^f uses the technology

$$Y_t^f = \mu_E z^F L^{\alpha_F} (n_t^F)^{1-\alpha_F} \tag{5.3.11}$$

where z^F is a productivity factor, L is land used in food production, n^F is rural workers labor, α_F and $1 - \alpha_F$ denote the share of land and labor in food output respectively. Entrepreneurs decide on the optimum surface for food production. We assume that the use of land for agricultural activities involves residual costs that support entrepreneurs.

The output from manufacturing goods and services is given by the technology

$$Y_t^m = \mu_E z^E k_{t-1}^{\alpha_E} (n_t^E)^{1-\alpha_E} \tag{5.3.12}$$

where z^E is the technology factor, n^E is labor hired by entrepreneurs from manufacturing workers, k the capital effectively utilized by the manufacturing and services firm, α_E and $1-\alpha_E$ represent the share of capital and labor in manufacturing and services output respectively. The capital stock k evolves according to the law of motion

$$i_t^k = k_t - (1 - \delta_k) k_{t-1} \tag{5.3.13}$$

where δ_k is the depreciation rate of the capital and i^k is the economy gross investment.

Entrepreneurs own all productive units in this economy. They finance investment for manufacturing and service firms and place their extra savings in government bonds. Their income includes corporate profits (from agricultural firms $\pi_t^F = p_t^f Y_t^f - w_t^R n_t^F$ and manufacturing and services firms $\pi_t^E = p_t^m Y_t^m - w_t^M n_t^E$.), rent payment by informal sector workers, and interest payment from government bonds. Entrepreneurs are subject to various taxes at the firm and individual levels. At the firm level, entrepreneurs pay corporate tax on profits. The corporate tax rate for agricultural firms τ_w^F, is below that of manufacturing and service firms τ_w^E. This difference in corporate taxation reflects preferential treatment for agriculture as illustrated by multiple tax exemptions granted to that sector. At the individual level, entrepreneurs pay income tax on their earnings from housing renting and interest payment on bonds, VAT on their purchase of goods and services, and property tax on their houses.

The budget constraint of the representative entrepreneur is given by

$$\begin{aligned}
&(1+\tau_f)p_t^f c_t^{Ef} + (1+\tau_m)p_t^m c_t^{Em} + (1+\tau_s)p_t^s c_t^{Es} + p_t^h(h_t^E - (1-\tau_h)h_{t-1}^E) \\
&+ p_t^h(h_t^r - (1-\tau_h)h_{t-1}^r) + p_t^k i_t^k + b_{t+1} + \delta_L L_t = \\
&(1-\tau_w^F)\pi_t^F + (1-\tau_w^E)\pi_t^E + (1-\tau_r)p_t^r h_t^r + (1+r_{t-1}(1-\tau_b))b_t + \Gamma_t^E + AC_t^E
\end{aligned} \tag{5.3.14}$$

where $c^{Ei}, i = f, m, s$ are consumption for food, manufacturing goods and services, respectively. They can buy and sell residential housing h^E and rental housing h^r, and receive the rent p^r, of rental houses from informal service workers. Regarding the data, we assume the total supply of land is fixed. The entrepreneur representative agent has a fixed land asset. So, the decision of the entrepreneur is to choose the arable area L, based on the cost of cultivating that area $\delta_L L$. b is government bonds bearing interest rate, r subject to a tax rate τ_b. Γ^E a lump sump transfer from the government. Entrepreneurs face internal adjustment costs when changing their housing and capital stock, $AC_t^E = (\psi_h/2)p_t^h(\frac{h_t^E - h_{t-1}^E}{\bar{h}^E})^2 + (\psi_h/2)p_t^h(\frac{h_t^r - h_{t-1}^r}{\bar{h}^r})^2 + (\psi_k/2)p_t^k(\frac{k_t - k_{t-1}}{\bar{k}})^2$.

The representative entrepreneur household maximizes its utility 5.3.2 subject to a budget constraint 5.3.14. The optimum condition for residential housing, rental

housing and bonds are

$$p_t^h = \frac{\varphi_h^E}{\lambda_t^E h_t^E} + \beta_E \mathbf{E}_t \frac{\lambda_{t+1}^E}{\lambda_t^E} p_{t+1}^h (1-\tau_h) \tag{5.3.15}$$

$$p_t^h = \beta_E \mathbf{E}_t \frac{\lambda_{t+1}^E}{\lambda_t^E} p_{t+1}^h (1-\tau_h) + (1-\tau_r) p_t^r \tag{5.3.16}$$

$$1 = \beta_E \mathbf{E}_t \frac{\lambda_{t+1}^E}{\lambda_t^E} (1 + r_{t-1}(1-\tau_b)) \tag{5.3.17}$$

and with respect to capital, land and labor,

$$1 = \beta_E \mathbf{E}_t \frac{\lambda_{t+1}^M}{\lambda_t^M} (1 - \delta_k + (1-\tau_w^E) p_{t+1}^m z^E \alpha_E (\frac{n_{t+1}^E}{k_t})^{(1-\alpha_E)}) \tag{5.3.18}$$

$$\delta_L = (1-\tau_w^F)(1+\sigma_f) p_t^f z^F \alpha_F (\frac{n_t^F}{L_t})^{1-\alpha_F} \tag{5.3.19}$$

$$(1-\alpha_E) p_t^m z^E (\frac{k_{t-1}}{n_t^E})^{\alpha_E} = w_t^M \tag{5.3.20}$$

$$(1-\alpha_F) p_t^f z^F (\frac{L}{n_t^F})^{\alpha_F} = w_t^R \tag{5.3.21}$$

The optimal allocations by entrepreneurs are affected by tax rates, which could switch production and saving incentives.

5.3.2 Government

The government collects tax revenue and has a redistributive role through lump sum transfers to households and public spending. The government budget constraint is given by:

$$T_t + B_{t+1} + Gr = g_t + (1 + r_{t-1}) B_t + \Gamma_t + A_t \tag{5.3.22}$$

T is total tax revenue, B is total government bond, g is government expenditure, Γ is total lump sump transfer to households and A is food subsidies to rural workers. Gr is fixed and represents other revenue received by the government, including grants and

voluntary contributions. We assume that government expenditure follows the path

$$g_t = \rho_g g_{t-1} + (1 - \rho_g)\overline{g} \tag{5.3.23}$$

where $\overline{g}$ is the steady state of the government expenditure and ρ_g is a positive constant smaller than one. $\Gamma_t^i \quad i = S, M, R, E$ are lump sump transfers to each agent and total transfer is Γ,

$$\Gamma_t^i = \gamma_i Y_t, \quad i = S, M, R, E \tag{5.3.24}$$

$$\Gamma_t = \mu_S \Gamma_t^I + \mu_M \Gamma_t^M + \mu_R \Gamma_t^R + \mu_E \Gamma_t^E \tag{5.3.25}$$

$$A_t = \sigma_R \mu_R p_t^f c^{Rf} \tag{5.3.26}$$

where Y is total output (GDP) and Y^f is total food production. Government tax revenue includes VAT, property tax, income taxes on wage, profit and interest payment. The total tax revenue collected in this economy is given by:

$$\begin{aligned} T_t = {} & \tau_f p_t^f C_t^f + \tau_m p_t^m C_t^m + \tau_s p_t^s C_t^s + p_t^h \tau_h H_{t-1} + \tau_b r_{t-1} B_{t-1} + \tau_r p_t^r \mu_E h_t^r \\ & + \xi \tau_w^I w_t^I + \tau_w^M W_t^M + \tau_w^R W_t^R + \tau_w^F \Pi_t^F + \tau_w^E \Pi_t^E \end{aligned} \tag{5.3.27}$$

where

$$C^i = \mu_S c_t^{Si} + \mu_M c_t^{Mi} + \mu_R c_t^{Ri} + \mu_E c_t^{Ei}, \quad i = f, m, s \tag{5.3.28}$$

$$H_t = \mu_S h_t^I + \mu_M h_t^M + \mu_E h_t^E \tag{5.3.29}$$

$$W_t^i = \mu_i l_t^i w_t^i, \quad i = I, M, R \tag{5.3.30}$$

$$\Pi_t^F = \mu_E \pi_t^F \tag{5.3.31}$$

$$\Pi_t^E = \mu_E \pi_t^E \tag{5.3.32}$$

$$B_t = \mu_E b_t \tag{5.3.33}$$

$C^i, \quad i = f, m, s$ is the aggregate consumption of food, manufacturing goods and service, respectively. H is the number of houses and is normalized to one, $W^i, \quad i = I, M, R$ is the wage income for informal, manufacturing, and rural sector respectively;

B is the stock of government's bonds. Π^F and Π^E are the aggregate profits from agricultural and manufacturing firms respectively.

5.3.3 Market Clearing

Non-housing good market clearing condition equates each type of output to total consumption of that type,

$$Y_t^f = \mu_E z^F L^{\alpha_F} (n_t^F)^{1-\alpha_F} = C_t^f \tag{5.3.34}$$

$$Y_t^s = \mu_S l_t^I z^I = C_t^s \tag{5.3.35}$$

$$Y_t^m = \mu_E z^E k_{t-1}^{\alpha_E} (n_t^E)^{1-\alpha_E} = C_t^m + \mu_E i_t + g_t \tag{5.3.36}$$

manufacturing goods are numeraire (i.e. $p^m = 1$) so it is equal to total manufacturing good consumption, capital investment and government expenditure. GDP is the sum of all production, respecting their prices

$$Y_t = p_t^f Y_t^f + p_t^m Y_t^m + p_t^s Y_t^s \tag{5.3.37}$$

The labor market clearing in agriculture and manufacturing are

$$\mu_E n_t^F = \mu_R l_t^R \tag{5.3.38}$$

$$\mu_E n_t^E = \mu_M l_t^M \tag{5.3.39}$$

The market clearing in the rental market, capital and total housing supply are

$$\mu_E h_t^r = \mu_S h_t^I \tag{5.3.40}$$

$$K_t = \mu_E k_t \tag{5.3.41}$$

$$H = 1 \tag{5.3.42}$$

An equilibrium is a set of prices $(p^f, p^m, p^s, p^h, p^r, p^k, r)$ and allocations of all consumption for each agents and each type, housing and leisure time so that maximize

the household utility functions subject to all constraints, market factors and market clearings.

5.4 Calibration

Table 5.1 – Calibrated parameters

Parameters	Symbol	Value
VAT on food,manufacturing,service	τ_f, τ_m, τ_s	$0.10, 0.20, 0$
Income tax on workers	$\tau_w^I, \tau_w^M, \tau_w^R$	$0.10, 0.20, 0.10$
Income tax on Entr.	τ_w^F, τ_w^E	$0.10, 0.30$
Tax on return, rent, property	τ_b, τ_r, τ_h	$0.15, 0.13, 0.05$
Share of each agent	$\mu_S, \mu_M, \mu_R, \mu_E$	$0.28, 0.32, 0.39, 0.01$
Targeted transfer	σ_R	0
Informality index	ξ	0
Discount factors	$\beta_I, \beta_M, \beta_R, \beta_E$	$0.95, 0.96, 0.94, 0.97$
Direct transfer	$\gamma_I, \gamma_M, \gamma_R, \gamma_E$	$0.028, 0.039, 0.010, 0.0007$
Coef. in utility, Service	$\varphi_f^S, \varphi_m^S, \varphi_s^S, \varphi_h^S, \varphi_l^S$	$1.1, 1, 0.82, 0.16, 7.5$
Coef. in utility, Manufac.	$\varphi_f^M, \varphi_m^M, \varphi_s^M, \varphi_h^M, \varphi_l^M$	$0.90, 1, 0.61, 0.15, 8.3$
Coef. in utility, Rural	$\varphi_f^R, \varphi_m^R, \varphi_s^R, \varphi_h^R, \varphi_l^R$	$1, 1, 0.50, 0, 8.6$
Coef. in utility, Entre.	$\varphi_f^E, \varphi_m^E, \varphi_s^E, \varphi_h^E, \varphi_l^E$	$0.95, 1, 0.80, 0.10, 0$
Capital depreciation rate	δ_k	0.1
Land preparation rate	δ_L	0.001
Elasticity of capital	α_E	0.35
Elasticity of land	α_F	0.70
Factor productivity	z_S, z_F, z_E	$1, 1.5, 0.96$
Adj. cost coeff.	ψ_k, ψ_h	$2.4, 2$
AR parameter of Gov.	ρ_g	0.95

Table 5.1 presents the value of the parameters which are consistent with macro data evidence in Moroccan economy from the national accounts, IMF and World Bank databases (see the steady state values in Table 5.2). Tax rates for VAT, income tax, property, and capital gains are from the Morocco's official tax codes. The share of each sector in total output and household consumption are derived from the input-output tables published in the EORA MRIO database. The distribution of households by type in the economy, the household wages and consumption of goods and services, and the transfers received from government are calculated from the 2007 Household Survey; and when the data were available from the 2014 Household survey.

The discount rate for entrepreneur is 0.97, which is consistent with a 3.6% average annual interest rate on 5-year Morocco treasury bonds 2007-8. The discount rate for

other agents reflects a relative preference for the present as opposed to entrepreneurs' preferences. For the benchmark model, targeted transfers of food for poor people is set to 0, and we assume the full informality in informal sector i.e. $\xi = 0$. The coefficient of manufacturing consumption in the utility functions is normalized to 1 and all other coefficients are set relative to this coefficient. The coefficient of leisure in the utility function is consistent with time allocation of $25\%, 27\%$ and 31% working hours per day for rural, informal and manufacturing workers based on household survey 2007. Coefficients of service consumption in the utility functions and productivity of service production target a 15% informality rate in all economy i.e. the value of all informal activity (in this paper it is $p^s Y^s$) per GDP is about 15% based on HCP (2009).

Factor productivity of food production and the coefficients of food consumption in the utility functions are calibrated in order to target the share of agriculture production ($p^f Y^f$) per GDP equal to 20% according to Karim and Mansouri (2015). Elasticity of capital and land , and factor productivity of manufacturing production are conventional parameters and resulted from 65% share of manufacturing products ($p^m Y^m$) per GDP. Coefficients of housing in the utility function reflects the housing market's structure of 40% rental housed, 53% worker homeowners and the remainder for entrepreneurs' houses. This setting correctly results in 2.1% property tax revenue per GDP, in line with rates from the General Tax Administration. Capital depreciation rate is set to 0.10 to target capital per GDP equal to 1.2 annually based on Schmitt-Grohé and Uribe (2015). According to the World Bank, urban residential areas in Morocco are about 2.7% of all land areas and agricultural farms are about 68%. This shows agricultural areas occupy about 25 times the land of residential areas. In this paper all residential areas are normalized to one, hence the land preparation rate δ_L is calibrated to have total agriculture area equal to 25 times of total residential area in the benchmark. We conduct a sensitivity analysis to calibrate the parameters to the adjustment cost functions and retain the values consistent with the short run volatility of the economy.

Table 5.2 – Steady state of the benchmark model per GDP.

Variable/GDP	symbol/Y	Steady State/Y
Consumption	C	0.54
Tax	T	0.25
Bond	B	0.67
Transfers	Γ	0.024
Capital	K	1.22
Grants	Gr	0.03
Wages	W^S, W^M, W^R	$0.15, 0.42, 0.06$
Government Exp.	g	0.24
Housing market	$p^h H$	0.43
Food market	$p^f Y^f$	0.20
Manufacturing and service market	$p^m Y^m$	0.65
Informal sector	$p^s Y^s$	0.15
Investments	$\mu_E i^k$	0.14
Housing/H*	h^S, h^M, h^E	$0.40, 0.53, 0.07$

* This row shows the share of agent's houses over all houses and not GDP.

5.5 Scenarios and analysis

In this section, we study the impact of tax reforms by analyzing the macroeconomic and welfare effects on households. The changes (1% for each parameter) are as follows; increasing VAT and property tax rates, decreasing food exemptions (for entrepreneurs) and corporate tax rate, enforcing personal income tax rate in the informal sector, and strengthening the social safety net (Generalized and targeted transfers [18]). We assume that economic agents anticipate the tax reform and fully internalize its implications to their economic decisions. In each of these simulations, our initial steady state is the same, calibrated to Morocco's economy as described in the calibration section, and we assess the transition to the new steady state after implementing the new tax policy. Table 5.3 summarizes the main long-run effects on output, tax revenues, consumption, and prices. In addition, tax multipliers, $\Delta = \frac{\Delta Y}{\Delta T}$, for each scenario are presented in the last column.

18. Generalized transfers reduce the cost of consumption for certain products. Targeted transfers are transfers to certain agents in the economy.

Table 5.3 – % change in the steady state for a 1% change in the policy parameters

Increasing the VAT rates	Y	T	C^f	C^m	C^s	p^h	Δ
Food	−0.03	0.91	−0.37	0.37	0.01	0.40	−0.033
Manufacture	0.14	0.88	0.28	−0.44	0.01	0.34	0.15
Reducing exemptions & CIP							
Decreasing exemption	0.12	0.76	−0.54	0.33	0.009	0.30	0.15
Decreasing Co. tax	0.58	−0.46	0.18	0.28	−0.01	0.33	−1.26
Both	0.71	0.30	−0.35	0.61	−0.004	0.63	2.3
Increasing the property tax							
property tax	0.20	0.93	0.13	0.17	0	−10.2	0.21
Social Safety net							
Generalized transfer	0.03	−0.18	0.43	−0.43	−0.02	−0.46	−0.16
VAT on food & Generalized transfer	0.008	0.72	0.09	−0.09	−0.004	−0.10	0.01
VAT on food & Targeted transfer	−0.06	0.61	−1.88	0.38	0.009	−0.11	0.09
Taxing the informal sector							
Income tax	0.003	0.65	−0.002	−0.002	−0.03	−0.2	0.004
VAT on Service	−0.11	0.70	0.06	0.08	−0.02	−0.15	−0.15
Both	−0.10	1.35	0.06	0.08	−0.06	−0.38	−0.07
Suggested Mix Policy							
Comprehensive tax strategy	1.0	1.8	−1.4	0.3	0	−9.8	0.55

5.5.1 Increase VAT rates

Increased VAT rates would boost government revenue, but the impact on output depends on which types of goods are subjected to the increased rates. A marginal increase in the VAT rate (1%) on food (respectively manufacturing goods) would raise government revenue by 0.9% (respectively 0.8%). However, GDP increases by 0.14% following an increase in VAT on manufacturing good but declines by 0.03% after the increase in VAT rate on food.

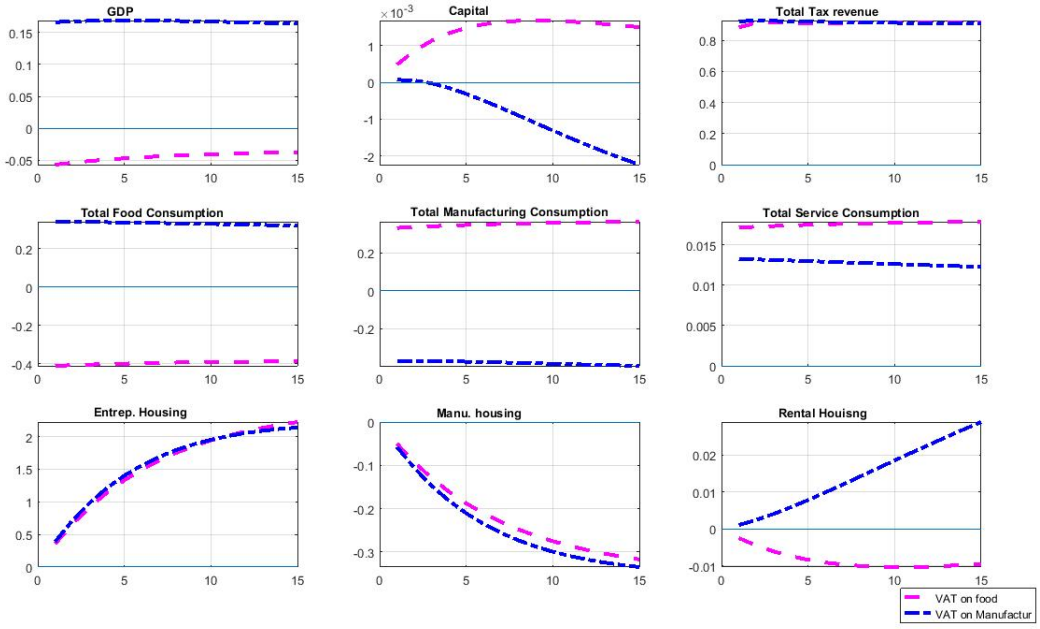

Figure 5.9 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables, 1% increase in VAT of food and manufacturing products.

Figure 5.9 shows the economy transition under the new VAT regime (food and manufacturing items); in the short run, output variations reflect changes in the work effort associated with marginal tax rates, while in the long run, higher (manufacturing good) prices induce greater capital accumulation. Increasing VATs benefits entrepreneurs the most as their profits increase, while workers would generally be worse off. Given Morocco's high VAT rates, and considering the growth effects of increased VAT on food, the appropriate approach to tax reform would seem to consists in aligning the reduced VAT rate on manufacturing goods to the standard VAT rate, to take advantage of both the growth and revenue enhancing impacts.

The short-run drop in the capital-labor ratio, followed by the increase on the VAT rate on manufacturing goods, produces a relative increase in after-tax return on housing. This leads entrepreneurs to invest more on real estate. The more demand for housing, the higher the housing price. This makes it more difficult for manufacturing households to buy houses. As a result, the manufacturing household demand for housing drops. From equation 5.3.16, the rent price in the steady state is a liner

function of the housing price,

$$p^r = \frac{1-\beta_E(1-\tau_h)}{1-\tau_r}p^h \tag{5.5.1}$$

so the rent price percentage change is the same as the housing price, ceteris paribus. However, due to dynamic equation 5.3.16, they pass in different paths. The rent price increases due to equation 5.5.1 and the fact that with a higher VAT food, the supply side of the rental houses declines. Increasing the manufacturing VAT has a positive effect on entrepreneurs' profits. The manufacturing product price is set to one as numerior, so alternatively, the food relative price increases and makes entrepreneurs better off in term of profits. This makes space for entrepreneurs to increase consumption and housing.

5.5.2 Reduce Exemptions and Corporate tax rate

A combination of lower exemptions and corporate tax rate would boost government revenues and output [19]. Formally, broadening the tax base is specified by corporate profits as a combination of agricultural and manufacturing firm profits and by applying relevant corporate tax rates. Reducing tax exemptions (e.g. to agricultural firm) would be equivalent to increasing corporate taxation for those firms. A combination of lower exemptions and lower corporate tax rates boosts government revenue and output. This combination expands the tax base and reduces tax avoidance.

19. We analyze the impact of reducing the income tax exemption on food producer, from 10% to 11%, decreasing corporate tax on manufacturing production from 30% to 29% and at the end, the impact of applying these two changes at the same time on the aggregate of key variables is assessed.

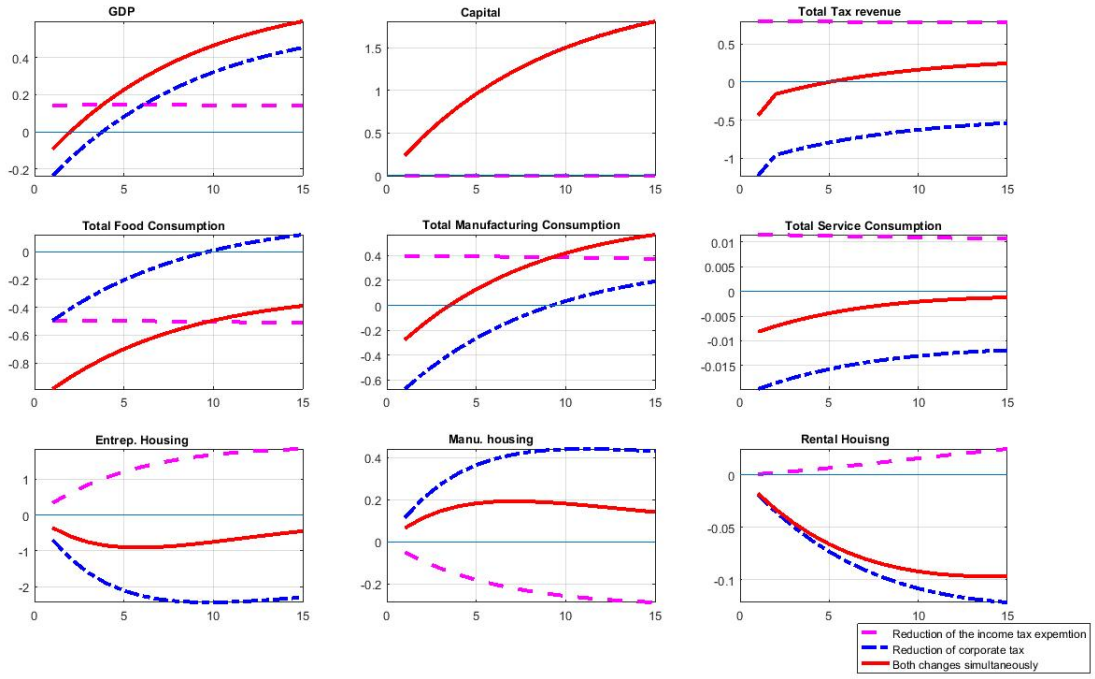

Figure 5.10 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables,targeted transfer to rural workers and 1% exemption reduction on food producers.

Following these changes, output increases. The lower corporate tax rate increases the rate of investments. The lower exemptions and corporate taxes induces substitution effects that encourage lower food consumption, but higher manufacturing goods consumption. These impacts are reinforced by the positive wealth effect among entrepreneurs who hold capital. These two factors also generate a substantial long-run jump in government revenues, because the lower exemptions compensate the revenue loss from the lower corporate tax rate.

By paying more tax, entrepreneurs decrease food production and move toward manufacturing. This increases manufacturing consumption and decreases food consumption in all agents. On the other hand, the mentioned policies increase the food price which offsets the impact of reducing food production. Hence, the entrepreneurs' profit increases (in this case about 0.12%) and entrepreneurs consequently consume more. Figure 5.12 show the dynamic effects of scenarios.

The reduction in corporate taxes has a positive influence on both food and

manufacturing consumption. It happens because after the reduction, entrepreneurs have more space, but due to the high productivity in agriculture industries, they prefer to partially move to manufacturing industries. Increasing investment in the capital stock leads to less consumption and saving for entrepreneurs and consequently less housing demands. As a result, the rental market and the housing prices decline. In this situation manufacturing workers have more opportunity to increase their housing demands.

5.5.3 Increasing property tax

A broad-based property tax associated induces beneficial substitution effects in asset accumulation. It encourages lower real estate, but higher capital accumulation, and thus increases manufacturing production. It generates an increase of 0.2% in long-run output, and of 0.9% in government revenues. House prices are a key channel for these effects, as they affect incentives to home ownership versus renting (see Equ. 5.5.1).

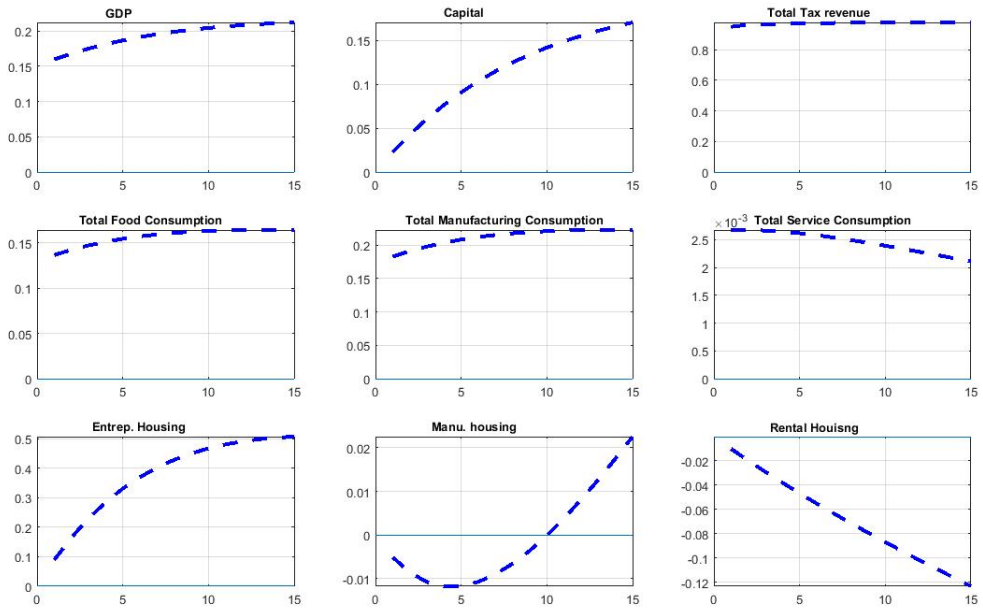

Figure 5.11 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables, 1% increase in property tax.

Being housing owners, manufacturing workers and entrepreneurs are affected directly

by changing property tax. Manufacturing workers reduce their demand due to the higher marginal cost. On the other hand, informal workers are exposed to this change indirectly through rental market. Due to the fixed total housing supply and the lower price, entrepreneurs increase their demand of housing. As a result, according to equation 5.5.1, the rent price has a positive correlation with property tax and the housing price. The housing price drops about 10% while property tax is increased only 1%.The conventional result is about 0.8% increase in the rent price. The higher the rent price, the lower rental demands which drops the supply side of rental market. This results in an increase in the rent price.

5.5.4 Social safety net

In this section, we analyze the impact of generalized and targeted transfers as well as mixed scenarios. In generalized transfer, government issues vouchers entitling the holder to a discount for a particular product or cards with credits. We assume that such a program exempts poor people of paying VAT on food, i.e. $\sigma_R = \tau_f$. The other aid scenario is targeted transfers to poor people and let them choose their consumption i.e γ_R form 0.01 to 0.02.

Generalized transfer increases GDP through an increase in food consumption. This increases the food price and the benefit of food producers. As a result, entrepreneurs decrease their consumption and savings to profit from more food production by increasing land and labor. This reduces entrepreneurs housing demands which results in a drop in the housing price. Manufacturing households use this situation to buy more houses. Entrepreneurs hire more rural labor. This has a positive distributional effect on rural wage. The higher the food price, the lower the food consumption of those agents who do not benefit from this kind of transfer. Rural workers are around 36% of all the population, so exempting them from paying tax has a negative effect on total tax revenue. By Having more profit, entrepreneurs decrease all consumption and saving to profit from more food production by increasing the usage of land to guaranty the maximum profit. This reduces entrepreneurs housing demands which results in a

drop in the housing price. Manufacturing households use this situation to buy more houses. The drop in entrepreneurs consumption has a negative distributional effect on the informal and manufacturing wages due to lower demand, but it has a positive distributional effect on the rural wage due to the increase in labor. Mixing generalized transfers and increasing food VAT does not change GDP and has positive effect on total tax revenue. VAT of food lowers the food price (as it is discussed in VAT section) but it is offset by the effect of the higher demand from rural workers due to the generalized transfers. On the other hand, the same plan with targeted transfers, inversely, has a negative impact on GDP with a lower tax revenue. This result is very important. Whiles generalized transfers increase rural wages, targeted transfers have negative impacts on wages. Targeted transfers motivate rural households to consume more but it does not target one type of consumption. More consumption positively affects all prices. With higher prices the consumption of other agents declines. This reduces the entrepreneur's profit and consequently, decreases investment and output.

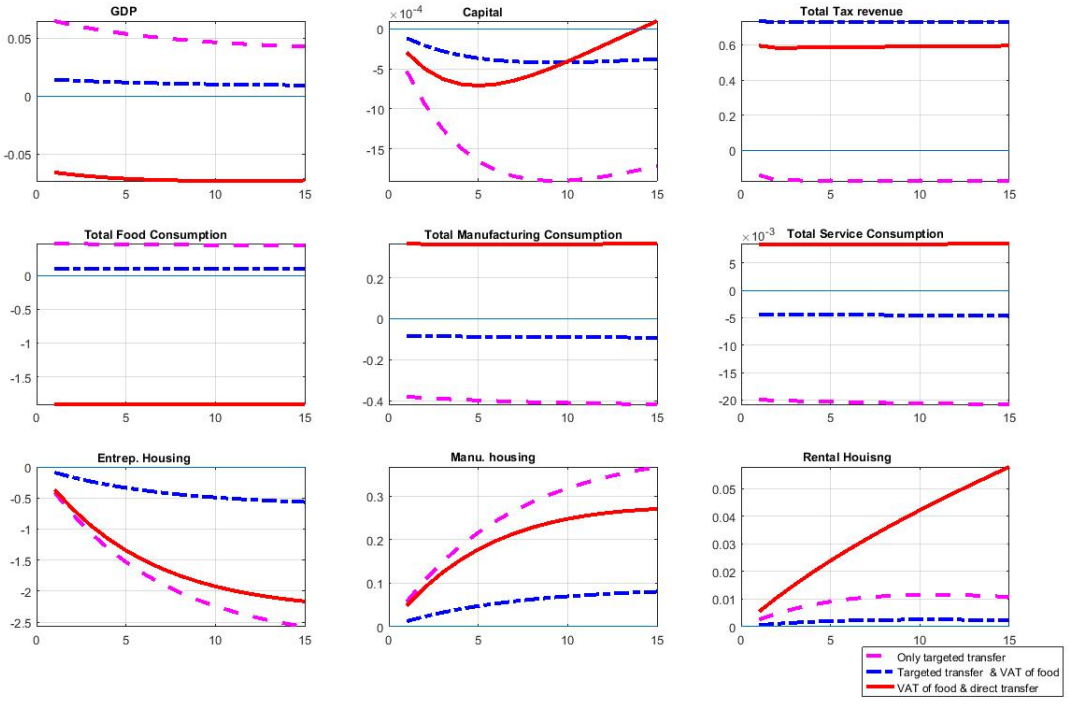

Figure 5.12 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables,targeted and generalized transfer to rural workers.

5.5.5 Taxing the informal sector

A fully informal service sector is assumed in the baseline model. We assume that government motivates [20] informal workers to declare their incomes, so 10% of informal workers are taxed [21]. We also assess the impact of 1% increase in the VAT of informal services form zero to one percent.

Figure 5.13 shows the perfect foresight path between two steady state. Decreasing informality has an insignificant negative effect on GDP right after the shock but in the long term it makes a raise in GDP that mostly comes from the increase in capital investment.

However, the decrease in informality has a positive effect on GDP and economy, it is not significantly important relative to costs and difficulties that the government should pay [22]. Nonetheless, the behavior of the rent price is the same as housing price in the case of the change in the VAT of food and manufacturing, it behaves differently in case of the VAT of informal services. Informal workers are renters and their demands for rental housings affect rental market.

20. Dougherty and Escobar (2013) empirically urges "that to reduce labour informality it is necessary to promote economic development, education, FDI openness, as well as the prevalence of corruption and the share of microenterprises."

21. We chose 10% just to magnitude the impact because the effect of 1% is relatively small. ξ is the parameter which captures informality. It moves from zero in the baseline model to 10%.

22. See Oviedo et al. (2009) to find about costs of decreasing informality.

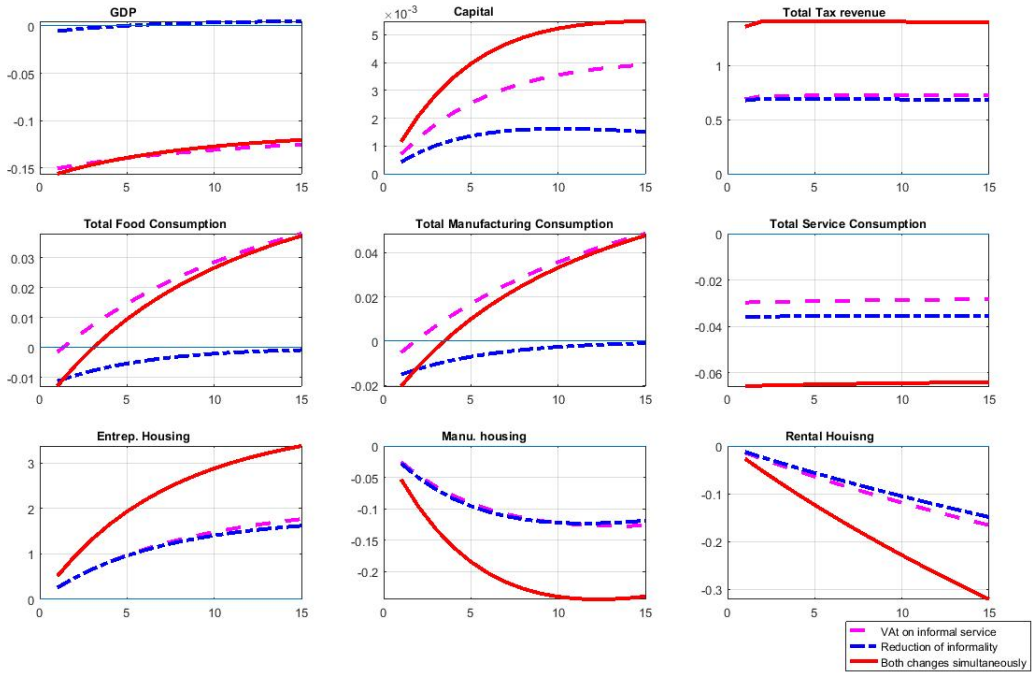

Figure 5.13 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables, 1% decrease in informality.

Applying a tax reduces the supply side of the informal market. By paying tax on their income, informal workers decrease their rental demands to smoothen consumption. This results in a drop in the rent price. This motivates entrepreneurs to move more toward buying residential houses than rental ones. The higher demand, the higher price, which forces manufacturing household to reduce their house demands in short-run.

5.5.6 Suggested policy: Comprehensive package

The simulations above show the impulse responses of macroeconomic variables to different fiscal policies. These simulations allow us to identify several recommendations that could be part of an optimal reform package. This comprehensive tax reform strategy should enhance tax revenues, boost growth, and improve fairness simultaneously. This 3-dimension target is the reason of launching the fiscal reform. Noting the results of each policy, it is clear that each policy is a trade-off. Macroeconomic policy questions involve trade-offs between competing

forces in the economy. The problem is how to assess the strength of those forces for the particular policy question at hand. Each policy improves a dimension of the target and decreases another one. For instance, decreasing corporate taxes boosts output but decreases tax revenues. To optimize our 3-dimension target, we simply combines several reform components from the list of reforms above. Note, there is not only one optimal policy for the whole economy. The optimal package depends on the needs of government and other economic considerations. The goal here is to do a pedagogic exercise and show that a mixed tax reform is a better policy for the economy than an individual reform. While a single tax reform has positive and negative impacts on the economy, a mixed tax policy offers better results by offsetting the adverse impact of a single reform and improving the positive effects. Hence, the size of changes (here, 1% change from the baseline) is only chosen to keep the simulation simple, standard and understandable. One can change the size of reforms based on the results of the simulation, government's plan and other political economic and technological considerations.

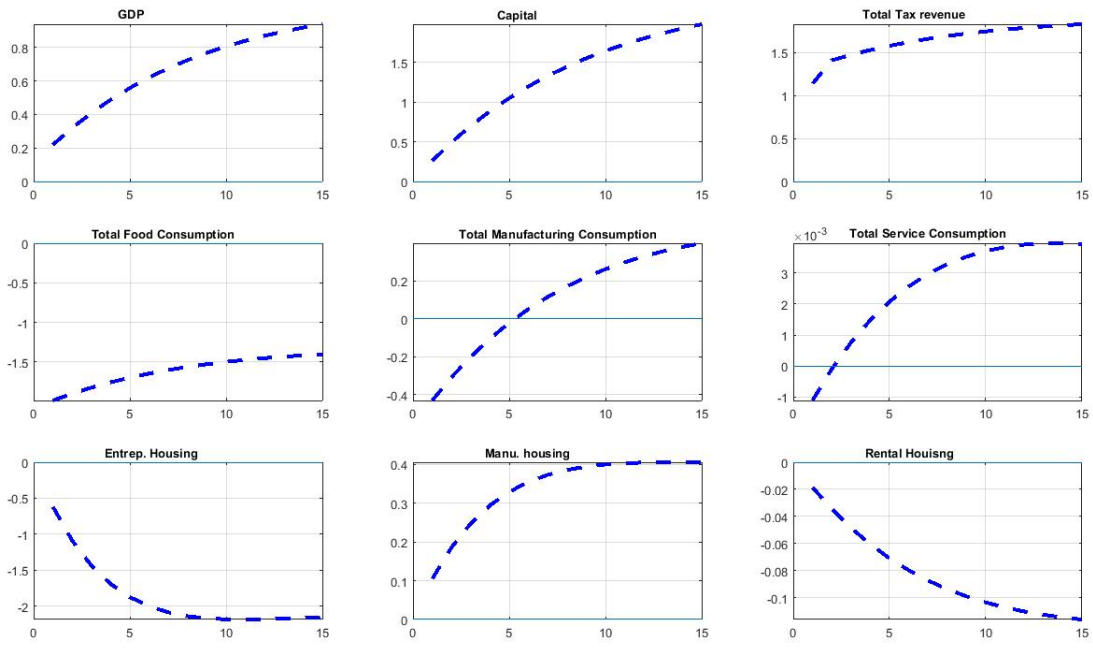

Figure 5.14 – (%) change from the baseline steady state, perfect foresight path, aggregate of key variables1% Lower exemptions and corporate tax, 1% increase in targeted social safety net, VAT increase in manufacturing goods, and property tax increase.

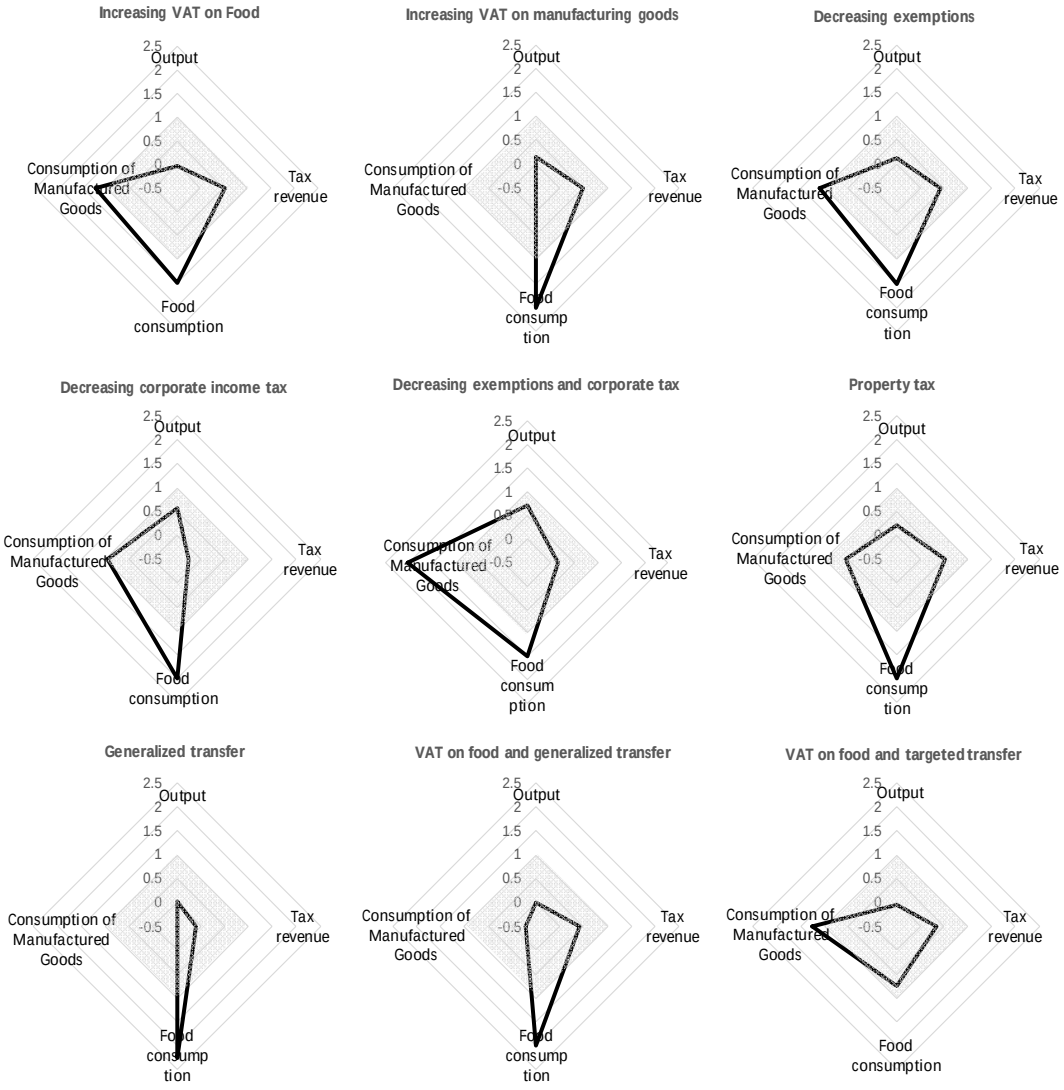

Figure 5.15 – Long-Run Effects of Tax Reform Scenarios on Macroeconomic Aggregates Compared
(Comprehensive Reform's Scenario = 1, better outcomes are greater than 1)

The suggested policy which satisfies our 3-dimension target is composed of a 1% decrease in exemptions and corporate tax, and a 1% increase in: generalized social safety net, the VAT of manufacturing goods and property tax. Figure 5.14 presents the impulse responses to the mixed policy. Table 5.3 shows that this reform approach could bring about significant benefits in terms of growth, revenue mobilization, and

welfare improvements. A comprehensive tax reform boosts growth by 1% in the long-run by encouraging business and sharpening incentives to production. In addition, it enhances government's revenue by 1.8% from initial steady state, which helps to reduce the fiscal deficit and create a fiscal space for investment and social spending. Finally, it improves fairness by addressing some lingering inequality and making the tax system progressive in its effects. The mixed package actives all mechanisms and channels already explained in previous sections. Some of these mechanisms are synergistic and some offset the impact of other mechanisms. More broadly, figure 5.15 shows that a comprehensive package yields better outcomes (represented by the grey area in the figure) than partial reforms.

5.6 Welfare effects

In order to calculate welfare effects, we apply the standard welfare measure used in the literature e.g. see Domeij and Heathcote (2004). In an economy with idiosyncratic shocks, the welfare is measured by expected future variables. On the other hand in the no-risk economy, the welfare change is a function of initial position. In this framework, welfare is measured in terms of annual consumption equivalents that is equal to $\Lambda_i, i = S, M, R, E$. The welfare measure Λ_i obtained [23] from

$$\sum_{t=0}^{\infty} \beta_i^t U((1+\Lambda_i)C_0^i, h_0^i, l_0^i) = \sum_{t=0}^{\infty} \beta_i^t U(C_t^i, h_t^i, l_t^i), \quad i = S, M, R, E \tag{5.6.2}$$

and the weighted average welfare measure is defined as $\Lambda_A = \mu_S\Lambda_S + \mu_M\Lambda_M + \mu_R\Lambda_R + \mu_E\Lambda_E$.

Table 5.4 summaries the welfare impacts of the scenarios developed in this paper. The

23. There are three different type of consumption in the utility function, but due to the Natural Logarithm characteristics, it is possible to express all consumption in one term and analyze the effect of changes in term of annual consumption equivalents. The rearranged utility function is

$$u_t^i(C_t^i, h_t^i, l_t^i) = \ln[\underbrace{(c_t^{if})^{\varphi_f^i}(c_t^{is})^{\varphi_s^i}(c_t^{im})^{\varphi_m^i}}_{C_t^i}] + \varphi_h^i \ln h_t^i + \varphi_l^i \ln(1-l_t^i) \quad i = I, M, R, E \tag{5.6.1}$$

Table 5.4 – welfare effects for related change

Change in	$\Lambda_S(\%)$	$\Lambda_M(\%)$	$\Lambda_R(\%)$	$\Lambda_E(\%)$	$\Lambda_A(\%)$
Food VAT	0.06	−0.93	−2.02	6.79	−1
Manufacture VAT	−0.03	−1.19	−0.15	5.51	−0.39
Property tax	0.36	−0.87	0.32	3.97	−0.012
Decreasing exemption	−0.05	−1.02	−0.20	4.71	−0.37
Decreasing Co. tax	−0.03	1.32	0.07	−5.85	0.38
Both	−0.09	0.28	−0.12	−1.29	0.003
Generalized transfer	−1.008	0.18	10.8	−8.41	3.93
VAT on food & Generalized transfer	−1.03	−0.73	9.70	−2.70	3.23
VAT on food & Targeted transfer	−1.80	−2.07	26.7	−8.89	9.18
Informality	−2.30	−0.03	−0.03	5.21	−0.62
Service VAT	−2.23	−0.09	−0.01	6.15	−0.59
Both	−4.48	−0.13	−0.04	11.5	−1.20
Comprehensive package	−1.6	−2.8	28	−7.4	9.8

welfare analysis also serves as a yardstick to gauge the impact of different tax reform on inequality across households types. The percentages in the figure present what percent of the first period consumption of agent is required to make agents indifferent between applying the change and having the benchmark value. Figure 5.16 shows that in the view point of average welfare, except for the scenarios including transfers and reducing taxes, the economy is worst off and faces the welfare loss in average for all agents. Figure 5.17 further shows the superiority of a comprehensive reform package relatively to partial reforms.

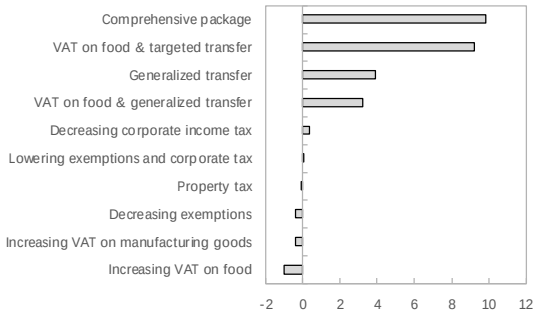

Figure 5.16 – Average household Welfare gained by tax reform scenarios (%).

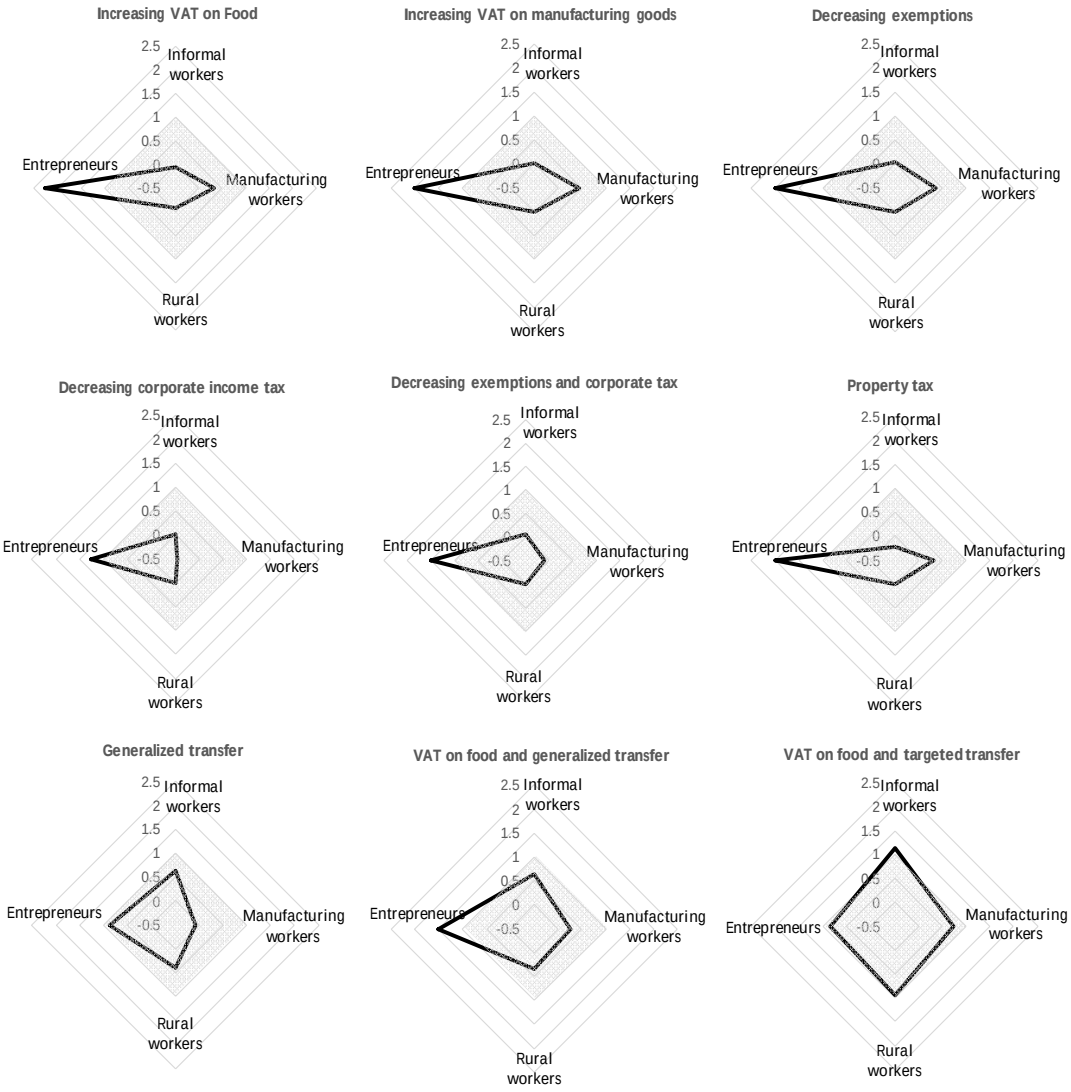

Figure 5.17 – Long-Run Effects of Tax Reform Scenarios on Household Welfare Compared (Comprehensive Reform's Scenario = 1, better outcomes are greater than 1)

5.7 Conclusion

A tax reform package implies complex trade-off between growth, government revenue, and equity. A comprehensive approach associated with better targeted social programs, broadens the tax base, removes tax distortions, better distributes the tax burden, and mitigates adverse distributional effects (that is improves welfare) by making the tax system more progressive and reducing inequalities. In emerging and developing economies, a comprehensive and pedagogical approach could help support fiscal reforms going forward. For Morocco, while achievements have been made, there is a need for greater clarity and communication on the overall reform strategy. There is agreement that the priority is to broaden the tax base and make the system more efficient and equitable. However, faster implementation of the agreed consensus reached in 2013 requires a more strategic and pedagogic approach, including the coordination, sequence, and timeframe of reforms, which could yield about 1.5-2 percent of additional public revenues over the medium term. This analysis proposed tax reform package for Morocco would involve *i*) aligning the reduced VAT rate on manufacturing goods and service to the standard VAT rate, *ii*) reducing tax exemptions, *iii*) a broader-based property tax rate, *iv*) lower corporate tax rate, and *v*) strengthened safety net. The proposed comprehensive tax reform package offers a tax mix that would allow Morocco to perform well along the key yardsticks used to assess tax system. It would enhances government's revenue from initial steady state, which help to reduce the fiscal deficit and to create a fiscal space for investment and social spending. It would boost growth by reducing government taxation on corporate to encourage business and sharpen incentives to production. Finally, it would improve fairness by addressing the lingering inequality and making the tax system progressive in its effects.

5.8 Appendix

5.8.1 Long-run impacts of each household

Long-run impacts on each household for all analyzed scenarios

Table 5.5 – % change in the steady state of total wage, consumption of each good and housing for each agent, 1% increase in VAT.

VAT on Food	W	C^f	C^m	C^s	h
Informal worker	0.47	-0.30	0.44	-0.006	0.04
Manu. worker	0	-0.75	0	-0.45	-0.40
Rural worker	-0.52	-1.24	-0.48	-0.93	0
Entre.	-0.20^*	2.12	2.89	2.43	2.48
VAT on Manu.					
Informal worker	0.44	0.32	-0.39	-0.003	0.08
Manu. worker	-0.004	-0.11	-0.82	-0.43	-0.34
Rural worker	0.39	0.26	-0.44	-0.05	0
Entre.	0.15^*	2.15	1.42	1.82	1.91

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

Table 5.6 – % change in the steady state of total wage, consumption of each good and housing for each agent, 1% increase in property tax.

Property tax	W	C^f	C^m	C^s	h
Informal worker	0.21	0.16	0.21	0	-0.61
Manu. worker	0.20	-0.11	-0.06	-0.27	0.41
Rural worker	0.18	0.13	0.18	-0.02	0
Entre.	0.19^*	1.27	1.33	1.11	0.49

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

Table 5.7 − % change in the steady state of total wage, consumption of each good and housing for each agent, targeted transfer to rural workers and 1% decreasing exemption to food producers.

Decreasing exemption	W	C^f	C^m	C^s	h
Informal worker	0.38	-0.51	0.37	-0.003	0.07
Manu. worker	-0.003	-0.88	0.001	-0.37	-0.29
Rural worker	0.34	-0.55	0.32	-0.04	0
Entre.	0.12*	1.05	1.95	1.57	1.65
Decreasing Cor. tax					
Informal worker	0.20	0.13	0.22	0.004	-0.10
Manu. worker	0.77	0.68	0.76	0.54	0.43
Rural worker	0.20	0.29	0.07	1.09	0
Entre.	0.57*	-2.14	-2.06	-2.27	-2.38
Both					
Informal worker	0.59	-0.37	0.60	0.001	-0.03
Manu. worker	0.76	-0.20	0.76	0.16	0.13
Rural worker	0.61	-0.35	0.62	0.02	0
Entre.	0.70*	-1.06	-0.10	-0.69	-0.72

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

Table 5.8 − % change in the steady state of total wage, consumption of each good and housing for each agent, targeted transfer to rural workers and 1% decreasing exemption to food producers.

Generalized Transfer	W	C^f	C^m	C^s	h
Informal worker	-0.54	-0.68	-0.51	0.007	-0.05
Manu. worker	-0.001	-0.16	0	0.52	0.46
Rural worker	0.60	10.4	0.56	1.09	0
Entre.	0.23*	-3.49	-3.33	-2.82	-2.88
VAT on food & Generalized transfer					
Informal worker	-0.12	-1.05	-0.11	0.001	-0.01
Manu. worker	0	-0.93	0	0.11	0.10
Rural worker	0.13	10	0.12	0.23	0
Entre.	0.05*	-1.66	-0.73	-0.61	-0.63
VAT on food & Targeted transfer					
Informal worker	0.18	-2.13	0.17	-0.003	0.29
Manu. worker	0.001	-2.30	0	-0.17	0.11
Rural worker	-0.47	4	6.46	6.27	0
Entre.	−0.18*	-4.71	-2.45	-2.63	-2.34

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

Table 5.9 – % change in the steady state of total wage, consumption of each good and housing for each agent, 10% decrease in informality.

Decreasing Informality	W	C^f	C^m	C^s	h
Informal worker	0.02	-0.9	-0.9	-0.9	-0.7
Manu. worker	0	0	0	-0.06	0.23
Rural worker	-0.001	-0.002	-0.06	-0.006	0
Entre.	-0.001^*	1.88	1.88	1.82	2.1
VAT on Service					
Informal worker	-0.85	-0.84	-0.82	-0.98	-0.67
Manu. worker	0.003	-0.02	0	-0.16	0.15
Rural worker	0.08	0.05	0.07	-0.08	0
Entre.	0.03^*	2.39	2.42	2.25	2.57
Both					
Informal worker	-0.82	-1.75	-1.73	-1.95	-1.36
Manu. worker	0.003	-0.02	0	-0.22	0.38
Rural worker	0.08	0.05	0.07	-0.15	0
Entre.	0.03^*	4.27	4.29	4.05	4.69

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

Table 5.10 – % change in the steady state of total wage, consumption of each good and housing for each agent, 1% Lower exemptions and corporate tax, 1% increase in targeted social safety net, VAT increase in manufacturing goods, and property tax increase.

Combined 1	W	C^f	C^m	C^s	h
Informal worker	0.9	-1.6	0.1	0	-0.3
Manu. worker	0.9	-1.9	-0.1	-0.2	0.7
Rural worker	1.2	5.2	7.2	7.1	0
Entre.	1.0^*	-4.4	-2.6	-2.7	-3.1
Combined 2	W	C^f	C^m	C^s	h
Informal worker	0.5	-1.9	-0.2	0	0.4
Manu. worker	0	-2.5	-0.8	-0.5	-0.1
Rural worker	0.7	4.9	6.7	7	0
Entre.	0.3^*	-3.5	-1.9	-1.6	-1.2

* This is total profit of entrepreneurs in the form of $(\Pi^f + \Pi^E)$.

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Chapter 6

Résumé des travaux de thèse

6.1 Conséquences macroéconomiques de la réallocation des actifs bancaires après défaillance de prêts hypothécaires

Cet article propose un modèle DSGE qui utilise des estimations bayésiennes pour évaluer une économie qui fait face aux défauts des emprunteurs vis-à-vis de leur prêt bancaire. Cette situation peut être comparé à la récession de 2008. La façon d'appréhender le mechanism des défauts est étudié dans cet article de la même manier que Iacoviello (2015). Le modèle de cet article ajoute un marché des obligations du Trésor à la littérature et montre que ce marché joue un rôle important dans cette économie. En effet, le défaut augmente l'écart entre le taux hypothécaires et celui de dépôts. Dans cette situation, les banques préfèrent compenser leurs pertes en réalisant des bénéfices sur le marché hypothécaire et ainsi, en diminuant leurs avoirs en obligations du Trésor. Ces changements propagent le choc à l'économie réelle à travers le marché de l'immobilier , celui du crédit, et aussi par l'effet sur les dépôts et les prêts gouvernementaux.

Les simulations reproduisent le comportement de variables économiques clés avant la grande récession; en particulier les prix de l'immobilier, les hypothèques, les dépôts et les avoirs en obligations du trésor par les banques. Ce modèle montre un effet de spirale descendante sur le prix de l'immobilier qui perdure après la crise.

En outre, les résultats montrent que les politiques macroprudentielles contribuent à atténuer les risques financiers. Cependant, les simulations montrent que les politiques de sortie de crise peuvent être inadéquates pour la restauration de l'économie après la crise.

6.2 Shadow banking, marchés de l'immobilier et du crédit: récit d'une récession

Cet article reprend le modèle de Gertler and Kiyotaki (2015) et l'augmente de plusieurs éléments. Il propose un modèle DSGE avec des retraits bancaires afin d'évaluer l'impact du marché de l'immobilier et de celui du crédit sur l'instabilité financière et sur les activités de shadow banking. Cet article montre que les canaux macro-financiers et macro-immobiliers amplifient le choc sur la productivité totale des facteurs de production à travers le bilan des ménages, le bilan des banques et via des canaux de liquidité.

Si le choc rend le secteur bancaire parallèle (shadow bank) insolvable, deux équilibres coexistent : un équilibre avec les retraits bancaires provoquant des faillites bancaires et un équilibre sans ceux-ci. De ce point de vue, le retrait bancaire est un échec de coordination. À l'équilibre avec faillite Si les ménages cessent de transférer leurs dépôts au secteur financier, les banques ne sont pas en mesure de financer leurs pertes par de nouveaux dépôts. Alors elles sont obligées de liquider leurs actifs à un prix de liquidation endogène.

Les simulations de l'équilibre avec faillite reproduisent le double creux du prix des logements, la spirale descendante de la production et la longue période de convalescence après la crise. En outre, des outils de politiques macroprudentiels, tels que des exigences d'adéquation des fonds et des ratios prêt-valeur, peuvent être utiles pour éliminer l'équilibre avec les faillite. Ces politiques protègent l'économie contre les crises extrêmes et aident à atténuer les risques systémiques en isolant les prix des actifs.

6.3 Fiscalité de l'immobilier et intermédiation financière

en collaboration avec Jean-François Rouillard, Professeur adjoint à l'Université de Sherbrooke, Canada

Cet article reprend le modèle de Alpanda and Zubairy (2016) en y ajoutant un secteur bancaire. En suite, ous l'angle d'un modèle d'équilibre général dynamique multi-agents, nous examinons les effets de quatre modifications d'imposition permanentes sur les agrégats macroéconomiques et le bien-être. Les modifications fiscales que nous examinons sont (i) la déduction des paiements d'intérêts hypothécaires pour les ménages impatients, (ii) la déduction des loyers imputés, (iii) la taxe foncière, et (iv) la déduction pour amortissement. Nous constatons que ces changements ont de très faibles effets sur l'activité économique à court terme. Les multiplicateurs d'impôt, à court terme, que nous trouvons sur un horizon de 20 trimestres vont de -0,02 à -0,13, tandis que les multiplicateurs d'impôt à long terme constatés vont de -1,43 à -0,81.

La mise en place des contraintes d'emprunt vis-à-vis des banques atténue les conséquences négatives de la fiscalité de l'immobilier sur la production, en particulier à court terme. La réduction de la déduction des paiements d'intérêts hypothécaires offre le plus faible multiplicateur à long terme.

Nous mettons également en œuvre des réformes fiscales sans incidence sur les revenus et constatons que l'abrogation de la déductibilité des prêts hypothécaires est la seule politique générant des gains de production.

6.4 Cycle économique avec intermédiation bancaire dans les économies pétrolières

en collaboration avec Hamid Reza Tabaraei et Asghar Shahmoradi, *senior Economists* au Fonds Monétaire International (FMI), États-Unis

Le modèle structurel présenté dans cet article propose un cadre fondé sur des fondements microécomiques qui intègre un secteur bancaire actif et un secteur de production pétrolière. L'ajout d'un secteur bancaire a pour objectif principal d'examiner le rôle d'un marché interbancaire en cas de choc, de mettre en place un fonds de développement national et d'étudier son lien avec le secteur bancaire et le gouvernement.

Le gouvernement et le fonds national de développement jouent directement un rôle clé dans la propagation du choc pétrolier. En revanche, le secteur bancaire et le marché du travail, par une substitution parfaite entre les secteurs pétrolier et non pétrolier, ont des impacts indirects majeurs sur la propagation des chocs.

6.5 Effets distributifs des réformes fiscales dans les pays en développement: une étude de cas du Maroc

en collaboration avec Jean Frederic Noah Ndela Ntsama, économiste principale au Fonds Monétaire International (FMI) et Gregory Auclair, assistante de recherche au Fonds Monétaire International (FMI), États-Unis.

Cet article évalue les effets macroéconomiques des réformes fiscales fondamentales dans les économies émergentes/en développement. Nous développons un modèle d'équilibre général dynamique avec les caractéristiques structurelles et institutionnelles des économies émergentes et en développement non pétrolières. Nous appliquons ce modèle au Maroc.

Les simulations du modèle suggèrent que les réformes fiscales impliquent des compromis complexes entre croissance, recettes publiques et équité. Une approche globale associée à des programmes sociaux mieux ciblés, élargit l'assiette fiscale, supprime les distorsions fiscales, permet de mieux répartir la charge fiscale et atténue les effets négatifs sur la répartition (améliorant le bien-être) en rendant le système fiscal plus progressif et en réduisant les inégalités.

Pour le Maroc, une réforme fiscale globale impliquerait *i*) une réduction des exonérations fiscales, *ii*) un impôt sur les biens à l'assiette plus large, *iii*) un taux d'imposition des sociétés plus bas, *iv*) l'alignement des taux de TVA existants sur un unique taux standard, et *v*) un filet de sécurité sociale mieux ciblé. De plus, l'article indique qu'un tel train de réformes est favorable à la croissance et a des implications sur inégalité.

6.6 References

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Summary

The modern economy, which is a result of intricate human society, compels economists and policy makers to build complex economic models. In addition to this complexity, each country requires its own economic policies. This thesis addresses these intricacies of modern economies. In the first three chapters of this thesis, I improve the current literature to assess the role of financial intermediary agents, housing and credit markets in the economy, using Dynamic Stochastic General Equilibrium (DSGE) models. Data from three periods in the US economy, including the economic climate before the Great Rescission, the systemic collapse in 2008, and post-crisis fiscal policies, are imputed into the models. Simple DSGE models have been criticized for not placing more emphasis on financial frictions. Here, I have included financial frictions on different sides of economy to resolve the failures of previous models. The results of simulations indicate that introducing these features to the economy reveals new channels and mechanisms which are neglected in simple models. As a result, my model gives a more accurate means to forecast economic movements. In addition, this thesis documents the significance of macroprudential policy regulations in financial stability, sustainability and welfare. Lastly, in the final two chapters of my thesis, I move away from the study of advanced markets and focus on developing economies. These chapters build new models and address a variety of economic questions pertaining to financial, public and labor economics in developing countries, through the lens of multi-agent dynamic general equilibrium models. I examine the impacts of real, monetary, fiscal and oil price shocks on the economic environment of developing countries. I then propose appropriate policy recommendations.

Résumé

L'économie moderne, qui résulte d'une société humaine hétérogène, oblige les économistes et les décideurs à élaborer des modèles économiques complexes. Outre cette complexité, les politiques économiques varient d'un pays à l'autre. Cette thèse aborde ces complexités des économies modernes. Dans les trois premiers chapitres de ma thèse, j'améliore les théories existantes pour évaluer le rôle des agents intermédiaires financiers, des marchés de l'immobilier et du crédit dans l'économie, en utilisant des modèles d'Équilibre Général Dynamique et Stochastique (EGDS). Les données de trois périodes de l'économie américaine, couvrant le climat économique avant la Grande Récession, l'effondrement systémique de 2008 et les politiques budgétaires après la crise, sont utilisées. Les modèles EGDS ont souvent été critiqués pour leur trop grande simplification des marchés financiers. J'ai inclus les frictions financières des différents côtés de l'économie, ainsi que d'un secteur immobilier. Cette combinaison des marché financier et immobilier est encore peu développé dans la littérature. Les résultats des simulations indiquent que l'introduction de ces nouvelles caractéristiques dans l'économie révèle de nouveaux canaux et mécanismes qui sont négligés dans les modèles simples. Par conséquent, les modèle de cette thèse donne un moyen plus précis d'analyser les mouvements économiques. En outre, cette thèse souligne l'importance des réglementations des politiques macroprudentielles pour la stabilité financière, la durabilité et le bien-être. Enfin, dans les deux derniers chapitres de ma thèse, je quitte l'étude des marchés avancés et je me concentre sur les économies en développement. Ces chapitres construisent de nouveaux modèles et abordent diverses questions économiques relatives à l'économie financière, publique et du travail dans les pays en développement, à travers le prisme des modèles EGD à agents hétérogènes. J'examine les impacts des chocs réels, monétaires, fiscaux et pétroliers sur l'environnement économique des pays en développement. Je propose ensuite des recommandations de politique économique.