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MONETARY AND FISCAL POLICY UNDER HETEROGENEITY: A TANK MODEL FOR MEXICO

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Summary

Heterogeneity among individuals is the norm, not the exception. However, traditional macroeconomic theory has been built around the concept of a representative agent, which allows for reasonable approximations in developed countries while reducing the computational complexity of accounting for the full distribution of agents. Nevertheless, in developing economies —where inequality is more pronounced— this simplification loses validity.

Over the past century, significant research has been conducted to understand the role of heterogeneity in macroeconomics. This emerging agenda has recognized that macroeconomics does not only influence inequality; rather, the relationship is bidirectional.

The objective of this thesis is to analyze how heterogeneity shapes the interaction between monetary and fiscal policy in the Mexican context. Specifically, we examine the effects of monetary policy, government spending, productivity, and risk premium shocks, calibrated to the Mexican case, under four fiscal scenarios: (i) a balanced budget with income taxation, (ii) a balanced budget with consumption taxation, (iii) a debt-targeting budget with income taxation, and (iv) a debt-targeting budget with consumption taxation.

Heterogeneity is introduced into the model by assuming the existence of two types of agents: Ricardian households —who have access to financial markets— and Hand-to-Mouth (HtM) households —who do not. To capture this heterogeneity, we employ a Two-Agent New Keynesian (TANK) model as an approximation of the more complex Heterogeneous Agent New Keynesian (HANK) models.

Our results are insightful, revealing that the Mexican case follows the pattern identified by Bilbiie (2018) in his Limited Asset Market Participation (LAMP) model, where the slope of the IS curve inverts in response to monetary policy shocks. Specifically, in the absence of heterogeneity, we obtain the predictions of the Standard Aggregate Demand Logic (SADL) framework: an increase in the real interest rate leads to a decline in aggregate consumption and output. However, when incor-

porating a high level of heterogeneity, we observe an Inverted Aggregate Demand Logic (IADL) effect: aggregate consumption actually rises following an increase in the real interest rate.

Our contribution, beyond calibrating the model to Mexico, lies in differentiating the effects across fiscal policy regimes:

- The behavior of the real interest rate is the key distinction between fiscal policies after a monetary policy shock. The Taylor Principle reverses under balanced budgets but remains standard under debt-targeting policies, impacting monetary policy design.
- Government spending shocks have a stronger impact when financed through consumption taxation. A 1% increase in government spending has a stronger impact under consumption taxation, as it directly affects the Euler equation of unconstrained households. Under a balanced budget, output rises, while under a debt-targeting policy, it contracts due to monetary policy differences. Hence, we suggest that economies with high LAMP should opt for consumption taxes, as they provide a stronger output boost while keeping fiscal balance.
- Productivity shocks lead to similar output effects under both tax regimes. Regardless of the tax type, greater heterogeneity leads to higher output growth due to a larger MPC.
- Risk premium shocks exhibit minor differences between tax regimes, but fiscal policy plays a decisive role. We observe that the fiscal framework matters. Under a balanced budget, output rises, while under a debt-targeting policy, it contracts due to differing monetary policy responses needed for determinacy.

To our knowledge, this is the first model developed with these specifications for the Mexican case. By incorporating heterogeneity, we offer a clearer view of the interaction between monetary and fiscal policy. Our findings reveal key differences in policy transmission across fiscal regimes and emphasize the need to account for heterogeneity in economic policy design. This study serves as a foundation for refining policies in developing economies with high heterogeneity, such as Mexico.

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The future of macroeconomics is the study of distributions
–S. Ahn, G. Kaplan, B. Moll, *et al.* (2018)

Introduction

Monetary and fiscal policies are the primary tools of macroeconomic policy and are widely implemented across the globe. However, the transmission of these policies throughout the economy is influenced by structural factors, such as the level of income and wealth inequality, which vary significantly across countries. Understanding how these inequalities affect macro policy outcomes is crucial. We aim to take the initial steps to analyze the dynamic effects of monetary and fiscal policy in the presence of heterogeneous agents for the case of Mexico.

A common misconception is that inequality is solely a consequence of economic conditions, with little influence on how economic policies are transmitted. However, recent advancements in macroeconomic theory challenge this view. The development of Heterogeneous Agent New Keynesian –HANK– models highlight how the degree of inequality within an economy can alter the transmission and effectiveness of monetary policy. These models emphasize that variations in income and wealth among households influence consumption, savings, and overall economic responses to policy changes. These insights challenge traditional models that treat households as homogeneous agents.

Applying this framework to Mexico allows for a deeper understanding of how inequality shapes the transmission mechanisms of monetary policy in a highly unequal economy. This analysis is essential for crafting economic policies that are both effective and equitable, tailored to the specific characteristics of the Mexican economy.

Our objective is to analyze how the transmission mechanisms of monetary policy operate in Mexico taking into account the heterogeneity of asset holdings by households under various fiscal policy scenarios. This thesis seeks to theoretically demonstrate the importance of this relationship and methodologically apply it to the Mexican case by utilizing Two Agent New Keynesian –TANK– model as an approximation of the more advanced HANK models.

This thesis consists of two parts. We first outline in **Chapters 1** and **2** the main ideas behind this new macroeconomic approach in order to provide a basic summary of the topic and facilitate understanding. Specifically, **Chapter 1** incorporates key data on inequality in Mexico and the transmission mechanisms of monetary policy as part of the contextualization. In **Chapter 2**, we review the existing literature regarding how monetary policy affects inequality; including new insights from HANK and how inequality affects the transmission of monetary policy. Secondly, in **Chapters 3** and **4** we formulate and calibrate a TANK model for the Mexican economy. The results of the HANK model are approximated using a TANK model for a Small Open Economy framework, which is suitable for describing the Mexican economy. This approach divides heterogeneity into two main categories: Constrained households and Ricardian –unconstrained– households, where the main difference between them is that Constrained households do not have access to financial markets while Ricardian household can smooth their consumption by holding assets. The analysis then explores how each group reacts to four different shocks –to monetary policy, government spending, productivity and the risk premium– under four fiscal policy scenarios: consumption taxation under a balanced budget fiscal policy, consumption taxation under a debt-targeting budget fiscal policy, income taxation under a balanced budget fiscal policy, and income taxation under an debt-targeting fiscal policy. Note that in the debt targeting model government spending is financed through a combination of taxes and government debt.

After a negative 1% monetary policy shock, we observe that when heterogeneity is high, the IS curve exhibits an inverted slope, similar to Bilbiie (2008). In the absence of heterogeneity, we find what the Standard Aggregate Demand Logic –SADL– framework stipulates: after an increase in the real interest rate, aggregate consumption and output fall. However, when we analyze the model with a high level of heterogeneity, we find an Inverted Aggregate Demand Logic –IADL– result: after an increase in the real interest rate, aggregate consumption actually increases. The key difference between fiscal policies lies in the behavior of the real interest rate: Under a balanced budget fiscal policy, monetary policy is passive for determinacy –the inverted *Taylor Principle* holds and thus the real interest increases in response to a negative monetary policy shock. Under a debt-financing fiscal policy, monetary policy is active for determinacy –the standard *Taylor Principle* holds– and the real interest rate falls in response to a negative monetary policy shock. However, the Inverted Aggregate Demand Logic remains valid in both cases. This inversion carries significant implications for monetary policy design, as the *Taylor Principle* is reversed under balanced budget policies for both consumption and income taxation. Conversely, when a debt-targeting fiscal policy is implemented, the *Taylor Principle* remains valid in its standard form.

Additionally, following a positive 1% government spending shock, fiscal policy financed by consumption taxation exhibits stronger effects on the economy than income taxation because consumption taxes directly impact the consumption Euler equation of unconstrained households. Under a balanced budget policy, output rises, while under a debt-targeting policy, output declines. This difference in the reaction of the output is due to monetary policy being different under the two fiscal policies. To finance the temporary increase in government spending, there is a greater reduction in government debt under consumption taxes and a larger tax rate decrease compared to income taxes. Moreover, we find that countries with a large Limited Asset Market Participation –LAMP– should use consumption taxation to stimulate the economy as they get a bigger increase in output, while still balancing the budget. Finally, we test the sensitivity of our results by introducing sunspot shocks into the analysis. These sunspot shocks arise from an expectational belief shock to inflation in the presence of indeterminacy. We find that indeterminacy affects the transmission mechanism of government spending shocks under both tax regimes.

Productivity shocks generate no significant differences between the two taxation schemes since higher heterogeneity leads to greater output due to a larger marginal propensity to consume –MPC. Under a balanced budget policy, inflation rises with higher marginal costs, while under debt-targeting policy, it decreases.

Regarding risk premium shocks, minimal differences are also found between the two tax regimes. However, when comparing between fiscal policies we find that under a balanced budget policy output increases while under a debt-targeting policy it decreases, where this difference is also related with the difference in the monetary policy needed for achieving determinacy.

Our results highlight that the monetary and fiscal policies in Mexico may not necessarily operate as in other small open economies. The findings underscore the critical need to account for inequality in economic policy design, particularly in Mexico, which ranks among the most unequal countries globally.

In the field of macroeconomics over the last few years, understanding how monetary policy transmission mechanisms change in the presence of inequality has become crucial. This thesis complements the first steps and efforts to understand the role heterogeneity plays for the design of monetary and fiscal policy in the case of Mexico by demonstrating that inequality not only results from macroeconomic conditions, but also actively shapes them, establishing a two-way relationship.

Chapter 1

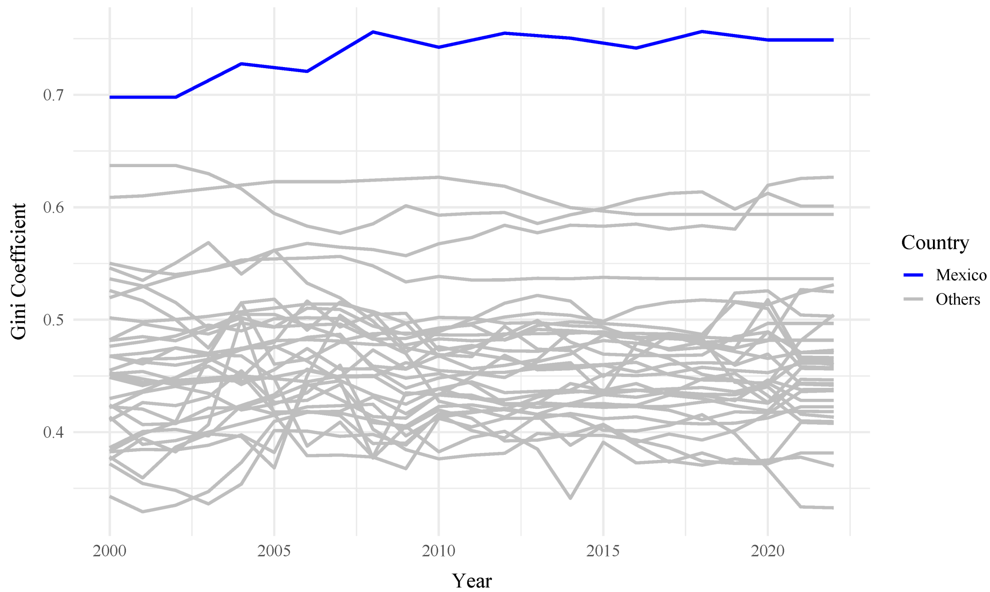
Background

1.1 Inequality in Mexico

This section briefly discusses some aspects of inequality in Mexico that are relevant to understand how inequality can affect monetary policy. It has the objective of illustrating some stylized facts for Mexico, rather than providing a detailed investigation into the issue of inequality.

For this purpose, we use the dataset curated by Thomas Piketty and published in the World Inequality Project –WIP–, which is considered one of the most accurate sources, because it includes both capital gains and labor income. We complement it with data from the ENFIH –*Encuesta Nacional sobre las Finanzas de los Hogares*–, and other sources. Using this data, Mexico's inequality level, measured by the Gini coefficient, increases from nearly 0.458 with ENIGH –*Encuesta Nacional de Ingresos y Gastos de los Hogares*– data to 0.75 as reported by WIP for 2022. This change in the Gini coefficient relies on the effort of WIP data to include the top incomes from capital. Furthermore, Mexico is one of the three most unequal countries in Latin America, alongside Chile and Brazil. Together, these countries exhibit the highest levels of inequality in the region, with the top 10% capturing nearly 60% of the average national income (WID, 2020). Furthermore, the Gini coefficient of Mexico is the highest among OECD countries, with a gap of at least five percentage points as shown in Figure 1.

Figure 1. Gini Coefficient in OECD countries (2000-2022)



Source: Own elaboration based on WIP data.

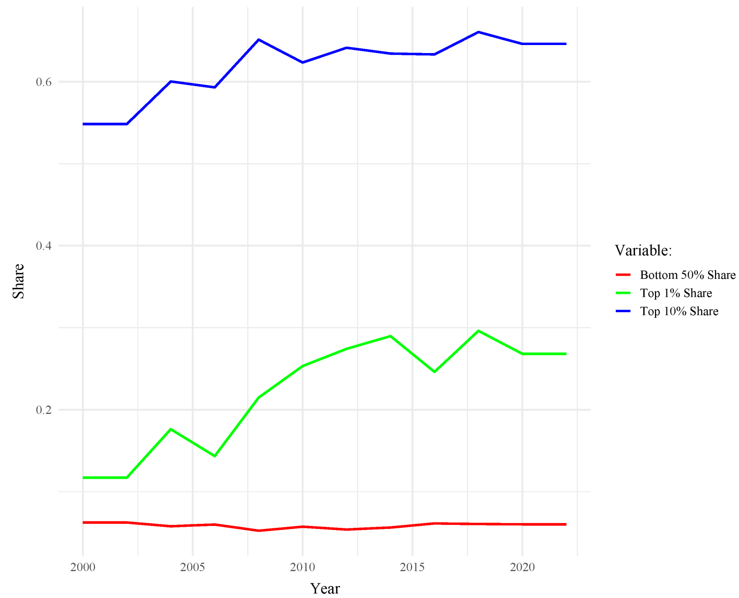
But the Gini Coefficient has been found insufficient to account for several factors of a complex, structural problem like inequality. There is still a behavior in the tails of the distribution that has not been emphasized enough, and it provides a significant explanation for the inequality. This is why a vast number of authors in the field[1] have suggested implementing ratios to acknowledge what happens in the tails, which are the segments that better describe inequality. One famous ratio is the P90/P10, which indicates the share of income that someone at the top of the distribution has in comparison to someone at the bottom.

Restricting attention to the tails of the income distribution, by using the WIP data in Figure 2, we observe that the top 10% of the income distribution has, on average, from 2000-2022, 61% of the total national income, while the top 1% has 22% and the bottom 50% has only 5% of the total national income. Furthermore, the ENIGH survey data shows that the first decile has an average income of 4,479.00 mxn, which contrasts with the top 10% that has an average income of 66,899.00 mxn, which means that during 2022, the top 10% received 15 times more than the bottom 10% in terms of current income (CEFP, 2023).[2]

[1]Gerardo Esquivel (2023) discusses alternative inequality measures, including Piketty's critique of synthetic indicators and Palma's focus on certain percentils of the distribution. For further research, see Piketty (2014) and Palma (2011).

[2]Money that is regularly received by households for the purchase of goods and services. It does not include financial-capital income.

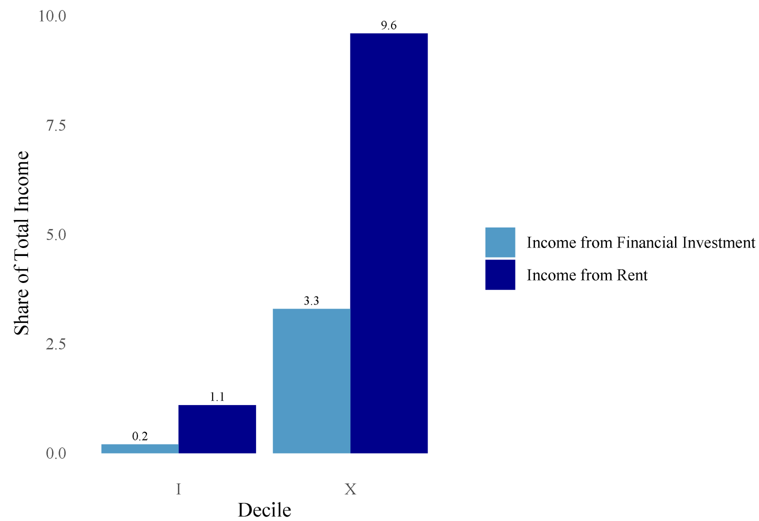
Figure 2. Income Share in Mexico by percentile (2000-2022)



Source: Own elaboration based on WIP data.

Finally, it is essential to know the income composition in every decile of the distribution to comprehend how individuals respond differently to various macroeconomic shocks. These differences underscore the importance of tailoring policies to specific economic contexts, as the same policy may lead to different results depending on the underlying economic conditions and the channels through which it operate. Figure 3 illustrates the composition of income for the top 10% of the highest-income earners and the bottom 10% of the lowest-income earners in Mexico during 2019; where income from rent and financial investments accounts for nearly 10% for the highest decile, while for the lowest decile, it does not even reach 2%.

Figure 3. Income Composition between 1st and 10th Decile in Mexico (2019)



Source: Own elaboration based on ENFIH 2019 data.

Furthermore, this income inequality data translates into a level of financial inequality. In Mexico, 32% of the population aged 18 to 70 would not be able to cover even a week of their expenses with their savings if they stopped receiving income, compared to 8.9% who could sustain themselves for more than six months.[3] Regarding the perception of individuals aged 18 and over about their financial situation, the ENFIH (2019) survey found that 20.7% do not have enough even for basic necessities, 66.5% can only cover the basics, and only 12.8% have money left to save.[4] Therefore, the inequality problem is extended to the use of financial instruments which has clear repercussions for how monetary policy and other shocks can be transmitted across the economy, including their duration.

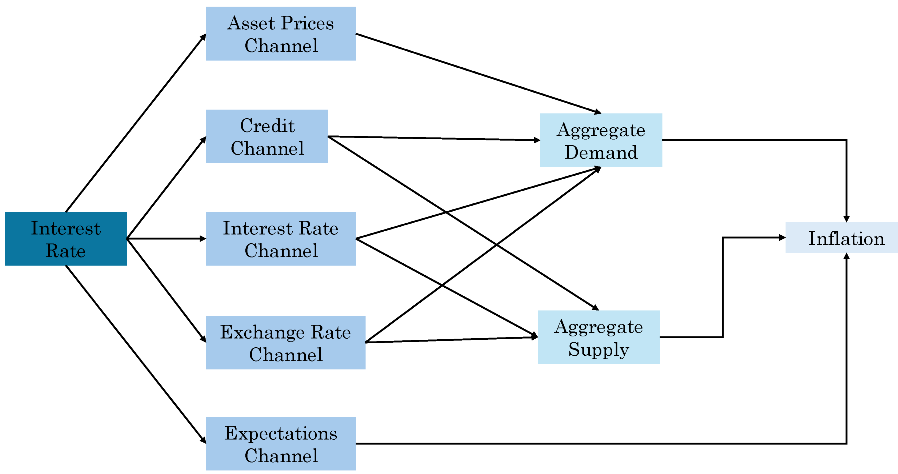
1.2 Mechanisms of Transmission of Monetary Policy

In this section, we summarize the standard mechanisms of the transmission of monetary policy in a representative agent environment. Figure 4 illustrates the channels of transmission of the monetary policy. There are five channels through which monetary policy has effects on the economy: asset prices, credit, interest rate, exchange rate and its effect over expectations.

[3]"Población de 18 a 70 años por tamaño de localidad y tiempo en que podría cubrir sus gastos con sus ahorros si dejara de percibir algún ingreso, según sexo". INEGI-ENIF (2021). Tabulados básicos.

[4]Nota técnica. INEGI-ENFIH (2019).

Figure 4. Channels of the Transmission of Monetary Policy



Source: Own elaboration based on
Informe Trimestral del Banco de México Enero-Marzo 2016.

- **Asset Prices Channel:** Changes in the interest rate affect the value of public and private debt, stocks, and real estate. For instance, a rise in the interest rate makes bonds more attractive, leading to the sale of stocks and lowering their price (Banxico, 2016).

- **Credit Channel:** Monetary policy influences the growth rate of credit in the economy, amplifying the effects of the interest rate channel. An increase in the interest rate prompts commercial banks to reduce lending, which also decreases investment and consumption (Banxico, 2016).

- **Interest Rate Channel:** The short-term interest rate moves in the direction the Central Bank adjusts the reference rate. This affects household borrowing costs and changes the timing of consumption and investment spending. Consequently, it impacts aggregate demand, which eventually influences inflation. An increase in the interest rate raises the cost of borrowing, leading to a decrease in consumption and investment. The key difference from the credit channel is that the interest rate channel affects consumers' decisions, while the credit channel impacts the availability of credit offered by commercial banks (Banxico, 2016).

- **Exchange Rate Channel:** According to the theory of uncovered interest rate parity, an increase in the interest rate makes domestic assets relative more attractive, boosting the demand for the national currency. This has two effects on aggregate demand: it raises the cost of exports and lowers the cost of imports. Currently, for Mexico, Sidaoui and Ramos-Francia (2006) note that this channel is less significant than before.

- **Expectations Channel:** This channel refers to the confidence in the Central Bank's commitment to maintaining the national currency's purchasing power. Therefore, an increase in the interest rate signals a reinforcement of this commitment, leading to lower inflation expectations depending on the level of credibility. Over time, this channel has become more relevant for Mexico, as discussed by Sidaoui and Ramos-Francia (2006).

Chapter 2

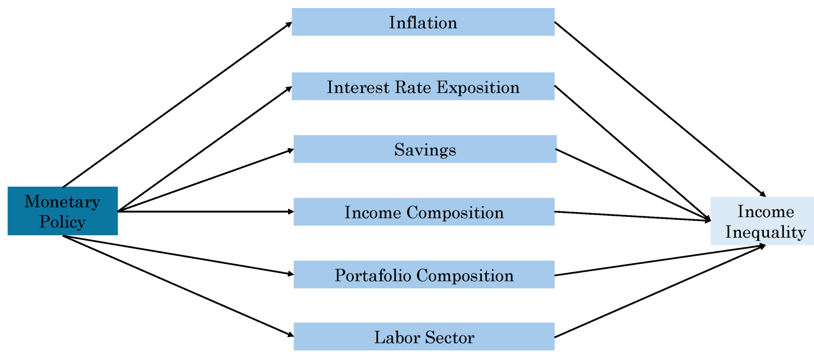
Literature Review

We first discuss the widely accepted influence of monetary policy on inequality levels. Then, we discuss the more novel question of how the transmission of monetary policy is affected by inequality to delve into the two-way relationship between monetary policy and inequality.

2.1 How Monetary Policy Affects Inequality: A Literature and Theoretic Overview

This section discusses the main channels through which inequality is affected by monetary policy measures, with a brief summary of papers that have found results according to each channel. Figure 5 summarizes those channels:

Figure 5. Diagram of the Transmission Channels of Monetary Policy for Inequality.



Source: Own elaboration.

The central bank utilizes various mechanisms to influence economic activity and reduce upward pressure on prices. However, McKay and Wolf (2023) found that monetary policy, through such measures, impacts income, unemployment, and the price of different types of assets. Given that agents within the same country hold different types of assets, work in various sectors, and rely differently on the labor market, monetary policy can have heterogeneous effects across households. In line with this reasoning, the following outlines the main channels through which conventional monetary policy can impact income inequality:

- **Inflation Channel:** An increase in inflation erodes the purchasing power of households with higher liquidity, and typically lower-income households are the most affected. Amaral (2017) points out that Erosa and Ventura (2002) found that a rise in inflation heightens inequality by acting as a regressive tax on consumption.
- **Interest Rate Exposure Channel:** Auclert (2017) suggests that real interest rates lead to redistribution effects. Net savers with short-term assets (like government bonds) and borrowers with long-term liabilities (like mortgages) benefit from expansionary monetary policy; conversely, net savers with long-term assets and borrowers with short-term liabilities do not benefit. However, understanding the redistribution through this channel is complicated due to limited information on the composition of assets and liabilities across the redistribution spectrum.
- **Savings Channel:** The effect on inequality depends on the types of assets that households across the income distribution hold. Amaral (2017) draws on Doepke *et al.* (2006) to show

that middle-class households tend to have long-term debt –i.e., mortgages. Conversely, high-income households usually hold short-term debt. Thus, expansionary policy can reduce inequality by improving the position of debtors —typically middle-class— relative to lenders, who are often wealthier.

- **Income Composition Channel:** In terms of income composition, lower-income households largely rely on government transfers, middle-income households on labor income, and high-income households on capital gains. Consequently, expansionary monetary policy could reduce income inequality by creating more jobs and lowering interest income for those at the higher end of the income distribution.

- **Labor Market Channel:** Amaral (2017) notes that Heathcote et al. (2010) find that monetary policy has the potential to affect labor income across households. Those at the top of the distribution are impacted by hourly wages, while those lower in the distribution are influenced by hours worked and the unemployment rate. Amaral (2017) explains this mechanism by referencing Carpenter and Rodgers (2004), who argue that an increase in interest rates raises unemployment for less-skilled workers. Therefore, expansionary monetary policy could reduce inequality through this channel.
  An interesting approach to further explore this channel is Ma's (2023) perspective suggesting that we can analyse distributional effects through labor supply, which heavily depends on productivity and the level/type of assets households hold. Agents exhibit different elasticities in their labor supply. Specifically, Ma (2023) notes that there is a decreasing elasticity with respect to income levels: lower-income households have high labor supply elasticity, while those at the upper end of the distribution have near-zero elasticity. This implies that lowering interest rates can increase labor supply at the extensive margin, meaning more low-income individuals work. However, wage increases are larger for those at the top of the income distribution, which could neutralize the effects.

Each channel has a different impact on income and wealth inequality. Notably, Raczyński (2022) highlights that income composition tends to have a greater effect on income inequality. In contrast, interest rate exposure, portfolio composition, and savings redistribution have a more pronounced effect on wealth inequality. However, all of these channels intersect, making it difficult to predict ex-ante the overall effect of monetary policy on both income and wealth inequality. Additionally, it is challenging to determine which, if any, of these channels dominates.

A pivotal paper in the consolidation of a research corpus leveraging representative agent models was Krusell and Smith (1998). They showed that an *approximate aggregation* occurs, where the average of the wealth distribution in equilibrium is enough to accurately represent the results of the economy. Krusell and Smith (1998) found that in precautionary savings models, optimal savings decisions are extremely close to linear, but they recognized that this was not the case for households with very little capital. Nonetheless, from their perspective, it did not matter since the savings decisions of households with little capital matter little for the dynamics of aggregate capital. They concluded that the dynamics of aggregate capital –and hence the interest rate– approximately depend on only the level of aggregate capital, not the distribution of capital across households (Kaplan, 2017). Hence, their main message is that adding heterogeneity did not change the results obtained under a representative agent model and that deviating from the representative agent approach added a high computational cost with no more informational gains (Kaplan and Violante, 2018).

2.2 How Inequality Affects Monetary Policy Transmission: A Literature and Theoretic Overview

Over the years, there has been a consensus that the transmission of monetary policy can be analyzed using the representative agent framework that chooses aggregate consumption, savings, and labor supply. Recently, a new research agenda (Ahn, Moll, Kaplan, 2018; Kaplan and Violante, 2018; Galí 2017; Bilbiie, 2008) has shown that analyzing the economy —particularly economies that show high levels of inequality— requires introducing the heterogeneity of households into the analysis.

The formalization of these new insights is reflected in Heterogeneous Agents New Keynesian –HANK– models, which arise from the need to address the gaps left by the representative agent framework. With the introduction of heterogeneity into dynamic macroeconomic models, this generated a new perspective on how the channel of monetary policy is transmitted. In that sense, the heterogenous-agent approach has emphasized that consumption-saving decisions can vary in different parts of the income distribution. Hence, a new perspective surrounding the relationship of these variables emerges: inequality also affects the transmission of monetary policy, being a two-fold relationship.

These models emerged formally after the Great Recession. Particularly, the first models tried to find the origins of the crisis, its propagation, and the observed policy responses, questions that could not be answered without incorporating household heterogeneity in terms of income, wealth, and balance sheets (Kaplan and Violante, 2018). Consequently, central bankers took notice and aimed to incorporate heterogeneity into their analysis too. One particular —and not trivial— example was the FED Chair Yanet Yellen in her speech on Boston in 2016, where she spoke about the actual macroeconomic research after the crisis and she recognized that the understanding of the effects and transmission of monetary policy can be better understood by incorporating the heterogeneity of households[1].

2.2.1 About HANK Models

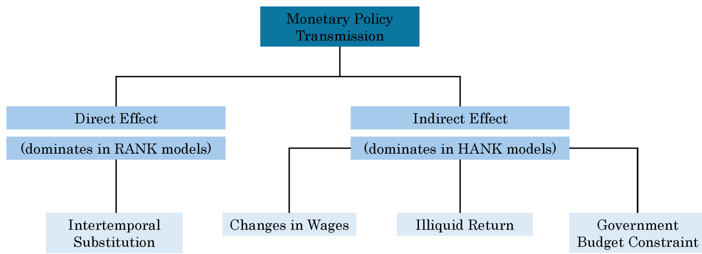
Kaplan, Moll, and Violante (2018) developed an organizational framework that synthesized previous research on the relationship between those two variables where inequality can affect the monetary policy mechanism.

They combined the two leading workhorses of modern macroeconomics. On the household side, they built an incomplete financial market model, with households that can save in two assets, a low-return liquid asset and a high-return illiquid asset that is subject to a transaction cost. On the firm side, they followed the New Keynesian tradition where prices are set by monopolistically competitive producers who face nominal rigidities, and monetary policy follows a *Taylor* rule.

The authors find that there are two effects in the transmission of monetary policy for the economy when the joint distribution of income and wealth is taken into account: direct and indirect. This contrasts with the unique direct effect found under a Representative Agent New Keynesian (RANK) model.

[1] "[. . .] in simple textbook models of the monetary transmission mechanism, central banks operate largely through the effect of real interest rates on consumption and investment. Once heterogeneity is taken into account, other important channels emerge. For example, spending by many households and firms appears to be quite sensitive to changes in labor income, business sales, or the value of collateral that in turn affects their access to credit conditions that monetary policy affects only indirectly. Studying monetary models with heterogeneous agents more closely could help us shed new light on these aspects of the monetary transmission mechanism."

Figure 6. Main Channel for the Transmission of Monetary Policy comparing RANK and HANK models.



Source: Own elaboration based on Kaplan (2018).

- **Direct effect:** A change in the interest rate modifies household consumption by intertemporal substitution such that, a real interest rate fall can induce households to consume more by borrowing —or saving less— (Moll, Kaplan and Violante, 2018).

- **Indirect effect:** The other effects arise after an increase in consumption –due to the fall of real interest rate–, occasioning an expansion of labor demand and, thus, in labor income (Moll, Kaplan and Violante, 2018).

The indirect effect, summarized in Figure 6, can be divided into three particular effects[2] that arise in general equilibrium after an increase in the real interest rate:

- **Changes in Wages:** An increase in intertemporal substitution causes non-hand-to-mouth households to increase consumption. To meet this additional demand for goods, intermediate firms increase their labor demand, pushing up wages. Overall, households increase their labor income by further increasing their consumption expenditures, which increased their income even more (Kaplan, Moll, and Violante, 2018).

- **Changes in Illiquid Return:** Since the liquid return changed, households may choose to rebalance their asset portfolio with deposits into –or withdrawals from– the illiquid account (Kaplan, Moll and Violante, 2018) depending on the prices of bonds. That can boost their consumption when nominal interest rate falls and the prices of bonds are higher.

[2]To better understand that, it is essential first to know the Marginal Propensity to Consume —MPC—- and understand that it changes across the income-wealth distribution. The MPC is the fraction of additional income spent rather than saved. The size and determinants of the aggregate MPC are uninsurable idiosyncratic risk, a precautionary savings motive, and endogenous wealth distribution (Kaplan and Violante, 2022).

- **Fiscal Response:** This refers to the government budget constraint response. With an accommodative monetary policy, the government's interest payments on its debt fall, but it also has higher tax revenues because of the additional labor income from the economic expansion (Kaplan, Moll, and Violante, 2018). This makes it easier for the government to increase transfers and spending that can boost overall consumption. Therefore, fiscal response emerges as a driver in the overall effectiveness of monetary policy, something at odds with the Ricardian nature of standard RANK economies (Kaplan, Moll, and Violante, 2018). Nonetheless, there is still no empirical evidence that anticipates what fiscal adjustment is the most likely to occur after a monetary policy shock (Kaplan, Moll, and Violante, 2018).

  Furthermore, as previously mentioned, the overall size of the indirect effect compared to the direct effect will depend on the fiscal response and the MPC of households. Indirect effects are substantial for households with zero liquid wealth, and the proportion of hand-to-mouth households –households at the bottom of the income/wealth distribution– is a crucial determinant of the monetary policy transmission mechanism (Kaplan, Moll, and Violante, 2018).

To compare the results between RANK and HANK, the authors compared their responses to a series of aggregate shocks standard in the study of business cycles. To make the results comparable, they implemented a RANK model with the same two-asset structure, the same functional forms for preferences, technology, transaction costs, and price adjustment costs, and the same production side, government, and monetary authority as in HANK. The only difference from HANK was the absence of any form of household heterogeneity.

Their results depended entirely on the shock analyzed (Kaplan and Violante, 2022): in response to a demand shock arising from a change in household discount factors, both models had the same results through the same channels. On the other hand, in response to a technology shock, while both models had similar aggregate dynamics this was obtained through different mechanisms. Moreover, with fiscal and monetary policy shocks, the two models generate different aggregate responses overall. These discrepancies in the results according to the shock can be traced to the fact that household consumption is more sensitive to income and less sensitive to interest rates in heterogeneous agent models than in representative agent models. This is due to the constraints that each household faces according to their position in the income-wealth distribution and the response of the government. Consequently, the indirect effects of an unexpected cut in interest rates —through the general equilibrium of an increase in labor demand and fiscal response— far outweigh the direct effects of intertemporal substitution.

2.2.2 About TANK Models

The previous subsection discussed that the main difference between HANK and RANK models was the lower sensitivity of heterogenous households to the interest rate and a higher response to disposable income. Nonetheless, implementing HANK models requires non-trivial computational complexities to manage the distribution of inequality in income/wealth. There are some easier models that can also generate these general results. The main model that can address this heterogeneity results is the Two-Agent New Keynesian (TANK) model proposed by authors in the past but perfected by Galí (2017).

Galí (2017) distinguishes between two types of households identified as unconstrained or constrained with a constant share in the population over time. The unconstrained households are assumed to have full access to the financial market, while constrained households are assumed to behave as *hand-to-mouth* consuming all their income. Some households lack access to financial markets, a feature shared by HANK and TANK models that is missing in RANK models. Then, HANK and TANK models differ from RANK models by modeling different behavior across households.

One of the main differences between HANK and TANK is that the former has a constant proportion between households that are either constrained or unconstrained, different from HANK in which the shocks can change the wealth/income distribution over time. That simplification makes TANK models easier. However, a simple TANK model correctly approximates the aggregate output dynamics of a HANK model in response to both monetary and non-monetary shocks. This simple division into two different types of households acknowledges the inequality between households, then, with a good approximation of the proportion of both type of households, HANK results can be reached by TANK models too (Gali, 2017).

2.2.3 When the heterogeneity level is too high

From now on, λ will refer to the proportion of households that are financially constrained, which means that they cannot smooth consumption over time. The previous scenarios considered a value of λ higher than zero. Nonetheless, different results can also emerge when λ is above a threshold. Particularly, the IS slope can switch sign as Bilbiie (2008) first showed.

Bilbiie (2008) derives a Limited Asset Market Participation –LAMP– dynamic general equilibrium model and develops a simple analytical framework for understanding the design of monetary policy. It is assumed that a fraction of agents (λ) have zero asset holding and do not smooth consumption while the remaining agents can smooth consumption by holding financial assets. He shows, using the Euler equation which is at the heart of modern macroeconomic literature, how the IS curve can be inverted when the degree of heterogeneity (λ) is high.

Bilbiie (2008) captures the influence of heterogeneity on aggregate dynamics through the aggregate elasticity to the real interest rate. It is well-known that movements in the real interest rate can modify intertemporal consumption and labor supply for asset holders. Moreover, this decision has implications for real wages. Nonasset holders are more sensitive to adjustment in the real wage, but are insensitive to interest rate changes. Furthermore, movements in the real wage are translated to changes in marginal costs leading to variations in profits. These variations in profits can reinforce or overturn the initial impact of a higher real interest rate on aggregate demand, the latter occurs when the share of non-asset holders is sufficiently high and the elasticity of labor is small. Hence, Bilbiie (2008) mentions that monetary policy –conducted by nominal interest rates– modifies real interest rates and shifts the labor supply curve –by changing the intertemporal consumption profile of asset holders. Bilbiie (2008) mentions that this has implications for monetary policy design, by showing that the *Taylor Principle* should be inverted too. In LAMP economies, the central bank needs to adopt a passive policy rule that increases the nominal interest rate by less than the increase in inflation –and decreasing the real interest rate– in order to achieve a determinate equilibrium.

2.2.4 Empirical results of heterogeneity models around the world

This section summarizes recent developments relating to HANK and TANK models. The analysis is divided into developed and developing countries to comprehend the differences that may arise depending on each country's level of inequality.

The US case is well described by Alves, *et. al.* (2021). It is one of the first papers to address the propagation of monetary shocks from a HANK model. They developed a calibrated two-asset HANK model using US data to analyze the aggregate demand effects after a monetary policy shock, with the primary objective of discussing the elements that are quantitively different from RANK models. The transmission does change because the indirect effect is mainly driven by equity prices rather than labor income. Most importantly, fiscal reaction to a monetary policy shock has a more substantial effect on the aggregate responses than other factors, contrasting with the RANK models where Ricardian equivalence holds. The fact that Ricardian equivalence fails in

HANK models means that shorter bond maturities translate into a more significant fiscal adjustment that amplifies the indirect effects after monetary policy shock. Finally, they found that an unequal incidence of labor income, profit income, and transfers can amplify or dampen the effect of a monetary policy. Nonetheless, the amplifying/dampening effect is negligible using US data. They conclude by suggesting that future research should investigate whether economies with exposure to heterogeneous households can affect the transmission of other shocks. A gap that this thesis addresses for the case of Mexico by studying the transmission of monetary policy and other shocks, such as productivity, risk premium, and government spending.

Bardóczy and Velásquez-Giraldo (2024) use a HANK model to study the distributional effects of monetary policy while considering the life cycle of households in the US. They show that after matching the age patterns with labor income and financial wealth, monetary policy affects the consumption of young households through labor income and old households through asset returns. More than half of the aggregate consumption response to an expansionary monetary policy shock comes from people below age 40, who respond mainly to labor market disturbances.

Moreover, Bayer, *et.al.* (2024) developed a HANK model of two countries with incomplete markets, idiosyncratic risk, and self-insurance in Europe. They show that the impact of a TFP shock in a monetary union, are concentrated in the distribution's tails because the middle class is almost unaffected. A monetary union has a strong bearing on the welfare impact of the shock by changing the way the real interest rate and taxes respond to the shock. Changes in the interest rate impact governments' budgets by altering the interest rate burden on the outstanding debt which, ultimately, results in an adjustment of the tax rate. Then, high-wealth households are directly affected by the interest rate changes because of their asset holdings, while low-wealth households are exposed through the tax response. Particularly, the monetary union shifts the impact horizontally across borders within the brackets of the wealth distribution, from the poor in one country to the poor in another country and not vertically within the country. Nonetheless, both effects are offset for the middle class, making them the political base for the monetary union to continue.

García, *et.al.* (2023) showed substantial heterogeneity in assets holdings, income sources, levels, and cyclicality along the distribution of Chilean households. There are more hand-to-mouth Chilean households than US households because they have lower access to financial markets. The authors mentioned that low quintiles' income are more responsive to shocks than the high quintiles. Finally, the macroeconomic effects are more persistent in the presence of this heterogeneity.

Finally, for the Mexican case, we can analyse Villarreal (2014). The author folllows the approach that Coibion et al. (2012) used to analyze the impact of monetary policy shocks on inequality in the United States. He discovered that an increase in the interest rate in Mexico reduces inequality, in contrast to the United States. He argued that this is due to financial frictions and because, in his model, household income heterogeneity is a function of current and past inflation. He concluded that in the Mexican case, the benefits of stabilizing inflation exceed its costs. Moreover, Villarreal (2018) employs a heterogeneity model and Mexican data using a TANK model to analyze how monetary policy mechanisms change when considering heterogeneity. In general, the author found that an increase in the interest rate reduces by 1% the consumption of worker households and by 67% the consumption of entrepreneurs households. In addition, the cost of reducing inflation with an increase in the interest rate is a reduction of more than three times the output and more than four times the aggregate consumption. He also measured how inequality is affected by monetary policy, namely that an increase of 80 basis points of the nominal interest rate can increase by 0.12 the Gini coefficient of the inequality of labor income of households.

The main difference between us and Villarreal (2018) is that we develop an open-economy TANK model under four different scenarios: balanced and unbalanced government budgets, financed using either income or consumption taxes. Moreover, we analyze this fiscal-monetary response under heterogeneity for other shocks: government spending and risk premium, in addition to the productivity and monetary policy shocks that Villarreal (2018) studies.

Chapter 3

A Small Open Economy Model with Heterogeneous Agents and Distortionary Taxation

We extend the Small Open Economy –SOE– model of McKnight (2014) in two directions. First, we introduce heterogenous agents into the model following the TANK literature. Similar to Bilbiie (2008), the heterogeneity of the households is simplified by dividing the heterogeneity into two major categories, depending on the access to financial markets: Constrained and Ricardian households –superscript C or R, respectively. The difference between Constrained (λ) –who can only consume their current income– and Ricardian Households $(1 - \lambda)$ –who can smooth their consumption by borrowing and lending from the financial market– introduces heterogeneity into the model by simplifying the approach of HANK models.

Secondly, we introduce distortionary taxation into the model where the government can raise revenues from levying either income taxes or consumption taxes. Furthermore, following Kurozumi (2010) we consider two different fiscal policy regimes: a balanced budget regime where the budget of the government is always balanced and a debt-targeting policy that allows the government to run short-run budget deficits. This unique approach allows us to analyze the role of heterogeneity and fiscal policy for Mexico in the response to shocks to **monetary policy, government spending, productivity, and the risk premium**.

It is assumed that the home country has a population of n and the rest of the world has a population of $1-n$. Preferences and technologies are assumed to be symmetric across the two countries. In what follows, the variables of the rest of the world are denoted with a superscript asterisk. Also, subscripts H and F denote variables of home or foreign origin.

The outline of this chapter is as follows: **Section 1** discusses the aggregate definitions of household consumption and the optimality conditions of each type of household, and it also derives some identities that are frequently used by the vast majority of the existing SOE literature. In **Section 2**, we assume that there is a continuum of monopolistically competitive firms that produce using labor only –there is no capital in this economy. Also, it will be assumed that prices are set according to Calvo (1983) due to the introduction of nominal rigidities. **Section 3** discusses the government by describing both monetary and fiscal policy. The fiscal policy we consider can either be a balanced-budget policy or a debt-targeting policy. Finally, **Section 4** derives all the market clearing conditions needed and **Section 5** defines the equilibrium of this economy.

3.1 Households

3.1.1 Consumption and Price Indexes

In the home economy, each type of household consumes home $C_{H,t}$ and foreign $C_{F,t}$ consumption bundles of goods composed of imperfectly substitutable varieties:

$$C^Z_{H,t} \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\theta}} \int_0^n (C_{H,t}(i)^Z)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \tag{1}$$

$$C^Z_{F,t} \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\theta}} \int_n^1 (C_{F,t}(i)^Z)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}. \tag{2}$$

The consumption index for each type of household is given by:

$$C^Z_t \equiv \left[(1-\gamma)^{\frac{1}{\eta}} (C^Z_{H,t})^{\frac{\eta-1}{\eta}} + (\gamma)^{\frac{1}{\eta}} (C^Z_{F,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{3}$$

where $Z \in \{C, R\}$ denotes whether the household is Constrained (C) or Ricardian (R). Also, we have $\gamma \equiv (1-n)a$ that captures the preferences for imported goods in the home country. This depends on the size of the foreign country –captured by $(1-n)$– and the degree of trade openness $a \in (0,1)$. In addition, we have $\eta > 1$ that refers to the elasticity of substitution between domestic goods and imports, and $\theta > 1$, which measures the elasticity of substitution between the differentiated goods.

The aggregate demand conditions for both Hand-to-Mouth (HtM) and Ricardian households are given by:

$$C^Z_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C^Z_t, \tag{4}$$

$$C^Z_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C^Z_t, \tag{5}$$

where $P_{H,t}$ refers to the price of the home-produced goods in the home country, which is in local currency. Also, $P_{F,t}$ refers to the price of the foreign-produced goods in the home country, which is also in local currency. Furthermore, the demand for individual goods is given by:

$$C^Z_{H,t}(i) = \frac{1}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} C^Z_{H,t}, \tag{6}$$

$$C^Z_{F,t}(i) = \frac{1}{1-n}\left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\theta} C^Z_{F,t}. \tag{7}$$

For the foreign country, it is assumed that only one type of household exists –Ricardian households. Thus, the aggregate consumption basket C^*_t of the rest of the world is:

$$C^*_{H,t} = \left[(1-\gamma^*)^{\frac{1}{\eta}}(C^*_{F,t})^{\frac{\eta-1}{\eta}} + (\gamma^*)^{\frac{1}{\eta}}(C^*_{H,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{8}$$

where $C^*_{H,t}$ refers to the imports of the foreign country and $C^*_{F,t}$ refers to the domestic consumption of the foreign country. Since, $\gamma^* \equiv na$, we have home bias $1-\gamma > \gamma^*$ due to $a < 1$.

The Foreign country has the following aggregate demand conditions:

$$C^*_{H,t} = (\gamma^*)\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} C^*_t, \tag{9}$$

$$C^*_{F,t} = (1-\gamma^*)\left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\eta} C^*_t, \tag{10}$$

where $P^*_{H,t}$ denotes the foreign currency price of the home-produced goods in the foreign country. Similarly, $P^*_{F,t}$ refers to the foreign currency price of the foreign-produced goods in the foreign country. Furthermore, the demand for individual home goods and imports for the foreign country is given by:

$$C^*_{H,t}(i) = \frac{1}{n}\left(\frac{P^*_{H,t}(i)}{P^*_{H,t}}\right)^{-\theta} C^*_{H,t}, \tag{11}$$

$$C^*_{F,t}(i) = \frac{1}{1-n}\left(\frac{P^*_{F,t}(i)}{P^*_{F,t}}\right)^{-\theta} C^*_{F,t}. \tag{12}$$

Next we derive the consumer price indexes (CPI), which are a weighted average of the prices of domestic goods and imports. To obtain the home index, first, we need to define the home prices in terms of the constrained and Ricardian households:

$$P_t = \lambda P^C_t + (1-\lambda)P^R_t, \tag{13}$$

$$P_{H,t} = \lambda P^C_{H,t} + (1-\lambda)P^R_{H,t}, \tag{14}$$

$$P_{F,t} = \lambda P^C_{F,t} + (1-\lambda)P^R_{F,t}, \tag{15}$$

where λ refers to the proportion of constrained households and $1-\lambda$ refers to the proportion of Ricardian households. Also, P^C_t and P^R_t denote the prices that constrained and Ricardian households face –respectively– and are defined as follows:

$$P^C_t = \left[(1-\gamma)(P^C_{H,t})^{1-\eta} + \gamma(P^C_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{16}$$

$$P^R_t = \left[(1-\gamma)(P^R_{H,t})^{1-\eta} + \gamma(P^R_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{17}$$

By plugging (16) and (17) into (13) we have:

$$P_t = \lambda\left\{\left[(1-\gamma)(P^C_{H,t})^{1-\eta} + \gamma(P^C_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}}\right\} + (1-\lambda)\left\{\left[(1-\gamma)(P^R_{H,t})^{1-\eta} + \gamma(P^R_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}}\right\},$$

and rearranging using (14) and (15), we have the home consumer price index:

$$P_t = [(1-\gamma)(P_{H,t})^{1-\eta} + \gamma(P_{F,t})^{1-\eta}]^{\frac{1}{1-\eta}}. \tag{18}$$

The foreign consumer price index is:

$$P^*_t = [(1-\gamma^*)(P^*_{F,t})^{1-\eta} + \gamma^*(P^*_{H,t})^{1-\eta}]^{\frac{1}{1-\eta}}. \tag{19}$$

The aggregate consumption indices are obtained by taking a weighted sum of both HtM and Ricardian households:

$$C_t = \lambda C_t^C + (1-\lambda) C_t^R, \tag{20}$$

$$C_{H,t} = \lambda C_{H,t}^C + (1-\lambda) C_{H,t}^R, \tag{21}$$

$$C_{F,t} = \lambda C_{F,t}^C + (1-\lambda) C_{F,t}^R. \tag{22}$$

It is assumed that the law of one price holds, where e_t refers to the nominal exchange rate [1]:

$$P_{H,t} = e_t P_{H,t}^*, \tag{23}$$

$$P_{F,t}^* = \frac{P_{F,t}}{e_t}. \tag{24}$$

The terms of trade, T_t is defined as:

$$T_t \equiv \frac{P_{F,t}}{P_{H,t}}. \tag{25}$$

The real exchange rate, Q_t is defined as:

$$Q_t \equiv \frac{e_t P_t^*}{P_t}. \tag{26}$$

3.1.2 Constrained Households

There is a proportion λ of constrained households that have no access to financial assets and cannot borrow or save. They solve a CRRA function to maximize their expected lifetime utility:

$$\max_{C_t^C, N_t^C} \left(\frac{(C_t^C)^{1-\sigma}}{1-\sigma} - \frac{(N_t^C)^{1+\omega}}{1+\omega} \right), \tag{27}$$

with a budget constraint in real terms that reflects the absence of access to financial securities:

$$(1+\tau_t^c) C_t^C = w_t N_t^C (1-\tau_t^y), \tag{28}$$

where $\sigma > 0$ is the inverse of the intertemporal elasticity substitution in consumption, $\omega > 0$ is the inverse of the elasticity of labor supply, C_t^C refers to the consumption of the HtM households,

[1] It is measured as the home currency in terms of a unit of foreign currency, which means that if the nominal exchange rate goes up, the domestic currency has depreciated against the foreign currency.

N_t^C refers to the hours worked by the HtM households, τ_t^c is the consumption tax, τ_t^y is the labor-income tax and $w_t = \frac{W_t}{P_t}$ is the real wage.

The current-value Lagrangian is:

$$\mathcal{L} = \left(\frac{(C_t^C)^{1-\sigma}}{1-\sigma} - \frac{(N_t^C)^{1+\omega}}{1+\omega} \right) + \Phi_t^C \left(w_t N_t^C (1-\tau_t^y) - (1+\tau_t^c) C_t^C \right), \tag{29}$$

where Φ_t^C is the Lagrangian multiplier.

First Order Conditions (FOC):

1. With respect to C_t^C:

$$\frac{\partial \mathcal{L}}{\partial C_t^C} = (C_t^C)^{-\sigma} - \Phi_t^C (1+\tau_t^c) = 0. \tag{30}$$

2. With respect to N_t^C:

$$\frac{\partial \mathcal{L}}{\partial N_t^C} = -(N_t^C)^{\omega} + \Phi_t^C w_t (1-\tau_t^y) = 0. \tag{31}$$

3. With respect to Φ_t^C:

$$\frac{\partial \mathcal{L}}{\partial \Phi_t^C} = w_t N_t^C (1-\tau_t^y) - (1+\tau_t^c) C_t^C = 0. \tag{32}$$

Rearranging (30) we have:

$$\Phi_t^C = \frac{(C_t^C)^{-\sigma}}{(1+\tau_t^c)}. \tag{33}$$

Rearranging (31) we have:

$$\Phi_t^C = \frac{(N_t^C)^{\omega}}{w_t (1-\tau_t^y)}. \tag{34}$$

By equating (33) and (34):

$$w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} = (N_t^C)^{\omega} (C_t^C)^{\sigma}. \tag{35}$$

After solving (35) using the budget constraint (28), we have the following optimal allocations of hours worked and consumption for the constrained households:

$$N_t^C = \left[w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} \right]^{\frac{1-\sigma}{\omega+\sigma}}, \tag{36}$$

$$C_t^C = \left[w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} \right]^{\frac{1+\omega}{\omega+\sigma}}. \tag{37}$$

3.1.3 Ricardian Households

There is a $1-\lambda$ proportion of households that have full access to all international financial securities, enabling them to save and borrow from incomplete international financial markets in order to smooth their consumption. They maximize the same CRRA type of expected lifetime utility function that the constrained households used in **Section 1.2** above:

$$\max_{C_t^R, N_t^R, B_t^R, B_t^{R*}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t^R)^{1-\sigma}}{1-\sigma} - \frac{(N_t^R)^{1+\omega}}{1+\omega} \right), \tag{38}$$

subject to the following budget constraint, which reflects the fact that this type of households can purchase domestic and foreign assets:

$$(1+\tau_t^c)C_t^R + \frac{b_t^R}{(1+R_t)} + \frac{Q_t b_t^*}{(1+R_t^*)\psi_t} = \frac{b_{t-1}^R}{\Pi_t} + \frac{Q_t b_{t-1}^*}{\Pi_t^*} + w_t N_t^R (1-\tau_t^y) + \frac{\Gamma_t}{P_t}(1-\tau_t^y), \tag{39}$$

where β is between (0,1) and denotes the subjective discount factor, τ_t^y is the income tax and it is the same rate for labor-income tax and real profit income, w_t denotes the real wage, $\frac{\Gamma_t}{P_t}$ refers to real profit income due to ownership of firms, Π_t and Π_t^* refer to the inflation rate for the domestic and foreign economy –respectively–, C_t^R refers to the consumption of the Ricardian households, N_t^R refers to the hours worked by the Ricardian households, $b_t^R = \frac{B_t^R}{P_t}$ refers to the home real bonds, which are in local currency, $b_t^* = \frac{B_t^*}{P_t^*}$ refers to the foreign real bonds, which are in foreign currency, R_t and R_t^* are the interest rate that the home real bonds and foreign real bonds pay –respectively–, Q_t denotes the real exchange rate and ψ_t is the risk-premium of foreign bonds.

The current-value Lagrangian is:

$$\begin{aligned}\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^R)^{1-\sigma}}{1-\sigma} - \frac{(N_t^R)^{1+\omega}}{1+\omega} \right. \\ & + \Phi_t^R \left(\frac{b_{t-1}^R}{\Pi_t} + \frac{Q_t b_{t-1}^*}{\Pi_t^*} + w_t N_t^R (1-\tau_t^y) + \frac{\Gamma_t}{P_t}(1-\tau_t^y) - (1+\tau_t^c)C_t^R \right. \\ & \left. \left. - \frac{b_t^R}{(1+R_t)} - \frac{Q_t b_t^*}{(1+R_t^*)\psi_t} \right) \right],\end{aligned} \tag{40}$$

where Φ_t^R is the Lagrangian multiplier.

First Order Conditions (FOC):

1. With respect to C_t^R:

$$\frac{\partial \mathcal{L}}{\partial C_t^R} = \beta^t \left[(C_t^R)^{-\sigma} - \Phi_t^R (1 + \tau_t^c) \right] = 0. \tag{41}$$

2. With respect to N_t^R:

$$\frac{\partial \mathcal{L}}{\partial N_t^R} = \beta^t [-(N_t^R)^{\omega} + \Phi_t^R w_t (1 - \tau_t^y)] = 0. \tag{42}$$

3. With respect to b_t^R:

$$\frac{\partial \mathcal{L}}{\partial B_t^R} = \frac{-\beta^t \Phi_t^R}{1 + R_t} + \beta^{t+1} E_t \left\{ \frac{\Phi_{t+1}^R}{\Pi_{t+1}} \right\} = 0. \tag{43}$$

4. With respect to b_t^*:

$$\frac{\partial \mathcal{L}}{\partial B_t^{R*}} = \frac{-\beta^t \Phi_t^R Q_t}{(1 + R_t^*)\psi_t} + \beta^{t+1} E_t \left\{ \frac{Q_{t+1} \Phi_{t+1}^R}{\Pi_{t+1}^*} \right\} = 0. \tag{44}$$

5. With respect to Φ_t^R:

$$\frac{\partial \mathcal{L}}{\partial \Phi_t^R} = \frac{b_{t-1}^R}{\Pi_t} + \frac{Q_t b_{t-1}^*}{\Pi_t^*} + w_t N_t^R (1 - \tau_t^y)$$
$$+ \frac{\Gamma_t}{P_t}(1 - \tau_t^y) - (1 + \tau_t^c) C_t^R - \frac{b_t^R}{(1 + R_t)} - \frac{Q_t b_t^*}{(1 + R_t^*)\psi_t} = 0. \tag{45}$$

Optimal Labor Supply Condition

Rearranging (41) we get:

$$\Phi_t^R = \frac{(C_t^R)^{-\sigma}}{(1 + \tau_t^c)}. \tag{46}$$

Rearranging (42) we get:

$$\Phi_t^R = \frac{(N_t^R)^{\omega}}{w_t (1 - \tau_t^y)}. \tag{47}$$

By equating (46) and (47):

$$w_t \frac{(1 - \tau_t^y)}{(1 + \tau_t^c)} = (N_t^R)^{\omega} (C_t^R)^{\sigma}. \tag{48}$$

Here, it is important to mention that, despite the heterogeneity of the agents, their real wage is the same because the labor market is assumed to be perfectly competitive.

Euler Equation

Rearranging (43):

$$\Phi_t^R = \beta(1+R_t)E_t\left\{\frac{\Phi_{t+1}^R}{\Pi_{t+1}}\right\}. \tag{49}$$

Substituting (46) in periods t and $t+1$ into (49) we get:

$$\frac{(C_t^R)^{-\sigma}}{(1+\tau_t^c)} = \beta(1+R_t)E_t\left\{\frac{(C_{t+1}^R)^{-\sigma}}{(1+\tau_{t+1}^c)\Pi_{t+1}}\right\}. \tag{50}$$

UIP Condition

First, we need to obtain the Euler Equation for foreign bonds of the home country.
Rearranging (44):

$$\Phi_t^R = \beta(1+R_t^*)\psi_t E_t\left\{\frac{Q_{t+1}}{Q_t}\frac{\Phi_{t+1}^R}{\Pi_{t+1}^*}\right\}. \tag{51}$$

Second, by equating the previous equation and (49) we have:

$$\beta(1+R_t)E_t\left\{\frac{\Phi_{t+1}^R}{\Pi_{t+1}}\right\} = \beta(1+R_t^*)\psi_t E_t\left\{\frac{Q_{t+1}}{Q_t}\frac{\Phi_{t+1}^R}{\Pi_{t+1}^*}\right\},$$

and substituting (46), we have:

$$E_t\left\{\frac{(C_{t+1}^R)^{-\sigma}}{(1+\tau_{t+1}^c)}\left[(1+R_t)-(1+R_t^*)\psi_t\frac{Q_{t+1}}{Q_t}\right]\right\} = 0. \tag{52}$$

3.1.4 Debt Elastic Premium

Following Motyovszki (2020), we introduce a risk premium ψ_t that depends negatively on the economy's Net Foreign Asset –NFA– position. The motive to include this debt-elastic risk premium is to ensure that bond holdings are stationary and that the model has a unique steady state. Motyovszki (2020) mentions that an intuitive way to think about it is that if the domestic economy were to go deeper in debt than some parameter ζ_t, then the foreigners would lend only with a higher interest rate. By modifying Motyovszki (2020), we have a risk premium in terms of the real foreign bond holdings and an exogenous variable ζ_t in where δ determines the sensitivity.

$$\psi_t = e^{-\delta\left(\frac{e_t B_t^*}{P_t Y}-\zeta_t\right)},$$

where Y refers to output in the steady state.

For further simplification, it is assumed that:

$$D_t = \frac{Q_t b_t^*}{Y} \tag{53}$$

since $Q_t = \frac{e_t P_t^*}{P_t}$ and $b_t^* = \frac{B_t^*}{P_t^*}$, implying that the risk premium can be expressed as:

$$\psi_t = e^{-\delta(D_t - \zeta_t)}. \tag{54}$$

3.2 Firms

Since the heterogeneity is introduced in the demand side of the economy, the supply side will remain as simple as possible. By keeping the supply side straightforward, we isolate the effects of demand-side heterogeneity so we ensure that any observed dynamics or variations in the outcomes can be attributed primarily to the heterogeneity in demand. In what follows the supply side of the model follows closely the models of Bilbiie (2008) and Boerma (2014).

3.2.1 Production

Each firm i hires labor to produce output and has an identical production technology function even though each firm produces a differentiated good:

$$Y_t(i) = A_t N_t(i) - F, \tag{55}$$

where A_t refers to a productivity and F is a fixed cost assumed to be common to all firms that can be treated as a free parameter governing the degree of returns to scale, as proposed by Bilbiie (2008). This fixed cost is important in obtaining an equitable steady-state between both types of households.

Each firm optimizes with a cost-minimizing choice of labor input:

$$\min_{N_t(i)} P_t w_t N_t(i)$$

$$s.t. Y_t(i) = A_t N_t(i) - F,$$

with a Lagrangian of the form:

$$\mathcal{L} = P_t w_t N_t(i) + MC_t(i)[Y_{t(i)} - A_t N_t(i) + F],$$

where $MC_t(i)$ is the Lagrange multiplier, which can be interpreted as the nominal marginal cost of firm *i*. Then, the First Order Condition is:

$$P_t w_t - MC_t(i) A_t = 0. \tag{56}$$

Furthermore, since $P_t w_t$ -the nominal wage rate- and productivity are the same across all intermediate firms, $MC_t(i) = MC_t$. Thus, (56) can be written as:

$$MC_t = \frac{P_t w_t}{A_t},$$

$$mc_t \equiv \frac{MC_t}{P_{H,t}} = \frac{w_t}{A_t}\frac{P_t}{P_{H,t}}, \tag{57}$$

where real marginal cost is mc_t.

3.2.2 Price Setting

It is assumed that the intermediate-goods-producing firms set prices in a staggered way according to Calvo (1983), which means that in each period, there is a constant probability $1 - \Psi$ that a firm will be randomly selected to change its prices, which is independent of history. Formally, each firm i chooses a price $\tilde{P}_{H,t}(i)$ to maximize the expected discounted value of current and future profits. By defining the demand function of each firm to be: $Y_t(i) = nC_{H,t}(i) + (1-n)C^*_{F,t}(i) + G_t(i)$, we have:

$$\Gamma_t(i) = [\tilde{P}_{H,t}(i) - P_{H,t} mc_t][nC_{H,t}(i) + (1-n)C^*_{H,t}(i) + G_t(i)], \tag{58}$$

and after substituting equations (6), (12) and defining $G_t(i) = (\frac{P_{H,t}(i)}{P_{H,t}})^{-\theta} G_t$ –i.e., assuming that the government only consumes Home products–, we have:

$$\Gamma_t(i) = \left(\frac{\tilde{P}_{H,t}(i)}{P_{H,t}}\right)^{-\theta} \left[C_{H,t} + C^*_{F,t} + G_t\right] [\tilde{P}_{H,t}(i) - P_{H,t} mc_t]. \tag{59}$$

Then, the optimization problem of each firm is:

$$\max_{\tilde{P}_{H,t}(i)} E_t \sum_{s=0}^{\infty} (\Psi)^s X_{t,t+s} \left\{ \left(\frac{\tilde{P}_{H,t}(i)}{P_{H,t+s}}\right)^{-\theta} \left[\tilde{P}_{H,t}(i) - P_{H,t+s} mc_{t+s}\right] \left[C_{H,t+s} + C^*_{F,t+s} + G_{t+s}\right] \right\}, \tag{60}$$

where $X_{t,t+s} = \beta^s [u(C^R_{t+s})/(u(C^R_t)](P_t/P_{t+s})[(1+\tau^c_t)/(1+\tau^c_{t+s})]$ is the stochastic discount factor used to value random date $t+s$ payoffs taking into account that only the Ricardian households own firms. Thus, the First Order Condition is:

$$E_t \left\{ \sum_{s=0}^{\infty} (\Psi)^s X_{t,t+s} \left[(1-\theta) \left(\frac{\tilde{P}_{H,t}}{P_{H,t+s}} \right)^{-\theta} + \theta\, mc_{t+s} \left(\frac{\tilde{P}_{H,t}(i)}{P_{H,t+s}} \right)^{-\theta-1} \right] \left[C_{H,t+s} + C^*_{F,t+s} + G_{t+s} \right] \right\} = 0, \tag{61}$$

and multiplying both sides for $\tilde{P}_{H,t}(i)$ and dividing by $1-\theta$ leads to:

$$E_t \left\{ \sum_{s=0}^{\infty} (\Psi)^s X_{t,t+s} \left[\tilde{P}_{H,t+s}(i) \left(\frac{\tilde{P}_{H,t}}{P_{H,t+s}} \right)^{-\theta} + \frac{\theta}{1-\theta} mc_{t+s} P_{H,t+s} \left(\frac{\tilde{P}_{H,t}(i)}{P_{H,t+s}} \right)^{-\theta} \right] \left[C_{H,t+s} + C^*_{F,t+s} + G_{t+s} \right] \right\} = 0. \tag{62}$$

Since all the firms that are allowed to reset their price in period t, all behave identically. Hence, $\tilde{P}_{H,t}(i) = \tilde{P}_{H,t}$. Also, $\tilde{P}_{H,t}$ does not depend on s. That leads to an optimal price of the form:

$$\tilde{P}_{H,t} = \frac{\theta}{\theta - 1} E_t \left\{ \sum_{s=0}^{\infty} q_{t,t+s} mc_{t+s} \right\}, \tag{63}$$

which means that the optimal price is a mark-up over the weighted average of current and future real marginal costs, where the weight $q_{t,t+s}$ is:

$$q_{t,t+s} \equiv \frac{(\Psi)^s X_{t,t+s} P_{H,t+s}^{\theta+1} \left(C_{H,t+s} + C^*_{F,t+s} + G_{t+s} \right)}{E_t \left\{ \sum_{s=0}^{\infty} (\Psi)^s X_{t,t+s} P_{H,t+s}^{\theta} \left(C_{H,t+s} + C^*_{F,t+s} + G_{t+s} \right) \right\}}. \tag{64}$$

Finally, by aggregating prices, we have the sub-index:

$$P_{H,t}^{1-\theta} = \Psi P_{H,t-1}^{1-\theta} + (1-\Psi) \tilde{P}_{H,t}^{1-\theta}. \tag{65}$$

3.3 Government

3.3.1 Monetary Policy

For monetary policy, we assume that the central bank sets the nominal interest rate following changes in contemporaneous CPI inflation and output. The main reason behind choosing this type of monetary policy rule resides in the fact that Mexico conducts its monetary policy in terms of CPI inflation –and inflation depends on the level of output. Then, the monetary policy rule is as follows:

$$R_t = R\left(\frac{\Pi_t}{\Pi}\right)^{\mu_\Pi}\left(\frac{Y_t}{Y}\right)^{\mu_Y} v_t, \tag{66}$$

where μ_π is the inflation response coefficient and μ_Y is the output response coefficient. Also, v_t refers to a monetary policy shock. Finally, $R = \frac{\Pi}{\beta} > 1$, Π, Y, are the nominal interest rate, the inflation level, and output in the steady state, respectively.

3.3.2 Fiscal Policy

For fiscal policy, we define the real budget constraint of the government, where the LHS refers to government spending and debt and the RHS reflects the income of the government from both taxes –consumption and income– and from issuing bonds:

$$G_t + \frac{b^g_{t-1}}{\Pi_t} = \tau^c_t C_t + \tau^y_t Y_t + \frac{b^g_t}{1+R_t}, \tag{67}$$

where $Y_t = w_t N_t + \frac{\Gamma_t}{P_t}$.

Following Kurozumi (2010), we consider two fiscal policy regimes. Under a balanced-budget policy, the government sets the tax rate to keep government debt permanently fixed at its steady state level:

$$b^g_t = \frac{B^g_t}{P_t} = \overline{b^g}. \tag{68}$$

Alternatively, under a debt-targeting policy, the government sets the tax rate in order to respond to outstanding government debt.

The *debt-targeting policy with income tax* is:

$$\tau^y_t Y_t = \tau^y Y\left(\frac{b^g_{t-1}}{b^g}\right)^{\phi_{b^g}}, \tag{69}$$

and for the *debt-targeting policy with consumption tax* we have:

$$\tau^c_t C_t = \tau^c C\left(\frac{b^g_{t-1}}{b^g}\right)^{\phi_{b^g}}, \tag{70}$$

where ϕ_{b^g} is the degree of the taxation policy response to outstanding government debt and τ^y, Y, τ^c, C and b_g are steady state values.

3.4 Market Clearing

3.4.1 Goods Market Clearing

Goods market clearing in the small open economy requires that the output of a home firm *i* is consumed domestically –by households and government– or exported. Thus, as previously mentioned, the demand for each firm is:

$$Y_t(i) = nC_{H,t}(i) + (1-n)C^*_{H,t}(i) + G_t(i). \tag{71}$$

Using equations (4) and (6), we have:

$$C^Z_{H,t}(i) = \frac{(1-\gamma)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left[\frac{P_{H,t}}{P_t}\right]^{-\eta} C^Z_t,$$

and using (21), we can write:

$$C_{H,t}(i) = \lambda\left[\frac{(1-\gamma)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C^C_t\right] + (1-\lambda)\left[\frac{(1-\gamma)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C^R_t\right],$$

$$C_{H,t}(i) = \left[\frac{(1-\gamma)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\right][\lambda C^C_t + (1-\lambda)C^R_t],$$

$$C_{H,t}(i) = \left[\frac{(1-\gamma)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\right] C_t.$$

By substituting the definition of $\gamma \equiv (1-n)a$, we have the individual consumption of the home country:

$$C_{H,t}(i) = \left[\frac{(1-(1-n)a)}{n}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\right] C_t. \tag{72}$$

Next it follows from equations (9) and (11) that:

$$C^*_{H,t}(i) = \left[\frac{\gamma^*}{n}\left(\frac{P^*_{H,t}(i)}{P^*_{H,t}}\right)^{-\theta}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta}\right] C^*_t,$$

and substituting $\gamma^* \equiv na$ we obtain:

$$C^*_{H,t}(i) = \left[a\left(\frac{P^*_{H,t}(i)}{P^*_{H,t}}\right)^{-\theta}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta}\right] C^*_t. \tag{73}$$

Using (72) and (73) the definition of the real exchange rate (26), and assuming that the government only purchases domestic goods, the market clearing condition (71) can be expressed as:

$$Y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} [[1-(1-n)a]C_t + (1-n)aC_t^* Q_t^\eta] + \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} G_t. \quad (74)$$

Then, as $n \to 0$ and inserting (74) into the aggregate domestic output: $Y_t \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\theta}} \int_0^n Y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$, we have the aggregate demand for home output:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} [(1-a)C_t + aC_t^* Q_t^\eta] + G_t. \quad (75)$$

3.4.2 Labor Market Clearing

Aggregation of Ricardian and HtM households in the labor market requires:

$$N_t = \lambda N_t^C + (1-\lambda) N_t^R. \quad (76)$$

3.4.3 Asset Market Clearing

Following Motyovszki (2020), we assume that local currency bonds are in zero net supply:

$$b_t \equiv (1-\lambda) b_t^R - b_t^g = 0. \quad (77)$$

Domestic Ricardian households can borrow or lend internationally depending on the net foreign asset position (see section 3.4.5 below), whereas local currency bonds can only be purchased by dometic Ricardian households.

3.4.4 Aggregate Production Function

In order to obtain the aggregate production function, we first have to define the demand schedule that each firm faces:

$$Y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} Y_t. \quad (78)$$

Substituting the production function (55) into the above and rearranging yields:

$$\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} Y_t = A_t N_t(i) - F,$$

$$Y_t \int_t^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} di = A_t \int_0^1 N_t(i)di - F,$$

$$Y_t = \frac{A_t N_t - F}{\Delta_t}, \tag{79}$$

where Δ_t is the degree of price dispersion:

$$\Delta_t \equiv \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} di. \tag{80}$$

3.4.5 Net Foreign Asset Condition

In order to construct the net foreign asset condition, it is necessary to combine the the government and households budget constraints. First, the government budget constraint in real terms is given by (67):

$$G_t + \frac{b^g_{t-1}}{\Pi_t} = \tau^c_t C_t + \tau^y_t Y_t + \frac{b^g_t}{1+R_t}.$$

Using $Y_t = w_t N_t + \frac{\Gamma}{P_t}$ and $C_t = (1-\lambda)C^R_t + \lambda C^C_t$, yields:

$$G_t + \frac{b^g_{t-1}}{\Pi_t} = \tau^c_t (1-\lambda) C^R_t + \tau^c_t \lambda C^C_t + \tau^y_t w_t N_t + \tau^y_t \frac{\Gamma_t}{P_t} + \frac{b^g_t}{1+R_t}.$$

Then, the budget constraint in real terms of each type of agent –(28) and (39)– is substituted using $\tau^c_t C^i_t$ for each type of household i:

$$\begin{aligned} G_t + \frac{b^g_{t-1}}{\Pi_t} = {} & \lambda \left[w_t N^C_t (1-\tau^y_t) - C^C_t\right] \\ & + (1-\lambda)\left[-\frac{b^R_t}{(1+R_t)} - \frac{b^*_t Q_t}{(1+R^*_t)\psi_t} + \frac{b^R_{t-1}}{\Pi_t} + \frac{b^*_{t-1} Q_t}{\Pi^*_t} + w_t N^R_t (1-\tau^y_t) \right. \\ & \left. + \frac{\Gamma_t}{P_t}(1-\tau^y_t) - C^R_t\right] + \tau^y_t w_t N_t + \tau^y_t \frac{\Gamma_t}{P_t} + \frac{b^g_t}{1+R_t}. \end{aligned}$$

Using the asset market equilibrium condition (77), aggregate consumption (20), and $Y_t = w_t N_t + \frac{\Gamma}{P_t}$, we obtain:

$$Y_t - G_t - C_t = \frac{b_t}{1+R_t} - \frac{b_{t-1}}{\Pi_t} + \frac{b^*_t Q_t}{(1+R^*_t)\psi_t} - \frac{b^*_{t-1} Q_t}{\Pi^*_t}. \tag{81}$$

3.5 Equilibrium

Given an exogenous sequence for foreign consumption $\{C^*_t\}$, a constant level of government expenditure $\{G\}$ and an initial condition for: $\{d_0, B^*_0, B^R_0, B^g_0\}$, an equilibrium for the small open economy of this model with heterogeneity consists of a sequence of prices $\{P_t, P_{H,t}, \tilde{P}_{H,t}, \Delta_t$ $w_t, mc_t, Q_t, T_t, e_t, \psi_t\}$, a sequence of allocations $\{C_t, Y_t, N_t, C_t^C, C_t^R,$ $N_t^C, N_t^R, B_t, B_t^*, B_t^g, B_t^R\}$, a monetary policy rule $\{R_t\}$, and a fiscal policy $\{\tau_t^c, \tau_t^y\}$. The equilibrium has to satisfy the following conditions: the optimality conditions of constrained households $(36), (37)$; the optimality conditions of Ricardian households $(39), (48)$, $(50), (52)$; the debt elastic premium (54); the aggregate consumption (20); the optimality conditions of firms $(57), (63), (65)$; the aggregate production function (78); the law of motion for price dispersion (80); the monetary policy rule (66); the fiscal policy rules $(68), (69), (70)$; the government budget constraint (67); the goods market clearing condition (75); the labor market clearing condition (76); the asset market clearing condition (77); the consumer prices index (18); the terms of trade identity (25) and the real exchange rate (26).

Chapter 4

Log-Linearization, the Steady State and Model Calibration

We solve the model outlined in **Chapter 3** by log-linearizing the equilibrium conditions in the neighborhood of the steady state. To do this, this chapter is structured as follows: **Section 1: steady state** discusses the steady state of the model. **Section 2: Log-Linearization** summarizes the log-linearized equations of the model. **Section 3: Calibration** discusses the calibration of the model for Mexico under either the balanced budget or debt-targeting fiscal policies.

4.1 Steady State

In order to log-linearize the model around a steady state, it is necessary to first derive the steady state. For this small open economy, it will be assumed that there is zero inflation, trade is balanced $B^* = 0$, that there are zero real profits from owning firms, no shocks, and zero growth –or constant variables. The remaining steady state variables will be denoted without a t. Then, according to the previously mentioned, we have:

$$\Pi = \Pi_H = \Pi^* = \Pi_H^* = 1,$$

which implies the following:

$$P = P_H = 1,$$

$$P^* = P_H^* = 1,$$

$$Q = e = T = 1. \tag{82}$$

From the Euler equation of domestic asset holders (50) we have:

$$\frac{1-\beta}{\beta} = R. \tag{83}$$

From the UIP condition (52) we have the following:

$$(1+R) = (1+R^*)\psi. \tag{84}$$

Since in the steady state $B^* = B = 0$, the risk premium (54) takes the form of:

$$\psi = 1. \tag{85}$$

Hence, $R = R^*$.

For firms, it follows from the optimal price setting condition (63) under zero inflation:

$$\tilde{P} = \frac{\theta}{\theta-1} mc = 1, \tag{86}$$

and it follows that real marginal cost is:

$$mc = \frac{\theta-1}{\theta} = w. \tag{87}$$

Since prices are fully flexible in the steady state, prices are a markup over the real marginal cost. Thus, the real marginal cost and the real wage are equal to the inverse of that markup.

In order to obtain the zero real profit condition, we need to define the following:

- Steady state net mark-up: $\mu \equiv (\theta - 1)^{-1}$

$$\Rightarrow 1 + \mu = \frac{\theta}{\theta - 1}.$$

- Steady state share of fixed cost in output: $F_Y = F/Y$.
- Share of labor income in total output: $WN/PY = (1 + F_Y)/(1 + \mu)$. To obtain this note

that:

$$\begin{aligned}\frac{wN}{Y} &= w\frac{(N-F+F)}{Y} \\ &= w\frac{(Y+F)}{Y} \\ &= \frac{\theta-1}{\theta}(1+F_Y) \\ &= \frac{1+F_Y}{1+\mu}.\end{aligned}$$

- Real profits share in total output: $(\Gamma/P)/Y = (\mu - F_Y)/(1+\mu)$. To obtain this, we need:
  - Nominal profits per firm:

$$\Gamma_t(i) \equiv P_{H,t}(i)Y_t(i) - P_{H,t}mc_tY_t(i) - P_{H,t}mc_tF$$

  - Demand of each firm:

$$Y_t(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} Y_t, \tag{78}$$

  - Price dispersion:

$$\Delta_t \equiv \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} di, \tag{80}$$

  - Price index:

$$P_{H,t}^{1-\theta} = \int_0^1 P_{H,t}(i)^{1-\theta}di. \tag{88}$$

First, we divide the nominal profits per firm by $P_{H,t}$ to obtain real profits and substitute $Y_t(i)$:

$$\frac{\Gamma_t(i)}{P_{H,t}} = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{1-\theta} Y_t - mc_t \left(\frac{\tilde{P}_{H,t}(i)}{P_{H,t}}\right)^{-\theta} Y_t - mc_tF.$$

Aggregating and rearranging yields real profits:

$$\frac{\int_0^1 \Gamma_t(i)di}{P_{H,t}} = \left[\left(\frac{\int_0^1 P_{H,t}(i)di^{1-\theta}}{P_{H,t}^{1-\theta}}\right) - mc_t \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} di\right] Y_t - mc_tF,$$

$$\frac{\Gamma_t}{P_{H,t}} = \left[1 - mc_t\Delta_t\right] Y_t - mc_tF.$$

Finally, to obtain the real profits' share in total output, we need to use the previous equation expressed in terms of the steady state and divide it by Y:

$$\left(\frac{\Gamma}{P_H}\right)/Y = \left[\frac{\mu - F_Y}{1+\mu}\right],$$

and since $P_{H,t} = P$ in the steady state, we have:

$$\left(\frac{\Gamma}{P}\right)/Y = \left[\frac{\mu - F_Y}{1+\mu}\right].$$

Then, it follows that $F_Y = \mu$ for the share of real profit in total output to be zero in the steady state.

Given that preferences are homogeneous across the two types of households, zero steady state profits implies that work hours and consumption are equalized also. This means that an equitable steady state is achieved. The importance of it relies on the fact that the budget constraint of the two types of households will be the same:

Budget constraint of HtM households in steady state:

$$(1+\tau^c)PC^C = WN^C(1-\tau^y).$$

Budget constraint of Ricardian households in steady state:

$$(1+\tau^c)PC^R = WN^R(1-\tau^y).$$

Consequently, the First Order Conditions of both types of households are the same in the steady state, yielding to the same labor-supply condition:

HtM households:

$$w\frac{(1-\tau^y)}{(1+\tau^c)} = (N^C)^\omega (C^C)^\sigma.$$

Ricardian households:

$$w\frac{(1-\tau^y)}{(1+\tau^c)} = (N^R)^\omega (C^R)^\sigma.$$

Finally, by solving for hours and consumption using the steady state version of the budget constraints and the steady-state labor-supply condition for each type of household, we get that in the steady state consumption, and hours worked are the same across the two household types:

$$N^C = N^R = \left[w\frac{(1-\tau^y)}{(1+\tau^c)}\right]^{\frac{1-\sigma}{\omega+\sigma}}, \tag{89}$$

$$C^C = C^R = \left[w \frac{(1-\tau^y)}{(1+\tau^c)} \right]^{\frac{1+\omega}{\omega+\sigma}}. \tag{90}$$

Thus, the steady state consumption of each type of household is also equal to the aggregate steady state consumption: $C = C^C = C^R$, just as in Bilbiie (2008).

Finally, by using the aggregate production function and $\Delta = 1$, we have the following relationship between output and labor:

$$Y = N - F$$

$$Y = [\lambda N^C + (1-\lambda) N^R] - F,$$

$$Y = \left[w \frac{(1-\tau^y)}{(1+\tau^c)} \right]^{\frac{1-\sigma}{\omega+\sigma}} - F. \tag{91}$$

4.2 Log-Linearization

In this section, we present the log-linearized equations of the model. A first-order Taylor approximation –or Uhlig's[1] method when convenient– is taken around the equitable steady state of the previous section. In what follows, a variable $\hat{X}_t$ denotes the log deviation of X_t with respect to its steady state value X. Then, we have:

Aggregate consumption (20)**:**

$$C_t = \lambda C_t^C + (1-\lambda) C_t^R,$$

which log-linearized yields:

$$C(1+\hat{C}_t) = \lambda C^C(1+\hat{C}_t^C) + (1-\lambda) C^R(1+\hat{C}_t^R).$$

Applying the result that in steady state the consumption of both types of households is the same, we get:

$$\hat{C}_t = \lambda \hat{C}_t^C + (1-\lambda) \hat{C}_t^R. \tag{LL-20}$$

[1]**Uhlig's Method of Log Linearization** With this method, mechanical rules are applied. The key to this log-linearization method is that a variable x_t can be replaced with $x^{ss}e^{\hat{x}_t}$ and that the following rules apply:

$$e^{(\hat{x}_t + a\hat{z}_t)} \approx 1 + \hat{x}_t + a\hat{z}_t \tag{Rule 1}$$

$$\hat{x}_t \hat{z}_t \approx 0 \tag{Rule 2}$$

$$E_t\{a e^{\hat{x}_{t+1}}\} \approx a + a E_t\{\hat{x}_{t+1}\} \tag{Rule 3}$$

Terms of trade (25)**:**

$$T_t \equiv \frac{P_{F,t}}{P_{H,t}},$$

which log-linearized is:

$$T(1+\hat{T}_t) = P_{F,t}(1+\hat{P}_{F,t})P_{H,t}^{-1}(1-\hat{P}_{H,t}).$$

Applying the zero-inflation assumption in the steady state, we obtain:

$$\hat{T}_t = \hat{P}_{F,t} - \hat{P}_{H,t}. \tag{LL-25}$$

CPI index (18):

$$P_t = [(1-\gamma)(P_{H,t})^{1-\eta} + \gamma(P_{F,t})^{1-\eta}]^{\frac{1}{1-\eta}},$$

which log-linearized is:

$$P^{1-\eta}(1+(1-\eta)\hat{P}_t) = (1-\gamma)(P_H)^{1-\eta}(1+(1-\eta)\hat{P}_{H,t}) + \gamma(P_F)^{1-\eta}(1+(1-\eta)\hat{P}_{F,t}).$$

Applying the zero inflation steady-state assumption, replacing $\gamma = a$ since $n \to 0$, and using $(LL-25)$, we have:

$$\hat{P}_t = (1-a)\hat{P}_{H,t} + a\hat{P}_{F,t},$$

$$\hat{P}_t - \hat{P}_{H,t} = a\hat{T}_t. \tag{LL-18}$$

First differentiating $(LL-18)$ we obtain a log-linearized equation for inflation of the form:

$$\hat{\Pi}_t - \hat{\Pi}_{H,t} = a\hat{T}_t - a\hat{T}_{t-1}. \tag{LL-82}$$

Real exchange rate (26)**:**

$$Q_t \equiv \frac{e_t P_t^*}{P_t},$$

and using (24) where $e_t = \frac{P_{F,t}}{P_{F,t}^*}$, yields:

$$Q_t \equiv \frac{P_{F,t}P_t^*}{P_{F,t}^*P_t}\frac{T_t}{T_t} \equiv \frac{P_{F,t}P_t^*}{P_{F,t}^*P_t}\frac{T_tP_{H,t}}{P_{F,t}} \equiv \frac{P_t^*T_tP_{H,t}}{P_{F,t}^*P_t}.$$

Log-linearizing gives:

$$Q(1+\hat{Q}_t) = \frac{P^*}{P}\frac{TP_H}{P_F^*}(1+\hat{P}_t^* - \hat{P}_t + \hat{T}_t + \hat{P}_{H,t} - \hat{P}_{F,t}^*),$$

and, by applying the zero inflation steady state assumption, noting that $\hat{P}_t^* = \hat{P}_{F,t}^* = 0$, using $(LL-18)$ to rearrange, and imposing that $\gamma = a$ since $n \to 0$, we have:

$$\hat{Q}_t = (1-a)\hat{T}_t. \tag{LL-26}$$

Optimal labor hours and consumption of constrained households:

Optimal Labor Hours of Constrained households (36)*:*

$$N_t^C = \left[w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} \right]^{\frac{1-\sigma}{\omega+\sigma}},$$

which log-linearized is:

$$\hat{N}_t^C = \left(\frac{1-\sigma}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c). \tag{LL-36}$$

Optimal Consumption of Constrained households (37)*:*

$$C_t^C = \left[w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} \right]^{\frac{1+\omega}{\omega+\sigma}},$$

which log-linearized is:

$$\hat{C}_t^C = \left(\frac{1+\omega}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c). \tag{LL-37}$$

Optimal labor supply of Ricardian households (48)**:**

$$w_t \frac{(1-\tau_t^y)}{(1+\tau_t^c)} = (N_t^R)^{\omega}(C_t^R)^{\sigma},$$

which log-linearized is:

$$\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c = \omega\hat{N}_t^R + \sigma\hat{C}_t^R. \tag{LL-48}$$

Euler Equation (50)**:**

$$\frac{(C_t^R)^{-\sigma}}{(1+\tau_t^c)} = \beta(1+R_t)E_t\left\{\frac{(C_{t+1}^R)^{-\sigma}}{(1+\tau_{t+1}^c)\Pi_{t+1}}\right\}.$$

In a zero-inflation steady state, the log-linearized version of the Euler equation is:

$$-\sigma\hat{C}_t^R + \left(\frac{\tau^c}{1+\tau^c}\right) E_t\{\tau_{t+1}^c\} = -\sigma E_t\{\hat{C}_{t+1}^R\} + \left(\frac{\tau^c}{1+\tau^c}\right)\tau_t^c + \hat{R}_t - E_t\{\hat{\Pi}_{t+1}\}. \qquad \text{(LL-50)}$$

Risk-premium (54)**:**

$$\psi_t = e^{-\delta(D_t-\zeta_t)},$$

then the log-linearized version is:

$$\hat{\psi}_t = -\delta(\hat{D}_t - \hat{\zeta}_t). \qquad \text{(LL-54)}$$

UIP condition (52)**:**

$$E_t\left\{\frac{(C_{t+1}^R)^{-\sigma}}{(1+\tau_{t+1}^c)}\left[(1+R_t) - (1+R_t^*)\psi_t\frac{Q_{t+1}}{Q_t}\right]\right\} = 0,$$

which log-linearized and substituting $(LL-54)$, yields:

$$\hat{R}_t = E_t\{\hat{Q}_{t+1}\} - \hat{Q}_t + E_t\{\hat{\Pi}_{t+1}\} - \delta(\hat{D}_t - \hat{\zeta}_t). \qquad \text{(LL-52)}$$

Real marginal cost (57)**:**

$$mc_t = \frac{w_t}{A_t}\frac{P_t}{P_{H,t}},$$

which log-linearized is:

$$mc(1+\hat{mc}_t) = w(1+\hat{w}_t)A^{-1}(1-\hat{A}_t) + P(1+\hat{P}_t)P_H^{-1}(1-\hat{P}_{H,t}).$$

Using (LL-18) and noting that $\gamma = a$ since $n \to 0$, we get:

$$\hat{mc}_t = \hat{w}_t - \hat{A}_t + a\hat{T}_t. \qquad \text{(LL-57)}$$

New Keynesian Phillips Curve: After log-linearizing equations (63) and (65) we obtain the following NKPC:

$$\hat{\Pi}_{H,t} = \beta\hat{E}_t\{\hat{\Pi}_{H,t+1}\} + k\hat{mc}_t, \qquad \text{(LL-94)}$$

where $\hat{\Pi}_{H,t} \equiv \hat{P}_{H,t} - \hat{P}_{H,t-1}$ is producer price inflation (PPI) and $k \equiv \frac{(1-\Psi)(1-\beta\Psi)}{\Psi} > 0$ is the real marginal cost elasticity of inflation.

Monetary policy rule (66)**:**

$$R_t = R\left(\frac{\Pi_t}{\Pi}\right)^{\mu_\Pi}\left(\frac{Y_t}{Y}\right)^{\mu_Y} v_t,$$

which log-linearized is:

$$\hat{R}_t = \mu_\Pi\hat{\Pi}_t + \mu_Y\hat{Y}_t + \hat{v}_t. \tag{LL-66}$$

Government budget constraint (67)**:**

$$G_t + \frac{b^g_{t-1}}{\Pi_t} = \tau^c_t C_t + \tau^y_t Y_t + \frac{b^g_t}{1+R_t},$$

rearranging we have the log-linearized version:

$$\begin{aligned} G\hat{G}_t + \left(\frac{b^g}{\Pi}\right)(\hat{b}^g_{t-1} - \hat{\Pi}_t) = C\tau^c(\hat{\tau}^c_t + \hat{C}_t) \\ + Y\tau^y(\hat{\tau}^y_t + \hat{Y}_t) \\ + \frac{b^g}{1+R}(\hat{b}^g_t - \hat{R}_t). \end{aligned}$$

By imposing balanced budget policy –$\hat{b}^g_t = 0$–, and noting that $(1+R) = \frac{1}{\beta}$ in the steady state, yields:

$$\begin{aligned} \frac{G}{Y}\hat{G}_t - \frac{b^g}{Y}\hat{\Pi}_t = \frac{C}{Y}\tau^c(\hat{\tau}^c_t + \hat{C}_t) \\ +\tau^y_t(\hat{\tau}^y_t + \hat{Y}_t) \\ -\frac{b^g}{Y}\beta\hat{R}_t. \end{aligned} \tag{LL-67.1}$$

On the other hand, for the target fiscal policy we have:

$$\begin{aligned} \frac{G}{Y}\hat{G}_t + \frac{b^g}{Y}(\hat{b^g}_{t-1} - \hat{\Pi}_t) = \frac{C}{Y}\tau^c(\hat{\tau}^c_t + \hat{C}_t) \\ +\tau^y_t(\hat{\tau}^y_t + \hat{Y}_t) \\ +\frac{b^g\beta}{Y}(\hat{b}^g_t) - \frac{b^g}{Y}\beta\hat{R}_t. \end{aligned} \tag{LL-67.2}$$

Balanced-budget policy (68)*:*

$$b^g_t = \overline{b^g},$$

which log-linearized is:

$$\hat{b}^g_t = 0. \tag{LL-68}$$

Debt-targeting policy with income taxation (69)*:*

$$\tau_t^y Y_t = \tau^y Y \left(\frac{b_{t-1}^g}{b^g}\right)^{\phi_{b^g}},$$

which log-linearized is:

$$\tau^y Y(1 + \hat{\tau}_t^y + \hat{Y}_t) = \tau^y Y(1 + \phi_{b^g} \hat{b}_{t-1}^g),$$

and rearranging gives:

$$\hat{\tau}_t^y + \hat{Y}_t = \phi_{b^g}(\hat{b}_{t-1}^g). \tag{LL-69}$$

Debt-targeting policy with consumption taxation (70)*:*

$$\tau_t^c C_t = \tau^c C \left(\frac{b_{t-1}^g}{b^g}\right)^{\phi_b},$$

which log-linearized is:

$$\tau^c C(1 + \hat{\tau}_t^y + \hat{C}_t) = \tau^c C(1 + \phi_{b^g} \hat{b}_{t-1}^g),$$

and rearranging yields:

$$\hat{\tau}_t^c + \hat{C}_t = \phi_{b^g}(\hat{b}_{t-1}^g). \tag{LL-70}$$

Aggregate demand (75)**:**

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} [(1-a)C_t + aC_t^* Q_t^\eta] + G_t,$$

which rearranged to be easily log-linearized can be first expressed as:

$$Y_t = P_{H,t}^{-\eta} {P_t}^\eta (1-a)C_t + P_{H,t}^{-\eta} {P_t}^\eta a C_t^* Q_t^\eta + G_t.$$

The log-linearized version is:

$$\begin{aligned} Y(1+\hat{Y}_t) = {} & \left(\frac{P_H}{P}\right)^{-\eta} (1-a)C(1 + \hat{C}_t - \eta \hat{P}_{H,t} + \eta \hat{P}_t) \\ & + \left(\frac{P_H}{P}\right)^{-\eta} aC^* Q^\eta (1 + \hat{C}_t^* + \eta \hat{Q}_t - \eta \hat{P}_{H,t} + \eta \hat{P}_t) \\ & + G(1 + \hat{G}_t), \end{aligned}$$

assuming that $\hat{C}^* = 0$, replacing $\gamma = a$ since $n \to 0$, and that in steady state $C = C^*$, we have:

$$\hat{Y}_t = \frac{C}{Y} \eta a \hat{T}_t + (1-a)\frac{C}{Y}\hat{C}_t + a\frac{C}{Y}\eta \hat{Q}_t + \frac{G}{Y}\hat{G}_t. \tag{LL-75}$$

Labor market clearing (76)**:**

$$N_t = \lambda N_t^C + (1-\lambda) N_t^R,$$

which log-linearized is:

$$N(1+\hat{N}_t) = \lambda N^C(1+\hat{N}_t^C) + (1-\lambda) N^R (1+\hat{N}_t^R),$$

which in an equitable steady state collapses to:

$$\hat{N}_t = \lambda \hat{N}_t^C + (1-\lambda)\hat{N}_t^R. \tag{LL-76}$$

Local bonds (77)**:**

$$b_t \equiv (1-\lambda) b_t^R - b_t^g = 0,$$

which log-linearized is:

$$\hat{b}_t = 0. \tag{LL-77}$$

Net foreign asset condition (81)**:**

$$Y_t - G_t - C_t = \frac{b_t}{1+R_t} - \frac{b_{t-1}}{\Pi_t} + \frac{b_t^* Q_t}{(1+R_t^*)\psi_t} - \frac{b_{t-1}^* Q_t}{\Pi_t^*},$$

which after substituting D_t we have:

$$Y_t - G_t - C_t = \frac{b_t}{1+R_t} - \frac{b_{t-1}}{\Pi_t} + \frac{Y D_t}{(1+R_t^*)\psi_t} - \frac{Y D_{t-1}}{\Pi_t^*},$$

and log-linearizing:

$$\hat{Y}_t - \frac{G}{Y}\hat{G}_t - \frac{C}{Y}\hat{C}_t = \beta \hat{D}_t - \hat{D}_{t-1}. \tag{LL-81}$$

Here is important to mention that $\hat{D}_t$ is a deviation around Y and not around its value in the steady state which is zero.

Aggregate production function (79)**:**

$$Y_t = \frac{A_t N_t - F}{\Delta_t},$$

which log-linearized is:

$$Y(1+\hat{Y}_t) = AN\Delta(1+\hat{A}_t + \hat{N}_t - \hat{\Delta}_t) + F\Delta\hat{\Delta}_t.$$

Noting that $\frac{AN}{Y} = 1 + F_y = 1 + \mu$ since $Y = AN - F$ in the steady state, we get:

$$\hat{Y}_t = (1+\mu)\hat{A}_t + (1+\mu)\hat{N}_t. \tag{LL-79}$$

4.2.1 Balanced Budget Model

The next step is to solve the 16 equations contained in the following Table 4.1 in order to find the 16 endogenous variables –$\hat{C}_t, \hat{C}_t^R, \hat{C}_t^C, \hat{Q}_t, \hat{\Pi}_t, \hat{\Pi}_{H,t}, \hat{T}_t, \hat{w}_t, \hat{\tau}_t^i, \hat{N}_t, \hat{N}_t^R, \hat{N}_t^C, \hat{R}_t, \hat{mc}_t, \hat{Y}_t, \hat{D}_t$– for the Mexican case in the *Balanced Budget Fiscal Policy* scenario with either i referring to a consumption or income tax –τ_t^c or τ_t^y, respectively–. The model will be calibrated for Mexico to analyze the effects of 4 exogenous shocks –change in the government spending $\hat{G}_t$, productivity $\hat{A}_t$, monetary policy $\hat{v}_t$ and risk premium $\hat{\zeta}_t$– that all follow an AR(1) process.

4.2.2 Debt Targeting Model

There is one more endogenous variable added to the previous model: $\hat{b}_t^g$. Giving then a total of 17 equations for 17 endogenous variables –$\hat{C}_t, \hat{C}_t^R, \hat{C}_t^C, \hat{Q}_t, \hat{\Pi}_t, \hat{\Pi}_{H,t}, \hat{T}_t, \hat{w}_t, \hat{\tau}_t^i, \hat{N}_t, \hat{N}_t^R, \hat{N}_t^C, \hat{R}_t, \hat{mc}_t, \hat{Y}_t, \hat{D}_t, \hat{b}_t^g$. The 17 equations are summarized in the following Table 4.2.

Hence, we extend McKnight's (2014) SOE model framework by incorporating household heterogeneity through Bilbiie's (2008) TANK approach, analyzing two different types of households with distinct budget constraints. Additionally, we introduce two types of taxation—consumption and income taxes—for each household, enabling a comparative analysis of monetary policy, government spending, productivity, and risk premium shocks under two fiscal policy regimes: balanced and unbalanced budgets. This framework is calibrated specifically for the Mexican case, as detailed in the following section.

Table 4.2: **Log-Linearization for the Debt-Target Fiscal Policy Scenario**

Variable	**Equation**
1. Aggregate Consumption	$\hat{C}_t = \lambda \hat{C}^C_t + (1-\lambda)\hat{C}^R_t$
2. Real Exchange Rate	$\hat{Q}_t = (1-a)\hat{T}_t$
3. Inflation	$\hat{\Pi}_t - \hat{\Pi}_{H,t} = a\hat{T}_t - a\hat{T}_{t-1}$
4. Labor Supply CH	$\hat{N}^C_t = \left(\frac{1-\sigma}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}^y_t - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}^c_t)$
5. Consumption CH	$\hat{C}^C_t = \left(\frac{1+\omega}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}^y_t - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}^c_t)$
6. Labor Supply RH	$\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}^y_t - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}^c_t = \omega\hat{N}^R_t + \sigma\hat{C}^R_t$
7. Euler Equation	$-\sigma\hat{C}^R_t + \left(\frac{\tau^c}{1+\tau^c}\right)E_t\{\hat{\tau}^c_{t+1}\} = -\sigma E_t\{\hat{C}^R_{t+1}\} + \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}^c_t + \hat{R}_t - E_t\{\hat{\Pi}_{t+1}\}$
8. UIP Condition	$\hat{R}_t = E_t\{\hat{Q}_{t+1}\} - \hat{Q}_t + E_t\{\hat{\Pi}_{t+1}\} - \delta(\hat{D}_t - \hat{\zeta}_t)$
9. Real Marginal Cost	$\hat{mc}_t = \hat{w}_t - \hat{A}_t + a\hat{T}_t$
10. NKPC	$\hat{\Pi}_{H,t} = \beta E_t\{\hat{\Pi}_{H,t+1}\} + k\hat{mc}_t$
11. Monetary Policy	$\hat{R}_t = \mu_\Pi \hat{\Pi}_t + \mu_Y \hat{Y}_t + \hat{v}_t$
12. Aggregate Demand	$\hat{Y}_t = \frac{C}{Y}\eta a\hat{T}_t + (1-a)\frac{C}{Y}\hat{C}_t + a\frac{C}{Y}\eta\hat{Q}_t + \frac{G}{Y}\hat{G}_t$
13. Labor Market Clearing	$\hat{N}_t = \lambda(\hat{N}^C_t) + (1-\lambda)(\hat{N}^R_t)$
14. Net Foreign Asset Condition	$\hat{Y}_t - \frac{G}{Y}\hat{G}_t - \frac{C}{Y}\hat{C}_t = \beta\hat{D}_t - \hat{D}_{t-1}$
15. Aggregate Production Function	$\hat{Y}_t = (1+\mu)\hat{A}_t + (1+\mu)\hat{N}_t$
16. Government Budget Constraint	$\frac{G}{Y}\hat{G}_t + \frac{b^g}{Y}(\hat{b^g}_{t-1} - \hat{\Pi}_t) = \frac{C}{Y}\tau^c(\hat{\tau}^c_t + \hat{C}_t) + \tau^y_t(\hat{\tau}^y_t + \hat{Y}_t) + \frac{b^g\beta}{Y}(\hat{b}^g_t) - \frac{b^g}{Y}\beta\hat{R}_t$
17. Debt-Targeting Policy with IT	$\hat{\tau}^y_t + \hat{Y}_t = \phi_{b^g}(\hat{b}^g_{t-1})$
18. Debt-Targeting Policy with CT	$\hat{\tau}^c_t + \hat{C}_t = \phi_{b^g}(\hat{b}^g_{t-1})$

4.3 Calibration

4.3.1 Parameter values

To calibrate the model to Mexico, it is essential to set values for the relevant parameters. Different sources were consulted, and some of them were estimated. Following McKnight, *et al.* (2021), we set the following parameter values: the inverse of the Frisch elasticity of labor supply ($\omega = 2$), the elasticity of substitution between home and foreign goods ($\eta = 0.62$), the inverse of intertemporal consumption substitution elasticity ($\sigma = 2$). For the degree of price stickiness needed to construct the inflation elasticity to the real marginal cost ($k = \frac{(1-\Psi)(1-\beta\Psi)}{\Psi}$), we choose a value of 0.5, which means that prices are fixed for two quarters. Furthermore, for the income/consumption tax average in the steady state (τ_t^i), we follow McKnight and Alba (2022). For trade openness, we set $a = 0.44$ following McKnight, *et al.* (2021). Aguiar and Gopinath (2007) estimate the discount factor $\beta = 0.98$ for Mexico, which we also use. For the risk premium sensitivity (δ) we set a value of 0.5 consistent with achieving determinacy. For the mark-up, where the elasticity of substitution of differentiated goods ($\mu = (\theta - 1)^{-1}$) is set at 11 to have a ten percent mark-up following Bilbiie (2008). Regarding the degree of the taxation policy response to outstanding government debt (ϕ_{b^g}), Kurozumi (2010) stipulates determinacy for values bigger than 0.12, we set it equal to 1.

For the proportion of constrained (λ) and Ricardian households ($1 - \lambda$) we calibrated $\lambda = 0.7$ using the ENIF survey from INEGI of the last two surveys (2 out of 4) that were published after the PNIF (2023) program for massive financial inclusion that the country experienced in order to capture the achievements after that policy. Moreover, steady-state consumption-output ratio ($\frac{C}{Y}$) and government expenditure share of total output in the steady-state ($\frac{G}{Y}$) were calibrated using OECD quarterly data in constant prices that were calendar and seasonally adjusted from 2000-Q1 to 2024-Q1 referring to final consumption expenditure on goods and services as a proportion of the GDP. For the steady-state government debt-output ratio ($\frac{b_g}{Y}$) it was also calibrated using quarterly OECD data –and then annualized– for the period 2006-Q1 to 2024-Q1 where we use the Public Sector Debt (PSD) that is the debt of the whole public sector which includes financial and non-financial public corporations as well as General Government as a proportion of GDP.

Since we have an *Inverted Aggregate Demand Logic* with our $\lambda = 0.7$, determinacy requires the *inverted* "Taylor Principle" and we set it $\mu_\pi = 0.5$; contrasting when $\lambda = 0$ and determinacy requires the "Taylor Principle". For the monetary policy response to output we follow Gali (2008) and set $\mu_y = 0.125$. All of the parameters are summarized in the following Table 4.3.

Table 4.1: **Log-Linearization for the Balanced Budget Fiscal Policy Scenario**

Variable	**Equation**
1. Aggregate Consumption	$\hat{C}_t = \lambda \hat{C}_t^C + (1-\lambda)\hat{C}_t^R$
2. Real Exchange Rate	$\hat{Q}_t = (1-a)\hat{T}_t$
3. Inflation	$\hat{\Pi}_t - \hat{\Pi}_{H,t} = a\hat{T}_t - a\hat{T}_{t-1}$
4. Labor Supply CH	$\hat{N}_t^C = \left(\frac{1-\sigma}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c)$
5. Consumption CH	$\hat{C}_t^C = \left(\frac{1+\omega}{\omega+\sigma}\right)(\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c)$
6. Labor Supply RH	$\hat{w}_t - \left(\frac{\tau^y}{1-\tau^y}\right)\hat{\tau}_t^y - \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c = \omega\hat{N}_t^R + \sigma\hat{C}_t^R$
7. Euler Equation	$-\sigma\hat{C}_t^R + \left(\frac{\tau^c}{1+\tau^c}\right)E_t\{\hat{\tau}_{t+1}^c\} = -\sigma E_t\{\hat{C}_{t+1}^R\} + \left(\frac{\tau^c}{1+\tau^c}\right)\hat{\tau}_t^c + \hat{R}_t - E_t\{\hat{\Pi}_{t+1}\}$
8. UIP Condition	$\hat{R}_t = E_t\{\hat{Q}_{t+1}\} - \hat{Q}_t + E_t\{\hat{\Pi}_{t+1}\} - \delta(\hat{D}_t - \hat{\zeta}_t)$
9. Real Marginal Cost	$\hat{mc}_t = \hat{w}_t - \hat{A}_t + a\hat{T}_t$
10. NKPC	$\hat{\Pi}_{H,t} = \beta E_t\{\hat{\Pi}_{H,t+1}\} + k\hat{mc}_t$
11. Monetary Policy	$\hat{R}_t = \mu_\Pi \hat{\Pi}_t + \mu_Y \hat{Y}_t + \hat{v}_t$
12. Aggregate Demand	$\hat{Y}_t = \frac{C}{Y}\eta a\hat{T}_t + (1-a)\frac{C}{Y}\hat{C}_t + a\frac{C}{Y}\eta\hat{Q}_t + \frac{G}{Y}\hat{G}_t$
13. Labor Market Clearing	$\hat{N}_t = \lambda(\hat{N}_t^C) + (1-\lambda)(\hat{N}_t^R)$
14. Net Foreign Asset Condition	$\hat{Y}_t - \frac{G}{Y}\hat{G}_t - \frac{C}{Y}\hat{C}_t = \beta\hat{D}_t - \hat{D}_{t-1}$
15. Aggregate Production Function	$\hat{Y}_t = (1+\mu)\hat{A}_t + (1+\mu)\hat{N}_t$
16. Government Budget Constraint	$\frac{G}{Y}\hat{G}_t - \frac{b^g}{Y}\hat{\Pi}_t = \frac{C}{Y}\tau^c(\hat{\tau}_t^c + \hat{C}_t) + \tau_t^y(\hat{\tau}_t^y + \hat{Y}_t) - \frac{b^g}{Y}\beta\hat{R}_t$

Table 4.3: **Log-Linearization for the Balanced Budget Fiscal Policy Scenario**

Parameter	**Value**	**Description**	**Source**
λ	0.7	Proportion of constrained households	Data: ENIF
a	0.44	Trade openness	McKnight, *et. al.* (2021)
ω	2	Inverse of the Frisch elasticity of labor supply	McKnight, *et.al.* (2021)
σ	2	Inverse of intertemporal consumption substitution elasticity	McKnight, *et.al.* (2021)
β	0.98	Discount factor	Aguiar and Gopinath (2007)
δ	0.5	Risk premium sensitivity to debt	(-)
μ	1/10	Mark-up	Bilbiie (2008)
η	0.62	Elasticity of substitution between home and foreign goods	McKnight, *et.al.* (2021)
Ψ	0.5	Price Stickiness	(-)
k	0.51	Inflation elasticity to real marginal cost	(-)
G/Y	0.15	Government expenditure in terms of the total output in steady state	Data: OECD
C/Y	0.85	Consumption in terms of the total output in steady state	Data: OECD
b_g/Y	1.32	Government debt in terms of the total output in steady state	Data: OECD
τ^y	0.13	Income tax in steady state	McKnight and Alba (2022)
τ^c	0.07	Consumption tax in steady state	McKnight and Alba (2022)
μ_π	0.5	Monetary policy response to inflation	(-)
μ_Y	0.125	Monetary policy response to output	Galí (2008)
ϕ_g	1	Taxation policy response to government debt	Kurozumi (2010)
ρ_A	0.94	Auto-correlation of productivity shock	Aguiar and Gopinath (2007)
ρ_v	0.5	Auto-correlation of monetary policy shock	Galí (2008)
ρ_G	0.91	Auto-correlation of government spending shock	Jiang and Li (2023)
ρ_ζ	0.69	Auto-correlation of risk premium shock	McKnight and Povoledo (2024)

4.3.2 Shocks

Each of the four shocks –government spending ($\hat{G}_t$), monetary policy ($\hat{v}_t$), productivity ($\hat{A}_t$) and risk premium ($\hat{\zeta}_t$)– follows an AR(1) process of the form:

$$x_t = \rho_x x_{t-1} + {\epsilon_t}^x,$$

where $\rho_x \in [0, 1)$ and ${\epsilon_t}^x$, is a zero mean white noise process.

Following Jiang and Li (2023), the shock persistence of the government spending shock (ρ_G) for developing countries is set equal to 0.91. Moreover, the shock's persistence of a monetary policy shock (ρ_v) is 0.50, according to Galí (2008). Additionally, for the shock's persistence of the productivity shock (ρ_A), we set a value of 0.94 following Aguiar and Gopinath (2007). Finally, for the shock's persistence of risk premium (ρ_ζ) we set a value of 0.69 following McKnight and Povoledo (2024).

Before proceeding to the results of the model, we summarize in Table 4.4 all the model variables for easy reference. The suffix CT refers to the scenario in which a consumption tax is implemented, while IT indicates the scenario that involves an income tax.

Table 4.4: Summary of Model Variables

Name of Variable	**Meaning**
c	Aggregate consumption
c_r	Ricardian consumption
c_c	Hand-to-mouth (HTM) consumption
π	General inflation
π_h	Domestic inflation
t	Trade balance
w	Real wage
τ_c	Consumption taxation
τ_y	Income taxation
n	Aggregate labor supply
n_r	Ricardian labor supply
n_c	HTM labor supply
mc	Real marginal cost
y	Aggregate output
d	Foreign bond holdings
r_{real}	Real interest rate

Chapter 5

Results for the Balanced Budget Model

This chapter presents the results of the calibrated model under a balanced budget fiscal policy to compare how a positive 1% shock to government spending, monetary policy, productivity, and the risk premium changes under both income and consumption taxation taking into account household heterogeneity.

The most interesting results relate to the monetary policy shocks. We find that the transmission mechanism of monetary policy shocks crucially depend on the degree of non-asset holder participants in the economy. For the Mexican case, where there is a high level of non-asset holder participants in the economy, this affects the slope of the intertemporal IS curve. In standard models, the IS curve is negatively sloped such that aggregate consumption falls in response to higher real interest rates –Bilbiie (2008) calls this the Standard Aggregate Demand Logic (SADL) . With a high level of non-asset holder participants in the economy, however, the IS curve can become positively sloped such that aggregate consumption increases in response to higher real interest rates –Bilbiie (2008) calls this the Inverted Aggregate Demand Logic (IADL). Moreover, this result persists under both taxation schemes.

Additionally, in the case of government spending shocks, there are both quantitative and qualitative differences between the two taxation schemes due to the different response of Ricardian households related to how each distortionary tax affects their consumption Euler equation.

In contrast, the productivity and risk premium shocks, there are no significant difference between the two taxation schemes, and the results are almost the same as under full asset-market participation.

5.1 Monetary Policy Shocks

Figure 5.1 shows the impulse response functions after a negative monetary policy shock for all the relevant variables of the balanced budget version of the model under either income or consumption taxation.

Aggregate consumption increases under both taxation schemes, but slightly more under consumption taxes. Decomposing aggregate consumption, we can observe the following results: firstly, under consumption taxation, the consumption of Ricardian households decreases more than under income taxation, while the consumption of HtM households increases more under consumption taxes than under income taxes. Even when the consumption of the Ricardian households falls, the proportion of HtM households is sufficiently large to more than offset this decrease in the aggregate.

The hours worked in the economy increases under both taxation schemes. However, under consumption taxation, the hours worked by Ricardian households increases more than under income taxes, while the hours worked of HtM households decreases more under consumption taxes than under income taxes. Summing up, the increase in the hours worked by Ricardian households outweighs the significant decrease in the labor supply of HtM households. The overall increase in labor supply results in an increase in output. Output increases more under consumption taxation than under income taxation. These movements also translated to real wages and marginal costs, where the increase is slightly higher under consumption taxes.

Both CPI and domestic inflation increase after the increase in the nominal interest rate. Furthermore, taxation rates increase, being more elevated under consumption taxes than income taxes. The increase in taxation is in line with the increase in government debt payments that result from the increase in the real interest rate.

The important observation to make is that aggregate consumption rises due to the increase in constrained households consumption caused by higher real wages. For Ricardian households, both consumption and savings fall –less acquisition of net foreign assets– and the country runs a trade deficit due to the increase of imports consumed by constrained households since aggregate consumption increases more than double the initial increase in output.

Overall, the increase in the nominal interest rate has a positive effect on inflation, aggregate demand, and output, which contradicts mainstream results. As we will explain below, this transmission mechanism arises from the IADL.

5.1.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 1.5$ which differs from the value of $\mu_\pi = 0.5$ used in our TANK model under a balanced budget policy.

Aggregate consumption decreases under both taxation schemes, but more under consumption taxes than income taxes. Furthermore, CPI and domestic inflation decrease under both taxation schemes, but slightly more under consumption taxation. This goes in line with the increase in the real interest rate and the increase in the taxation rates.

The aggregated labor market contracts under both taxation schemes, but slightly more under consumption taxation. Consequently, output decreases under both taxation schemes but more under consumption taxes. Moreover, real wages and marginal cost fall under both taxation schemes. Finally, households reduce their net foreign asset holdings under both taxation schemes –it increases under consumption taxes at the moment of the shock but it falls quickly after.

If follows from Figure 5.2, that an increase in the nominal interest rate is contractionary: output, hours worked, and consumption all decrease. Furthermore, the effect is exacerbated under consumption taxation. The reason behind this is what we mentioned previously: in a balanced budget, the increase in the real interest rate makes government debt increase, which must be compensated with an increase in taxation. In this case, the so-called public finance channel of monetary policy reinforces the results of an increase in the interest rate, being more prominent under consumption taxes since it enters into the Euler equation whereas income taxes does not. Hence, aggregate consumption falls after a rise in the real interest rate in SADL economies as households save more. Households hold more domestic assets and switch away from purchasing net foreign assets. Since the fall in exports is greater than the fall in imports, the trade balance deteriorates. The results under the SADL economy ($\lambda = 0.01$) contrast with the results under the IADL economy ($\lambda = 0.7$) where we have the opposite results: an increase in real interest rate, increases output, hours worked, and aggregate consumption.

Figure 5.1: IRF of a monetary policy shock

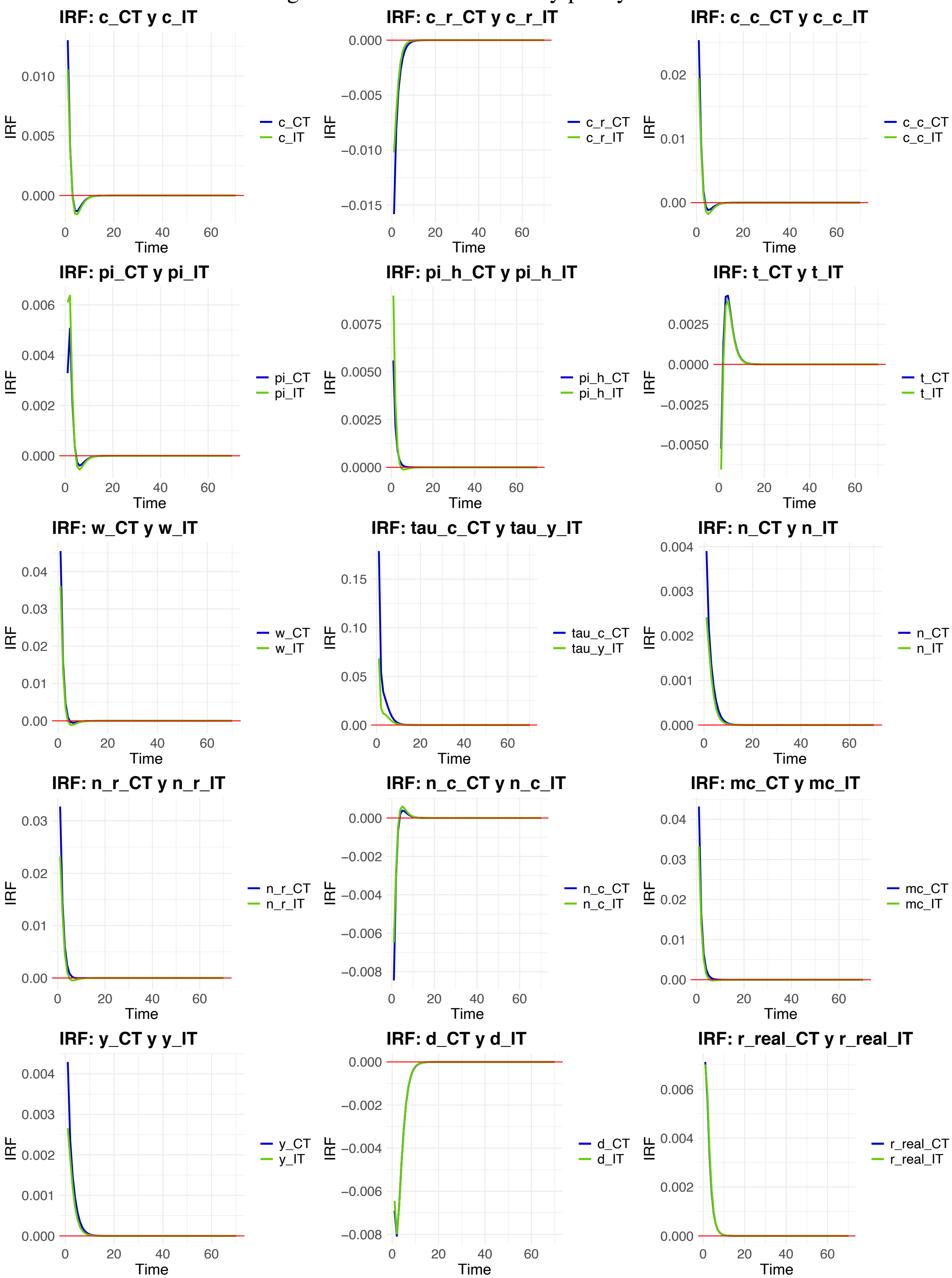
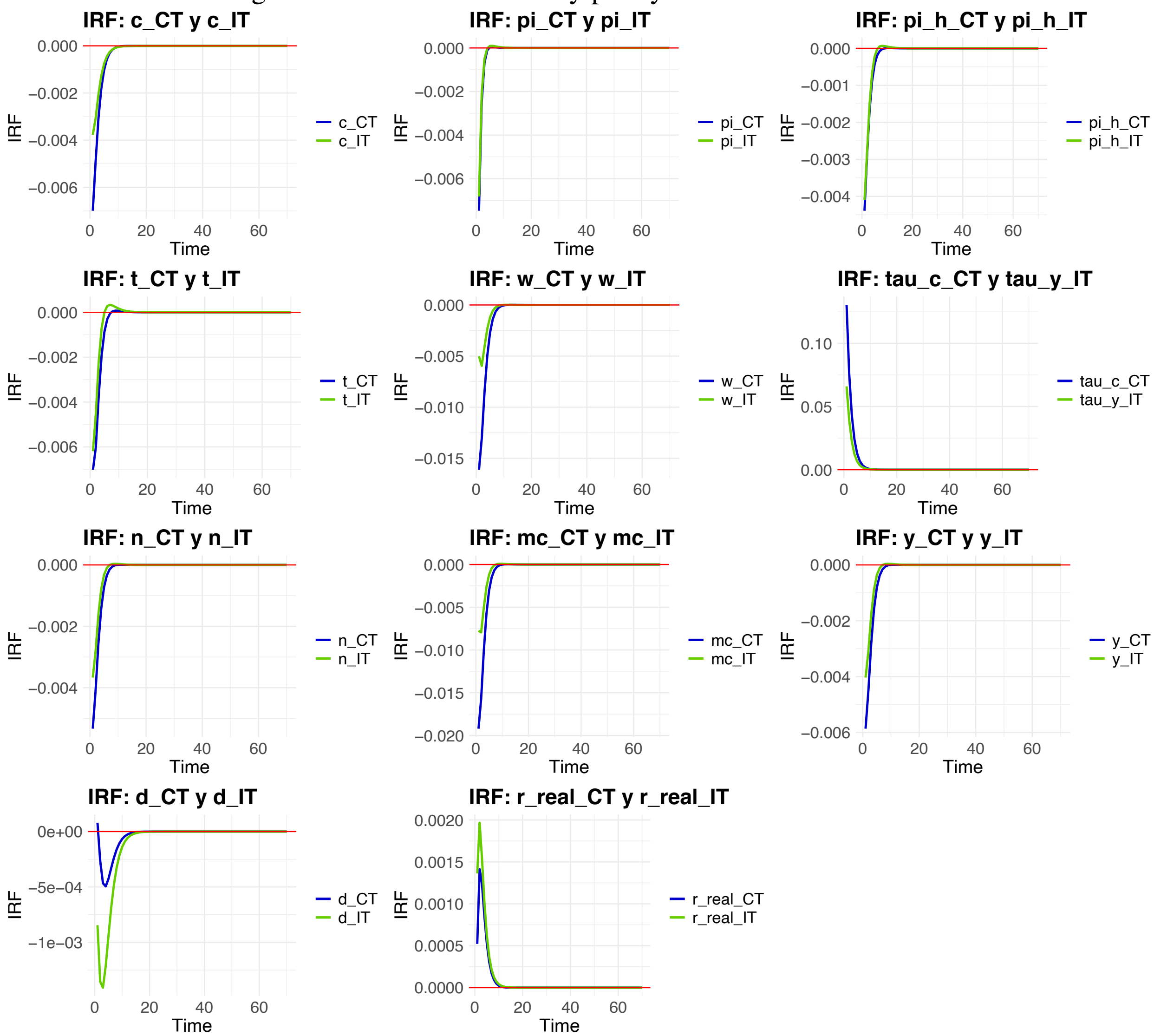


Figure 5.2: IRF of a monetary policy shock with a $\lambda = 0.01$



5.1.2 Mechanism of Transmission

The mechanism behind these results aligns with Bilbiie (2008) and is due to the inverted aggregate demand logic. Bilbiie (2008) mentions that when the proportion of non-asset holders surpasses a threshold, a real interest rate rise increases aggregate demand. Then, monetary policy is expansionary even with a contractionary increase in both the nominal and real interest rates.

Typically, an increase in the real interest rate modifies asset holders' intertemporal consumption and labor supply, allowing them to smooth their consumption. In SADL economies, an increase in the real interest rate yields a fall in output, consumption, and hours worked, as shown in Figure

5.2. For developing countries such as Mexico, where λ is higher, the effect of the real interest rate is overturned: the IS curve has a positive slope. Then, in equilibrium under this restriction of asset markets, consumption, output, and hours worked increase. Bilbiie (2008) mentions that for equilibrium to be consistent with the initial incentives, labor demand has to shift rightward more than labor supply to increase real wages. This mechanism is observed in Figure 5.1, where output increases more than 0.004 under consumption taxes, and labor supply increases less than that; under income taxes, output increases more than 0.0025, while labor supply again increases by a smaller amount. This results in an upward movement of the real wage and, hence, an increase in the demand by constrained households who do not have asset holdings and merely consume their wage income. Then, as Bilbiie (2008) concludes, non-asset holders and asset holders interact through the interdependent functioning of labor and asset markets. An increase in the real interest rate makes Ricardian households lend more and contract their consumption, moreover, they increase their supply of work. Hence, real wages go upwards, which in turn elevates the consumption of HtM households and diminish their hours worked. Since the latter affect dominates, the net result is an overall increase in aggregate consumption.

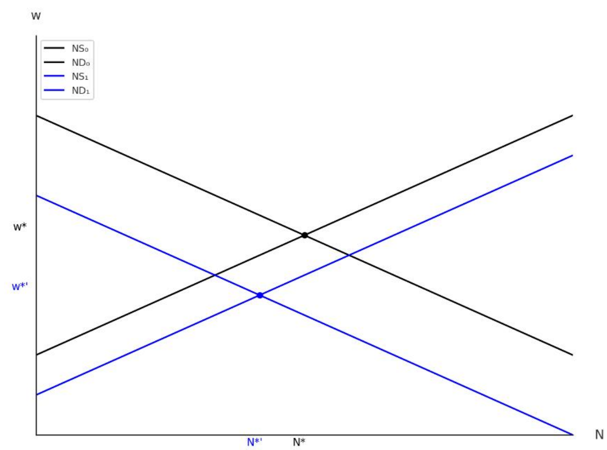
Furthermore, these results have important implications for local stability. In IADL economies, the *Taylor Principle* must be inverted in order to prevent indeterminacy: the central bank needs to adopt a passive policy rule –the nominal interest rate increase is by less than inflation- for policy to be consistent with a unique rational expectations equilibrium. In our model, it was also the case since we had to put $\mu_\pi = 0.5$, a much lower value than the commonly used $\mu_\pi = 1.5$, to achieve determinacy.

Under a consumption tax, the IADL effect is stronger because of the significant increase in consumption after the increase in the real interest rate. Under a consumption tax, the benefit of a higher real wage –that stimulates HtM consumption– and the significant proportion of non-asset holders weigh more than the contraction of Ricardian's consumption in the aggregate. Consequently, monetary policy shocks have a bigger effect on output under consumption taxes than income taxes in a balanced budget scenario when limited asset market participation is present in the model.

However, the question remains: why would labor demand increase? To answer this, it is important to refer to the explanation provided by Bilbiie (2008), which applies also in our case. As previously mentioned, for the IADL to occur, the shift in labor demand must outweigh the increase in labor supply to push real wages upward. To analyze this, let us first examine a full participation scenario. Following an increase in the real interest rate, asset holders –representing all households in this scenario– reduce their consumption to save more, as dictated by intertemporal substitution.

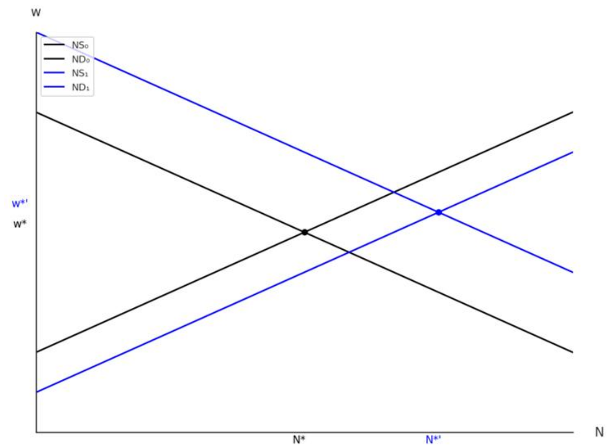
However, this creates a negative income effect on Ricardian households, leading them to offer more labor. The resulting increase in labor supply pushes real wages downward. Furthermore, labor demand decreases due to the decline in aggregate demand. This results in an equilibrium characterized by lower aggregate consumption, output, hours worked, and real wages. When heterogeneity is introduced but remains below a certain threshold $(\lambda < \lambda^*)$, the effect appears monotonic, as the proportion of Hand-to-Mouth households is insufficient to stimulate a significant increase in output. Figures 5.3 and 5.4 show this mechanism, where NS represents Labor Supply and ND refers to Labor Demand; the blue lines, in turn, indicate the respective scenarios after the shock.

Figure 5.3: Labor Market in a RANK model



Nonetheless, when heterogeneity is high $(\lambda > \lambda^*)$ and/or labor elasticity is small, the dynamics change. The complete mechanism operates as follows: an increase in the real interest rate prompts Ricardian households to reduce their consumption and increase their savings. This negative income effect increases their labor supply, as seen in a standard SADL framework. However, the only way for labor demand to increase and surpass the rise in labor supply –thus driving real wages higher– is if intermediate firms maintain positive profits.

Figure 5.4: Labor Market in a TANK model with a high level of heterogeneity



This occurs because the initial decrease in real wages incentivizes firms to produce more. Lower labor costs increase profits, enabling firms to expand their labor demand. The resulting increase in labor demand raises real wages beyond the initial decline. As real wages rise, HtM households increase their consumption, driving aggregate demand higher. To better understand this, it is helpful to recall the definition of real profits used by Bilbiie (2008):

$$\Gamma_t = -mc_t + \frac{\mu}{1+\mu} y_t$$

Positive profits after an increase in real wages are only possible if aggregate demand rises sufficiently. This happens because a larger proportion of the population bases its consumption on higher real wages. Therefore, there exists a specific combination of parameters where real wages increase –but not so much as to make profits negative– resulting in an equilibrium where both labor demand and aggregate demand rise.

These conclusions make it imperative to take account of household heterogeneity when setting monetary policy due to the change in the transmission mechanism under IADL economies compared to SADL economies. Bilbiie (2008) mentions that an optimal monetary policy under these conditions should not only focus on inflation levels but also consider the labor market when designing monetary policy given the limited financial market participation levels.

5.2 Government Spending Shocks

Figure 5.5 shows the impulse response functions after a positive government spending shock for all the relevant variables of the balanced budget version of the model under either income or consumption taxation.

For aggregate consumption, it is clear to notice that under both types of taxation, there is a contraction as taxes rise to finance the temporary increase in government spending. Nonetheless, the negative effects are slightly worse under income taxation. Disaggregating the consumption components, we can see that under income taxation, the consumption of the Ricardian households decreases less than the consumption of HtM households. The opposite happens under consumption taxation, where HtM households' consumption is less affected than Ricardian consumption. Initially, this may seem contradictory because the consumption tax increases by more than double the income tax. However, HtM households must consume all their after-tax income, while Ricardian households can decide to postpone their consumption by buying financial assets. Since consumption taxation enters in the consumption Euler equation of Ricardian households, with higher future taxes, Ricardian households postpone current consumption relatively more than under income taxation. Consequently, by saving more, the country increases its holdings of net foreign assets relatively more than under consumption taxation.

Inflation decreases under both taxation schemes. However, both CPI and domestic inflation fall less under consumption taxation. Although aggregate consumption falls in response to higher government spending, the net effect is an increase in aggregate demand and output under both tax systems. Consequently, firms labor demand rises and households increase the number of hours worked, which is slightly higher under consumption taxation. Since the interest rate is a weighted function of output and CPI inflation, the previously mentioned movements caused the nominal interest rate to fall less under consumption taxes than under income taxes. Under both taxes, the real interest rate also falls, but it decreases more under consumption taxation than income taxation.

Although real wages increase under both taxes, the increase in real wages is greater under consumption taxes than labor taxes. The labor market shows an increase in labor supply under both tax systems. Nonetheless, it is notable that the increase in hours worked in the economy is bigger under consumption taxation, where the increase is due to the increase in hours worked by both Ricardian and HtM households. The increase in marginal cost is higher under consumption taxation, which explains why CPI and domestic inflation both fall relatively less under consumption taxation.

Finally, there is an increase in net foreign assets holdings and the increase is higher under consumption taxes than under income taxes. Thus, Ricardian households consume less in the present and save more. The main reason behind this is that in our model output is higher but aggregate consumption is lower with higher government spending. Therefore, under both taxes the country's net exports increase resulting in an increase in net foreign asset holdings.

In summary, an increase in government spending leads to a decrease of the real interest rate that causes Ricardian households to hold more net foreign assets. Furthermore, while aggregate consumption falls, output is stimulated overall resulting in an increase in real wages and marginal costs. This pattern is the same under both taxation schemes. However, the magnitude varies between taxes.

5.2.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 1.5$ which differs from the value of $\mu_\pi = 0.5$ used in our TANK model under a balanced budget policy.

The results of a positive government spending shock under a representative agent calibration are shown in Figure 5.6. By inspection, we can notice a decrease in aggregate consumption under both taxation schemes. Hours worked also increases under both taxation schemes, increasing the output to satisfy the increase in aggregate demand.

The difference between the taxation schemes relies on the net foreign assets holdings of the representative agent. Under consumption taxes, net foreign assets increase, suggesting that net exports increases –similar to the baseline $\lambda = 0.7$ model. However, under income taxes, net foreign assets fall and the country runs a trade deficit and must import relatively more to meet the increased consumption of the government. This seems to be the main difference compared to the $\lambda = 0.7$ model.

Figure 5.5: IRF of a government spending shock

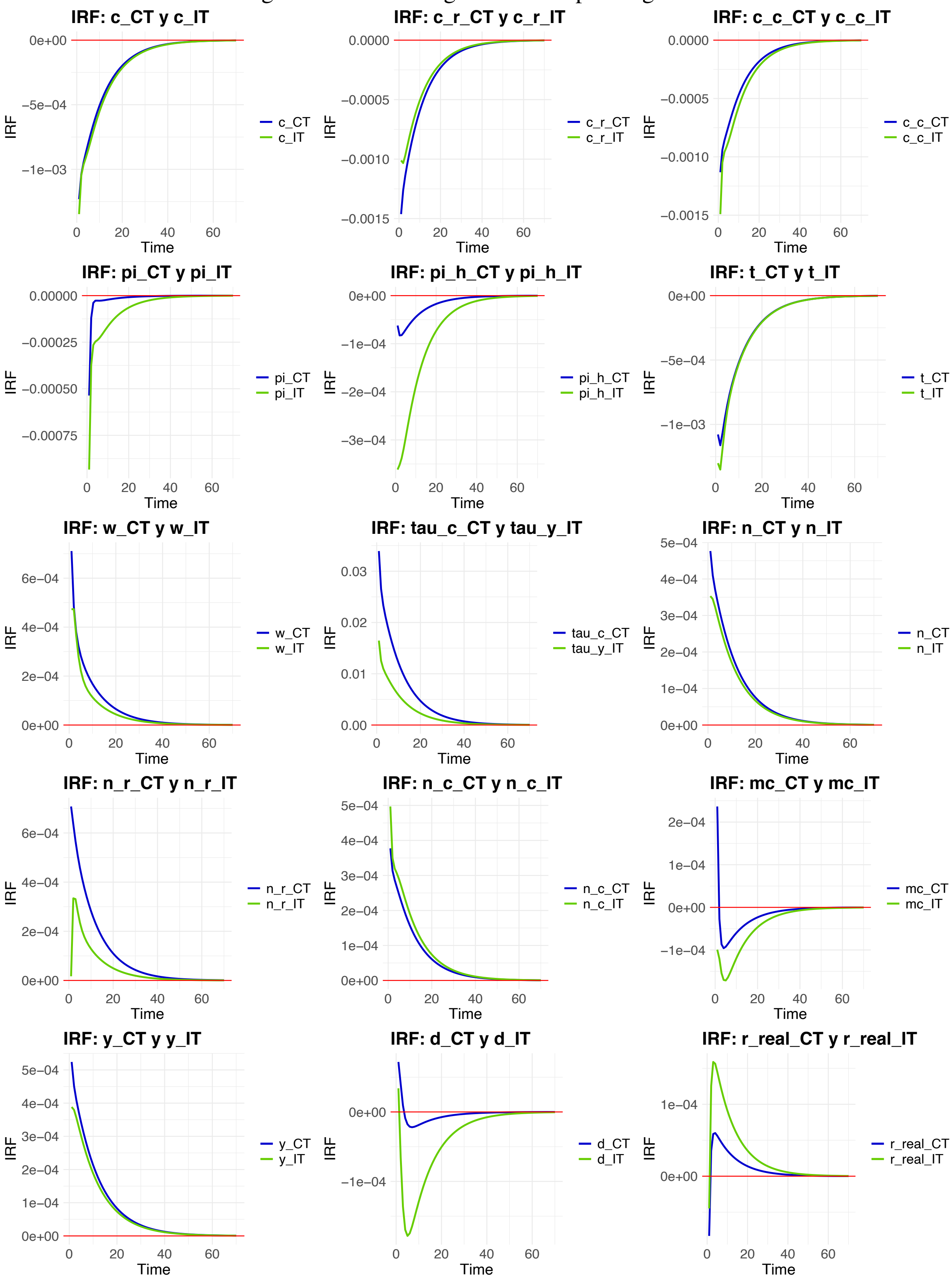
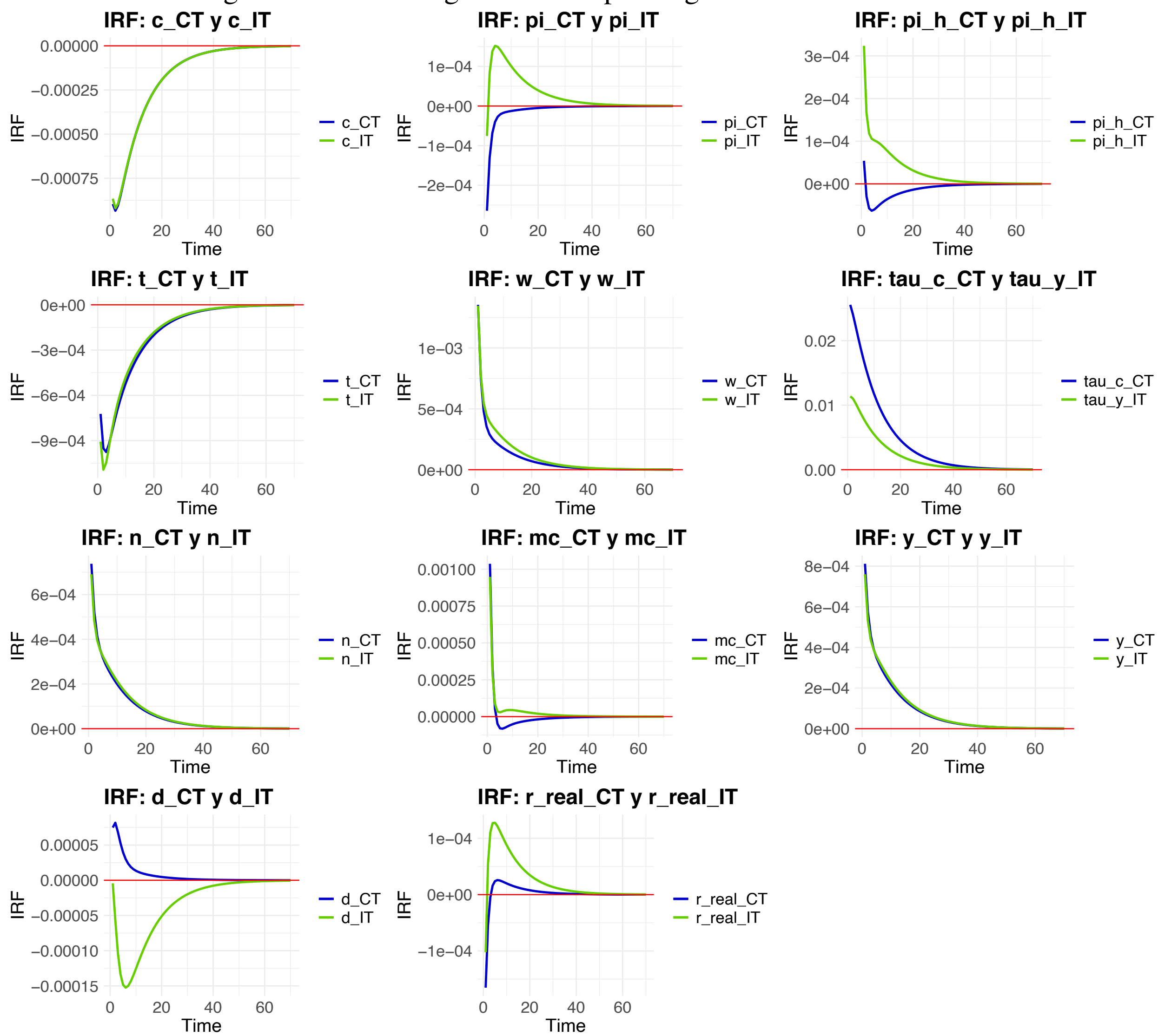


Figure 5.6: IRF of a government spending shock with a $\lambda = 0.01$



5.2.2 Mechanism of Transmission

In order to visualize the transmission mechanism of government spending shocks for aggregate consumption, it is necessary to inspect the log-linearized Euler equation to see the differences under each tax scheme.

Under consumption taxes:

$$\sigma\left(\frac{\hat{C}_{t+1}-\lambda C^{C}_{t+1}}{(1-\lambda)}-\hat{C}_t-\lambda C^{C}_t(1-\lambda)\right)=\left(\frac{\tau^c}{1+\tau^c}\right)(\tau^c_t-E_t\{\tau^c_{t+1}\})+\hat{R}_t-E_t\{\hat{\Pi}_{t+1}\}. \tag{LL-50a}$$

Under income taxes:

$$\sigma\left(\frac{\hat{C}_{t+1}-\lambda C^{C}_{t+1}}{(1-\lambda)}-\hat{C}_t-\lambda C^{C}_t(1-\lambda)\right)=\hat{R}_t-E_t\{\hat{\Pi}_{t+1}\}. \tag{LL-50b}$$

These equations are derived after substituting $(LL-20)$ into the Euler equation of the unconstrained households $(LL-50)$. Here, the consumption tax affects intertemporal consumption smoothing, while income taxation does not.

In IADL economies, a decrease in the real interest rate, should decrease consumption, and that effect is accompanied with the taxation effect as it enters also into the Euler equation in the case of consumption taxation.

Under a balanced budget policy, if government spending goes up, taxes must rise to balance the budget. Furthermore, the consumption tax increase is bigger, considering that the steady-state rate is lower. The increase in the consumption tax pushes consumption downwards because households prefer to consume when the tax on its consumption is lower. Therefore, in response to higher government spending, the fall in Ricardian consumption will be greater under consumption taxation and thus the rise in real wages will be greater. Consequently, the fall in constrained consumption will be relatively lower since real wages are relatively higher under consumption taxation.

The key point is that under both tax systems government spending increases aggregate demand and output, but the effect on output is greater under consumption taxation. Aggregate consumption falls less under consumption taxation since non-Ricardian consumption is relatively higher and outweighs the Ricardian consumption fall. Thus countries with a large LAMP should use consumption taxation to stimulate the economy as they get a bigger increase in output –while still balancing the budget.

5.2.3 Sunspot Shocks

In this section, we analyze how the dynamics of the economy are affected in response to a positive sunspot shock. To do this we introduce an expectational belief shock to inflation in the presence of indeterminacy. These sensitivity tests aim to analyze two things: (1) how sunspot shocks to inflation are transmitted in our model economy; and (2) how the transmission mechanism of government spending shocks are affected under indeterminacy.

To induce indeterminacy the parameter of μ_π is changed from 0.5 to 1.5. This allows us to investigate the implications of self-fulfilling expectations in our model. The idea is to define an expectational error (sunspot) as a new variable in the model ($s_t = \hat{\pi}_t - E_{t+1}\hat{\pi}_t$) to decrease the number of forward-looking variables by one and satisfy the Blanchard-Kahn conditions.

Figure 5.7 summarizes the results of an expectational belief shock to inflation. Under both taxation schemes, the behavior of the shock is the same, but the magnitude differs. In both tax systems, aggregate output contracts as does Ricardian consumption, while aggregate and HtM consumption increase. The shock is self-fulfilling so the CPI inflation rate increases similar to the expectational shock. Aggregated hours worked increases, as does the increase in Ricardians' labor supply, while the HtM's hours worked decreases. This results in an increase in output. Real wages and marginal costs increase, too. Nonetheless, the magnitude of these effects previously mentioned is higher under consumption taxation.

Hence, when there is an expectational belief shock to inflation, the impact on the economy is greater under consumption taxation. The key is that under a sunspot shock, constrained consumption increases but Ricardian consumption falls relatively more under consumption taxes. The increase in the domestic real interest rate decreases the demand for net foreign assets and the trade balance deteriorates in comparison with the version of the model that does not have self-fulfilling expectations on inflation.

Indeterminacy does not just allow us to consider sunspot shocks but it also changes the transmission mechanism of the other shocks. For example, Figure 5.8 shows how the transmission mechanism of government spending shocks change under indeterminacy.

Inflation increases under both taxation schemes, even though for income tax it barely reacts at the beginning; this increase is due to the self fulfilling inflation expectations. The real interest rate increases under both tax systems aligning with the movements on inflation. It also contrasts with the baseline model, where inflation and real interest rates decreased under both taxation schemes.

Aggregate consumption has mixed results depending on the taxation scheme analyzed; it increases under consumption taxes and decreases under income taxes. This contrasts with the baseline model, which had an aggregate consumption contraction under both tax systems. These differences are driven by the role played by self-fulfilling inflation expectations. In LAMP models, self-fulfilling inflation expectations cause the real interest rate to increase for both taxes as it makes CPI inflation higher –for income tax, it decreases at the beginning but it corrected immediately after–; this, contrasts with the decrease of real interest rate when the self-fulfilling inflation expectations are absent from the model.

As in the baseline model, aggregate hours increase under both taxation schemes. However, the hours worked by HtM households decrease under the consumption tax. This also contrasts with the baseline model, where the hours worked by both types of households under both tax systems increases. Nonetheless, output increases more in the sunspot model than compared to the baseline. The increase in real wages under a consumption tax is at least 10 times more in the sunspot model than in the baseline, being a possible channel to explain the increase in the HtM's consumption and the decrease in their hours worked. Marginal costs increases under a consumption tax, reducing the profits received by Ricardian households and reducing their consumption while increasing their hours worked.

Figure 5.7: IRF of an expectational belief shock to inflation

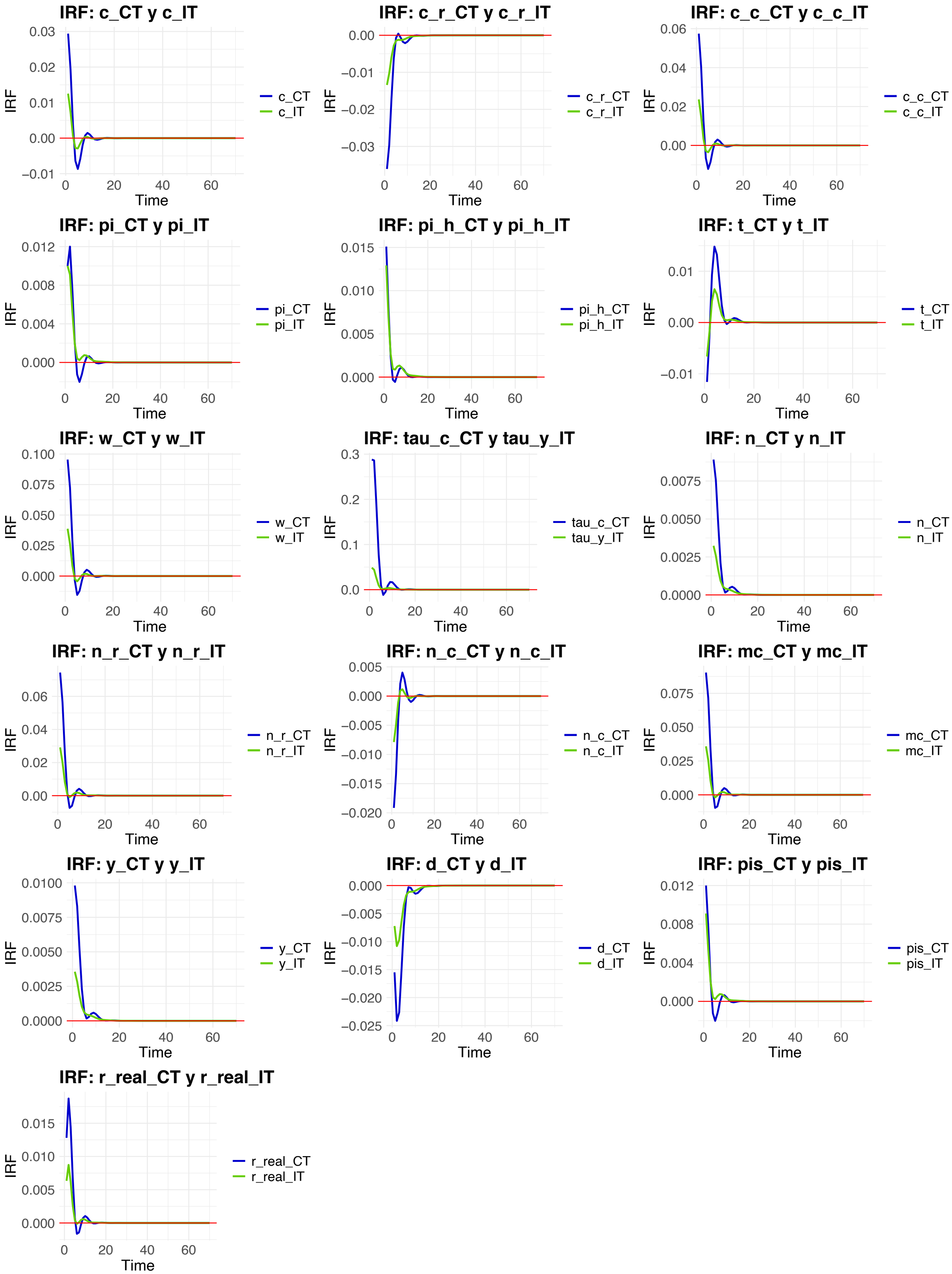
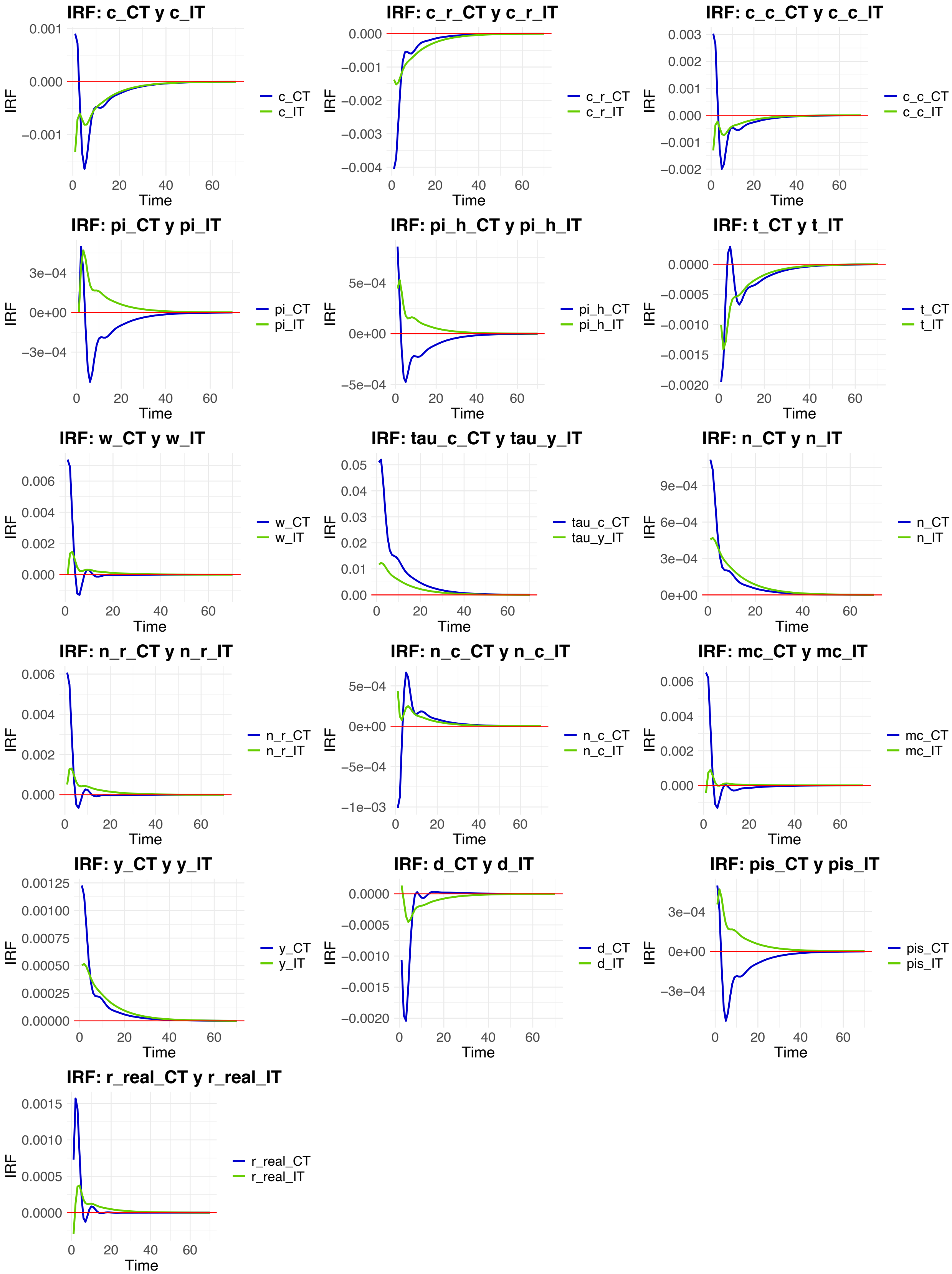


Figure 5.8: IRF of a government spending shock under the sunspot model-version



5.3 Productivity Shocks

Figure 5.9 shows the impulse response functions after the positive productivity shock for all the relevant variables of the balanced budget version of the model under either income or consumption taxation.

Aggregate consumption increases under both tax regimes. This increase is due to an increase in consumption of both Ricardian and constrained households under both scenarios. Both domestic and CPI inflation increase, followed by an increase in the real interest rate.

Regarding the labor market, hours worked fall in the aggregate. This decrease in the aggregate labor supply goes in line with the decrease in hours worked for both types of households. Notwithstanding, output increases, since labor is now more productive, which raises real wages. This increase in real wages is translated into higher marginal costs for the firms.

Finally, Ricardian households stop holding net foreign assets while the real interest rate increases under both taxation schemes. The taxation rate also decreases under both tax regimes due to the increase in income and consumption. Furtheremore, the trade balance improves as output increases more than consumption resulting in higher exports than imports.

Overall, both tax regimes generate the same results at the moment of the shock. There is an increase in aggregate consumption, inflation, output, real wages, trade balance, and marginal cost, accompanied by a decrease in hours worked, foreign asset holdings, and taxation rates. Productivity shocks have the same effect on both types of agent: by increasing the real wage, both agents respond by consuming more and working less.

5.3.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 1.5$ which differs from the value of $\mu_\pi = 0.5$ used in our TANK model under a balanced budget policy.

The results of a positive productivity shock under a representative agent calibration are shown in Figure 5.10. By inspection, we can notice that aggregate consumption increases. CPI and domestic inflation decreases under both tax regimes but fall slightly more under income taxes. Nonetheless, the real interest rate increases.

Hours worked decreases under both tax regimes. However, output increases as expected with a productivity shock. Under income taxes, real wages increased; however, under consumption taxes, they decreased. Notwithstanding, marginal costs decreased under both taxation schemes.

Under both taxation schemes, households prefer to hold more net foreign assets. Additionally, both taxation rates decrease since consumption and output increase. Moreover, the trade balance improves.

Comparing with the baseline calibration where $\lambda = 0.7$ we have that in both SADL and IADL economies, positive productivity shocks results in an increase in aggregate consumption, output, the real interest rate and a decrease in debt, the tax rate, labor supply and marginal costs. However, in the IADL economy, real wages and inflation increases, whereas in the SADL economy they decrease. Additionally, the magnitude of the increase of consumption and output is higher with $\lambda = 0.7$ under both tax systems than with $\lambda = 0.01$. Kaplan and Violante (2008) mention that for HANK models, the increase in consumption results from the increase in income and the large MPC, making more prominent the increase in consumption when there is heterogeneity than when $\lambda = 0.01$. Furthermore, the responses are larger under income taxes than consumption taxes for both model versions under a balanced budget policy.

Figure 5.9: IRF of a productivity shock

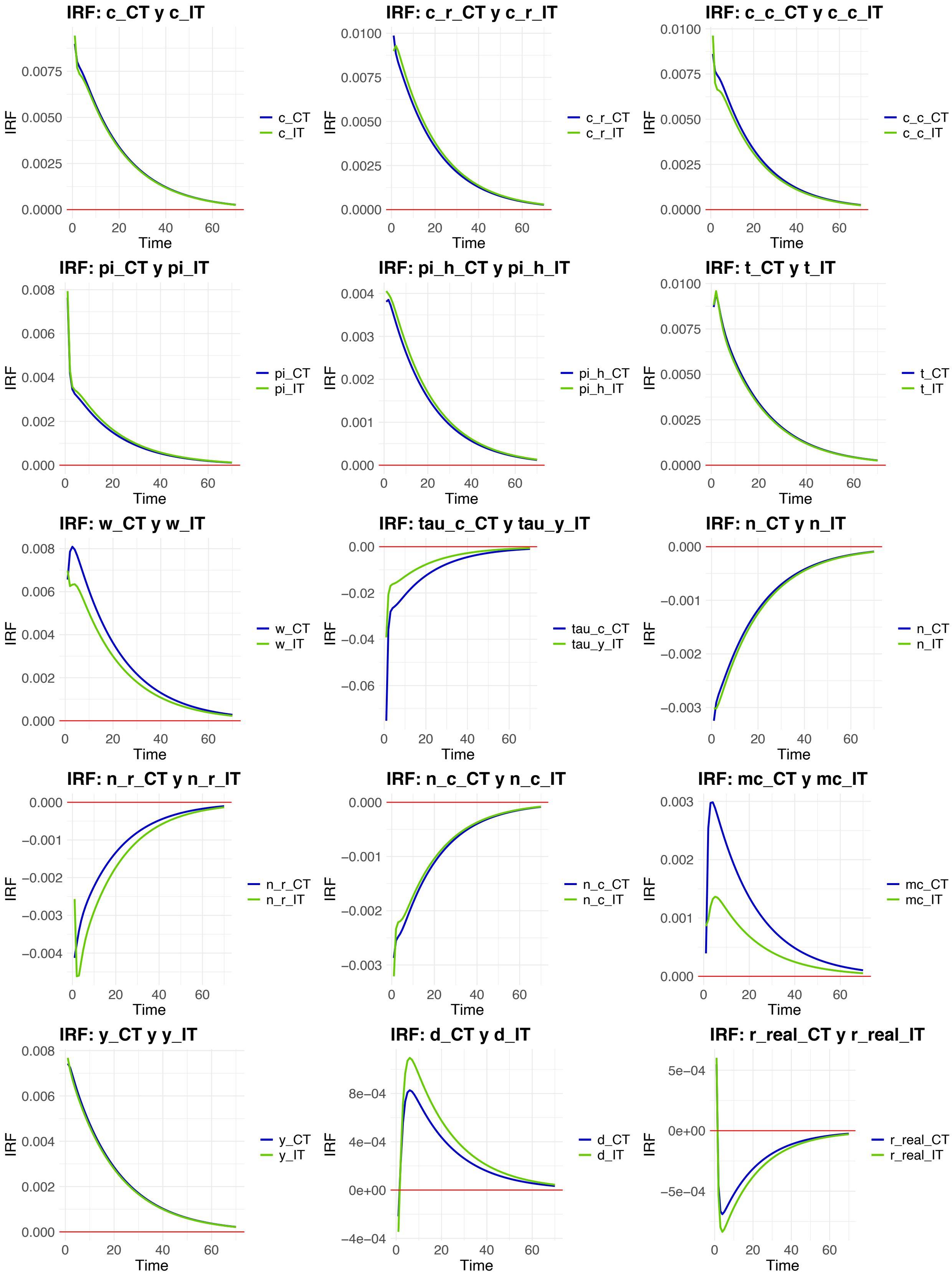
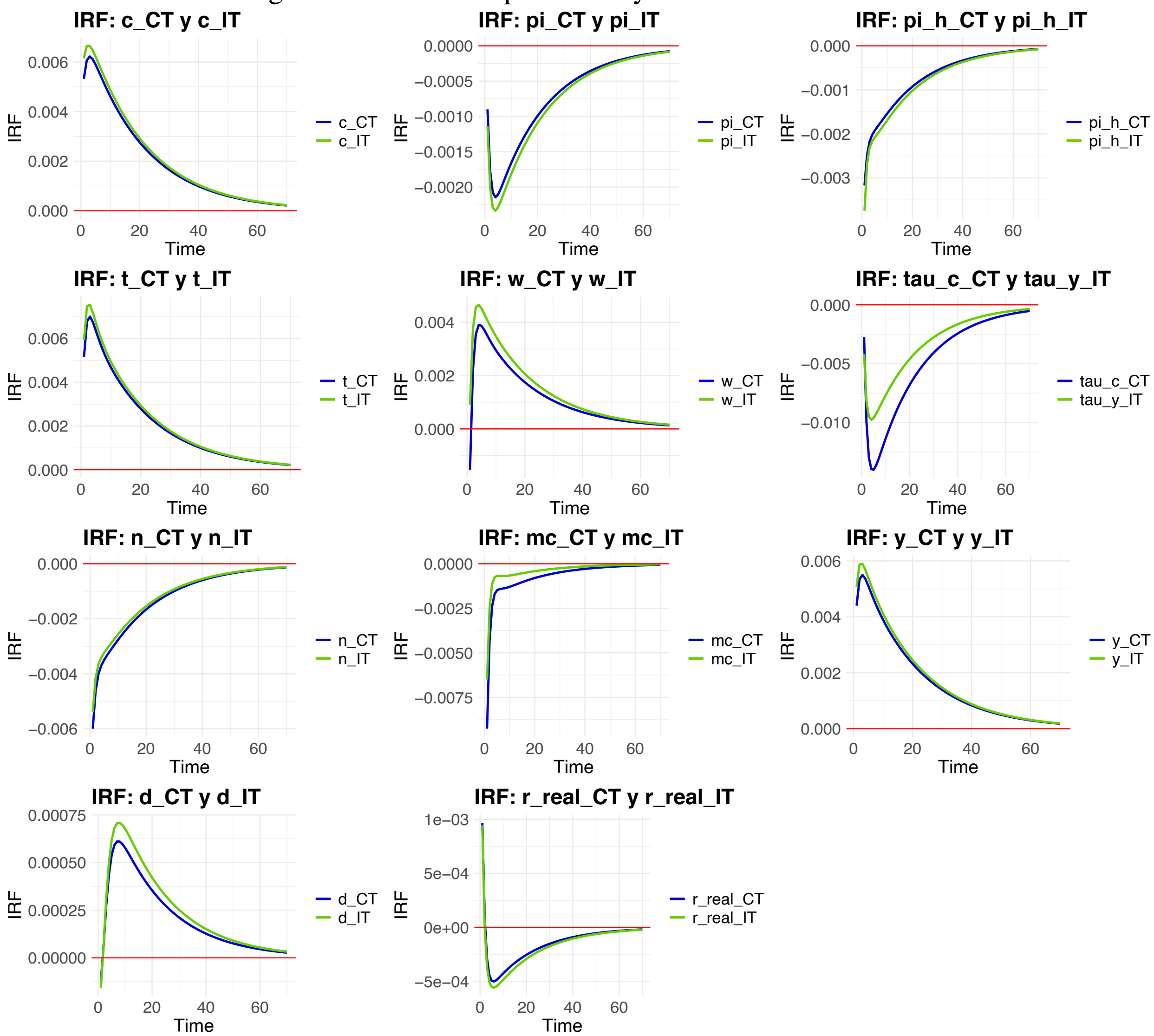


Figure 5.10: IRF of a productivity shock with a $\lambda = 0.01$



5.4 Risk Premium Shocks

Figure 5.11 shows the impulse response functions after a positive risk premium shock for all the relevant variables of the model for either income or consumption taxation.

Aggregate consumption is reduced under both taxes. The decrease in consumption of both types of households explains this result. CPI inflation increases under both tax systems, but domestic inflation decreases. These results for CPI inflation result in an increase in the real interest rate. Consequently, a higher risk premium increases the domestic interest rate.

The hours worked in the economy increases under both taxation schemes. It is mainly driven by the increase in hours worked by HtM households, which outweighs the decrease in labor supply of Ricardian households. Output increases under both taxation schemes. However, the real wages fall under both taxation schemes. This affects mainly HtM households who rely only on this for income, and it helps to explain the contraction in HtM consumption, which is greater than the consumption contraction of Ricardian households.

Ricardian households decrease their consumption and increase their savings. Furthermore, they buy more net foreign assets. Additionally, taxation rates decrease under both schemes, but it decreases slightly more under consumption taxation. Furthermore, the trade balance improves as output increases and aggregate consumption decreases resulting in an increase in net exports.

Overall, an increase in the risk premium led to an increase in inflation, in the real interest rate, net foreign assets holdings, and hours worked in the aggregate. This was accompanied by a contraction of aggregate consumption, real wages, taxation rates, and hours worked by Ricardian households. Moreover, under a balanced budget, there was no clear distinction between the two tax regimes.

5.4.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 1.5$ which differs from the value of $\mu_\pi = 0.5$ using in our TANK model under a balanced budget policy. The results barely change when we change the λ value. Particularly, the results of Figure 5.11 are almost identical to Figure 5.12.

Figure 5.11: IRF of a risk premium shock

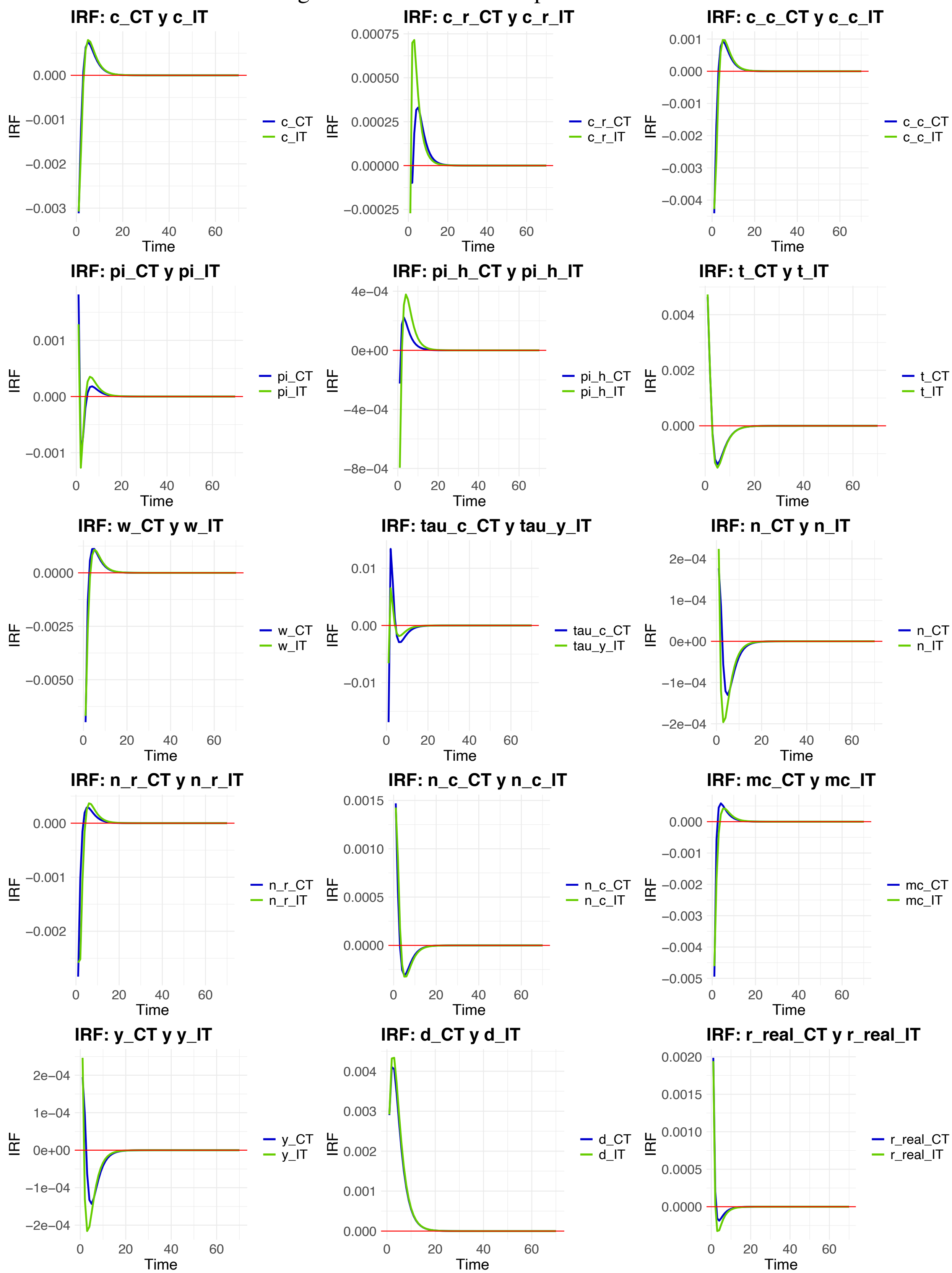
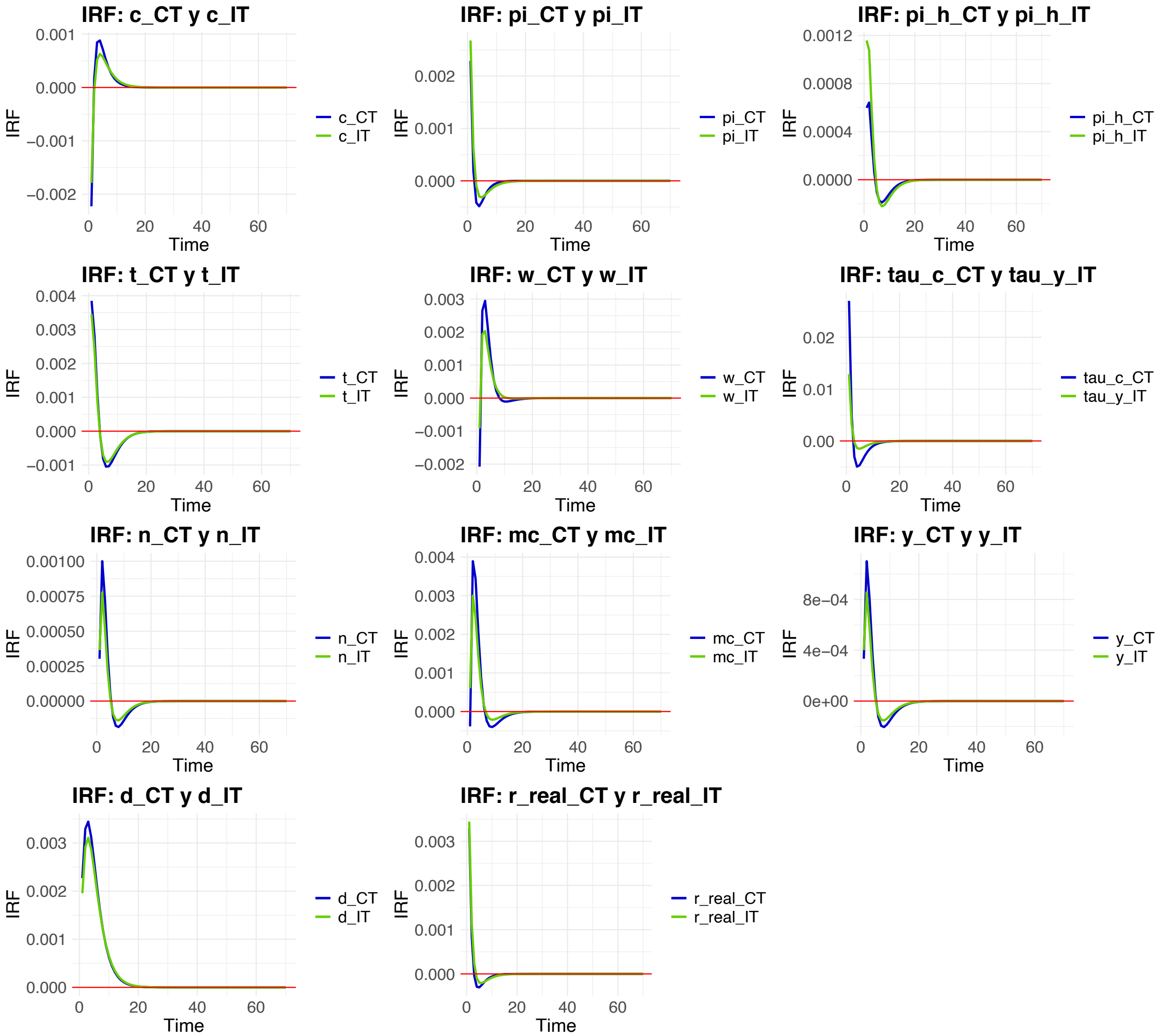


Figure 5.12: IRF of a risk premium shock with a $\lambda = 0.01$



Chapter 6

Results for the Debt Targeting Model

This chapter presents the results of the calibrated model for a debt targeting fiscal policy to compare how an increase of a positive 1% shock to government spending, monetary policy, productivity, and risk premium changes under both income and consumption taxation taking into account the heterogeneity of the households and comparing it when there is full participation, under our different shocks. Moreover, it is important to mention that the parameter values we set for the monetary policy rule (μ_π) are different in comparison with the balanced-budget model, this is because the determinacy conditions have changed. Mainly, μ_π is set equal to 1.5% as the *Taylor Principle* stipulates.

The most interesting results again relate to monetary policy shocks. After a 1% increase in the nominal interest rate, for the Mexican case where there is a high level of non-asset holder participants in the economy, there is still a reverse in the the slope of the intertemporal IS curve. Hence, the real interest rate contracts while consumption and output falls. Moreover, this result is obtained under both taxation schemes as it did under the balanced budget policy. The main contrast with the balanced budget model relies on the behavior of the real interest rate: under a balanced budget policy it increases whereas under a debt-targeting policy it decreases. But the Inverted Aggregate Demand Logic –IADL– still holds.

Additionally, government spending shocks also have important distinctions comparing both types of fiscal policy: under the balanced budget policy output increases while under debt-targeting policy output decreases. Another distinction is how the government spending shock is divided into two sources to finance it: tax rates and government debt. Here, we notice that under consumption taxes there is a higher contraction on government debt and tax rate cuts than under income taxes when there is not full participation in financial markets.

Regarding the productivity shocks there is no significant difference between both taxation schemes under debt-targeting, but there are changes when we compare different values of λ. Particularly, there is higher output in the heterogeneity model since there is a larger MPC. Relative to a balance budget policy, where inflation increases, in the case of a debt-targeting policy it decreases.

Finally, risk premium shocks do not present a significant difference between both taxation schemes under debt-targeting policy but there are important differences when we compare between the full participation and constrained financial market cases: government debt contracts when there are financial asset limitations but increases under full participation. Finally, when comparing between fiscal policies we find that under balanced budget policy output increases while under debt-targeting policy it decreases.

6.1 Monetary Policy Shocks

Figure 6.1 shows that after an increase in the nominal interest rate, aggregate consumption contracts, even in the presence of heterogeneity, under both types of taxation –this contrasts with the increase in aggregate consumption that happened under a balanced budget policy. Moreover, there are mixed results between households: Ricardian households increase their consumption while HtM decrease their consumption under both taxation schemes. The later effect dominates in the aggregate since there is a higher proportion of HtM households. This is due to the behavior of the real interest rate. Monetary policy was inverted under a balanced budget rule and thus the real interest rate increased in response to a higher nominal interest rate. Here the real interest rate falls under the standard *Taylor Principle*.

CPI and domestic inflation decrease under both taxation schemes. Moreover,the decrease in the real interest rate causes Ricardian households to increase their foreign asset holdings and the trade balance improves. All of these effects are almost the same under both types of taxes. Aggregate hours worked fall under both taxation schemes. This is mainly driven by the contraction in Ricardian hours worked, even though HtM hours worked increase. Since labor supply decreases, output also falls, and this results in a contraction of real wages and marginal costs. These effects are the same across the two tax regimes.

The shock of an increase in the nominal interest rate, even with a fall in the real interest rate, makes government debt contract. However, the magnitude of this contraction is more prominent under consumption taxation. Moreover, both tax rates go up. Overall, the government prefers to finance spending using taxes rather than from issuing more debt.

In general, an increase in the nominal interest rate under a debt-targeting policy, for both tax systems results in: a decrease in aggregate consumption, HtM consumption, inflation, real wages, aggregate hours worked, Ricardian's hours worked, marginal costs, output, government debt, and the real interest rate; an increase in foreign asset holdings, taxation rates, HtM hours worked and Ricardian consumption. Additionally, there is no critical difference between the taxation schemes. The only one we can highlight is that government debt contracts relatively more and tax rates increase relatively more under consumption taxation.

6.1.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model, the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 0.5$, which differs from the value of $\mu_\pi = 1.5$ used in our TANK model under a debt targeting fiscal policy.

Aggregate consumption increases under both taxation schemes. This is in part due to the contraction of taxation rates and in part due to the effect of a real interest rate reduction, which should lead to an increase of aggregate consumption since we are in a SADL economy. This happens under both taxation schemes, with almost the same quantitative effect.

Both CPI and domestic inflation also increase, consistent with the real interest rate contraction. Moreover, foreign asset holdings increase more under income than consumption taxes. There was also a contraction under both tax systems in terms of government debt and tax rates. However, the contraction in government debt is higher under consumption taxation.

Additionally, labor supply increases in the economy, which results in an increase in output. Moreover, real wages and marginal costs also increase.

Almost all the results are similar across the two tax regimes. However, two variables are different: net foreign assets holdings and government debt. Households increase their holdings of foreign assets –lending more— under consumption taxes, but decrease their foreign assets –borrowing more—under income taxes. Moreover, government debt is relatively higher under income taxation than consumption taxation. Consumption taxation affects the consumption-saving decision of households, whereas income taxation does not. This explains the difference in saving behavior under the two tax regimes.

Comparing the monetary policy shock in an SADL economy relative to the IADL economy also leads to different results. On the one hand, in the debt targeting model, after an increase in the nominal interest rate, in the IADL economy, the decrease in real wages results in a large contraction in aggregate consumption driven by lower HtM incomes. Also, Ricardian households increase their net foreign asset holdings under both taxation rates and reduce their labor supply. Finally, real interest rates fall, and taxation rates go up. On the other hand, in SADL economies, as shown in Figure 6.2, we had the opposite effect: tax rate cuts accompanied by a real interest rate increase under both taxation schemes. This led to different behavior in asset holdings between taxes, particularly under income taxes. Households borrow more and hold fewer foreign assets, allowing them to increase their consumption more.

Figure 6.1: IRF of a monetary policy shock

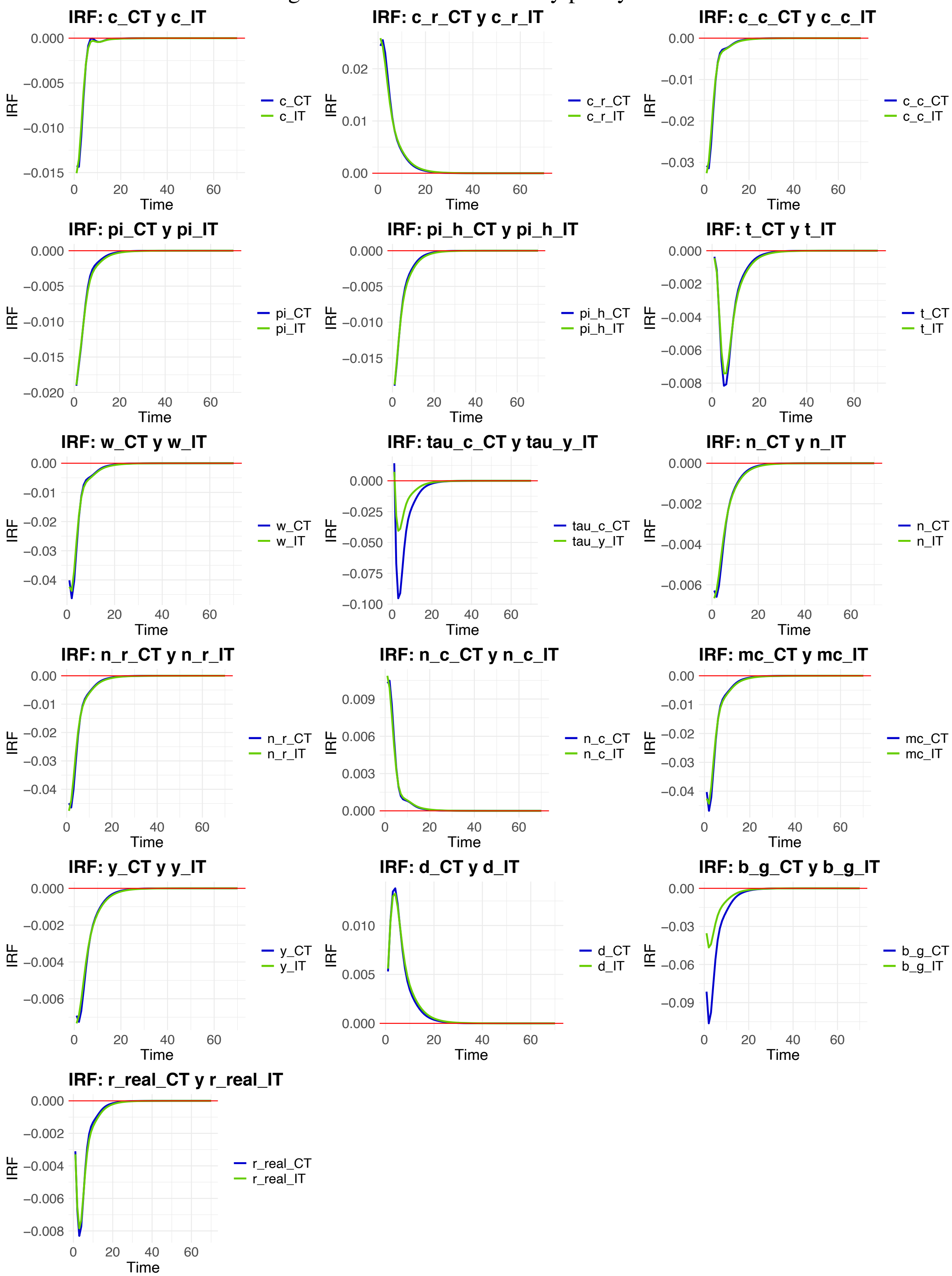
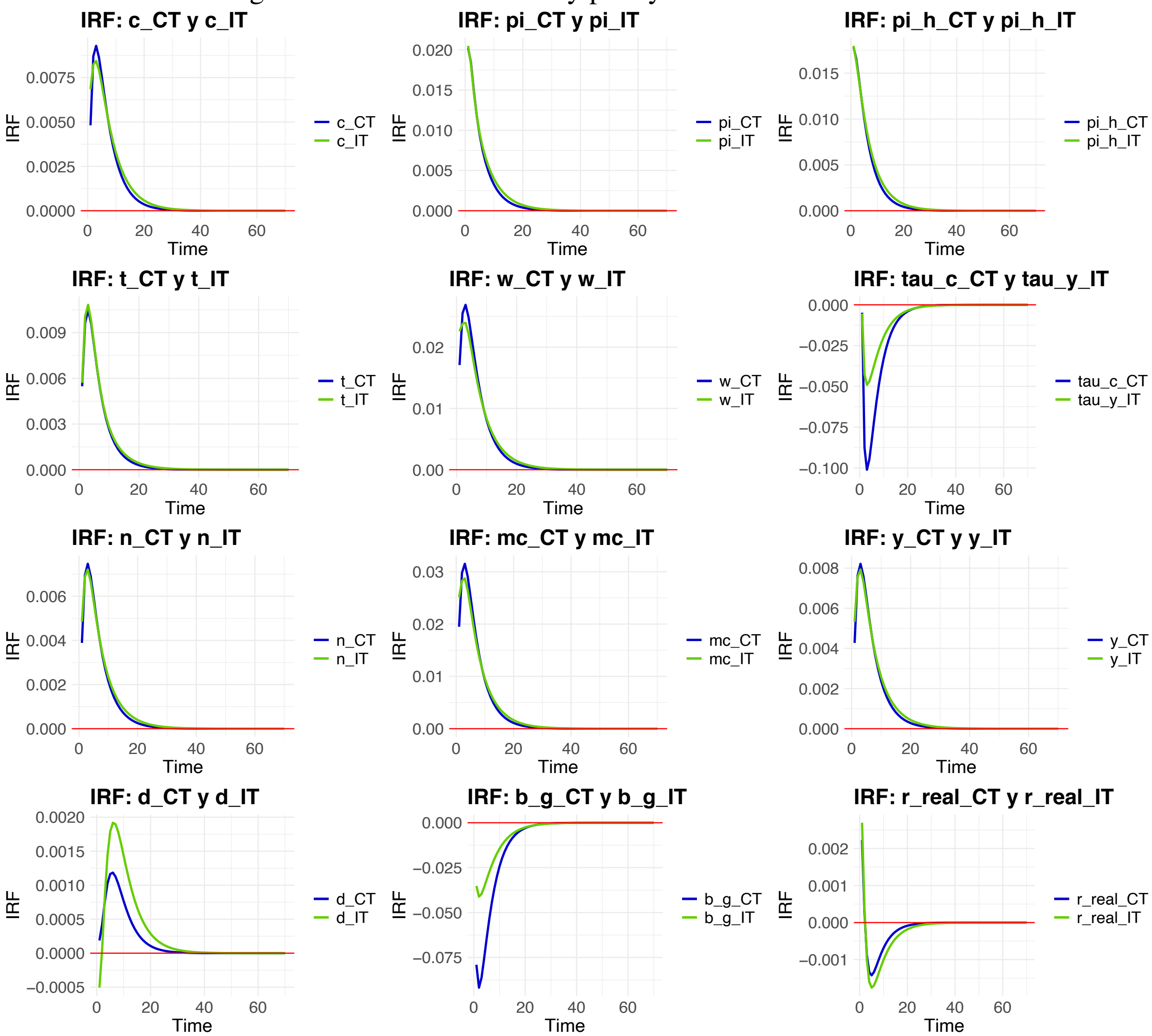


Figure 6.2: IRF of a monetary policy shock with a $\lambda = 0.01$



6.2 Government Spending Shocks

Figure 6.3 shows the implications of an increase in government spending, where aggregate consumption decreases under both tax systems. While Ricardian households increase their consumption, HtM households decrease their consumption under both taxation schemes. The contraction of HtM consumption results from the contraction of real wages. Additionally, CPI and domestic inflation decrease under both taxation schemes even though the real interest rate falls. Ricardian households increase their foreign asset holdings and save more. Moreover, the trade balance improves since the reduction in output is less than the reduction in aggregate consumption.

Regarding the labor market, we observe that hours worked decreases in the aggregate under both taxation schemes. However, Ricardian households decrease their hours worked while HtM households increase their labor supply under both taxation schemes. The contraction in aggregate labor supply explains why output falls under both tax regimes. Consequently, real wages and marginal costs go downwards.

In contrast with Chapter 4, the increase in government spending results in both higher taxes and larger government debt. This is the main difference between the two fiscal policies: under a debt-financing policy the the government can finance spending from two sources. Additionally, the increase in government debt and tax rate are more prominent under consumption taxes than income taxes.

In summary, a temporary increase in government spending under a debt-targeting fiscal policy leads to: an increase in Ricardian consumption, Ricardians' net foreign asset holdings, HtM hours worked, government debt, and taxation rates; a decrease in aggregate consumption, HtM consumption, real wages, hours worked, output, inflation and the real interest rate. There is no crucial difference compared to a balanced budget policy. The most important conclusion is that when a government spending shock is financed by two sources this helps to smooth the increase of taxation –at least 2 times smaller for both tax rates– in contrast with the balanced budget model.

6.2.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model, the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 0.5$, which differs from the value of $\mu_\pi = 1.5$ used in our TANK model under debt targeting fiscal policy.

Figure 6.4 shows that aggregate consumption increases under both taxation schemes when there is full participation. CPI and domestic inflation increases under both taxation schemes; however, the real interest rate decreases. Moreover, households increase their foreign asset holdings, and the trade balance improves.

Hours worked increased in the aggregate under both taxation schemes. The increased hours worked helps output to increase, too, under both taxation schemes. Additionally, real wages and marginal costs increase since the demand for labor is higher.

Furthermore, there is an increase in government debt that, in this case, compensates for the decrease in taxation rates; this behavior is observed under both tax regimes. However, the increase in government debt is higher under consumption taxation, and the tax rate is relative lower under income taxation. In SADL economies, the government finances higher spending with debt rather than higher taxes, considering that the tax base increases.

Hence, in SADL economies, a temporary increase in government spending under a debt-financed policy for both taxes results in: an increase in aggregate consumption, inflation, real wages, hours worked, hours worked, output, foreign asset holdings, and government debt; a decrease in the real interest rate and taxation rates.

In stark contrast to IADL economies, in SADL economies aggregate consumption, labor supply and output increase after a positive government spending shock. In IADL economies, real wages fall forcing HtM households to decrease their consumption, which results in a fall in aggregate consumption. This impacts tax revenue, forcing government to raise taxes. Moreover, the government prefers to rely more on debt when there is full participation compared to when there is limited asset market participation. In SADL economies, since all domestic households can purchase government debt, this helps to smooth consumption relative to sharp tax adjustments.

Figure 6.3: IRF of a government spending shock

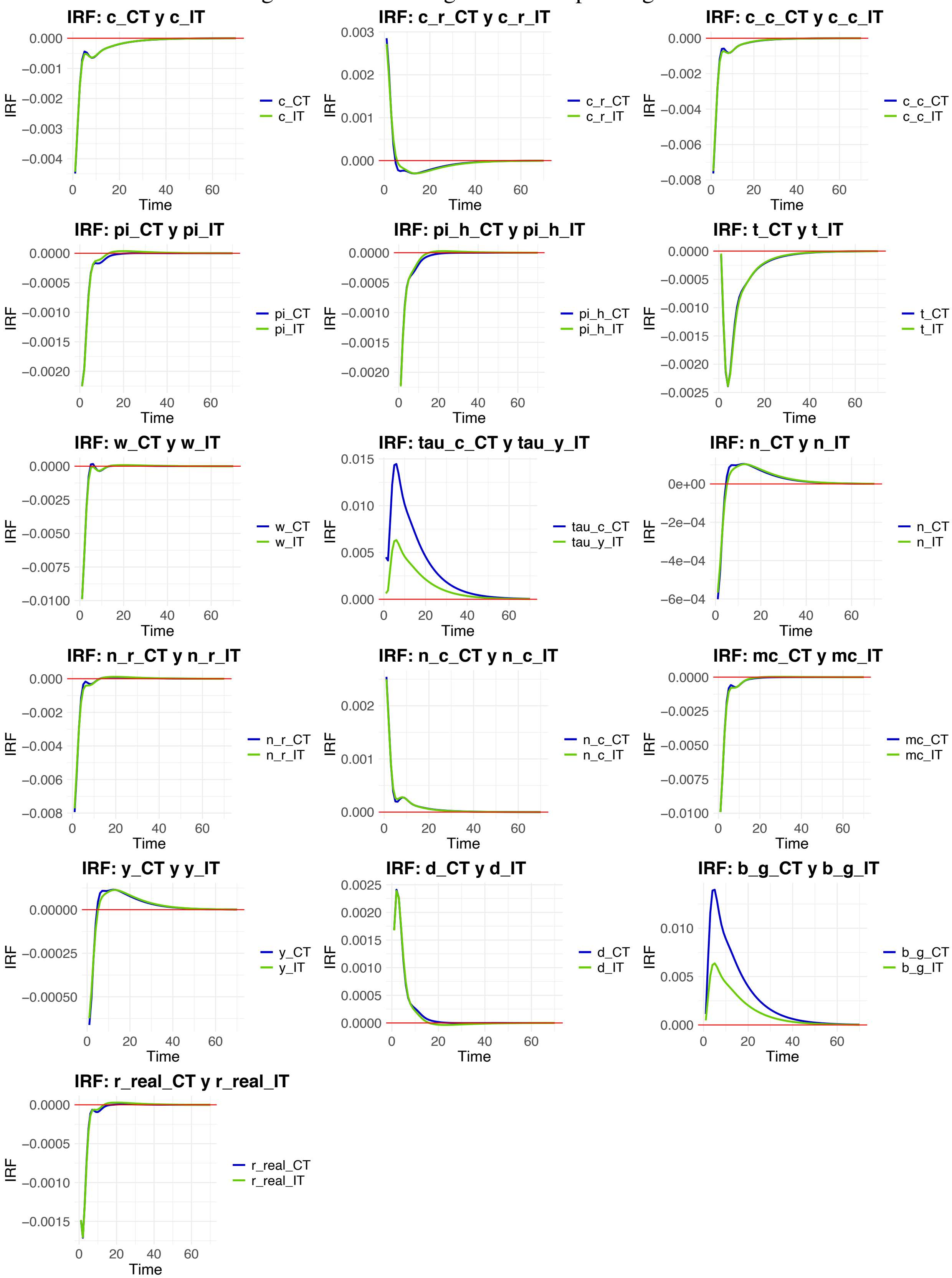
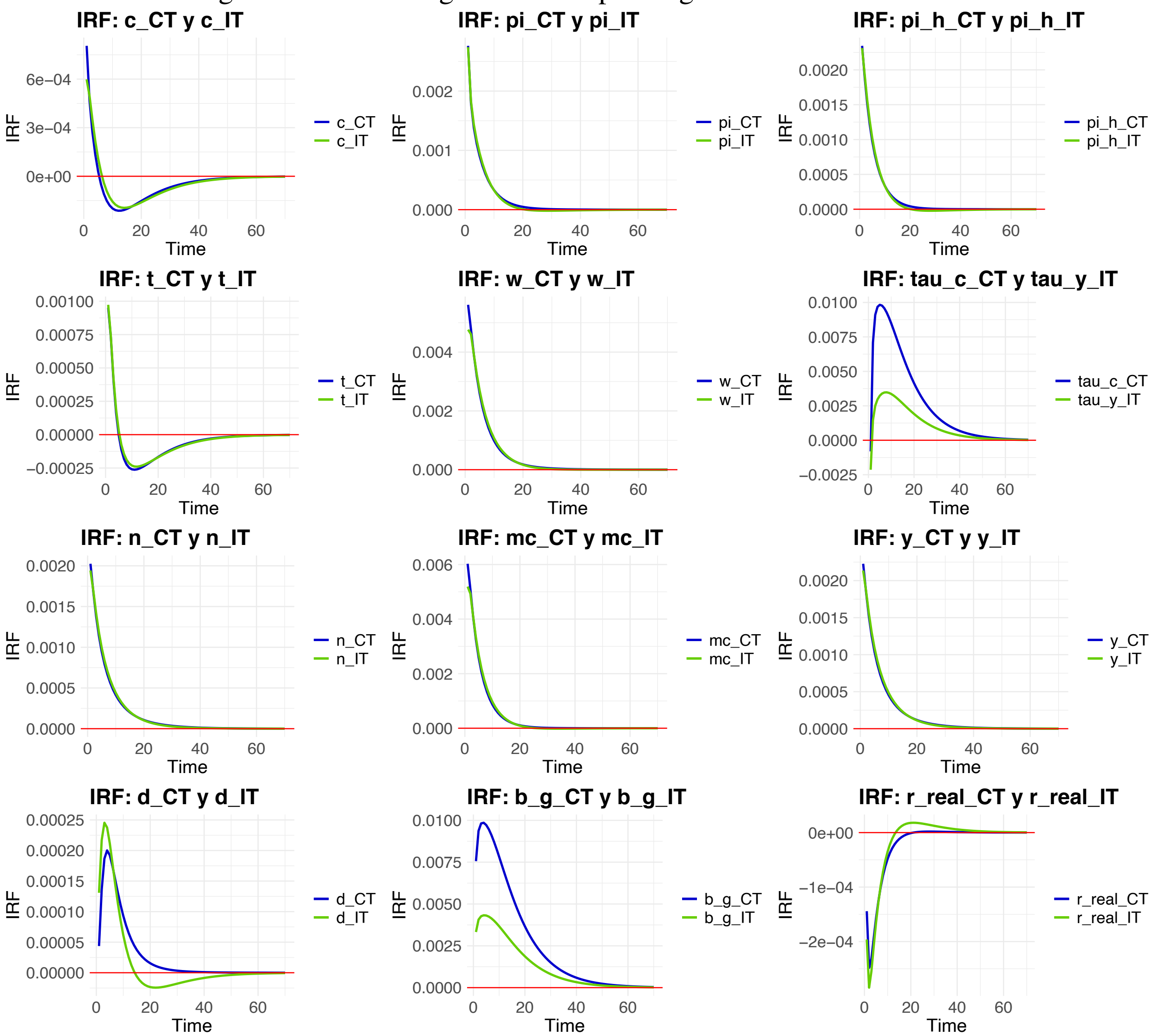


Figure 6.4: IRF of a government spending shock with a $\lambda = 0.01$



6.3 Productivity Shocks

Figure 6.5 shows that after a temporary increase in productivity, aggregate consumption increases under both taxation schemes. Moreover, the sharp increase observed is supported by the increase in the consumption of both types of households. Additionally, CPI and domestic inflation both decrease since the real interest rate rises. On the other hand, Ricardian households decrease their foreign asset holdings –they borrow more–, which helps to understand the increase in their consumption, which is higher than the consumption increase of HtM households.

Hours worked decreases in the aggregate and between household types under both types of taxes. Nonetheless, output increases, as expected and real wages are higher. Moreover, the trade balance deteriorates since the rise in aggregate consumption exceeds the increase in output. Finally, government debt and taxation rates decrease, which can be explained by an increase in the tax base.

Then, even in the presence of heterogeneity, the productivity shock yields the mainstream results: an increase in consumption and output while decreasing hours worked in the economy for both types of households under both taxation schemes under a debt targeting model. Finally, when comparing both types of policy we can notice that under a balanced budget policy inflation increases –since marginal cost rises– but under a debt-targeting policy it decreases.

6.3.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model, the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 0.5$, which differs from the value of $\mu_\pi = 1.5$ set in our TANK model under debt targeting fiscal policy.

Figure 6.6 shows that consumption increased in the aggregate after an increase in productivity when we assume full participation in financial markets. Households increase their borrowing by holding fewer foreign assets at the moment of the shock, even though the real interest rate is higher. Moreover, CPI and domestic inflation both increase even though the real interest rate has increased.

Hours worked is reduced and output increases since productivity increased. Also, the trade balance improves since the economy produces more and it was able to export more. Finally, government debt increases, and taxation rates went down; this contrasts with when there was no full participation in financial markets, where both government debt and tax rates decreased. The results of the model under full participation are almost the same under both taxation schemes except for government debt: the increase in government debt in the full participation model is higher under consumption tax.

The main difference between the standard representative agent model and the LAMP model is that real wages decrease, inflation increases, and government debt increases. Moreover, output increases more in the LAMP economy than under the full participation model.

Figure 6.5: IRF of a productivity shock

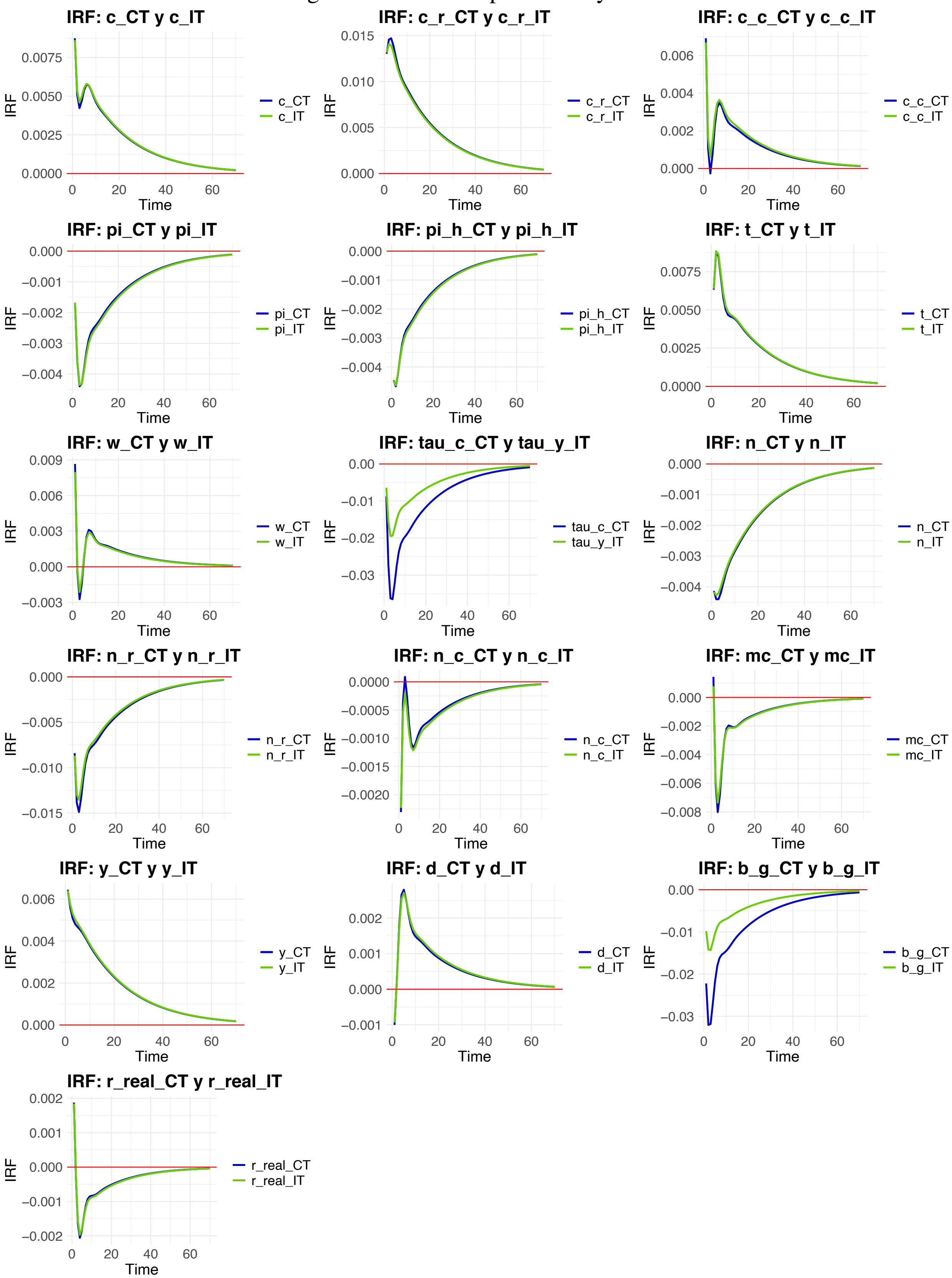
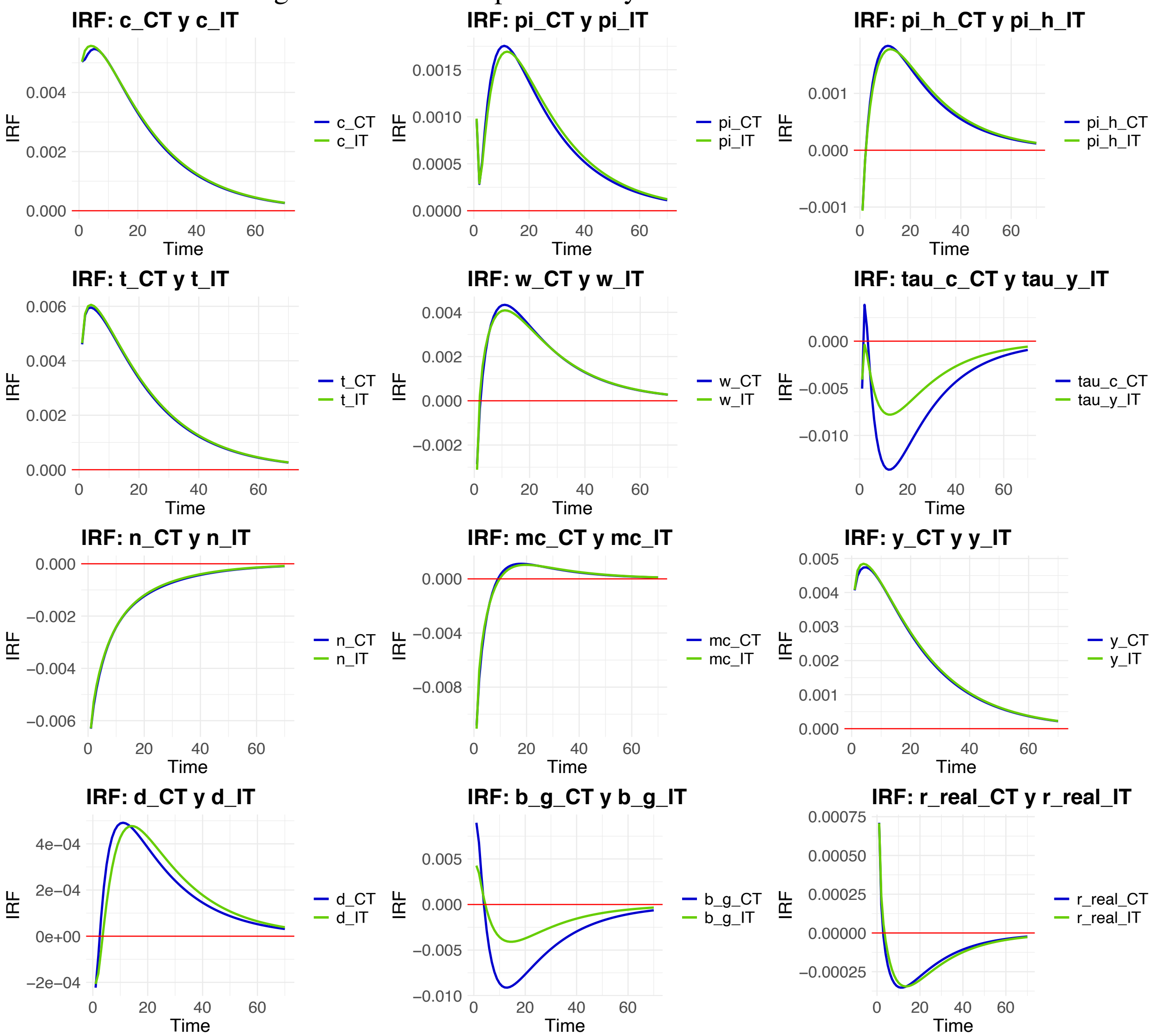


Figure 6.6: IRF of a productivity shock with a $\lambda = 0.01$



6.4 Risk Premium Shocks

Figure 6.7 shows how an increase in the risk premium, leads to an aggregate decrease in consumption, which is explained by the contraction of HtM consumption. Moreover, both CPI and home inflation decrease, which aligns with the real interest rate going upwards. Furthermore, Ricardian households increase their foreign asset holdings.

Hours worked decreases in the economy for both taxation rates. Moreover, the contraction of Ricardian hours worked outweighs the increase in HtM households. Since hours worked decreases, so does output. Hence, real wages and marginal costs fall. The decrease in real wages helps to understand why HtM households tried to increase their hours worked since they rely on it to finance their consumption. However, since consumption drops relatively more than output, the trade balance improves. We can observe that government debt contracts under both taxation schemes. However, it falls more under a consumption tax.

Hence, under a debt-targeting policy, an increase in the risk premium under a limited asset market yields a decrease in aggregate consumption, output, aggregate hours worked, real wages, taxes, and government debt but increases foreign asset holdings and real interest rates. Particularly, the more affected households are HtM households, which cannot benefit from increasing interest rates to hold more foreign assets and instead rely only on the lower real wages while trying to work more to compensate. Moreover, there is no apparent difference between taxes, except for the magnitude of the contraction in government debt, which is higher under consumption taxes. Finally, when comparing between fiscal policies we have that output increases under a balanced budget policy, but falls under a debt-targeting policy.

6.4.1 Comparing with $\lambda = 0.01$

In order to compare the results with the standard representative agent model, we set a value of $\lambda = 0.01$. In order to achieve determinacy in the representative agent model, the *Taylor Principle* must be satisfied. Therefore, we set $\mu_\pi = 0.5$, which differs from the value of $\mu_\pi = 1.5$ set in our TANK model under a debt targeting fiscal policy.

Figure 6.8 shows that after an increase in the risk premium, full participation in financial markets yields a decrease in aggregate consumption. In this case, consumption falls compared to the increase presented in the LAMP model. CPI and domestic inflation decrease, which is in line with the increase in the real interest rate. Moreover, households increase their foreign asset holdings and then lend more, which can help explain why their consumption contracted. With respect to hours worked, they increase at the moment of the shock, but immediately overturned. The same pattern is shown for output. Moreover, real wages and marginal costs decrease. Finally, government debt increases under both taxation schemes, but it rises more under consumption taxes

Hence, an increase in the risk premium in a full-participation model yields a decrease in aggregate consumption and an instantaneous increase in hours worked, output, and trade balance that is immediately overturned. Moreover, government increases, in contrast to the LAMP model.

Figure 6.7: IRF of a risk premium shock

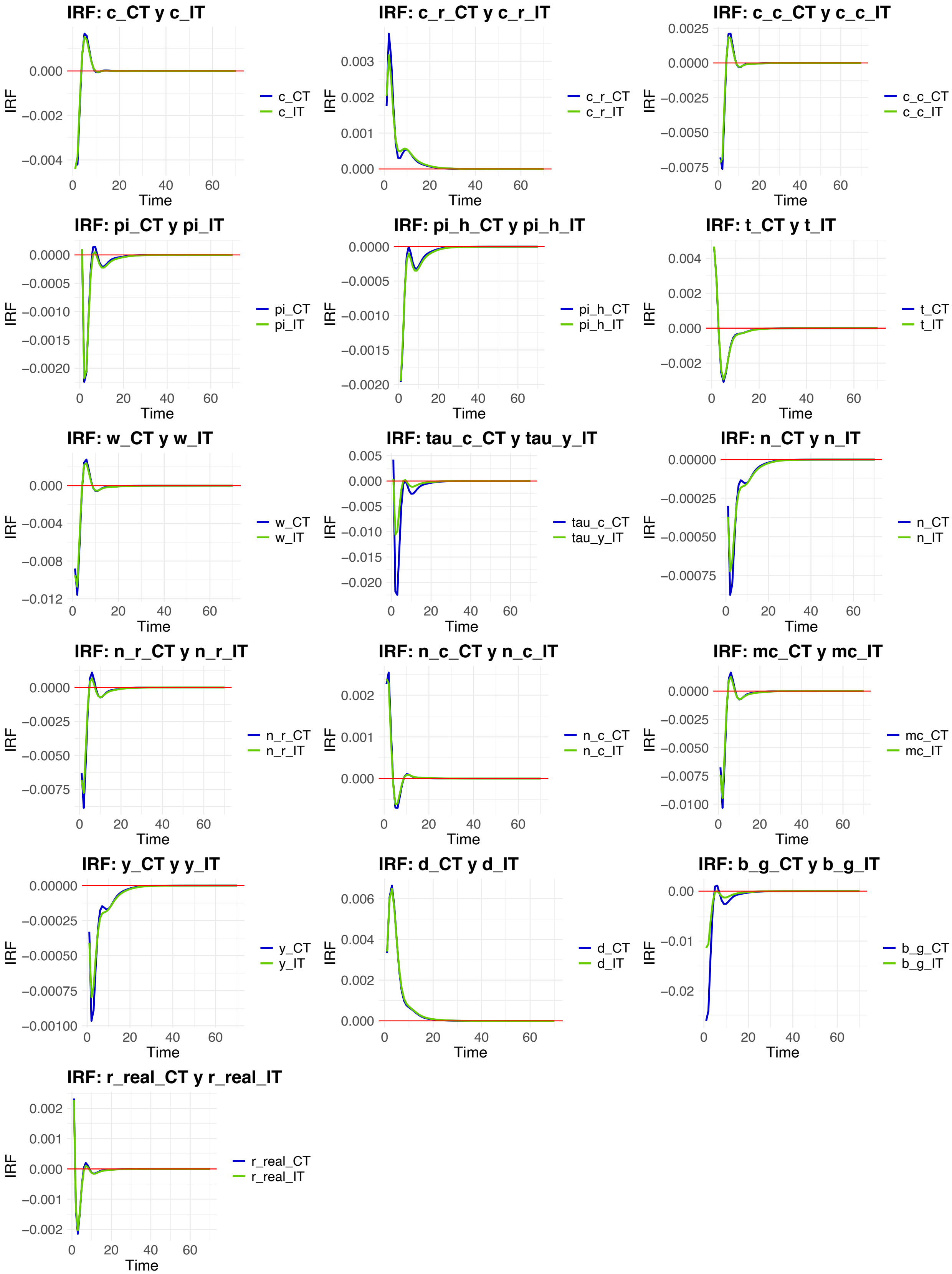
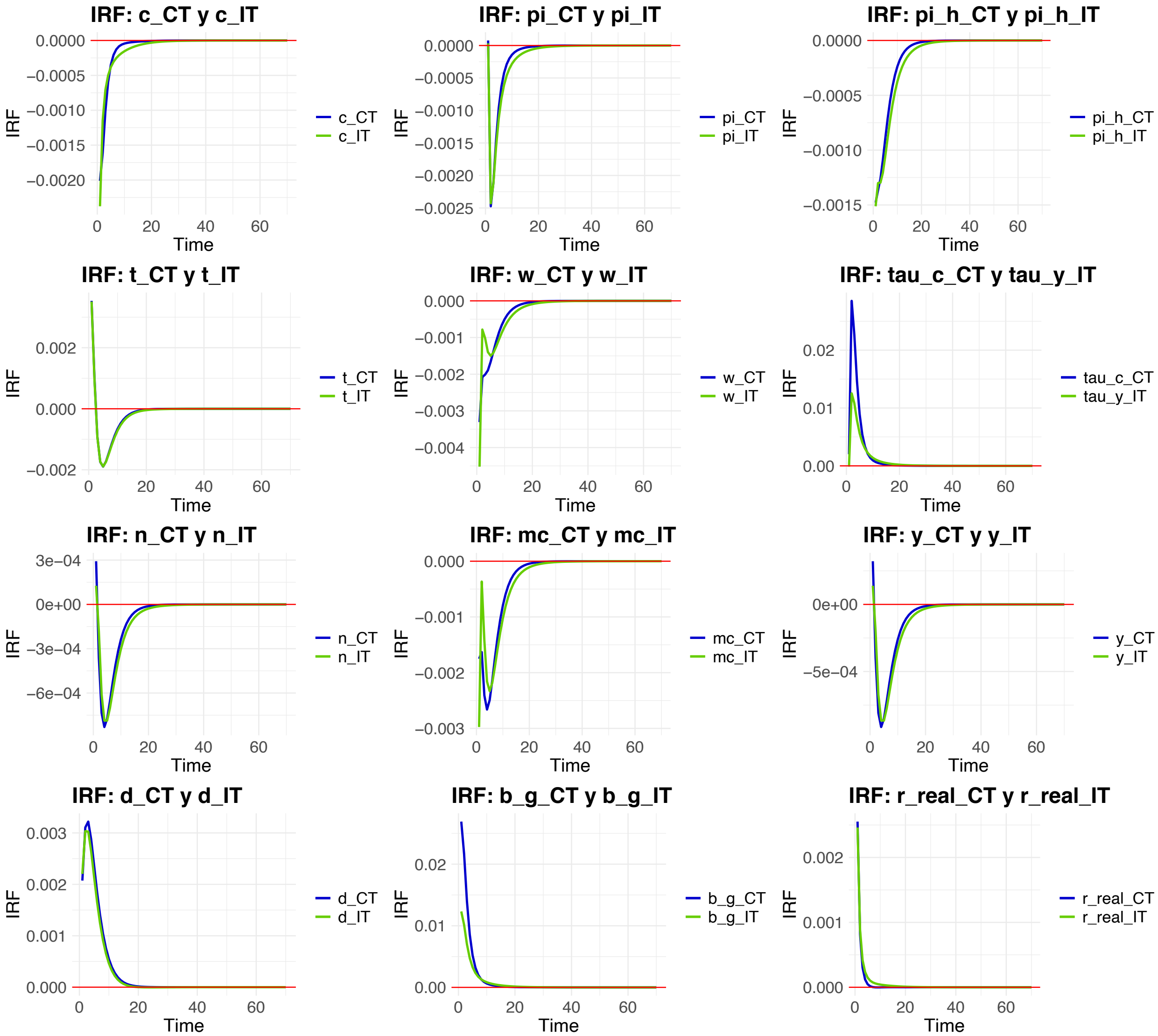


Figure 6.8: IRF of a risk premium shock with a $\lambda = 0.01$



Conclusion

This thesis has studied the role of household heterogeneity for the case of Mexico. Using an open-economy TANK model, it has considered how different fiscal policies, financed using either consumption taxation or income taxation, affect the transmission mechanism of popular demand and supply shocks.

We found that for monetary policy shocks, the the slope of the IS curve can become inverted. This result is prone to occur when there is a high level of inequality in terms of access to financial markets, as is the case for Mexico. Moreover, inequality has implications for equilibrium determinacy, as we found that under a balanced budget policy, the *Taylor Principle* fails to achieve determinacy, while under a debt-targeting policy it is achieved. This finding offers a new perspective compared to the representative agent New Keynesian framework, where an increase in the real interest rate typically controls inflation by contracting aggregate demand due to the negative slope of the IS curve. Hence, as Bilbiie (2008) concludes, central bank policy should also take into account the degree of heterogeneity in access to financial markets, particularly in developing countries like Mexico.

Furthermore, we found that after a government spending shock, the economy's response is amplified under a consumption taxation rather than under income taxation, as the former enters directly into the Euler equation of unconstrained households. We also observed differing responses based on the fiscal policy: under a balanced budget policy, output rises, while under a debt-targeting policy, output declines. Additionally, productivity shocks with higher heterogeneity led to larger increases in output due to a larger marginal propensity to consume. Regarding risk premium shocks, when comparing fiscal policies, we find that under a balanced budget policy, output increases, while under a debt-targeting policy, it decreases.

In summary, this thesis highlights the importance of accounting for heterogeneity among economic agents when designing macroeconomic policies. Understanding how different types of households respond to the same shock based on their position in the income and wealth distribution is crucial, as their reactions can diverge from traditional results. For Mexico, a developing country with one of the highest levels of inequality globally, incorporating heterogeneity is not only essential to capture the economy's true response to macroeconomic shocks but also a natural step to consider in the analysis.

By including heterogeneity, it becomes clear that adjustment mechanisms can differ significantly from those predicted by representative agent models –just as the inverted slope of the IS curve we found, which also reversed the *Taylor Principle* in the balanced budget scenario. Hence, it is important for policymakers to adopt frameworks that acknowledge household heterogeneity so they can obtain more realistic insights and evaluate the distributional effects of their decisions, which will ultimately lead to the design of more inclusive policies too.

We believe that this model could be expanded in several ways to address aspects we did not cover, as we simplified it and left out some features that also influence how monetary policy behaves when accounting for heterogeneity. One natural extension would be developing a HANK model to explore how Mexico's economic heterogeneity affects the transmission of monetary policy, particularly when considering different types of taxation under balanced or unbalanced budgets. It would also be interesting to study the effects of supply shocks, such as those caused by the COVID-19 pandemic and the war in Ukraine, to understand how different types of households responded to these events. Finally, future research could expand the approach of this model by including different types of asset liquidity, which would make it easier to analyze unconventional monetary policies and work toward identifying the optimal monetary policy for a HANK model, as outlined by Kaplan, Moll, and Violante (2018), but tailored to the Mexican context.

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