London School of Economics and Political Science

Essays on Heterogeneity in Macroeconomics

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I declare that my thesis consists of 23,000 words.

Statement of co-authored work

I confirm that Chapter 3 was co-authored jointly with Cristiano Cantore and I contributed 50% of this work.

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Abstract

This PhD thesis delves into the role of household heterogeneity in macroeconomics and its interplay with fiscal and monetary policies. The research is segmented into three papers.

The first dissects the earning and spending habits of workers in tradable and non-tradable sectors. Findings indicate that non-tradable sector workers face more earning volatility and have a higher propensity to consume out of unexpected shocks. This behaviour affects economic cycles, particularly in response to sectoral shocks, and the potency of monetary policy.

The second paper zooms in on fiscal automatic stabilizers, such as progressive taxes and unemployment benefits, designed to mitigate economic fluctuations. The effectiveness of these stabilizers in reducing the variance of the macroeconomics aggregates varies significantly based on monetary environment, such as domestic inflation targeting versus being in a currency union. While they can stabilize consumption, they inadvertently increase output volatility due to the distortionary effects of taxes.

Lastly, the third paper explores how fiscal and monetary policies combined influence household savings. It reveals a balance between policies promoting saving as a safety net and those affecting investment opportunities. Notably, even if policies boost investment, these don't always lead to more job opportunities, leaving many dependent on wages.

In summary, the thesis offers a view of the intricate relationship between fiscal and monetary policies, emphasizing their profound impacts on individuals and the economy when financial markets are incomplete and therefore prevent them from fully insuring against idiosyncratic shocks. Through rigorous models and analyses, it provides valuable insights into crafting more effective and balanced economic strategies for the future.

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Chapter 1

Earnings, consumption and the business cycle: the role of tradable vs. non-tradable

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Abstract

This study explores the heterogeneity in earnings and consumption patterns among workers in the tradable and non-tradable sectors by making three key contributions. First, by estimating a life-cycle model of worker earnings, it shows that employees in the non-tradable sector face labour income shocks that are twice as volatile as those experienced by their counterparts in the tradable sector. Second, it estimates the marginal propensity to consume (MPC) of workers using unemployment as an unexpected earnings shock, and reveals that employees in the non-tradable sectors display an MPC that exceeds their tradable counterparts by 30%. This discrepancy doubles when focusing solely on workers in a more refined non-tradable categorisation, specifically those in retail and restaurant sectors. Finally, a multi-sector, open-economy, general-equilibrium model is constructed, incorporating heterogeneous agents subjected to unique income shocks and a fragmented financial market. The findings suggest that recognising disparities in average MPCs across sectors significantly affects how the economy responds to sector and policy shocks, especially when juxtaposed with a hypothetical economy where the average MPCs remain homogeneous.

Keywords: Heterogeneity, Tradable vs. non-tradable sectors, Earning shocks, Consumption, Multi-sector general-equilibrium model
J.E.L. codes: E21, E24, E32, F41, J31.

1.1 Introduction

In the context of globalisation, the distinction between tradable and nontradable sectors is central to economic analysis, but recent protectionist sentiments worldwide have prompted a need to understand how globalisation affects different sectors and their workers. Previous research, such as the seminal works of Bernard et al. (1995); Bernard and Jensen (1999) and subsequent studies such as Bernard et al. (2007b,a, 2009); Melitz and Redding (2014) have shown that firms engaged in international trade tend to perform better, but there is a gap in understanding the impact on workers. This paper aims to address this gap by exploring differences between workers in tradable and non-tradable sectors and their implications for responses to shocks and policy.

The analysis presented in this chapter explores whether the sectoral heterogeneity observed at the firm level extends to workers. In the existing literature, empirical analysis at the firm level has been heavily based on firm-level data with limited access. The study uses a publicly available dataset, the Panel Study of Income Dynamics (PSID), which contains a wide array of demographic characteristics for single individuals, as well as information related to their labour income and consumption expenditures. While it does not allow one to categorise individual workers according to whether they work for a trading firm or not, a sectoral approach is taken to consider whether they work in a tradable sector. The categorisation of the tradable sector relies on an intuitive approach based on the import and export share in the sector relative to its total production, a conservative method suited for a dataset spanning several decades. If workers in tradable sectors differ from their counterparts in non-tradable sectors in terms of earning processes and marginal propensity to consume, this difference could significantly influence aggregate behaviour in response to sectoral shocks, especially in the context of business cycles. Furthermore, this dataset also includes details about spouses, which allows me to increase the sample size.

This analysis focuses on two dimensions of heterogeneity among workers in tradable and non-tradable sectors: their marginal propensity to consume and the volatility of their earning processes. Since sectoral shocks have varying impacts on incomes across sectors, this leads to disparities in individual-level consumption responses. These behaviours are influenced by the marginal propensity to consume of individuals in each sector and subsequently impact aggregate variables, particularly consumption, savings, and trade in goods and assets with the rest of the world.

The heterogeneity is quantified using the PSID, a data set that contains the essential demographic, labour income, and consumption expenditure information required for the estimation procedures.

The analysis proceeds by estimating the earning risk of workers in the two sectors. This is accomplished by employing a standard labour income process that models residualized log-earnings as a combination of a permanent and a transitory component. The estimation, conducted through minimum distance techniques, reveals that both sectors exhibit strong persistence in the earning process, but workers in non-tradable sectors are subject to transitory income shocks.

The estimation of the marginal propensity to consume is carried out using the methodology outlined in Patterson (2023). To do this, aggregate consumption expenditures at the household level must be imputed, since the PSID consistently collects only food expenditures throughout the entire reference period, which is unsuitable for estimation purposes. The results reveal a significant heterogeneity along this dimension among workers in the two types of industries. Specifically, it is observed that the consumption response to changes in labour earnings is 30% higher for workers in non-tradable industries compared to those in tradable ones. This difference becomes even more pronounced, doubling in fact, when the analysis narrows its focus to workers in retail and restaurants, sectors that are inherently nontradable.

The findings can be reconciled in conjunction with the evidence indicating that tradable sectors offer higher wages compared to non-tradable ones. In a world characterised by incomplete markets, the marginal propensity to consume of individuals is influenced by their capacity to save in order to withstand income shocks, which, in turn, affects the pace at which they approach borrowing constraints. Workers in non-tradable sectors face greater earning risk, prompting them to build a larger cash buffer to safeguard against hitting these constraints. However, their lower wage levels hinder their ability to do so, and the heightened earning risk accelerates their approach to the constraint, consequently increasing their marginal propensity to consume.

Armed with this empirical evidence, the analysis proceeds to calibrate an Open-

Economy Heterogeneous Agent New Keynesian (OE-HANK) model, incorporating a production block similar to the one presented in Devereux and Engel (2007). Within this framework, households and the government consume a differentiated nontraded final good, which is produced using both tradable and nontradable intermediate inputs. These intermediate inputs, in turn, are produced using a linear production function in labour. The model calibrates the marginal propensities to consume (MPCs) of agents using sector-level productivities, as these factors have an isomorphic impact on the average skill of workers. Furthermore, households face idiosyncratic productivity risk within a world characterised by incomplete financial markets. As a result, they can only save in short-term government bonds, with interest rates set internationally, and hence representing an exogenous parameter for the small open economy, being is part of a currency union.

The analysis finds that a positive productivity shock in the non-tradable sector leads to an increase in real wages, consumption, and output. This surge in demand for complementary inputs spills over to the tradable sector, affecting both domestic and foreign producers. On the international front, this increase in domestic consumption reduces domestic debt holdings and triggers the expected real appreciation of the currency. In particular, the baseline economy with heterogeneous MPCs experiences stronger inflationary pressures than its counterfactual counterpart, primarily due to differences in aggregate consumption behaviour. In contrast, a productivity shock in the tradable sector triggers largely similar aggregate responses in both model economies, driven by increased productivity and rising sectoral wages. The main qualitative difference lies in the wage response of the tradable sector. The shock also has implications for the real exchange rate, with the counterfactual economy showing a more subdued inflationary response.

My analysis further examines the effects of an unexpected monetary loosening at the currency union level. There are distinct quantitative differences between the two model economies. Although the increase in output is comparable in both economies, showing a minimal difference of 5bps on impact, their compositional reactions differ. Specifically, both consumption and government spending initially increase. However, over a longer period, consumption's contribution becomes negative, and government spending, fuelled by higher labour income taxes, sustains the growth. The inflation trajectory presents another striking contrast. In an economy characterised by varied average marginal propensities to consume, unexpected monetary easing leads to more pronounced inflation. This seems to be rooted in the behaviour of tradable prices and wages. Although tradable wages increase in tandem with growing demand, it prompts a switch from domestic goods to imports and a decrease in exports. Consequently, the reaction of the tradable sector is more subdued compared to the nontradable sector, unaffected by foreign goods competition. This disparity is mirrored in the current account, which becomes negative, necessitating a real appreciation of the currency to attract foreign bond investments. In the medium term, the real exchange rate overcompensates, leading to a decline in tradable sector wages and a subsequent dip in consumption. Given that in the homogeneous MPC scenario, workers in this sector possess a higher MPC than the baseline, the consumption downturn is more profound in the counterfactual.

The paper develops as follows. Section 2 delves into the literature review. The heterogeneity of earnings and MPCs across different sectors are explored from an empirical perspective in Section 3, with sub-sections detailing the data used, the methods of consumption imputation, the criteria for classifying industries, and the methodologies for estimating the marginal propensity to consume and labour income risk. Building on this empirical foundation, Section 4 introduces the theoretical framework of the study, discussing production, policy, and then I proceed to describe how the equilibrium is defined and calibrated within the model in Section 5. The article then transitions to its core theoretical analyses in Section 6, examining the repercussions of sectoral shocks, and concludes with an exploration of the implications of an unanticipated monetary policy shock.

1.2 Literature review

The interplay between trade, wage inequality and unemployment has long been a focal point of economic research, with both theoretical and empirical studies offering rich insights into their complex relationships. Theoretically, the pioneering work of Yeaple

(2005) delved into the mechanisms through which trade can influence wage distributions within countries. This was complemented by the efforts of Ohnsorge and Trefler (2007), who further elucidated the nuances of trade's impact on labour markets. Helpman et al. (2010) provided a comprehensive framework, integrating various facets of trade and labour market dynamics, thereby setting a benchmark for subsequent research in the field.

On the empirical front, the landscape is vast and varied. Schank et al. (2007) were among the first to provide empirical evidence on the relationship between trade liberalisation and wage inequality, setting the stage for a series of studies that sought to validate and expand upon theoretical predictions. Krebs et al. (2010) explored the implications of trade on unemployment, offering a more holistic view of labour market outcomes. The works of Frías et al. (2012) and Krishna and Senses (2014) further enriched the empirical discourse, providing nuanced insights into the sectoral and regional variations of trade's impact. The more recent contributions of Rodrik (2021) and Helpman et al. (2017) have brought contemporary challenges and perspectives into the fold, emphasising the evolving nature of global trade and its implications for wage inequality and unemployment. In this context, this paper seeks to make a novel contribution by emphasising the heterogeneity in workers' earnings shocks and marginal propensities to consume. The aim is to provide a deeper understanding of the effects of general equilibrium in developed countries, an area that remains ripe for exploration.

Turning to the burgeoning field of heterogeneous-agent international macroeconomics, the emphasis on individual and sectoral differences has become increasingly pronounced. Cugat et al. (2019) made significant strides in highlighting the role of agent heterogeneity in shaping international macroeconomic outcomes. This was further built upon by De Ferra et al. (2020), who provided a comprehensive analysis of the implications of agent heterogeneity for global economic dynamics. The subsequent studies by Auclert et al. (2021) and Oskolkov (2023) have added layers of complexity to the discourse, emphasising the multifaceted nature of agent heterogeneity and its many implications. In line with these studies, this paper endeavours to bring to the fore the critical role of sectoral composition and heterogeneity, by focusing on quantifying a so-far unexplored dimension of heterogeneity across workers in tradable and non-tradable sectors, and the implication this may have for the propagation of sectoral shocks as well as conventional monetary policy. Drawing from empirical estimates, it seeks to provide a more granular and nuanced understanding of the subject, bridging the gap between theory and empirical realities.

1.3 Earnings and MPCs heterogeneity across tradable and non-tradable sectors

1.3.1 Data description

The main dataset for my analysis is the Panel Study of Income Dynamics by the University of Michigan, a well-known and explored dataset in the literature on household behaviour, particularly for studies on consumption and labour income dynamics. The versatility of this dataset is due to its unbalanced panel structure, providing a rich set of information regarding individuals' demographic, earnings, and consumption, as well as its longevity. Sample collection started in 1968 and continued annually until 1997, after which it became biennial. For the purpose of estimation, I focus on observations for which I observe the required demographic, earnings, and consumption characteristics. In particular, I focus on people between 25 and 62 years of age to avoid interference with education and retirement decision, and for whom the biennial change in earnings and consumption is below four log-points.[1]. Finally, I consider only observations that were employed at $t-2$, consistent with the methodology outline below.

The survey includes detailed characteristics of both the household's representative and their spouse, if present, a feature which I exploit by creating a second spousal observation for such households. In particular, all the information required for my analysis, detailed below, is available at the individual level, except for consumption levels. I solve this issue by imputing consumption, via the methodology detailed below, at the household level. Although this is an imperfect imputation of consumption at the individual level, it is nevertheless important for me to include spousal observations in my analysis, as this increases the size of my sample and, therefore, the precision of my

[1] This restriction on outliers is similar to the ones in Gruber (1997) and Hendren (2017).

estimation. This is the subject of the next section.

1.3.2 Consumption imputation

A shortcoming of using the PSID for consumption data is that this survey consistently collects only data on food expenditure in all sampling years. Such a measure of consumption is ill-suited for the computation of marginal propensities to consume because of the nature of food as a necessity, which makes its share of total consumption range within the income distribution, and the many state funded programmes, e.g., food stamps, that limit fluctuations in this expenditure category. Indeed, Tables 1.B.2 and 1.B.3 show that annual food expenditures are not statistically different between households in different groups within my sample, suggesting that there is no meaningful heterogeneity at the aggregate level. However, after 1997, it also started to collect data on more general expenditure categories, and I exploit this to impute a more widely defined consumption expenditure at the household level across the entire sample, following the methodology in Attanasio and Pistaferri (2014), detailed in Appendix 1.A. The logic behind this methodology is to estimate a consumption function at the household level by using the latter part of the sample and then to impute consumption backward for the preceding years. As such, this imputation methodology is entirely self-contained within the PSID. Figure 1.2 plots the histogram with the result of the imputation, and it shows that the distribution of imputed consumption expenditures for household of workers in the tradable sector is shifted moderately to the right with respect to the non-tradable sectors in my sample. Interestingly, it also picks up that when considering the wider non-tradable category ("General non-tradable"), its distribution has a fatter right-tail, consistent with the introduction of higher-skilled, higher-paying-service workers in the sample.

1.3.3 Classification of tradable and non-tradable industries

The final step in preparing my data for analysis is the classification of workers according to the tradability of the industry in which they are employed. For this purpose,

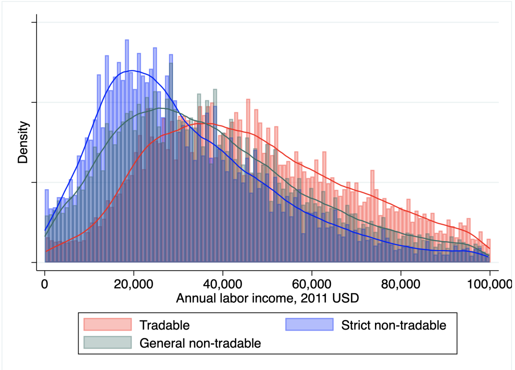

Figure 1.1: Histogram of annual labour income for tradable and non-tradable sectors

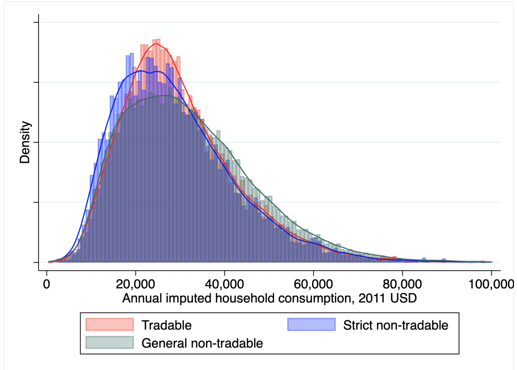

Figure 1.2: Histogram of imputed aggregate consumption at the household level. for tradable and non-tradable sectors

I borrow the industry categorisation from Mian and Sufi (2014). In particular, my starting point is what they define as *a classification based on retail and world trade.* They define a four-digit NAICS industry as tradable

"if it has imports plus exports equal to at least $10,000 per worker, or if total exports plus imports exceeds $500M. Non-tradeable industries are defined as the retail sector and restaurants. A third category is construction, and any industry in the construction category is not included in the tradable or non-tradeable category."

The main advantage of this categorisation is that it is quite intuitive, as it is based on the share of global trade, and it largely identifies manufacturing as tradable, which is in line with the traditional literature on the topic. At the same time, it does not categorise all industries in the tradable or non-tradable bin, and it can be seen in the data description that over the years most individuals fall into the "Other" category, with only about 48% of the classified individuals falling into either of the categories of interest. To solve this problem, for most of the rest of the article, I consider somewhat less of a coarse classification, by adding the category "Other" as part of nontradeable. This makes sense because these two categories appear to have similarities along their demographic and labour income dimensions, as shown by Table 1.B.1 in the Appendix.

One key step to carry out the classification is bridging the difference in how industries are codified in the trade data dataset (4-digit NAICS code) and in the PSID (3-digit 1970 Census code until 2003, 3-digit 1990 Census code from 2003 to 2017, 4-

digit 2012 Census code afterwards). For the 1990 and 2012 Census codes, I use the official crosswalks provided by the Census, whereas for the 1970 Census code, I take the extra step of utilising the crosswalk provided by Autor et al. (2003). Naturally, industry codes have changed through the years, and in particular some industries might have been split into more codes in subsequent waves or, conversely, collapsed to broader categories. With a view to obtaining a tradable/nontradable categorisation that is as exhaustive as possible, we handle these changes as follows. First, for earlier codes that are grouped into a single newer one, I classify each of the former using the single classification of the latter. Then, for the reverse, I manually check whether the multiple codes to which the single earlier code is matched all share the same classification. If they do, I adopt such classification for the earlier code, whereas if they do not, I discard the code.

In Table 1.1 I report the share of matched codes for each classification system out of the total in the respective crosswalks, from which we can see that I am able to classify around two thirds of industry codes for each classification system.

Industry Classification System	**Categorized (%)**
3-digit 1970 Census	64.23%
3-digit 2000 Census	65.66%
4-digit 2012 Census	65.66%

Table 1.1: Share of Industry Classified According to Mian and Sufi (2014) for Each Classification System

Table 1.2 reports the partition of my sample according to these different categories, considering only individuals that I was able to categorize. As expected, most of observations fall into the "Other" categories, for which reason I decide to apply the looser categorization outlined above.

Armed with this dataset, I turn to the estimation of the earning process and the marginal propensity to consume for workers in the tradable vs. non-tradable sector in the next two subsection.

Industry Category	Number	Share
Other	32,763	58.03%
Tradable	13,490	23.89%
Non-Tradable	7,896	13.98%
Construction	2,314	4.10%
Total	56,463	100.00%

Table 1.2: Number and Share of Individuals per Industry Category

1.3.4 Labour income risk estimation

In order to assess the impact of worker heterogeneity by tradability of the sector of employment on the aggregate macroeconomic dynamics, I use the PSID dataset to estimate labour income processes for both the tradable and the generic nontradable sector. For this, I follow seminal papers in the literature such as Meghir and Pistaferri (2004) and Guvenen (2009), and assume that the life-cycle log-earnings[2] follow an AR(1) with a transitory shock,

$$\log(y_{i,a}) = \mu + z_{i,a} + \epsilon_{i,a}$$

$$z_{i,a} = \rho z_{i,a-1} + u_{i,a}$$

$$u_{i,a} \sim (0, \sigma_u)$$

$$z_{i,0} \sim (0, \sigma_{z_0})$$

$$\epsilon_{i,a} \sim (0, \sigma_\epsilon)$$

where i denotes the individual and a their age.

Conveniently, the parameters of this process can be estimated by a minimum distance estimator based on the empirically estimated, within-individual variance-covariance matrix of the labour income process. In particular, I restrict the estimation to individuals who have been employed in a single industry category for their entire (observed) work history.

The results of the estimation in Table 1.3 show that the earning process of workers in the two sectors, once controlling for observable characteristics, are similar in terms of

[2]The estimation is carried out on the residualised log-income process from a Mincerian regression that includes the available demographic characteristics of the individuas.

persistence of the process, and such persistence is very high, in line with seminal papers on the topic starting from MaCurdy (1982), and more recently Meghir and Pistaferri (2004) and Guvenen (2009).

Industry Category	$\boldsymbol{\rho}$	$\boldsymbol{\sigma_u}$ (Permanent)	$\boldsymbol{\sigma_\epsilon}$ (Transitory)
Tradable	0.9817	0.0093	0.2967
	(0.0111)	(0.0050)	(0.0361)
General Non-Tradable	0.9883	0.0136	0.5783
	(0.0095)	(0.0055)	(0.0288)

Note: Asymptotic standard errors in parenthesis.

Table 1.3: Estimated Parameters for the Process of Residualized Log-Income from a Mincerian Regression

Furthermore, it shows that workers in nontradable sectors are exposed to much more volatile transitory earning shocks than workers in the tradable sector. In particular, we can get a sense of the nominal amount of this volatility if we focus exclusively on the transitory shock, in which case the earning process is log-normally distributed with a standard deviation equal to

$$[[\exp(\sigma_{\epsilon,i}) - 1] \exp(2\mu_i + \sigma_{i,\epsilon})]^{\frac{1}{2}} \tag{1.1}$$

which allows us to quantify a sizable difference in annual earning risk between tradable (USD 15,136) and non-tradable (USD 26,958). Although the scope of the study is different, this result is in line with the idea that workers in firms that trade are subject to lower earning volatility, largely due to the possibility of their firms to diversify their revenue streams across markets. Notwithstanding the fact that my result is at the sectoral level, I believe that it represents an interesting point of departure for further study with firm-level data, which, however, might not have the sample length or panel structure required for this type of estimation.

1.3.5 Estimation of the marginal propensity to consume

To estimate the marginal propensity to consume I follow the methodology laid out in Patterson (2023). In particular, I exploit the panel structure of the PSID to estimate

$$\Delta_{t-2}C_{t,h} = \sum_x (\beta_x x_{t-2,i}\Delta_{t-2}E_{t,i} + \alpha_x x_{t-2,i}) + \delta_t + \gamma_s + \epsilon_{t,i} \tag{1.2}$$

where $C_{t,h}$ is total household h consumption, which is common for representative and spouse from the same household, $E_{t,i}$ is labour earnings of individual i, δ_t and γ_s are time and state fixed effects, which capture any variation that is common to all individuals within a state and in a given year, and $x_{t,i}$ are individual characteristics, including five lagged income bins, a quadratic in age, female and black dummies, black interacted with female, and black interacted with age. As I was referring above, I consider two-year changes in both income and consumption to include data from 1995 onward, when the PSID frequency became bi-annual. The causal relationship between income and consumption is identified by using unemployment as an income shock instrument for the variation in labour income $\Delta_{t-2}E_{t,i}$. While it's possible for unemployment to directly impact consumption through altered shopping behaviors, as shown in Kaplan and Menzio (2016), or health changes, as in Sullivan and Von Wachter (2009), such effects wouldn't violate the exclusion restriction if they follow the significant income shocks. Moreover, using unemployment offers a key advantage in my setting, since it represents a substantial, impactful shock that captures relevant income variation specifically for workers, which are the focus of my paper, which a purely transitory shock such as others used in previous literature would not be able to capture.

Using the estimated β_x, we can calculate the MPC for each individual as

$$\widehat{MPC}_{t,i} = \sum_x \hat{\beta}_x x_{t-2,i}. \tag{1.3}$$

The result of the estimation are presented in Figure 1.3. The estimates are well in line with others found in previous literature, which I report for comparison in Table 1.B.5. The Figure illustrates how the pooled estimation of MPCs within the sample masks important heterogeneity across sectors classified by tradability, as there is substantial variations in MPCs around the 0.46 average that the left-most estimate shows,

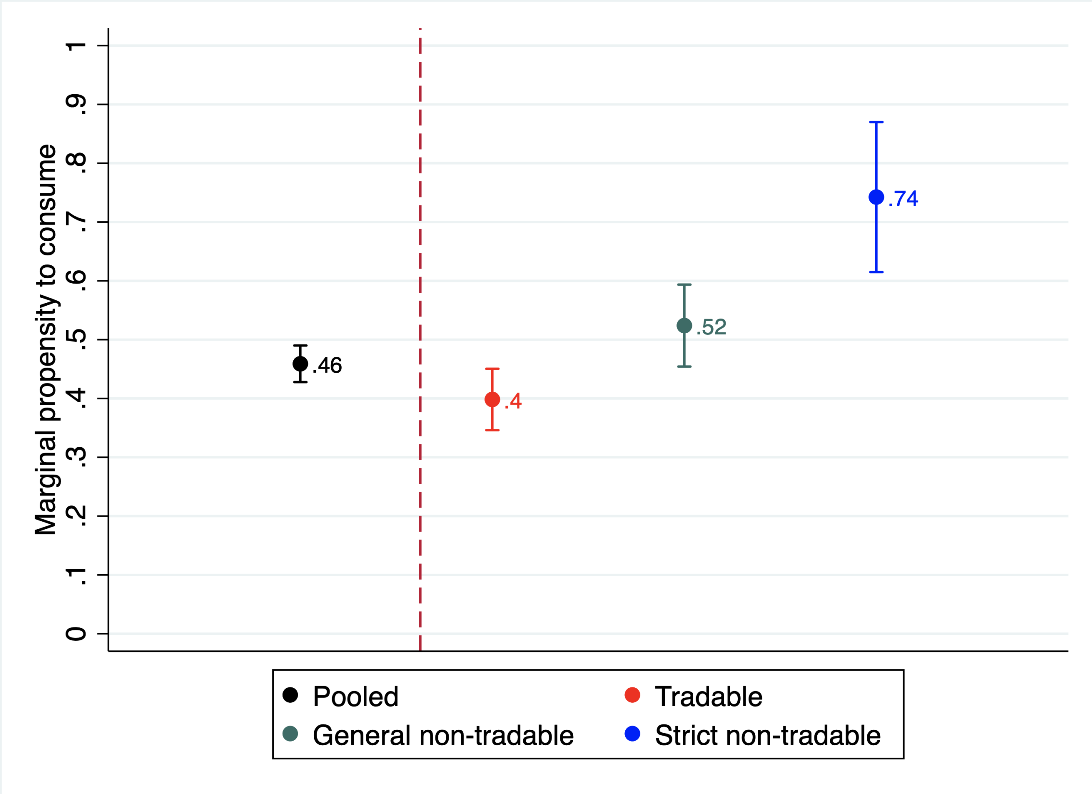

Figure 1.3: Annual average MPC estimates. 95% confidence intervals around the estimate are computed using the Delta method.

which I obtain by running a pooled estimation on the whole sample. In particular, the average consumption expenditure drop per dollar of lost income is 30% higher for workers in sectors classified as non-tradable vs. tradable, estimated at 0.52 vs. 0.40 respectively. The difference becomes even larger when I consider a more strict non-tradable classification that limits such sectors to retail and restaurants. In this case, the procedure yields an estimate of 0.74. This is unsurprising, as such workers have notoriously lower wages that would prevent them from building a saving buffer in the event of a labour income shock.

Overall, the estimation has uncovered an interesting heterogeneity in the marginal propensity to consume and the labour earning process of workers employed in tradable vs. non-tradable sectors. In particular, I estimate workers in the tradable to sector to have lower marginal propensity to consume and less volatile earning processes than their non-tradable counterpart, and the magnitude of these differences are economically significant. Although the implications of these are clear at the individual level, the purpose of this paper is to understand whether they are meaningful in shaping macroeconomic dynamics in response to sectoral shocks. For this purpose, I build an open economy, heteogeneous agent, New Keynesian model, to which I will turn next.

1.4 Model

To study the implications of the heterogeneity in earning processes and consumption behaviour upon earning shocks uncovered in my empirical analysis, I build a continuous time, general equilibrium model of a small open economy in a currency union, taking as a model economy a U.S. state. There is no aggregate uncertainty, and shocks will be of the MIT variety. The economy is populated of a unitary mass of agents i which work in either a domestic tradable or a non-tradable sector, $j \in \{H, NT\}$ according to a fixed proportion ν and $1 - \nu$ respectively.[3]

Workers are subject to idiosyncratic risk in the form of a skill shock z_{it}^j following a diffusion process that is the continuous-time equivalent of the one estimated in discrete time from PSID data, and I will detail in the calibration section how I convert between the two. Furthermore, I will allow such process to vary across sectors. Workers supply a unitary amount of labour inelastically at the prevailing wage in the respective sectors, and I do not allow them to switch across sectors. They can save in federal government bonds that are issued at a rate r_t, as well as borrow in the same asset at a penalty rate, $r_t^l = r^* + \Delta_b$, where Δ_b is the borrowing wedge. The latter is taken as given at the state level given the assumption of a small open economy. I normalize the nominal exchange rate to 1, and this will be constant throughout, in the spirit of a currency union. Finally, I assume that workers pay a labour income tax at rate τ_w.

Given this representation, the workers solve the following maximization problem under a budget constraint expressed in real terms,

$$\max_{c_{it}^j} \ \mathbb{E}_0 \int_0^\infty e^{-\rho t} u(c_{it}^j) dt \tag{1.4}$$

$$\text{s.t. } \dot{a}_{it}^j = (1 - \tau_w) w_t^j z_{it}^j l_{it}^j + (r_t^* - \pi_t)\, a_{it}^j + \Delta_b \min\{a_{it}^j, 0\} - c_{it}^j \tag{1.5}$$

$$a_t \geq \underline{a}. \tag{1.6}$$

[3]The inability of agents to switch sectors is in line with the empirically-estimated transition matrix in the Appendix, displaying very low off diagonal elements.

1.4.1 Production

On the production side, there are three sectors, two at the intermediate and one at the final level. The production sector is represented through nested CES technologies.

Intermediate sectors Goods at the intermediate level of production are distinguished between domestic tradables and non-tradables. They are produced using a linear technology in labour,

$$q^j = \nu^j A_t^j \int_0^J z^j l^j(a,z) dG^j_{a,z}, \qquad \text{for } j \in \{H, NT\} \tag{1.7}$$

where ν^j represents the respective measure of workers in each sector and $G^j_{a,z}$ is the sectoral distribution of workers across assets and skill states. I allow for different TFPs A_t^j across sector in order to study the incidence of sectoral shocks. I make the assumption of perfect competition at this stage, which implies $W_t^j = P_t^j$, where with usual notation I denote the wage per efficiency unit and the price in each sector. Such assumption is in line with the evidence in Bils and Klenow (2004) and Nakamura and Steinsson (2008), which point to a higher flexibility of prices in the intermediate sector with respect to those of final goods.

Producers in the non-tradable sector can only sell their output domestically, i.e., within the state, whereas domestic tradable goods can be traded abroad, i.e.,

$$q_t^D = q_t^H + q_t^E, \tag{1.8}$$

where q^H is the quantity sold domestically and q^E is the quantity exported. As customary in the small open economy literature, I model the latter in reduced form as

$$q_t^E = \left(\frac{P_t^E}{\mathcal{E}}\right)^{-\theta_e} q^*, \tag{1.9}$$

where $\mathcal{E}$ is the fixed nominal exchange rate and q^* is a foreign demand shifter. Given the assumption of frictionless trade in goods, the domestic tradable price is the same at home and abroad, $P_t^H = P_t^E$.

Final good producers There is a continuum of domestic final good producers s. For production, they bundle together non-tradable and tradable goods through a CES production technology,

$$(q_{st})^{\frac{\theta-1}{\theta}} = \eta^{\frac{1}{\theta}} (q_{st}^T)^{\frac{\theta-1}{\theta}} + (1-\eta)^{\frac{1}{\theta}} (q_{st}^{NT})^{\frac{\theta-1}{\theta}}. \tag{1.10}$$

Tradable goods are themselves a CES aggregate of domestic and foreign tradables q_{st}^F, that is, imports, in the form of

$$(q_{st}^T)^{\frac{\theta_g-1}{\theta_g}} = \alpha^{\frac{1}{\theta_g}} (q_{st}^H)^{\frac{\theta_g-1}{\theta_g}} + (1-\alpha)^{\frac{1}{\theta_g}} (q_{st}^F)^{\frac{\theta_g-1}{\theta_g}}. \tag{1.11}$$

The final products are differentiated and produced in a competitive monopolistic environment. As such, firms in this sector must solve a cost-minimization problem for the choice of inputs as well as a price-setting problem for profit maximization.[4] The former is standard and outlined in the Appendix.

Given monopolistic competition, final producers choose their optimal price to maximize the future discounted stream of profits subject to a quadratic Rotemberg (1982) adjustment cost,

$$\max_{\pi_{st}} \int_0^\infty e^{-\int_0^t r_h^* dh} \left[\frac{(1+\hat{\tau})P_{st} - M_{st}}{P_t} q_{st} - \frac{\phi q_t}{2} \pi_{st}^2 \right] dt, \tag{1.12}$$

subject to the final good demand in (1.14) and $\dot{P}_{st} = \pi_{st} P_{st}$.

I assume that the price-adjustment costs are virtual and therefore do not enter the resource constraint of the economy. Given the assumption of symmetry across final-good producers and the subsidy $\hat{\tau}$ setting a unitary markup in steady state, the outcome of this problem is a standard new Keynesian Phillips curve,

$$\dot{\pi} - \left(r_t^* - \frac{\dot{q}}{q} \right) \pi_t = \frac{\theta_r}{\phi} (1 - mc_t). \tag{1.13}$$

The final good is sold to consumers as well as to the government. Because of the standard assumption of CES aggregators for the individual final goods, the final

[4]Throughout the rest of the paper, I will denote with lowercase letter the real counterparts of prices, i.e., $p_t^j = \frac{P_t^j}{P_t}$, where P_t is the price of the final consumption good, i.e., the CPI in this economy.

demand for each producer is

$$q_{st} = \left(\frac{P_{st}}{P_t}\right)^{\theta_f} \left(c_t^T + c_t^{NT} + g_t\right) \tag{1.14}$$

where c_t^j denotes the total consumption of the final good by workers in sector j.

1.4.2 Policy

The local government runs a balanced budget with a constant issuance of debt. Therefore, it adjusts government expenditure to match its revenue stream, provided by the flat labour income tax, the interest revenue on its debt, and the rebates of both final good producers' profits and the profits from the interest rate differential between the lending and saving rates. The real budget constraint therefore reads as follows:

$$\begin{aligned} g_t = r_t^* b_t + \tau_w &\left(\nu w^T \int z dG_t^T(a,z) + (1-\nu) w^{NT} \int z dG_t^{NT}(a,z)\right) \\ + (r_t^* - r_t^b) &\left(\nu \int \min\{a,0\} dG_t^T(a,z) + (1-\nu) \int \min\{a,0\} dG_t^{NT}(a,z)\right) \\ + (1-m_t) q_t. & \end{aligned} \tag{1.15}$$

The clearing condition for the bond market is given by $b_t + b_t^* + a_t = 0$, where b_t^* is the amount denoted by foreign investors. Given this, by aggregating the budget constraint across workers and using results from the cost minimization of the firm, we obtain the balance of payment identity of this economy,

$$\dot{b}_t^* = r_t^* b_t^* - \underbrace{p_t^E q_t^E - p_t^F q_t^F}_{\text{Net exports}}. \tag{1.16}$$

If the state is a net exporter to the rest of the world, then it must also be a net saver in foreign bonds, that is, its bond position must increase more than just the total interest payments it receives from its current overall position.

Given the small open economy and the assumption of the currency union, the interest rate on saving assets is set exogenously at the federal level. Additionally, because the wealth of agents in HANK models is stationary, one does not need to introduce an element to induce it, as discussed in Schmitt-Grohe and Uribe (2003).

1.5 Equilibrium definition and calibration

Given the model outlined above, an equilibrium is defined as follows.

Definition 1. *Given the exogenous sequence of federal interest rates* $\{r_t^*\}$ *and sectoral TFPs* $\{A_t^T, A_t^{NT}\}$, *and the processes* $\{z_{it}^j\}$, *an equilibrium is sequences for inflation* $\{\pi_t\}$, *relative prices* $\{p_t^{NT}, p_t^T, mc_t\}$, *quantities* $\{q_t, q_t^{NT}, q_t^T\}$, *government purchases* $\{g_t\}$, *bond holdings* $\{a_t\}$, *policy functions* $\{c_{j,t}(a,y)\}$ *and distributions* $\{G_{j,t}(a,y)\}$ *that solve the following system of equation*

- *Hamilton-Jacobi-Bellman equation(s) for individuals in sector T and NT*
- *Kolmogorov Forward Equation(s) for the asset distribution of workers conditional on working in the tradable or non-tradable sector,*
- $\{q_t, q_t^{NT}, q_t^T, q_t^H, q_t^F, q_t^E, g_t\}$ *satisfying the equilibrium condition for cost minimization and final good market clearing, combined with the balanced government budget constraint,*
- $\{\pi_t\}$ *and* $\{p_t^{NT}, p_t^T, p_t^H, p_t^F, p_t^E, e_t, mc_t\}$ *are consistent with the definition of real marginal cost from cost minimization, domestic tradable and non-tradable good market clearing, the definition of aggregate prices given the nested CES structure of the economy, and the New-Keynesian Phillips Curve.*

Calibration To compute the steady state, I normalise all prices to one. The interested reader can find the value obtained from the calibration procedure in Table 1.4. The key pieces of calibration in my model are the average MPCs within the two sectors and the earning process. I calibrate the productivities in the two sectors to match the sectoral MPCs that I have found in my empirical estimation. The rationale behind this is that such parameters in my model are isomorphic to a multiplicative modifier of the mean skill for the idiosyncratic shocks for workers. Together with the normalisation of all prices to unity, this implies that workers in both sectors receive the same wage per efficiency unit, but not the same wage, given the difference in TFPs. As for the income process, its calibration requires the conversion of the discrete-time, log-earning process that I have estimated using my panel dataset into a continuous-time equivalent process. Because of the efficiency of the choice of the discrete-time process to estimate, I can rely on Lemma 1 in the Appendix, which explicits the mapping between a discrete AR(1) process and an Ornstein-Uhlenbeck process.

Parameter	**Value**	**Description**
	Internally calibrated	
ν	0.700	Share of Workers in Tradable Goods Sector
α	0.805	Home Bias Coefficient
η	0.541	Weight on Tradable Goods in Domestic Demand
q^*	1.370	Magnitude of Export Demand
$A^i,\ i \in \{H, NT\}$	0.7183, 0.9300	Steady-state productivity
	Externally calibrated	
σ	1.000	Intertemporal Substitution Elasticity
ρ	0.025	Discount Rate
τ_w	0.200	labour Income Tax Rate
θ	1.500	Elasticity of Substitution (Tradables vs. Non-Tradables)
θ_g	3.000	Elasticity of Substitution (Home vs. Foreign Tradables)
θ_e	3.000	Elasticity of Export Demand
r^*	0.015	Domestic Real Interest Rate on Savings
r^l	0.030	Domestic Real Interest Rate on Loans

Table 1.4: Calibration

While most calibration parameters are taken from the literature, it is worth noticing a few of them. To calibrate the demand system across different levels of production in the economy, I follow Guo et al. (2023) in setting the elasticities of my CES aggregators such that tradable and non-tradable goods are less substitutable than tradable goods of different origins. Furthermore, I equalise the elasticity at home and abroad, to make demand for exports and for imports equally sensitive to price movements. Finally, I calibrate the parameters of the home bias α and the share of tradables versus non-tradables in production η to match the degree of openness of the economy, in terms of the share of tradables, as well as the external ownership of domestic debt.

1.6 Response to a shock in the nontradable sector

To understand the role of sectoral heterogeneity, all shocks considered in the remainder of the paper are of the "MIT" variety. In particular, I induce dynamics in each of these variables separately by assuming paths of the form

$$\psi_t = \begin{cases} 0, & t < 0 \\ \psi_0 e^{-\delta t}, & t \geq 0 \end{cases} \tag{1.17}$$

that is, an initial jump of size ψ_0 decaying at a rate δ. This implies that I first consider the economy to be in steady state. Then, the unforeseen shock takes place, and the economy moves back to the steady state through a perfect foresight path from that moment onward.

In this section, I will present the main results of my theoretical analysis, that is, the effects of shocks to sectoral productivity. In particular, I first focus on a quarterly shock of 2.5% to productivity in the non-tradable sector. The impulse responses to the main prices and quantities of interest can be found in Figures 1.4 and 1.5. This Figure shows responses for two different economies. In blue, I plot the impulse responses for my baseline economy, in which the average marginal propensity to consume across sectors is heterogeneous and calibrated according to my empirical findings. In red, I plot the impulse responses for the same shock in a counterfactual economy, where I conduct the calibration assuming that the two sectors have the same average MPC, equal to the corresponding average MPC of the overall economy in my baseline calibration. I will keep this colour code for the rest of the paper. Additionally, all impulse responses are presented in deviation from steady state, except for the one for domestic inflation, as is customary in the literature.

Following an increase in the productivity of labour in the non-tradable sector, according to the linear production function assumed, the supply of input produced by this sector increases, which induces a fall in its relative price, in line with the analysis of this type of shocks in the literature. However, the fall in the price is not enough to counteract the increase in productivity, and hence overall the real wage in this sector

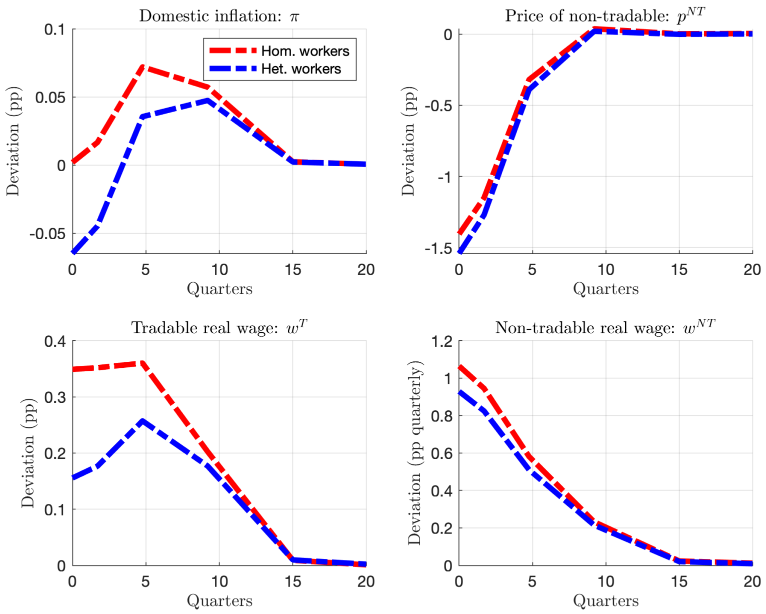

Figure 1.4: IRF of prices to positive productivity shock in the non-tradable sector

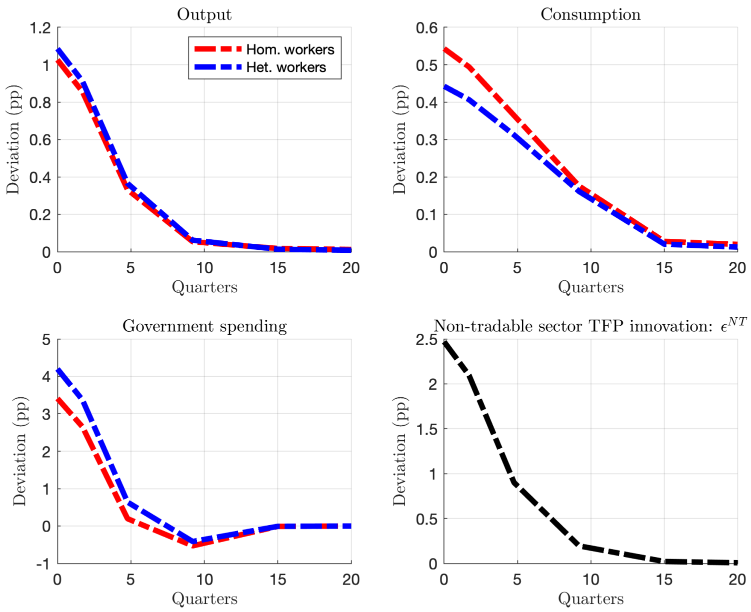

Figure 1.5: IRF of quantities to positive productivity shock in the non-tradable sector

increases. The increase in labour income induces an increase in consumption and, therefore, output, given the New-Keynesian nature of my model that implies that output is demand-determined. This increase in output raises the demand for complementary input from the overall tradable sector. The latter trickles down to domestic and foreign producers of tradable goods. In the former case, it induces an increase in the price of the domestically produced tradable good, as shown by the response of wages in this sector, which are equal to the price times productivity due to the assumption of perfect competition at the intermediate level.

At the international level, due to the increase in domestic household consumption, the level of domestic debt held by domestic residents falls. Given my assumption of a constant government debt supply, this fall has to be absorbed by foreign holders of domestic debt, and it induces, therefore, an expected real appreciation of the currency, which first depreciates. Because I am considering a fixed exchange rate regime, the latter can only take place in the economy with an initial fall in the inflation rate. In fact, the response to inflation is the opposite to that of the real exchange rate.

Although the responses are in line with a standard sectoral shock studied in the literature, it is interesting to compare these to the ones obtained in the counterfactual economy for which I calibrate the MPCs to be equal across sectors to the economy-wide average in the baseline economy. As we can see from the red lines in the Figures, the relevant difference is the behaviour of aggregate consumption, which increases on impact by 10bps, which is induced in large part by the stronger response of tradable wages and the higher marginal propensity to consume in the sector. This induces a larger expected appreciation of the currency, which results in much stronger domestic inflation pressures.

1.6.1 Comparison with a tradable sector shock

Another interesting comparison is the one that can be drawn across sectoral shocks. For this purpose, I report the impulse responses from a productivity shock in the tradable sector of the same relative magnitude as the one considered above in Figures 1.6 and 1.7.

The productivity shock qualitatively induces largely the same behaviour in the aggregate. This is in line with expectations, given that the two sectors are modelled almost symmetrically. However, unlike before, there are virtually no differences between the baseline and the counterfactual economy.

The only apparent qualitative difference in response can be seen in the wages of the tradable sector, which is due to the nature of the shock. In fact, the increase in productivity dominates the response of sectoral wages, which rise sharply compared to

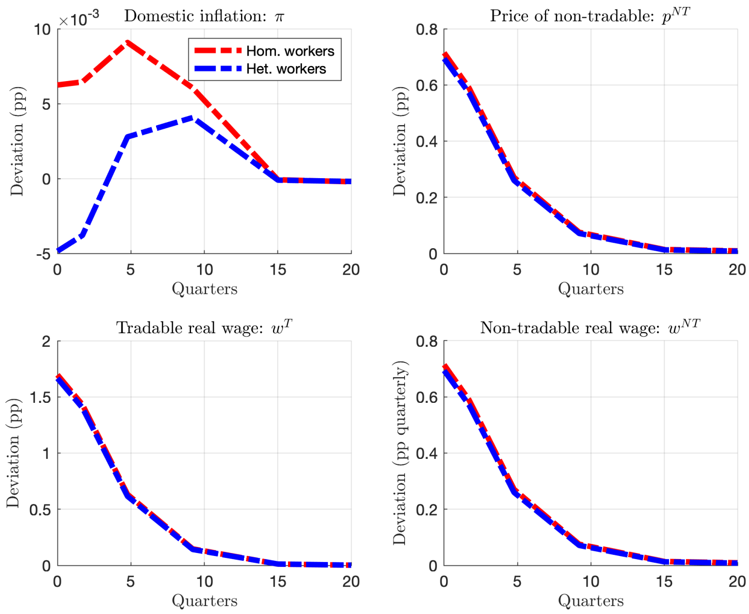

Figure 1.6: IRF of prices to positive productivity shock in the tradable sector

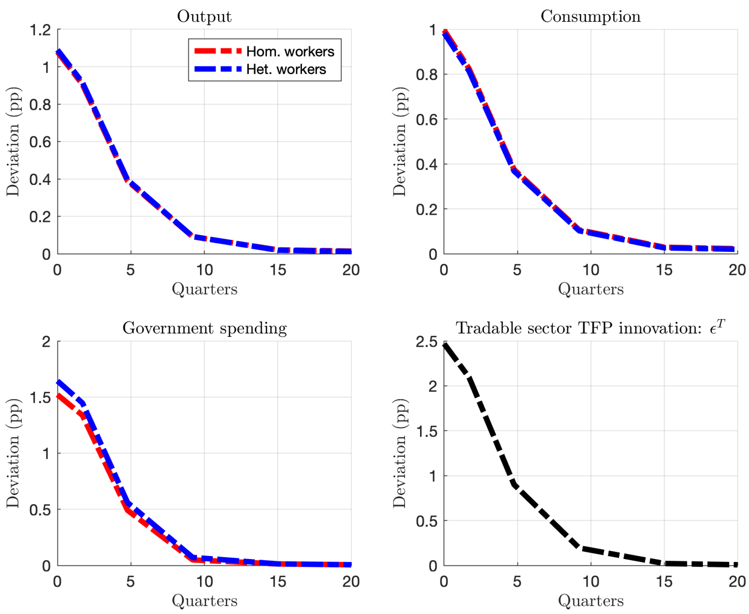

Figure 1.7: IRF of quantities to positive productivity shock in the tradable sector

before. A sharper increase in tradable prices induces an increase in the price of export due to the law of one price, and due to the high elasticity of demand abroad $\theta_e > 1$, the value of exports falls. By the balance of payment identity in the economy, this induces a lower absorption of domestic government bonds from foreign. The latter induces a more subdued response from the real exchange rate, evidenced by the significantly lower response of inflation.

In conclusion, we can draw some interesting parallels with a recent experience in the real world. More concretely, the government-induced lockdowns in response to the COVID-19 pandemic can be considered, for example, as a negative productivity shock in the non-tradable sector. These have, in fact, reduced the supply of many services, especially at the local level, such as leisure activity and restaurant, which can be modelled as an exogenous reduction in the productivity of these workers. Far from being the only source of inflationary pressures in the post-COVID world, my analysis does suggest that considering the heterogeneity of workers across the two sectors would have given insight into the strong inflationary pressures that were building in countries that are part of a currency union, such as the ones that are experiencing the members of the Eurozone. Furthermore, the origin of the shock mattered, as a similar shock in the tradable sector would not have created the same driving forces for inflation, according to my model. Therefore, the natural question is what the central bank can do to tame such inflationary pressures. Although the analysis of optimal monetary policy is beyond the scope of this article, I believe it would still be interesting to understand the potency of conventional central bank policies in the baseline and counterfactual environment. This is what we shall turn to in the next section.

1.6.2 Monetary policy shock

In this subsection, I analyse the impulse responses of the economy to an exogenous shock to the interest rate at the currency union level of the same kind as the one considered for the sectoral productivity experiments.

As we can see in Figures 1.8 and 1.9, which report the responses of prices and quantities, respectively, there are some notable quantitative differences in the behaviour of the two model economies considered. In particular, whilst the surge in output is roughly similar in the two economies, with a difference of only 5bps on impact, the composition of the response is notably different. In particular, we see that, whilst on impact both consumption and government spending contribute to the surge in output, in the medium term the contribution of consumption is negative, whereas the drive of the sustained increase is government spending, pushed by the higher labour income taxes.

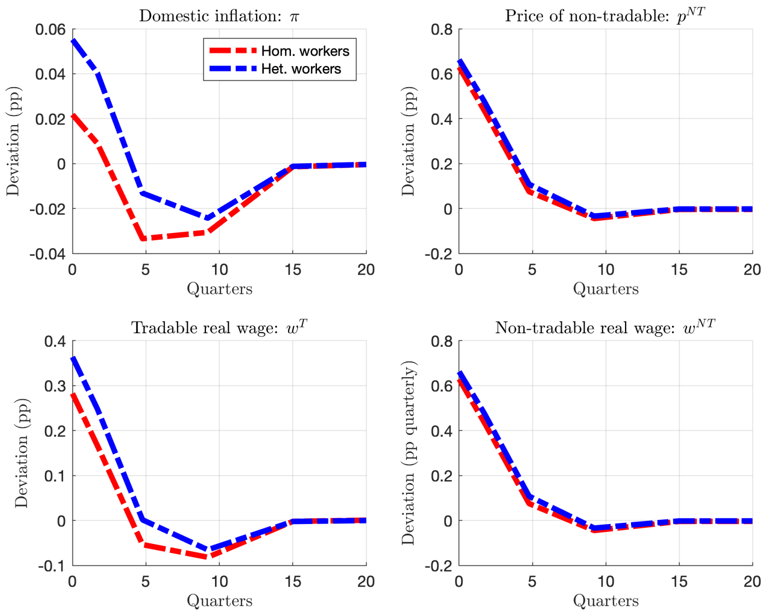

Figure 1.8: IRF of prices to an unexpected monetary loosening at the currency union level

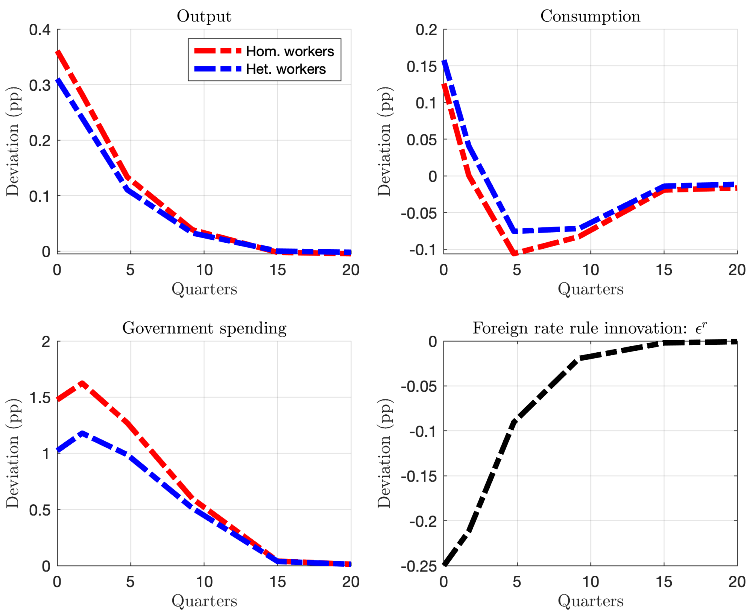

Figure 1.9: IRF of quantities to an unexpected monetary loosening at the currency union level

Even more striking is the difference in the path of inflation. In an economy with heterogeneity in the average marginal propensities to consume, the inflationary impact following an unannounced monetary loosening is much stronger. Once again, this appears due to the behaviour of tradable prices and wages, whereas the responses in the nontradable sectors are largely the same. Tradable wages increase, in line with the expansion in demand, but such an increase triggers substitution from local goods to imports, as well as reduces exports. Therefore, the response of the tradable sector is more muted than that of the nontradable sector, which is not affected by competition with foreign goods. The counterpart to this is the current account, which, given the behaviour of imports and exports, turns negative and calls for a real appreciation of the currency in order for foreign investors to hold more domestic bonds. The real exchange rate overshoots in the medium term, creating a fall in the wages of the tradable sector and contributing to a period of depressed consumption. Because the homogenous MPCs case workers in this sector have a higher MPC than the baseline, the contraction in consumption is deeper under the counterfactual.

1.7 Conclusion

This paper has sought to shed light on the heterogeneity of workers across tradable and non-tradable sectors, as well as its implications for aggregate behavior in response to shocks and policy changes. Using publicly available data from the Panel Study of Income Dynamics, the study uncovers notable heterogeneity between workers in tradable and non-tradable sectors in terms of their earning processes and marginal propensity to consume. This heterogeneity is shown to significantly influence aggregate responses to sectoral shocks, particularly in the context of business cycles.

In particular, the study finds that the consumption response to changes in labour earnings is 30% higher for workers in non-tradable industries compared to those in tradable ones. This difference is even more pronounced among workers in the retail and restaurant sectors, quintessentially non-tradable industries, where the MPC difference between the two types of workers doubles. This variation can be partially attributed to higher earning risk among non-tradable workers, which, combined with lower wages, leads to a higher MPC.

The paper then proceeds to calibrate an Open-Economy Heterogeneous Agent New Keynesian model to examine the consequences of sectoral and monetary shocks. In the event of a productivity shock in the non-tradable sector, the model predicts a surge in real wages, consumption, and output. The increase in domestic consumption reduces domestic debt holdings and triggers expected real appreciation of the currency. Furthermore, an economy with heterogeneous MPCs experiences stronger inflationary pressures than its counterfactual counterpart due to differences in aggregate consumption behavior.

The paper also explores the effects of an unexpected monetary loosening at the currency union level. Despite a similar increase in output across both model economies, they exhibit distinct quantitative differences. An economy characterized by varied average MPCs exhibits a more pronounced inflation response, driven by a greater response in tradable wages to growing demand, which prompts a switch from domestic goods to imports and a decrease in exports. This, in turn, affects the current account and necessitates currency real appreciation to attract foreign bond investments.

In summary, this study highlights the importance of considering worker-level heterogeneity across tradable and non-tradable sectors in analyzing the effects of shocks and policy changes on the economy. The empirical findings and model experiments underscore the substantial impact of such heterogeneity on aggregate responses to sectoral and monetary shocks. Therefore, the paper emphasizes the need for policymakers to take into account the characteristics and behavior of workers across sectors when designing and implementing policies to address economic challenges.

Appendices

1.A Details of the consumption imputation procedure

The imputation of consumption at the household level is conducted following Attanasio and Pistaferri (2014). This methodology exploits the relationship between food consumption and total consumption in the later part of the sample to impute total consumption for the previous remaining year.[1]

First, I fit the following equation on all household representatives between 25 and 62 years of age

$$\ln n_{i,t} = Z_{i,t}\beta + p_t\gamma + g(f_{i,t};\theta) + u_{i,t}, \tag{1.18}$$

where $n_{i,t}$ is total household consumption, $Z_{i,t}$ are demographic and labor variables, p is a set of prices, and f is food consumption.[2] The imputation assumes that individuals' preferences remain constant over time, maintaining a consistent relationship between overall and food consumption. Then, I use estimated $\hat{\beta}, \hat{\gamma}, \hat{\theta}$ to compute

$$\hat{c}_{i,t} = f_{i,t} + e^{Z_{i,t}\hat{\beta} + p_t\hat{\gamma} + g(f_{i,t};\hat{\theta})}. \tag{1.19}$$

[1] The expanded consumption measure in the PSID encompasses various housing, transportation, education, child care, health, and food expenses.

[2] Following Attanasio and Pistaferri (2014), I parameterize controls in Z, incorporating a third-degree polynomial in food consumption, demographic and socioeconomic dummies, hours worked by the household head, homeownership, family metrics, relevant CPIs (overall CPI, CPI for food at home and or food away from home, and CPI for rent), household income, and the spouses' labor market variables.

1.B Appendix tables

Characteristics	Tradable	Strict NT	Other NT	Const.
Worker Characteristics				
Average Worker Age	40.41	39.02	40.98	40.23
Percentage Male	76.94%	56.25%	47.69%	86.75%
Percentage Black	28.46%	29.47%	27.46%	23.11%
Percentage College Educated	30.59%	28.9%	50.97%	33.54%
Job Characteristics				
Average Annual Earnings (USD2011)	$58,818	$38,003	$49,643	$48,884

Table 1.B.1: Summary Statistics for the PSID Sample Used for Estimation

	Tradable	Non-tradable	Total
Annual Household Food Consumption	4,749.4	4,777.0	4,759.6
	(6,300.9)	(8,529.6)	(7,204.3)
Annual Individual labour Income	42,053.4	28,539.2	37,063.8
	(81,461.3)	(46,201.7)	(70,826.1)
Observations		21,386	

Note: Standard deviations of the variable are shown in parentheses.

Table 1.B.2: Group-wise Means of labour Income and Food Expenditures for Individuals Employed in Tradable vs. Non-Tradable Sectors

Variable	Difference in the Means
Food Expenditure	-27.53
	(-0.27)
Labour Income	13,514.2***
	(13.52)
Bi-annual Change in Food Consumption	-72.13
	(-0.67)
Bi-annual Change in labour Income	1,889.8***
	(3.79)
N	21,386

t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 1.B.3: t-Test of the Difference in the Means

	Other NT	**Tradable**	**Strict NT**	**Construction**
Other NT	0.91	0.04	0.04	0.01
Tradable	0.10	0.86	0.03	0.01
Strict NT	0.16	0.04	0.79	0.01
Construction	0.10	0.09	0.03	0.78

Table 1.B.4: Inefficient Transition Matrix

Reference	**Data Source**	**Estimate**	**Notes**
Jappelli and Pistafelli (2014)	Italian Survey Data	0.48	-
Kaplan and Violante (2014)	Tax Rebates, 2001 and 2008	0.25	Quarterly
McKee and Verner (2015)	Nielsen Consumer Panel	0.6 - 0.9	Out of Unemployment Benefits
Fagereng et al. (2018)	Norwegian Administrative Data	0.55	-

Table 1.B.5: Estimates of Marginal Propensity to Consume (MPC) in the Literature

1.C Cost minimization problem of the final good producer

Inputs are chosen optimally according to

$$\min_{q_{st}^{NT}, q_{st}^{H}, q_{st}^{F}} p_{st}^{NT} q_{st}^{NT} + p_{st}^{H} q_{st}^{H} + p_{st}^{F} q_{st}^{F} \tag{1.20}$$

$$\text{s.t. } q_{st} \geq \underline{q}. \tag{1.21}$$

The real price of imports is given by $p_{st}^F = e_t p^*$, where e_t is the real exchange rate, $e_t = \frac{\mathcal{E}}{P_t} = \frac{1}{P_t}$and p^*, i.e., the foreign price level, is normalized to one. Such problem gives rise to a standard set of isoelastic input demand functions,

$$q_{st}^T = \eta \left(\frac{p_t^T}{mc_t} \right)^{-\theta} q_{st} \quad \text{and} \quad q_{st}^{NT} = (1 - \eta) \left(\frac{p_t^{NT}}{mc_t} \right)^{-\theta} q_{st} \tag{1.22}$$

$$q_{st}^{H} = \alpha \left(\frac{p_t^H}{p_t^T} \right)^{-\theta_g} q_{st}^{T} \quad \text{and} \quad q_{st}^{F} = (1-\alpha) \left(\frac{p_t^F}{p_t^T} \right)^{-\theta_g} q_{st}^{T}. \tag{1.23}$$

The real marginal cost of the retailer satisfies, after cost minimization,

$$(mc_{st})^{1-\theta} = \eta \left(p_{st}^{T}\right)^{1-\theta} + (1-\eta) \left(p_{st}^{NT}\right)^{1-\theta} \tag{1.24}$$

where

$$\left(p_{st}^{T}\right)^{1-\theta_g} = \alpha \left(p_{st}^{H}\right)^{1-\theta_g} + (1-\alpha) \left(p_{st}^{NT}\right)^{1-\theta_g}. \tag{1.25}$$

1.D Calibration of income process in continuous time

Lemma 1. *Consider a generic Ornstein-Uhlenbeck process,*

$$dx_t = \theta(\mu - x_t)dt + \sigma dB_t. \tag{1.26}$$

The sampling path at discrete intervals $X_k = x(k\Delta t)$ of such process can be described by a first-order autoregressive process,

$$X_{k+1} = c + \varphi X_k + \epsilon_k, \tag{1.27}$$

with the following mapping across parameters

$$X_0 = x(0) \tag{1.28}$$

$$\varphi = e^{-\theta \Delta t} \tag{1.29}$$

$$c = (1-\varphi)\mu \tag{1.30}$$

$$\epsilon_k \sim \mathcal{N}\left(0, \frac{1}{2\theta}\sigma^2 \left(1 - e^{-2\theta\Delta t}\right)\right) \tag{1.31}$$

Proof. To prove the lemma, one starts with the stochastic differential equation for the

Ornstein-Uhlenbeck process,

$$dx_t = \theta(\mu - x_t)dt + \sigma dB_t$$

Standard Ito calculus yields:

$$d(x_t e^{\theta t}) = \theta\mu e^{\theta t}dt + \sigma e^{\theta t}dB_t.$$

Now we obtain the following by integrating from t to $t + \Delta t$:

$$\begin{aligned}
X_{t+\Delta t}e^{\theta(t+\Delta t)} - X_t e^{\theta t} &= \theta\mu \int_t^{t+\Delta t} e^{\theta s}ds + \sigma \int_t^{t+\Delta t} e^{\theta s}dB_s \\
X_{t+\Delta t}e^{\theta(t+\Delta t)} - X_t e^{\theta t} &= \mu(e^{\theta(t+\Delta t)} - e^{\theta t}) + \sigma \int_t^{t+\Delta t} e^{\theta s}dB_s \\
X_{t+\Delta t}e^{-\theta\Delta t} - X_t &= \mu(1 - e^{-\theta\Delta t}) + \sigma \int_t^{t+\Delta t} e^{-\theta(t+\Delta t-s)}dB_s \\
X_{t+\Delta t} &= X_t e^{-\theta\Delta t} + \mu(1 - e^{-\theta\Delta t}) + \sigma \int_t^{t+\Delta t} e^{-\theta(t+\Delta t-s)}dB_s.
\end{aligned}$$

The RHS integral is a Gaussian rv with mean zero and variance

$$\frac{\sigma^2}{2\theta}(1 - e^{-2\theta\Delta t}),$$

as desired. To obtain the AR(1) process, one needs to set $\Delta t = 1$. □

Chapter 2

Heterogeneous agents in a small open economy: the effectiveness of fiscal stabilisers

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Abstract

This paper investigates the effectiveness of fiscal automatic stabilization in open economies under alternative monetary policy regimes. In particular, it asks the question of whether fiscal automatic stabilization is valuable in a currency peg. For this, a New Keynesian model of a small open economy is augmented with a measure of agents that do not have access to complete financial markets and are subject to idiosyncratic labour market shocks, and two sets of fiscal automatic stabilizers, a progressive income tax and a system of unemployment benefits. The efficacy of automatic stabilisers varies based on the interaction between the monetary regime in place and the nature of the small open economy's trade relationship with the rest of the world. Stabilisers mitigate the variance in aggregate consumption in economies bound by a peg and are particularly effective when trade goods possess high substitutability with global counterparts due to pronounced expenditure-switching effects. However, stabilisers amplify output volatility, largely due to the distortionary repercussions of taxes, leading to higher variance.

Keywords: Fiscal Stabilization, Currency Peg, Incomplete Financial Markets,
J.E.L. codes: E24, E52, E62, E63, F41.

2.1 Introduction

In recent years, particularly following the Great Recession and the COVID-19 pandemic, there has been a renewed call within academic and policy arenas for fiscal strategies to actively mitigate business cycle fluctuations, a role traditionally delegated to monetary policy. Bernanke (2016) and Spilimbergo et al. (2011) have emphasised the need for collaborative efforts between fiscal policy makers and central banks, advocating for fiscal measures that are timely, potentially large, and sustainable, especially when the effectiveness of monetary policy is limited. Echoing these sentiments, Lagarde (2022) and the European Central Bank Governing Council have championed fiscal policies that are "temporary, targeted, and tailored", with the aim of supporting households and firms post-pandemic without compromising the overarching goal of monetary price stability. In this landscape, fiscal stabilisers emerge as a prime candidate. Defined by their automatic adjustments to fiscal inflows and outflows in response to business cycle shifts, these stabilisers inherently share the recommended characteristics. Blanchard et al. (2010) argue that they are especially potent during downturns due to their ability to avoid the typical policy delay associated with discretionary fiscal actions.

McKay and Reis (2016) have shown that fiscal automatic stabilisers play an important role in the stabilisation of the business cycle in the context of a closed economy. Their efficacy increases when monetary policy is not able to carry out business cycle stabilization due to the existence of an effective lower bound to nominal interest rates. This paper asks about the effectiveness of automatic stabilisers in the context of a peg. Similar to the case of an effective lower bound, this framework presents a limited array of options for the domestic monetary policymaker.[1]

To understand whether fiscal automatic stabilisation is a valuable complement to a non-independent monetary policy in open economies, I build a model of a small open economy with nominal rigidities in the form of sticky prices, and incomplete financial markets. I do this by adapting the workhorse model of Galí and Monacelli (2005) and merging it with the heterogeneity in McKay and Reis (2016). The world is composed

[1]Note that domestic monetary policy independence and a peg would not be mutually exclusive in the context of an economy with capital controls. This is the much-debated trilemma in international economics, which has been first theorised by Mundell (1963), and recently reconsidered by Rey (2015) and Farhi and Werning (2014), but such economies are beyond the scope of the present work.

of a continuum of countries, and I focus on a specific one, called Home, which can undertake frictionless trade in final consumption and investment goods with the other small open economies, considered as an aggregate and, therefore, labelled Foreign. The framework presented assumes that the size of the home economy is negligible relative to that of the world economy, and hence we can take world aggregates as exogenous. My economy is populated by a unitary measure of agents that can perfectly insure against idiosyncratic risk through a complete set of Arrow-Debreu securities traded internationally, and a different measure of agents that live in financial autarky, being able to hold assets only in the form of domestic, risk-free government bonds and subject to a tight borrowing constraint. As such, these agents have no means to insure against idiosyncratic shocks to skill level and labour force status. The work focuses only on two main automatic stabilizers on the household side, namely a progressive income tax and a skill-dependent system of unemployment benefits. This is the smallest set of instruments that allows me to keep a simplified framework whilst at the same time not sacrificing any of the channels of transmission identified by the literature. Early research on economic stabilization emphasized two primary mechanisms: one reduces the volatility of disposable income, as in Brown (1955), stabilizing consumption and investments, and the other influences marginal incentives, as in Christiano (1984), redistributing work effort in a countercyclical manner. However, recent studies, and in particular McKay and Reis (2016) on the back of Blinder (1975), have underscored the significance of the redistribution and social insurance channels of stabilization. These mechanisms, rooted in wealth redistribution and risk perception reduction, necessitate the inclusion of a heterogeneous population in models, as a singular representative agent would eliminate these effects.

To study the role of fiscal automatic stabilisers under different monetary regimes, I consider three aggregate shocks, i.e. a technology shock, a cost-push shock in the form of a mark-up shock, and a world demand shock. These represent the source of aggregate volatility against which fiscal stabilization is measured. I calibrate the model economy to Spain, which is standard practice in the small open economy literature. I first impose a stark assumption and describe a strict domestic inflation targeting regime compared against a peg. In a validation exercise, I then relax this assumption to accommodate a more realistic standard interest rate rule. The main object of comparison to gauge the effectiveness of the fiscal provisions considered in stabilising the business cycle is the ergodic variance of the main aggregate time series, such as output and consumption, across different regimes. Through this, I uncover important complementaries when analysing the role of automatic stabilisers in an open economy. In particular, two features play a key role in this in the context of an open economy, which would be disregarded in the context of a closed economy. These are the independence of the domestic monetary policy, as expected, and the trade elasticity of substitution between final consumption goods. Indeed, the possibility of switching across goods provides a supplementary dimension of stabilisation through the income effect coming from switching to the less expensive good. Therefore, this changes the variance of the output of the final consumption good produced domestically. Such an effect will be stronger the more substitutable such goods are, and the more flexible the terms of trade. However, when compared with a simple interest rate rule, automatic stabilisation in a currency union is always more powerful with respect to consumption and less distortionary with respect to aggregate output.

The paper is structured as follows. After a review of the literature in Section 2.2, I lay out the details of my model and then the definition of equilibrium in Sections 2.3 and 2.4. Afterwards, I provide a brief explanation of the solution method adopted in Section 2.5. Subsequently, Section 2.6 presents the main counterfactual comparison between a small open economy with monetary independence and one in a currency union, and how the result extends when considering a more realistic simple monetary rule.

2.2 Literature Review

The research on the effects of fiscal policies on the aggregate macroeconomic cycle is wide-ranging. A significant portion of this literature focuses on the evaluation of fiscal multipliers and discretionary tax policy in closed economies, and has been thoroughly re-evaluated with the advent of new New-Keynesian model that introduce agent heterogeneity. Works by Huntley and Michelangeli (2014) and Kaplan and Violante (2014) estimate multipliers tied to discretionary tax rebates, while Heathcote (2005) explores the responsiveness of consumption to tax shocks. Another recent wave of studies, such as **?**, Bhandari et al. (2021), and Auclert et al. (2018), delves into the interplay between fiscal policy and demand shocks. A growing body of literature deals specifically with fiscal policy in open economies, often within the context of currency unions. Noteworthy contributions include Galí and Monacelli (2008) and Ferrero (2009), which aim to characterize optimal fiscal policy. More recent studies, such as Nakamura and Steinsson (2014), Galí and Monacelli (2016), and particularly Dupor et al. (2023), focus on empirical aspects like price adjustment and trade linkages as critical factors for fiscal policy transmission.

Unlike these studies, the focus of the present paper is not on discretionary fiscal policy but rather on automatic stabilizers and, in particular, their ability to stabilize the economy, as measured by a reduction in the ergodic variance of the aggregate macro series, in a similar fashion to McKay and Reis (2016). In particular, I focus on studying the implications of these provisions in the context of a small open economy, and how their stabilization properties vary across exchange rate regime. My contribution is to uncover whether, in the context of a currency union, the utilization of fiscal stabilizers can supply a source of stabilization to an economy for which monetary policy is otherwise focused on maintaining a peg.

The literature on automatic stabilizers is not as explored as that on discretionary fiscal policy and most studies focus on quantifying their effect from an empirical perspective and in closed economies. Articles often use the ratio of public expenditure to GDP as a proxy for the strength of automatic stabilizers, suggesting a negative correlation between the size of automatic stabilizers and output volatility. Debrun and Kapoor (2010) found a negative correlation between government size and real GDP growth variability in a sample of industrial and developing countries, but this correlation was no longer present when industrial countries were excluded, while Fatás and Mihov (2010) and IMF (2015) found clearer negative correlations within OECD and advanced economies. More recently, Karras and Yang (2022) critiques the use of government size as a proxy and proposes an elasticity-based approach. Such study confirms a negative relationship between automatic stabilizers and output volatility. In my paper I adopt a theoretical approach, by developing a DSGE model that allows me to compare counterfactuals across key dimensions for the understanding of the working of automatic stabilizers in open economies, i.e., the currency regime and the type of trade that the economy under consideration engages in.

Lastly, this paper touches upon the optimal currency area theory initiated by seminal works like Mundell (1961), McKinnon (1963), and Kenen. These have largely focused on the factors contributing to the success of currency unions. The more recent work of Farhi and Werning (2017) extends this theory to fiscal unions as optimal risk-sharing arrangements. While these works tend to explore the optimal design of fiscal stabilizers, this paper stops short of this and instead focuses on the characterization of business cycles and welfare outcomes tied to different fiscal stabilizers and monetary regimes. I see my article as laying the groundwork for further studies on the efficacy of fiscal stabilization in a currency union, as the synergy between fiscal and monetary policies have come to the forefront in recent year, and particularly in the within unions composed of heterogeneous countries. Further work should explore whether there exist an optimal calibration of fiscal stabilizers across countries part of a currency union that reduces the volatility of the business cycle, and whether this should differ meaningfully across parametrization, to complement the stabilization role played by the monetary authority at the union level.

2.3 The baseline model

I model a small open economy using an extended framework of the standard model developed by Galí and Monacelli (2005) that incorporates fiscal stabilizers like a proportional labor income tax and unemployment benefits, as well as heterogeneous workers hit by idiosyncratic shocks to skill and labor force status. My model focuses on a specific small economy, denoted “Home”, which engages in frictionless trade with other small economies, collectively called “Foreign”. In the remainder of the chapter, I will adopt the following notational conventions. Variables related to the economy of interest will be indexed by a subscript H, while foreign variables in the domestic unit of accounts will be denoted by F, and the world variable will have a star superscript.

The latter will be taken as given by the small open economy. Moreover, variables with no subscript other than time refer to aggregate bundles of Home and Foreign. Finally, the variables with superscript e refer to the patient household, while I denote a generic impatient household as $h \in [0, \nu]$.

2.3.1 Households

The economy is populated by two groups of households that differ in their ability to insure against idiosyncratic shocks, as well as in their level of patience. I will analyse them in turn.

Patient households The first group of households is relatively more patients and has access to a full set of Arrow securities traded internationally. Therefore, we can talk about a representative patient household, whose preferences are

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\log C_t^e - \psi_1 \frac{N_t^{e\,1+\psi_2}}{1+\psi_2} \right), \tag{2.1}$$

where N_t^e is labour, and C_t^e is a consumption index defined through a Dixit-Stiglitz aggregator of the form $C_t^e \equiv \left((1-\upsilon)^{\frac{1}{\eta}} C_{H,t}^e{}^{\frac{\eta-1}{\eta}} + \upsilon^{\frac{1}{\eta}} C_{F,t}^e{}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$. In the latter, $C_{H,t}^e$ denotes consumption of final domestic goods, and $C_{F,t}^e \equiv \left(\int_0^1 C_{i,t}^e{}^{\frac{\gamma-1}{\gamma}} di \right)^{\frac{\gamma}{\gamma-1}}$ where $C_{i,t}^e$ is the consumption of final good from country i. The parameter υ captures the degree of home bias, ranging from $\upsilon = 0$ for a closed economy to $\upsilon = 1$ for a very open economy. Furthermore, γ represents the elasticity between the goods produced in different foreign countries, and η the elasticity between the domestic and foreign goods. Moreover, the CES formulation allows us to work with composite measures rather than individual components. It is therefore without any loss of generality that from now onward I will refer to the small open economies populating the rest of the world as a single entity, characterised as Foreign.

These households seek to maximize their utility subject to the following budget constraint and law of motion for capital

$$P_{H,t}C^e_{H,t} + P_{F,t}C^e_{F,t} + \tilde{B}^e_{H,t+1} - \tilde{B}^e_{H,t} + P_{H,t}I^e_{H,t} + P_{F,t}I^e_{F,t} \tag{2.2}$$

$$\leq P_t \left[\Gamma^e_t - \tau\left(\Gamma^e_t\right)\right] \tag{2.3}$$

$$K^e_{t+1} = I^e_t + (1-\delta)K^e_t. \tag{2.4}$$

In Equation (2.3), $P_{H,t}$ is the producer price index (PPI) of the domestic final good, $P_{F,t}$ is specified analogously for the aggregate Foreign consumption bundle, and P_t is the consumer price index (CPI), defined below. Households consume aggregates of domestic and foreign imported goods and can save in domestic government securities. The real income of the patient household is

$$\Gamma^e_t = i_{t-1}\tilde{B}^e_{H,t} + D_t + W_t s^e N^e_t. \tag{2.5}$$

It equals the sum of income derived from interest on government bonds, dividends from firm ownership and labour, and is taxed progressively according to the function $\tau(\cdot)$, which is specified below in Section 2.3.4.

As in McKay and Reis (2016), I assume that these households can also trade in complete international financial markets, allowing them to insure perfectly against idiosyncratic risk from the rest of the world. These securities are omitted in the budget constraint above for the purpose of keeping light on notation, and this is without loss of generality as in equilibrium they will net out to zero.

Impatient households There is a measure ν of impatient households in the Home economy, indexed by $h \in [0, \nu]$. They have the same period utility function as in (2.1), but following Krusell and Smith (1998) we assume that they are more impatient, $\hat{\beta} \leq \beta$. They do not have access to the Arrow security market, but can lend through the purchase of home government bonds.

They choose $C_t(h), N_t(h), \tilde{B}_{H,t+1}(h)$ to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \hat{\beta}^t \left(\log C_t(h) - \psi_1 \frac{N_t(h)^{1+\psi_2}}{1+\psi_2}\right). \tag{2.6}$$

They can save using risk-free nominal government bond, and pay capital and labor income taxes, so that their budget constraint is

$$P_{H,t}C_{H,t}(h) + P_{F,t}C_{F,t}(h) + \tilde{B}_{H,t+1}(h) - \tilde{B}_{H,t}(h) \tag{2.7}$$

$$\leq P_t \left[\Gamma_t(h) - \tau\left(\Gamma_t(h)\right)\right] \tag{2.8}$$

coupled with a borrowing constraint, $\tilde{B}_{H,t+1}(h) \geq 0$.

Unlike their patient counterpart, impatient households are subject to two kinds of idiosyncratic shocks: an unemployment shock $e_t(h)$ determining their labour-force status, and a skill shock $s_t(h)$. In particular, we assume that such shocks follow two independent Markov processes with, respectively, two and three states, and I denote transition probabilities from state s to state s' as $\omega_{s,s'}$. For this reason, there will be six discrete types of households in this economy. Accordingly, conditional on the realization of such idiosyncratic shocks, the income of the household in period t will be given by:

$$\Gamma_t(h) = \begin{cases} i_{t-1}\tilde{B}_{H,t}(h) + W_t s_t(h) N_t(h), & \text{if } e_t(h) = 1, \\ \bar{T}^u \min\left\{s_t(h), \bar{s}^u\right\}, & \text{if } e_t(h) = 0. \end{cases} \tag{2.9}$$

Hence, in case the impatient household is employed, he will receive labour income as his patient counterpart, given his choice of time devoted to working. Otherwise, he will be eligible for unemployment benefit, which I treat as taxable following the provisions in the Spanish system, taken as the basis for my model economy. Furthermore, the dependence of the latter on the skill level of the agent is in line with most unemployment benefit programs being related to previous earnings. However, notice that this state-dependency makes unemployment benefits inadequate to entirely dispel the idiosyncratic risk of the impatient household. Therefore, the real channel at play here is the redistribution rather than the social insurance one.

Consumption and investment expenditures The Dixit-Stiglitz formulation of the composite consumption and investment goods allows to split the problem of both types of households in two steps. First, as shown in the Appendix, they will maximize the composite measures subject to a fixed expenditure. As it is a standard result in this context, at such optimum we will have the following relations

$$P_{H,t}C_{H,t} + P_{F,t}C_{F,t} = P_tC_t \quad \text{and} \quad P_{H,t}I_{H,t} + P_{F,t}I_{F,t} = P_tI_t.$$

This is very convenient because it permits the solution of the second-stage household problem, i.e. optimal choice of consumption, investment and labour decision, with respect to the composite themselves.

2.3.2 Firms

There are two types of firms in the economy, producing final consumption goods and intermediate goods used in production, respectively.

Final good firms These firms operate in a competitive market and combine intermediate goods according to the following production function

$$Y_{H,t} = \left(\int_0^1 Y_{H,t}(j)^{\frac{1}{\mu_t}} dj \right)^{\mu_t} \tag{2.10}$$

where μ represents the elasticity across varieties of intermediate goods produced within a given country. I allow for shocks in the elasticity of substitution between intermediate good varieties, μ_t, which will cause movements in the desired markups of the intermediate firms.

The representative firm in this sector takes its own prices $P_{H,t}$ as given and pays $P_{H,t}(j)$ for each input. Cost minimization and zero-profit condition imply that

$$Y_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{\frac{\mu_t}{1-\mu_t}} Y_{H,t} \tag{2.11}$$

$$P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{\frac{1}{1-\mu_t}} dj \right)^{1-\mu_t}. \tag{2.12}$$

Intermediate good firms The economy is populated by a unitary mass of firms producing differentiated intermediate goods and operating in a monopolistically competitive market. A typical firm $j \in [0, 1]$ adopts a Cobb-Douglas, constant return to scale technology

$$Y_{H,t}(j) = A_{H,t}K_t(j)^{\alpha}L_t(j)^{1-\alpha}, \tag{2.13}$$

where $A_{H,t}$ represents productivity in the Home country, and $L_t(j)$ and $K_t(j)$ are respectively labour and capital demands of firm j. In particular, I assume that productivity shocks follows an AR(1) process in logs

$$\log(A_t) = \rho_A \log(A_{t-1}) + \epsilon_{A,t}.$$

As it is standard in the New-Keynesian literature, I introduce nominal rigidities in the form of staggered price setting á la Calvo (1983). In particular, in each period a generic firm j is able to re-optimize its prices with probability θ, which is a parameter that is decreasing in the level of price rigidity.

Hence, given the nominal profits of the firm,

$$\Gamma_t(j) = P_{H,t}(j)Y_{H,t}(j) - P_t W_t L_t(j) - P_t r_t K_t(j), \tag{2.14}$$

the problem of a generic firm j is to choose $P^*_{H,t}(j)$, $\{L_{t+k}, K_{t+k}\}_{k=0}^{\infty}$ in order to maximize the expected future stream of profits generated while such price remains fixed,

$$\sum_{k=0}^{\infty} \theta \mathbb{E}_t (1-\theta)^k \left\{ Q_{t,t+k} \left(\frac{P_{H,t}(j)}{P_{H,t+k}} Y_{H,t+k|t}(j) - \frac{P_{t+k}}{P_{H,t+k}} W_{t+k} L_{t+k}(j) - \frac{P_{t+k}}{P_{H,t+k}} r_{t+k} K_{t+k}(j) \right) \right\} \tag{2.15}$$

where $Q_{t,t+k} \equiv \beta \dfrac{u_{c,t+1}}{u_{c,t}}$ is the stochastic discount factor, subject to the sequence of demand constraints and the production technology

$$Y_{H,t+k|t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t+k}} \right)^{\frac{\mu_{t+k}}{1-\mu_{t+k}}} Y_{H,t+k} \tag{2.16}$$

$$Y_{H,t+k}(j) = A_{H,t+k} K_{t+k}(j)^{\alpha} L_{t+k}(j)^{1-\alpha}. \tag{2.17}$$

2.3.3 The terms of trade and the real exchange rate

Given the open economy nature of my model, I need to keep track of several price indices. In particular, they will be defined as follows: Home's Consumer Price Index (CPI) $P_t \equiv \left((1-\upsilon) P_{H,t}^{1-\eta} + \upsilon P_{F,t}^{1-\eta} \right)^{\frac{1}{1-\eta}}$, Home's Producer Price Index (PPI) $P_{H,t} \equiv \left[\int_0^1 P_{H,t}(j)^{1-\mu_t} dj \right]^{\frac{1}{1-\mu_t}}$, and the index for imported goods $P_{F,t} \equiv \left[\int_0^1 P_{i,t}^{1-\gamma} di \right]^{\frac{1}{1-\gamma}}$, where $P_{i,t} \equiv \left[\int_0^1 P_{i,t}(j)^{1-\mu} dj \right]^{\frac{1}{1-\mu}}$ is country i's PPI.

I define the effective nominal exchange rate between Home and Foreign, $\mathcal{E}_t$, such that an increase in this variable corresponds to a depreciation of the home currency. I will assume that the Law of One Price holds, and therefore $P_{F,t} = \mathcal{E}_t P_t^*$, P_t^* is the world price index, which can be normalized without loss of generality, $P_t^* = 1$.

The effective terms of trade are $\mathcal{S}_t \equiv \frac{P_{F,t}}{P_{H,t}}$ and the effective real exchange rate is $\mathcal{Q}_t = \mathcal{E}_t \frac{P_t^*}{P_t}$. Given this notation and similarly to Galí and Monacelli (2016) we assume that aggregate export for domestic final good takes the following functional form,

$$X_t \equiv \upsilon \mathcal{S}_t^{\eta} Y_t^* \tag{2.18}$$

where world output Y_t^* is assumed to be affected by a world demand shock that follows a AR(1) process in logs. Finally, it is worth noting that for tractability I assume that the foreign economy is entirely populated by patient households that can self-insure against idiosyncratic risk through a complete set of internationally traded Arrow-Debreu securities.

2.3.4 Fiscal and monetary policy

Fiscal authority The model considers two tools for fiscal automatic stabilisation, namely a progressive income tax and a system of unemployment benefit, and abstracts from others, such as a corporate income tax or a system of targeted, state-dependent transfers. The reason is that the fiscal policies under consideration are widely adopted in most developed and emerging economies, and they represent the smallest set of provisions that allow me to introduce all channels outlined in the introduction, whilst not complicating the model further.

In particular, the government taxes household income, both from labour and interest accrued on savings, and uses its proceeds, together with debt issuance, to finance the unemployment benefit programme. Given the focus on fiscal automatic stabilisation, we abstract from government consumption.

The household taxes are described by the function

$$\tau(\Gamma) = \left[\Gamma - \lambda \Gamma^{1-\tau}\right] + \kappa \Gamma, \tag{2.19}$$

following the specification in Serrano-Puente (2020), which is in turn a composite of two terms that are widely used in the literature on progressive taxation. The first term, in brackets, corresponds to the functional specification of Heathcote et al. (2017) to study the optimal tax progressivity. In this, τ represents the level of progressivity of the tax system for $\tau > 0$, while λ is the average tax. Clearly, when $\tau = 0$, λ represents the flat tax rate in the economy. García-Miralles et al. (2019) show that such specification traces out very closely the effective average tax rates for Spanish households, which justifies its adoption for my purposes. The second term represents alternative sources of fiscal revenues from other taxes, from which this model abstracts. This term is modelled as a proportional income tax, in accordance with other examples in the literature, e.g. Castaneda et al. (2003) and Díaz-Giménez and Pijoan-Mas (2019). While the choice on this functional form is for the sake of simplicity, I will show in the following that it approximates in a suitable way the income tax progressivity of Spain, the real-world counterpart to my model economy.

Therefore, the government budget constraint is

$$P_t\left[\tau(\Gamma_t^e) + \int_0^{\nu} \tau(\Gamma_t(h))dh\right] + \tilde{B}_{H,t+1}^S \tag{2.20}$$

$$= P_t\left[\int_0^{\nu} T_t^u(h)dh + \frac{\zeta}{2}\left(\frac{\Delta B_{H,t+1}^S}{B_{H,t}^S}\right)^2 B_{H,t}^S\right] + i_{t-1}\tilde{B}_{H,t}^S \tag{2.21}$$

where the last term on the left-hand side is a quadratic adjustment cost that prevents the government from running a Ponzi scheme. This cost is calculated on the real value of government debt issuance, $B_{H,t}^S \equiv \dfrac{\tilde{B^S}_{H,t}}{P_{t-1}}$.

Monetary authority My analysis of the baseline specification is carried out under alternative monetary policy regimes. Following Galí and Monacelli (2016), at the two extremes I will assume that the Central Bank can either directly set the level of domestic inflation,

$$\Pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}} = 1, \tag{2.22}$$

or is part of a home currency union, or alternatively a credible hard peg of its exchange rate,

$$\mathcal{E}_t = \mathcal{E}_0. \tag{2.23}$$

The appeal of these two rules is that they represent clear extremes that make the interpretation of my findings more understandable. I will also allow for more realistic assumptions on the conduct of monetary policy in due time below, both as a form of robustness check and as an extension to account for intermediate situations representing managed exchange rate regimes.

2.3.5 Market clearing

Market clearing in the domestic good, bonds and labour market requires

$$Y_{H,t} = C^e_{H,t} + \int_0^\nu C_{H,t}(h)dh + I^e_{H,t} + X_t, \tag{2.24}$$

$$B^S_{H,t} = B^e_{H,t} + \int_0^\nu B_{H,t}(h)dh, \tag{2.25}$$

$$\int_0^1 L_t(j)dj = N^e_t + \int_0^\nu N_t(h)dh. \tag{2.26}$$

It will be useful to combine all these conditions together with the budget constraints of the patient and impatient households, and of the government, to obtain the following aggregate resource constraint

$$\frac{\upsilon(C_t + I_t)}{g(\mathcal{S}_t)^{1-\eta}} = \frac{\upsilon \mathcal{S}_t^\eta Y_t^*}{q(\mathcal{S}_t)} - \frac{\zeta}{2}\left(\frac{\Delta B_{H,t+1}}{B_{H,t}}\right)^2 B_{H,t} \tag{2.27}$$

where

$$g(\mathcal{S}_t) \equiv \frac{P_t}{P_{F,t}} \equiv \left[(1-\upsilon)\mathcal{S}_t^{\eta-1} + \upsilon\right]^{\frac{1}{1-\eta}}$$

$$q(\mathcal{S}_t) \equiv \frac{P_t}{P_{H,t}} \equiv \left[1 - \upsilon + \upsilon \mathcal{S}_t^{1-\eta}\right]^{\frac{1}{1-\eta}}$$

2.4 Equilibrium

An equilibrium in this economy is a collection of aggregate quantities $\{Y_t, C_t^e, N_t^e, B_{H,t+1}^e, K_{t+1}^e\}$, aggregate prices $\{P_{H,t}, P_t, \mathcal{E}_t, \mathcal{S}_t, \mathcal{Q}_t, W_t, r_t\}$, impatient households decision rules $\{C(B_t(h), e_t(h), s_t(h)), N(B_t(h), e_t(h), s_t(h))\}$, a distribution of households over assets and employment statuses, individual firm variables $\{Y_{H,t}(j), P_{H,t}^*(j), L_t(j), K_t(j), \Gamma_t(j)\}$ and policy choices $\{B_{H,t+1}^S, i_t\}$, such that:

1. patient households maximize (2.1) subject to (2.3) and (3.1),
2. the impatient household decision rules maximize (2.6) subject to (2.8), (2.9) and the borrowing constraint,
3. the distribution of household over assets and employment evolves consistently with the decision rules and the exogenous shocks,
4. final good firms behave optimally according to equations (2.11) and (2.12),
5. intermediate good firms maximize (2.15) subject to (2.16) and (2.17),
6. fiscal policy respects (2.21), and monetary policy is conducted according to (2.22) or (2.23),
7. markets clear according to (2.24), (2.25), (2.26),
8. foreign aggregate price and quantities are taken as given.

In the Appendix, I derive the standard optimality conditions for the problem facing households and firms. Together with the market clearing conditions, they represent the set of conditions characterizing the equilibrium of the small open economy.

2.5 Model solution and calibration

I have presented a model of a small open economy with heterogeneous agents and price rigidities. The solution method borrows from McKay and Reis (2016) in following the approach proposed by Reiter (2009), hence adopting a combination of both the projection and the perturbation techniques. Hence, I first outline this procedure, and then the baseline calibration, before moving to the analysis of the results in the following two sections.

2.5.1 Solution method

The model is solved with the solution approach to heterogeneous agent model proposed by Reiter (2009). It can be summarised in the following steps.

First, I proceed to discretize the saving and labour decision functions of impatient agents, as well as the wealth distribution. The former is done through the usage of piecewise linear splines on a grid of 100 knot points each. Notably, this allows for an easy incorporation of the borrowing constraint characterising these households by setting to zero the minimum value of asset holding. Then, I deal with the latter by using a histogram with 250 bins for each discrete type of household, characterised by a skill-labour status pair.

Subsequently, I solve for the symmetric, no-inflation steady-state of the model. Following the literature, I define a symmetric steady state such that $\mathcal{S} = 1$ and $C + I = C^* + I^* = Y^*$. In this case, $X = \upsilon Y^*$, and we are in a situation of balanced trade at the steady state.

Finally, I need to collect the numerous equations characterizing the model. In particular, the discretization of the wealth distribution provides 250 equations per type of household, whilst 200 equations per type are provided by imposing that the household intertemporal and intratemporal optimality conditions hold with equality at the knots point of the splines. Furthermore, 29 equations are obtained from the problems of the patient consumers, the firms and the policy block. Given this system of equations characterising the equilibrium, linearisation around the previously computed steady state is carried out through automatic differentiation, and the model is solved as a rational expectation model using the method proposed by Sims (2002).

2.5.2 Calibration

The calibration of the model is carried out borrowing from the main resources in the literature on small open economies, and in particular the series of articles by Galí and Monacelli (2005, 2008, 2016), as well as the article by Serrano-Puente (2020). The latter in particular focuses on a closed-economy, Aiyagari model calibrated to match the Spanish economy, and studies the optimal progressivity of taxes in this context. It is natural, therefore, for me to leverage on his calibration of the heterogeneity as well as for the baseline parameters of my progressive tax specification.

The parameterisation describing the stochastic processes for exogenous shocks is reported in Table 2.5.1, and it is obtained from the calibration of a small open economy shock in Galí and Monacelli (2016). As I have outlined in the model section of the paper, I introduce four aggregate shocks in the economy - productivity, markup, monetary and world demand shock -, all in the form of an autoregressive process of order one. As such, for each shock, I need to specify an autoregressive coefficient and the volatility of the white noise component.

Parameter	**Value**	**Description**
ρ_a	0.75	Autocorrelation of Productivity Shock
σ_a	0.0064	Standard Deviation of Productivity Shock
ρ_μ	0.85	Autocorrelation of Markup Shock
σ_μ	0.025	Standard Deviation of Markup Shock
ρ_v	0.62	Autocorrelation of Monetary Shock
σ_v	0.004	Standard Deviation of Monetary Shock
ρ_y	0.9	Autocorrelation of World Demand Shock
σ_y	0.0057	Standard Deviation of World Demand Shock

Table 2.5.1: Calibration: Shock Processes

The calibration of structural parameters is described in Table 2.5.2. In particular, I calibrate the progressive tax function externally using the estimates in García-Miralles et al. (2019), which use an administrative panel dataset containing a stratified random sample of tax returns from Spanish State Agency of Tax Administration (2019). As can be seen in Fig. 2.5.1, the functional form in Equation (2.19) fits the 2015 household data very precisely, confirming the validity of using it in the model economy.

Heterogeneity is calibrated based on Serrano-Puente (2020), which targets wealth statistics in the 2019 wave of the Spanish Survey of Household Finances. The result of this calibration is reported in Table 2.5.3.

Note that this transition matrix represents the skill transition of households conditional on being employed and that the first level is normalised to one. Given that my idiosyncratic skill shock has three states, whereas the model in Serrano-Puente (2020)

Parameter	Value	Description
		Preferences
β	0.97	Discount Factor of Patient Households
$\hat{\beta}$	0.96	Discount Factor of Impatient Households
ψ_1	19.7	Labor Supply
ψ_2	2	Curvature of Labor Disutility
		Heterogeneity
ν	4	Impatient to Patient Households
s^e	12.80	Skill Level of the Patient Household
$s(h)$	[1, 2.71, 7.80]	Skill Levels of Impatient Households
		Technology
μ	1.2	Steady-State Level of Markup
θ	0.29	Calvo Probability of Price Rigidity
α	0.23	Coefficient on Capital in Production
δ	0.011	Depreciation Rate
		Policy
λ	0.8924	Average Level of Income Taxation
τ	0.1146	Progressivity of Income Taxation
λ	0.0524	Linear Term on Remaining Taxes
$\bar{T}_u$	0.3	Unemployment Benefit Replacement Rate
$\bar{s}_u$	0.66	Maximum Unemployment Benefit
ζ	1	Strength of Government Issuance Adjustment Costs
		Open Economy
υ	0.4	Degree of Home Bias
η	[1, 2]	Trade Elasticity of Substitution

Table 2.5.2: Calibration: Structural Parameters

Values		**s'=1**	**s'=2**	**s'=3**
1.00	**s=1**	89.58	10.36	0.06
2.71	**s=2**	2.42	96.54	1.04
7.80	**s=3**	0.01	3.60	96.39

Table 2.5.3: Transition Matrix for the Idiosyncratic Skill Shock

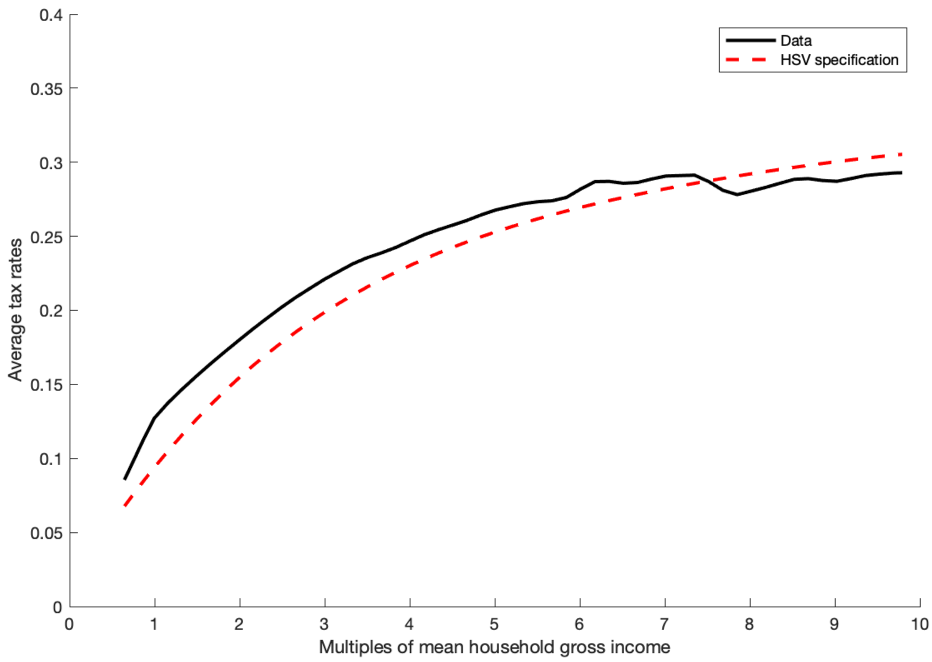

Figure 2.5.1: Fitting of the HSV specification to the data

considers four, I reduce the state space to the first three and treat the fourth, which amounts to what the literature on the subject has come to define as a "superstar" state that can only rarely be achieved, as the patient state. Although I do not allow impatient agents to become patient, the very high persistence of this state in the original reference justifies my choice. In fact, the existence of such a "superstar" state is used in the literature to obtain a sensible calibration of the wealth distribution. However, I do not need this modelling device, as I have already employed different discount factors between the two types of agents, in the spirit of Krusell and Smith (1998).

Table 2.5.4 reports the fit of the model to the main statistics of the wealth distribution of the Spanish economy. As it can be seen, despite the external calibration, the model fits the small open economy of reference satisfactorily, and provides a good benchmark to study the role of fiscal automatic stabilization in the context of alternative monetary policies.

Country	**Gini**	$< 40\%$	$40-60\%$	$60-80\%$	$80-100\%$
Spain (ES)	0.68	3.62	9.65	18.11	68.62
Baseline Economy (BE)	0.66	2.80	6.20	16.21	74.76

Table 2.5.4: Comparison of Wealth Distribution between the Baseline Economy (BE) and the Spanish Economy (ES)

2.6 Automatic stabilizers in the open economy

In this section, I apply the model of heterogeneous agents in the open economy to the study of the effectiveness of fiscal automatic stabilizers. In particular, I am interested in comparing two settings. On the one hand, I continue to approximate the optimal policy with a strict form of domestic inflation targeting, borrowing from the standard result in Galí and Monacelli (2005). On the other hand, I will consider a situation in which the small open economy is included in a monetary union that for my purpose corresponds to a hard peg of its domestic currency. The interest in the latter stems primarily from the fact that it represents a situation in which domestic monetary policy is impaired to deliver optimality of its behaviour due to international commitments, since it has delegated the decisions on monetary policy to a central bank that keeps union-wide inflation at zero. Furthermore, as pointed out in Galí and Monacelli (2005), this regime is the one that amplifies the most fluctuations in both output gap and inflation, and therefore the one in which a priori I could expect there to be more scope for the working of automatic stabilisers. Finally, it is important to notice that I am making a further simplifying assumption that, for the sake of simplicity, there is no distiction between foreign countries within and outside of the currency union. In what follows, I will first analyze impulse responses in order to point out meaningful differences, and then I will move to the comparison of second order moments.

2.6.1 Impulse responses

Figures 2.6.1 and 2.6.2 present the conditional responses to shocks in my baseline model with heterogeneous agents and automatic stabilizers.

An interesting parallel can be made across the two different monetary policy regimes, i.e. strict domestic inflation targeting and currency union. They illustrate the impor-

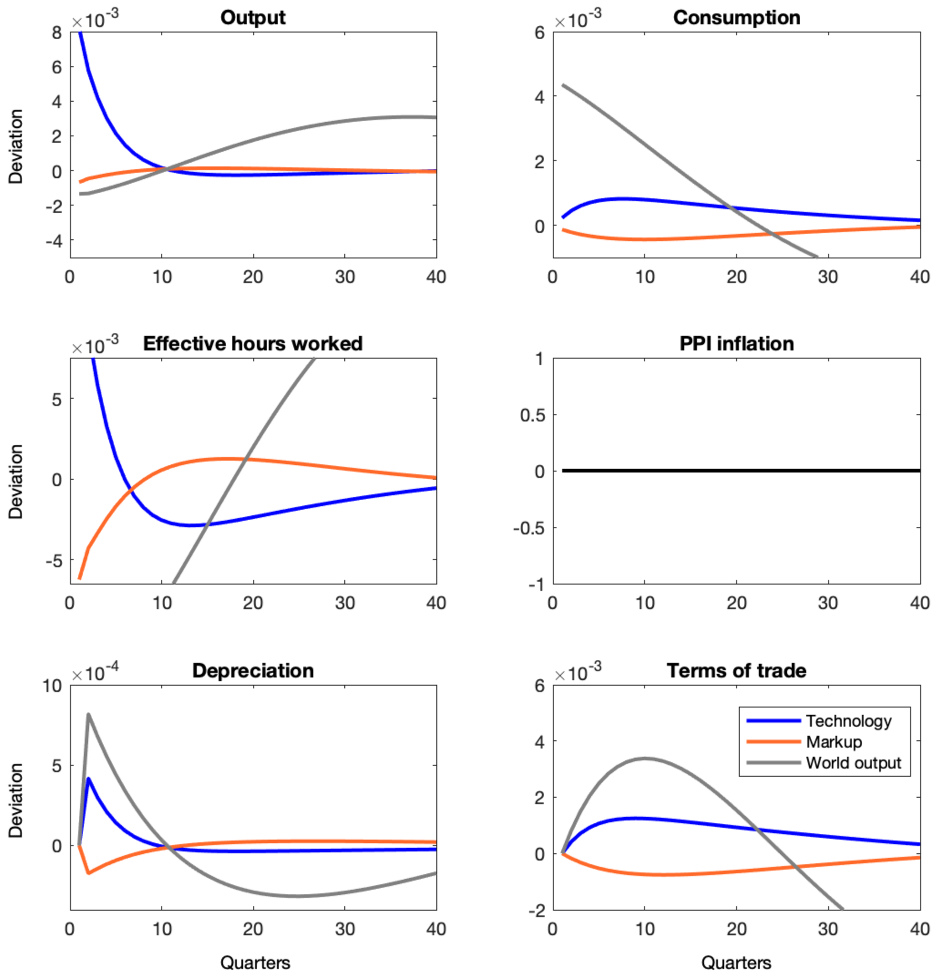

Figure 2.6.1: Impulse responses for the baseline model under domestic inflation targeting

tant result that the burden of adjustment of the terms of trade to maintain international competitiveness will fall on the variable that is not constrained, i.e. the nominal exchange rate in the first case and the domestic inflation rate in the latter, and this interchange leaves the behaviour of real variables largely unchanged. However, a notable exception is in the behaviour of aggregate output following a surge in aggregate world demand. In fact, in a currency union there cannot be the sharp depreciation characterizing the response of the flexible exchange rate regime, and therefore the domestic interest rate will remain stable at the same level as its foreign counterpart. This means that the surge in world demand will increase domestic aggregate output on impact. However, in order to maintain competitiveness in the international export market, the

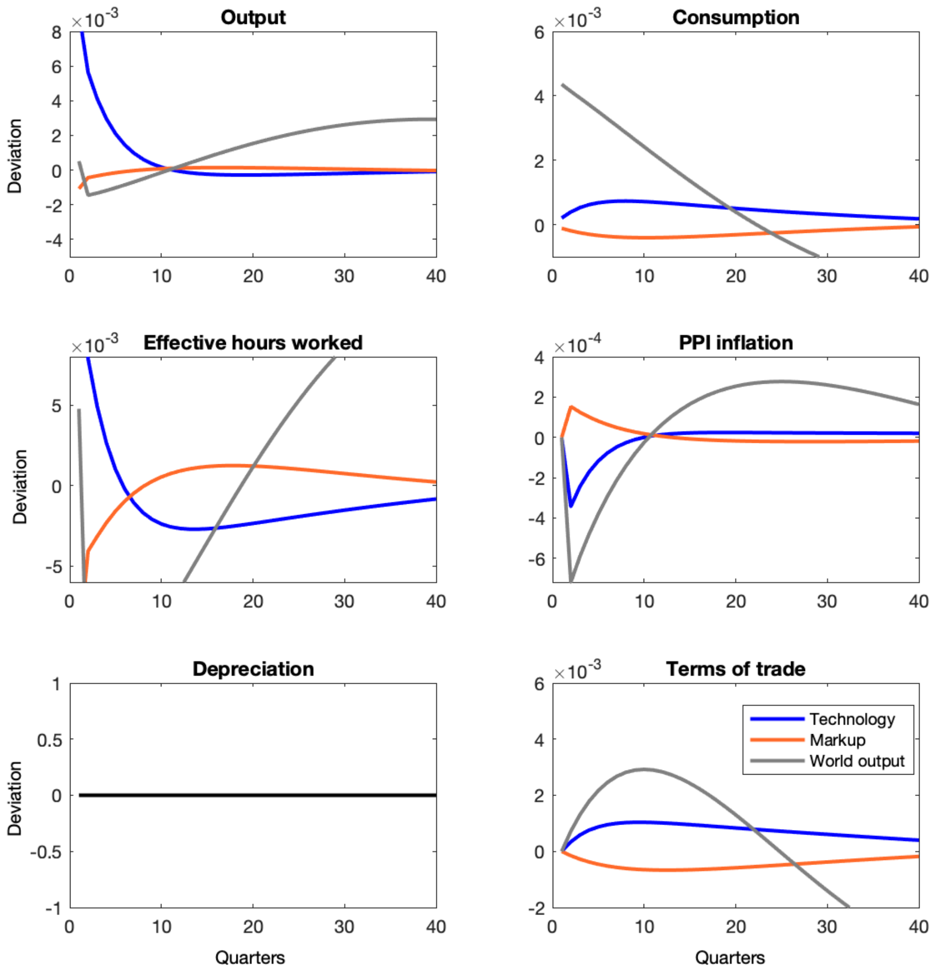

Figure 2.6.2: Impulse responses for the baseline model under a currency union

domestic economy will have to undergo a process of internal devaluation, in the form of a sharp drop in aggregate output, that will allow the domestic price level to fall, creating favourable terms of trade. Additionally, the future positive inflation expectations, coupled with the invariant nominal interest rate, will imply a lower real interest rate that will discourage savings, and hence domestic consumption will increase.

2.6.2 Simulation

In this section, I present the main result of the chapter, which comes from the simulation of the model in order to compute the unconditional moments of the macro aggregates of interest. In particular, I am going to explore the possibility of whether fiscal automatic stabilizers have an effect on the variance of the simulated time series, and whether such effect is larger in the setting in which domestic monetary policy is constrained away from domestic monetary autonomy and the possibility of operating according to a strict domestic inflation targeting rule, which in our setting will coincide with the context of a currency union.

Before moving to the quantitative conclusions of my model, I will lay out the intuitive channels through which automatic stabilizers could play a role in an international setting. Via the redistribution channel, a more potent set of automatic stabilizers could directly sustain aggregate domestic output by redistributing wealth across agents, and in particular towards constrained agents with a higher marginal propensity to consume. In the presence of traded good, these consumption could be unevenly distributed across final goods of different origins. In particular, the higher is the substitutability of traded goods the greater will be the role played by the relative price of imports to exports in this context, i.e. of the terms of trade. In other words, the strength of the expenditure switching effect will play an important part in determining whether automatic stabilisers will play a useful role in the stabilization of the economy. It is natural, given this argument, that I conduct my analysis conditional on several values for my trade elasticity of substitution, η. The empirical literature devoted to estimating this parameter has not converged to a consensus, providing a wide range of estimates. In particular, there are stark differences between trade and international macroeconomics academics. To provide an example of how wide the range of estimates is in the literature, Broda and Weinstein (2006) report a mean value between 4 and 6, whereas Hooper et al. (2000) estimate trade elasticities for G-7 countries between 0 and 0.6. More importantly for my purpose, model with low elasticities of substitution between Home and Foreign goods have been shown to provide a more suitable description of the international business cycles, and therefore have been commonly used in such literature. In order to remain agnostic on the actual value of this parameter, I will allow for two different values: moderate substitutability $\eta = 1$, and high substitutability, $\eta = 2$. First, I am going to consider a crude measure of the potency of automatic stabilizers. Following Smyth (1966), I will quantify the effects of a reduction in automatic stabilization, i.e. a proportional fall of the income tax rate and the level of unemployment benefits, through the stabilization coefficient, defined as

$$\mathbb{S} \equiv \frac{V_L}{V_B} - 1 \tag{2.28}$$

where V_L is the variance of the aggregate time series of interest conditional on the reduction in stabilization, and V_B is the value it takes in our baseline model. As pointed out by McKay and Reis (2016), this addresses precisely the question of whether automatic stabilizers can reduce fluctuations in the business cycle.

In Table 2.6.1, I report the stabilization coefficient for both output and the consumption aggregate conditional on the monetary policy regime and the substitutability of domestic and foreign final goods. In this exercise, I consider a reduction in the level of fiscal automatic stabilization in both the progressivity of the tax system and the generosity of the unemployment benefits. In particular, I replace the progressive taxation with a flat tax that provides the same amount of fiscal revenues in steady state, but, in virtue of its flatness, loses the role of automatic stabilization. Then, I reduce the unemployment benefits to 20% of the value they have in the baseline calibration. Clearly, I cannot eliminate this source of income altogether, as this would leave unemployed agents at the borrowing constraint with no means to finance their consumption.

	Output			**Consumption**		
	DIT	PEG	DITR	DIT	PEG	DITR
$\eta = 1$	-0.36	-0.32	-0.93	-0.03	-0.08	-0.89
$\eta = 2$	-0.08	-0.06	-0.78	0.003	0.20	-0.82
	Hours			**RER**		
	DIT	PEG	DITR	DIT	PEG	DITR
$\eta = 1$	-0.41	-0.32	-0.96	-0.29	-0.31	-0.89
$\eta = 2$	-0.16	-0.05	-0.90	-0.04	-0.07	-0.76

Table 2.6.1: Change in Quarterly Volatility after a Reduction in Automatic Stabilizers

The first regularity that can be gauged from Table 2.6.1 is a reduction of the automatic stabilizers according to the experiment laid out above induces a reduction in the variance of macroeconomic aggregate time series under most of the structural regimes considered. This is a feature that has already been noticed in the paper by McKay and Reis (2016), which studies a similar question in the context of the U.S., conceived as a closed economy. However, the effects in my baseline calibration is much larger than in the cited paper. The reason for this is to be found in the different level of progressivity of the fiscal system in the U.S. vs. Spain, considered as my model small open economy. The latter in fact is higher vis-à-vis the United States, and as such the marginal tax rate faced by households exhibits greater variation throughout the business cycle, which induces a larger effect on the second moment. Furthermore, the higher degree of progressivity of the tax system in continental Europe also worsens the reinforcing argument between sticky prices and monetary policy, i.e., that changes in nominal interest rate have only a partial pass-through onto the effective interest rate according to which households make their saving decisions, which hence induces more volatile responses of output and hours. For these reasons, a reduction in stabilizers is actually beneficial in terms of a reduction in the volatility of the business cycle aggregates.

Going into more details, one of the features that is apparent from the table is the high sensitivity of the stabilization coefficient defined in Equation (2.28) to different assumptions about the model, and, in particular, the monetary policy regime considered and the structural parameter η, representing the trade elasticity of substitution between domestic and imported goods.

In particular, an increase in this parameter induces a stronger expenditure switching effect in response to movements in international relative prices, which in itself is a form of automatic stabilization. This has two effects. On the one hand, it lowers the volatility of individual consumption, as agents are more willing to switch across goods of different origin. On the other hand, it increases the importance of the ability of relative prices in changing to induce such substitution. Given price stickiness in the economy, the latter is impaired in the context of a peg, as the aggregate price level adjusts more slowly than the exchange rate under the inflation targeting regime, which is an argument that bears back to Mussa (1986)'s pointing to the "excess smoothness" of the terms of trade in a peg with respect to a flexible exchange rate regime. Therefore, the lower redistribution due to my experiment will have a lower effective in the inflation targeting regime, in which movements of the exchange rate make up partly for the loss in fiscal automatic stabilization.

Given the wide range of estimates that the literature has uncovered for this parameter, my analysis suggests that the original hypothesis of fiscal automatic stabilization being more powerful under a fixed exchange rate regime, as a situation in which monetary policy cannot achieve optimal stabilization, is a possibility for some real world economies, depending on the type of trade that they are engaged in with the rest of the world.

Households patience and the distribution of wealth The distribution of wealth, by affecting the level of the marginal propensity to consume and therefore how consumption changes in response to changes in income, necessarily plays an important role in the effectiveness of automatic stabilizers. For this reason, it is interesting to study how the latter changes given changes in the wealth distribution. In particular, I will study a more unequal economy in steady state by changing the level of patience of agent and adopting the parameterization in McKay and Reis (2016). The latter paper is based on the U.S., which is much more unequal wealth-wise than Spain, with a Gini coefficient of 0.895 in 2019 according to the Global Wealth Databook (2019) by Credit Suisse compared to the 0.68 of the Spanish economy, and, as such, their calibration yields discount coefficients of agents at $\beta_h = 0.98$ and $\beta_e = 0.99$ for the impatient and the patient individuals respectively. In my model, this creates correctly a larger wealth inequality, that can be summarized by a Gini coefficient of 0.85. For the purpose of this comparison, I will limit myself to studying the case of a unitary trade elasticity.

I compute the coefficients of variation for my main experiment under this alternative calibration in a way similar to what I have done above. The reduction in fiscal automatic stabilization has a lower impact on the volatility of output and aggregate hours, and the reason for this is to be found in the third real variable. The increased inequality strengthens the redistributionary role of fiscal automatic stabilization, and, when this is weakened in the economy, the volatility of consumption increases considerably. Since consumption represents a sizable portion of aggregate output, the increase in the volatility of this variable represents a counteracting force with respect to the channels outlined above. Moreover, it is interesting to notice that the effect on consumption is stronger under the peg. This provides an interesting insight into the benefit of fiscal automatic stabilization in small, open, emerging market economies, that are likely to share a combination of structural factors that heavily increase the benefits provided by fiscal automatic stabilizers in the form of lower consumption volatility: a fixed exchange rate regime, a high level of wealth inequality, and trade in commodities or goods that have a large trade elasticity of substitution.

2.6.3 Simple interest rate rule

In the following section, I explore the implications of an alternative policy rule that may be perceived as more realistic than the stylized ones that provided a useful, clear benchmark for my baseline analysis. In particular, I first assume a standard domestic-inflation-targeting Taylor-rule

$$i_t = i^* + \phi\left(\Pi_{H,t} - 1\right) + v_{m,t}. \tag{2.29}$$

First, the adoption of a Taylor-type rule such as the one in Equation (2.29) provides a useful robustness check against which to compare my findings. In fact, a simple rule of this kind approximates sufficiently well a strict domestic inflation targeting regime, as pointed out in Galí and Monacelli (2005). Then, through the introduction of this rule, I can consider an additional shock $v_{m,t}$, namely a monetary policy shock, which is being modelled as an unexpected deviation of the nominal interest rate from the path prescribed by the rule itself, and follows an AR(1) process.

Unlike the benchmark analysis above, under this more realistic regime, the performance of the automatic stabilisers with respect to the volatility of all the variables considered is negative and large in absolute value. Therefore, it is interesting to see how an imperfect form of inflation targeting, such as the one that this rule suggest and which is arguably the real-world counterpart of the one considered above, makes such a large impact on the efficacy of stabilizers.

Furthermore, I document a monotonicity of this effect in the substitutability of final consumption goods. In fact, the change in the variance of output declines when moving to a higher degree of substitutability across domestic and foreign goods. The reason for such a strong decrease in variance is akin to the one already outlined in the previous section, and revolves around the interaction of progressivity of interest income and monetary policy shock. Such a fiscal system induces a lower sensitivity of the actual interest rate to policy changes, and a larger volatility of output and hours. This is only mildly attenuated by the expenditure switching effect deriving from a higher calibration of η. Nevertheless, this observation points towards the existence of greater benefits in designing a more substantial package of automatic stabilizers in a currency union with respect to an independent monetary policy, at least when the latter follows a simple Taylor-type rule. Likely, a form of flexible domestic inflation rate targeting is better at approximating the optimal policy in this setting than the two policies considered above, and this will restrict the scope for automatic stabilizers.

Adopting a robust system of automatic stabilizers, which ensures greater wealth redistribution benefiting insured households, doesn't inherently decrease the variability of output and consumption in a small open economy. Their effectiveness is contingent upon the interplay between the substitutability of domestic and foreign goods and the prevailing monetary policy. When monetary policies offer less flexibility in terms of trade adjustments, and trade elasticity of substitution is high, automatic stabilizers better stabilize output, but may be less effective or even detrimental for consumption. It's assumed in this context that reducing volatility around a steady state is optimal for agent welfare, providing a practical real-life benchmark. However, the steady state isn't necessarily efficient in this model or reality. This research doesn't delve into the welfare implications of fiscal stabilization due to complexities in defining social welfare in varied agent scenarios, but it offers a foundation for future exploration.

2.7 Conclusions

In this paper, I have analyzed a New-Keynesian small open economy with incomplete financial markets in which a fraction of the households can trade only in domestic-risk free bonds and are subject to borrowing constraints. This feature prevents them from insuring against two types of idiosyncratic shocks affecting their skill level and labour force status. As a result, fluctuations in the real exchange rate, i.e. the relative price of foreign and domestic final consumption good, play a stronger role in determining the intratemporal choice of consumption in this economy and, therefore, the pass-through onto output of shocks. This is due to the fact that the introduction of incomplete markets dilutes the standard international risk-sharing result, limiting the magnitude of consumption smoothing across time and states.

Subsequently, I have applied this model to the study of the role of stabilizing fiscal policy in such a small open economy. For this purpose, I have focused on a narrower set of automatic stabilizers than what exist in the legislation of several developed economies, namely a progressive labour income tax system and unemployment benefits. Despite the importance of including a more realistic selection of fiscal tools, I believe that focusing on these two simple instruments help solidify the understanding of the role of the redistribution channel, which has been identified in the literature as the main contributor to the potency of automatic stabilizers, without much losses from a qualitative point of view. Additionally, these stabilizers are the ones that are traditionally studied in the literature on the topic. The aim of my exercise was to uncover whether fiscal stabilizers could be more efficacious in situations in which monetary policy is hindered from stabilising fluctuations in the domestic business cycle because of an alternative mandate. For this reason, I have compared two alternative monetary policy regimes, strict domestic inflation targeting and a currency union modelled as a fixed peg.

The simulation of the model under three different types of shocks shows that automatic stabilizers, by redistributing wealth in the economy from insured agents towards the ones subject to idiosyncratic risk, are more powerful at reducing the volatility of consumption within the currency union in the case of higher substitutability between domestic and foreign final consumption goods. In fact, when goods are stronger substitutes and the terms of trade are less flexible because their adjustment suffers from nominal rigidities, i.e. under strict exchange rate targeting, the higher volatility induced by the distortionary taxation system is counterbalanced by the lower volatility in consumption. Therefore, reducing these fiscal provisions across the board induces a rise in the aggregate consumption volatility which is not counterbalanced by the moderate fall in output volatility, which is one order of magnitude smaller.

Because of the inherent stylization of the domestic targeting regime considered initially, I have then proceeded to analyze the case of more realistic monetary policy rule in the forms of a simple interest rate rule, which have been shown to approximate well monetary policy in inflation targeting regimes. Such investigation has provided further substantive evidence of the interplay between the nature of trade and the monetary policy regime when quantifying the magnitude of the stabilization provided by automatic stabilizers. Furthermore, insofar as the simple interest rate rule can be viewed as a better approximation of the optimal monetary policy than the two regimes considered in my benchmark analysis above, these results also consolidate the intuition that the role of these fiscal tools will be enhanced when domestic monetary policy is impaired because of delegation to an entity with union-wide jurisdiction.

Given the results in the paper, I believe that the introduction of heterogeneous agents in a small open economy can provide for some interesting further avenues for research. In particular, it would be interesting to generalise the model to a full-fledged two-countries, large open economies general equilibrium setting to explore whether the conclusions hold true in such a setting. Such a model would allow the quantification of "stabilization spillovers" onto trading partners from a more powerful system of welfare redistribution in one country. Furthermore, it could be interesting to quantify the magnitude of the effect given shocks of different origins, and in particular coming from within versus outside the currency union. Finally, depending on the nature of their trade, countries may have an incentive to come together and design a common optimal scheme of automatic stabilizers to prevent the cannibalization of the demand for the goods produced by some countries by trading partner with a more advanced level of redistribution.

Appendices

2.A Derivation of the equilibrium conditions

2.A.1 Households

The households problem can be solved in steps. First, I characterize the optimal allocation of consumption between imported goods of different origin, and domestic and imported goods. Then, I look at the extensive margin of consumption, as well as the allocation of hours worked and savings.

Intratemporal margin of consumption and investment allocation The optimality conditions describing this step are very similar for both patient and impatient consumers, and for consumption and investment goods. Therefore, I will adopt the notation of the former, but the same conditions will hold also for the latter. Additionally, I will consider only the case of consumption. The problem is that of maximizing the consumption aggregate subject to a fixed level of expenditure. For the allocation of expenditure across goods of foreign origins, such optimization looks as follows

$\max_{C^e_{i,t}} \left(\int_0^1 C^e_{i,t}{}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$

s.t. $\int_0^1 P_{i,t} C^e_{i,t} di = E_t$.

Clearly, an analogous problem can be written also for the allocation of expenditures across goods of domestic and foreign origin. The first order conditions for both problems yield

$$C^e_{i,t} = \left(\frac{P_{i,t}}{P_{F,t}} \right)^{-\gamma} C^e_{F,t}$$

and

$$C^e_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C^e_t \quad \text{and} \quad C^e_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C^e_t.$$

This characterization is useful because it allows us to rewrite the budget constraint in terms of the consumption aggregate, as at the optimum the following equalities hold

$$\int_0^1 P_{i,t}C_{i,t} = P_{F,t}C_{F,t} \quad \text{and} \quad P_{H,t}C_{H,t} + P_{F,t}C_{F,t} = P_tC_t.$$

Standard household optimization problem By taking first order conditions of the patient consumer problem one obtains

$$\begin{aligned}
\frac{1}{C^e_t} &= \beta E_t\left\{\frac{(1+i_t)}{\Pi}\frac{1}{C^e_{t+1}}\right\} \\
C^e_t\psi_1 N_t^{\psi_2} &= (1-\tau)W_t s^e_t \\
\frac{1}{C^e_t} &= \beta E_t\left\{\frac{(1+r_t-\delta)}{C^e_{t+1}}\right\}.
\end{aligned}$$

Additionally, patient households can trade on a complete set of Arrow securities traded internationally. This provides the following first order condition,

$$\frac{V_{t,t+1}}{C^e_t} = \xi_{t,t+1}\beta\left\{\frac{1}{C^e_{t+1}\Pi_{t+1}}\right\}.$$

Assuming that such relations holds also at the world economy, and that the population for the rest of the world is made up exclusively by patient people, we can obtain the following risk-sharing relations

$$C^e_t = \vartheta Q_t C^*_t$$

where ϑ is a coefficient that depends only on the initial relative expenditure shares between the domestic country and the rest of the world, and it is parameterized so as that this equation holds in the steady state.

By following the same steps, one obtains similar first order conditions for also for the impatient household for what concerns the choice of consumption, labour effort in case of the agent is employed, and domestic bond savings.

2.A.2 Firms

Intermediate good firms The first order conditions with respect to $L_{t+k}(j)$ and $K_{t+k}(j)$ is

$$\frac{P_{t+k}}{P_{H,t+k}}W_{t+k} = (1-\alpha)M_{t+k}A_{t+k}K_{t+k}(j)^{\alpha}L_{t+k}(j)^{-\alpha}$$
$$\frac{P_{t+k}}{P_{H,t+k}}r_{t+k} = \alpha M_{t+k}A_{t+k}K_{t+k}(j)^{\alpha-1}L_{t+k}(j)^{1-\alpha}$$

which allows already to express dividends as a function of factor prices

$$\Pi_t = \int_0^1 \Pi_t(j)dj = Y_t - M_t A_t L_t.$$

Then, turning to the optimal price setting problem[1], we obtain

$$\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k}(1-\theta)^k \left[\frac{1}{1-\mu} \left(\frac{P^*_{H,t}}{P_{H,t+k}} \right)^{\frac{\mu}{1-\mu}} \frac{Y_{t+k}}{P_{H,t+k}} - M_{t+k}\frac{\mu}{1-\mu} \left(\frac{P^*_{H,t}}{P_{H,t+k}} \right)^{\frac{\mu}{1-\mu}-1} \frac{Y_{t+k}}{P_{H,t+k}} \right] = 0,$$

which provides a solution for $P^*_{H,t}$

$$\frac{P^*_{H,t}}{P_{H,t}} = \frac{P_{H,t}\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k}(1-\theta)^k M_{t+k}\mu \left(\frac{P_{H,t}}{P_{H,t+k}} \right)^{\frac{\mu}{1-\mu}-1} \frac{Y_{t+k}}{P_{H,t+k}}}{P_{H,t}\mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k}(1-\theta)^k \left(\frac{P_{H,t}}{P_{H,t+k}} \right)^{\frac{\mu}{1-\mu}} \frac{Y_{t+k}}{P_{H,t+k}}} \equiv \frac{\bar{P}^A_t}{\bar{P}^B_t}.$$

We can also rewrite $\bar{P}^A_t$ and $\bar{P}^B_t$ recursively

$$\bar{P}^A_t = M_t\mu_t Y_{t+k} + \mathbb{E}_t \left[Q_{t,t+1}(1-\theta)\Pi_{H,t+1}^{\frac{-\mu}{1-\mu}} \bar{P}^A_{t+1} \right]$$
$$\bar{P}^B_t = Y_{t+k} + \mathbb{E}_t \left[Q_{t,t+1}(1-\theta)\Pi_{H,t+1}^{\frac{-\mu}{1-\mu}-1} \bar{P}^B_{t+1} \right].$$

We then express the relationship between $P^*_{H,t}$ and $\Pi_{H,t}$. The price index for the final good is

$$P_{H,t} = \left(\int_0^1 P_t(j)^{\frac{1}{1-\mu}} \right)^{1-\mu}$$

[1] For the sake of keeping light on notation, I have dropped the time subscript on μ_t.

and given the assumption of Calvo pricing we obtain

$$P_{H,t} = \left((1-\theta) \int_0^1 P_{H,t-1}(j)^{\frac{1}{1-\mu}} dj + \theta P^{*\frac{1}{1-\mu}}_{H,t} \right)^{1-\mu}$$
$$= \left((1-\theta) P^{\frac{1}{1-\mu}}_{H,t-1} + \theta P^{*\frac{1}{1-\mu}}_{H,t} \right)^{1-\mu}$$

and so

$$\Pi_{H,t} = \left(\frac{1-\theta}{1-\theta \left(\frac{P^*_{H,t}}{P_{H,t}} \right)^{\frac{1}{1-\mu}}} \right)^{1-\mu}.$$

Finally, we can combine the production function of the intermediate firm and the demand curve it faces to obtain

$$\left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{\frac{\mu}{1-\mu}} Y_t = A_t L_t(j) \quad \text{and}$$

$$\int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{\frac{\mu}{1-\mu}} dj Y_t = A_t \int_0^1 L_t(j) dj,$$

which combined with market clearing results in

$$S_t Y_t = A_t K_t^{\alpha} L_t^{1-alpha},$$

where S_t characterizes the efficiency loss due to price dispersion, defined as

$$S_t \equiv \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{\frac{\mu}{1-\mu}} dj,$$

and it evolves as

$$S_t = (1-\theta) S_{t-1} \Pi_{H,t}^{\frac{-\mu}{1-\mu}} + \theta \left(\frac{P^*_{H,t}}{P_{H,t}} \right)^{\frac{\mu}{1-\mu}}$$

Chapter 3

Monetary-fiscal interaction and the liquidity of government debt

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Abstract

We study how the interaction of monetary and fiscal policy alters households' saving incentives by affecting asset returns and the implications of this interaction on the aggregate response and stabilization of the economy. In our model, agents can save in assets with different liquidity profiles to insure against idiosyncratic risk. Policy mixes affect saving incentives differently according to their effect on the liquidity risk premium, and the effect this has on economic dynamics following standard shocks. Two competing forces are at play, a self-insurance-driven demand channel and a policy-driven supply channel, and that the relative strength of the two is tightly linked to the policy mix that is in place. Furthermore, we show that, in regimes for which there is a strong increase in investment, the effect of this on labour demand is not high enough to represent a sizable source of indirect insurance for agents that rely on labour income for their consumption.

Keywords: Monetary-fiscal interaction, Public debt liquidity, Limited heterogeneity.
J.E.L. codes: E21, E44, E52, E62, E63.

3.1 Introduction

A burgeoning research agenda has highlighted the empirical differences in portfolios across the wealth distribution and its relevance in terms of policy effectiveness and macroeconomic dynamics. In a seminal contribution, Kaplan et al. (2018) distinguish types of households by the prevalence of liquid or illiquid assets in their portfolios and describe the implications of different type of households for the transmission of monetary policy. Bayer et al. (2023) point to the importance of the liquidity channel of fiscal policy for its overall effect: the issuance of liquid government debt to finance discretionary government spending leads to a fall in the liquidity risk premium, thereby inducing the households to save more in liquid assets that improve their ability to smooth consumption after negative shocks. We analyze a novel channel through which the interaction of monetary and fiscal policy shapes economic stability and recovery, i.e., via its effect on the portfolio choice of private agents. The purpose of this paper is to provide a comprehensive study of how different combinations of active and passive policies affect the liquidity properties of the portfolios of different types of agents in the economy, and, through this, the aggregate response and stabilization of the economy.

For this, we use a New-Keynesian model with limited household heterogeneity in which three types of agents differ in their ability to trade in financial assets, in the spirit of Bilbiie (2019). The model features incomplete financial markets, on which agents can only trade liquid, nominal government bonds and an illiquid, real physical asset, i.e., capital. Leaving a more detailed treatment of the characteristics of each agent in the model for the respective section below, we introduce: capitalists, who are able to trade in both markets; savers, who can only adjust their liquid asset portfolio and cannot access the return from capital investments for consumption purposes; and hand-to-mouth households, who cannot engage in the purchase of any asset, therefore relying on their labour income and previously accumulated government bonds for their consumption. Households are subject to idiosyncratic shocks that make them switch type according to an exogenous transition probability. When moving across types, households may only carry with them their government bonds. This characteristic defines the liquidity of this asset with respect to capital.

Additionally, the presence of nominal government debt in a model with idiosyncratic uncertainty serves the further purpose of extending the range of policy mixes that we are able to consider in our analysis. In particular, this modelling choice makes the price level always determinate in our model. In fact, when government bonds are nominal, shifts in the price level affect the real value of debt and thus affect real aggregate demand.

By considering the monetary-fiscal regime together with the portfolio choice, we are able to explore two different channels. First, due to the liquidity friction, government bonds are the preferred assets to build up a buffer stock of savings to partially insure against idiosyncratic uncertainty. Therefore, regimes that worsen the consumption ability of the hand-to-mouth by lowering their labour income or their bond income from previous states would increase the demand for self-insurance of the capitalist type, leading to a shift in their portfolios towards more liquid assets, *ceteris paribus.* This is what we will label the "self-insurance" channel, and it works through asset demand. In the paper, we highlight the importance of this "self-insurance" channel for the dynamics of the liquidity premium, taken as encompassing the trade-off between investing in the liquid and illiquid asset, by means of an equation that relates it directly to consumption differentials across types. Then, the policy regime will also determine the change in the supply of nominal government debt, due to the change in the interest payment on its stock and the strength through which the government will curb the movement in debt. This is the "supply" channel and it will have a further effect on the liquidity premium as the asset returns will have to adjust for markets to clear. Different policy mixes will affect the relative strength of these two channels and therefore provide different results in terms of the relationship between the liquidity premium and the portfolio choice of households.

We then use the model to answer questions regarding the aggregate implications of our novel portfolio channel under different monetary and fiscal regimes. In particular, in our first experiment we explore a standard shock in the literature, i.e., a technology shock. Our objective is two-fold. On the one hand, we want to gauge the relative strength of the two channels highlighted above under different policy regimes. On the other hand, we want to explore the relative strength of the trade-off between the "self-insurance" channel and the "insurance-through-investment" channel. The latter comes from the fact that whilst a decline in liquid asset is negative in principle because of the lower ability of agents to smooth consumption, a concomitant increase in capital investment may represent an indirect form of insurance, by potentially increasing the demand for labour and therefore the income of the hand-to-mouth type.

Through this experiment, we show first that in regimes in which there is a large change in government debt, for example because the monetary policy changes the interest rate strongly and the fiscal policy does not intervene through taxes (active monetary, active fiscal regime), the supply channel reinforces the gap in the liquidity premium, inducing the profit motive of capitalist to prevail. In this case, an increase in the liquidity premium actually leads capitalist to move towards less liquid assets, spurring an increase in investment. Regimes for which the change in government debt is more tamed, however, see a dominance of the self-insurance mechanism, whereby a worsening of the risky state induces a shift of capitalists towards the more liquid asset. Then, we show that in our model, in which we adopt a standard Cobb-Douglas production function, the "investment-through-insurance" channel highlighted above is very weak, due to the poor complementarity between the two productive assets. This implies that the building of more capital stock does not represent a viable substitute to liquid savings for agents in the hand-to-mouth state.

In our second experiment, we look at the effects of a fiscal stimulus with different combinations of the monetary/fiscal policy mix. An increase in government spending that produces a strong income effect for the hand-to-mouth agents reduces the "self-insurance" channel and induces capitalists to swap bonds for capital. At the same time, the fiscal stimulus increases the bond supply. We show that, once again, the relative strength of these two effects depends on the policy mix.

When monetary policy is active the supply channel dominates independently from the actions put in place by the fiscal authority. Whereas a more active fiscal policy generates a larger cumulative fiscal multiplier, capitalists keep investing in bonds at the expenses of capital. However, with passive monetary policy a different picture emerges. The fiscal stimulus now induces a larger income effect on the hand-to-mouth which pushes the liquidity premium further down and makes the "self-insurance" channel stronger. Under both fiscal policy scenarios capitalists now substitute bonds with capital, which generates substantially larger fiscal multipliers compared to the active monetary policy simulations.

3.1.1 Literature review

Understanding monetary-fiscal policy dynamics is crucial to the formulation and implementation of effective policy measures aimed at promoting economic growth and stability. We see our paper contributing and merging two streams of the existing literature, i.e., the study of monetary and fiscal interactions, and the aggregate consequences of households' portfolio choices, both of which are extremely prolific.

First, we delve into the evolving discourse surrounding the interplay between monetary and fiscal policies. Initially, Sargent and Wallace (1981) introduced the notion of "unpleasant monetarist arithmetic", illustrating the quandary faced by a central bank dedicated to curbing inflation while needing to accommodate inherently inflationary fiscal policies. Building upon this, Sargent (2013) extended the discussion to show how shifts in fiscal policy could undermine a central bank's commitment to maintaining low inflation. This research underscored the significance of fiscal policy expectations in influencing the efficacy of monetary policy, adding a crucial dimension to the discourse on the interaction of fiscal and monetary policies. Subsequently, Leeper (1991) introduced the concepts of "active" and "passive" monetary and fiscal policies, and illustrated how both monetary and fiscal policies are endogenously determined within a model. Leeper's analysis highlighted the pivotal role of the chosen policy regime, whether fiscal or monetary policy is active or passive, in shaping the economy's response to shocks.

Building upon these foundations, a further series of studies explored the implications of policy rules and regime switching in the context of monetary and fiscal policy interactions. Davig et al. (2006) and Davig and Leeper (2011) explored the potential for regime switching over time. This added a dynamic dimension to the analysis of monetary and fiscal policy interactions, moving away from the static characterization previously adopted. Their work opened the door to the examination of how variations in policy rules over time, responding to economic conditions, can significantly impact economic stability and performance. The importance of considering regime switching over time was also emphasized by Canzoneri et al. (2008, 2010), Bianchi and Melosi

(2019), and Bianchi et al. (2020), enriching the understanding of how policy interplay varies over time and under different economic circumstances.

Additionally, leveraging the work of Hagedorn (2018), the exploration of policy interaction is extended beyond the traditional parameter space. To the best of our knowledge, ours is the first paper that combines Hagedorn et al's set up and a tractable heterogeneous agent New-Keynesian model (THANK) á la Bilbiie to study the dynamic evolution of the economy under different policy combinations. This allows for a broader, more comprehensive investigation of how variations in the fiscal-monetary policy mix can impact different aspects of the economy, thus significantly expanding the scope of this field of study.

Then, our study adds to the dialogue on the aggregate consequences of households' portfolio decisions in the presence of assets varying by their liquidity attributes. The role of government debt as liquidity, previously addressed by Woodford (1990), has recently gained renewed attention, as evidenced by studies such as Bayer et al. (2023), Bilbiie et al. (2022) and Bilbiie (2019). While Bayer et al. (2023) strive to quantitatively identify the liquidity channel's influence on the effectiveness of fiscal policy using a model with a fully heterogeneous population of households, our study adopts an approach more closely aligned with that of Bilbiie et al. (2022) and Bilbiie (2019), focusing on limited heterogeneity among household types. This method allows us to retain key elements of the larger, more complex models while clearly illustrating the proposed novel mechanism of transmission.

The paper is structured as follows. In Section 3.2 we outline our three-agents, New Keynesian model with monetary and nominal fiscal policy. Then, in Section 3.3 we explore the results of our experiments. In particular, we first look at a technology shock to answer the question of which of the channels outlined above prevails under different regimes, and then we move to the transmission of a fiscal shock, to study what the addition of the portfolio choice implies for the transmission of fiscal policy given different policy stances. We conclude by outlining further work that we want to carry out in further iterations of this work.

3.2 The benchmark model

In this section, we present the model economy. As the main action takes place on the household side of the economy, we will be mainly focusing on detailing this. The production side is going to follow the standard New-Keynesian specification (see Galí, 2015), with CES final good producers and monopolistically competitive, Rotemberg-pricing intermediate good firms.

3.2.1 Households

The household side is modelled in a way that can be defined as Luetticke (2020) meets Bilbiie et al. (2022) in that we are going to borrow the infrequent capital trading friction from the former and introduce it into the latter model of limited heterogeneity. In particular, we are going to focus on a three-agent model, in which households will switch between such three states with exogenous transition probabilities governed by the matrix Λ with generic component $\lambda_{i,j}$ for $(i,j) \in \{H, S, K\}^2$ as the transition probability of moving from state i to state j. The difference among the three agents is going to be in their ability to access financial markets to insure against future income shocks. In particular, capitalists (indexed by K) can access capital markets in a way that allows them to adjust both their bond and capital holdings, whereas savers (indexed by S) will only be able to adjust and ripe the returns from government bonds. Finally, hand-to-mouth agents (H) will consume their labour income every period, as well as their saving income from bonds that have been saved by other types in previous periods. It is in this sense that we define government bonds as a liquid asset and capital as an illiquid one, i.e., in terms of their consumption-smoothing insurance value to households. We think of each type of agent as living on an island populated by their own type. Bonds can be carried across such islands, though they can only be adjusted on island K and S, and, as such, forward-looking agents will consider the consumption risk moving forward in their portfolio decision, and, due to our analytical set-up, we will show this by means of an appropriate equation in a section below. However, the benefits from holding capital can only be enjoyed on the K island, therefore presenting a trade-off between the higher return commanded by its illiquidity and the desire to smooth consumption across states.

3.2.1.1 Population and financial accounting

We can think about the three types of consumers as inhabiting three distinct islands. We normalize the total population in the economy to 1 and denote with $\Pi_{i,t}$ for $i \in \{H, S, K\}$ the share of population on each of the islands. Given our normalization, we have that $1 - \Pi_{S,t} - \Pi_{K,t}$. The evolution of each of these two shares follows the following laws of motion:

$$\Pi_{K,t+1} = \lambda_{K,K}\Pi_{K,t} + \lambda_{S,K}\Pi_{N,t} + \lambda_{H,K}(1 - \Pi_{K,t} - \Pi_{S,t}) \tag{3.1}$$

$$\Pi_{N,t+1} = \lambda_{K,S}\Pi_{K,t} + \lambda_{S,S}\Pi_{N,t} + \lambda_{H,S}(1 - \Pi_{K,t} - \Pi_{S,t}). \tag{3.2}$$

We look for the stationary distribution by setting $\Pi_{i,t+1} = \Pi_{i,t} = \Pi_i$ in the system above which can be solved for the stationary shares as a function of the exogenous transition probabilities. From now onward, when referring to population shares we mean the stationary ones, therefore omitting time subscripts.

We follow the notation in Bilbiie et al. (2022) and call B^j_{t+1} the beginning-of-period $t+1$ holdings, with a "bold" letter $\mathbb{B}$ denoting island-wide stocks, and Z^j_{t+1} $j \in K, N$ the end-of-period t per-capita holdings of bonds of agent j, which the agents can choose before they learn about their type. The former evolve given the latter as follows:

$$\mathbb{B}^K_{t+1} = \Pi_K B^K_{t+1} = \lambda_{K,K}\Pi_K Z^K_{t+1} + \lambda_{S,K}\Pi_S Z^S_{t+1} \tag{3.3}$$

$$\mathbb{B}^S_{t+1} = \Pi_S B^S_{t+1} = \lambda_{K,S}\Pi_K Z^K_{t+1} + \lambda_{S,S}\Pi_S Z^S_{t+1} \tag{3.4}$$

$$\mathbb{B}^H_{t+1} = (1 - \Pi_K - \Pi_S) B^H_{t+1} = \lambda_{K,H}\Pi_K Z^K_{t+1} + \lambda_{S,H}\Pi_S Z^S_{t+1}. \tag{3.5}$$

3.2.1.2 Household problem

Each of these types will maximize the discounted sum of lifetime utility depending on the same specification as a function of the final consumption good and a disutility from labor. Following the literature on the topic, we assume that there is a union that centralizes the wage-setting decision by pooling the labor supply of both types and allocates the hours equally across types, i.e. $N^K_t = N^S_t = N^H_t = N_t$.

Therefore, agents will choose a path of consumption and, when possible, asset holdings to maximize the following period utility function

$$\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t u(C_t^j, N_t^j) \tag{3.6}$$

for $j \in \{H, S, K\}$ subject to their respective flow of resources. For capitalists,

$$P_t C_t^K + Z_{t+1}^K + P_t I_t^K = P_t W_t N_t^K + (1 + R_{t-1}^b) \frac{\mathbb{B}_t^K}{\Pi_K} + (1 + R_t^k) P_t \frac{K_t^K}{\Pi_K} + P_t \frac{D_t}{\Pi_K} - \frac{T_t^K}{\Pi_K} - \frac{\tau^K}{\Pi_K}, \tag{3.7}$$

and similar for the purely bond savers ("Savers"),

$$P_t C_t^S + Z_{t+1}^S = P_t W_t N_t^S + (1 + R_{t-1}^b) \frac{\mathbb{B}_t^S}{\Pi_S} - \frac{T_t^S}{\Pi_S} - \frac{\tau^S}{\Pi_S}. \tag{3.8}$$

Finally, as hand-to-mouth agents will not be able to trade bonds, their budget constraint will define their consumption as follows

$$P_t C_t^H = P_t W_t N_t^H + (1 + R_{t-1}^b) \frac{\mathbb{B}_t^H}{\Pi_H} - \frac{T_t^H}{\Pi_H} - \frac{\tau^H}{\Pi_H}. \tag{3.9}$$

C_t^j is nominal consumption, N_t^j hours of work (for j=K,S,H), K_t^K is capitalists capital stock, I_t^K is investment in capital, W_t nominal wages, R_t^b the risk free nominal interest rate on bonds, R_t^K the rental rate of capital, $\mathbb{B}_t^j$ is the island-wide beginning of period bond holdings, Z_t^j is the per-capita end of period bond holdings, D_t are economy-wide firms profits, T_t^j are lump sum taxes, τ^j are steady state transfers to equate agents consumption and δ is capital depreciation.

We assume equal redistribution of the total tax revenue needed by the government. Note that, although type-H agents cannot trade in bonds, there will be a certain stock of this asset on the island as agents can carry these with them across type switches.

We also assume that investment in capital is subject to a convex adjustment cost ι so that capital accumulation reads:

$$K_t^K = I_t^K \left(1 - \iota \left(\frac{I_t^K}{I_{t-1}^K} - 1 \right)^2 \right) + K_{t-1}^K \left(1 - \delta\right). \tag{3.10}$$

Since one of our focuses is fiscal policy, we introduce this adjustment cost in order to obtain fiscal multipliers in line with what found in the literature, e.g., (Cantore and Freund, 2021; Hagedorn et al., 2019), under the active monetary policy regime, thereby making our analysis more realistic.

3.2.2 Firms

Since our model enriches the household side of the economy, we model firms according to a standard New Keynesian model with Rotemberg (1982) adjustment costs. Hence, a representative firm seeks to maximize its profit by optimally choosing its price $P_t(i)$ subject to the demand it faces and adjustment costs. The firm's problem is represented by the following dynamic optimization problem:

$$\max_{\{P_t(i)\}_{i=1}^{1}} E_0 \sum_{t=0}^{\infty} \beta^t \left[P_t(i)Y_t(i) - W_t L_t(i) - R_t K_t(i) - AC_t\right]$$
$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} Y_t,$$

where $\epsilon > 1$ is the elasticity of substitution between different varieties of goods. Here, $P_t(i)$ is the price set by the firm, $Y_t(i)$ stands for the output produced by the firm, W_t denotes the nominal wage rate, $L_t(i)$ signifies the labor employed by the firm, R_t represents the rental rate of capital, $K_t(i)$ is the capital employed by the firm, and AC_t corresponds to the Rotemberg adjustment costs.

We specify Rotemberg adjustment costs AC_t according to the standard quadratic representation:

$$AC_t = \frac{\phi}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t,$$

where ϕ is a positive parameter which dictates the cost of adjusting prices.

By optimizing this problem, the firm sets the price to equate the marginal cost to a markup over price, subject to adjustment costs. The first order condition for this problem generates the New Keynesian Phillips curve, providing the connection between inflation and output.

3.2.3 Policy block

The Central Bank operates according to a standard Taylor rule of the form:

$$\frac{1+R_t^b}{1+R_b^*} = \left(\frac{1+R_{t-1}^b}{1+R_b^*}\right)^{\rho_{R^b}} \left(\frac{\Pi_t}{\Pi^*}\right)^{(1-\rho_{R^b})\phi_\pi} \epsilon_{m,t}, \tag{3.11}$$

where ϵ_m is a standard monetary policy shock.

The government is in charge of fiscal policy. In particular, it responds to an shock to nominal government expenditures, which follows a standard AR(1) process,

$$\frac{G_t}{G^*} = \left(\frac{G_{t-1}}{G^*}\right)^{\rho_g} \epsilon_{g,t}, \tag{3.12}$$

by raising lump sum taxes following a fiscal rule of the form

$$\frac{T_t}{T^*} = \left(\frac{T_{t-1}}{T^*}\right)^{\rho_T} \left(\frac{B_{t-1}}{B^*}\right)^{(1-\rho_T)\gamma_T} \left(\frac{G_t}{G^*}\right)^{(1-\rho_T)\gamma_{TG}}. \tag{3.13}$$

Government debt is a residual pinned down by the inter-temporal government budget constraint:

$$G_t + B_{t+1} = (1+R_{t-1}^B)B_t + T_t, \tag{3.14}$$

with aggregate government debt being:

$$B_t = \Pi_K Z_t^K + \Pi_S Z_t^S. \tag{3.15}$$

3.2.4 Calibration

Table 3.2.1 summarizes the calibration of the model. The value of the discount factor and capital depreciation are standard in quarterly models. We assume log-utility ($\sigma = 1$) in order to highlight the precautionary savings coming purely from the liquidity channel while we set $\varphi = 0.2$ in line with the high value of Frish elasticity in the TANK literature (see Cantore and Freund (2021)). Investment adjustment costs are set to 2.5. Hours in steady state assume that each agent works 1/3 of their time. We calibrate the steady state share of government spending in output (20%) and the annual debt to output ratio (57%) to match the average for the US economy from 1984 to 2018. Rotemberg price adjustment costs are calibrated to match a frequency of price adjustment of 3.5 quarters. We assume no smoothing in interest rate and taxes. Taxes response to government spending will remain fixed to $\gamma_{TG} = 0.1$ as in Galí et al. (2007). The rest of the parameters of the monetary and fiscal policy rules will vary across exercises. Passive fiscal policy will imply $\gamma_T = 1$ while active $\gamma_T = 0.4$ which is the lower variable that ensures stability under all the scenario analyzed below. Active monetary uses $\phi_\pi = 1.2$ while passive $\phi_\pi = 0.8$. Reducing further the response to inflation will generate much larger effects of fiscal policy. Transition probabilities are calibrated in order to ensure that capitalists remain in the K island with probability $\lambda_{K,K} = 0.8$ or move the the H one with probability $\lambda_{K,H} = 0.02$. Hand-to-mouth instead have $\lambda_{H,K} = 0.0541$ probability to become capitalists and savers $\lambda_{S,S} = 0.95$ to stay savers. In line with the TANK literature we assume that 0.279% of the population live hand-to-mouth, 10% is capitalists while the rest is made of savers.

3.2.5 The dynamics of the liquidity premium

Before moving on to the baseline experiments in the following sections, we believe it will be helpful to provide a characterization of the dynamics of the liquidity premium to understand better the determinants of the portfolio choice of the capitalists. The proof of the following proposition, as well as further details on the analytics of the model, can be found in Appendix 3.B.

Proposition 1. *The dynamics of the liquidity premium can be characterised to the first order as follows:*

$$lp_t = -\sigma \mathbb{E}_t \left[\lambda_{KS}(c^S_{t+1} - c^K_{t+1}) + \lambda_{KH}(c^H_{t+1} - c^K_{t+1}) \right] \tag{3.16}$$

where the liquidity premium is defined as $\mathbb{E}_t \left[\tilde{r}^K_{t+1} - \tilde{r}^B_{t+1} \right]$.

Equation (3.16) helps us underpin in higher analytical details the mechanism that generates variations in the liquidity premium as related to self-insurance. The main mechanism is driven by the difference between the consumption of the capitalists and that of the other two types. The intuition behind this is to be found in that what determines the liquidity premium is the poor insurance quality of the capital asset. If

Parameter	Value	Description
Preferences and technology		
β	0.99	Discount factor
σ	1	Intertemporal elasticity of substitution
δ	0.025	Capital depreciation rate
φ	0.2	Inverse of Frisch elasticity
ι	2.5	Investment adjustment cost parameter
ζ	6	Elasticity of substitution between goods varieties
ξ	42.7	Rotemberg price adjustment cost parameter
Population		
Π_K	0.1	Share of K-type households
Π_H	0.279	Share of hand-to-mouth households
$\lambda_{K,K}$	0.8	Probability of a K-type staying K
$\lambda_{K,H}$	0.02	Probability of a K-type moving to H-type
$\lambda_{H,K}$	0.0541	Probability of an H-type moving to K-type
$\lambda_{S,S}$	0.95	Probability of an S-type staying S
Policy		
ρ_{R^b}	0	Interest-rate smoothing parameter
ϕ_π	0.8 or 1.2	Taylor rule parameter
ρ_g	0.9	Government spending persistence parameter
ρ_T	0	Tax persistence parameter
γ_T	0.4 or 1	Tax response to debt
γ_{TG}	0.1	Tax response to government spending
Steady state		
N^*	0.33	Steady-state labor supply
Π^*	1	Steady-state inflation rate
$\frac{G^*}{Y^*}$	0.2	Steady-state government spending-to-output ratio
$\frac{B^*}{Y^*4}$	0.57	Annualized steady-state debt-to-output ratio

Table 3.2.1: Calibration

the change in the consumption of the three agents is identical in every period, then the liquidity premium is neutralized, as there is no need for self-insurance to begin with. This will make the two assets perfect substitutes. In fact, in this case the change in consumption will always be the same, regardless of which type the current capitalist will be in the next period. By contrast, if we consider a shock which induces a stronger response of the consumption of the non-Ricardian type vis-à-vis those of the Ricardian types, we see that the last term in the final equation in the figure above is likely to dominate. Assuming further that such deviation is positive, we see that it will generate a fall in the liquidity premium. Intuitively, such a shock makes the perspective of the risky hand-to-mouth state not as undesirable and, therefore, reduces the need for self-insurance. For this reason, the willingness to hold government bonds falls and the real interest rate must increase for the market to clear. Through this mechanism, we see the importance of the interplay between monetary and fiscal policies in shaping the portfolio choice of agents with access to both capital markets and liquid assets. In fact, changes in the supply of government assets, coupled with a change in their remuneration induced through monetary policy, will generate consumption inequality across the different categories, thereby affecting the need for insurance of the capitalist. This is what we will turn to study in the rest of the paper.

3.3 The portfolio channel of monetary and fiscal policy interaction

In this section we report the analysis from the experiments that we conduct in our baseline model.

3.3.1 Technology shock

First, we want to analyze the consequences of the portfolio channel on the transmission of a standard shock analysed in the literature, i.e., a persistent ($\rho_z = 0.75$) technology shock. In line with the previous section, we classify monetary and fiscal policy as either active or passive, and analyze the difference across specifications in terms of responses to the shock, which we report in Figure 3.3.1 and Figure 3.3.2. In particular, each figure plots different fiscal regimes for the same monetary regimes.

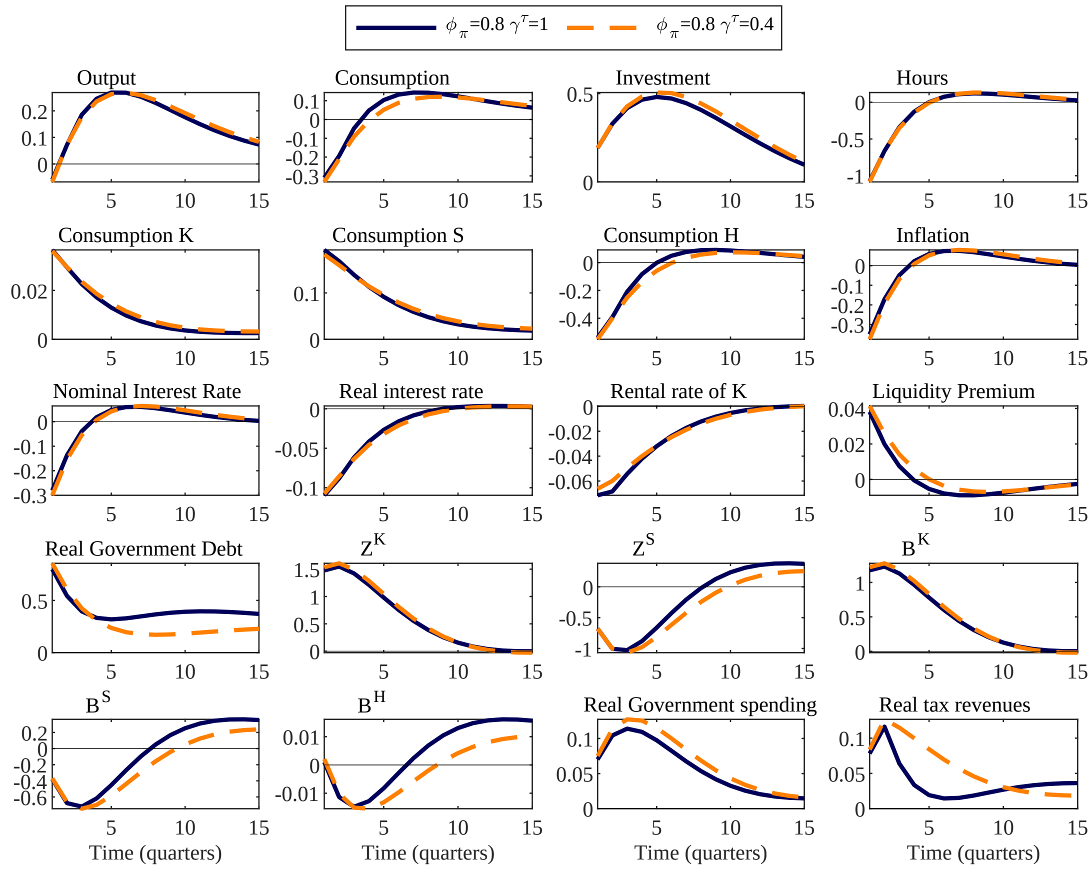

Figure 3.3.1: Impulse responses to a temporary 1% increase in A for active and passive fiscal policy when monetary policy is passive ($\phi_\pi = 0.8$).

The general transmission mechanism is the one previously established in the New Keynesian literature for this type of shock. The technology shock lowers the real marginal cost of capital, which determines a fall in inflation. Furthermore, it also generates an increase in investments and a fall in labor hours. The latter triggers our self-insurance mechanism. In particular, the fall in hours determines a fall in the consumption of the hand-to-mouth, which increases the desirability of liquid government bonds for self-insurance purposes. This can be seen from the portfolio choice of capitalists, who increase their holdings of this type of asset. On the other hand, for savers, who only have access to the bond markets, the standard interest rate channel is dominant and they respond to the fall in interest rate by disinvesting and consuming. Given the current calibration, we see that the bond holdings of hand-to-mouth follows a similar negative path as that of savers, which further worsens the dip in consumption of the

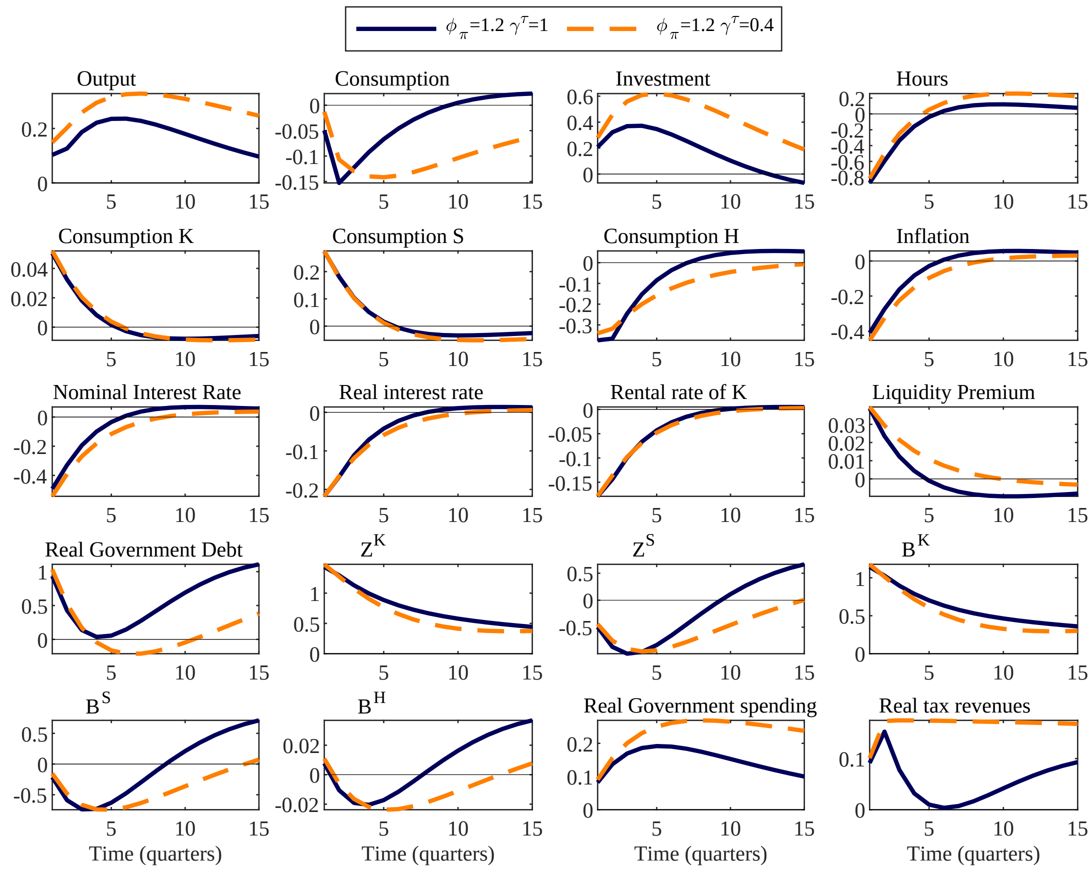

Figure 3.3.2: Impulse responses to a temporary 1% increase in A for active and passive fiscal policy when monetary policy is active ($\phi_\pi = 1.2$).

former. In line with the higher demand for self-insurance of the capitalists, the liquidity premium, which quantifies the insurance value of government bonds as pointed out in Proposition 1, increases.

By moving to a comparative analysis across regimes, we can see how different combinations affect the portfolio channel and, therefore, the aggregate dynamics in the economy. In particular, a comparison across Figures 3.3.1 and 3.3.2 shows how a more active monetary policy in response to a deflationary technology shock induces stronger movements in output, which moves in the opposite direction, and consequently a smaller fall in hours, which translates in general into a smaller contribution to the fall in hand-to-mouth consumption and, consequently, in the rise in the liquidity premium. Importantly, this logic is not peculiar to technology shocks, but will hold for all shocks that move inflation and output in opposite directions in the context of a monetary policymaker that does pure inflation targeting, such as a cost-push shock: a stronger monetary policy response to tame inflation is going to have a destabilizing effect on output which will limit the response of hours.

The interaction of monetary and fiscal policy brings a further mechanism at play. After an initial increase, due to the shift in capitalists portfolios and counterbalanced by an increase in taxes for government budget constraint to hold, real government debt experiences a fall for two reasons, i.e., the declining demand of capitalists and the reduced interest payment on the existing stock. The strength of this fall is driven by the monetary reaction as well as how strongly the government tries to stabilize it through taxes. In particular, if the fiscal policy does not react strongly to the change in debt, i.e., in the active fiscal regime in Leeper (1991) terminology, the stock of government debt is going to follow a more strongly declining path, especially coupled with an active monetary policymaker that changes rates aggressively and, in our case, lowers the interest payments on government debt. This is evident in Figure 3.3.2. This strong decline in the supply of real government debt has a feedback effect on the liquidity premium, which increases further. Given the larger gap between capital and government debt, the profit motive of the capitalist is stronger than the self-insurance motive and we see that investment increases much more in this regime compared to its passive monetary policy counterpart. This supply effect is largely non-present in Figure 3.3.1, where we see that the dynamics for Z^K are in line with a dominance of the self-insurance motive, i.e., higher liquidity premium because of a higher demand for government debt.

In conclusion, it seems that, at least for the current calibration, the trade-off between self-insurance and "insurance-through-investment" is resolved in favour of the former. In fact, for the shock that we have analyzed here, an increase in investment lowers the demand for labour and creates a substitution effect that worsens the position of the hand-to-mouth. It would be interesting to explore this trade-off in the context of a more general production function, e.g. of the CES form, which could allow for a more flexible calibration of the substitutability between capital and labour.

3.3.2 Fiscal Shock

How does fiscal policy transmit with different combination of the monetary/fiscal policy mix? We answer this question by looking at shock to government spending and focus our attention on the effect on real public debt when different combination of monetary and fiscal policy lead to different behaviour of inflation. Following Leeper (1991) we consider two scenarios for monetary policy: *passive* ($\phi_\pi = 0.8$) when the nominal interest rate respond less than one to one to inflation; *active* ($\phi_\pi = 1.2$) when the Taylor principle is satisfied. For each of these cases we consider two scenarios for fiscal policy: *passive* ($\gamma_T = 1$) when nominal taxes respond one to one to the increase in nominal debt; *active* ($\gamma_T = 0.4$) when the reaction in taxes is more muted and just enough to ensure the stability of the model (ie. fiscal policy *actively* decides not to increase taxes in order to stimulate the economy).

Figure 3.3.3 shows the responses of key variables to a persistent ($\rho_g = 0.9$) increase in G of 1% in terms of output for the case of active monetary policy. The increase in government purchases raises the level of aggregate demand in the economy. Following the standard New Keynesian narrative, firms operating under monopolistic competition raise their prices, however, given nominal rigidities this change is insufficient to fully restore the original equilibrium. The labor demand curve shifts outwards, hours worked and, hence, output rise; so does the real wage (not shown). In contrast to the representative-agent paradigm, the presence of high marginal propensity to consume/non PIH agents (H) means that they will see a boost in their disposable income and raise their consumption. In contrast capitalists and savers, who have access to financial markets, will reduce their consumption. Investment in capital is crowed-out in line with the standard transmission mechanism in the presence of investment adjustment costs.

The effect on real debt can be decomposed into a demand and a supply side effect. From the demand side, the strong income effect that pushes up consumption of the hand-to-mouth makes the H state less undesirable and therefore lowers the liquidity premium making bond and capital closer substitutes. This induces a shift of the capitalists out of the bond market and into the capital market as their demand for *insurance* via bonds is reduced (Z^K declines for the first couple of quarters and the initial drop in investment is contained). However there is a contrasting supply side effect on capital vs bond investment. This is due to the increase in nominal debt issuance generated by the increase in government spending and by the increase in real debt due to the jump in inflation and the real interest rate. This standard “interest rate” channel makes bonds more attractive with respect to capital.

The relative strength of these two effects depends on the policy mix. When monetary policy is active the supply side effect dominates (Figure 3.3.3). When fiscal policy is passive (solid blue line) the rise in tax revenues corresponds to a smaller increase in inflation which translates smaller decline and faster recovery in the liquidity premium compared with the active fiscal policy case (dashed orange line). If the self-insurance motive of capitalists would dominate we would observe a smaller drop in investment in the active fiscal policy case while our simulations actually show the opposite. This is evidence that the supply side effect is driving the response of real debt to the fiscal shock.

The different behaviour of inflation and the liquidity premium explain also the different fiscal multipliers under the two fiscal policy scenarios. On impact the fiscal multiplier is slightly larger under active fiscal policy but the difference widens when looking at the cumulative effect.

Figure 3.3.4 shows the responses for the case of passive monetary policy. Compared to the case of active monetary, the impact of the shock is qualitatively similar for many variables as the standard New-Keynesian narrative also applies in this case. Quantitatively however we observe a substantially larger fiscal multiplier, a larger increase in inflation and a smaller raise in the real rate. When the central bank lets inflation increase by a larger amount the demand effect of the fiscal shock is magnified. This induces a stronger income effect on the hand-to-mouth which reduces even further the self insurance motive of capitalists. Their shift away from the bond market is much more pronounced and persistent. Therefore in this case the demand effect now dominates over the supply of new public debt. Under both fiscal policy scenarios capitalists substitute bonds for capital (Z^K is negative and persistent). When fiscal policy is active we even observe a decline in real government debt for a few quarters and a small increase in investment on impact following the fiscal expansion. Finally we also notice

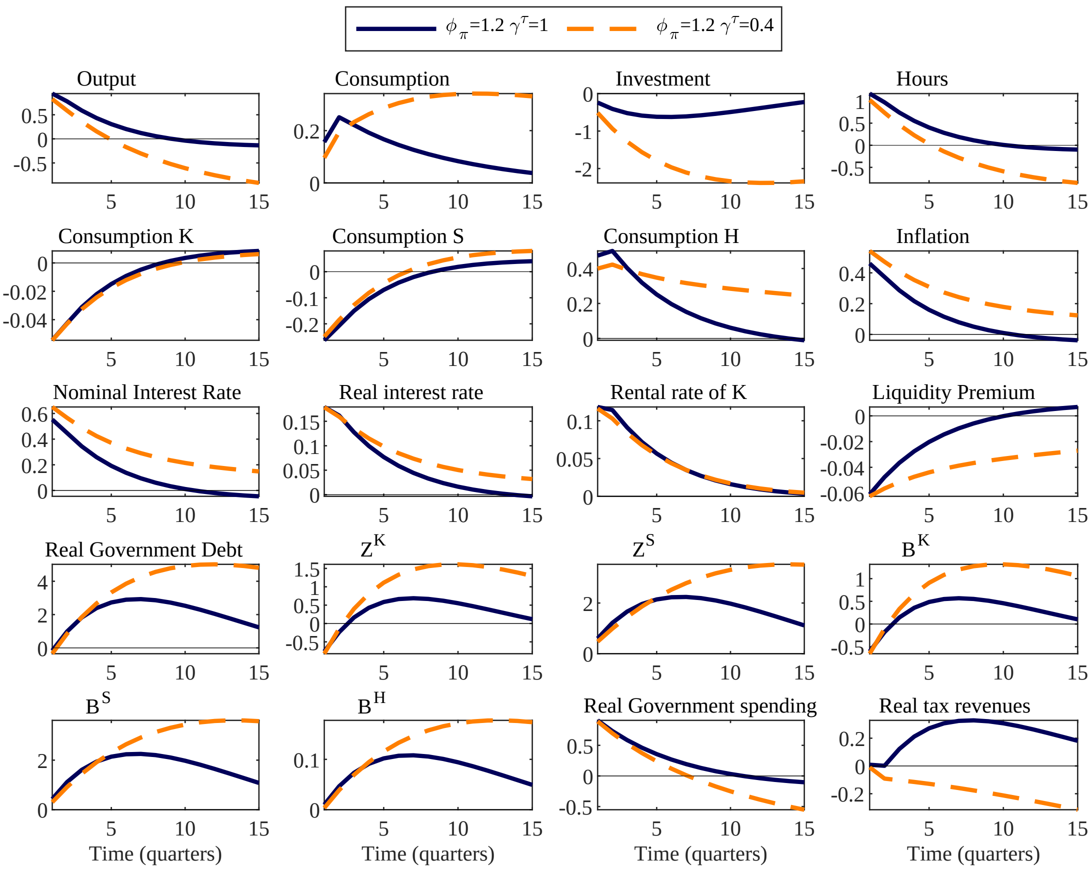

Figure 3.3.3: Impulse responses to a temporary 1% increase in G for active and passive fiscal policy when monetary policy is active ($\phi_\pi = 1.2$).

Note: All variables are expressed in real terms except for Hours, Inflation and Nominal interest rate. All variables related to fiscal policy are in % deviation from the steady state of output. The remaining variables are in % deviations from their own steady state. We plot the next period realized rental rate of capital (R^K_{t+1}). Consumption, Z's and B's are island-wide figures (multiplied by the population sizes Π's).

how under active fiscal policy the increase in inflation is so large that generates a substantial decline in real tax revenues which frees up disposable income and generates an increase in consumption for both capitalists and savers.

Another way to highlight the importance of the demand side effect coming from the reduced insurance motive of capitalists is to look at the same exercise in a version of the model where only the supply side effect is at play. In the Appendix 3.C we show the response to the same fiscal expansion in the two-agent version of the model (as in Bilbiie et al. (2022)) where there are no savers and therefore there is no meaningful portfolio choices of capitalists affecting the demand for Government debt. Impulse responses for the active monetary policy case are very similar given the dominance of the supply side of debt. This is not the case when looking at passive monetary policy

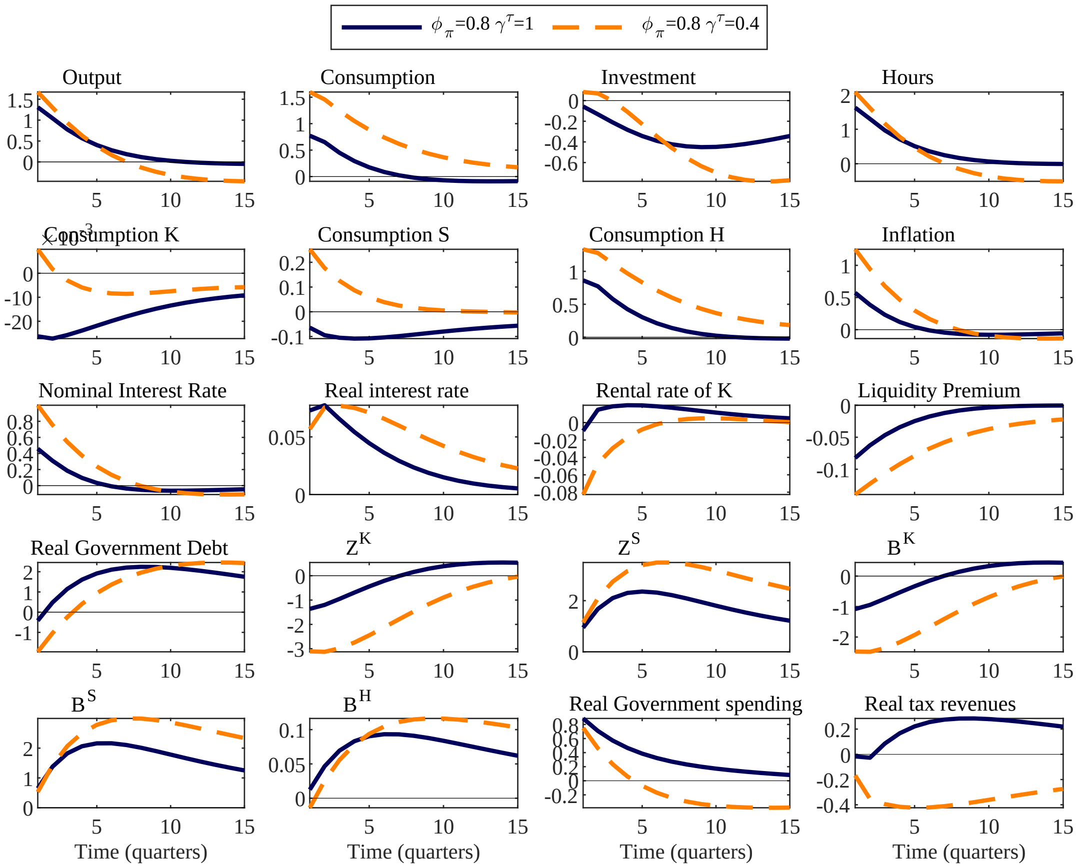

Figure 3.3.4: Impulse responses to a temporary 1% increase in G for active and passive fiscal policy when monetary policy is passive ($\phi_\pi = 0.8$).

Note: All variables are expressed in real terms except for Hours, Inflation and Nominal interest rate. All variables related to fiscal policy are in % deviation from the steady state of output. The remaining variables are in % deviations from their own steady state. We plot the next period realized rental rate of capital (R^K_{t+1}). Consumption, Z's and B's are island-wide figures (multiplied by the population sizes Π's).

(Figure 3.C.2). In the two agents set up capital and bonds are perfectly substitute and therefore the capitalists do not substitute bonds for capital leading to a larger decline in investment. Note also the standard decline in the consumption of capitalists which further contributes to generate a smaller fiscal multiplier in the two-agents set up.

3.4 Conclusions

This paper has provided an in-depth investigation into the reciprocal interplay of fiscal and monetary policy and its impact on the liquidity properties of the portfolios of various types of agents within an economy. In doing so, we built upon the burgeoning research agenda focusing on the empirical differences in portfolios across wealth distribution and its impact on policy effectiveness and macroeconomic dynamics.

Utilizing a New-Keynesian model with limited household heterogeneity, we considered a novel channel through which monetary and fiscal policy interact with the portfolio choices of private agents. This analysis revealed two crucial channels, the "self-insurance" and "supply" channels, that determine the liquidity premium in different policy regimes and shape the relationship between this premium and the portfolio choices of households.

Our first experiment illustrated how these channels manifest and interact in response to a standard technology shock. We found that when there is a large change in government debt, the supply channel enhances the gap in the liquidity premium, causing the profit motive of capitalists to prevail. On the contrary, in regimes where changes in government debt are more tempered, the "self-insurance" mechanism dominates. However, our model suggested that the "insurance-through-investment" channel is weak due to the poor complementarity between the two productive assets, indicating that the building of more capital stock does not serve as a viable substitute for liquid savings for agents in the hand-to-mouth state.

In our second experiment, we explored the effects of a fiscal stimulus within different combinations of the monetary/fiscal policy mix. The relative strength of the self-insurance and supply channels was found to be dependent on the policy mix. Under active monetary policy, the supply effect dominated, while under passive monetary policy, a larger income effect on hand-to-mouth agents made the "self-insurance" channel stronger.

This study provides valuable insights into the complex dynamics between fiscal and monetary policy and their influence on the portfolio choices of different types of agents. Through this, we are able to understand more deeply how policy regimes impact both the liquidity properties of agent portfolios and the stabilization and aggregate response of the economy.

However, as with all explorations into the complex workings of economic systems, this paper also underscores the need for continued research. Further work could extend our analysis to consider other policy mixes, different shocks, and even more granular household heterogeneity. Such efforts will continue to improve our understanding of the dynamic evolution of the economy to different combinations of the fiscal-monetary policy mix, and thus our capacity to respond effectively to future economic shocks and challenges.

Appendices

3.A Solution

The solution of the model is obtained by writing down the Bellman equations for both types of agents

$$
\begin{aligned}
V^K(\mathbb{B}_t^K, K_t^K) = & \max_{\{N_t^K, Z_{t+1}, K_{t+1}^K\}_{t=0}^{\infty}} \left\{ \frac{C_t^{K\,1-\sigma}}{1-\sigma} - \psi_0 \frac{N_t^{K\,1+\psi_1}}{1+\psi_1} \right. \\
& \left. + \beta \mathbb{E}_t \left[V^K(\mathbb{B}_{t+1}^K, K_{t+1}^K) + \frac{\Pi_S}{\Pi_K} V^S(\mathbb{B}_{t+1}^S) + \frac{\Pi_H}{\Pi_K} V\left(\mathbb{B}_{t+1}^H\right) \right] \right\} \\
& \text{s.t. } (3.7), (3.9), (3.10), (3.3), (3.4), (3.5)
\end{aligned}
$$

and similarly,

$$
\begin{aligned}
V^N(\mathbb{B}_t^N) = & \max_{\{N_t^S, Z_{t+1},\}_{t=0}^{\infty}} \left\{ \frac{C_t^{S\,1-\sigma}}{1-\sigma} - \psi_0 \frac{N_t^{S\,1+\psi_1}}{1+\psi_1} \right. \\
& \left. + \beta \mathbb{E}_t \left[\frac{\Pi_K}{\Pi_S} V^K(\mathbb{B}_{t+1}^K, K_{t+1}^K) + V^S(\mathbb{B}_{t+1}^S) + \frac{\Pi_H}{\Pi_S} V\left(\mathbb{B}_{t+1}^H\right) \right] \right\} \\
& \text{s.t. } (3.8), (3.9), (3.3), (3.4), (3.5).
\end{aligned}
$$

Moreover, hand-to-mouth agents will not consume on their Euler equation, but will choose the amount of labour hours optimally, giving rise to a standard intra-temporal condition detailed below.

Using dynamic programming techniques, we can show that the optimality conditions to these programs can be expressed in terms of three Euler equations,

$$C_t^{K-\sigma} = \beta\mathbb{E}_t\left[\frac{\left(R_{t+1}^K + (1-\delta)Q_{t+1}\right)C_{t+1}^{K}{}^{-\sigma}}{Q_t}\right] \tag{3.17}$$

$$C_t^{K-\sigma} = \beta\mathbb{E}_t\left[\frac{1+R_t^B}{\Pi_{t+1}}\left(\lambda_{KK}C_{t+1}^{K}{}^{-\sigma} + \lambda_{KS}C_{t+1}^{S}{}^{-\sigma} + \lambda_{KH}C_{t+1}^{H}{}^{-\sigma}\right)\right] \tag{3.18}$$

$$C_t^{N-\sigma} = \beta\mathbb{E}_t\left[\frac{1+R_t^B}{\Pi_{t+1}}\left(\lambda_{NK}C_{t+1}^{K}{}^{-\sigma} + \lambda_{NN}C_{t+1}^{N}{}^{-\sigma} + \lambda_{NU}C_{t+1}^{U}{}^{-\sigma}\right)\right] \tag{3.19}$$

and three intra-temporal conditions

$$\psi_0\frac{N_t^{K\psi_1}}{C_t^{K-\sigma}} = W_t \tag{3.20}$$

$$\psi_0\frac{N_t^{N\psi_1}}{C_t^{N-\sigma}} = W_t \tag{3.21}$$

$$\psi_0\frac{N_t^{U\psi_1}}{C_t^{U-\sigma}} = W_t. \tag{3.22}$$

3.A.1 Labour union

Following much of the literature on models with limited heterogeneity, we assume the existence of a labour union that pools the labour supplies of the different types, sets the wage and redistributes labour hours equally among agents. This is done by weighting the individual labour supplies by the respective population weights. As such, bearing in mind that $\psi_1 = 1$ in our calibration, the total labour supply in the economy is given by

$$\psi_0 N_t = W_t\left(\Pi_K C_t^{K-\sigma} + \Pi_N C_t^{N-\sigma} + \Pi_U C_t^{U-\sigma}\right) \tag{3.23}$$

ψ_0 can be calibrated in order to ensure that the number of hours worked in steady state is the standard 0.33 adopted in the literature

3.B Proofs

Proof of Proposition 1

Proof. Consider the two Euler equations for the capitalist type,

$$C_t^{K^{-\sigma}} = \beta \mathbb{E}_t \left[R_{t+1}^K C_{t+1}^{K^{-\sigma}} \right] \tag{3.24}$$

$$C_t^{K^{-\sigma}} = \beta \mathbb{E}_t \left[R_{t+1}^B \left(\lambda_{KK} C_{t+1}^{K^{-\sigma}} + \lambda_{KS} C_{t+1}^{S^{-\sigma}} + \lambda_{KH} C_{t+1}^{H^{-\sigma}} \right) \right] \tag{3.25}$$

where we have redefined R_{t+1}^i for $i \in \{K, B\}$ as the gross real return on capital and bonds respectively. We now define R_{t+1}^K what we defined $\frac{\left(R_{t+1}^K + (1-\delta) Q_{t+1}\right)}{Q_t}$ before.

Then, by taking a first-order approximation of the two around the deterministic steady state and combining them we obtain

$$\beta \mathbb{E}_t \left[\tilde{r}_{t+1}^K - \tilde{r}_{t+1}^B \right] = -\sigma \mathbb{E}_t \left[\lambda_{KS} (c_{t+1}^S - c_{t+1}^K) + \lambda_{KH} (c_{t+1}^H - c_{t+1}^K) \right] \tag{3.26}$$

where "$\tilde{(\cdot)}$" denotes that the variable has been linearized, as opposed to log-linearized, in line with how the literature treats variables that are already expressed as percentages.

Finally, we conclude the proof by recognizing that the left-hand side of equation (3.26) is the approximation to the first order of the liquidity premium as defined in the main text. □

3.C Comparison with 2-agent THANK

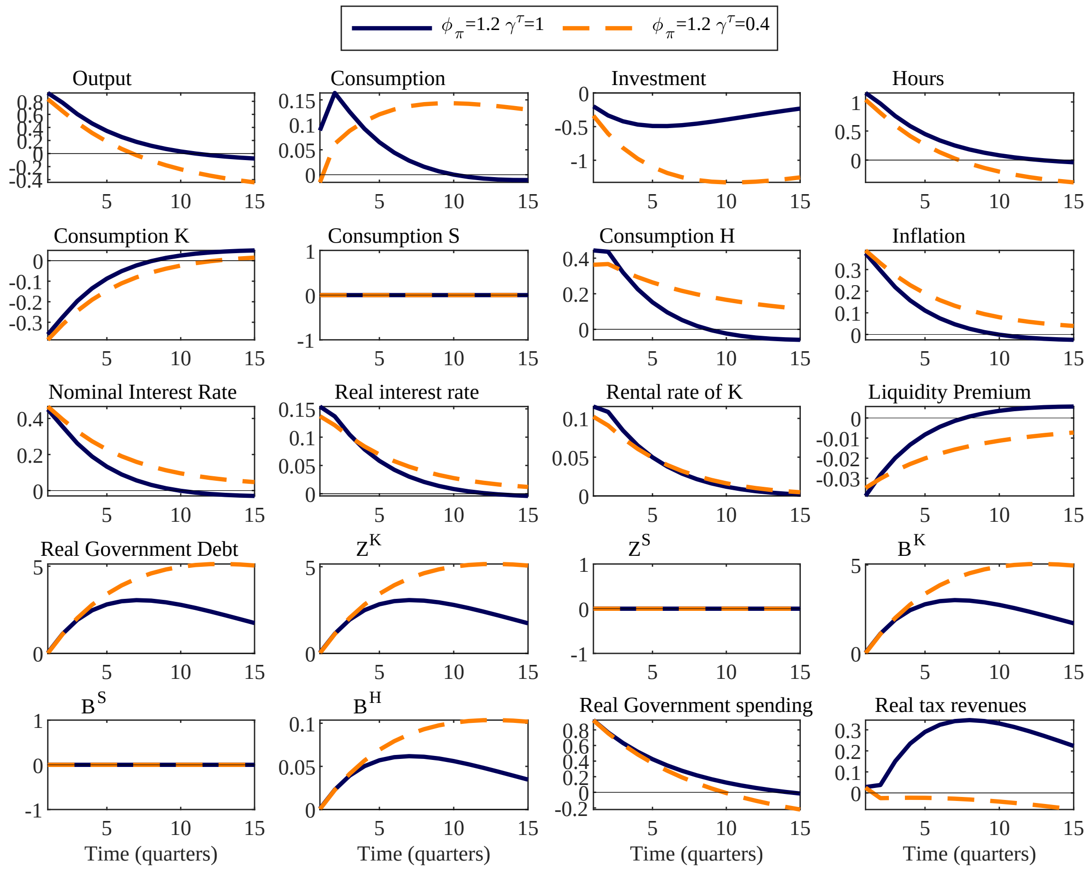

Figure 3.C.1: THANK: Impulse responses to a temporary 1% increase in G for active and passive fiscal policy when monetary policy is active ($\phi_\pi = 1.2$).

Note: All variables are expressed in real terms except for Hours, Inflation and Nominal interest rate. All variables related to fiscal policy are in % deviation from the steady state of output. The remaining variables are in % deviations from their own steady state. We plot the next period realized rental rate of capital (R^K_{t+1}). Consumption, Z's and B's are island-wide figures (multiplied by the population sizes Π's).

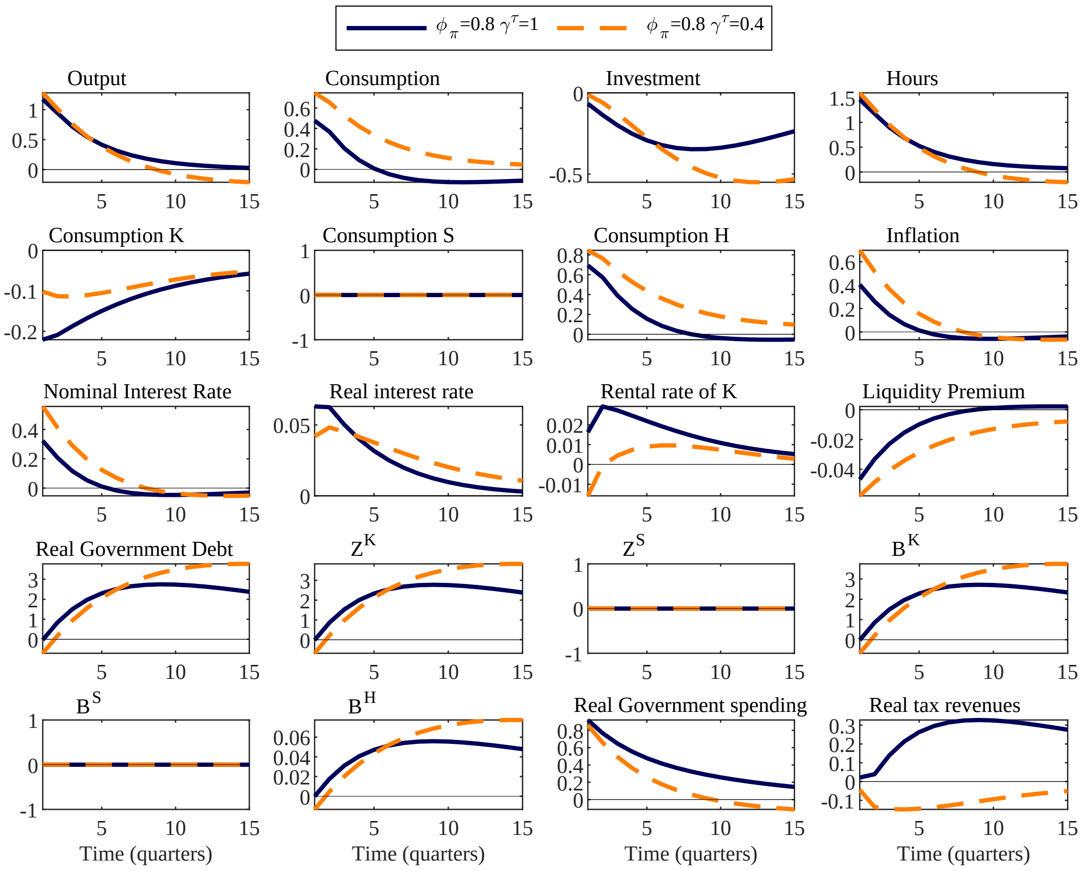

Figure 3.C.2: THANK: Impulse responses to a temporary 1% increase in G for active and passive fiscal policy when monetary policy is passive ($\phi_\pi = 0.8$).

Note: All variables are expressed in real terms except for Hours, Inflation and Nominal interest rate. All variables related to fiscal policy are in % deviation from the steady state of output. The remaining variables are in % deviations from their own steady state. We plot the next period realized rental rate of capital (R^K_{t+1}). Consumption, Z's and B's are island-wide figures (multiplied by the population sizes Π's).

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