Fiscal policy effectiveness and its redistributive consequences: a theoretical and empirical exploration

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Ph.D.

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Economics

July 2014

Abstract

This thesis contributes to three important topics on the conduct of fiscal policy. First, although the positive effects of fiscal policy on the aggregate economy are often discussed, the literature frequently omits a normative analysis and, moreover, fails to consider political frictions to policy: something frequently observed in fiscal policy debates. This thesis attempts to address these omissions through constructing New Keynesian 'dynamic stochastic general equilibrium' (DSGE) models with heterogeneous agents. Exogenous shocks are shown to impact households differently and in polarizing ways, and the results imply that there is a normative justification for countercyclical fiscal policy, but on redistributive rather than aggregate grounds; austerity is observed to have the biggest impact on those agents who do not engage in capital markets, unless targeted on raising production taxes. Second, DSGE models frequently fail to replicate the empirical regularity that private consumption crowds in fiscal stimuli. This thesis overcomes this anomaly through combining the assumptions of external habit persistence and credit-constrained households, both of which are frequently used in the literature, but often in isolation of one another. External habit persistence creates an interaction between the heterogeneous agents whereby the consumption of one impacts the future preferences of others, and in so doing, introduces herding behaviour into an otherwise standard DSGE model. Finally, there is widespread evidence that procyclical fiscal policies have been prevalent in developing countries and often in some industrial nations. It is therefore surprising that, in contrast to the wealth of studies on the sources of such policy, potential consequences have been largely ignored in the existing literature. This thesis empirically estimates that fiscally procyclical countries have lower rates of economic growth and higher rates of output volatility and inflation.

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Acknowledgements

For stimulating a passion in economics I would like to thank my first teacher in the subject Paul Hodgson, and for encouraging me to do a Ph.D. my undergraduate supervisor Luigi Sciliani. I owe many thanks to Gulcin Ozkan, my supervisor, for her patience, support and friendship, and to Andrew Pickering and Neil Rankin, for further guidance as part of my Thesis Advisory Group. All staff and students at the Department for Economics and Related Studies at the University of York contributed to a fantastic experience and great learning environment. I should also recognise the contributions of Ant, Daniele, Dawid, Dominic and Neill whose input, mainly with respect to coding, directly contributed to the work contained in this thesis. Thanks to my family, both biological and not, especially those who did not support this endeavour, whose arguments ultimately convinced me to do it. Most of all, I am deeply grateful for the love and support from Julia and Parker without whom this might have been possible, just much less fun.

For financial support I thank the Economics and Social Research Council for the stipend, expenses, and many other opportunities to improve my research skills throughout (award number: ES/H011528/1).

Gulcin, I apologise for being ‘bonkers’.

Author's declaration

The contents of Chapter 3 have been presented at: the 'White Rose DTC Economics' Ph.D. conference, Leeds University, in March 2012; and the 'Credit where due' conference, University of Cambridge, in September 2012.

The contents of Chapter 4 have been presented at: the 'White Rose DTC Economics' Ph.D. conference, University of York, in April 2013; and the Royal Economics Society annual conference, Royal Holloway University, also in April 2013. A paper version of the contents of Chapter 4 has been accepted for publication in the journal 'Oxford Economics Papers'.

The contents of Chapter 5 is joint work with Professor F. Gulcin Ozkan (University of York) and Dawid Trzeciakiewicz (University of York): all co-authors contributed equally. A paper version has been presented at: the European Monetary Forum, University of Glasgow, in March 2013; the Money, Macro and Finance Conference, Queen Mary University of London, September 2013; at the Royal Economics Society Annual Conference, University of Manchester, March 2014; and at the 'Questioning austerity: realities and alternatives' conference, University of York, in April 2014.

The contents of Chapter 7 is joint work with Professor F. Gulcin Ozkan and and has been accepted for publication in the journal 'Fiscal Studies' (forthcoming): both co-authors have contributed equally.

Chapter 1

Introduction

The 2008 financial crisis and subsequent global economic downturn has renewed political and academic debates on the conduct of fiscal policy. These debates have manifested themselves both domestically and internationally as world leaders looked to coordinate policy actions. The April 2009 G20 Summit resulted in an announcement of a combined global stimulus package in excess of $5 trillion as collective wisdom saw such measures as necessary to combat depressed demand. However, this response led to subsequent fears over sovereign debt as 'fiscal responsibility' and 'consolidation' became the widespread political rhetoric.

Despite the initial resurgence and return to fiscal policy, there is still much doubt and debate as to whether such policy has the desired effects. These debates are not a new phenomenon, are often highly contested, and in recent years have fallen under the category of 'austerity versus stimulus' debates, commonly seen throughout Europe. This thesis seeks to contribute to the academic literature on the conduct of fiscal policy, discussing topics on it's empirical and theoretical effectiveness and on its associated redistributive consequences.

Much of the recent literature has focused on the impact of policy on the aggregate economy, typically focusing on the government spending multiplier, empirical estimates for which are often observed to be greater than one (see for example Blanchard and Perotti; 2002).[1] However traditional New Keynesian dynamic stochastic general equilibrium (DSGE) models fail to predict this and much of the theoretical literature has aimed to rectify this anomaly: see for example Linnemann and Schabert (2003), Coenen and Straub (2005), Linnemann (2006), Galí et al. (2007) and Monacelli and Perotti (2008). The experience of the recent downturn combined with low central bank rates

[1] However it should be noted that empirical results do vary with estimates below one; see for example Ramey (2011) and Ilzetzki et al. (2013).

has prompted a discussion on the impact of fiscal policy when the nominal interest rate is at the zero lower bound, see for example Christiano et al. (2011), Eggertsson (2011), Hall (2011), and Woodford (2011), where again the focus is the positive impact of policy on the aggregate economy. The fiscal-DSGE literature currently has two key omissions: first, through focusing on the positive properties of policy the analysis is lacking a comprehensive consideration of the normative consequences; and second, through focusing on aggregate dynamics and using the often assumed representative agent, the analysis abstracts away from any heterogeneity of the impacts of fiscal policy.

Chapters 2, 3 and 4 of this thesis seek to address these omissions through constructing a small scale New Keynesian DSGE model with a proportion of credit-constrained agents. Although this segregation between agents is crude, splitting between those who have access to credit (Ricardian agents) and those who do not (non-Ricardian, or 'rule-of-thumb', agents), it is reflective of typical fiscal debates where two clear camps are frequently observed. Moreover, the increasing presence of DSGE models which also make this distinction, including in policy institutions, allows the procedures developed here to be directly incorporated into the existing literature.

This question is first addressed in Chapter 3 in a model which abstracts from fiscal policy. This is performed to provide a robust analysis of the transmission mechanisms involved and results are obtained through deriving algebraic properties in general equilibrium, dynamic simulations of the model and through observing welfare movements through the evaluation of a second order Taylor series expansion of the heterogeneous households homogeneous utility function. In the presence of recessionary shocks, non-Ricardian households increase their supply of labour, above that which would prevail were they to be able to borrow, in order to increase their disposable income and insulate themselves from the impact of the shock. In general equilibrium this increases employment and output, however non-Ricardian households are unable to purchase all the additional production as their increased labour supply results in a fall in real wages. The surplus is consumed by Ricardian households who are observed to both consume more and work less than their non-Ricardian neighbours in the presence of recessionary shocks and moreover, consume more and work less than if they were in a fully Ricardian economy; the credit-constrained agents are seen to insulate both the unconstrained and the economy more broadly. In the presence of a shock causing a fall in output, non-Ricardian households are seen to lose welfare whereas Ricardian households can gain welfare, given a sufficient weight of credit-constrained agents.

When stabilising fiscal policy is incorporated in the economy in Chapter 4, it is found that countercyclical policy is to the benefit of the rule-of-thumb agents as it smooths the business cycle and removes some of the costs of not having access to credit. However, countercyclical policy is to the detriment of Ricardian households, both in the presence of recessions and more broadly over the business cycle, as the insulating impact of the responsive labour supply of non-Ricardian households is more effective than government intervention. This results in a conflict of preferences over the conduct of fiscal policy between the heterogeneous agents. Further, non-Ricardian households prefer policy which is debt financed and reversed over a long time horizon, whereas Ricardian households prefer prompt repayment of any initial stimulus. There is a normative justification for countercyclical fiscal measures, however the quantitative aggregate gains of stabilisation policy are minimal. The main normative justification comes from the redistributional consequences of countercyclical policy, reducing the inequality of shocks. The gains from policy of the rule-of-thumb agents are (nearly) matched by the losses of the Ricardian agents; in many respects, the conduct of fiscal policy is performed in a de-facto zero sum game which is the source of the polarized preferences in the model. The results in Chapter 4 further suggest that preferences become more polarized between the two agents when fiscal policy is conducted at the monetary zero lower bound: when nominal interest rates are at, or close to, zero.

Chapter 5 further extends this analysis by considering the positive, normative and income distribution effects of austerity in a medium scale New Keynesian DSGE model including nominal rigidities in price and wage setting, real frictions of adjustment costs and monopolistic competition, and distortionary taxation on labour, capital and consumption. The resulting model provides nine separate fiscal instruments in which to comprehensively explore the redistributive impact of specific policy packages. Austerity is found to have a range of positive and normative effects, depending on the speed and composition of consolidation. A trade off emerges between the efficiency and equity of austerity, with policies focusing on government spending reductions having the smallest impact on output, average incomes and welfare, but having the greatest impact on the distribution of incomes and welfare. Tax based austerity, on the other hand, tends to be more detrimental to both output, income and welfare, but in a more equitable way. These impacts (when considering the lifetime of the fiscal consolidation) are sensitive to the composition of austerity but are largely unaffected by its speed. Chapter 5 also examines the implications of some recent consolidation packages enacted by developed countries, through applying data obtained from IMF Fiscal Monitors (IMF, 2013 & 2014).

As mentioned above, traditional New Keynesian DSGE models frequently fail to replicate the typical empirical result that private consumption crowds in fiscal stimuli either through government spending increases or tax cuts. Papers such as Galí et al. (2007) and Monacelli and Perotti (2008) have induced positive comovements between public and private consumption by introducing credit-constrained households and complementary preferences between consumption and work respectively, however the latter maintains Ricardian equivalence and the former is criticised for the level of imperfection required to obtain this comovement. Chapter 6 illustrates that empirically appropriate theoretical fiscal multipliers can be obtained at reasonable parameter values by combining the modelling assumptions of external habit persistence and rule-of-thumb agents. These assumptions are frequently used in the literature, but often in isolation of one another, where their inclusion is introduced to allow theoretical models to better match empirical data. Habit persistence imposes a weight in the utility function such that agents obtain disutility from movements away from the previous period's average level of consumption: for this reason it has also been labelled 'catching up with the Joneses'. However, the concept of catching up with others is trivial when combined with the representative agent assumption. Through introducing heterogeneity across the actions of households through including rule-of-thumb consumers, the combination of these two modelling assumptions provides compelling results, particularly with respect to fiscal policy.

The inclusion of both heterogeneous agents and habit persistence can have significant long run consequences on the effectiveness of fiscal policy. Not only do these factors impact the results individually, there is also an intuitive relationship whereby they work in union such that the feedback process of one is amplified by the other. In effect, through introducing an empirically appropriate interaction between heterogeneous agents, only a small proportion of individuals who behave differently from the perceived optimal approach are required in order to produce a larger aggregate impact than when this interaction is not present: there is a contagion of private spending as one type of household attempts to 'keep up with' the other. In this respect, the combination of these two modelling assumptions is imposing a form of herding behaviour or 'animal spirits' on the model.

Finally, Chapter 7 conducts an empirical study on the consequences of procyclical fiscal policy. There is widespread evidence that fiscal policy has been procyclical (expansionary in good times and contractionary in bad) in many developing and emerging market countries, and frequently in developed nations (see for example Gavin and Perotti; 1997; Kaminsky et al.; 2004; Talvi and Végh; 2005; Woo; 2009). However, despite the wealth of literature discussing potential causes of such behaviour there is limited discussion on the consequences to the macroeconomy: it is implicit in the analysis that procyclical policy is undesirable. Through constructing a dataset consisting of 114 countries between 1950 and 2010, Chapter 7 presents evidence to suggest that fiscally procyclical countries have lower rates of economic growth, higher rates of output volatility, and higher rates of inflation.

For the purposes of brevity, Chapter 2 derives a New Keynesian DSGE model with a proportion of credit-constrained agents. This model is used in both Chapters 3 and 4 and is the base for the model applied in Chapter 6. Chapter 2 also includes a discussion on the empirical literature identifying rule-of-thumb consumption behaviour, and discusses properties of the model which will be important for the analysis performed. Chapter 8 concludes.

Chapter 2

A DSGE model with credit-constrained agents

2.1 Introduction

This chapter derives and discusses the properties of a New Keynesian dynamic stochastic general equilibrium (DSGE) model with a proportion of credit-constrained agents: this model forms the skeleton for the remaining theoretical chapters of this thesis. This builds upon the recent research using non-Ricardian (or rule-of-thumb) agents who are assumed not to have access to credit and therefore consume 'hand-to-mouth' by spending their disposable income each period. This assumption means that these agents cannot smooth their consumption (unlike traditional Ricardian agents who follow the permanent income hypothesis) and their inclusion in models is as a result of the empirical observation that for many individuals their spending closely tracks their income: see Section 2.2 for a further discussion on this empirical literature. The justification for the inclusion of rule-of-thumb households in DSGE models is supported by the observation that these models better match empirical data: see for example Galí et al. (2007), Andrés et al. (2008), Graham (2008), Furlanetto and Seneca (2009, 2012) and Boscá et al. (2011). This improvement in performance has led to rule-of-thumb consumers appearing in many central banks and policy institutions DSGE models.[1]

The model derived is similar to those of Galí et al. (2007) and Bilbiie (2008). Compared to the former this model abstracts from physical capital accumulation, and compared

[1]Institutions that use such households include the European Central Bank (NAWM), the European Commission (QUEST III), the Federal Reserve Board (SIGMA) and the International Monetary Fund (GIMF).

to the latter it abstracts from fixed costs to production. Moreover, this model is differentiated from Bilbiie (2008) by allowing rule-of-thumb households to control their labour supply in order to optimise in any given time period. These abstractions allow the algebraic properties of the resulting small scale DSGE model to be explored. Incorporating rule-of-thumb agents into an otherwise standard model imports many unique features which are discussed in this chapter. Moreover, including heterogeneity in the actions of households allows for these different households to respond differently to exogenous shocks and subsequently have different preferences over policy interventions. This is a theme which will be explored throughout this thesis.

The chapter proceeds in the following way: Section 2.2 discusses the empirical literature on the observation of rule-of-thumb consumption behaviour. Section 2.3 derives a model with a proportion of credit-constrained agents and Section 2.4 discusses the properties of such a model. Section 2.5 concludes.

2.2 Empirical results on non-Ricardian households

This section reviews the empirical literature on the argument that a proportion of individuals behave in a non-Ricardian, or rule-of-thumb, manner. These agents are identified as departing from the predictions of the permanent income hypothesis, having a high degree of dependence on current disposable income for their current levels of consumption. This literature is vast and uses a variety of techniques and data to not only attempt to quantify the prevalence of such behaviour but also seek to identify the reasons for such activity.

2.2.1 Empirical identification of non-Ricardian behaviour

If the economy consists of entirely forward looking rational agents then, under reasonable assumptions, Hall (1978) shows that this would lead aggregate consumption (C_t) to follow a random walk; the difference in consumption today from yesterday is generated only from shocks received today about future income:[2]

$$\Delta C_t = \epsilon_t$$

where ϵ_t is new information received in period t. This Euler equation approach is a direct way to test the predictions of the permanent income hypothesis and is a method

[2] Specifically, the result requires the conditions that utility is quadratic and movements in marginal utility are small.

that has been commonly applied to the data. When it is applied, however, it is often found that the predictions of the theory are rejected and that current information can predict future levels of consumption; see for example Hall (1978), Flavin (1981), Hall and Mishkin (1982) and Evans (1993).

To reconcile this anomaly Campbell and Mankiw (1989) modified this approach by nesting within the model the hypothesis that although a fraction $(1-\lambda)$ of total income (Y_t) accrues to these forward looking rational agents, the remaining fraction (λ) accrues to agents who consume wholly and directly out of this income: consume 'hand-to-mouth'.[3] This nested model is represented algebraically:

$$\Delta C_t = \lambda \Delta Y_t + (1-\lambda)\epsilon_t \tag{2.1}$$

where equation (2.1) can be estimated using instrumental variables, where current income is instrumented because it is likely to be correlated with ϵ_t.[4] This specification allows for a direct test of rule-of-thumb behaviour, measured by the value and significance of λ. Campbell and Mankiw (1989), using such an approach on US data, conclude that approximately half of agents in the economy act in a rational forward looking manner and half in a rule-of-thumb manner.[5]

Tests similar to that proposed in equation (2.1) have been performed on a wide range of data with a wide range of alternative specifications testing different hypotheses. Some studies perform cross country tests to see how the degree of rule-of-thumb behaviour changes internationally; Table 1 presents a summary of some of these studies for those countries who appear in at least three separate papers. A clear message from this table, which is a common theme throughout the literature, is that the estimates of λ are broad; these estimates seem highly sensitive to the country used in the sample, the sample period, the length of each period and the specification applied. There also appears to be a lack of consistency of the relative rankings across the countries involved in these studies with some economies being reported as having the lowest values of λ in some studies and the highest in others. However, another common theme in Table

[3] This innovation is introduced in Campbell and Mankiw (1989) as a method of testing the permanent income hypothesis and no rationale is given to why consumers may behave in such a way. Potential explanations for this would be a lack of access to capital markets, impatience, or myopia.

[4] The approach used by Campbell and Mankiw (1989) was to instrument using lagged values of income.

[5] It should be noted that there are other interpretations than the simple 'rule-of-thumb' perspective given by Campbell and Mankiw (1989). For example, Carroll (1997) builds a model with income uncertainty and risk averse individuals who when they are sufficiently impatient will have a preference towards maintaining a buffer stock of savings. Carroll uses this model to intuitively link back to the Campbell and Mankiw 'rule-of-thumb' explanation for consumption tracking income.

1, and the literature in general, is that despite this broad range, positive, non-trivial and significant values of λ are consistently found.

The paper of Evans and Karras (1996) performs estimates on 54 separate countries; Table 2 presents a summary of these estimates where countries have been grouped by income categories defined by the World Bank. The results show that, on average, developing economies have a larger proportion of non-Ricardian agents than developed economies and that the estimation of this proportion is less precise with higher average standard errors associated to these estimates. However, the table also implies that whereas developing countries have consistently higher levels of asset market non-participation, there is more variability in the developed economies results; the average standard deviation of the λ estimates is higher in developed economies.

Much of the literature focuses on testing different specifications to US data with very similar results; a non-trivial value of rule-of-thumb behaviour is observed despite broad ranges for λ being found. When these studies test relationships over time, it is often found that the level of non-Ricardian behaviour is diminishing with time, but not at a fast rate: see for example Aschauer (1993), Graham (1993) and Cushing (1999).[6]

The predictions of the permanent income hypothesis has also been tested against specific individuals and households using microeconometric methods. Similar results are found both in terms of departures away from consumption smoothing and rule-of-thumb type behaviour: see for example Shea (1995), Parker (1999), Souleles (1999), Shapiro and Slemrod (2003) and Souleles et al. (2006).[7] Experimental economics has also been applied to the topic with excessive sensitivity of current consumption to current income found in these scenarios: see for example Hey and Dardanoni (1988), Carbone and Hey (2004) and Carbone (2005).[8]

2.2.2 Hypotheses behind non-Ricardian behaviour

The literature has also attempted to investigate and identify reasons behind such widespread departures from the permanent income hypothesis. Jappelli and Pagano (1989) in their cross country investigation adopt a two stage approach; first, they

[6] Campbell and Mankiw (1989) also address this with a sample of six countries and find no discernible relationship between λ and the time period used when considering all these countries.

[7] For microeconometric analysis that shows more support of consumption smoothing refer to Paxson (1993), Browning and Collado (2001) and Hsieh (2003); however, these studies test the movement of consumption to large and predictable movements in income that occur at regular intervals. The papers showing less support, cited in the body, are for less predictable infrequent movements in income.

[8] Carbone (2005) uses her larger sample of 498 participants to identify if certain demographics behaved significantly different from others with respect to their consumption smoothing, with no significant differences highlighted (test were made across age, gender, household characteristics, educational experience and employment, amongst others).

TABLE 1: International estimates of λ

Author (date)	Period	CAN	FRA	GER	GR	ITA	JAP	ESP	SWE	UK	US
Campbell and Mankiw (1989)	1953-1985	0.616***	1.095***	0.646***		0.400***	0.553***			0.221	0.478***
Jappelli and Pagano (1989)	1961-1984				0.60***	0.58***	0.52***	0.72***	-0.05	0.51***	0.17**
Evans and Karras (1996)	1950-1990	0.32***	0.27**	0.35*	-0.88	0.46***	0.49***	0.66***	-0.2	0.79***	0.52***
Sarantis and Stewart (2003)	1960-1994	0.855***	0.632***	0.944***	0.680***	0.781***	0.918***	0.849***	0.798***	0.331**	0.806***

The table includes only those countries for whom at least three separate papers report values. The standard star convention is used; *** signifies that the coefficient is significant to 1% significance, ** to 5% significance and * to 10% significance.

Table 2: Estimates of λ and the level of development

	$Ave(\lambda)$	$Ave(SE)$	$StdDev$	Count
Developed countries	0.389	0.221	0.442	25
Developing countries	0.717	0.218	0.333	29

SOURCE: Author's analysis of results presented in Evans and Karras (1996). Developed countries are those that are described by the World Bank as 'High Income'; Developing countries are those who are not described as 'High Income'. The statistic $Ave(SE)$ relates to the mean standard error on the estimate of λ for that income group. The statistic $StdDev$ relates to the standard deviation in the estimated λ values within the income group in question.

identify rule-of-thumb behaviour in seven OECD countries and subsequently investigate the differences across countries in the levels of this behaviour. It is found that there are more non-Ricardian agents in economies where the ratio of consumer debt to aggregate consumption is low, and moreover, that this is caused not by a lack of demand for consumer debt, but from a lack of supply: individuals are concluded not to have access to capital markets. Zeldes (1989) uses a panel of US households to test the same hypothesis, where this panel is split into two separate types of household: those with assets and those without. The latter households are found to consume out of their current income whereas for the former households a standard Euler equation cannot be rejected. The concept proposed by Zeldes is that it is the lack of assets by these rule-of-thumb households that prohibits their access to capital markets, and therefore subsequent consumption behaviour.[9] Sarantis and Stewart (2003) use both cross country regression and panel data to conclude that it is the presence of liquidity constraints, and to a lesser extent, a precautionary savings motive, that causes cross country deviations in rule-of-thumb behaviour.

Sullivan (2008) performs a separate microeconometric study to see how disadvantaged households supplement their consumption through the use of credit cards in response to a temporary shortfall in earnings. It was found that those households defined as being 'very low asset holders' did not borrow in such times, whereas those households defined as 'low asset holders' borrowed 11 cents for each dollar lost.[10] Moreover, it was identified that households rich in wealth did not borrow in response to temporary shocks. The implication being that some households, with very low wealth, wish to be able to borrow in hard times but are credit-constrained, others can borrow but on high interest credit cards, and the wealthiest can either use their savings or more attractive forms of debt when experiencing temporary income shortfalls.

[9] Shea (1995) performs a similar test through segregating the sample by wealth and finds no support for liquidity constraints explaining departures from the permanent income hypothesis. However, this test was performed on a smaller, more restrictive sample.

[10] Very low asset holders were defined as those households in the bottom decile of total wealth; the study was performed on US data.

The link between limited wealth resources and access to capital markets has been highlighted by other authors, including in Mankiw (2000) who also highlighted the divergence between wealth inequality and income inequality. In the United Kingdom the lowest two quartiles of the wealth distribution hold approximately 10% of the total wealth (Daffin; 2009); this compares the lowest two quartiles of the income distribution earning 29% of total income (ONS, 2011). In terms of Gini coefficients, the statistics for wealth and income distributions are 0.61 (Daffin; 2009) and 0.34 (Barnard et al.; 2011) respectively. When just financial wealth is considered, wealth which is most liquid, the Gini coefficient determining this distribution is 0.81 (Daffin; 2009): “25 percent of households had net financial wealth that was negligible” (Daffin; 2009, p. xxii). The evidence suggests that there is a significant proportion of agents who are unable to save from their current earnings, which prohibits them access to credit markets in the presence of adverse income shocks.

2.2.3 Discussion

The literature on the consumption behaviour of economies and individuals suggests that there are significant proportions of agents within developed and developing countries who do not follow the predictions of the permanent income hypothesis, and whose consumption follows closely the path of their disposable income. This general conclusion is robust across countries, data and specifications. The literature also suggests that this observation is at least partially driven by a lack of access to capital markets by some proportion of agents, who therefore cannot smooth their consumption. It is implied that this lack of access is related to low and negative levels of assets, for these individuals who cannot therefore provide collateral to financial institutions.

It is a key premise of this thesis that the households classified as ‘non-Ricardians’ are distinct economic agents.[11] It is also proposed, given the lack of wealth prohibiting capital market transactions and from general intuition, that non-Ricardian households will come from the lower end of the income distribution, and given how skewed this distribution is, a consequence of this discussion is that the share of households that are credit-constrained in an economy will be greater than λ from equation (2.1); with the

[11] This is an important distinction because it could be thought that every economic agent uses a proportion (λ) of their income for direct consumption and a proportion $(1-\lambda)$ in a rational, permanent income hypothesis, way. If this were true then each agent in the economy would be identical and there would be no deviation across them.

high estimates of λ in Tables 1 and 2 this could leave a very significant proportion of the population as being non-Ricardian.[12]

The lack of asset market participation is, however, an empirical regularity and for some consumers formal restrictions to participation seems to be a fair reflection, whereas for other this restriction appears to be ex post appropriate. However, the modelling technique that disaggregates households into those who participate in financial markets and those who do not should not be used without consideration of these issues and appropriate qualifications.

2.3 The model

The model presented below is a cashless DSGE model with sticky prices including six types of economic agent: a continuum of households split into two heterogeneous groups; a continuum of monopolistically competitive firms producing intermediate goods and a perfectly competitive market producing the final good; and a monetary and fiscal authority. The model is similar to Galí et al. (2007), the seminal paper in the rule-of-thumb DSGE literature and the benchmark from which most subsequent models follow. The model differentiates itself from Galí et al. (2007) by abstracting from physical capital accumulation: this is to simplify the model such that transmission mechanisms can be identified, and further, algebraic properties can be observed. Moreover, the shocks come from non-policy sources and as such the government sector is modelled fully through reaction functions, responding to the business cycle and levels of debt.

2.3.1 Households

There is a continuum $[0, 1]$ of infinitely lived households, all of which consume the final good and supply labour to firms. A proportion of these households $(1 - \lambda)$ are 'Ricardian' who have access to capital markets and can trade in a full set of state contingent securities. The remaining proportion (λ) are 'non-Ricardian' and have no access to capital markets. The period utility function, U_t^i, is assumed to be the same for both types of household and is given by:

[12] Equation (2.1) works on the assumption that λ represents the proportion of income that goes to hand-to-mouth agents; if these agents receive less than the average levels of income per capita there will be more weight of them in terms of people (proportion of the population) than λ (proportion of income).

$$U_t^i = \varepsilon_t^b \left(\frac{\left(C_t^i\right)^{1-\sigma}}{1-\sigma} - \frac{\left(N_t^i\right)^{1+\varphi}}{1+\varphi} \right) \tag{2.2}$$

where C_t and N_t are the amount of consumption and employment consumed and supplied respectively in period t, and ε_t^b represents an exogenous shock to the discount rate which affects intertemporal substitution preferences of households. The parameter σ is the coefficient of relative risk aversion and φ is the inverse elasticity of work with respect to the real wage. Superscript i differentiates these variables between Ricardian ($i = R$) and non-Ricardian ($i = NR$) households.

Ricardian households

Ricardian households gain income from their labour supply (at a wage rate W_t), from the dividends paid on share ownership, D_t^R, and from maturing one period bonds purchased in the previous time period, B_t^R. They can use this income in order to purchase the consumption good (at a price P_t), reinvest in the bond market (at a given return R_t), and to pay any lump sum tax levied by the fiscal authority, T_t^R. This leaves a budget constraint to Ricardian households given by:

$$P_t C_t^R + \frac{B_{t+1}^R}{R_t} + P_t T_t^R \leq W_t N_t^R + D_t^R + B_t^R \tag{2.3}$$

Ricardian households maximise expected lifetime utility (given by the sum of (2.2) from $t = 0$ to $t = \infty$) discounting future periods of utility by a factor $\beta^R \in (0, 1)$, subject to the budget constraint (2.3) with respect to consumption, employment and bond purchases, where all prices are taken as given. Performing this optimisation provides the following first order conditions:

$$\left(N_t^R\right)^{\varphi} \left(C_t^R\right)^{\sigma} = \frac{W_t}{P_t} \tag{2.4}$$

$$R_t^{-1} = \beta^R E_t \left\{ \left(\frac{C_{t+1}^R}{C_t^R} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \left(\frac{\varepsilon_{t+1}^b}{\varepsilon_t^b} \right) \right\} \tag{2.5}$$

Equation (2.4) is a function describing the labour supply function for Ricardian households and equation (2.5) is a typical Euler equation describing the relationship between intertemporal consumption and interest rates.

Non-Ricardian households

Non-Ricardian households do not have access to bond markets and as such cannot intertemporally substitute consumption. Moreover they do not own company shares. They simply consume, period-by-period, their disposal income generated through their supply of labour; this provides the non-Ricardian consumption function:

$$P_t C_t^{NR} = W_t N_t^{NR} - P_t T_t^{NR} \tag{2.6}$$

where equality is given by assumed strictly positive marginal utility from consumption. This consumption behaviour is either exogenously imposed or can be endogenously rationalised in a framework similar to Iacoviello (2005) whereby non-Ricardian households are more impatient than Ricardian households, $\beta^R > \beta^{NR}$, and can default on their debt up to the value of their collateral. With no durable goods in the non-Ricardian utility function, impatience prohibits the accumulation of collateral, and as such they are prohibited from engaging in bond and capital markets.[13] Non-Ricardian households still optimise their period-by-period utility by making decisions on how much labour to supply at a given wage rate: maximising (2.2) subject to the budget constraint (2.6) with respect to consumption and employment where prices and wages are taken as given, resulting in the following:

$$\left(N_t^{NR}\right)^{\varphi} \left(C_t^{NR}\right)^{\sigma} = \frac{W_t}{P_t} \tag{2.7}$$

Which describes the supply of labour for non-Ricardian households. Note that this condition is similar to that of (2.4), the supply of labour of Ricardian households, which is due to the assumed identical period utility function of the two heterogeneous households.

Labour market assumptions

Similar to Galí et al. (2007), two labour market assumptions will be utilised. The first will be that of perfectly competitive markets where each agent can supply labour at a given wage rate to the market. The negotiation of this wage happens frictionlessly and instantly.

In the second labour market assumption a continuum, indexed $k \in [0, 1]$, of monopolistically competitive unions add a markup to wages: this can be performed because each

[13]Section 2.2 above discusses empirical results on both low wealth holdings for some individuals and the observation that some agents consume 'hand-to-mouth'.

union supplies a differentiated labour input. There is no friction to wage negotiations, and all households are treated indiscriminately receiving the same wages and working the same hours. This is performed by the unions aggregating preferences across households to find a weighted average labour supply function. Each union is assumed to have a ratio of non-Ricardian to Ricardian members of $\lambda : (1 - \lambda)$. Effective labour in firm j is now given by a CES aggregation function:

$$N_t(j) = \left(\int_0^1 N_t(j,k)^{\frac{\epsilon_w - 1}{\epsilon_w}} di \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}$$

where $N_t(j,k)$ represents the input of firm j of labour from union j and ϵ_w represents the elasticity of substitution across different labour types. Such a technology leads to a demand schedule similar to (2.8) which acts as the constraint to each union, who maximise a weighted average of household utility.

Steady state consumption, employment and utility

It will be assumed that the government set steady state lump sum taxes on the two types of households such that the increased income from dividends for the Ricardian agents is eliminated. Note, that this could also be achieved through assuming that no profits are made in steady state, through imposing a fixed cost in production (as assumed in Chapter 5), or through fully taxing these profits lump sum. Note also that as the transfer is lump sum, it does not impact on the steady state properties of the model, just the steady state allocation; Section 3.6.2 also demonstrates algebraically how the dynamics of the model are unaffected by this assumption, if λ is treated as the share of income accruing to non-Ricardian agents, as opposed to the share of these households in the population (as is the case in the empirical literature: see Section 2.2).

The assumption, combined with the identical utility function assumed for the two types of households, leads to the same consumption and employment profile of the heterogeneous households in steady state: $C^{NR} = C^R = C$ and $N^{NR} = N^R = N$. This assumption simplifies the calculations but is not critical to the main results of the model.[14] However it provides the benchmark whereby if the economy remains in steady state, both types of households will consume and work in identical proportions and consequently derive identical period utilities.

[14]This assumption does go against the hypothesis discussed above that non-Ricardian households are financially poorer than Ricardian households. However, the results are not sensitive to this assumption, and significant results can be obtained without imposing this hypothesis on the model. A full discussion of the implications of relaxing this assumption is presented in Chapter 3.

2.3.2 Firms

The production sector is made up of a continuum of monopolistically competitive producers, indexed $j \in [0,1]$, who employ household labour in order to produce differentiated intermediate goods. These goods are then purchased by a perfectly competitive firm who makes the final good Y, consumed by both households and the fiscal authority.

Final good firm

The sector which produces the final good is modelled as a single representative perfectly competitive market which combines the intermediate goods using a standard Dixit-Stiglitz aggregator:

$$Y_t = \left(\int_0^1 Y_t\,(j)^{\frac{1}{1+\mu_t}}\, dj \right)^{1+\mu_t}$$

where Y_t represents the final good, $Y_t\,(j)$ represents the intermediate good quantity from firm j, and μ_t represents a stochastic time varying markup charged by intermediate good firms, given by $\mu_t = \mu + \varepsilon_t^{\mu}$. This markup is possible because each intermediate firm produces a differentiated product with the elasticity of substitution across goods given by ϵ, such that the steady state markup is given by $\mu = 1/(\epsilon - 1)$: ε_t^{μ} represents an $AR(1)$ shock process in log-linear form. Profit maximisation of the final good market, taking all prices as given, yields the following standard demand schedules:

$$Y_t\,(j) = \left(\frac{P_t\,(j)}{P_t} \right)^{-\frac{1+\mu_t}{\mu_t}} Y_t \quad \forall\, j \in [0,1] \tag{2.8}$$

where $P_t\,(j)$ is the price of the intermediate good $Y_t(j)$ and P_t is the price of the final good, in period t. The market is perfectly competitive and as such makes zero profits, which provides the following aggregate price index condition:

$$P_t = \left(\int_0^1 P_t\,(j)^{-\frac{1}{\mu_t}}\, dj \right)^{-\mu_t}$$

Intermediate goods firms

A continuum of firms are assumed to produce the differentiated intermediate goods subject to Cobb-Douglas technology where capital is fixed and normalised:

$$Y_t(j) = \varepsilon_t^a N_t(j)^{1-\alpha} \tag{2.9}$$

where $N_t(j)$ is the level of labour employment by firm j, and ε_t^a represents a productivity shock. A Calvo (1983) pricing structure is assumed for intermediate goods, where firms in any period get the opportunity to reset prices with probability $(1-\theta)$. This probability is fixed, exogenous, and independent of when the firm was last randomly selected to reset their prices. With assumed identical intermediate firms, all $(1-\theta)$ firms 'reseting' their price in period t will do so at the same price, P_t^*. With this pricing structure, the dynamics of aggregate prices, P_t, is given by:

$$P_t = \left[\theta P_{t-1}^{-\mu_t^{-1}} + (1-\theta)\left(P_t^*\right)^{-\mu_t^{-1}}\right]^{-\mu_t} \tag{2.10}$$

A firm that is able to reset their price in any given period will do so such as to maximise expected future profits given the new reset price, P_t^*. Algebraically:

$$\max_{P_t^*} \sum_{k=0}^{\infty} E_t\left\{Q_{t,t+k}\left(P_t^* Y_{t+k|t}(j) - \Psi_{t+k}\left(Y_{t+k|t}(j)\right)\right)\right\}$$

subject to the demand from the final good firms (2.8) where $\Psi_{t+k}(.)$ is a nominal cost function, $Y_{t+k|t}(j)$ is the expected output in period $t+k$ for a firm who last reset its price in period t, and $Q_{t,t+k} = \left(\beta^R\right)^k \left\{(C_{t+k}/C_t)^{-\sigma}\left(P_t/P_{t+k}\right)\right\}$ is the stochastic discount factor for nominal payoffs.[15] Solving this problem provides the following first order condition:

$$\sum_{t=0}^{\infty} \theta^k E_t\left\{Q_{t,t+k} Y_{t+k|t}(j)\left(P_t^* - (1+\mu_t)\psi_{t+k|t}\right)\right\} = 0 \tag{2.11}$$

where $\psi_{t+k|t} = \Psi'_{t+k}$ denotes the nominal marginal cost in period $t+k$ for a firm who reset its price in period t. The remaining suppliers, θ, must maintain the same price as they had in period $t-1$.

[15] Note that in this economy the nominal cost function is one of only wages and the level of employment.

2.3.3 Monetary authority

For the conduct of monetary policy a simple log-linear Taylor rule is assumed where the nominal interest rate responds positively and contemporaneously to deviations in both inflation and output:

$$r_t = \varphi_\pi \pi_t + \varphi_y y_t + \varepsilon_t^r \tag{2.12}$$

where lower case letters represent log deviations of variables from their non-stochastic, zero inflation, zero government debt, steady state values; r_t is the log deviation in the nominal interest rate in period t, π_t the log inflation rate between period t and $t-1$, and y_t is the log deviation of output from steady state.[16] The policy parameters φ_π and φ_y define the responsiveness of the nominal interest rate to movements away from target rates of inflation and output respectively. An exogenous $AR(1)$ shock process, ε_t^r, is included in the monetary policy setting process, which represents movements in the nominal interest rate which are not determined by movements in the aggregate economy.

2.3.4 Fiscal authority

The fiscal authority purchases a proportion of the final goods for public consumption, G_t, raises lump sum taxes from the two households, T_t^R and T_t^{NR}, and issues nominal risk-free one-period bonds, B_{t+1}. As such, the flow constraint of the government is given by:

$$P_t G_t + B_t \leq P_t (T_t^R + T_t^{NR}) + \frac{B_{t+1}}{R_t} \tag{2.13}$$

The model includes a proportion of non-Ricardian households and therefore the dynamics and evolution of government expenditures, taxes and debt are relevant. Simple log-linear feedback rules are considered which allow the government to respond to the business cycle and ensure that debt is stabilised. Formally:

$$\widehat{g}_t = \varphi_g y_t + \varphi_{b,g} \widehat{b}_t \tag{2.14}$$

$$\widehat{t}_t = \varphi_T y_t + \varphi_{b,T} \widehat{b}_t \tag{2.15}$$

[16] Note that this could have been written in its 'pre-log-linear' form with $R_t/R = (\Pi_t/\Pi)^{\varphi_\pi} (Y_t/Y)^{\varphi_y} \varepsilon_t^r$.

where *hatted* lower case variables represent deviations from steady state as a proportion of steady state output: for example $\widehat{x}_t = (X_t - X)/Y$.[17] To simplify, it will be assumed throughout the analysis $\widehat{t}_t^{NR} = \widehat{t}_t^{R} = \widehat{t}_t$; changes in lump sum taxes are equal across all households and there is no redistribution between households through taxation. This means the results abstract away from progressive or regressive taxes. The coefficients φ_g, φ_T, $\varphi_{b,g}$ and $\varphi_{b,T}$ are policy parameters set by the fiscal authority. Setting either $\varphi_g < 0$ or $\varphi_T > 0$ means that government spending rises, or taxes fall in response to a shock resulting in lower than natural output levels; countercyclical fiscal policy. Setting these parameters to nil is equivalent to an acyclical policy, or with reversed signs, a procyclical policy. The above rules allow the fiscal variables to respond to the level of government debt which acts to preserve the solvency constraint.[18] Log-linearising (2.13) and substituting (2.14) and (2.15) into the resulting expression provides the condition:

$$\widehat{b}_{t+1} = (1+\rho_R)\left[\widehat{b}_t\left(1+\varphi_{b,g}-\varphi_{b,T}\right)+y_t\left(\varphi_g-\varphi_T\right)\right] \tag{2.16}$$

The dynamics of government debt are stationary providing that $(1+\rho_R)(1+\varphi_{b,g} - \varphi_{b,T}) < 1$, or equivalently $\varphi_{b,T} - \varphi_{b,g} > \rho_R/(1+\rho_R)$, where $\rho_R = (1-\beta^R)/\beta^R$ is the steady state interest rate; this condition states that in the long run the fiscal authority must pay back debt faster than interest accrues on it.[19]

2.3.5 Market clearing, aggregation and equilibrium conditions

In equilibrium, aggregate consumption and employment are equal to the weighted average of the two variables across households:

$$C_t = (1-\lambda)\,C_t^R + \lambda C_t^{NR} \tag{2.17}$$

$$N_t = (1-\lambda)\,N_t^R + \lambda N_t^{NR} \tag{2.18}$$

Moreover, all output must be consumed by either the government or private individuals:

[17] Similar to the Taylor rule, we could have written these fiscal rules in their pre-log-linear format.

[18] The government is assumed to satisfy the solvency constraint that in the long run all debts are fully repaid: algebraically, $\lim_{t\to\infty} B_{t+1}/R_t = 0$.

[19] Note that the condition $\varphi_g = \varphi_T$ provides a balanced budget at all times and nil government debt; the counter(pro)cyclical reaction of one fiscal policy variable must be matched by an equal and opposite pro(counter)cyclical reaction in the other variable.

$$Y_t = C_t + G_t \tag{2.19}$$

The model is solved by deriving log-linear approximations of the key optimality conditions and policy rules around the non-stochastic steady state with zero inflation and zero government bonds: these conditions can be found in Appendix A.1. Once all calculations have been performed the general equilibrium model can be expressed through the policy and non-policy blocks, the latter of which can be represented through an aggregate demand condition and a New Keynesian Phillips curve.

Aggregate demand

The aggregate demand relationship can be obtained by combining log-linear versions of the goods market clearing condition (2.19), the production function (2.9), and the Euler equation obtained through combining the optimisation of the Ricardian and non-Ricardian household utility. In a general format the aggregate demand condition can be written as:

$$\begin{aligned} y_t \;=\; & E_t\left\{y_{t+1}\right\} - \Phi E_t\left\{\triangle\widehat{g}_{t+1}\right\} - \Phi\Theta_A\left(r_t - E_t\left\{\pi_{t+1}\right\} - E_t\left\{\Delta\varepsilon^b_{t+1}\right\}\right) \\ & +\Phi\Theta_B E_t\left\{\Delta\varepsilon^a_{t+1}\right\} + \Phi\Theta_C E_t\left\{\triangle\widehat{t}^{NR}_{t+1}\right\} \end{aligned} \tag{2.20}$$

where the coefficients Φ, Θ_A, Θ_B and Γ depend upon the labour market assumption. When perfectly competitive labour markets are assumed these coefficients are defined by (derived in Appendix A.3):

$$\begin{aligned} \Phi^{PC} &= \frac{\left(\Gamma^{PC}\right)^{-1}}{\left(\Gamma^{PC}\right)^{-1} - \gamma_c\varphi\lambda\left(1+\varphi\right)} \\ \Theta^{PC}_A &= \gamma_c\left(1-\lambda\right)\frac{1}{\sigma}\left(\varphi(1+\mu)\gamma_c + \sigma\left(1-\alpha\right)\right)\Gamma^{PC} \\ \Theta^{PC}_B &= \gamma_c\varphi\lambda(1+\varphi)\Gamma^{PC} \\ \Theta^{PC}_C &= \gamma_c\varphi\lambda(1+\mu)\Gamma^{PC} \\ \Gamma^{PC} &= \left[\varphi(1+\mu)\gamma_c + \sigma\left(1-\alpha\right)\left[1-\lambda\left(1+\varphi\right)\right]\right]^{-1} \end{aligned} \tag{2.21}$$

where superscript PC represents coefficients that result from an economy with a perfectly competitive labour market. When labour markets are assumed to be imperfectly competitive, the coefficients are defined by (derived in Appendix A.4):

$$\begin{aligned}
\Phi^{IC} &= \frac{\left(\Gamma^{IC}\right)^{-1}}{\left(\Gamma^{IC}\right)^{-1} - \gamma_c \lambda \left(1+\varphi\right)} \\
\Theta_A^{IC} &= \gamma_c^2 \left(1-\lambda\right) \frac{1}{\sigma} (1+\mu) \Gamma^{IC} \\
\Theta_B^{IC} &= \gamma_c \lambda \left(1+\varphi\right) \Gamma^{IC} \\
\Theta_C^{IC} &= \gamma_c \lambda (1+\mu) \Gamma^{IC} \\
\Gamma^{IC} &= \left[(1+\mu)\gamma_c - \lambda \sigma \left(1-\alpha\right)\right]^{-1}
\end{aligned} \tag{2.22}$$

where superscript IC represents coefficients that result from an economy with imperfectly competitive labour markets. Demand is a function of fiscal and monetary policy, where the extent of each element is dependent upon the share of non-Ricardian households in the economy. When $\lambda = 0$, the expression becomes a simple log-linear Euler expression in output, with intertemporal substitution between periods defined through the real interest rate (and where the perfectly competitive and perfectively competitive labour market aggregate demand coefficients are the same). As λ increases so too does the coefficient Φ, which is a coefficient reflecting that both employment and the real wage rate (which combine to give non-Ricardian households' disposable income) can be expressed as functions of output. Non-Ricardian consumption is a function of output which itself is a function of non-Ricardian consumption, which creates a multiplier effect between demand and any initial stimulus.

New Keynesian Phillips curve

The production sector of the economy is independent of the proportion of rule-of-thumb consumers and can be summarised by a typical New Keynesian Phillips curve (derived in Appendix A.5):

$$\begin{aligned}
\pi_t &= \beta^R E_t \left\{\pi_{t+1}\right\} + \omega \left(mc_t^r + \varepsilon_t^\mu\right) \\
\omega &= \frac{1-\alpha}{1-\alpha+\alpha\epsilon} \frac{\left(1-\beta^R\theta\right)\left(1-\theta\right)}{\theta} \\
mc_t^r &= y_t \left[\frac{\sigma}{1-\gamma_g} + \frac{\varphi+\alpha}{1-\alpha}\right] - \widehat{g}_t \left[\frac{\sigma}{1-\gamma_g}\right] - \varepsilon_t^a \left[\frac{1+\varphi}{1-\alpha}\right]
\end{aligned} \tag{2.23}$$

where $E_t\{\pi_{t+1}\}$ is the expectation in the current time period of inflation in the next and mc_t^r represents the (log deviations of) real marginal costs of the monopolistically competitive firms in the current time period. Increases in output increase consumption in the economy and thus reduce labour supply as households substitute consumption for leisure, and increase the demand for labour in order to produce the extra output. Both of these factors push up the real wage and therefore increase the real marginal cost of production, mc_t^r, to firms. The decrease in the labour supply can be muted by increases in government spending as this removes resources from private consumption and therefore reduces the substitution effect: increases in government consumption, for a given level of output, reduce real wages.

Exogenous shocks and the closed system

The two equations above illustrate that the four exogenous shocks can be grouped into three separate categories: those which only enter aggregate demand (preference and interest rate shocks); those which only enter the Phillips curve (exogenous movements in the desired markup); and those which enter both (productivity shocks). Preference and interest rate shocks enter the aggregate demand condition because movements in both impact the consumption decisions of Ricardian households. Exogenous increases in the desired markup charged by intermediate firms acts as a cost push shock on the economy, providing additional inflation given a certain level of output. Productivity increases, on the other hand, increase the productive capacity of the economy at no additional cost to inflation and moreover impact the labour demanded by firms. The former impacts the Phillips curve whilst the latter impacts aggregate demand through the consumption of non-Ricardian households.[20] Although the model is too simple to include the vast array of exogenous processes of larger DSGE models, these four shocks provide us with three possibilities that cover many further extensions. All logarithms of shocks are assumed to follow a first order autoregressive process with persistence ρ_i and an i.i.d error term η_t^i for $i = \{a, b, l, r\}$.

2.4 Properties of the model

This section explores the properties of DSGE models including rule-of-thumb households by reflecting upon the properties of the general form model presented above and comparing these against those found in the literature: the most comprehensive existing analysis comes from Bilbiie (2008).

[20] Bilbiie (2008) also demonstrated that technology shocks enter additively in both the aggregate demand condition and New Keynesian Phillips curve.

2.4.1 Non-Keynesian region

It is commonly observed that increases in government spending, tax cuts and reductions in interest rates lead to an increase in aggregate demand, all other things being equal. However, this is only true if Φ, Θ_A, Θ_B and Γ are positive in the aggregate demand condition (2.20); as can be seen from the definitions of these coefficients, however, this assumption does not always hold.

Proposition 1. (The 'non-Keynesian region') *There exist a range of λ, and other relevant parameters, such that the expected demand relationships of increases (decreases) in government spending and cuts (rises) in interest rates and taxes lead to a rise (fall) in demand, are reversed.*

Proof. The above proposition will be true when the coefficient Φ is negative which in turn is true when the denominator of this coefficient is negative (noting that the numerator is always greater than the denominator); Bilbiie (2005) refers such calibrations as those where the economy is in the 'non-Keynesian region'. Solving this condition with respect to λ for the economy with perfectly and imperfectly competitive labour markets respectively, provides the following two calibrations at which point this non-Keynesian region is reached:

$$\begin{aligned} \lambda^*_{PC} &= \frac{\varphi\gamma_c(1+\mu)+\sigma(1-\alpha)}{(1+\varphi)\left[\varphi\gamma_c+\sigma(1-\alpha)\right]} \\ \lambda^*_{IC} &= \frac{\gamma_c(1+\mu)}{(1+\varphi)\gamma_c+\sigma(1-\alpha)} \end{aligned} \tag{2.24}$$

where λ^* follows the notations of Bilbiie (2008): the calibration of λ where the economy goes from the Keynesian to the non-Keynesian region. At all values of $\lambda > \lambda^*$, the expected directions of movement in the aggregate demand condition (2.20) are reversed (with the potential exception of government spending, see Proposition 4): Bilbiie describes this as 'inverted aggregate demand logic' (Bilbiie; 2008, 164). □

Figure 1 plots different values of Φ for different λ whilst holding all other relevant parameters constant; within this it is possible to see that there is a critical calibration of λ, where the value of Φ reverses, and this is given by λ^*. This is an important property of the model as it will have a significant impact on the determinacy conditions; however, it will be trivial if $\lambda^* > 1$.

Corollary 1. *Providing the markup charged by the intermediate good firms is not unreasonably large, $\lambda^* < 1$.*

Proof. From the definitions of λ^* for both labour market assumptions it is possible to derive that providing:

$$\mu < \varphi + \sigma(1-\alpha)(\gamma_c)^{-1}$$

$\lambda^* < 1$, and therefore not trivial. □

2.4.2 The non-linear feedback mechanism

The presence of the non-Keynesian region in models which include a proportion of credit-constrained agents is an interesting property which provides further scope to this class of models. This region comes about as a result of a feedback mechanism whereby output is a function of non-Ricardian consumption which itself is a function of output due to the way increased activity in the economy leads to increases in wages and subsequently disposable incomes. In this respect a traditional Keynesian multiplier is present in the model.

Proposition 2. (Feedback Effect) *The higher the proportion of non-Ricardian consumers, up until the point λ^*, the greater the impact to aggregate demand of changes in fiscal and monetary policy.*

Proof. Algebraically this can be illustrated by partially differentiating the coefficients in the aggregate demand condition (2.20) with respect to λ. For both labour market assumptions Appendix A.6 demonstrates that:

$$\frac{\partial\Phi}{\partial\lambda} > 0; \quad \frac{\partial\Phi\Theta_A}{\partial\lambda} > 0; \quad \frac{\partial\Phi\Theta_B}{\partial\lambda} > 0; \quad \frac{\partial\Phi\Theta_C}{\partial\lambda} > 0 \tag{2.25}$$

in the region $0 < \lambda < \lambda^*$. □

Any changes in the aggregate demand of the economy consequently impact on wage levels and subsequently the disposable income of all agents. When this occurs, the consumption of non-Ricardian households deviates and correspondingly this changes aggregate demand; there is a feedback mechanism that amplifies any movements in aggregate demand. The greater the proportion of non-Ricardian agents in the economy, those agents who consume out of disposable income, the greater this amplification is. Again Φ is the key parameter and from equations (2.21) and (2.22) it can be seen that this is a rectangular hyperbola with respect to λ (as is demonstrated in Figure 1), implying that this feedback effect will accelerate.

Proposition 3. (Non-Linear Feedback Effect) *The result found in Proposition 2 will be non-linear in λ such that the higher the level of λ, up until λ^*, the greater the increase in aggregate demand coefficients associated with a unit change in λ.*

Proof. Proposition 3 directly follows on from Proposition 2 and can be demonstrated by partially differentiating the conditions in (2.25) with respect to λ. Appendix A.7 demonstrates, in the region of $0 < \lambda < \lambda^*$:

$$\frac{\partial^2 \Phi}{\partial \lambda^2} > 0; \quad \frac{\partial^2 \Phi \Theta_A}{\partial \lambda^2} > 0; \quad \frac{\partial^2 \Phi \Theta_B}{\partial \lambda^2} > 0; \quad \frac{\partial^2 \Phi \Theta_C}{\partial \lambda^2} > 0$$

Hence Proposition 3 is demonstrated. □

Proposition 3 states that the feedback effect found in Proposition 2 is non-linear; as more agents act hand-to-mouth the impact from an initial demand impulse will be amplified to greater degrees. Again this is an important property of this class of models and highlights the importance of the value of λ. This non-linear feedback effect of credit-constrained individuals has been seen in previous work; most comprehensively in the papers of Bilbiie and Straub (2004) and Bilbiie (2008). Although not explicitly reflected upon, the non-linear effect can also be seen in a number of other papers in the literature, when the sensitivity of results in these papers are tested against varying degrees of λ.[21] This property can also be observed in Figure 1.

The result found in Proposition 1 states that the non-linear feedback property of these models is unsustainable; there is a limit at which the relationship collapses, at calibrations of $\lambda \geq \lambda^*$. Bilbiie (2008) stated that the key parameter in the λ^* relationship is φ, the inverse elasticity of the labour supply with respect to real wages. As the elasticity of labour supply decreases (φ increases), additional output can only be produced by a large increase in real wages needed to increase the supply of labour. When this occurs, there is a large comovement between real wages and employment and therefore also in the non-Ricardian households' disposable income. When λ reaches λ^*, the amplification process becomes unstable and beyond this point the relationship is reversed. Bilbiie (2008) relates this situation to where marginal costs are increasing by so much they squeeze the profits of production firms, therefore reducing the dividends paid out in general equilibrium and restricting consumption of Ricardian agents; this intuition is supported by the observation that $\partial\lambda^*/\partial\mu > 0$. Further, the λ^* condition is a function of both σ and $(1-\alpha)$ where higher values of each decrease λ^* because they elicit larger

[21] See for example Coenen and Straub (2005), Galí et al. (2007), Furlanetto and Seneca (2009) and Colciago (2011).

increases in wages necessary to increase output, the former because it reduces the utility from consumption (and therefore decrease the utility from additional income) and the latter because it increases the marginal product of labour.

2.4.3 Quasi-Keynesian region

The two regions described above (the Keynesian and non-Keynesian regions) do not fully describe the model. There is a third region, referred to here as the quasi-Keynesian region, because although the relationship between aggregate demand and taxes and interest rates remain inverted, the 'normal' relationship between demand and government spending is restored. This region was not reflected upon in Bilbiie (2008) as in that paper there was no fiscal sector.

Proposition 4. (The 'quasi-Keynesian region') *At sufficiently high values of λ, Φ will go from being negative to positive. At this point the economy is said to be in the quasi-Keynesian region as the expected relationship of greater government spending leading to increases in output will be restored.*

Proof. Although the proof to Proposition 1 covered the ranges where the denominator and numerator of Φ are both positive (the Keynesian region) and where the former is negative and the latter positive (the non-Keynesian region), there exists plausible calibrations where both the denominator and the numerator are negative and therefore where Φ is positive (the quasi-Keynesian region). For such a region to exist there needs to be a range of λ where the following is true, for the perfectly and imperfectly competitive labour market assumptions, respectively:

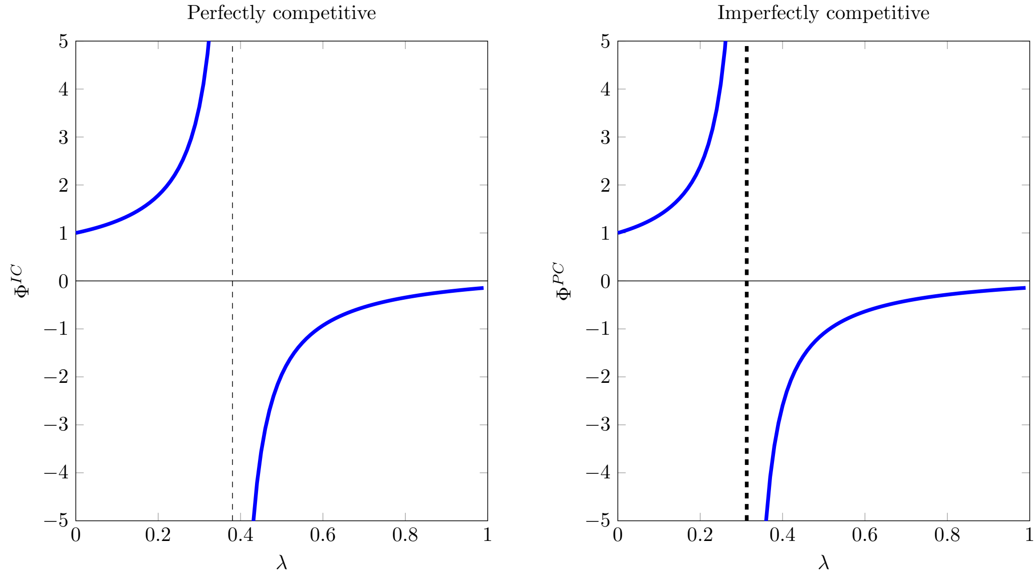
$$\begin{aligned}
\lambda'_{PC} &> \frac{\varphi\gamma_c(1+\mu)+\sigma(1-\alpha)}{\sigma(1-\alpha)(1+\varphi)} \\
\lambda'_{IC} &> \frac{\gamma_c(1+\mu)}{\sigma(1-\alpha)}
\end{aligned} \tag{2.26}$$

Therefore, under such a scenario there is a region such that $1 > \lambda > \lambda'$ where the economy is in the quasi-Keynesian region. □

2.4.4 A graphical representation

To demonstrate these properties Figure 1 plots the values for Φ for both labour market assumptions, using the calibration applied in Chapter 4; namely, $\alpha = 1/3$, $\varphi = 2$,

FIGURE 1: Model properties: Φ at different values of λ



The left plot measures the value of Φ for different values of λ for the perfectly competitive labour market, and the right hand plot does the same for the imperfectly competitive market. All other parameters are fixed: specifically, $\alpha = 1/3$, $\varphi = 2$, $\gamma_c = 0.8$, $\mu = 0.2$ and $\sigma = 1$. The dashed-vertical line represents the value of $\lambda*$ in both plots.

$\gamma_c = 0.8$, $\mu = 0.2$ and $\sigma = 1$. Note that Φ is the key parameter in these properties as it appears in all the coefficients within the aggregate demand condition. In this figure it is possible to observe: the 'non-Keynesian region' above λ^* (Proposition 1); the non-linear feedback mechanism up until the value of λ^* (Propositions 2 and 3); and that $\lambda^*_{PC} > \lambda^*_{IC}$. Note at this calibration, the 'quasi-Keynesian' region is not applicable as $\lambda' > 1$.

2.5 Conclusions

The introduction of credit-constrained households into DSGE models is increasingly popular. This is due to the empirical relevance of such consumption behaviour and moreover due to the better performance for these models to match empirical data. Despite the widespread use of these models, however, limited analysis is performed considering the heterogeneous experiences of the different agents and this is a significant focus of this thesis. This chapter derives a tractable New Keynesian DSGE model with the inclusion of credit-constrained agents and explores the algebraic properties of the model. The inclusion of rule-of-thumb agents adds specific properties to such class of models, which have been demonstrated and discussed, and which we will return to in the following Chapters.

Chapter 3

"We're all in this together"? A DSGE interpretation

3.1 Introduction

The recent global economic downturn has resulted in hardship for many individuals in many countries; the unequal distribution of this hardship across agents is a topic of political significance, which is frequently debated. In the autumn of 2008, before the extent of the recession was known, The Economist (October 23, 2008) suggested that there was a desire for an 'equality of sacrifice' in the looming downturn with the fear that this equality would not be reached. A commentary in the Financial Times (March 25, 2011) reflecting upon the movements in share prices for different retail firms, inferred that the middle and lower classes in the US and UK were suffering more than the wealthiest in the current recession, supporting the concerns of the earlier Economist article.[1] Beyond this class and income divide there is clear anecdotal evidence that the recent recession is impacting some more than others. Perhaps the most globally widespread, at least in Europe, are the high levels of youth unemployment. These debates and fears entered the political rhetoric of the recession with calls of a '*squeezed* and *anxious* middle' in the UK and US respectively.[2] Despite this there are continuing calls from ruling politicians that 'we're all in this together'.[3]

[1] The article compares the appreciation in shares in companies such as Tiffany and Saks against the depreciation in companies such as Walmart. Another article in the Financial Times came to similar conclusions using anecdotal evidence interviewing families in the US (Financial Times, July 30, 2010).

[2] The 'anxious middle' is an expression used in the US by Larry Summers, former US Treasury Secretary; in the UK, the leader of the opposition Ed Miliband has frequently used the phase the 'squeezed middle' (Financial Times, December 20, 2011).

[3] This is most noticeably used by David Cameron in the UK and has also been used by others such as Barack Obama. The former in a speech given on the August 15 2011 (for example) and the latter in an interview with CBS News April 19, 2009.

Lucas (2003) abstracted from these heterogeneity issues to propose that the impact of business cycles on aggregate welfare was negligible. Through analysing movements in aggregate US consumption around trend, the welfare gain of removing economic fluctuations was calculated to be the utility equivalent of less than one-tenth a percentage point increase in average consumption. However, a number of papers have challenged this result by removing the representative agent assumption of Lucas' analysis. Krusell and Smith (1999) claim that the welfare costs of business cycles are of interest because of the heterogeneous distribution of these costs: abstracting away from this abstracts away from the crux of the issue. Through introducing idiosyncratic agent productivity shocks combined with incomplete insurance markets, Krusell and Smith (1999) show that eliminating business cycles would be to the benefit of the poor and unemployed: fluctuations hurt these the most, something reflected in the anecdotal evidence of the recent downturn. Krusell et al. (2009) obtain comparable results showing that business cycle fluctuations disproportionately impact the poor and rich more than the middle classes. Mukoyama and Şahin (2006) perform a similar analysis to conclude that it is unskilled workers who suffer most from business cycles. Carroll (2000) further suggests that the distribution of wealth is an important determinant in agents' experiences from macroeconomic phenomena, a concept also emphasised by Mankiw (2000) when discussing the aggregate effects of fiscal policy. This heterogeneity may also reconcile the result that when using subjective measures of welfare the implied costs of business cycles are larger than those originally suggested by Lucas: see for example Wolfers (2003).

The innovation of this chapter is to address this question using a New Keynesian DSGE model with a proportion of credit-constrained agents as derived in Chapter 2. We propose that these two agents (Ricardian and non-Ricardian households) represent two clear distinct groups in society of empirically non-trivial proportions, and hypothesise that the latter will come from those individuals at the lower end of the income distribution; although the results are not sensitive to this hypothesis, the interpretations of these results are. This is supported by the growing literature that includes credit-constrained agents into their model: see Chapter 2. However, despite the growing use of these models, limited analysis currently exists on disaggregated variables. Although some papers do report on heterogeneous dynamics, this tends to only give more detail behind the aggregate variables.

The contribution of this chapter is to apply these now standard models to perform a detailed analysis of heterogeneous dynamics, with specific reference to adverse shocks: defined here as those which generate a negative output gap. The results provided by the model present a clear and intuitive message. When an adverse shock strikes the economy non-Ricardian households can only use their employment decisions to optimise, which they do through increasing their labour supply above that which would prevail if they had access to credit. This increases their disposable income and aggregate production, however the former is not sufficient to purchase all of the latter, and the surplus is consumed by the Ricardian agents who purchase this through additional dividends paid by firms through an improvement in profits from the supply of cheap non-Ricardian labour. The non-constrained agents both work less and consume more than their constrained counterparts; there is a redistribution of welfare from non-Ricardian to Ricardian households. These results are obtained through deriving algebraic properties in general equilibrium, dynamic simulations and through observing welfare movements through the evaluation of a second order Taylor series expansion of the heterogeneous households homogeneous utility function. Not only is it shown that Ricardian households achieve higher levels of welfare from the adverse shocks than non-Ricardian households, they are also shown to experience positive welfare movements in the presence of these shocks: the Ricardian households gain compared to steady state values. The results support the conclusion of Lucas (2003) that in aggregate welfare losses are small, but this hides a disparity across agents with one set losing significantly whilst the other gain. These results are robust and are also supported by an empirical investigation performed in the chapter showing a negative correlation between growth and income inequality.

The chapter proceeds in the following way: Section 3.2 discusses the benchmark model which includes a fraction of non-Ricardian households. Section 3.3 analyses the heterogeneous impact of adverse shocks on agents by deriving analytical expressions, through observing dynamic simulations and deriving a disaggregated welfare criterion. Section 3.4 tests the robustness of the results to the labour market assumption and Section 3.5 empirically tests the implication of the model. Section 3.6 performs further sensitivity analysis and Section 3.7 concludes.

3.2 The model

The model is the same as was derived in Chapter 2 however the economy abstracts away from a fiscal sector. This further abstraction from the Galí et al. (2007) simplifies the calculations sufficiently to allow a significant amount of the analysis to be performed on algebraic properties, independent of parameter calibration. Without a fiscal authority we have $\gamma_c = 1$ and the market clearing condition (2.19) becomes $Y_t = C_t$; the model can be described by the aggregate demand condition (2.20), the New Keynesian Phillips curve (2.24) and the Taylor rule (2.12) where $\varphi_g = \varphi_T = \varphi_{b,g} = \varphi_{b,T} = \gamma_g = 0$. The resulting set of equations can then be presented in the following system:

$$E_t \{u_{t+1}\} = \mathbf{A} u_t + \mathbf{B} \varepsilon_t \tag{3.1}$$

where $u_t = [y_t, \pi_t]'$, $\varepsilon_t = [\varepsilon_t^r, E_t \left\{\Delta \varepsilon_{t+1}^b\right\}, \varepsilon_t^a, \varepsilon_{t+1}^a, \varepsilon_t^\mu]'$ and the matrices $\mathbf{A}$ and $\mathbf{B}$ are given by:

$$\mathbf{A} = \begin{bmatrix} 1 + \Theta_A \Phi \varphi_y + \left(\beta^R\right)^{-1} \omega_y \Theta_A \Phi & \Theta_A \Phi (\varphi_\pi - \left(\beta^R\right)^{-1}) \\ -\left(\beta^R\right)^{-1} \omega_y & \left(\beta^R\right)^{-1} \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} \Phi\Theta_A & -\Phi\Theta_A & \Phi\Theta_B - \left(\beta^R\right)^{-1} \Phi\Theta_A \omega_\varepsilon & -\Phi\Theta_B & \left(\beta^R\right)^{-1} \omega \Phi \Theta_A \\ 0 & 0 & \left(\beta^R\right)^{-1} \omega_\varepsilon & 0 & -\left(\beta^R\right)^{-1} \omega \end{bmatrix}$$

where $\omega_y = \omega\left[\sigma + (\varphi + \alpha)/(1-\alpha)\right]$ and $\omega_\varepsilon = \omega(1+\varphi)/(1-\alpha)$. The properties of the model as discussed in Section 2.4 hold, the only difference being that now $\gamma_c = 1$ in these derivations. The most significant property of this model with respect to the determinacy of the system is the λ^* property (Proposition 1) as identified in Bilbiie (2008), due to its effect on the sign of parameters in the aggregate demand condition. The model has two forward looking ('jump') variables (y_t, π_t) and therefore determinacy requires that both eigenvalues in matrix $\mathbf{A}$ lie outside the unit circle (are 'unstable'). Woodford (2003, 670) shows that either of two cases need to be satisfied for determinacy of the model:

Case I:

A1 $\det\mathbf{A} > 1$; and

A2 $\det\mathbf{A} - \mathrm{tr}\mathbf{A} > -1$; and,

A3 $\det\mathbf{A} + \mathrm{tr}\mathbf{A} > -1$.

Case II:

B1 $\det\mathbf{A} - \mathrm{tr}\mathbf{A} < -1$; and,

B2 $\det\mathbf{A} + \mathrm{tr}\mathbf{A} < -1$.

where all conditions in each 'Case' need to be met, and where $\mathbf{A}$ is the matrix defined in system (3.1). For simplicity, the following discussion on the determinacy conditions will set $\varphi_y = 0$; this does not change the main result but simplifies the algebra in order to make the analysis clearer. A discussion on setting $\varphi_y > 0$ will be presented at the end of the section.

3.2.1 Determinacy when $\lambda < \lambda^*$

Applying the criteria outlined in Woodford (2003), the following conditions for Case I when $\lambda < \lambda^*$ can be obtained:

A1 $\varphi_\pi > 0$;

A2 $\Phi\Theta_A \left(\varphi_\pi - 1\right) > 0$;

A3 $\Phi\Theta_A \left(\varphi_\pi + 1\right) > -\frac{2(\beta^R+1)}{\omega_y}$.

Note that when $\lambda < \lambda^*$, Φ and Θ_A are positive and therefore all three conditions are satisfied providing $\varphi_\pi > 1$. This is the 'Taylor Principle', which stipulates that for determinacy and price stability the monetary authority needs to respond more than one-for-one with the nominal interest rate to inflation.

3.2.2 Determinacy when $\lambda > \lambda^*$

Applying the criteria outlined in Woodford (2003), the following conditions for Case I when $\lambda > \lambda^*$ can be obtained:

A1 $\varphi_\pi < \left(\Phi\Theta_A\right)^{-1}\left(\frac{\beta^R-1}{\omega_y}\right)$;

A2 $\varphi_\pi < 1$;

A3 $\varphi_\pi < -\left[1 + \left(\Phi\Theta_A\right)^{-1}\left(\frac{2(\beta^R+1)}{\omega_y}\right)\right]$.

The calibrations that satisfy these conditions are not as clearly defined as those for when $\lambda < \lambda^*$. Whereas the previous conditions set a lower limit on the value of φ_π with no upper limit, the above conditions set an upper limit with no lower limit. One of these potential upper limits (A2) is 1 which means that the Taylor Principle is violated; when $\lambda > \lambda^*$ the Taylor Principle does not guarantee uniqueness and moreover, under Case I, it will lead to indeterminacy. Case II of Woodford (2003) provides the following:

B1 $\varphi_\pi > 1$; and,

B2 $\varphi_\pi > -\left[1 + \left(\Phi\Theta_A\right)^{-1}\left(\frac{2(\beta^R+1)}{\omega_y}\right)\right]$.

These results both put a lower limit on the value of φ_π as in the situation with the Taylor Principle.[4] Therefore, combining the two results from Case I and Case II the following condition for φ_π is required for determinacy when $\lambda > \lambda^*$:

$$\begin{aligned}\varphi_\pi \quad \in \quad & \min\left\{1, (\Phi\Theta_A)^{-1}\left(\frac{\beta^R - 1}{\omega_y}\right), -\left[1 + (\Phi\Theta_A)^{-1}\left(\frac{2(\beta^R + 1)}{\omega_y}\right)\right]\right\} \\ & \cup \max\left\{1, -\left[1 + (\Phi\Theta_A)^{-1}\left(\frac{2(\beta^R + 1)}{\omega_y}\right)\right]\right\}\end{aligned} \tag{3.2}$$

Where the first expression in (3.2) is when ‘Case A’ above is met, and the second interval is when ‘Case B’ is met. These results are in line with those derived in Bilbiie (2008) and state that either monetary policy needs to be passive (Case I) or very aggressive (Case II) when $\lambda > \lambda^*$.

3.2.3 Allowing for $\varphi_y > 0$

Allowing φ_y to be positive does not significantly change the determinacy conditions of the model. In the case where $\lambda < \lambda^*$ the Taylor Principle ($\varphi_\pi > 1$) ensures determinacy, but the Taylor Principle represents the limit condition for when $\varphi_y \to 0$: any positive values of φ_y relaxes this condition. When $\lambda > \lambda^*$, Case I above represents the ‘least passive’ monetary policy needs to be when allowing $\varphi_y > 0$; greater values of φ_y result in more passive values of φ_π allowed to provide determinacy. Similarly, Case II above represents the most aggressive the monetary authority needs to be when allowing $\varphi_y > 0$. In all three cases, φ_y is acting as an extra condition that can provide stable prices. When aggressive monetary policy is required, a higher value of φ_y relaxes the conditions on φ_π and when monetary policy is required to be passive, higher values of φ_y lead to the opposite effect. The derivation of these results are presented in Appendix B.1.

3.3 Heterogeneous impacts of adverse shocks

This section uses the model derived in Section 2.3 to address the main question of this paper: what are the heterogeneous impacts of adverse shocks across households?

[4] Note that when $\lambda > \lambda^*$, Φ and Θ_A are both negative. Under reasonable calibrations, the condition (B2) would result in φ_π needing to be a large (positive) figure; monetary policy would be required to be very aggressive. The analysis of Bilbiie (2008) largely ignored this possibility due to the implied large value of φ_π.

This is performed in the first instance in a model with perfectly competitive labour markets which provides clear and intuitive results. First, this question is addressed by reviewing algebraic properties; the model is sufficiently simple to allow for these properties to be identified which permits the question to be answered independent of calibration. Next, the question is reviewed by performing simulations on the benchmark model to observe disaggregated impulse response functions in the presence of adverse shocks. Finally, a welfare criterion is derived from which these simulations can be converted into quantifiable comparisons of utilities of the two households.

3.3.1 Algebraic properties

Aggregate relationships

Section 3.2 demonstrates how the model can be reduced to two equations. Using the method of determined coefficients we can assert that $y_t = \Psi_y \varepsilon_t^i$ and $\pi_t = \Psi_\pi \varepsilon_t^i$, where Ψ_y and Ψ_π are the undetermined coefficients and using these equations, their corresponding lead counterparts and the formula for the shock process, whilst setting $\varepsilon_t^i = 0 \; \forall \; t > 1$, we can obtain the results:

$$\begin{aligned}
\Psi_y^r &= -\frac{(1-\beta^R\rho_r)\Phi\Theta_A}{(1-\beta^R\rho_r)(1-\rho_r+\Phi\Theta_A\varphi_y)+\Phi\Theta_A\omega_y(\varphi_\pi-\rho_r)} \\
\Psi_\pi^r &= \frac{\omega_y\Psi_y^r}{1-\beta^R\rho_r} \\
\Psi_y^b &= -\frac{(1-\beta^R\rho_b)\Phi\Theta_A(1-\rho_b)}{(1-\beta^R\rho_b)(1-\rho_b+\Phi\Theta_A\varphi_y)+\Phi\Theta_A\omega_y(\varphi_\pi-\rho_b)} \\
\Psi_\pi^b &= \frac{\omega_y\Psi_y^b}{1-\beta^R\rho_b} \\
\Psi_y^\mu &= -\frac{\Phi\Theta_A\left(\varphi_\pi-\rho_\mu\right)\omega}{(1-\beta^R\rho_\mu)(1-\rho_\mu+\Phi\Theta_A\varphi_y)+\Phi\Theta_A\omega_y(\varphi_\pi-\rho_r)} \\
\Psi_\pi^\mu &= \frac{\omega_y\Psi_y^\mu+\omega}{1-\beta^R\rho_\mu} \\
\Psi_y^a &= \frac{\Phi\Theta_A\omega_\varepsilon(\varphi_\pi-\rho_a)-\Phi\Theta_B(1-\rho_a)(1-\beta^R\rho_a)}{(1-\beta^R\rho_a)(1-\rho_a+\Phi\Theta_A\varphi_y)+\Phi\Theta_A\omega_y(\varphi_\pi-\rho_a)} \\
\Psi_\pi^a &= \frac{\omega_y\Psi_y^a-\omega_\varepsilon}{1-\beta^R\rho_a}
\end{aligned} \tag{3.3}$$

where these coefficient represent 'impact multipliers' from the reduced form model such that (for example) $\Psi_y^i = \partial y^i/\partial\varepsilon^i$. The signs for each of these, in the region of $\lambda > \lambda^*$, are all easily derived, noting that both β^R and ρ_i lie between zero and one, that $\varphi_\pi > 1$, and that each of the aggregate demand relationships are positive when $\lambda < \lambda^*$. These relationships are summarised in Table 3.

TABLE 3: Aggregate algebraic relationships in general equilibrium: impact multipliers derived using the method of undetermined coefficients

	Output		Inflation	
Demand shocks	$\Psi_y < 0$	(Y1)	$\Psi_\pi < 0$	(Π1)
Supply (markup) shocks	$\Psi_y < 0$	(Y2)	$\Psi_\pi > 0$	(Π2)
Technology Shocks	$\Psi_y \lesseqgtr 0$	(Y3)	$\Psi_\pi < 0$	(Π3)

All conditions trivially require that $\lambda < \lambda^*$, $\phi_y \geq 0$ and $\phi_\pi \geq 1$.

A positive exogenous movement in the interest rate or the Ricardian discount factor leads to a reduction in both output (Y1) and inflation (Π1), whereas positive movements in the desired markup lead to a reduction in output (Y2) with a rise in inflation (Π2); these are intuitive results that have been identified before and which are true of a fully Ricardian economy. The ambiguous result between technology shocks and output (Y3) derives from an increase in productivity leading to a reduction in labour with ambiguous impacts on non-Ricardian disposable income. In a fully Ricardian economy, the increase in productive capacity is the only relevant factor and output unambiguously improves. In an economy with or without non-Ricardian households the presence of a positive productivity shock leads to a fall in inflation as the same level of output can be produced at a lower labour cost.

Disaggregate relationships

The modelling assumption for rule-of-thumb agents makes it possible to track their employment and consumption behaviour relative to output. These, in unison with the market clearing conditions, can be used in turn to infer Ricardian agents' disaggregated dynamics. This task is straight forward in the absence of productivity shocks as in such a scenario movements in output are directly related to movements in employment. When these technology changes are ignored, the following expressions can be obtained for the model under the assumption of perfectly competitive labour markets, where relevant derivations are presented in Appendix B.2 (this appendix also discusses the results in the presence of productivity shocks):[5]

[5] Specifically, the first of these equations is derived by obtaining a log-linear expression of non-Ricardian consumption, which itself is a function of non-Ricardian employment and the real wage, which can substituted for using log-linear conditions of labour supply functions, the production function and the market clearing condition. The second of these equations can then be obtained by using the aggregate consumption function and rearranging for Ricardian consumption. Finally, the third and fourth conditions are obtained applying labour supply functions, the production function, and the goods market clearing condition. More details can be found in Appendix B.2.

$$
\begin{aligned}
c_t^{NR} &= \frac{(1+\varphi)(\varphi+\sigma(1-\alpha))}{\varphi(1+\mu)+\sigma(1-\alpha)} y_t \\
c_t^{R} &= \left[\frac{\lambda}{1-\lambda}\frac{(1+\mu)\varphi+\sigma(1-\alpha)-\lambda(1+\varphi)(\varphi+\sigma(1-\alpha))}{1+\mu+\sigma(1-\alpha)}\varphi\right] y_t \\
n_t^{NR} &= \frac{1}{\varphi}\left[\frac{\varphi+\sigma(1-\alpha)}{1-\alpha} - \frac{\sigma(1+\varphi)(\varphi+\sigma(1-\alpha))}{(1+\mu)\varphi+\sigma(1-\alpha)}\right] y_t \\
n_t^{R} &= \frac{y_t}{1-\lambda}\left[\frac{1}{1-\alpha} - \frac{\lambda}{\varphi}\left[\frac{\varphi+\sigma(1-\alpha)}{1-\alpha} - \frac{\sigma(1+\varphi)(\varphi+\sigma(1-\alpha))}{(1+\mu)\varphi+\sigma(1-\alpha)}\right]\right]
\end{aligned}
$$

where these 'partially reduced form' expressions can be combined with (3.3) to obtain reduced form expressions specific to individual shock processes. Table 4 summarises the properties of these disaggregate relationships.

TABLE 4: Disaggregate algebraic relationships in general equilibrium in the absence of productivity shocks

Disaggregated Consumption		Disaggregated Employment	
$\frac{\partial c_t^{NR}}{\partial y_t} > 0$	(C1)	$\frac{\partial n_t^{NR}}{\partial y_t} \lesseqgtr 0$	(N1)
$\frac{\partial c_t^{R}}{\partial y_t} > 0$	(C2)	$\frac{\partial n_t^{R}}{\partial y_t} > 0$	(N2)
$\frac{\partial c_t^{NR}}{\partial y_t} > \frac{\partial c_t}{\partial y_t} > \frac{\partial c_t^{R}}{\partial y_t}$	(C3)	$\frac{\partial n_t^{NR}}{\partial y_t} < \frac{\partial n_t}{\partial y_t} < \frac{\partial n_t^{R}}{\partial y_t}$	(N3)

Results (C3), (N2) and (N3) require that $\mu < \varphi + \sigma(1-\alpha)$: this is a reasonable restriction. Result (C2) is true providing $\lambda < \lambda^*$. Results (C3) and (N3) assume $\lambda > 0$ otherwise aggregate variables would become Ricardian variables. Adverse shocks are defined as those resulting in $y_t < 0$. Note that in aggregate $\partial c_t/\partial y_t = 1$ and $\partial n_t/\partial y_t = 1/(1-\alpha)$ in the absence of exogenous movements in productivity.

An adverse shock leads to a decrease in both non-Ricardian and Ricardian consumption (C1 and C2), however, the fall of the former is bigger than that of the latter (C3). The Ricardian agents have access to capital markets and profits and therefore can substitute future consumption for consumption today, which they do to maximise utility. Rule-of-thumb agents, on the other hand, do not have this access and as a result their consumption is more volatile: the only way they can smooth consumption is through their labour supply decisions. In the presence of an adverse shock, this is performed through increasing their labour supply above that which would prevail were they to have access to credit in order to increase their disposable income: they substitute leisure for consumption. This reaction is confirmed through observing that the reduction in non-Ricardian employment as a result of an adverse shock is smaller than that of their Ricardian neighbours (N3); credit-constrained households work more than the unconstrained in order to insulate themselves from the impact of the shock, and at certain calibrations their employment will rise in the presence of reducing output (N1). Ricardian households unambiguously decrease their labour supply and this occurs for two reasons: first, less output is produced in the economy overall, therefore lowering demand for labour; and second, the rule-of-thumb agent's increase in labour supply drives down the real wage which makes Ricardian agents substitute consumption for leisure. The reaction of rule-of-thumb households to increase their labour supply in the presence of adverse shocks appears to insulate Ricardian consumption, because its movement with respect to output is less than unity (C3): that which would prevail in a fully-Ricardian economy. However, this result does not take into account that the inclusion of the credit-constrained households may amplify the aggregate response to exogenous shocks (see below).

The presence of productivity shocks, however, provides ambiguous results compared to those discussed above because increases in productivity allow increases in output with no additional increases in employment. Using the method of undetermined coefficients it is possible to produce algebraic results similar to those used to find the properties in Table 4, however the inference is no longer clear. Disposable income for non-Ricardian households can fall in the presence of a shock increasing productivity, at certain calibrations, as a rise in wages (reflecting an increase in the marginal product of labour) is tempered by a fall in labour demand. Note that a shock increasing productivity is an 'adverse' shock as defined above because the presence of sticky prices means that output capacity expands at a greater rate than actual production, leading to a negative output gap. Although a productivity increase will lead to a fall in inflation it may also lead to a reduction of output when the demand effect of a reduction in non-Ricardian consumption outweighs the impact of the increase in productive capacity: this will occur at high values of λ and low levels of ρ_a.

However, results and intuition from Table 4 still follow through. An adverse technology shock leads to a rise in Ricardian consumption which dominates that of non-Ricardian consumption, which may indeed fall. In order to insulate themselves from this divergence, rule-of-thumb agents will supply more labour in order to increase their disposable income: non-Ricardian labour will be greater than Ricardian labour.

When imperfectly competitive labour markets are assumed (C1), (C2) and (C3) can be derived under the same conditions as those labelled in Table 4 using the following conditions (derived in Appendix B.2):

$$\begin{aligned} c_t^{NR} &= \frac{1+\varphi+\sigma(1-\alpha)}{1+\mu} y_t \\ c_t^{R} &= \frac{1}{1-\lambda}\left[1-\frac{\lambda\left(1+\varphi+\sigma(1-\alpha)\right)}{1+\mu}\right] y_t \end{aligned}$$

Under the assumption of imperfectly competitive labour markets however, $n_t^{NR} = n_t^R = n_t$ and therefore (N1) and (N3) no longer hold. However, the discussion with respect to perfectly competitive labour markets gives us the intuitive result that non-Ricardian households would prefer higher levels of employment and Ricardian households lower levels of employment, compared to those negotiated when a weighted average of their preferences are used, in response to an adverse shock.

Aggregate relationships and asset market non-participation

Increasing the share of non-Ricardian households in the economy has two effects on the coefficients in Table 3: first, the impact of the shock is increased due to the non-linear relationship between any stimulant and λ, demonstrated in the λ^* relationship (2.24) and in Proposition 3 (in Chapter 2); and second, any adverse impact is met with an increase in labour supply from these rule-of-thumb agents who attempt to insulate themselves from the impact of the recession. This latter effect also insulates the economy and can be seen through the increasing impact of monetary policy at higher levels of λ.[6] The first effect will always dominate leading to a larger impact from any exogenous shock.

3.3.2 Dynamic simulations

Calibration

The algebraic properties above can now be observed through dynamic simulations using the calibration outlined below. Each unit of time is a quarter and the Ricardian and non-Ricardian discount factors, β^R and β^{NR}, are set at 0.99 (corresponding to a steady state rate of return to bonds of 4%) and 0.973 respectively.[7] The preference parameters are set such that $\sigma = 1$, which represents log utility with respect to consumption, and $\varphi = 0.2$, the inverse elasticity of work with respect to the real wage.[8] The degree of decreasing returns to labour, α, is set to equal 1/3 and the steady state markup, μ, is calibrated to 0.2; this value corresponds to a elasticity of substitution across the intermediate goods, ϵ, of 6. The parameter governing the stickiness of prices, θ, is set at 0.75 leading to the average price duration for a given firm of four quarters. The

[6] It can be shown that providing $\lambda < \lambda^*$, $\partial\Phi\Theta_A/\partial\lambda > 0$.

[7] Lawrance (1991) presents evidence to suggest that rates of annual time preference vary by 7% between rich and poor households.

[8] Under this specification with log utility of consumption, Bilbiie (2008) finds that non-Ricardian employment is constant as the income and substitution effects cancel one another out. However, the introduction of steady state transfers (see Section 2.3.1), even at a constant steady state level, drives a wedge between the income and substitution effects due to movements in the real wage such that this is not true in our model.

Taylor rule parameters are set such that $\varphi_\pi = 1.5$ and $\varphi_y = 0.125$. The persistence parameter of all shocks, ρ_i, are set equal to 0.8 to make comparisons across the results for different shocks.

This calibration follows closely that of Galí et al. (2007), which has been criticised for its low value of the wage elasticity of employment.[9] As demonstrated in equation (2.24), if it is required that $\lambda < \lambda^*$, there is a constraint on the calibration of other parameters: through setting $\varphi = 0.2$ a calibration of $\lambda = 0.5 < \lambda^*$ is achievable ($\lambda = 0.5$ is reflective of empirical observations, see Section 2.2, and is the calibration used in Galí et al. 2007). The value of λ^* with other parameters at reasonable calibrations is too low, which is primarily due to the simplicity of the model. It has been implicitly shown that through including further rigidities such as fixed capital accumulation, habit persistence, Kimball demand curves and firm specific capital, the values of λ^* increase.[10] Moreover, Chapter 6 (equation (6.13)) algebraically demonstrates that λ^* will increase if habit persistence is included in the model. To demonstrate the proposal that it is a lack of complexity of the model that limits the value of λ^*, if non-Ricardian households are included into the medium scale DSGE model of Smets and Wouters (2003) with reasonable parameter calibrations, a value of $\lambda^* > 1$ is provided.

It is a preference to not overcomplicate the model in order to identify algebraic properties and transmission mechanisms. Moreover, it is desired that the share of the two types of households are approximately equal to their empirical size because the paper reviews welfare movements, and with appropriate proportions of each household comes appropriate weighted average welfare calculations. Sensitivity of the results to the calibrations of φ and λ parameters, amongst others, will be commented on throughout.

Simulations

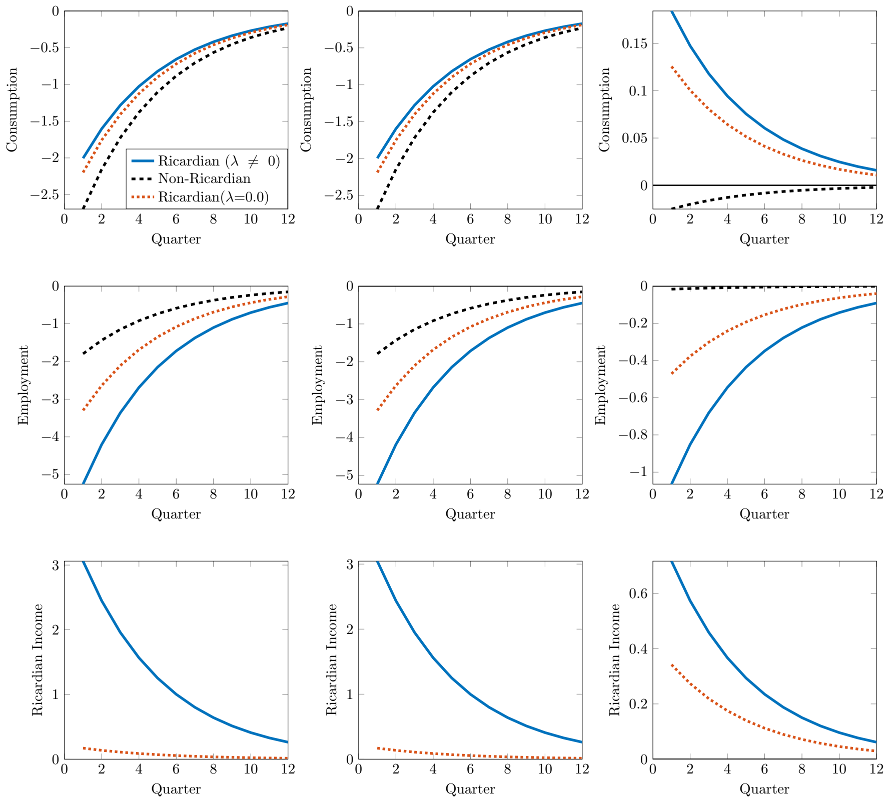
The aggregate impacts of the three individual shocks are those predicted in Table 3: output falls in response to both a positive interest rate shock and a positive markup shock whereas inflation falls and rises with these two shocks respectively. Output is found to increase following a positive productivity shock in this calibration and, as predicted above, inflation falls. The disaggregate responses to these shocks, which are the main focus of this chapter, are presented in Figure 2 for adverse demand (first column), cost push (second column) and productivity (third column) shocks, where the

[9] In particular, this calibration has been questioned in Furlanetto and Seneca (2009) and Colciago (2011); on the other hand, Galí et al. (2007) cite Rotemberg and Woodford (1997) as evidence to support this calibration.

[10] Although this cause and effect is not explicitly shown, it is highlighted through sensitivity analysis which varies the level of λ. The examples above are shown in Galí et al. (2007) and Furlanetto and Seneca (2009).

first and second rows presents disaggregated consumption and employment responses respectively, and the third row presents dynamics for the disposable income of Ricardian households.

FIGURE 2: Disaggregate dynamics from adverse shocks



Dynamics achieved through the calibration discussed in Section 3.3.2 and through setting $\eta_t^r = 1.0$ when $t = 1$ for demand shocks, setting $\eta_t^\mu = 1.4$ when $t = 1$ for cost push shocks, and setting $\eta_t^a = 0.4$ when $t = 1$ for productivity shocks. The latter two calibrations were performed to make the welfare loss (gain) equal to that of the interest rate shock in a fully Ricardian economy for the cost push (productivity) shocks. Note only interest rate shocks have been included to represent an aggregate demand shock because, as discussed above, preference shocks enter the aggregate demand condition (2.20) in the same way and therefore the analysis would be identical. The first row presents results for disaggregated consumption, the second row results for disaggregated employment and the third row dynamics on Ricardian disposable income given by the sum of their employment income and dividends received. The graph also presents results for Ricardian household dynamics in a fully-Ricardian economy ($\lambda = 0$).

As is illustrated in the figure, the predictions of Section 3.3.1 are observed; non-Ricardian households work more and consume less than their Ricardian neighbours, who themselves work less and consume more in the presence of the rule-of-thumb agents, compared to a similar shock in a fully-Ricardian economy ($\lambda = 0$). Rule-of-thumb agents use the labour market as their smoothing resource and in the presence of adverse shocks they do this through increasing their labour supply. This results in additional disposable income for these agents and additional production in the economy, however the former is not sufficient to purchase all of the latter and the surplus goes to the Ricardian agents. This is funded by these agents through additional profits which is as a result of cheap labour in the market and also due to the Ricardian agents sharing dividends across only a fraction of the population when $\lambda \neq 0$.[11] The reduction of both Ricardian employment and wages means that these agents' labour incomes fall as a result of the adverse shock, however the rise in profits (dividends) compensates them for this. The third row in Figure 2 shows that as a result of all adverse shocks Ricardian disposable income increases in the presence of rule-of-thumb agents, relative to the fully-Ricardian benchmark. Ricardian income rises whilst non-Ricardian income falls despite the former working less than the latter: the path of rule-of-thumb income is given by their consumption (by definition).

Note that these results would be affected were non-Ricardian agents to have access to the profits of the firms. We could have assumed that shares of company profits were distributed equally across all agents in the economy, and as such profits would enter both the non-Ricardian consumption function and subsequently the aggregate demand relationship. However, given rule-of-thumb agents' impatience, a restriction must be made such that these shares could not be sold. Otherwise, these agents would optimise by divesting their firm ownership to the more patient.

A clear redistribution of welfare is observed from non-Ricardian to Ricardian households as a consequence of the former's employment decisions and the latter's access to capital. This is with respect to the arguments in the utility function but moreover in income streams: a clear inequality of experience is observed in the model as a result of adverse shocks.

3.3.3 A welfare criterion

The dynamic responses for the heterogeneous households in these examples are clear to see, interpret and evaluate; the responses for Ricardian households' variables strictly dominate those for the non-Ricardian households in both the employment and consumption dimensions. Moreover, the presence of the non-Ricardian households benefits the Ricardian households whose dynamics where $\lambda \neq 0$ strictly dominate their dynamics in an economy where $\lambda = 0$. However, a more formal analysis can be performed by determining a welfare criterion based on a second order Taylor series expansion of the utility function around steady state values. This procedure provides a criterion expressed as the equivalent one period consumption loss, as a proportion of steady state

[11] Dividends paid out through profits are subject to the relationship $D_t = (1-\lambda)D_t^R$, as only Ricardian agents receive dividends.

consumption, that leaves the agent indifferent between living through the shock or the one period consumption loss (the derivation of which is in Appendix B.3):

$$W^i = E_0 \sum_{t=0}^{\infty} \beta^{i,t} \left(c_t^i + \frac{1-\sigma}{2} \left(c_t^i\right)^2 \right) - \frac{(1-\alpha)}{\gamma_c(1+\mu)} E_0 \sum_{t=0}^{\infty} \beta^{i,t} \left(n_t^i + \frac{1+\varphi}{2} \left(n_t^i\right)^2 \right) \quad (3.4)$$

Welfare results are derived using a second order approximation of the model because, as Walsh (2010) highlights, a first order approximation can be inappropriate. Applying the disaggregated dynamics of the three adverse shocks simulated above to this criterion gives the results presented in Table 5. The table confirms the above analysis; Ricardian households experience greater welfare, as a result of the adverse shocks, than non-Ricardian households, and when the latter are present the Ricardian households experience greater levels of welfare than when they are not. However, one result that is not directly predicted through observing the disaggregated dynamics is that these Ricardian households experience a welfare gain as a result of the adverse shocks. In the two shocks that lead to a fall in output, the large fall in employment more than compensates Ricardian households for their small fall in consumption. Moreover, in the presence of the adverse technology shock output rises and gains accrue to Ricardian agents. The unambiguous fall in lifetime utility is observed for the non-Ricardian households for adverse demand and cost push shocks, and in the presence of adverse productivity shocks, at this calibration, they experience a mild gain of welfare.

TABLE 5: Disaggregated welfare - perfectly competitive labour markets

	Non-Ricardian	Ricardian	Weighted Average
Demand (interest rate) shock			
$\lambda = 0$	N/A	-0.010	-0.010
$\lambda = 0.5$	-0.060	0.046	-0.007
Cost push (markup) shock			
$\lambda = 0$	N/A	-0.010	-0.010
$\lambda = 0.5$	-0.061	0.041	-0.010
Productivity shock			
$\lambda = 0$	N/A	0.010	0.010
$\lambda = 0.5$	0.003	0.016	0.009

The welfare loss is expressed as the equivalent one period consumption loss, as a proportion of steady state consumption, that would leave the household indifferent between living through the shock or the one period sacrifice. Dynamics achieved through the calibration discussed in Section 3.3.2 and through setting $\eta_t^r = 1.0$ when $t = 1$ for demand shocks, setting $\eta_t^\mu = 1.4$ when $t = 1$ for cost push shocks, and setting $\eta_t^a = 0.4$ when $t = 1$ for productivity shocks. The latter two calibrations were performed to make the welfare loss (gain) equal to that of the interest rate shock in a fully Ricardian economy for the cost push (productivity) shocks. A second order approximation of the model is applied to derive welfare results.

3.3.4 Discussion

This section has shown that there is a redistribution of welfare as a result of adverse shocks from non-Ricardian to Ricardian households. This has been illustrated through identifying algebraic properties of the model, through dynamic simulations, and through deriving a disaggregated welfare criterion for the two households based on a second order Taylor series expansion of their utility functions. This redistribution of welfare comes as a result of the rule-of-thumb agents increasing their labour supply in order to smooth their consumption. This action consequently insulates the economy which indirectly insulates the Ricardian households whose welfare improves as a result of the presence of the credit-constrained agents. It has been shown that Ricardian household's welfare is unambiguously better than their non-Ricardian neighbours and, moreover, these agents actually gain as a result of adverse shocks under reasonable calibrations. In aggregate, the weighted average welfare movement as a result of the shocks is small: this is in line with the analysis of Lucas (2003). However, the disaggregate movements within this overall mean average are not trivial with a negative covariance between the experiences of the different households. This negative correlation of agents' welfare implies that we are not 'all in this together' and provides support for the anecdotal evidence presented in Section 3.1.

The results also lend support to the concept of the *squeezed* or *anxious* middle, depending on the beliefs on the identification of the rule-of-thumb agents.[12] We argued that these non-Ricardian households will be predominantly those agents at the lower end of the income distribution. This hypothesis, in conjunction with estimates on their relative share, implies that the middle class could be within this credit-constrained group. Moreover, as the economic downturn continued, access to credit became more restrictive, therefore eliminating further agents from this smoothing resource. The combination of the theoretical results and the proposal that rule-of-thumb agents come from the lower end of the income scale is coherent with the literature of Krusell and Smith (1999), Mukoyama and Şahin (2006) and Krusell et al. (2009), and also with the anecdotal evidence. However, these results have been derived with a stylised labour market which plays an important role in the transmission mechanisms in the economy, which is relaxed in the next section.

[12]This conclusion also requires considerations of the shock process generating the recent recession. As is seen above, an 'adverse' technology shock increases output (but at less than its potential), therefore, if it is believed a negative technology shock produced the recession then the analysis would be inverted. Ireland (2011) use variance decomposition techniques to estimate that the recent recession was mainly as a result of demand shocks and there were positive productivity shocks to compensate for this: this conclusion is reached in other papers.

3.4 An alternative labour market assumption

This section tests the sensitivity of the above results to the assumptions made of the labour market. It is through the labour market that the non-Ricardian households perform their optimisation and insulate themselves against the impact of the shocks: an important transmission mechanism in the above results. To test the sensitivity of the results to the labour market assumption, the imperfectly competitive labour market of Galí et al. (2007) is used. With such an assumption there is no heterogeneous supply of labour across households: this will have a significant impact on both the aggregate and disaggregate economy. In the presence of an adverse shock, non-Ricardian households have a preference to increase their labour supply, whereas Ricardian households have a preference to decrease theirs; the aggregation process across households results in the former working less and the latter more than if they were allowed to supply labour independently.

One important aspect to consider when performing simulations under this different labour market will be that of the calibrated value of λ, because the change in the labour market will have a corresponding change in λ^* as demonstrated in (2.24). The strategy here is to maintain a constant value for the ratio λ/λ^*, where this constant is determined by the perfectly competitive labour market analysis above; this strategy isolates the impact that the change in the labour market assumption is creating by eliminating the impact of a change in λ^*.

TABLE 6: Disaggregated welfare - imperfectly competitive labour markets

	Non-Ricardian	Ricardian	Weighted Average
Demand (interest rate) shock			
$\lambda = 0$	N/A	-0.010	-0.010
$\lambda = 0.5$	-0.062	0.023	-0.008
Cost push (markup) shock			
$\lambda = 0$	N/A	-0.010	-0.010
$\lambda = 0.5$	-0.065	0.025	-0.008
Productivity shock			
$\lambda = 0$	N/A	0.010	0.010
$\lambda = 0.5$	0.002	0.014	0.009

The welfare loss is expressed as the equivalent one period consumption loss, as a proportion of steady state consumption, that would leave the household indifferent between living through the shock or the one period sacrifice. Dynamics achieved through the calibration discussed in Section 3.3.2 and through setting $\eta_t^r = 1.0$ when $t = 1$ for demand shocks, setting $\eta_t^\mu = 1.4$ when $t = 1$ for cost push shocks, and setting $\eta_t^a = 0.4$ when $t = 1$ for productivity shocks. A second order approximation of the model is applied to derive welfare results.

Comparable results to those in Table 5 are presented in Table 6 for an economy with the new labour market assumption subjected to the three types of shock. These show that the welfare gains of the Ricardian households are reduced in an economy which includes non-Ricardian households compared to the perfectly competitive labour market benchmark. This is an intuitive result; the aggregation process performed by the trade unions in order to derive an aggregate labour supply function results in these households working more than they otherwise would, were they to supply labour independently. Moreover, because non-Ricardian households are working less compared to the benchmark of the perfectly competitive labour markets, profits distributed to the Ricardian agents are not rising to a similar degree. Likewise, the welfare penalty for non-Ricardian households is also observed whose utility losses are increased as a result of the new labour market assumption. The redistribution of welfare is still observed and the results are robust to the change in the labour market.

This extension does merit further consideration. Subjecting both types of household to the same labour market conditions may be inappropriate if it is believed that there is a distinct difference between both types of agent in the model; under this circumstance separate labour markets for the two types of household may be deemed more appropriate. For example, the hypothesis we proposed was that the rule-of-thumb agents would predominantly come from the lower end of the income spectrum. These agents would have lower skill levels and it is these who are observed to be most empirically vulnerable to business cycles. The experience of unemployment during recessions is what causes the most pain to individuals; the fact that the above results were obtained in a model that does not include unemployment and where labour can move freely is compelling.

3.5 An empirical investigation

The model presents clear results with respect to both welfare and income movements of the two types of agents as a result of adverse shocks. Combined with our proposal that the non-Ricardian households come predominantly from the lower end of the income distribution, a working hypothesis is provided that income inequality will increase during periods of recession; this is in line with the anecdotal evidence and can be tested empirically. The method proposed here is to review the correlation between the changes in the Gini coefficient against movements in the cyclical component of growth. The Gini coefficient is a measure of income inequality and if the proposed hypothesis is correct it would be expected that this should increase in times of negative cyclical growth. The following panel regression is applied:

$$\Delta Gini_{i,t} = \alpha_i + \beta CYCGrowth_{i,t} + \theta Z_{i,t} + \varepsilon_{i,t} \tag{3.5}$$

where $\Delta Gini_{i,t}$ is the change in the Gini coefficient from year $t-1$ to year t in country i, α_i are country specific constants identified using a fixed effects panel, $CYCGrowth_{i,t}$ is the cyclical component of growth for country i in year t identified using the Hodrick-Prescott filter, $Z_{i,t}$ a group of control variables and $\varepsilon_{i,t}$ is an error term. The problems with such an approach is the availability of data on the Gini coefficient and the selection of appropriate control variables. For such a specification to be worthwhile, data on inequality needs to be observed for a number of consecutive years, to ensure an appropriate number of observations, and from the same study to ensure consistent methodology for comparable statistics. The selection of control variables is complicated by the short term nature of the annual changes: inequality movements are generally studied over longer horizons.

Empirical results from estimating (3.5) are presented in Table 7. In all, seven countries are used which represents the number of developed nations with more than 10 consecutive observations for Gini coefficients, each year from the same study, in the United Nations World Income Inequality dataset. The results show that not only are the coefficients attached to the $CYCGrowth$ variable always with the expected sign, but moreover, they are always significant to at least 5% confidence levels. This is true across five separate specifications with different combinations of independent variables, controlling for the political stance of ruling parties and a time trend to pick up the universal steady growth of inequality post 1979.[13] Further, the results are not sensitive to the regression method used, countries in the sample and the method of detrending GDP data: similar results can be achieved from OLS and random effects panel regression; from dropping any one country in the sample and from dropping both France and Germany which represent the two countries with the smallest number of observations; and from detrending growth rate data using a polynomial time trend. The results suggest a redistribution of welfare from the poor (non-Ricardian households) to the rich (Ricardian households) occurs during times of below trend growth. Although it is beyond the scope of this chapter to provide a fully fledged empirical analysis, results presented in Table 7 are supportive of the anecdotal evidence presented in Section 3.1, for the theoretical modelling of divergent experiences during recessions and moreover the hypothesis that non-Ricardian households come from the lower end of the income distribution.

[13] The former was calculated using information on government formation over the period and benefited from sample countries having predominantly a two party system. The latter was included due to the pervasive increases in inequality observed for all countries in the dataset.

Table 7: Inequality during recessions: an empirical investigation

	(1)	(2)	(3)	(4)	(5)
CYCGrowth	-7.285**	-5.180***	-5.217***	-3.907**	-3.944**
	(0.023)	(0.002)	(0.002)	(0.016)	(0.015)
LWing			0.037		0.051
			(0.628)		(0.480)
Time				0.249***	0.251***
				(0.001)	(0.000)
Observations	184	148	148	148	148
R^2	0.029	0.054	0.058	0.131	0.136

The dependent variable is $\Delta Gini_{i,t}$, where $Gini_{i,t}$ is obtained from the United Nations World Income Inequality dataset. The dataset includes the countries of Australia (41), Canada (19), France (11), Germany (11), Japan (18), United Kingdom (41) and the USA (44), where the numbers in parenthesis represent the number of observations for each country in the total sample. The results are obtained using a fixed effects panel regression where the country fixed effects and constant are not presented. The specification in column (1) represents all data in the sample where all other columns excludes those years where the change in the Gini coefficient is equal to or greater than one in modulus. $LWing$ is a dummy variable that takes the value 1 if the country has a political party in power that is from the centre-left of the political scale for that country, and zero otherwise. $Time$ is a dummy variable which takes the value 1 for any observation between the years 1979 and 2000 inclusive, 0 otherwise. Data used to calculate $CYCGrowth_{i,t}$ was obtained from the IMF International Financial Statistics. P-values of t-statistics for each individual coefficient are presented in parenthesis. The notation * is used to represent t-statistics significant to at least 10%, ** significant to at least 5% and *** significant to at least 1%.

3.6 Further sensitivity tests

The redistribution of welfare from non-Ricardian to Ricardian households associated with adverse shocks has been shown to be algebraically robust and illustrated through dynamic simulation: the results have also been seen not to be sensitive to the labour market assumption. This section further tests the robustness of the results.

3.6.1 Non-adverse shocks

The above analysis has been performed considering only adverse shocks, defined as those leading to a negative output gap. This restriction was made to consider the impact of the current recession. The model is linear and therefore the impact from non-adverse shocks would be the reverse of those presented above: non-Ricardian households would benefit at the expense of Ricardian households in boom periods. However, it could be argued that such behaviour over the course of the business cycle leads to lower levels of welfare as the linear impacts net-off but the variance in consumption will be higher for credit-constrained agents, thus leading to lower levels of utility.

Table 8: Consumption variance throughout the business cycle

	Labour Market			
	Perfectly Competitive		Imperfectly Competitive	
	$\varphi = 0.2$	$\varphi = 1.0$	$\varphi = 0.2$	$\varphi = 1.0$
$\text{Var}\left(c_t^{NR}\right)/\text{Var}\left(c_t\right)$	1.26	2.92	2.63	4.96
$\text{Var}\left(c_t^{R}\right)/\text{Var}\left(c_t\right)$	0.92	0.85	0.82	0.82
$\text{Var}\left(c_t^{R}\right)/\text{Var}\left(c_t \mid_{\lambda=0}\right)$	0.95	0.90	0.89	0.89

Results achieved through simulating the model with both perfectly competitive (columns 2 & 3) and imperfectly competitive (columns 4 & 5) labour markets with equal standard deviation weights for demand, cost push and productivity shocks (where demand shocks are shared across both interest rate and preference shocks); the results are not sensitive to this equal weighting. A simulation period of 10,000 quarters is used where the first 200 observations were dropped from the analysis. A calibration of $\lambda_{PC} = 0.3$ is used as this is in line with many estimation results from DSGE analysis and $\lambda_{IC} = 0.22$ to maintain a constant λ/λ^* ratio; results are amplified at higher values of λ. Moreover, a calibration of $\varphi = 1$ is used as a sensitivity check as this is more in line with the literature and moreover, as demonstrated, has a significant impact on the results. $\text{Var}\left(C_t \mid_{\lambda=0}\right)$ is the variance of (Ricardian) consumption in a fully Ricardian economy.

To extend the analysis to consider the whole business cycle, simulations of the model are performed and key statistics observed and documented in Table 8. This is performed under both labour market assumptions and also where φ is increased to 1 because the imperfectly competitive labour market and a higher wage elasticity to employment are more coherent with empirical observations. Ricardian households experience a lower variance in consumption than their non-Ricardian neighbours and moreover, than in a fully Ricardian economy; credit-constrained households insulate the unconstrained despite the fact that their presence increases the impact of shocks and therefore exposes the aggregate economy more to these exogenous movements. In a model with perfectly competitive labour markets the variance in non-Ricardian consumption is nearly a third greater than that in Ricardian consumption; however in the more empirically appropriate assumption of imperfect labour markets this increases to 263% greater as rule-of-agents are less able to smooth consumption through their labour supply. When φ is allowed to increase to more frequently used calibrations (with a corresponding reduction in λ to maintain a constant λ/λ^* ratio) these results are amplified; with imperfectly competitive labour markets non-Ricardian consumption variance is nearly six times greater than their Ricardian neighbours. This occurs because agents are more adverse to movements in employment and therefore use this resource less to smooth consumption.

3.6.2 The degree of asset market non-participation

As was discussed in Section 3.3.1 the greater the share of non-Ricardian households the greater the impact of a shock on the aggregate economy due to the non-linear feedback mechanism between any exogenous movement and aggregate demand. From a disaggregate perspective two factors are influencing the welfare of individual agents: first, the increased aggregate impact of the shock is leading to a larger labour supply reaction by rule-of-thumb agents; and second, as the proportion of rule-of-thumb households increase, the proportion of Ricardian households is decreasing, and therefore so too are the agents who can take advantage of the additional employment and dividends in the economy. These two factors work in unison such that the losses of non-Ricardian households and the gains of Ricardian households are amplified and so too is the redistribution of welfare. However, movements in λ are having the greatest impact on Ricardian agents: for example, an increase of $\lambda = 0.3$ to $\lambda = 0.5$ leads to a rise in Ricardian gains of 85% with a rise in non-Ricardian losses of only 4% for demand and cost push shocks (see the top left pane in Figure 3). This dominance occurs due to the impact of having fewer agents from which to share dividends across. However, these quantitative movements are met with the same intuition and qualitative responses: at all calibrations in the region of $\lambda < \lambda^*$ and in the presence of adverse shocks Ricardian welfare always dominates non-Ricardian welfare.

We can also remove the assumption that both types of agent consume and work the same amounts in steady state. The only impact this would have on the model would be to change the aggregate consumption condition to:[14]

$$c_t = \chi c_t^{NR} + (1 - \chi) c_t^R$$

where $\chi = \lambda C^{NR}/C$. Empirical studies on rule-of-thumb consumption behaviour, for which the calibration of λ is based, are finding χ as they are estimating the share of income accruing to rule-of-thumb households. Therefore, if the proposition that these agents will come from the lower end of the income distribution is believed, this will result in more non-Ricardian households than their share of total income; the only impact that this will have on the above results is to change the weighted average welfare figures. More details of the algebra for this are given in Appendix B.4.

[14] Note that the remaining areas where disaggregate steady state levels arise in the derivation of the model (the welfare criterion and the log-linear non-Ricardian consumption function) require the ratio of these variables (N^i/C^i), which given the assumed identical period utility function will be equal in steady state.

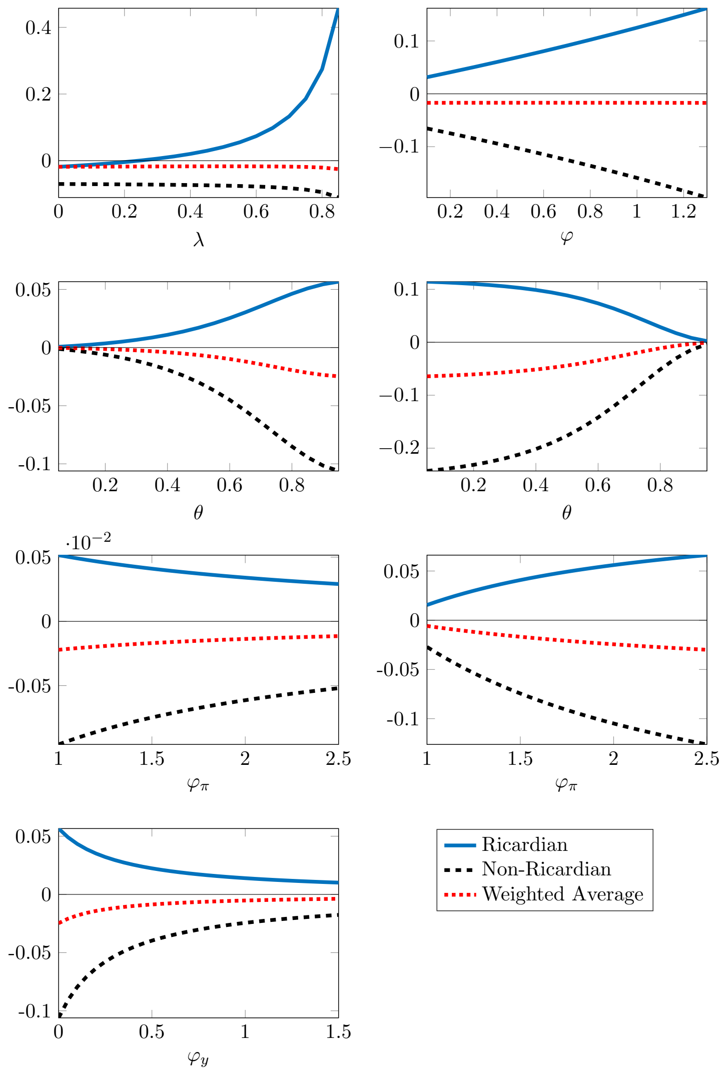
3.6.3 Other parameters

The calibration used, which follows closely that of Galí et al. (2007), has been criticised for its low value of the wage elasticity of labour (see for example Furlanetto and Seneca; 2009). The main reason for having φ set at 0.2 is to allow λ to be set at 0.5, recalling from equation (2.24) that these two variables cannot be independently calibrated if all other parameters are, whilst maintaining $\lambda < \lambda^*$. An increase in this parameter has three main effects: first, as the disutility of labour increases, the labour response of rule-of-thumb agents to adverse shocks will decrease; second, the value of λ^* will decrease leading a bigger impact from shocks for a given value of λ; and third, the weight attached to squared movements in employment in the welfare criterion (3.4) increase. These impacts combine to increase the redistribution of welfare in the presence of adverse shocks as the second of these will dominate. An increase from $\varphi = 0.2$ to $\varphi = 1$, for example, will lead to Ricardian gains and non-Ricardian losses approximately trebling and doubling respectively (see the top right pane in Figure 3).

The calibration is also criticised for the high level of price stickiness (see again Furlanetto and Seneca; 2009) with $\theta = 0.75$ leading to an average price duration of one year. With respect to demand and productivity shocks, an increase in θ increases the aggregate impact of the shock thus increasing the redistribution of welfare. With respect to cost push shocks, however, the reverse is true because at high levels of θ the shock is not transmitted into the economy, as is clear through inspection of the New Keynesian Phillips curve (2.24). These impacts are shared across both types of households; for example, an increase from $\theta = 0.5$ to $\theta = 0.75$ leads to an increase in Ricardian gains and non-Ricardian losses equal to approximately 150% for demand shocks and a fall of approximately 55% for cost push shocks (see the the second row in Figure 3).

Finally, the policy parameters are of significance because the two types of agent may have differing preferences over these. In general, more conservative monetary policy leads to a lower impact from shocks and therefore will reduce both gains and losses to Ricardian and non-Ricardian households respectively: these impacts, although quantitatively small, are shared across both types of agent. The only exception to this is with cost push shocks where a higher calibration of φ_π leads to a greater aversion to the inflation these shocks generate and subsequently the impact they have on output: in this scenario, higher values lead to a rise in the gains and losses of Ricardian and non-Ricardian households respectively (see the final right hand side pane in Figure 3). However, these are only quantitatively small changes and qualitatively the above results are robust.

Figure 3: Chapter 3 sensitivity



Results achieved through shocking the economy with an adverse interest rate shock ($\eta_t^r = 1$) in period $t = 1$ using the calibration outlined in Section 3.3.2 where in each pane one parameter is varied from this calibration (determined by the notation on the x-axis). For sensitivity results with respect to θ and φ_π the source of the shock is significant and therefore for these a separate pane of results is shown where $\eta_t^\mu = 1.4$ in period $t = 1$. The left hand pane for these results represent demand shocks and the right hand pane cost push socks. In all other parameters the analysis from demand shocks give the relationships involved and therefore for brevity only these results are presented.

3.7 Conclusions

The objective of this chapter was to identify whether a simple DSGE model with heterogeneity among households could provide theoretical support for the recent anecdotal evidence of an inequality of sacrifice in the recent recession: the results have gone some way towards dispelling the notion that ‘we’re all in this together’. This was performed by distinguishing agents with respect to their engagement with capital markets, which was argued to be empirically appropriate and apt in the current *credit crisis*. It was found that those agents who are credit-constrained disproportionately lose in the presence of adverse shocks in the economy. Further, it was observed that this suffering from one set of individuals was to the benefit of the other, whereby the actions of the rule-of-thumb households insulated the economy; under reasonable calibrations the Ricardian households gain as a result of the adverse shocks. These results were shown through algebraic proof, dynamic simulation and through a derivation of a disaggregated welfare criteria based on a second order Taylor series expansion of the utility function. The results from the model are also shown to be supported through an empirical investigation that suggested a negative correlation between cyclical growth and income inequality.

These results are important because it provides a further critique to the Lucas (2003) argument that the welfare consequences of economic fluctuations are trivial. In this respect it contributes and compliments the existing literature that finds similar results suggesting business cycles disproportionately impact the poor, low skilled and unemployed: this is coherent with the proposition behind the identification of these agents. A further contribution of the chapter is to provide simple and tractable techniques that can be applied in the growing DSGE literature that includes a fraction of rule-of-thumb agents. Up to date, welfare analysis from DSGE models has been performed on a representative agent, the same assumption used by Lucas (2003) to suggest that such studies are not an important priority. This chapter illustrates that there are disaggregated and redistributional impacts to exogenous shocks and subsequent policy actions. These impacts by themselves are of importance but moreover provide potential frictions that can commentate on why some policies are followed over others; the model can be used to discuss political motives to policy. The potential extensions that follow this line of argument are vast, certainly with the debate around current and recent policy actions, and the next chapter extends this analysis to consider potential polarized preferences in the conduct of fiscal policy.

Chapter 4

Austerity versus stimulus: the polarizing effect of fiscal policy

4.1 Introduction

The 2008 financial crisis and the subsequent global economic downturn has brought fiscal policy back into the political and academic agenda. Across the developed economies, governments looked to large fiscal stimuli in order to counteract the effects of recession and boost demand. Despite this resurgence and return to fiscal policy there is still much doubt and debate as to whether such policy has the desired effects. Recently in Europe these discussions have centred around the 'austerity versus stimulus' debate. These arguments were voiced both in the UK and internationally as the topic of 'fiscal responsibility' has become a key theme in the rhetoric of the recent downturn. In fiscal debates around the world, there consistently appears to be two clear factions in the discussions and 'austerity versus stimulus' is no exception. The conduct of fiscal policy and the polarized preferences associated with it are rife in today's political and economic agenda and are the subject of this chapter.

This chapter seeks to contribute to two literatures: that reflecting on the heterogeneous welfare impacts of business cycles, discussed in Chapter 3, and the fiscal-DSGE literature. The dynamic stochastic general equilibrium (DSGE) literature focusing on fiscal conduct has largely abstracted away from the normative gains of policy and has been occupied with the question of the size of the fiscal multiplier. Estimates for these multipliers from the empirical literature are often observed to be greater than one (see for example Blanchard and Perotti; 2002), however traditional New Keynesian DSGE models fail to predict this.[1] Much of the fiscal-DSGE literature has aimed to rectify this anomaly: see for example Linnemann and Schabert (2003), Coenen and Straub (2005), Linnemann (2006), Galí et al. (2007), Bilbiie et al. (2008) and Monacelli and Perotti (2008). The experience of the recent downturn, combined with low central bank rates, has prompted a discussion on the impact of fiscal policy when the nominal interest rate is at the zero lower bound, and moreover, the appropriate policy mix with respect to the balance between spending and tax movements.[2] Currently, we argue, the fiscal-DSGE literature has two key omissions: first, through focusing on the positive properties of policy the analysis is lacking a comprehensive consideration of the normative consequences; and second, through focusing on aggregate dynamics and using the often assumed representative agent, the analysis abstracts away from any heterogeneity and politics, something clearly evident in the conduct of fiscal policy. This chapter, and the next, looks to address these omissions.

The innovation of this chapter is to address this question using a New Keynesian DSGE model with a proportion of credit-constrained agents, as derived in Chapter 2. We propose that these two agents (the Ricardian and non-Ricardian households) represent two clear distinct groups in society of empirically non-trivial proportions, and hypothesise that the latter will come from those individuals at the lower end of the income distribution; although the results are not sensitive to this hypothesis, the interpretations of these results are. This is supported by the growing literature that includes credit-constrained agents into DSGE models: see Chapter 3. However, despite the growing use of these models, limited analysis currently exists on disaggregated variables. Although some papers report heterogeneous dynamics, these tend to only give more detail behind the aggregate variables and no in depth analysis of divergences are discussed.

Through developing an agent specific welfare criteria using a second order Taylor series expansion of the utility function, normative analyses of exogenous shocks and subsequent policy can be made. This adds insight into the different experiences of agents and moreover identifies whether there are any differing preferences associated with policy.

In the absence of fiscal policy, credit-constrained agents experience a lower level of welfare than their non-constrained counterparts who are seen to gain as a result of adverse shocks. This divergence, as found in Chapter 3, is quantitatively non-trivial and is due to the employment decision of the rule-of-thumb households: from this benchmark the impact of policy can be analysed with four key results observed. First, countercyclical

[1] However, it should be highlighted that empirical results do vary with estimates below one, see for example Ramey (2011) and Ilzetzki et al. (2013).

[2] See for example Christiano et al. (2011), Eggertsson (2011), Hall (2011), and Woodford (2011). Within this literature, the effectiveness of policy is measured through the aggregate effects on the economy: the fiscal multiplier.

fiscal policy is to the benefit of rule-of-thumb agents and the detriment of their Ricardian neighbours: there are polarized preferences to policy. This occurs because the Ricardian agents gain as a result of the adverse shocks due to the responses of their credit-constrained neighbours, and through stabilising the economy the fiscal authority are reducing this impact. Second, these rule-of-thumb agents benefit more through countercyclical policy that is paid back slowly over the medium term, whereas Ricardian households prefer prompt repayment: they are more debt averse than the non-Ricardian households. Third, countercyclical measures which favour spending increases over tax cuts are more productive for the economy as a whole, but credit-constrained individuals are largely indifferent between spending increases or tax cuts. Finally, there is a normative justification for countercyclical fiscal measures, however, the quantitative aggregate gains of stabilisation policy are minimal: this is in line with the results from Lucas (2003). The real normative justification comes from the redistributional consequences of countercyclical policy, reducing the inequality of adverse shocks, with the gains from policy of the rule-of-thumb agents being (nearly) matched by the losses of the Ricardian agents: in many respects, the conduct of fiscal policy is performed in a de-facto zero sum game. This is the source of the polarizing preferences in the model and provides a clear commentary of the current austerity versus stimulus debate. It is the non-Ricardian agents who have a preference towards stimulus and their Ricardian neighbours who have a preference towards austerity. This is with respect to both the cyclical response and debt aversion priorities of the two households, with the same conclusions reached from the two perspectives. These debates are observed to be amplified when monetary policy is at the zero lower bound.

The chapter proceeds in the following way. Section 4.2 discusses a model that includes a share of non-Ricardian households and Section 4.3 reviews the algebraic properties of fiscal variables in the model. Section 4.4 discusses both the positive and normative consequences of fiscal policy across households, and Section 4.5 considers further extensions to this benchmark case. Section 4.6 performs sensitivity analysis confirming the robustness of the key results, and Section 4.7 concludes.

4.2 The model

The model is the same as that described in Section 2.3 and can therefore be described through the following six equations: the aggregate demand condition (2.20); the New Keynesian Phillips curve (2.24); the Taylor rule (2.12); the flow constraint for government debt (2.16); and the government spending and taxation rules (2.14) and (2.15). These six equations in six unknowns can subsequently be manipulated to produce a system of three variables (y_t, π_t and $\widehat{b}_t$), details of which are given in Appendix C.1. The model therefore has three forward looking predetermined variables and therefore determinacy requires that three eigenvalues lie outside the unit circle; the determinacy properties of such a system are similar to those derived in Section 3.2. These are too complicated to present, but intuitive relationships can be established and subsequently quantitatively tested. When $\lambda < \lambda^*$, a simple Taylor Principle delivers determinacy ($\varphi_\pi > 1$) and when $\lambda > \lambda^*$ either passive or extremely aggressive policy is required. Irrespective of the value of λ, the fiscal determinacy condition of $\varphi_{b,T} - \varphi_{b,g} > \rho_R/(1+\rho_R)$ is also required. Moreover, to ensure price stability policy cannot be too procyclical, the degree to which this is true is determined by the other stabilising parameters in the policy rules.[3]

The chapter reflects upon normative consequences of fiscal policy which are sensitive to the assumed presence, or not, of government spending in the utility function. We propose to bypass this issue by only focusing on those policy actions which do not lead to a net discounted movement in government spending over the lifetime of the policy.[4] This has the advantage that any conclusions reached are not sensitive to this empirically questionable issue. This process leaves two policy experiments with which to focus the analysis on. The first (from now on referred to as 'policy experiment 1') is where short term government spending increases (decreases) are repaid in the longer term through future spending cuts (rises: $\varphi_g < 0, \varphi_{b,g} < 0$). As demonstrated in the log-linear government flow constraint (2.16) interest accrues on debt at a rate of $\left(\beta^R\right)^{-t}$ whereas the impact on utility will be discounted at $\left(\beta^i\right)^t$. This experiment therefore results in negligible discounted government spending movement (this is explained more fully in Appendix C.2). The second (from now on referred to as 'policy experiment 2') is where short term tax cuts (rises) are repaid in the longer term through tax rises (cuts: $\varphi_T > 0, \varphi_{b,T} > 0$).

4.3 Algebraic properties

4.3.1 Steady state properties of fiscal policy

In order to consider the steady state properties of fiscal policy, Appendix C.3 demonstrates how the following condition can be derived considering the relationship between

[3] In a similar way as φ_y can relax the determinacy conditions found in Section 3.2, φ_g and φ_T can also be used in such a fashion, if countercyclical. The reverse is also true: procyclical fiscal policy requires stronger countercyclical monetary policy to ensure price stability.

[4] Note that if government spending entered the utility function separably, net discounted government spending would enter a welfare criterion based on a second order Taylor series expansion of this utility function separably. Therefore, if this is zero, the utility derived from government spending is irrelevant to households over the lifetime of the policy.

steady state private and public consumption:

$$G = \left[\frac{C^{\sigma}\epsilon}{(\epsilon-1)(1-\alpha)}\right]^{-\frac{1-\alpha}{\varphi+\alpha}} - C$$

and from this it can be shown that:

$$\frac{\partial G}{\partial C} = \frac{-(1-\alpha)\sigma\left(\frac{C^{\sigma}\epsilon}{(1-\alpha)(\epsilon-1)}\right)^{-\frac{1-\alpha}{\varphi+\alpha}}}{C(\alpha+\varphi)} = -\frac{\gamma_c(\alpha+\varphi)}{\sigma(1-\alpha)}$$

where all variables are defined in Chapter 2. This states that a permanent increase in government spending will crowd out private consumption. Moreover, from the above we can infer that the bigger the share of private consumption in output (γ_c), the higher the crowding out of private consumption. This is a common result and is due to the increased employment required to produce additional government consumption; agents derive disutility from this additional labour and optimise by trading off private consumption for leisure. Moreover, from the above it is possible to show that this crowding out can be bigger than the initial increase in government spending ($\partial G/\partial C < -1$) when:

$$\gamma_c > \frac{\sigma(1-\alpha)}{\alpha+\varphi}$$

In such a scenario, an increase in government spending reduces output.

If lump sum taxation were increased to pay for any increase in steady state government consumption, the crowding out of private consumption would be distributed equally across the two types of agent in the model. However, were debt to permanently increase to pay for this, non-Ricardian consumption would fall more than Ricardian consumption in steady state, as the latter own government debt and therefore receive the interest on this higher level of debt.[5] Note that steady state debt is determined by the excess of steady state spending over taxation, and the rate at which interest accrues on this in steady state is determined by the reciprocal of the Ricardian discount factor $\left(\beta^R\right)$.

[5] Alternatively, the lump sum transfers between agents would need to increase which equalises the consumption levels between the two agents, now taking into account both the allocation of dividends and debt interest.

4.3.2 Dynamic properties of fiscal policy

This section analytically reviews the dynamic (out of steady state) algebraic relationships between aggregate demand and fiscal policy variables, which follow from Propositions 2 and 3 in Chapter 2. From the aggregate demand condition (2.20) it is possible to show, in the region of $0 < \lambda < \lambda^*$, the following three results:

$$\frac{\partial y_t}{\partial \widehat{g}_t} > 0, \ \frac{\partial y_t}{\partial \widehat{t}_t} < 0, \ \left|\frac{\partial y_t}{\partial \widehat{g}_t}\right| > \left|\frac{\partial y_t}{\partial \widehat{t}_t}\right| \tag{4.1}$$

all other things being equal.[6] The first and second of these conditions follows from the observation that $\partial y_t / \partial \widehat{g}_t = \Phi$ and $\partial y_t / \partial \widehat{t}_t = -\Phi\Theta_C$, and noting that the condition $\lambda < \lambda^*$ results in each of these aggregate demand coefficients to be positive; the third of these conditions is provided observing that $\Phi > \Phi\Theta_C$ when $\lambda < \lambda^*$.

First, increases in government spending increase aggregate demand: this is true in a fully-Ricardian economy and the magnitude of this (the fiscal multiplier) has been studied extensively in the DSGE literature. Second, tax cuts increase aggregate demand: in a fully-Ricardian economy this would not be true as Ricardian equivalence would hold. The introduction of non-Ricardian households means that taxes are relevant because they impact on these agents' disposable income and subsequently their consumption. Third, the aggregate demand impact of a unit change in government spending is greater than the aggregate demand impact of a unit change in taxes. This is an intuitive result and occurs for two main reasons: first, tax movements only impact the consumption decisions of rule-of-thumb agents (at least in the first instance) because Ricardian agents maximise over their life time and therefore adhere to Ricardian equivalence. Given that the share of rule-of-thumb households is less than one, there are some consumers for which this fiscal action will not initially impact. Second, government spending movements directly affect demand. The impact of tax movements on aggregate demand depend on the decisions of households, who can use, say, a tax cut to both purchase more consumption and/or more leisure: the latter of which will reduce production in the economy. The magnitude to which government spending increases (decreases) dominate tax cuts (rises) can be algebraically shown to be inversely proportional to the level of asset market non-participation, λ, and positively related to the level of private consumption in steady state, γ_c, and the markup charged by intermediate firms, μ.

[6] This ceteris paribus assumption eliminates how debt resulting from policy is repaid. However, it is possible to show that providing there is no existing debt and that debt aversion parameters are not excessively high, the results hold. The purpose of this partial analysis is to provide an algebraic grounding of intuitive relationships which are discussed through the chapter.

Ricardian equivalence in this model holds for any policy which only impacts lump sum taxation of Ricardian households, who maximise over their lifetime; note that in the aggregate demand condition (2.20), were $\lambda = 0$ (a fully Ricardian economy) the coefficient $\Theta_C = 0$ and therefore temporary movements in taxes do not impact output. However, note that when $\lambda > 0$, the presence of credit-constrained agents impacts the general equilibrium which has a subsequent impact of on the behaviour of Ricardian households. Therefore, although Ricardian agents will not respond specifically to the movements of lump sum taxes in policy experiment 2, they will respond to the movements in wages and interest rates as a result of the actions of rule-of-thumb households under such a policy.

Within these relationships, an intuitive key determinant is the proportion of rule-of-thumb agents in the economy, λ. Propositions 2 and 3 show that increases in the fraction of non-Ricardian households increases the impact that changes in government spending and taxes have on aggregate demand, and does so in a non-linear way. The more rule-of-thumb agents in the economy the more of an impact tax cuts will have in stimulating aggregate demand because there will be fewer agents adhering to Ricardian equivalence. Likewise, an increase in public consumption will increase labour demand and wages such that it increases disposable incomes. Whereas Ricardian agents see a negative wealth effect to an increase in government spending (therefore cutting their private consumption), non-Ricardian agents simply consume this temporary increase in incomes. This relationship is non-linear, demonstrating a typical Keynesian multiplier effect.

4.4 Dynamic simulations

4.4.1 Calibration

For dynamic simulations the calibration as discussed in Section 3.3.2 is used. The exceptions to this are the share of government spending in output, γ_g, is set equal to 0.2 (correspondingly, $\gamma_c = 0.8$) and the fiscal policy parameters (φ_g, φ_T, $\varphi_{b,g}$ and $\varphi_{b,T}$) which will be varied throughout the analysis. Moreover, as φ is an important parameter for welfare, and for the impact of fiscal policy from an aggregate and disaggregate perspective, we revert to the common calibration of $\varphi = 2$; correspondingly, we calibrate the proportion of non-Ricardian households (λ) at 0.3 to maintain that $\lambda < \lambda^*$. As was the case in Chapter 3, the model with perfectly competitive labour markets will be used to obtain benchmark results and subsequently sensitivity to these results tested against imperfectly competitive labour markets.

4.4.2 The positive consequences of fiscal policy

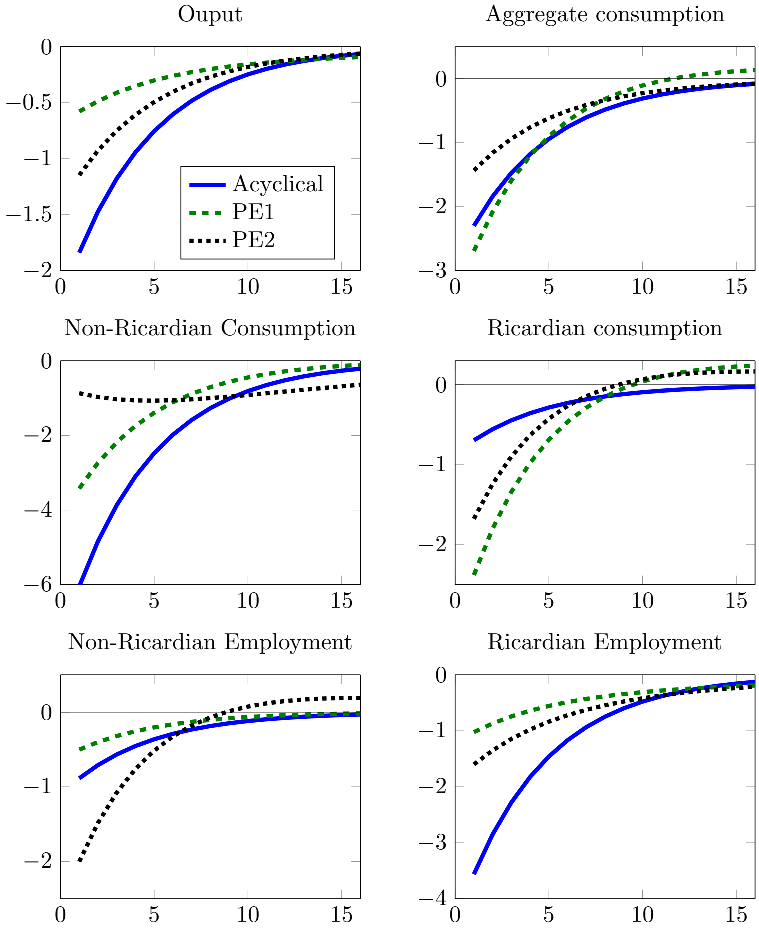
An acyclical fiscal response

As a benchmark, the dynamics of an economy with no active fiscal policy will be considered. It will be against these results that the impact of fiscal interaction will be analysed. These results are in line with those presented in Chapter 3 which are summarised here for ease of reading. The impact of fiscal policy is not sensitive to the initial shock and therefore, for brevity, the results for an exogenous adverse monetary policy shock will be considered: sensitivity of the results to other shocks will be discussed. Figure 4 illustrates the dynamics of an economy hit by a one percent shock to interest rates under the circumstances of acyclical fiscal policy and the two fiscal experiments.

In the presence of acyclical fiscal policy, an exogenous positive monetary policy shock leads to a fall in output in the economy; Ricardian consumers postpone consumption due to higher rates of returns on savings, and non-Ricardian consumers respond to the decline in the economy and subsequent drop in their disposable income. As a result, both aggregate consumption and employment fall in general equilibrium. These results are also true of a fully-Ricardian economy, although the initial impact of the shock increases with the level of asset market non-participation, λ, due to the non-linear feedback mechanism discussed in Chapter 2 and above; in this calibration, output initially falls by approximately 2% from it's steady state level but this diminishes over time as the impact of the shock reduces.

Both Ricardian and non-Ricardian consumption fall following the shock; the former due to higher nominal interest rates and the latter due to both the fall in real wages in the economy, driven by lower labour demand, and lower levels of employment both contributing to reduce disposal income. However, the fall in consumption for the rule-of-thumb agents is greater than that of their Ricardian counterparts. This is an intuitive result that occurs for all time periods. Rule-of-thumb households alleviate the impact of the shock through their labour market decisions: their supply of labour. In the presence of an adverse shock, the credit-constrained agents supply more labour to the market, compared to Ricardian households, in order to increase their disposable income and therefore consumption. However, the result of this increase in labour supply, and the overall reduction in output, leads to a fall in wages and therefore the consumption of non-Ricardian households still falls. These agents are supplying more labour to the market, therefore increasing aggregate output, but they are unable to consume all of this additional production; the surplus is consumed by the Ricardian households who are being insulated as a result of the actions of the credit-constrained agents. They are able to purchase this surplus through greater dividends in general equilibrium

FIGURE 4: Dynamics under different fiscal experiments



Dynamics achieved through using the calibration described in Section 4.4.1 and with a 1 percent monetary policy shock (η_t^r) in period $t = 1$. The x-axis represents the number of quarters and the y-axis the percentage deviation of the variable from steady state levels. Acyclical policy is when all fiscal parameters are set to zero; 'PE1' represents policy experiment 1 with calibration $\varphi_g = -3$ and $\varphi_{b,g} = -0.1$; 'PE2' represents policy experiment 2 with calibration $\varphi_T = 3$ and $\varphi_{b,T} = 0.1$. These fiscal parameters are arbitrarily set for the purposes of demonstration in the figure. Note, debt aversion parameters equal to 0.1 in modulus relates to an expected half life of debt of two years, using equation (2.16).

brought about by the supply of cheap labour. As in Chapter 3, the assumption of the distribution of profits is important in these results, and the impact of the impatience of non-Ricardian households.

Overall, income of Ricardian households dominates that of non-Ricardian households despite the fall in the former's labour supply and the rise of the latter's. Ricardian households both consume more and work less than their non-Ricardian neighbours. This is illustrated in Figure 4 for an adverse monetary policy shock, and this intuitive transmission mechanism is not sensitive to the original shock and similar results for other shocks can be observed (although the aggregate dynamics underlying these will differ).

The impact of fiscal policy

Figure 4 also presents the impact of the two policy experiments (calibrated to be countercyclical) to the aggregate and disaggregate economy. As predicted by the algebraic analysis in Section 4.3 in both experiments aggregate demand, and subsequently output, initially increases compared to the acyclical benchmark. In policy experiment 1, where spending increases in the short term are funded by future spending cuts, this increase in demand comes directly from the government. Aggregate private consumption initially falls in the economy (it is 'crowded out' by the fiscal action) however, this aggregate movement hides disparity across agents; non-Ricardian consumption increases and Ricardian consumption falls, compared to the acyclical benchmark. This rise in rule-of-thumb consumption is driven by an increase in real wages as labour demand in the economy rises due to the increase in output. Ricardian households, on the other hand, substitute leisure for consumption as the increase in labour demand increases their employment levels: they optimise by reducing their consumption. In policy experiment 2, where tax cuts today are funded by future tax rises, this rise in aggregate demand and subsequently output comes entirely through private consumption. Non-Ricardian consumption increases and Ricardian consumption falls, however the increase in the former is greater than that of the latter. Rule-of-thumb consumption increases as a result of both the tax cut, which directly increases disposable income, and also through an increase in wages as labour demand in the economy increases. In a fully-Ricardian economy ($\lambda = 0$), the impact of policy experiment 2 would be nil; Ricardian equivalence would hold and private consumption would remain unchanged. However, with $\lambda > 0$, a small short term fall in Ricardian consumption is observed, compared to the acyclical benchmark, as a result of increasing Ricardian employment leaving them with a preference to substitute consumption for leisure.

The effectiveness of policy experiment 1 over policy experiment 2 with respect to aggregate output, as predicted in (4.1), is illustrated in Figure 4. In both cases, output initially dominates the acyclical benchmark but the direct government injection of public spending is more effective than private tax cuts as the latter are used (partially) to purchase more leisure. Over longer horizons, the fiscal policy actions need to be repaid and as such the stimulating impact is reduced until output falls below that of the acyclical benchmark: in this calibration this occurs after 14 and 17 quarters for policy experiments 1 and 2 respectively.

From a disaggregate perspective clear results are presented as a consequence of the fiscal experiments. Compared to the acyclical benchmark, consumption rises and employment falls (with the exception of a slight rise in employment in policy experiment 1) initially for rule-of-thumb households with the reverse results for Ricardian households. However, these results are only immediate consequences of the policy and as the fiscal authority starts to repay resulting debt these dynamics are reversed.

4.4.3 The normative consequences of fiscal policy

This section reviews whether there is a normative justification to fiscal policy by evaluating the different agent's welfare under the policy experiments discussed above. This is performed by deriving a welfare criterion based on a second order Taylor series expansion of the utility function around the non-stochastic, zero debt, zero inflation, steady state values. This procedure provides a criterion expressed as the equivalent one period consumption loss, as a proportion of steady state consumption, that leaves the agent indifferent between living through the shock or the one period consumption loss. This process provides the same criterion as derived in Section 3.3.3 with the resulting function (3.4). As mentioned above, if government spending were to enter the utility function separably this welfare criterion would also have a weight attached to the net discounted movements in government spending; this will be zero for the two policy experiments outlined in Section 4.2. Welfare results are derived using a second order approximation of the model because, as Walsh (2010) highlights, a first order approximation can be inappropriate.

An acyclical fiscal policy response

The top row of Figure 5 presents welfare valuations of the two policy experiments when the economy is struck by the same one percent adverse monetary policy shock discussed above, for differing values of the cyclical response parameters; the vertical lines represent acyclical policy ($\varphi_g = \varphi_T = 0$). The results show the intuitive result from the disaggregated dynamics presented above; in the absence of fiscal policy, Ricardian welfare dominates non-Ricardian welfare as the former both consume more and work less. The resulting dynamics mean that these unconstrained agents gain welfare as a result of the shock; their fall in employment provides enough of a utility reward to compensate for the penalty of a fall in consumption. These results are in stark contrast to the non-Ricardian agents who see a significant fall in welfare as a result of the shock. In aggregate, there is a mild improvement in welfare as there is a majority of Ricardian agents who discount the future less whose gains are being netted against a smaller fraction of rule-of-thumb agents; these results are coherent with those presented in Chapter 3 (in Table 5) but quantitatively larger predominantly due to the higher calibration of φ. There is a redistribution of welfare from non-Ricardian to Ricardian agents as a result of the adverse shock. This is not sensitive to the type of shock causing the deviations and the intuitive transmission mechanism is maintained.

The impact of fiscal policy

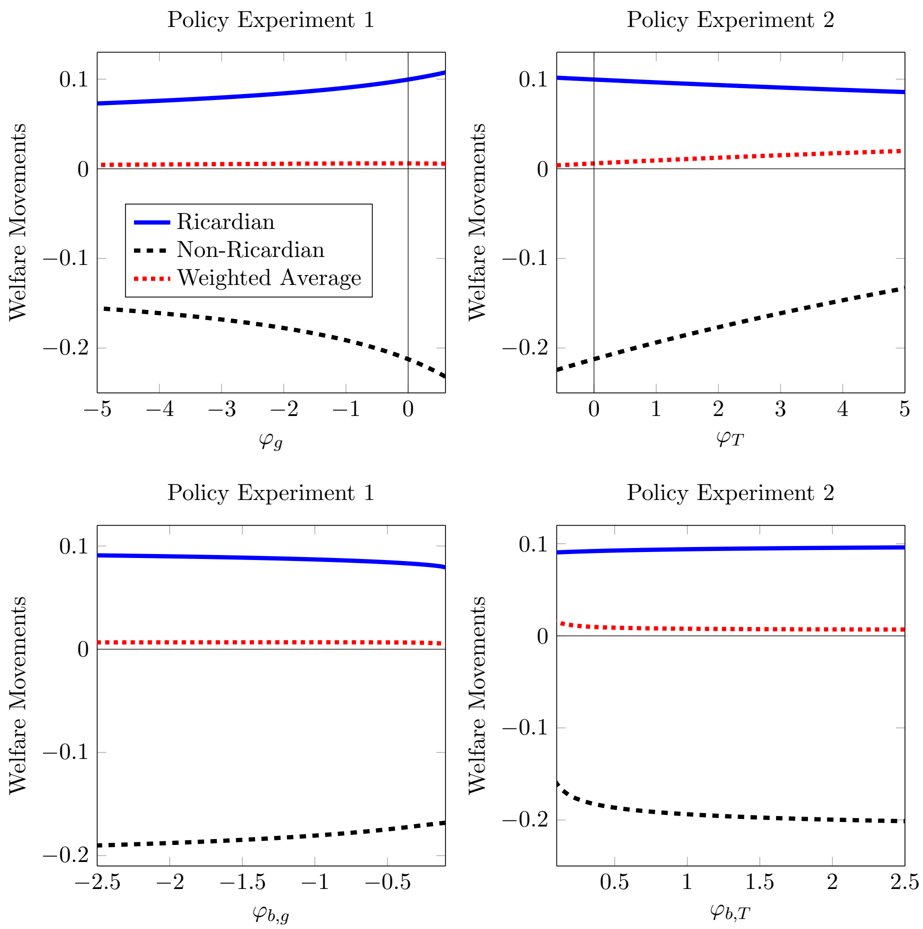
Figure 5 presents the normative consequences of fiscal policy: as discussed above, the first row illustrates the movement in welfare when the cyclical response parameters (φ_g and φ_T) are varied whilst the debt aversion parameters are fixed ($\varphi_{b,g}$ and $\varphi_{b,T}$); the second row reverses this, varying the debt aversion parameters whilst fixing the cyclical response parameters. From these figures four clear results emerge. First, non-Ricardian households gain and Ricardian households lose as a result of countercyclical fiscal policy: this is an intuitive result. Countercyclical policy stabilises the economy by reducing the impact of the exogenous shock. This stabilising role reduces the need to use capital markets to smooth consumption and therefore reduces the welfare losses associated to not being able to do this. However, because the stabilisation policy is insulating the economy, the increase in the rule-of-thumb labour supply is reduced and as such, the gains from the shock that the Ricardian agents experience are reduced through countercyclical policy. There is a clear divergence of preferences between the two households.

Second, rule-of-thumb households are largely indifferent between countercyclical measures which increase government spending and those which reduce taxes in response to a recessionary shock. It was observed in equation (4.1) that the former have a greater impact on the aggregate economy than the latter and this is demonstrated in Figure 4. The normative results imply that rule-of-thumb agents benefit both from general increases in aggregate demand and through direct injections into their disposable income. Ricardian households prefer countercyclical measures which cut taxes over those that increase spending because they have less of a stabilising role, and therefore maintain their improved position as a result of the shock.

Third, high degrees of debt aversion lead to lower movements in relative welfare as a result of policy (the second row in Figure 5). This occurs because the initial impact of the intervention is shortened as the repayment for the policy is accelerated in the economy.[7] Therefore, the results from above are maintained, rule-of-thumb agents

[7] Similar effects of the impact of lower debt aversion on the impact of both aggregate and disaggregate variables are found in Bilbiie and Straub (2004).

FIGURE 5: Welfare consequences of fiscal experiments



Dynamics achieved through using the calibration described in Section 4.4.1 with a 1 percent monetary policy shock (η_t^r) in period $t = 1$. In the top left pane φ_g is varied whilst $\varphi_{b,g} = -0.1$; in the top right pane φ_T is varied whilst $\varphi_{b,T} = 0.1$; in the bottom left pane $\varphi_{b,g}$ is varied whilst $\varphi_g = -3$; and in the bottom right pane $\varphi_{b,T}$ is varied whilst $\varphi_T = 3$. Note, debt aversion parameters equal to 0.1 in modulus relate to an expected half life of debt of two years, using equation (2.16). Vertical lines in the top row represent acyclical fiscal policy. Welfare movement is expressed as the equivalent one period consumption loss, as a proportion of steady state consumption, that would leave the household indifferent between living through the shock, or this one period sacrifice. A second order approximation of the model is applied to derive welfare results.

benefit from countercyclical fiscal policy, and Ricardian households lose, and moreover, rule-of-thumb agents would prefer that such policy be repaid slowly, when the impact of the shock on the economy has passed. This further contributes to the austerity versus stimulus debate. To some extent the expression 'debt aversion' could be replaced with 'austerity preference'. Many western economies performed an initial fiscal stimulus as a result of the financial crash in 2008, with limited controversy. When the downturn persisted the austerity versus stimulus debate ignited with the 'austerity-camp' looking to repay the initial stimulus quickly with the counter-argument that such repayment was inappropriate whilst the economy was still struggling. These results provide a further polarizing preference to the conduct of fiscal policy.

Finally, there is a normative aggregate justification for countercyclical fiscal measures but these are quantitatively small: this result is in line with Lucas (2003). The real normative justification comes from the redistributional consequences of policy because it reduces the inequality of sacrifice between the two households as a result of the shock. Through having a stabilising influence on the economy, the countercyclical policy limits the impact of the adverse shocks and in so doing reduces the redistribution of welfare associated with the shock. The fact that aggregate welfare gains as a response of fiscal intervention are small is the cause of the polarizing preferences in the model: as one agent gains welfare, the other agent loses.

Other shock processes

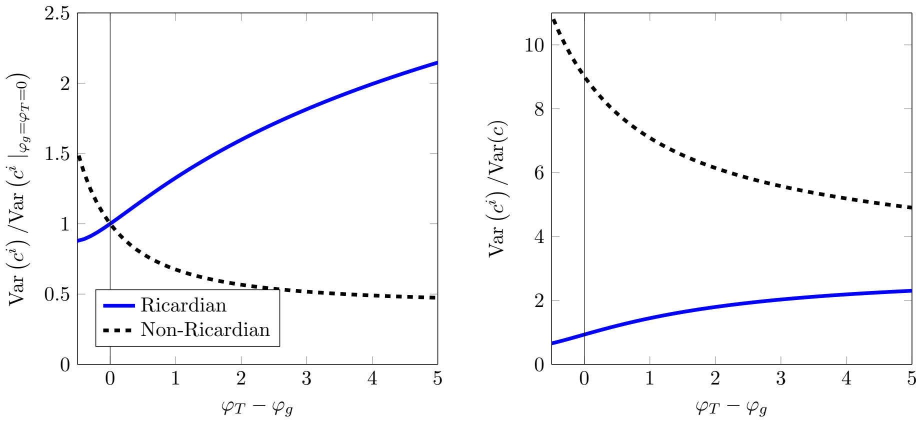
The same analysis as presented in Figures 4 and 5 can be performed for when the initial shock originates from any of the other microfounded shock processes. The redistribution of welfare, in the presence of the adverse shock and acyclical fiscal policy, from non-Ricardian to Ricardian households is observed whereby the former agents' labour market decisions improves welfare for the latter agents over their steady state levels. From this benchmark, fiscal policy interacts with the economy in a similar way as to those presented for adverse nominal interest rate shocks, and the disaggregated welfare experiences of the two households also follow similar paths. This consistency of results is due to the way fiscal policy interacts within the economy through the aggregate demand condition.

4.4.4 The conduct of fiscal policy over the business cycle

The above analysis has been performed considering only adverse shocks, defined as those leading to a negative output gap. This restriction was made to consider the conduct of fiscal policy relevant for the current recession. The model is linear and therefore the results above would be reversed in the presence of non-adverse shocks: Ricardian households benefit from countercyclical fiscal policy in a boom when the redistribution of welfare operates in the other direction.

To consider the conduct of fiscal policy over the whole business cycle, simulations of the model are made with a mixed fiscal strategy where $-\varphi_{b,g} = \varphi_{b,T} = 0.05$ and where the cyclical response parameters are varied but set equal to each other in absolute terms ($-\varphi_g = \varphi_T$). The results are not sensitive to this mixed strategy and the remainder of calibrated parameters are as set out in Section 4.4.1. Simulations are run with equal weights for demand, cost push and productivity shocks and key statistics observed and documented in Figure 6.

FIGURE 6: Fiscal policy and consumption variance through the business cycle



Dynamics achieved through using the calibration described in Section 4.4.1 with equal standard deviation weights for demand, cost push and productivity shocks (where demand shocks are shared across both interest rate and preference shocks); the results are not sensitive to this equal weighting. A simulation period of 1,000 quarters is used where the first 200 observations are dropped from the analysis. Debt aversion parameters are set such that $-\varphi_{b,g} = \varphi_{b,T} = 0.05$ and where cyclical response parameters are varied and set such that $-\varphi_g = \varphi_T$. The left hand pane measures the variance in consumption of the two types of agent, compared against a benchmark of the respective agent's consumption variance with acyclical policy; the right hand pane measures the variance in consumption of the two types of agent as a ratio of the variance of aggregate consumption at that parameter calibration.

A countercyclical fiscal response to the business cycle leads to a fall in the variance of non-Ricardian consumption and a rise in the variance of Ricardian consumption compared to an acyclical benchmark (the first pane of Figure 6). The fall in the variance of non-Ricardian consumption arises because the fiscal action acts to stabilise disposable income, either directly through taxation or indirectly through government demand. For Ricardian households, the insulating actions of their non-Ricardian neighbours are more effective than those of the fiscal authority and the countercyclical conduct of the latter therefore leads to a rise in the variance of their consumption. To these agents, movements in government spending raises their consumption variance as they substitute consumption for leisure, and movements in taxes are ignored, at least in partial equilibrium. Therefore, over the course of the business cycle, countercyclical fiscal policy works to the advantage of non-Ricardian households at the expense of Ricardian households. There is a strong negative covariance between non-Ricardian and Ricardian consumption which drives the polarizing preferences for fiscal policy:

countercyclical policy reduces this covariance.[8] Policies focusing on changing lump sum taxes have a bigger impact on non-Ricardian households as they directly influence their disposable income: correspondingly, policies focusing on government spending reduces the detrimental impact on Ricardian households.

These results are not sensitive to the calibration used, in particular with respect to λ, φ, and fiscal parameters, or changing the weights on different standard deviation of shocks. Moreover, they are not sensitive to the labour market assumed. However, when more frequently applied modelling assumptions and calibrations are used the point at which non-Ricardian consumption variance is lower than that of Ricardian consumption variance is significantly extended: this is particularly true of a more restrictive labour market.[9]

These results are of particular significance because they contribute to the literate that observes fiscal policy to be frequently procyclical, especially in developing nations: see for example Kaminsky et al. (2004) and Chapter 7. This can be reconciled to our model by observing that the results above are amplified the higher the proportion of credit-constrained agents, see Section 4.6, and therefore the returns to procyclical policy for Ricardian households are greater in such economies. Empirical data illustrates that the proportion of credit-constrained agents is greater in developing countries, see for example the work performed by Evans and Karras (1996) and discussed in Table 2 above, and that voter turnout in both parliamentary and presidential elections are lower in these countries.[10] Providing sufficient voting power is retained in the remaining Ricardian households of a nation, the model would predict the empirical regularity that these developing countries are more fiscally procyclical as they provide more insulation for the capital owners within the economy.

[8] This is illustrated by the fact that a weighted average of the variance of Ricardian and non-Ricardian consumption normalised by the variance of total consumption is substantially higher than one (the second pane in Figure 6).

[9] Optimal policy in such a framework where a benevolent social planner minimises variation in both output and inflation is numerically estimated to be where $\varphi_g = -3.7$ and $\varphi_T = 2.3$: both of which represent countercyclical policy but with an emphasis on government spending as a more effective tool. Moreover, the Ramsey policy for government spending where the social planner is not constrained by specific policy functions will lead to a reduction in the variance of non-Ricardian consumption and a rise in the variance of Ricardian consumption as government spending responds countercyclically to the business cycle.

[10] Evans and Karras (1996) estimate the proportion of credit-constrained agents in 54 different countries and applying World Bank classifications the mean estimate for developing countries is nearly double that of developed countries: this is summarised in Table 2. Moreover, applying the same World Bank classifications to voter turnout data from the Institute for Democracy and Electoral Assistance, rates of 78% are found for developed economies followed by a monotonic decline with the level of development, with rates of 65% for low income countries. Studies into the socio-economic factors influencing voter turnout frequently show that it is those with less education and less income who are less likely to vote (see for example Nevitte et al.; 2009): those individuals most likely not to participate in capital markets.

4.4.5 Discussion

The results observed from the theoretical model are simple, intuitive and reflective of empirical debates. Polarized preferences to fiscal policy are predicted where policies affect heterogeneous households differently: rule-of-thumb agents have preferences for strong countercyclical fiscal policy which is paid back slowly over the medium term; Ricardian agents, on the other hand, prefer an acyclical response of fiscal variables to the business cycle with limited government intervention. If there are to be stimulating actions, these agents prefer measures which cut taxes and raise them in the future, where the latter is performed quickly in order to pay for the tax reductions.[11] These two sets of preferences are reflected in recent policy debates. Two clear camps appear in these political discussions whose arguments follow similar lines to those predicted by the model; this is with respect to the cyclical nature of the fiscal response, policy mixes and the degree of debt aversion. We proposed that the rule-of-thumb agents will come predominantly from those in the lower end of the income distribution; this proposition is coherent with the preferences outlined above because it is the political left wing who argue for policy measures similar to those desired by the non-Ricardian agents, and the political right wing who argue for those preferences observed for the Ricardian households. This alignment of preferences from the model to the empirical debates provides support for the model and also the hypothesis about the identification of the two types of agent. Moreover, it provides further evidence towards the preferences over the policy mix as with a progressive tax system (not assumed in the model) it will be the Ricardian agents paying the majority of the taxes in the economy, therefore receiving the majority of any cuts, further reducing the aggregate impact of these and diminishing the welfare gains of countercyclical policy to rule-of-thumb agents.

Although the modelling assumption is a crude division of an otherwise more diverse population, its ability to predict the real world polar fiscal debates is persuasive. Beyond this segregation of agents the implied intuition is clear; if some agents gain and others lose during different phases of the business cycle, the former have an incentive to prolong the conditions from which they are benefiting and are averse to policy measures that prohibit this.

[11] These results are also consistent with the empirical findings in IMF (2012a) which observes a rise in income inequality during fiscal consolidations, especially those which favour spending cuts over tax rises.

4.5 Further extensions

4.5.1 Fiscal policy at the zero lower bound

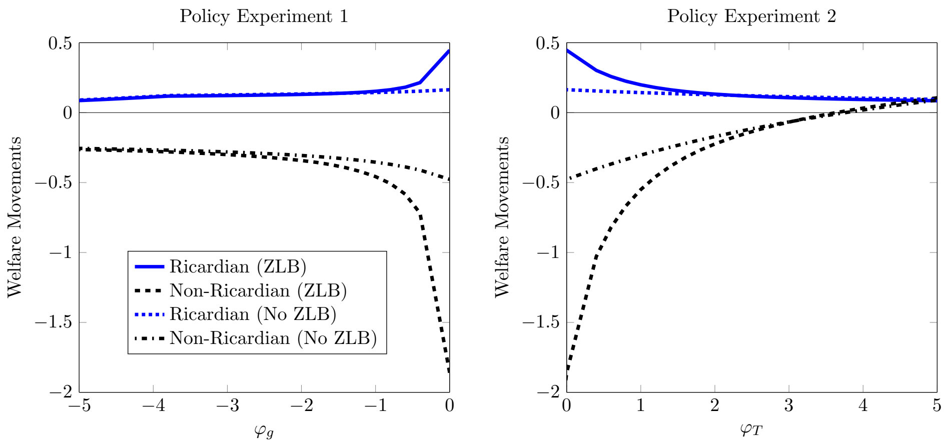
A characteristic that has been prevalent in the recent recession, and for which has received much academic attention, is that monetary policy has been operating at its' lower bound: where nominal interest rates reach, or are close to, zero. Under such a scenario fiscal multipliers are shown to increase as the deflationary impact of higher interest rates associated with higher levels of output are removed: see for example Christiano et al. (2011). When nominal interest rates reach zero, the expansionary impact of a cut in these rates is no longer possible and as such the impact of shocks that take the economy below this point become larger, as the monetary authority has lost its ability to stabilise the economy: this increases the scope for fiscal policy.

To see how the results are altered when the nominal interest rate is at its lower bound, the economy above is exposed to a preference shock such that interest rates are zero for six periods in the presence of acyclical fiscal policy: from this benchmark the impact of fiscal policy on the welfare outcomes of the two agents are illustrated in Figure 7.[12] In the presence of acyclical policy, the amplification of the impact of the shock leads to an amplification in the welfare consequences; non-Ricardian losses and Ricardian gains are increased, where the former are greater than the latter, leading to an increase in the weighted average welfare losses of the economy. From this benchmark fiscal policy has more scope to rebalance this larger redistribution of welfare. As before, the weighted average welfare movements from policy are not large, although are larger, and as such any improvements to non-Ricardian households from countercyclical policy are at the expense of Ricardian households. Sufficiently countercyclical policy in experiment 2 can lead to non-Ricardian households' welfare dominating that of Ricardian households. This occurs because the asymmetry in the behaviour of monetary policy means the period when the lower bound is binding is of more importance than when it is not because these impacts are amplified. As is illustrated in Figure 4, countercyclical policy experiment 2 leads to significant short term utility losses of Ricardian agents whose benefits from the policy accrue over the medium and long term. If this initial period is amplified and fiscal policy is sufficiently countercyclical, this can result in these agents losing welfare as a result of the shock and non-Ricardian agents gaining welfare. Countercyclical policy in this framework can also act to shorten the period when the monetary zero lower bound is binding: at calibrations of $\varphi_g = -5$ and $\varphi_T = 5$, this period is three and four quarters respectively, compared to six with

[12]The algorithm designed in Holden and Paetz (2012) is applied which provides a shock to interest rates whenever their dynamics are below zero to increase them to this lower bound. These shocks are fully anticipated by agents in the economy.

acyclical policy. Although this analysis has shown that the conclusions above are robust to when monetary policy is at its lower bound, it does show that the polarization between the two agents is amplified by this empirically relevant scenario.

FIGURE 7: Fiscal policy at the zero lower bound



Dynamics achieved through using the calibration described in Section 4.4.1 with $\eta_t^b = 0.1$ in period $t = 1$. The algorithm used in Holden and Paetz (2012) was applied in order to derive the results. In the left pane φ_g is varied whilst $\varphi_{b,g} = -0.03$; in the right pane φ_T is varied whilst $\varphi_{b,T} = 0.015$ where these calibrations are necessary to secure results from the algorithm. Benchmark results are presented for an economy subjected to the same shock but where no zero lower bound is imposed ('No ZLB'). Note that only a first order approximation of the model is used to derive these results, given the complexity of the computing process.

4.5.2 Distortionary taxation

The analysis above has been performed using lump sum taxation however, were distortionary taxes to be included, similar results would be derived. From the structure of the model it is possible to include taxes on consumption, employment income and employment by firms such that these rates react to the business cycle and the level of debt similar to (2.15): see Appendix C.4 for details of the structure of this model. If these are included, similar results as those presented for lump sum taxes are derived: countercyclical policy is to the advantage of non-Ricardian households and the expense of Ricardian households. Consumption and employment income taxes are more effective at rebalancing these welfare impacts, compared with employer social security contributions, as the latter accrue to Ricardian agents through dividends; however a countercyclical response of these taxes leads to an incentive to increase employment during downturns. This leads to a stabilisation of the economy, and as such a lower response from rule-of-thumb agents: fiscal policy is still played in a near zero sum game.[13]

Simulations performed over the course of a business cycle provide similar results to those presented above: countercyclical policy focusing on any combination of distortionary taxes, but especially on consumption and income taxes, is to the benefit of non-Ricardian agents, whereas Ricardian households prefer procyclical policy. Intuitively the result that those agents who are most exposed to business cycles gain from policy which stabilises these is maintained. Moreover, the concept that in the presence of acyclical policy credit-constrained agents insulate Ricardian households through their labour market transactions is also maintained. What distortionary taxation does provide is further scope for politics to interact with the economy and influence decisions, and it allows for more polarizing combinations of policies. For example, a policy which cuts consumption taxes today and raises capital taxes in the future is seen to benefit non-Ricardian households at the expense of Ricardian households, with the opposite result from the opposite policy. Moreover, a policy which actively looks to redistribute income between the two types of agent can more directly cause conflict. For example, targeting tax cuts to rule-of-thumb agents and paying for these through tax rises on Ricardian households will increase the positive and normative consequences of policy. As distortionary taxes are explicitly redistributive, they distort the political discussion about policy: from the perspective of those agents most vulnerable to business cycles the most important characteristic of policy is that it is countercyclical.

4.6 Sensitivity

The sensitivity of the results above have already been tested against the cyclical response of the fiscal authority (φ_g and φ_T), the degree of debt aversion ($\varphi_{b,g}$ and $\varphi_{b,T}$), as well as the initial shock process. In all cases small changes to the quantitative results were observed but not to those of the qualitative messages from the analysis. This section performs further robustness tests of the results.

4.6.1 Multipliers

A potential critique of the above results is that through introducing a proportion of non-Ricardian agents the model is implicitly generating large fiscal multipliers through

[13] It should be noted that the results provided are less clear cut in such a model because, even with acyclical policy, movements in other variables now lead to movements in debt. For example, it can be observed in equation (C.1) that movements in consumption, employment and real wages lead to movements in debt, independent to the cyclical response of the fiscal authority.

increasing the private consumption response to stimuli over the traditional real business cycle model. However, as can be observed in Figure 4 government spending (in the calibration used) crowded-out private consumption leading to a lower than unity multiplier in policy experiment 1. To further address this issue, the model can be manipulated to find fiscal policy multipliers associated with the different experiments. The response functions (2.14) and (2.15) can be adapted to include shocks to fiscal variables. This is performed because the resulting multiplier calculations from using the above analysis are sensitive to the arbitrary calibration of the cyclical response parameters: they are not sensitive under the new specification.[14] Table 9 presents the results from this analysis.

Table 9: Fiscal multipliers

	Multiplier	
	Impact	One Year
Experiment 1	0.84	0.83
Experiment 2	0.21	0.21

The ‘Impact’ multiplier is calculated using $y_t/\widehat{g_t}$ in policy experiment 1 and $y_t/|\widehat{t_t}|$ in policy experiment 2. The ‘One Year’ multiplier is calculated using $\sum_{t=1}^{t=4} y_t/\sum_{t=1}^{t=4}\widehat{g_t}$ in policy experiment 1 and $\sum_{t=1}^{t=4} y_t/|\sum_{t=1}^{t=4}\widehat{t_t}|$ in policy experiment 2. Multipliers achieved through shocking either government spending or taxes: the calibration is as that set out in Section 4.4.1. Debt aversion parameters are set with $\varphi_{b,g} = -0.1$ and $\varphi_{b,T} = 0.1$. A positive multiplier for tax shocks corresponds to the rise in output as a result of a fall in taxes.

As demonstrated by the table, even with the inclusion of the rule-of-thumb households the model does not produce large aggregate multipliers from fiscal actions, because there are few other rigidities in the model. Therefore, the model is providing the results despite the multipliers associated with it, not because these are being amplified through the inclusion of non-Ricardian households. This is somewhat by design: the chapter attempts to explore if DSGE models can present differing preferences over the conduct of fiscal policy and whether these shed light on the current austerity versus stimulus debate. We do not aim to provide a positive aggregate justification to fiscal policy but a normative disaggregate justification. Increasing the multipliers generated by the model would do both, but even without these the analysis provides clear, intuitive and robust results. There is a normative justification to countercyclical fiscal policy, even in the absence of a significant positive one.

The modelling procedure used to find multiplier figures can also be used to test for the results if fiscal policy was conducted through shock processes rather than automatic

[14] They will be sensitive to these cyclical response parameters because the higher their value the lower the impact of the shock will be under rational expectations. This will lead to a lower fiscal response to the shock and therefore the policy is becoming more effective despite the quantitative response being smaller.

rules. If this was performed, similar conclusions as those reached above would be made: the analysis is not sensitive to the way the fiscal authority is modelled.

4.6.2 The labour market assumption

A key assumption for all results has been that of the perfectly competitive labour market, because it is through the labour market that non-Ricardian households perform their constrained optimisation and through these dynamics from which the redistribution of welfare derives. As a result, the design and assumptions of this market and how it operates is important to the analysis. If the model were adapted to include imperfectly competitive labour markets, as discussed in Chapter 2, where a continuum of trade unions bargain to add a markup on wages by aggregating individual preferences to create a weighted average labour supply function, the results remain qualitatively and quantitatively unchanged as those presented above. There is a redistribution of welfare observed in the presence of an adverse shock and this can be reduced through countercyclical fiscal measures. These results can be observed in Figure 8.

Although it is the labour market response of non-Ricardian households which drives the redistribution from exogenous shocks, perfectly competitive labour markets provide these agents with the most flexibility in which to minimise their loses. With imperfectly competitive labour markets, there is still a desire to increase non-Ricardian labour supply in response to a fall in disposable income, and trade unions incorporate this preference in their negotiations, resulting in a fall in real wages: this subsequently maintains the redistribution of welfare to capital owners. The model presented provides a simple intuitive framework from which to consider the heterogeneous impacts of shocks and subsequent policy: the results obtained are not sensitive to the labour market assumption.

4.6.3 The share of non-Ricardian households

As was discussed above, the greater the share of non-Ricardian households the greater the impact of a shock on the aggregate economy due to the non-linear feedback mechanism between any exogenous movement and aggregate demand. From a disaggregate perspective, three factors are influencing the welfare of individual agents: first, the increased aggregate impact of the shock is leading to a larger labour supply reaction by rule-of-thumb agents; second, as the proportion of rule-of-thumb households increase, the proportion of Ricardian households is decreasing, and therefore so too are the agents who can take advantage of the additional employment and dividends in the economy;

and third, an increase in the share of non-Ricardian agents leads to a greater effectiveness of fiscal policy as is demonstrated in condition (2.25). These combine to lead to a greater quantitative impact of exogenous shocks on agents at higher levels of λ, which is particularly true of Ricardian households who are now sharing surplus production across fewer agents. However, the interaction of fiscal policy with the aggregate and disaggregate economy remains qualitatively unchanged: countercyclical policy is to the benefit of non-Ricardian agents and at the expense of Ricardian agents. These results can be observed in Figure 8 for a calibration where $\lambda = 0.15$.

We can also remove the assumption that both types of agent consume and work the same amounts in steady state. Similar results as those discussed in Section 3.6.2 would result.

4.6.4 Other parameters

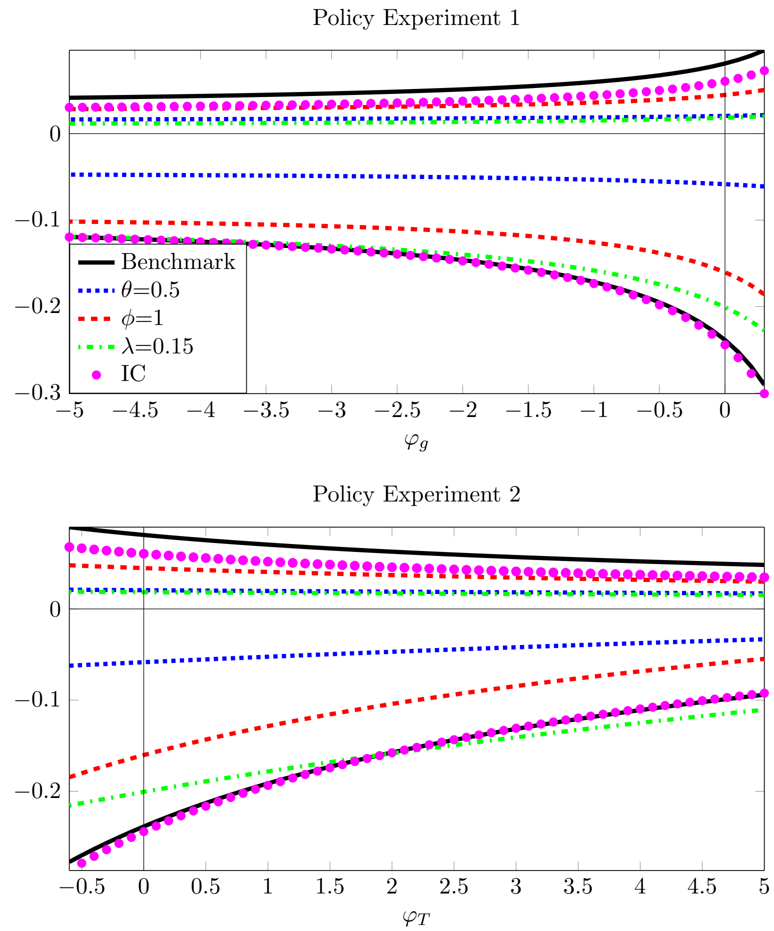
Lower values of the the inverse elasticity of work with respect to the real wage, φ, lead to a lower aggregate impact of shocks for two reasons: first, through decreasing the disutility from work the labour supply response of rule-of-thumb agents will be increased; and second, a lower value of φ leads to a higher value of λ^* thus decreasing the impact of the shock. These results can be observed in Figure 8 for a calibration where $\varphi = 1$. Similarly, with the exception of movements in the desired markup of intermediate good firms, lower values of price stickiness lead to a lower impact from exogenous shocks as they are propagated for longer in the economy. These both lead to a decrease in the scope of fiscal policy to rebalance the smaller redistribution of welfare associated with lower calibrations of both.[15] Again, however, although there are small quantitative changes in welfare from these calibrations, the impact of fiscal policy on relative welfare remains unchanged: countercyclical policy is to the benefit of non-Ricardian households at the expense of Ricardian households. These results can be observed in Figure 8 for a calibration where $\theta = 0.5$.

4.7 Conclusions

The aim of this chapter was to perform a normative assessment of fiscal policy in the presence of adverse shocks in a DSGE model. This was done using a model that included heterogeneous households which provides an avenue for differing preferences over policy to emerge within the model. The findings are intuitive and representative

[15] It can be shown algebraically from (2.20) that impact multipliers are increasing in φ: providing $\lambda < \lambda^*$, $\partial\Phi/\partial\varphi > 0$ and $\partial\Phi\Theta_C/\partial\varphi > 0$.

FIGURE 8: Chapter 4 sensitivity



Results achieved through shocking the economy with an adverse interest rate shock ($\eta_t^r = 1$) in period $t = 1$. The top pane represents results from policy experiment 1 where φ_g is varied and $\varphi_{b,g} = -0.1$, and the bottom pane represents results from policy experiment 2 where φ_T is varied and $\varphi_{b,T} = 0.1$. With the exception of the change notated in the legend all other parameters are calibrated as discussed in Section 4.4.1. In all cases Ricardian households welfare dominates that of non-Ricardian households and therefore the same style of line-style is used for both to simplify notation.

of that observed in the real world. Adverse shocks to an economy impact constrained non-Ricardian households more than their unconstrained counterparts. In aggregate the welfare loss from such actions are small, but this hides a big loss of rule-of-thumb agents netting off gains of their Ricardian neighbours. When fiscal policy is allowed to interact with the business cycle key themes and intuitive results are observed. Rule-of-thumb agents have a preference towards countercyclical fiscal policy that is repaid over a long time horizon. Ricardian households, on the other hand, have opposing preferences, preferring acyclical policy to maintain their position; if fiscal policy is to be countercyclical, these agents prefer measures that favour tax cuts and that are repaid quickly. In effect, these fiscal decisions are played in a virtual zero-sum game where the gains of one household are netted off against the losses of the other, and this is the source of polarizing preferences in the model. These are coherent with those observed in the real world and the intersection of preferences to empirical debates is compelling. With regards to the current austerity versus stimulus debate, the model predicts its existence and those involved on the two sides of the debate; moreover, the model predicts the debate is of greater significance when monetary policy is at the zero lower bound. These results come from a model which assumes away progressive taxes and one with modest multipliers. The normative justification comes despite the lack of a significant positive one.

The importance of this research is that it broadens the scope of DSGE models to not only comment on the positive and normative consequence of shocks and policy from an aggregate perspective, but also from a disaggregate perspective. Such analysis complements the current literature because it provides further understanding behind various policy implications and, moreover, provides a commentary of potential political obstacles policy makers face which may prohibit certain actions. Given that models which include heterogeneity in the actions of households are now commonplace, the methods and procedures applied here are easily tractable into this current research. The potential extensions of this research are vast and include extending the model developed here for further rigidities and fiscal instruments, but moreover, include adopting the procedures performed here to other policy scenarios and other methods of diversifying individuals.

Chapter 5

Who's afraid of austerity? The redistributive impact of fiscal policy in a DSGE framework

5.1 Introduction

There has been a great revival of interest in fiscal policy issues in both policy and academic circles following the 2008-09 global financial crisis. Substantial fiscal stimulus packages that were put in place in response to the crisis were followed by much reduced fiscal revenues during the subsequent Great Recession, leading to a clear loss of fiscal discipline, particularly in advanced economies.[1] For example, in 2009 debt to GDP ratios reached an average of 92.3 per cent in OECD countries with 89 per cent in the UK, 99 per cent in the US, 126 per cent in Italy and 210 per cent in Japan (see for example OECD; 2012).

Such fiscal sustainability issues that surfaced soon after the adoption of the large fiscal stimulus packages have forced widespread policy reversals. The resulting fiscal consolidation has proved difficult both politically and economically in many countries. Challenges fiscal austerity posed for different sections of the society have been at the top of the political agenda in both the US and the UK since 2010, for example. A key question related to fiscal adjustment is therefore, how the cost of consolidation is distributed. Although the effectiveness of fiscal programs, both stimulus and consolidation, is widely explored in existing work, the distributional impact of fiscal policy is

[1] The fiscal stimulus programmes were as large as 5.9 per cent of GDP in the US, 3.3 per cent on average in OECD and 4.8 per cent in China in 2008 among many others (see for example OECD; 2009).

largely ignored.[2] This is somewhat surprising given the clear distributional implications of fiscal austerity, as is evident from the recent policy discussions.

It is also widely acknowledged that austerity programs that are viewed as 'unfair' are unlikely to succeed (see, for example, IMF; 2012b). Agnello et al. (2012) and IMF (2012b) present empirical evidence suggesting that periods of fiscal consolidation are associated with increases in income inequality. Moreover, Granados (2005) find that the composition of consolidations play a key role on their consequences for income inequality. Indeed, Woo et al. (2013) show that spending-based consolidations tend to worsen inequality more significantly, as compared with tax-based consolidations.

This chapter explores both the aggregate and distributional impact of fiscal austerity by utilizing a dynamic stochastic general equilibrium model with real and nominal frictions. To that end, our framework incorporates heterogeneity of agents regarding access to credit into a medium scale New Keynesian DSGE model. Ricardian consumers own the entire capital stock of the economy and possess access to the financial markets, that are assumed to be complete. Non-Ricardian households, on the other hand, simply consume their total disposable income arising from labour and transfers. Firms produce differentiated goods, choose labour and capital inputs and set prices similar to the method proposed by Calvo (1983). The monetary authority sets the nominal interest rate according to a Taylor rule. The fiscal authority has a set of policy instruments at its disposal with which to respond to the cyclical changes in debt.

This chapter makes two distinct contributions. The first is to combine a comprehensive examination of the distributive consequences of fiscal austerity, which has received very little attention in the existing literature, with one which focuses on other macroeconomic outcomes. Our distributional analysis has two dimensions: welfare and income distribution. We examine the normative implications of different fiscal packages for both types of households, and as such shed light on the ranking of policies based on the relative well-being of different groups. We also examine the changes in the relative incomes of the two types of agents, which allows us to relate our results to the existing empirical findings on the income distribution implications of fiscal consolidations. Our second contribution lies in the scope of our fiscal policy analysis; we examine a much richer set of fiscal instruments than has been provided in the existing literature on fiscal consolidations.[3] In addition to public consumption, public investment, income and lump-sum taxes that are widely explored in previous work, we incorporate capital

[2]Due to the the sharp contraction in global economic activity since 2008, recent work has primarily focussed on the output implications of theoretical fiscal policy and thus on the size of fiscal multipliers identifying a wide range of values: varying from 1.6 (Romer and Bernstein; 2009) to much smaller figures that are close to zero (Cogan et al.; 2010).

[3]One exception is Coenen et al. (2013) who extend the ECB's New Area-Wide Model to include a wide variety of fiscal instruments.

taxes, consumption taxes, social security contributions as well as public employment as sources of fiscal adjustment packages. Our choice of this particular set of fiscal instruments is motivated by the actual composition of both the fiscal stimulus and fiscal consolidation packages since 2009.

Our findings can be summarized as follows. First, we find that both the cumulative aggregate and the distributional consequences of fiscal austerity are determined by its composition much more than its speed. Specifically, we show that the greater the share of tax-based adjustments, the greater the size of resulting output contraction. Second, the welfare consequences of fiscal consolidations are unevenly distributed among agents with more detrimental impacts on credit-constrained households than those with full access to credit markets. As opposed to its output effects, tax-based austerity leads to more favourable distributional consequences in the form of less skewed welfare and income outcomes. In contrast, spending-based fiscal adjustment tends to worsen income inequality. We also explore the implications of the zero lower bound on the welfare consequences of fiscal consolidations. We find that, in spite of their well-known favourable impact on the effectiveness of fiscal policy, the presence of the zero lower bound doesn't alter the welfare ranking of credit-constrained versus unconstrained consumers following fiscal austerity. However, we also show that the composition of consolidations gains more importance at the monetary lower bound. Overall, a trade-off emerges between normative equity and positive efficiency effects of fiscal consolidations; spending cuts increase inequality while tax increases generate greater aggregate fluctuations, posing a serious challenge for policymakers in designing appropriate fiscal adjustment programs.

The rest of the chapter is organised as follows. Section 5.2 sets out the benchmark model. Both the positive and the distributive consequences of fiscal austerity are explored in Section 5.3. An analysis of international consolidation packages and an extension to the monetary zero lower bound are presented in Section 5.4. Finally, Section 5.5 provides conclusions and policy implications.

5.2 The model

Our benchmark model shares many features with Smets and Wouters (2003), Christiano et al. (2005) and Bhattarai and Trzeciakiewicz (2012) featuring nominal rigidities in price and wage setting, real frictions in adjustment costs and monopolistic competition, and distortionary taxation on labour, capital and consumption. The economy is populated by: a continuum of households indexed by h, a share of which, $(1-\theta)$, have access to capital markets (Ricardian households) and the remainder, θ, do not (non-Ricardian households); two types of firms producing final and intermediate goods respectively; and a fiscal and a monetary authority.

The model is also similar to that presented in Chapter 2 of which this can be seen as an extended version. For clarity, all features of the model are discussed here instead of referring the reader back to specific elements in Chapter 2 on a piecemeal basis. The notation of variables and parameters between the two chapters is not consistent: this is in order to keep the notation in line with versions of the papers in circulation.

5.2.1 Households

Utility for both types of household is assumed to be the same and evolves according to:

$$E_0 \sum_{t=0}^{\infty} \varepsilon_t^b \left(\beta^i\right)^t \left(\ln\left(C_t^i(h)\right) - \frac{1}{1+\sigma_l}\left(L_t^i(h)\right)^{1+\sigma_l}\right) \tag{5.1}$$

where E_0 is the expectation operator, $\beta^i \in (0,1)$ is the discount factor, σ_l denotes the inverse of the Frisch labour supply elasticity, C_t and L_t denote consumption and labour respectively, and ε_t^b represents a first-order autoregressive exogenous shock process to preferences. Superscript i differentiates variables between Ricardian ($i = R$) and non-Ricardian ($i = NR$) households.

Ricardian households

Each period Ricardian household, h, faces a budget constraint which states that the household's total expenditure on consumption, C_t^R, investment in physical capital, I_t, and accumulation of a portfolio of riskless one-period contingent claims, B_t, must equal the household's total disposable income:

$$\begin{aligned}
(1+\tau_t^c)\, C_t^R(h) + I_t(h) \quad = \quad & \left(1-\tau_t^l-\tau_t^{ee}\right) w_t\,(h)\, L_t^R\,(h) + div_t\,(h) \\
& + \left[\left(1-\tau_t^k\right) r_{k,t} u_t\,(h) - a(u_t\,(h))\right] \bar{K}_{t-1}\,(h) \\
& + \frac{(1+i_{t-1})B_{t-1}(h)}{\pi_t} + T_t\,(h) - B_t(h)\,(1+\eta_{B,t})
\end{aligned} \tag{5.2}$$

where τ_t^c, τ_t^l and τ_t^{ee} represent taxes on consumption, labour income and employee social security contributions, and w_t the real wage; div_t represents dividends paid out of firms' profits; τ_t^k is a tax on capital, $r_{k,t}$ the real return on capital services, u_t the capital utilisation rate where the cost of capital utilization is given by $a(u_t)\bar{K}_{t-1}$, and $\bar{K}_{t-1}$ the stock of physical capital; i_{t-1} represents the net nominal interest rate on one-period bonds, π_t the gross inflation rate, and the gross nominal interest rate is given by $R_t = 1 + i_t$; T_t represents a lump sum transfer; finally, $\eta_{B,t}$ represents an exogenous shock to government borrowing, discussed more fully in Section 5.2.4. Following Christiano et al. (2005), we assume complete markets for the state contingent claims in consumption and capital but not in labour, which implies that consumption and capital holdings are the same across Ricardian households: consequently, $C_t^R(h) = C_t^R$ and $K_t^R(h) = K_t$.

In line with most of the existing literature, we maintain that physical capital accumulates in accordance with:

$$\bar{K}_t = (1-\delta_k)\bar{K}_{t-1} + \left[1 - S\left(\varepsilon_t^i \frac{I_t}{I_{t-1}}\right)\right] I_t \tag{5.3}$$

where we follow Schmitt-Grohe and Uribe (2006) and define the cost of investment adjustment function as $S\left(I_t/I_{t-1}\right) = \left[(\phi_k/2)(I_t/I_{t-1} - 1)^2\right]$ and ε_t^i is an investment specific first-order autoregressive shock process.[4] Each Ricardian household maximises utility (5.1) subject to the flow budget constraint (5.3), the capital accumulation function (5.3), and the labour demand from companies (discussed below). The first-order conditions as a result of this maximisation are presented in Appendix D.1.

Non-Ricardian households

As discussed above, non-Ricardian households are credit-constrained agents who simply consume current after-tax income which comprises of after-tax labour income and transfers. As discussed in Chapter 2, this behaviour can be rationalised in a framework where non-Ricardian households are more impatient than Ricardian households, $\beta^R > \beta^{NR}$, and can default on their debt up to the value of their collateral (see for example Iacoviello; 2005). With no durable goods in the non-Ricardian utility function, impatience prohibits the accumulation of collateral and as such non-Ricardians are prohibited from engaging in bond and capital markets.[5] The budget constraint of non-Ricardian households is therefore:

[4]Where $S(1) = S'(1) = 0$, and $S''(1) = \phi_k > 0$ are assumed for the adjustment cost function process.

[5]For a full discussion of the empirical observation of this type of consumption behaviour see Section 2.2.1.

$$\left(1+\tau_t^c\right) C_t^{NR} = \left(1-\tau_t^l-\tau_t^{ee}\right) w_t L_t^{NR} + T_t$$

Following Erceg et al. (2006) we assume that each non-Ricardian household sets its wage equal to the average wage of optimising households (discussed below). Given that all households face the same labour demand, the labour supply and total labour income of each Ricardian and non-Ricardian households will be the same: by extension, consumption for all rule-of-thumb agents will also be the same, $C_t^{NR}(h) = C_t^{NR}$.

5.2.2 Wage-setting behaviour

Households provide differentiated labour inputs $(L_t(h))$ to firms and therefore can act as price setters. Firms subsequently aggregate these labour inputs using a Dixit-Stiglitz function:

$$L_t = \left[\int_0^1 \left(L_t(h)\right)^{\frac{\nu-1}{\nu}} dh\right]^{\frac{\nu}{\nu-1}}$$

where $\nu > 0$ is the elasticity of substitution among the differentiated labour inputs and L_t the aggregate labour index. This leads to demand functions for each household labour given by:

$$L_t(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\nu} L_t$$

where $W_t(h)$ is the corresponding nominal wage rate for household h. This leads to an aggregate wage index given by:

$$W_t = \left[\int_0^1 \left(W_t(h)\right)^{1-\nu} di\right]^{\frac{1}{1-\nu}}$$

Nominal wages are set in a staggered-price mechanism as in Calvo (1983), where every period, each Ricardian household faces a fixed probability $(1-\varpi_W)$ of being able to adjust the nominal wage. The household then sets nominal wages to maximize expected future utility subject to labour demand from firms. Those who cannot reoptimize set wages in accordance with the indexation rule, $W_t = \pi_t^{\gamma_w} W_{t-1}$, where $\gamma_w \in \langle 0, 1\rangle$ is a parameter that measures the degree of wage indexation. The objective is to maximise the following with respect to $\tilde{W}_t$ (the wage rate for those permitted to reset):

$$E_t \sum_{l=0}^{\infty} \left(\beta^R \varpi_w\right)^l \left\{ \begin{array}{c} -\frac{1}{1+\sigma_L} \left(\left(\frac{\tilde{W}_t X_{tl}}{W_{t+l}} \right)^{-\nu} L_{t+l} \right)^{1+\sigma_L} \\ +\lambda_{t+l}^{\tau} \left(1-\tau_{t+l}^{l}\right) \frac{\tilde{W}_t}{P_{t+l}} X_{t,l} \left(\frac{\tilde{W}_t X_{tl}}{W_{t+l}} \right)^{-\nu} L_{t+l} \end{array} \right\}$$

where $X_{tl} = \pi_t \times \pi_{t+1} \times ... \times \pi_{t+l-1}$ for $l \geqslant 1$ and $X_{tl} = 1$ for $l = 0$ as in Altig et al. (2011). The maximisation results in:

$$E_t \sum_{l=0}^{\infty} \left(\beta^R \varpi_w\right)^l L_{t+l}^{\tau} \lambda_{t+l} \left\{ \frac{\tilde{W}_t X_{tl}}{P_{t+l}} \frac{U_{c,t+l}}{\left(1+\tau_{t+l}^{c}\right)} - \frac{\nu}{(1-\nu)} \frac{U_{l,t+l}}{\left(1-\tau_{t+l}^{l}\right)} \right\} = 0$$

The first-order condition implies that Ricardian households set their wages so that the present value of the marginal utility of income from an additional unit of labour is equal to the markup over the present value of the marginal disutility of work. When all households are able to negotiate their wage contracts each period, the prevailing wage is $\tilde{W}_t / P_t = (\nu / (1-\nu)) \left(U_{l,t} \left(1+\tau_t^c\right) / U_{c,t} \left(1-\tau_t^l\right)\right)$.[6] Finally, the wage index can be transformed into the following:

$$W_t = \left[(1-\varpi_w) \tilde{W}_t^{1-\nu} + \varpi_w \left(\left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{t-1} \right)^{1-\nu} \right]^{\frac{1}{1-\nu}}$$

Non-Ricardian agents are assumed to take on the same aggregate contract negotiated by Ricardian agents, working the aggregate amount of labour hours (L_t) at the aggregate wage rate (W_t).

5.2.3 Production

A competitive final good producer purchases differentiated goods from intermediate producers and combines them into a single consumption good. The final good, Y_t^P, is produced by aggregating the intermediate goods, $Y_{j,t}^P$, with technology:

$$Y_t^P = \left[\int_0^1 \left(Y_{j,t}^P\right)^{\frac{s-1}{s}} dj \right]^{\frac{s}{s-1}}$$

Profit in the final good sector, Π_t^F, can be stated as:

$$\Pi_t^F = P_t Y_t^P - \int_0^1 P_{j,t} Y_{j,t}^P dj$$

where $P_{j,t}$ is the price of the intermediate good j.

[6]Where $U_x = \partial U / \partial X$.

The intermediate good production sector is populated by monopolistic firms indexed by j that use the following production function:

$$Y_{j,t}^{P}=\varepsilon_{t}^{a}\left(K_{j,t-1}\right)^{\alpha}\left(L_{j,t}^{P}\right)^{1-\alpha}\left(K_{j,t-1}^{G}\right)^{\alpha_{G}}-\Phi \tag{5.4}$$

where K_G denotes public capital, Φ represents a fixed cost of production, and ε_t^a represents total factor productivity shock that follows a first-order autoregressive process. Firms rent capital services $K_{j,t-1}$, and incur a cost of labour equal to $(1+\tau_t^{er})\,W_t$, where τ_t^{er} denotes employers social security contributions. As is standard in the New Keynesian framework, intermediate-good sector firms face three constraints: the production function, a demand constraint, and price rigidity determined by a Calvo (1983) mechanism. Each firm acts to minimise its total costs, $(1+\tau_t^{er})W_tL_{j,t}^P+R_{k,t}K_{j,t-1}$, subject to the production function (5.4). The nominal marginal cost is represented by the following:

$$P_tmc_t=\left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\left(\varepsilon_t^A\right)^{-1}K_{g,t-1}^{-\alpha_g}\left(\left(1+\tau_t^{er}\right)W_t\right)^{1-\alpha}\left(R_{k,t}\right)^{\alpha}$$

Intermediate goods producers act as price setters where each period a given firm faces a constant probability, $(1-\varpi)$, of being able to reoptimise its nominal price. Those who can, maximize expected future profits at these prices ($\widetilde{P}_t$):

$$E_t\sum_{l=0}^{\infty}(\beta^R\varpi)^l\lambda_{t+l}\left[\frac{\widetilde{P}_tX_{tl}}{P_{t+l}}-mc_{t+l}\right]P_{t+l}Y_{j,t+l}-P_{t+l}mc_{t+l}fc$$

subject to the standard demand ($Y_{j,t}=(P_{j,t}/P_t)^sY_t$) and maximisation results in:

$$E_t\sum_{l=0}^{\infty}(\beta^R\varpi)^l\lambda_{t+l}\left[\frac{\widetilde{P}_tX_{tl}}{P_{t+l}}-\frac{s}{1-s}mc_{t+l}\right]P_{t+l}Y_{j,t+l}=0$$

In the case that all firms are allowed to reoptimise their prices, the above condition reduces to, $\widetilde{P}_t=(s/(s-1))P_tmc_t$, which indicates that the optimised price is equal to a markup over the marginal costs. In addition, $(\beta^R\varpi)^l\lambda_{t+l}$ denotes a discount factor of future profits for firms. Here λ_t denotes the Lagrange multiplier on the Ricardian household's budget constraint and is treated by firms as exogenous. The price index can be written as:

$$P_t=\left[(1-\varpi)\,\widetilde{P}_t^{1-s}+\varpi\left(\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_p}P_{t-1}\right)^{1-s}\right]^{\frac{1}{1-s}}$$

5.2.4 Macroeconomic policy

The government budget constraint requires that total expenditure on government consumption, G_t, public investment, I_t^G, and public employment, L_t^G, be paid through either taxes or transactions in the bond market:

$$\begin{aligned} G_t + I_t^G + (1+\tau_t^{er})\, w_t L_t^G + T_t &= \left(B_t(1+\eta_{B,t}) - \frac{(1+i_{t-1})B_{t-1}}{\pi_t} \right) + \tau_t^c C_t \\ &\quad + \left(\tau_t^l + \tau_t^{ee} + \tau_t^{er} \right) w_t L_t + \tau_t^k r_{k,t} u_t K_{t-1} \end{aligned}$$

where $\eta_{B,t}$ represents an i.i.d. exogenous shock to government borrowing, which can either represent a change in spending, tax revenue, or borrowing conditions, exogenous to the model. This, for example, could take the form of an exogenous rise in outgoings (e.g. a bank bail out), or a revenue windfall. Public capital accumulates according to:

$$K_t^G = (1-\delta_k^G)K_{t-1}^G + I_t^G$$

which is equivalent to the accumulation of private capital in (5.3) but without cost to adjustment (as is common in the literature) and where δ_k^G represents depreciation specific to public capital.

We maintain that the nine fiscal instruments in steady state ensure a non-increasing level of debt, and out of steady state these instruments respond to maintain the solvency condition of the government:[7]

$$\frac{X_t}{X} = \left(\frac{B_{t-1}}{B} \right)^{\phi_{B,x}} \tag{5.5}$$

where $X = \left\{ \tau^c, \tau^k, \tau^l, \tau^{er}, \tau^{ee}, G, I^G, L^G, T \right\}$, where variables with no time subscript represent their steady state values, and where $\phi_{B,x}$ represents the 'debt aversion' parameters.

The design fiscal rules as in (5.5) is used to ensure that debt converges back to its steady state level, and is assumed (at least in our experiments) to play no other role; fiscal instruments neither respond to the business cycle (as in Chapter 4), nor respond to their own exogenous shock movements (as in Chapter 6). When debt is moved away

[7]Note that labour income taxes and employees social security contributions enter the model in the same way, hence we drop the latter in our simulations and focus on the former.

from its steady state value, the calibration of $\phi_{B,x}$ ensures that debt converges back either through taxes rises and/or through cuts in expenditure. Steady state debt is not moving, by definition, and is determined by the excess of spending over tax revenues.

Note that these experiments also incorporate an approximation of the scenario where steady state government debt levels are permanently raised. This occurs when the $\phi_{B,x}$ parameters are set to *just* ensure determinacy, such that debt converges back to steady state, but at a slow rate; given the discounting of the future, the welfare effects under this policy, with debt taking decades to converge back to steady state levels, is a close approximation to a permanent debt increase. In the steady state, as Ricardian households own government debt, any increase in this increases their income. Simultaneously, tax rises and/or spending cuts will be required in order to service the additional interest requirements. The net impact of these two effects will provide the impact of a debt increase to Ricardian households, whereas the latter impact is only relevant for non-Ricardian agents who, by assumption, do not own government debt due to impatience.

As standard in the literature, the monetary authority sets nominal interest rates (R_t) by following a Taylor rule which responds to both output and inflation with some persistence:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_y}\right]^{1-\rho} \eta_{R,t}$$

where ρ is the interest rate smoothing parameter and $\eta_{R,t}$ represents an i.i.d. shock to the nominal interest rate: all other variables are as defined earlier.

5.2.5 Market clearing, aggregation and equilibrium conditions

Total output is the sum of private and public sector output where the equilibrium conditions are given by:

$$Y_t = C_t + G_t + I_t + I_t^G + a(u_t)\bar{K}_{t-1} + (1 + \tau_t^{er})\, w_t L_t^G$$

$$L_t = L_t^P + L_t^G$$

where C_t and L_t denote aggregate consumption and employment which are given by the weighted averages of the consumption and employment of Ricardian and non-Ricardian households. Similarly, the market for capital and bonds are in equilibrium when demand equals supply.[8]

5.3 Implications of fiscal austerity

To explore the aggregate and the distributional consequences of fiscal consolidation, we consider a situation where there is a positive shock to government debt ($\eta_{B,t}$) such that debt is exogenously accumulated.[9] We then examine a number of fiscal scenarios corresponding to different fiscal adjustment packages designed towards paying off the additional debt created by this positive debt shock. The reason for making debt repayment as the basis of our fiscal scenarios is the observation that stabilizing debt to GDP ratios has been an important objective of most fiscal consolidation packages since 2010.

Our fiscal consolidation scenarios vary across two dimensions: the composition of fiscal adjustment and the speed of debt repayment. Regarding the composition, we consider two alternative sets of policies. In the first, the burden of debt repayment is shared equally among all fiscal instruments. This takes the form of reductions in all expenditure items (public consumption, public investment, public employment and transfers) and increases in all tax instruments (consumption taxes, capital taxes, labour income taxes and employer social security contributions): in what follows, we refer to this policy as 'all-instruments' fiscal consolidation. Second, we examine fiscal adjustment through either only cutting expenditure or only raising taxes. Regarding the speed of adjustment, for all fiscal scenarios we consider the impact of austerity over a range speeds associated with each consolidation, controlled for by the 'debt aversion' parameters ($\phi_{B,x}$).[10]

5.3.1 Calibration and welfare calculation

We follow a calibration procedure in line with the existing literature with common parameters fixed in a standard way, as is listed in Table 10. Steady state tax rates

[8]The non-stochastic steady state of the model is solved, and the perturbation method in Dynare is used to apply a second-order approximation of the model. Stochastic simulations are also computed using Dynare.

[9]If we were to employ any of the microfounded shock processes to generate debt in the economy, the results would be similar to those from shocking $\eta_{B,t}$, once we removed the effects of the initial shock and only concentrated on repaying the debt.

[10]In order to quantify this speed we present the 'half-life' of consolidation which represents the time (in quarters) for the packages to halve the level of new debt as a result of the shock.

on consumption, capital, labour income and employee and employer social security contributions (τ^c, τ^k, τ^l, τ^{ee} and τ^{er}) are set at 0.2, 0.4, 0.18, 0.05 and 0.07 respectively and the level of government debt in steady state is set at 60 per cent of output. We select a lower value of the depreciation of public capital compared to private capital with $\delta_k^G = 0.02$, and we fix the share of public employment in total employment at 0.15. The elasticity of public capital in the production function, σ_G, is set at 0.02 which is slightly higher than the value calibrated by Straub and Tchakarov (2007) for the US and the euro area. We fix the share of public investment in GDP at 0.02, whereas the share of public consumption at 0.1. This calibration implies the ratio of private investment to GDP is 0.11 whereas private consumption to GDP is 0.65. Finally, the share of non-Ricardian consumers is set equal to 0.3, in line with those in the existing literature.

Our welfare calculations are performed by deriving a welfare criterion based on a second order Taylor series expansion of the utility function around the non-stochastic steady state values. This procedure provides a criterion expressed as the equivalent one period consumption loss, as a proportion of steady state consumption, that leaves the agent indifferent between living through the shock or the one period consumption loss. The resulting expression for welfare is of the following form (derived in Appendix D.2):

$$\begin{aligned} W^i &= E_0 \sum_{t=0}^{\infty} \beta^{i,t} \left(c_t^i + \frac{1-\sigma_c}{2} \left(c_t^i\right)^2 \right) \\ &\quad - \frac{1-\alpha}{1+\tau^{er}} \frac{1}{\mu^w} \frac{1-\tau^l-\tau^{ee}}{1+\tau^c} \frac{Y}{C^i} E_0 \sum_{t=0}^{\infty} \beta^{i,t} \left(n_t^i + \frac{1+\sigma_l}{2} \left(n_t^i\right)^2 \right) \end{aligned} \tag{5.6}$$

where i denotes the type of consumer. In (5.6) lowercase variables represent log-deviations of their uppercase counterparts and $\mu^w = \nu/(\nu-1)$. This criterion provides disaggregate calculations for each set of households in the economy.

5.3.2 Fiscal adjustment and macroeconomic outcomes

Figure 9 illustrates the economy's response to a 3 per cent rise in the debt-to-GDP ratio where all fiscal instruments contribute equally towards the resulting debt repayment.[11] Consolidations have a negative effect on output, arising from both lower private demand (due to lower incomes and higher taxes) and lower government demand (as part of the austerity package). The magnitude of the fall in output as well as the profile of recovery

[11] This size of debt shock is in line with the scale of fiscal stimulus packages put in place in 2009: the OECD average stood at 3.3 per cent of GDP.

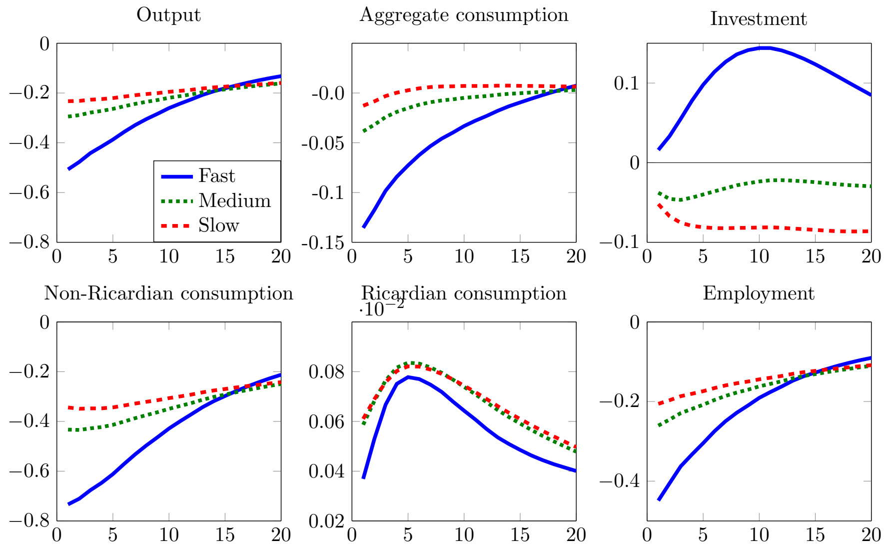
Table 10: Chapter 5 calibration

Share/parameter	Description	Value
Expenditure shares		
C/Y	Private consumption to GDP	0.65
G/Y	Public consumption to GDP	0.1
I/Y	Private investment to GDP	0.11
I^G/Y	Public investment to GDP	0.02
Preferences		
β^R	Discount factor Ricardian	0.99
β^{NR}	Discount factor non-Ricardian	0.973
σ_l	Inverse Frisch elasticity	2
θ	Share of non-Ricardian households	0.3
Technology		
δ_k	Depreciation rate: private capital	0.025
δ_k^G	Depreciation rate: public capital	0.02
α	Share of capital in production	0.31
ϕ_k	Investment adjustment cost parameter	5
κ	Capital utilisation adjustment parameter	0.6
ϖ	Stickiness in prices	0.75
ϖ_W	Stickiness in wages	0.5
γ_p	Price indexation	0.15
γ_w	Wage indexation	0.15
s	Elasticity of substitution in consumption	6
ν	Elasticity of substitution in labour	6
Φ	Fixed costs in production	0.15
Monetary policy		
ρ	Monetary policy persistence	0.8
ρ_π	Inflation Taylor rule weight	1.5
ρ_y	Output Taylor rule weight	0.125
Fiscal policy		
τ^c	Steady state consumption tax	0.2
τ^k	Steady state capital tax	0.4
τ^l	Steady state labour income tax	0.18
τ^{ee}	Steady state employee social security tax	0.05
τ^{er}	Steady state employer social security tax	0.07
B/Y	Government debt to annual GDP	0.6
α_G	Elasticity of public capital in production	0.02
wL^G/Y	Share of public to total employment	0.15

vary with the speed of adjustment; both output and employment are initially lowest with the fastest fiscal adjustment. However, although short sharp episodes have the biggest initial impact on GDP in the short run, they also result in a quicker convergence of output to steady state levels.

Consolidations also reduce aggregate consumption, but by less than output since the cuts in government spending elicit some crowding in of both consumption and investment. This small reduction in aggregate consumption, however, hides a disparity across

FIGURE 9: Dynamics from austerity experiments - all instruments



Dynamics are achieved through shocking debt by 3% of its steady state level: the x-axis represents time in quarters, and the y-axis represents percentage deviations from steady state. Half-life of debt represents the time for debt to be reduced by 50%; under 'Fast' this is 10 quarters, 'Medium' 20 quarters, and 'Slow' 40 quarters.

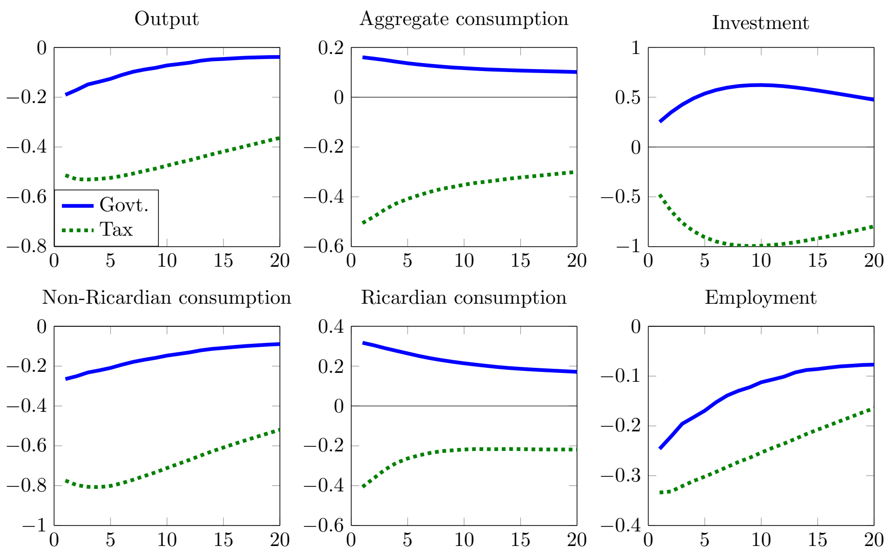
households where non-Ricardian consumption falls and Ricardian consumption rises. This is because Ricardian agents can smooth their consumption whereas non-Ricardian households are fully exposed to the fall in labour demand and, thus, in wages. Moreover, lower interest rates and lower government spending further contribute to increasing Ricardian consumption.

Figure 9 also portrays an interesting investment profile. There are two channels through which fiscal adjustment impacts on investment: through its effect on interest rates and through its effect on the return on capital (net of capital taxes). A fiscal consolidation leads to a fall in interest rates leading to a rise in interest-sensitive investment. On the other hand, fiscal adjustment also raises capital taxes leading to a fall in the net return to capital, reducing incentives to invest. The higher the pace of consolidation, the greater the likelihood of the first effect dominating the second, due to the fact that the faster the pace of fiscal adjustment, the sharper the response of the monetary authority.

The composition of adjustment We now turn to an analysis of spending versus tax-based fiscal adjustments where the outstanding debt is repaid only through reducing government spending in the former and only through tax increases in the latter.

Macroeconomic outcomes under the two types of consolidation programs are displayed in Figure 10.

FIGURE 10: Dynamics from austerity experiments - government spending instruments versus tax instruments



Dynamics are achieved through shocking debt by 3% of its steady state level: the x-axis represents time in quarters, and the y-axis represents percentage deviations from steady state. For both experiments the half-life of debt is calibrated to 20 quarters.

It is clear that tax-based consolidations lead to sharper responses compared with spending-based ones in all variables, with the greatest fall in non-Ricardian consumption. Two other features are evident from Figure 10. First, Ricardian consumption rises in the wake of spending-based consolidations in contrast to tax-based austerity where the opposite is the case. This is due to the crowding in of Ricardian consumption in response to a cut in government spending, which in turn drives the movement in aggregate consumption. Second, private investment also rises following spending cuts, as opposed to following tax increases. This is because tax-based consolidations raise the marginal cost of production through increases in both capital and labour taxes, while spending cuts bring about lower real interest rates.

Overall, tax-based fiscal adjustment produces lower output (combining both lower consumption and lower investment) and lower employment than spending-based adjustment programs. Existing empirical work on fiscal adjustment programs indicates that this has indeed been the profile of the macroeconomic responses to fiscal adjustment programs in practice (see for example Agnello et al.; 2012; IMF; 2012b; Woo et al.; 2013).

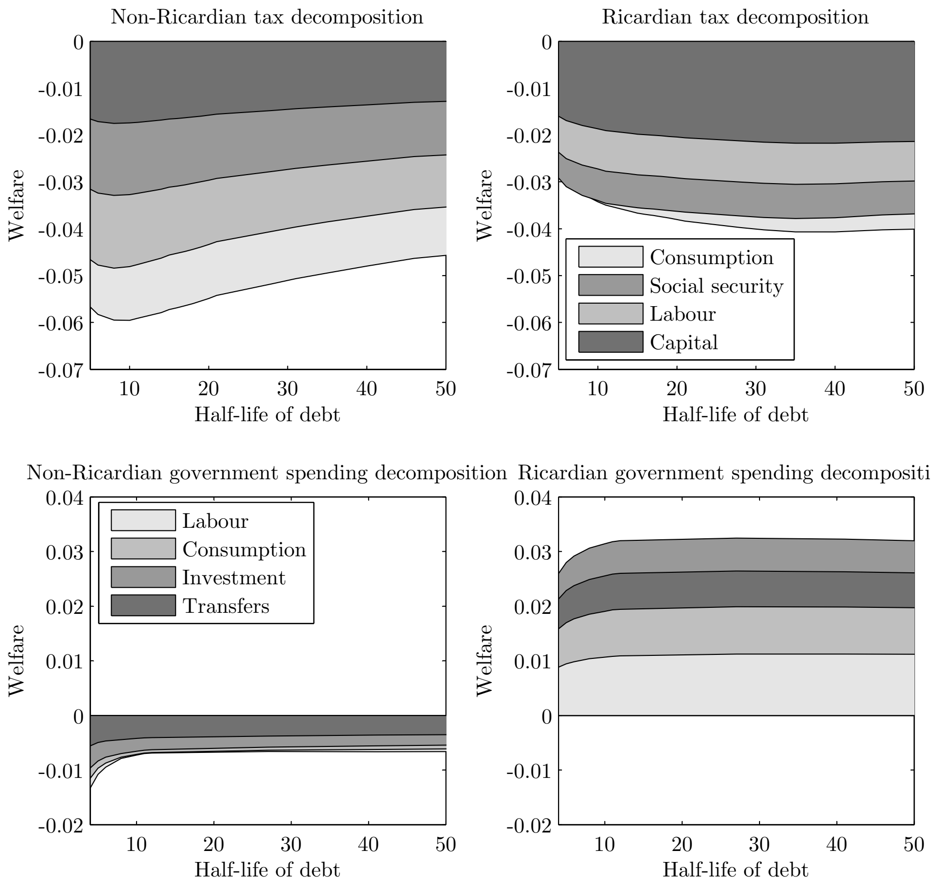
5.3.3 Fiscal austerity and welfare

We now turn to the welfare implications of fiscal consolidations. Figure 11 plots the welfare of the two types of households against the speed of fiscal adjustment for the two consolidation packages, focusing on just tax and just spending instruments, respectively. In Figure 11, the bottom line represents the aggregate impact where shaded areas represent the composition of this aggregate in individual fiscal instruments that are components of the fiscal package in each case. As is seen from the first column in Figure 11, austerity reduces non-Ricardian welfare in all cases and the scale of this reduction is greater the quicker the speed of consolidation. This is due to the fact that non-Ricardian agents are exposed to austerity through their dependence on the overall health of the economy through wages and employment, both of which decline in response to austerity. Moreover, higher labour and consumption taxes and lower transfers (under the tax-based fiscal adjustments) decrease the disposable income and subsequently the consumption of the credit-constrained agents.

As is also seen from the bottom right pane of Figure 11, in contrast, spending-based consolidations result in Ricardian consumers being better off, irrespective of the speed of adjustment, due to both higher levels of consumption and lower levels of employment. Consumption is improved following the reductions in interest rates and government spending. Households in the model are assumed not to gain utility from government consumption and public employment and reductions of these, from the perspective of Ricardian agents, leads to welfare improvements as they can crowd in private consumption and investment. Both consumers are worse off under tax-based consolidations, though Ricardian welfare dominates that of non-Ricardians unless debt is repaid over long time horizons. Ricardian agents do not directly respond to movements in transfers and are therefore less affected by cuts in these than their non-Ricardian neighbours. Overall, the welfare consequences are unevenly shared by the two types of agents; austerity tends to harm non-Ricardian households more than the Ricardian households.

An interesting question related to the welfare implications of spending and tax-based austerity is whether the welfare outcomes vary significantly between adjustments based on individual instruments. Figure 11 also presents a decomposition of total welfare implications of austerity, highlighting the contribution made by each fiscal instrument. The worst case scenario for both households is fiscal adjustment by increases in capital taxes, resulting in the lowest welfare for each household as it both reduces incomes in the short run, and impacts on the productive capacity of the economy over the medium term. However, it must also be noted that rises in capital taxes exert a bigger impact on Ricardian households who directly pay this tax. For similar reasons, increases in labour taxes have large negative normative consequences for non-Ricardian households

Figure 11: Welfare effects of fiscal austerity



Welfare results are expressed as the equivalent of one-period steady state consumption that would leave the agent indifferent between living through the shock or forgoing the one period loss. The bottom line represents the aggregate impact where shaded areas represent the decomposition of this aggregate into component fiscal instruments. The top row represents welfare from just using tax instruments and the bottom row just from spending instruments; the left column depicts results for non-Ricardian households and the right column for Ricardian households.

for whom a rise directly reduces disposable income. In contrast, austerity through cuts in government consumption and government employment produces the two best welfare outcomes. Figure 11 once again confirms that austerity always harms the constrained households while the unconstrained are either better off (under spending-based adjustment) or less worse off than the constrained households (under the tax-based adjustment).[12]

[12]Note that Figure 11 also demonstrates the approximate effect of a permanent increase in government debt as the welfare effects are plateauing as the halflife of debt increases. In the case of non-Ricardian agents, a permanent increase in debt has a negative effect on long run welfare, however, this is minimised if the additional debt interest is repaid through spending cuts. This is similar for Ricardian households, however these agents gain from a permanent increase in debt paid for through a cut in government spending, as it is these agents who own the government debt, and therefore the additional interest repayments of the government acts as additional income.

5.3.4 Fiscal austerity and income distribution

An important aspect of distributional outcomes arising from fiscal policy changes is related to their implications for income distribution. This is important for two reasons. First, as is widely recognized, income distribution plays a key role in political and economic stability and thus has a wider significance (see for example Alesina and Perotti; 1996). Second, income distribution outcomes are more easily measurable than welfare ones, which enables us to put our results in perspective in light of the existing empirical findings on the income distribution implications of fiscal adjustment programs.

Figure 12 presents discounted incomes of both households in the face of all three types of fiscal consolidation packages. The top row considers income movements over the whole lifetime of the experiment, whereas the bottom row considers a shorter five year horizon. Clearly, non-Ricardian income is most exposed to austerity, both in the short and long term, leading to a widening of inequality in the economy. The second and third columns of Figure 12 confirm the welfare results presented in Figure 11; spending-based consolidations tend to worsen income inequality more than tax based-ones, a finding supported by recent empirical evidence (see for example Woo et al.; 2013). However, it has also been shown that tax-based fiscal adjustments are less likely to be longer-lasting than those based on spending ones (see for example Alesina and Perotti; 1996). Our findings point to a source of such reduced longevity for tax based adjustment programs; they do not only reduce the welfare of both types of households, they also bring about greater aggregate fluctuations.

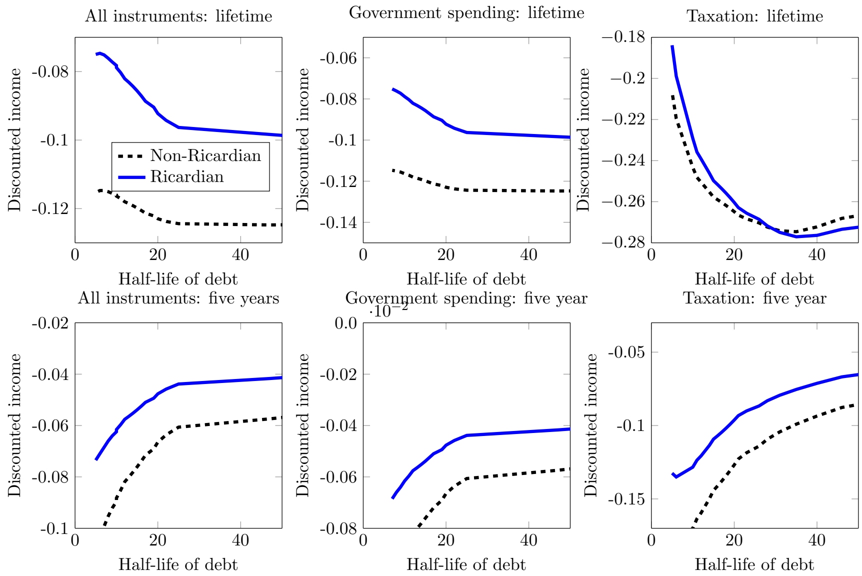
5.4 Further extensions

5.4.1 International consolidation packages

The above results consider the aggregate and distributional impact of fiscal consolidations in a range of benchmark calibrations. In order to obtain a direct perspective on the austerity measures implemented in recent times, we simulate our model using actual composition of fiscal packages based on international data (IMF; 2013, 2014), as summarised in Table 11.[13]

[13] Specifically, we obtain information on the size of fiscal adjustments between 2009 and 2013 from both revenue and expenditure measures from IMF Fiscal Monitor (2013: Figure 2) and combine this with data on individual spending measures (IMF; 2014, Figure 2.2) and tax measures (IMF; 2014, Table 9).

FIGURE 12: Income effects



Discounted income effects under consolidation packages using 'all instruments', just 'Government spending' instruments' and 'Taxation' instruments, calculated over the whole lifetime of the experiment (the top row), and over the first five years of the experiment (the bottom row): future periods are discounted by relative discount factors.

Comparing the debt to GDP ratios in 2007 to those in 2013 reveals that there were significant increases in indebtedness in most countries, where doubling of the debt ratio is observed in nearly half of the sample. The rise in debt ratios, in turn, required substantial fiscal adjustment, as large as 17.8 per cent of GDP in Greece, 7.6 per cent in Ireland and 7.4 per cent in Portugal. An interesting aspect of these consolidation packages has been the wide variation in their composition. Table 11 suggests that countries that have carried out substantial adjustment packages such as Greece, Ireland, Portugal and Spain carried out most of this adjustment through expenditure-based measures, compared against those with smaller consolidations (the most notable exception is Germany, who have adopted spending based austerity in order to finance tax cuts).

We employ the same empirical composition of consolidation packages currently in place in each country and impose the same 3 per cent shock to steady-state government debt as above over a variety of speeds of repayment. Figure 13 groups the countries into high consolidators (Greece, Ireland, Portugal and Spain), medium consolidators (UK, Netherlands and US), and low consolidators (France, Belgium, Austria and Germany) and presents predicted welfare movements, and Figure 14 presents the sum of discounted output (using β^R) from the model.

Table 11: International consolidation data

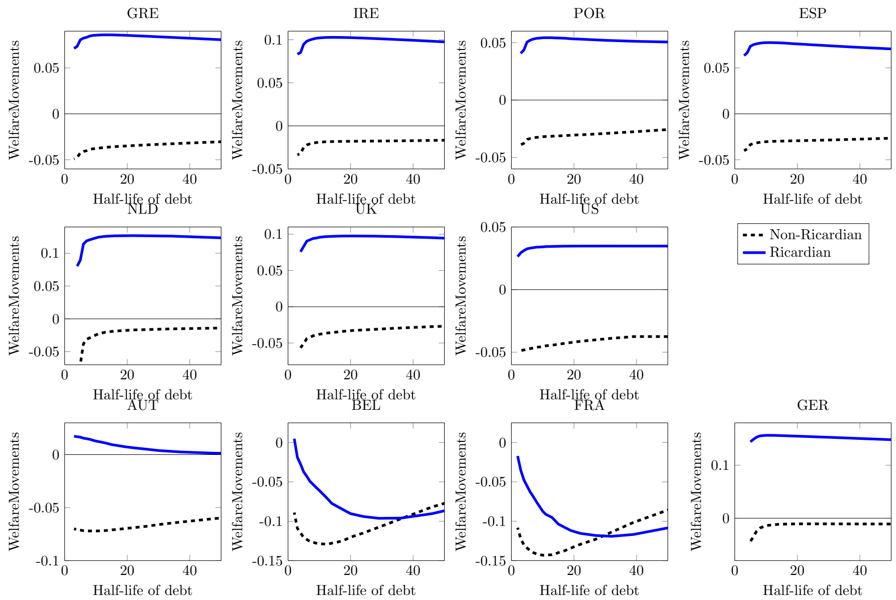
	Debt to GDP			Proportions	
	2007	2013	Consolidation	Revenue	Expenditure
GRC	95.6	173.8	17.8	26%	74%
IRL	24.9	122.8	7.6	9%	91%
PRT	63.6	128.8	7.4	48%	52%
ESP	36.1	93.9	6.9	38%	62%
GBR	44.1	90.1	6.2	40%	60%
NLD	45.5	74.9	4.6	49%	51%
USA	62.1	104.5	4.3	61%	39%
FRA	35.2	93.9	3.0	124%	-24%
BEL	82.8	99.7	2.2	135%	-35%
AUT	59.5	74.2	1.0	65%	35%
DEU	65.0	78.1	0.9	-81%	181%

'Consolidation' represents the sum of both revenue and expenditure based fiscal adjustments, expressed as the proportion of potential GDP on cyclically adjusted data (obtained from IMF fiscal monitor); and 'Revenue' and 'Expenditure' represent the individual proportions of this overall consolidation figure.

Figures 13 and 14 enables us to make a number of observations. First, the composition of consolidation is of far more importance to its positive results, compared with the speed of consolidation. In line with our earlier results, those policies which target government expenditure have the lowest impact on output, and as in the case of Germany, spending cuts to finance some tax cuts can have a beneficial impact to output. Similarly, Figure 13 reveals that the composition of consolidation is also of much more importance to its distributive outcomes than its speed; specifically, consolidations which focus on tax revenues as opposed to spending cuts have the most equitable normative effects, as is seen above, and is supported by cross-country simulated evidence. For example, in countries where fiscal adjustment is carried out mostly through expenditure related measures, as was the case in high consolidation countries (the top row), the outcome is the substantial gap in the welfare of the constrained and unconstrained households. This gap is clearly smaller in low consolidation countries such as Austria, Belgium, and France who mostly utilized tax-based instruments. France is the best example of this with the only consolidation package where non-Ricardian welfare can dominate Ricardian welfare (beyond 30 quarters for the half-life of debt).

Interestingly, the greatest gap between the welfare of the constrained and the unconstrained households is in Germany, who have enacted cuts to transfers, government consumption and government employment to pay for cuts in income taxes and social security contributions and increased public investment. Germany's composition also has a positive impact on output, the only one to do so.

FIGURE 13: International consolidation comparison: welfare effects



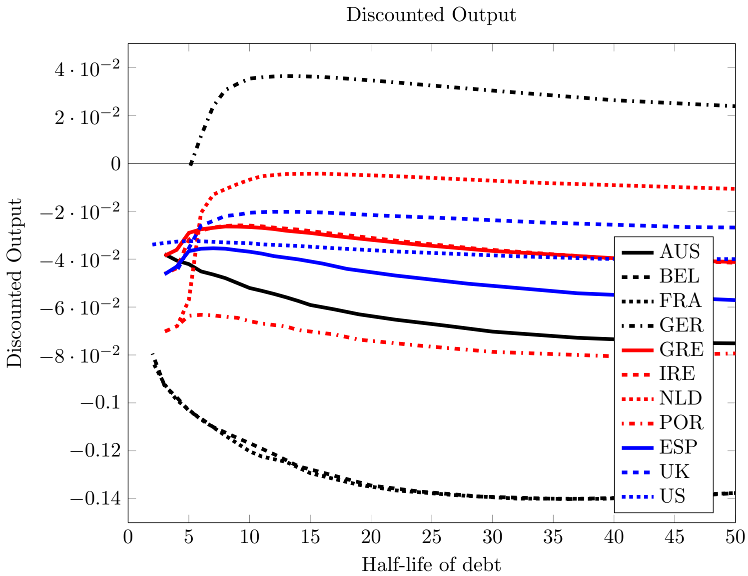
Results are obtained by utilizing IMF Fiscal Monitor data on the composition of current fiscal adjustment packages and assuming a similar composition for future consolidation, and through the same shock of 3% of steady state debt to aid comparisons. The calibration is as that of Table 10 but where the fiscal parameters are calibrated differently for the EU countries (where we use Coenen et al.; 2013), the UK (where we use Bhattarai and Trzeciakiewicz; 2012) and the US (where we use Leeper et al.; 2010).

Overall, the trade-off between equity and positive efficiency of fiscal adjustment programs found above is maintained. Whereas spending-based consolidations can lead to lower overall effects with respect to output, incomes and welfare, tax-based austerity is associated with more equality of sacrifice whereby all agents lose more, but do so together. Although non-Ricardian agents tend to lose less in absolute terms with spending based programmes than in tax-based ones, the relative welfare considerations carry great significance in practice. This is illustrated by the political consequences of austerity over recent years, especially in the high consolidation countries, those which rely more on cuts in spending; all three countries Greece, Spain and Portugal have witnessed greatest anti-austerity protests observed across Europe, following the adoption of fiscal consolidation.

5.4.2 Austerity at the zero lower bound

A key distinguishing feature of the recent recession, for which has received much academic attention, is that monetary policy has been operating at its lower bound where

FIGURE 14: International consolidation comparison: discounted output effects

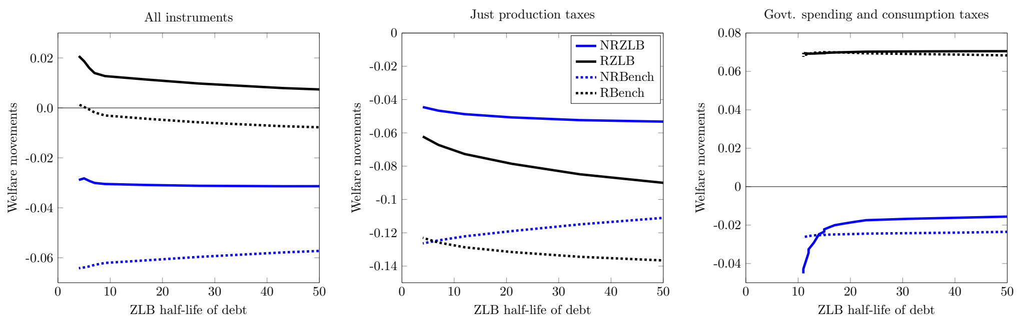


Results are obtained by utilizing IMF Fiscal Monitor data on the composition of current fiscal adjustment packages and assuming a similar composition for future consolidation, and through the same shock of 3% of steady state debt to aid comparisons. The calibration is as that of Table 10 but where the fiscal parameters are calibrated differently for the EU countries (where we use Coenen et al.; 2013), the UK (where we use Bhattarai and Trzeciakiewicz; 2012) and the US (where we use Leeper et al.; 2010).

nominal interest rates reach, or are close to, zero. Under such a scenario fiscal multipliers are shown to increase as the contractionary impact of higher interest rates associated with higher levels of output are removed: see, for example, Eggertsson (2011), Christiano et al. (2011) and Hall (2011). An interesting question is whether the presence of the zero lower bound has any impact on the welfare consequences of fiscal consolidation.

Figure 15 presents the welfare movements in three fiscal scenarios: where all fiscal instruments are used; when only the three production taxes (labour, capital and employer social security) are used; and when all government spending instruments are used, as well as consumption taxes. As is clear in Figure 15, the the monetary zero lower bound doesn't alter the welfare outcomes to a strong degree. However, at the monetary lower bound the composition of consolidation becomes more important: if austerity is executed through increases in production taxes, one can have a more fruitful consolidation as these rises have an expansionary effect due to the inflationary pressures they provide the economy, thus lowering the real interest rate: this is a result highlighted in Eggertsson (2011). However, spending based consolidations, or those focussing on consumption taxes, are worse when conducted at the lower bound.

FIGURE 15: Welfare effects of austerity at the zero lower bound



Welfare results are expressed as the equivalent of one-period of steady state consumption that would leave the agent indifferent between living through the shock or forgoing the one period loss. The three panes represent the three different experiments from using 'all instruments' from using only 'production taxes' (labour, capital and employer social security contributions) and from using all spending instruments and consumption taxes. In the legend 'NR' and 'R' represent results for non-Ricardian and Ricardian households respectively and 'Bench' represents benchmark results from when the monetary zero lower bound is not binding.

However, these results do hide a timing disparity, whereby during the period of the zero lower bound (which is what Europe, the UK and the US has been of late) the impact is heightened. Therefore, consolidations based on spending cuts and front loaded will be felt much worse. It is interesting to note that those high consolidating countries such as Greece, Ireland and Spain performed the significant majority of their austerity through spending cuts, and in a front-loaded fashion. Over the whole period of consolidation, however, when the initial phase is averaged out, these effects look smaller.

5.4.3 Sensitivity analysis

We have simulated our model, both for the positive and normative implications, across a wide range of parameter values of wage and price stickiness, the proportion of credit-constrained consumers, Taylor rule parameters, as well as the horizon of welfare calculations to better reflect the shorter political horizon. We find that varying these parameter values has a negligible qualitative and quantitative impact on the results (not reported).

5.5 Conclusions

This chapter explored the aggregate and distributional impact of fiscal austerity by utilizing a medium scale DSGE model with a rich set of fiscal instruments. We examined aggregate, welfare and the income distribution outcomes in different types of fiscal adjustment that vary with its composition and the speed of adjustment.

Our main results are as follows. First, we find that fiscal austerity gives rise to a variety of distributional outcomes, determined predominantly by the composition of fiscal adjustment. In almost all cases, austerity tends to harm credit-constrained households more than those with full access to capital markets. We find that spending-based fiscal adjustment improves Ricardians' welfare while non-Ricardians lose out. In contrast, tax-based fiscal consolidations reduce welfare of both types of households but disproportionately more of non-Ricardians. In addition to making everyone worse off, tax based consolidations also bring about greater contractions in output and employment. These two aspects of tax-based consolidations versus spending-based ones may have important implications for the continuity of these programs. Indeed, existing empirical literature on fiscal adjustments presents evidence for tax based consolidations to be more shorter lived than spending based ones.

We also examined the implications of the monetary zero lower bound on the welfare consequences of fiscal consolidations. We find that, in spite of their well-known favourable impact on the effectiveness of fiscal policy, the presence of the monetary zero lower bound doesn't alter the welfare ranking across different sets of consumers following fiscal austerity. However, we also show that the composition of consolidations gains more importance at the lower bound. For example, we find that fiscal adjustment through capital taxes are less bad in welfare terms at the monetary zero lower bound, in contrast to adjustment through government spending or consumption taxes where the opposite is true.

Overall, our findings also point to a clear trade off between the efficiency and the equity aspects of austerity. Policies that lead to greater aggregate fluctuations (tax-based) are also those that generate smaller inequality both in terms of welfare and income distribution. Given the severity of the recent downturn in most advanced economies that have adopted austerity, and the resulting preoccupation with GDP figures, this trade-off between growth and distributional consequences of fiscal consolidation is likely to pose serious challenges to policymakers in many countries.

Chapter 6

Contagious irrationality: fiscal policy and catching up with the Joneses

6.1 Introduction

Previous chapters have predominantly considered the normative consequences of fiscal policy. This chapter is more in line with much of the existing literature by focussing on the effectiveness of fiscal policy on the aggregate economy and the size of the fiscal multiplier. Neoclassical models suggest that the theoretical impact of tax movements on the aggregate economy is nil, as Ricardian equivalence holds, and that increases in government spending will have a less than one-for-one correspondence on output as private consumption is crowded out by public expenditure. However, these findings contradict empirical results which show positive output movements to tax cuts and increases in private consumption in response to increased government purchases (see for example Blanchard and Perotti; 2002). This empirical literature typically employs vector autoregressions and is varied both with respect to the identifying conditions applied and to the results obtained, from findings insignificant from zero (Ramey; 2011) to 2 year cumulative multipliers of 2 or more (Galí et al.; 2007; Caldara and Kamps; 2008). New Keynesian models are able to obtain larger government spending multipliers, however, crowding out of private consumption is still prevalent and multipliers of one or greater require empirically inappropriate levels of accommodative monetary policy (Woodford; 2011). Moreover, the continued use of fully rational infinite lifetime agents ensures that Ricardian equivalence still holds. Studies such as Galí et al. (2007) and Monacelli and Perotti (2008) have induced positive comovements between public and private consumption by introducing credit-constrained households and complementary preferences between consumption and work respectively, however, the latter maintains Ricardian equivalence, and the former is criticised for the level of imperfection required to obtain this comovement.

The innovation of this chapter is to illustrate how through combining the modelling assumptions of external habit persistence and rule-of-thumb agents, empirically appropriate fiscal multipliers can be obtained at reasonable parameter values. These modelling assumptions have been used predominantly in the literature, but often in isolation of one another, where their inclusion has been based on microeconomic evidence: see for example Kiley (2010). Moreover, macroeconomic models which comprise these elements are seen to better match empirical data. The introduction of external habit formation, where relative and absolute movements in consumption are valued by agents, has been shown to provide hump-shaped dynamics often observed in the data. This assumption imposes a weight in the utility function such that agents obtain disutility from movements away from the prior period's average level of consumption: for this reason it has also been labelled 'catching up with the Joneses'. However, the concept of catching up with others is trivial when combined with the representative agent assumption. Through introducing heterogeneity across the actions of households by imposing a fraction of agents consume directly from their disposable income 'rule-of-thumb', the combination of these two modelling assumptions provides compelling results, particularly with respect to fiscal policy.

We find that long run fiscal multipliers increase with both greater rule-of-thumb behaviour and higher levels of habit persistence, and that there is an effective trade off between these two parameters to obtain a given multiplier value. The first of these results is commonly found in the literature as non-Ricardian households both violate Ricardian equivalence and increase private spending in the face of increased public spending. The second result is derived through the specific modelling assumption of 'global habit persistence' creating an interaction between the two heterogeneous agents. In response to increased consumption of non-Ricardian households to a fiscal shock, the otherwise prudent Ricardian households follow in kind and increase their own consumption. This means that fewer rule-of-thumb agents are required to produce a similar aggregate impact in the presence of habit persistence than without; in effect, less irrational or myopic individuals are required when this behaviour is contagious on the otherwise typical lifetime optimising agents. Moreover, through increasing their own private consumption, Ricardian agents push up the aggregate level of consumption which results in higher habit levels for the future, further fuelling levels of aggregate consumption and subsequently output. Over the long run, habit persistence increases multipliers as the impact of heterogeneous agents consuming at different levels creates a consumption bubble in the economy. These results are found both through dynamic simulation and also through algebraic properties derived on a smaller version of the model. In effect, this combination of modelling assumptions is imposing a form of animal spirits in the economy whereby the two types of households respond to the actions of each other, acting more like one agent, deepening the impact of any shock.

The next section derives a New Keynesian DSGE model with both habit persistence and credit-constrained consumers. Section 6.3 considers a smaller version of this model for which algebraic properties, independent of parameter calibrations, can be observed. Section 6.4 tests these properties on the larger model using dynamic simulations on four fiscal experiments. Section 6.5 concludes.

6.2 The model

The model is similar to that presented in Chapter 2 with the inclusion of habit persistence, capital accumulation and trade unions who suffer adjustment costs in the wage setting process. The impact of the inclusion of habit persistence is the main focus of the chapter whereas the inclusion of the two latter features extends λ^* in the model (see Proposition 1 in Chapter 2). The model is similar to Furlanetto and Seneca (2012) who despite including both habit persistence and rule-of-thumb households, the former is imposed on each household individually such that each agent forms habits based on prior levels of their own disaggregate consumption. In the model presented below, habit persistence acts across households which intuitively adds additional dynamics in the model in response to shocks, where private agents will converge towards similar consumption profiles.[1]

6.2.1 Households

There is a continuum $[0, 1]$ of infinitely lived households, all of which consume the final good and supply labour to firms. A proportion of these households $(1 - \lambda)$ are 'Ricardian' who have access to capital markets and can trade in a full set of state

[1] A handful of models do include this global habit persistence (where habits are based on aggregate consumption) in conjunction with non-Ricardian agents: see for example Muscatelli et al. (2004) and Erceg et al. (2006). However, although Ricardian households maximise subject to this level of habit persistence, non-Ricardian household are frequently modelled as either taking the wage decisions of these fully rational agents (as in the case of Erceg et al.; 2006) or modelled to have constant working hours (as in the case of Muscatelli et al.; 2004) and therefore this utility function and interaction across agents is only working in one direction. Through ignoring the optimisation of the rule-of-thumb agents, these models are ignoring the additional avenue of interaction, which is the focus of this paper.

contingent securities. The remaining proportion (λ) are 'non-Ricardian' who have no access to capital markets. The period utility function is assumed to be the same for both types of household and is given by:

$$U_t^i = \frac{\left(C_t^i - H_t\right)^{1-\sigma}}{1-\sigma} - \frac{\left(N_t^i\right)^{1+\varphi}}{1+\varphi} \tag{6.1}$$

where C_t and N_t are consumption and employment in period t, and $H_t = hC_{t-1}$ describes external habit formation. The parameter σ is the coefficient of relative risk aversion and φ is the inverse elasticity of work with respect to the real wage. Superscript i differentiates these variables between Ricardian ($i = R$) and non-Ricardian ($i = NR$) households.

Ricardian Households

Ricardian households earn income from their labour supply (at a wage rate W_t), from the dividends paid on share ownership, D_t^R, from maturing one period bonds purchased in the previous time period, B_t^R, and from the return on their capital stock K_t^R (at rental rate R_t^k). They use this income to purchase the consumption good (at a price P_t), reinvest in capital, reinvest in the bond market (at a given return R_t), to pay lump sum taxes levied by the fiscal authority, T_t^R, and to pay union fees F_t. This leaves a budget constraint to Ricardian households given by:

$$P_t\left(C_t^R + I_t^R\right) + \frac{B_{t+1}^R}{R_t} \leq W_t N_t^R + D_t^R + B_t^R + R_t^k K_t^R + -P_t T_t^R - F_t \tag{6.2}$$

The Ricardian household's capital evolves according to the following constraint:

$$K_{t+1}^R = (1-\delta)K_t^R + \Xi\left(\frac{I_t^R}{K_t^R}\right)K_t^R \tag{6.3}$$

where the rate of depreciation is given by δ, and where a capital adjustment cost function is imposed, $\Xi(\cdot)$, which satisfies $\Xi(\delta) = \delta$, $\Xi' > 0$, $\Xi'(\delta) = 1$ and $\Xi'' \leq 0$. Ricardian households maximise expected lifetime utility (given by the sum of (6.1) from $t = 0$ to $t = \infty$) discounting future periods of utility by a factor $\beta \in (0, 1)$, subject to constraints (6.2) and (6.3) with respect to consumption, bond purchases, investment and capital, where all prices are taken as given.

Non-Ricardian Households

Non-Ricardian households do not have access to bonds markets and as such cannot intertemporally substitute consumption. Moreover they do not own company shares or capital. They simply consume, period by period, their disposal income generated through their supply of labour, which provides the non-Ricardian consumption function:

$$P_t C_t^{NR} = W_t N_t^{NR} - P_t T_t^{NR} - F_t \tag{6.4}$$

where equality is given by assumed strictly positive marginal utility from consumption. Non-Ricardian households optimise their period by period utility by making decisions on how much labour to supply at a given wage rate: maximisation of (6.1) subject to the budget constraint (6.4) with respect to consumption and employment, where prices and wages are taken as given. This process is performed on their behalf by the labour unions discussed below.

6.2.2 Firms

The design of the production sector is similar to that set out in Section 2.3.2. In this chapter only fiscal shocks are considered and as such the desired markup charged by intermediate good firms is constant: $\mu_t = \mu \; \forall \; t$. Moreover, we also ignore exogenous movements in total factor productivity, and the introduction of capital in the model changes the production function for intermediate good firms to:

$$Y_t\,(j) = K_t\,(j)^{\alpha}\,N_t\,(j)^{1-\alpha} \tag{6.5}$$

6.2.3 Labour unions

A continuum of trade unions are assumed, $z \in [0, 1]$, who bargain with firms on behalf of their members, a continuum of workers representative of the whole population.[2] These unions set wages for their members who service labour demand at the given wage. Each union provides labour which is differentiated from each other and therefore assert market power. The services provided by each union is an aggregate of its individual members, and the labour used by intermediate good firms is a Dixit-Stiglitz aggregate of services provided by all unions. Each period, the union set wages such that it

[2] The ratio of non-Ricardian to Ricardian households in each union is given by $\lambda : (1 - \lambda)$.

maximises a weighted average of the present value of utility for its members subject to labour demand by firms (similar to equation (2.8) where a parameter ϵ_w governs the elasticity of substitution across labour types) and subject to an adjustment cost process, similar to Rotemberg (1982), which is assumed to be a quadratic function of the wage increases demanded by the union and proportional to the aggregate wage bill in the economy.[3] Each union member pays an equal share towards these negotiation costs which provides the relationship:

$$F_t(z) = \frac{\phi_w}{2}\left[\frac{W_t(z)}{W_{t-1}(z)} - 1\right] W_t N_t \tag{6.6}$$

where $F_t(z)$ is the fee paid to union z and where the parameter ϕ_w governs the extent of the adjustment cost for the labour unions.[4]

6.2.4 Monetary authority

The monetary authority follows a Taylor rule similar to that of (2.12) but where in the analysis presented below there is no discussion of exogenous monetary policy shocks:

$$r_t = \varphi_\pi \pi_t + \varphi_y y_t \tag{6.7}$$

6.2.5 Fiscal authority

The fiscal authority purchases a proportion of the final goods for public consumption, G_t, raises lump sum taxation from the two households, T_t^R and T_t^{NR}, and issues nominal risk-free one-period bonds, B_{t+1}. As such, the flow constraint of the government is given by:

$$P_t G_t + B_t \leq P_t(T_t^R + T_t^{NR}) + \frac{B_{t+1}}{R_t} \tag{6.8}$$

The model includes a proportion of non-Ricardian households and therefore the dynamics and evolution of government expenditures, taxes and debt is relevant. As is typical

[3] Although the bargaining process is not explicitly modelled, Furlanetto and Seneca (2012) liken this environment to where more economic resources are required to achieve a higher increase in wages.

[4] Note, assuming a sticky wage setting process for trade unions as in the case of intermediate firms would provide similar aggregate dynamics but would provide disaggregated heterogeneity across agents. Whereas Ricardian agents are assumed to insure away this risk, non-Ricardian agents cannot and this Rotemberg (1982) structure provides similar results with homogeneous wages and working hours: this is an advantage highlighted by Furlanetto and Seneca (2012).

in the literature, movements of fiscal variables away from steady state values will be modelled as a result of exogenous shocks where long run debt is stabilised through debt aversion parameters. More formally:

$$\widehat{g}_t = \varepsilon_t^G + \varphi_{b,g}\widehat{b}_t; \quad \varepsilon_t^G = \rho_g \varepsilon_{t-1}^G + \eta_t^G \tag{6.9}$$

$$\widehat{t}_t = \varepsilon_t^T + \varphi_{b,T}\widehat{b}_t; \quad \varepsilon_t^T = \rho_t \varepsilon_{t-1}^T + \eta_t^T \tag{6.10}$$

where, as before, *hatted* lower case variables represent deviations from steady state as a proportion of steady state output: for example $\widehat{x}_t = (X_t - X)/Y$. To simplify, it will be assumed throughout the analysis $\widehat{t}_t^{NR} = \widehat{t}_t^R = \widehat{t}_t$; changes in lump sum taxation are equal across all households and there is no redistribution between households through taxation. Moreover, it will be assumed that the government set steady state lump sum taxes on the two types of households such that the increased income effect of dividends and returns on capital for the Ricardian agents are eliminated. This assumption, combined with the identical utility function assumed for the two types of households, leads to the same consumption and employment profile of the heterogeneous households in steady state: $C^{NR} = C^R = C$ and $N^{NR} = N^R = N$. This assumption simplifies the calculations but is not critical to the main results of the model. The above rules allow the fiscal variables to respond to the level of government debt which acts to preserve the solvency constraint.[5]

The inclusion of two shock processes and two debt aversion parameters lead to four individual policy experiments for the conduct of fiscal policy, where one exogenous process and one debt aversion parameter are enacted at a time: a shock to government spending where resulting debt is repaid through medium term decreases in government spending or increases in taxes, henceforth referred to as policy experiments 1 & 2 respectively; alternatively, a shock to taxes where resulting debt is repaid through medium term increases in taxes or decreases in government spending, henceforth referred to as policy experiments 3 & 4 respectively. These policy experiments provide clear comparisons across fiscal actions which will form the structure of the analysis.

[5] The government is also assumed to satisfy the solvency constraint that in the long run all debts are fully repaid: algebraically, $\lim_{t\to\infty} B_{t+1}/R_t = 0$. In this example, the condition $\varphi_{b,T} - \varphi_{b,g} > \rho_R/(1+\rho_R)$, where $\rho_R = (1-\beta)/\beta$ is the steady state interest rate, ensures that the solvency constraint is adhered to, stating that the fiscal authority must pay back debt faster than interest accrues on it.

6.2.6 Market clearing, aggregation and equilibrium conditions

In equilibrium, aggregate consumption and employment are equal to the weighted average of the two variables across households, similar to (2.17) and (2.18). Moreover, all output must be consumed by either the government, private individuals, investment or trade unions:

$$Y_t = G_t + C_t + I_t + F_t \tag{6.11}$$

The model is solved by deriving log-linear approximations of key optimality conditions and policy rules around the non-stochastic steady state with zero inflation and zero government bonds: Appendix E.1 presents these conditions.

6.3 A benchmark model

This section reviews the consequences of including both rule-of-thumb agents and habit persistence on the effectiveness of fiscal policy in a simplified version of the above model. This simplified version abstracts away from both capital and labour unions which provides a reduced form of the above model consisting of an aggregate demand condition, a standard New Keynesian Phillips curve and policy rules. A perfectly competitive labour market similar to Chapter 2 is assumed, where there are no frictions or adjustment costs in the wage setting process, and where each households can supply labour at a given wage rate independent of other agents. Capital is assumed fixed and normalised in the production function (6.5) as in (2.9). With this smaller model algebraic properties can be derived and analysed which provides a rigorous and intuitive benchmark which further analysis can be built upon.

6.3.1 Aggregate demand

Under the conditions described above, an aggregate demand function can be derived which is a function of policy variables and shock processes. This is achievable because the above abstractions simplify the economy in such a way that rule-of-thumb consumption is a relationship in only output and taxes which can be combined with a standard Euler equation for Ricardian households. Once the calculations have been performed, the following equation can be derived (see Appendix E.2 for the full derivation):

$$
\begin{aligned}
y_t &= \Phi_A E_t\{y_{t+1}\} - \Theta_A(r_t - E_t\{\pi_{t+1}\}) - \Phi^{''} y_{t-1} - \Phi E_t\{\widehat{g}_{t+1}\} \\
&\quad + \Phi^{'}\widehat{g}_t + \Phi^{''}\widehat{g}_{t-1} + \Theta_B E_t\left\{\Delta\widehat{t}_t^{NR}\right\} \\
\Phi_A &= \left[\Gamma - \lambda(1-h)(1+\varphi)\varphi\gamma_c\right](\Gamma^{''})^{-1} \\
\Theta_A &= \gamma_c(1-\lambda)\frac{1}{\sigma}(1-h)\left[\gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\right](\Gamma^{''})^{-1} \\
\Phi^{''} &= \left[\lambda\varphi\sigma(1-\alpha)h - (1-\lambda)h\left[\gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\right]\right](\Gamma^{''})^{-1} \\
\Phi &= \Gamma(\Gamma^{''})^{-1} \\
\Phi^{'} &= \Gamma^{'}(\Gamma^{''})^{-1} \\
\Theta_B &= \gamma_c\lambda\varphi(1+\mu)(1-h)(\Gamma^{''})^{-1} \\
\Gamma^{''} &= \Gamma^{'} - \lambda(1-h)(1+\varphi)\varphi\gamma_c \\
\Gamma^{'} &= \gamma_c\varphi(1+\mu)(1-h)\left[1+(1-\lambda)h\right] + \sigma(1-\alpha)\left[1-\lambda(1+\varphi)(1+h)+h\right] \\
\Gamma &= \gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\left[1-\lambda(1+\varphi)\right]
\end{aligned} \tag{6.12}
$$

This aggregate demand condition can be combined with log-linear policy rules (6.7), (6.8), (6.9) and (6.10) as well as a standard New Keynesian Phillips Curve in order to close the model. From the demand function (6.12) algebraic relationships in partial equilibrium relating fiscal policy actions with output can be found, as well as other important properties of the model, which can be analysed prior to simulation.

6.3.2 Properties of the model

Determinacy and asset market non-participation

As was discussed in Section 2.4 there is a critical value of λ such that the aggregate demand relationships and determinacy are inverted. In the simplified model discussed above this point will be at:

$$
\lambda^* = \frac{(1+h)\left[\gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\right]}{(1+\varphi)\left[\sigma(1-\alpha)(1+h) + \varphi\gamma_c(1-h)\right] + h\gamma_c\varphi(1+\mu)(1-h)} \tag{6.13}
$$

An important relationship to highlight is the result that $\partial\lambda^*/\partial h > 0$: increases in habit persistence increase the critical value of asset market non-participation. This occurs because habit persistence acts as a buffer between output movements and non-Ricardian consumption, where rule-of-thumb agents look to temper relative movements in their personal consumption, thereby minimising the feedback effect between this and output.

The short term impacts of fiscal policy on aggregate demand

Similar to the relationships in equation (4.1) it is possible to show for aggregate demand (6.12) that, in the region of $0 < \lambda < \lambda^*$, the following partial equilibrium results:

$$\frac{\partial y_t}{\partial \widehat{g}_t} > 0, \ \frac{\partial y_t}{\partial \widehat{t}_t} < 0, \ \left|\frac{\partial y_t}{\partial \widehat{g}_t}\right| > \left|\frac{\partial y_t}{\partial \widehat{t}_t}\right| \tag{6.14}$$

where the implications and intuition of these relationships are discussed in Section 4.3. The first and second of these conditions follows from the observation that $\partial y_t / \partial \widehat{g}_t = \Phi'$ and $\partial y_t / \partial \widehat{t}_t = -\Phi\Theta_B$, and noting that the condition $\lambda < \lambda^*$ results in each of these aggregate demand coefficients to be positive; the third of these conditions is provided observing that $\Phi' > \Theta_B$ when $\lambda < \lambda^*$.

Within these the following relationships, in the region of $0 < \lambda < \lambda^*$, can be observed and are derived in Appendix E.3:[6]

$$\frac{\partial \Phi'}{\partial \lambda} > 0, \ \frac{\partial \Phi'}{\partial h} < 0, \ \frac{\partial \Theta_B}{\partial \lambda} > 0, \ \frac{\partial \Theta_B}{\partial h} < 0 \tag{6.15}$$

Which illustrate two further important properties: higher values of λ and h increase and decrease the impact of fiscal policy on aggregate demand respectively, both of which lead from the λ^* condition (6.13) above. As the share of the rule-of-thumb agents increase, the proportion of households whose consumption is directly determined by output also increases. This occurs because output has a positive impact on wages and therefore an increase in the former increases the latter which increases non-Ricardian consumption, all other things being equal. Therefore fiscal policy has a larger aggregate effect at higher values of λ. This relationship is non-linear in λ and it can be shown that $\partial^2 \Phi' / \partial \lambda^2 > 0$ and $\partial^2 \Theta_B / \partial \lambda^2 > 0$.[7] The second relationship in (6.15) states that higher levels of habit persistence are associated with lower initial aggregate demand effects of fiscal policy. Higher calibrations of h lead to individuals valuing relative movements in consumption as well as absolute movements. This means that when a shock hits the economy which increases demand, consumers will respond sluggishly as they trade

[6] The first, second and fourth of these results require extra conditions to hold: these are $1+\mu < \sigma(1-\alpha)/[\lambda h(\sigma(1-\alpha)-\varphi\gamma_c)-\varphi\gamma_c]$, $\lambda < ((1-h)^2\gamma_c\varphi(1+\mu)+2\sigma(1-\alpha))/((1-h)^2\gamma_c\varphi(1+\mu)+2\sigma(1-\alpha)(1+\varphi))$ and $\lambda < (2\sigma(1-\alpha)+\gamma_c\varphi(1-h)(1-\lambda)[(\mu)(1-h)+\lambda(1+\varphi)])/2\sigma(1-\alpha)(1+\varphi)(1+h)$, respectively, neither of which represent significant restrictions at reasonable parameter values.

[7] The first of these results requires the first condition from the previous qualification set out for (6.15): again, this is not restrictive at reasonable parameter values.

off the extra utility from increased consumption over the penalty of this being higher than yesterdays' consumption. This will have the (partial equilibrium) effect of the full impact of the shock taking more time to mature and as such will result in lower impact multipliers to any fiscal action.[8]

However, this goes against the finding of Monacelli and Perotti (2008) and Furlanetto and Seneca (2012) who show that government spending multipliers increase with habit persistence because this generates sluggishness in the dynamics of private consumption which, due to the substitution effect, falls in aggregate in response to a public spending rise. This intuitive result is not shown above because (6.15) represents a partial equilibrium result. This sluggishness in private consumption can be shown algebraically by observing $\partial\Theta_A/\partial h < 0$, meaning that Ricardian agents discount the impact of rising real interest rates associated with the government spending rise at higher values of habit persistence.[9] For tax rises however, this tardiness works against the rise in private consumption and therefore suppresses impact multipliers of such actions.

The long run aggregate demand impacts of fiscal policy

The properties of the initial effects of fiscal policy on aggregate demand above provide intuitive insight however are not informative on the long run impacts. As is observed in the aggregate demand condition (6.12), there is both a lead (because of rational expectations) and a lag (because of habit persistence) term in this relationship making it a second order differential process. Performing similar procedures as those above, the following four conditions, in the region of $0 < \lambda < \lambda^*$, can be observed and are derived in Appendix E.4:[10]

$$\frac{\partial\Phi_A}{\partial\lambda} < 0, \ \frac{\partial\Phi_A}{\partial h} < 0, \ \frac{\partial\Phi^{''}}{\partial\lambda} > 0, \ \frac{\partial\Phi^{''}}{\partial h} > 0 \tag{6.16}$$

The coefficient on the lead expression gets smaller and the coefficient on the lag expression bigger at higher values of λ and h: these both increase the long run impact of any aggregate demand stimulant, including those from fiscal policy. When habit persistence is included in the model both types of agent consider past values of aggregate

[8]This impact is increasing in h where it is possible to show $\partial^2\Phi^{'}/\partial h^2 > 0$ meaning that the coefficients are decreasing at a decreasing rate. The proof of the latter requires the same additional condition as the final expression in (6.15).

[9]The proof for this condition is only true when $2 + h - 2(1+\varphi)\lambda h > 0$ which is a condition stating that neither h nor λ can go to extreme values.

[10]For the first and third of these properties the algebraic proof requires the additional (and reasonable) condition that $\mu < \varphi$. The second and fourth results also require additional conditions, however these are complicated expressions, which are met for all reasonable parameter values, and hold at their limit providing $\lambda < 1/h(1+\varphi)$.

consumption in today's decision making. When a demand shock strikes the economy an increase (decrease) in consumption today will lead to households tomorrow also increasing (decreasing) their consumption, relative to when $h = 0$; this impacts the following period, which impacts the next, and so on and so forth. Moreover, an increase in the proportion of credit-constrained agents increases the aggregate impact of private consumption of any given shock as more agents are reacting simultaneously rather than smoothing the effects over a longer time horizon. This will subsequently increase those effects which take time to unwind due to the presence of habit persistence, and the following two intuitive relationships can be demonstrated for when $\lambda < \lambda^*$:[11]

$$\frac{\partial^2 \Phi_A}{\partial\lambda\partial h} < 0,\ \frac{\partial^2 \Phi''}{\partial\lambda\partial h} > 0 \tag{6.17}$$

which states that the long run fiscal fiscal effects on aggregate demand increase at an increasing rate at higher values of λ and h and that there is an interaction between these two variables.[12]

In sum, the inclusion of both heterogeneous agents and habit persistence can have significant long run consequences relating to the impact and effectiveness of fiscal policy. Not only do these factors impact the results individually but the analysis highlights the intuitive relationship that they work in union such that the feedback process of one is amplified by the other. In effect, through introducing an empirically appropriate interaction between heterogeneous agents only a small proportion of individuals who behave differently from the perceived optimal approach are required in order to produce a much larger aggregate impact than when this interaction is not present: there is a contagion of private spending as one type of household attempts to 'keep up with' the other. In this respect the combination of these two modelling assumptions is imposing a form of herding behaviour or animal spirits on the model.

6.3.3 Dynamic simulations

To illustrate the above properties, simulations are performed on the simplified model to obtain a more complete understanding of the transmission mechanisms involved when

[11] The coefficients attached to these properties are too complicated for algebraic proof, but it can be numerically demonstrated that these relationships hold providing both λ and h are not at the upper end of their limits: similar to the conditions for (6.16). This demonstration uses Monte Carlo simulation techniques where all parameters are selected within a reasonable distribution (dictated either by natural restrictions or through typical prior estimates used in Bayesian estimation) and the coefficient being estimated over a large number of separate iterations.

[12] It can also be numerically demonstrated that, providing $\lambda < \lambda^*$, long run fiscal multipliers are increasing at an increasing rate with respect to λ, $\partial^2\Phi_A/\partial\lambda^2 < 0$ and $\partial^2\Phi''/\partial\lambda^2 > 0$, and increasing at a decreasing rate with respect to h, $\partial^2\Phi_A/\partial h^2 > 0$ and $\partial^2\Phi''/\partial h^2 < 0$, where the latter two results are found for when λ and h are not at the upper ends of their limits.

both rule-of-thumb agents and habit persistence are included into a simple DSGE model. This allows for clear understanding prior to performing further analysis on the bigger model.

Calibration

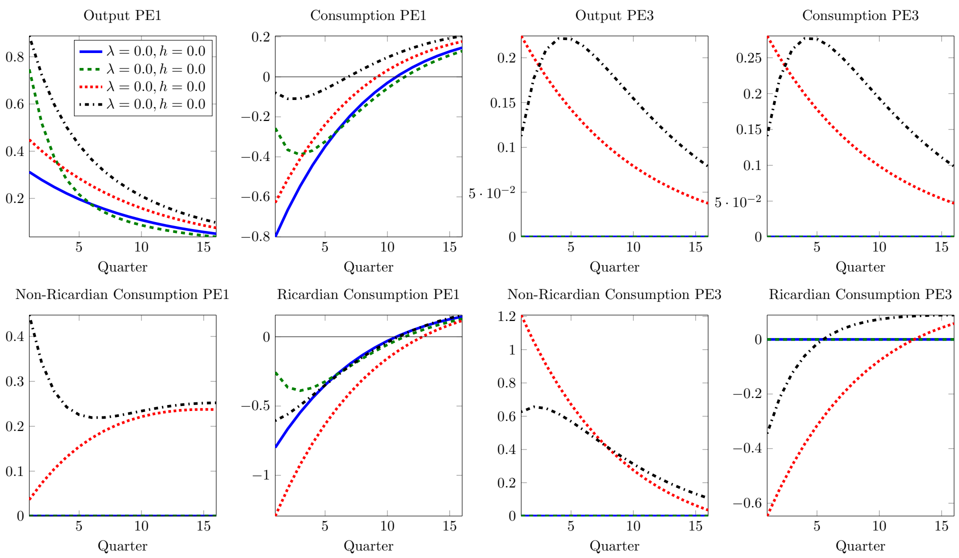
For dynamic simulations, a similar calibration as those discussed in Sections 3.3.2 and 4.4.1 will be used. The exception to this is to set the inverse elasticity of labour with respect to real wages, φ, to 1. Depending on the policy experiment, the debt aversion parameters will be set such that $\varphi_{b,g} = -0.1$ and $\varphi_{b,T} = 0.1$, when not zero, and the persistence of fiscal shocks (ρ_g and ρ_t) are set equal to 0.8; these values represent a half life of existing government debt of less than two years and of the disequilibrium shock of less than one year using equation (2.16). Given the importance of the parameters λ and h these will be set at different levels throughout. Typically, values in the range of 0.25-0.5 and 0.6-0.8 are used in the literature for the proportion of credit-constrained agents and habit persistence, respectively.

Simulations

Figure 16 presents impulse response functions for key aggregate and disaggregate variables under policy experiments 1 & 3 where in both examples the fiscal shock acts to increase output (a government spending rise and tax cut respectively) and the size of the shock is normalized to one percentage point of steady state output. Note that policy experiments 2 & 4 differ from 1 & 3 respectively only through the way resulting debt is repaid and as such presentation of these results are not included for brevity. The figure presents the impact of the shock under four separate calibrations: a fully Ricardian economy with no habit persistence ($\lambda = 0$, $h = 0$); a fully Ricardian economy with habit persistence ($\lambda = 0$, $h = 0.7$); a mixed economy with no habit persistence ($\lambda = 0.5$, $h = 0$); and a mixed economy with habit persistence ($\lambda = 0.5$, $h = 0.7$).

Consider the dynamics where there has been a negative shock to lump sum taxation which in the medium term is repaid through future tax rises: policy experiment 3. This provides an interesting benchmark because Ricardian equivalence holds in a fully Ricardian economy ($\lambda = 0$) and, moreover, because the way the fiscal shock interacts with the aggregate economy is directly through the actions of private agents. When there is some proportion of non-Ricardian households ($\lambda > 0$) they respond to the tax cut through increasing their consumption as their disposable income rises. The introduction of these credit-constrained agents also impacts on the disaggregated actions of the Ricardian households who now reduce their consumption in response to the tax

FIGURE 16: Dynamics under different fiscal experiments



Dynamics achieved through applying policy experiment 1 with respect to the first two columns and policy experiment 3 with respect to the second two columns, and where the shock to fiscal policy is normalized to one percentage point of steady state output. The x-axis represents time in quarters and the y-axis the percentage deviation of the variable from its steady state value.

cut. These agents anticipate future tax rises but see a fall in their net lifetime income as profits fall over the short term. This occurs because the non-Ricardian households substitute consumption for leisure as a result of the tax cut, increasing the real wage and therefore driving down profits. The net impact is to increase aggregate consumption in the economy, as the rise in non-Ricardian consumption is greater than the fall in Ricardian consumption, because the action of the latter agents is smoothed over the course of their lifetimes. When habit persistence is included ($h = 0.7$), the figures illustrate that this movement in aggregate consumption is initially smaller than where there was no habit persistence: as predicted by (6.15) the initial impact multiplier of the tax cut is lower. This occurs because non-Ricardian agents raise their consumption by less due to the preference towards habit persistence. However, as time continues, output with habit persistence dominates that without because although non-Ricardian consumption falls when $h = 0.7$ compared to $h = 0$, Ricardian consumption rises by more. This occurs because these Ricardian agents experience consumption levels below the lagged-average values and therefore increase their consumption in order to keep up with their non-Ricardian neighbours. This pushes up aggregate consumption in the economy which means both agents are reverting back to a higher level of lagged aggregate consumption. Over the long term this output domination becomes significant.

Similar results are also found when considering a policy whereby government spending rises today are repaid in the future by spending cuts: policy experiment 1. Positive fiscal multipliers are observed with this experiment, even in a fully Ricardian economy, because the government is directly increasing aggregate demand through public consumption. However, multipliers are less than one as Ricardian agents substitute consumption for leisure, because the increase in government spending increases their labour requirement. When habit persistence is included in the actions of these agents, impact multipliers increase. This goes against the partial equilibrium result of (6.15) and occurs, as discussed above, because in general equilibrium the corresponding fall in Ricardian consumption is slower as these agents value relative movements in consumption. This suppresses the reduction in private consumption which therefore reduces output by less. When rule-of-thumb agents are included in the model, the impact of the shock is increased, as was anticipated in (6.15). This occurs because there is an increase in labour demand in order to produce the additional government consumption, which subsequently raises wages and therefore disposable incomes of non-Ricardian households. As was the case in policy experiment 3, the inclusion of rule-of-thumb agents reduces the consumption of Ricardian households because profits fall in general equilibrium. When both credit-constrained agents and habit persistence are included in the model both short and long run multipliers are at their highest. This occurs because there is the double effect of an increasing proportion of agents initially responding positively with their private consumption to the increase in public consumption and, moreover, falls in future consumption are minimised by relative movements becoming important to all agents.

An alternative explanation behind these results is that through assuming global habit persistence across the actions of heterogeneous households, in effect we are imposing a form of animal spirits on the model. As can be seen in Figure 16, in the absence of this 'catching up with the Joneses' assumption there is a negative covariance between the consumption responses of the two agents in the model, where non-Ricardian spending rises whilst Ricardian spending falls. This negative covariance occurs because an increase in rule-of-thumb consumption reduces rule-of-thumb labour supply thus increasing marginal costs and reducing profits. These responses mirror each other in such a way that the aggregate consumption profile is hedged with the divergent agents. When global habit persistence is included however, the interaction this imposes on the two households means that they move more as one entity: the consumption rises of one impact on the other who attempt to 'catch up'. These animal spirits lead to deeper impacts of shocks in the model, which is in line with the original intuition of herding behaviour, and further adds to the ability of DSGE models to account for more extreme reactions from exogenous shocks.

6.4 Asset market non-participation, global habit persistence and fiscal policy

With the understanding derived with the smaller model this section now brings in all elements of the model discussed in Section 6.2. With this comes two distinct advantages: first, the additional elements of the model (capital accumulation with adjustment costs, and frictions in the labour market) have been argued to be more empirically appropriate, making any inference from the model more robust; and second, such rigidities increase the value of λ^*. This latter benefit occurs because the additional rigidities provides a buffer between non-Ricardian consumption and output which supresses the associated feedback mechanism. This allows the analysis to consider a greater range of values for λ over that which would be possible with the smaller model outlined above.

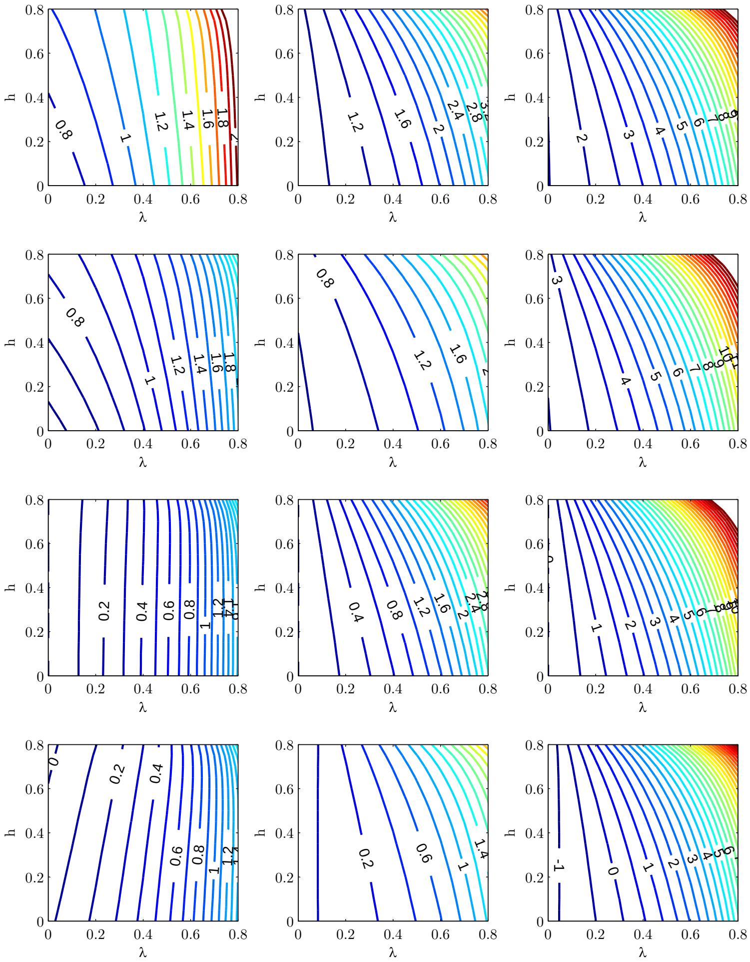
To incorporate the additional elements of the model, the calibration of Section 6.3.3 is updated. Specifically, we calibrate the ratios of steady state output as $\gamma_c = 0.62$, $\gamma_i = 0.18$ and $\gamma_g = 0.2$. Further, we set $\epsilon_w = 4$ and $\phi_w = 174.7$ which is equivalent to wage stickiness equal to 0.75 in a Calvo setting. Further, the adjustment cost to capital η is set equal to 1. This calibration is in line with Furlanetto and Seneca (2012).

6.4.1 Short, medium and long run fiscal multipliers

Figure 17 presents contours for multipliers associated with the four fiscal experiments under a range of calibrations of both λ and h and where the multiplier is evaluated over three different time horizons: an impact multiplier, a two year cumulative multiplier and a cumulative long run multiplier. From the figure we can observe the following results.

First, an increase in the proportion of non-Ricardian consumers increases the value of fiscal policy multipliers in all four policy experiments and across all three time horizons. This result is a consequence of the non-linear feedback mechanism between output and non-Ricardian consumers and was predicted in relationship (6.15). However, the impact of increasing habit persistence has an ambiguous effect with respect to which experiment is applied. This was also predicted above, both in the partial equilibrium results and also in the dynamic simulations of the smaller model. In policy experiments 1 and 2 private consumption falls in aggregate and habit persistence delays this process therefore increasing short run multipliers; in policy experiments 3 and 4 private consumption increases and smaller impact multipliers result. Over time however, the impact of higher habit persistence across agents is to increase the long run impact of the fiscal action, independent of the policy experiment, as was anticipated in relationship

FIGURE 17: Fiscal experiments and multipliers at different calibrations of λ and h



The graphs presents contours representing different fiscal multipliers for different values of both λ and h. The first row presents multipliers as a result of policy experiment 1, the second row, contours as a result of policy experiment 2, the third row policy experiment 3 and the fourth row policy experiment 4. The first column represents impact multipliers as a result of the respective policy experiment calculated using y_t/x_t, the second column cumulative two year multipliers calculated using $\sum_{t=1}^{t=8} y_t / \sum_{t=1}^{t=8} x_t$ and the final column lifetime multipliers approximated as $\sum_{t=1}^{t=100} y_t$; where for the first two rows $x_t = g_t$ and the second two rows $x_t = -t_t$, and therefore a positive tax multiplier represents an increase in output from a decrease in taxes. Note that the lifetime multiplier is calculated as the total movement in output once the debt has been repaid and therefore fair comparisons can be made across all four policy experiments. Also note that we could have discounted future periods of output but this would have a negligible impact on the two year multipliers and an amplifying impact on the lifetime multipliers, as the contractionary period of repaying debt is discounted; the results and method used above are the most prudent, giving the lowest multiplier values.

(6.16). Moreover, there is an observed trade-off between the parameters of λ and h required in order to obtain a given long run impact to fiscal policy, as was anticipated in relationship (6.16). To obtain a cumulative two year multiplier of 1, for example, and moving from $h = 0.0$ to $h = 0.7$ results in reduction of λ of approximately 80%, 35%, 25% and 10% respectively in the four policy experiments. This trade off becomes more extreme as the length of the time horizon is extended to allow the transmission mechanism of one household keeping up with the other to propagate fully: the animal spirits take time to transmit throughout the economy. Moreover, we observe that this trade-off and amplification process become stronger at higher values of λ and h, as predicted by relationship (6.17), which is observed by the decreasing distance of the contours in the graphs. Habit persistence and non-Ricardian behaviour are observed to increase multipliers and these two factors interact with one another in union when animal spirits take over.

The contours are relatively inelastic suggesting that habit persistence does not have a large individual impact on fiscal multipliers comparative to non-Ricardian households. However, this conclusion will be weighted by the fact that typical levels of h are much larger than λ, and moreover, it can be observed that this impact is increasing at higher levels of λ: as anticipated by (6.17). This reinforces the message that it is the combination of the two factors which have a significant impact, and that it is the presence of heterogeneous agents reacting differently to the shock but then converging, as one tries to keep up with the other. Although rule-of-thumb agents can increase multipliers in isolation, when $h = 0.7$ these more than double over the long run; less irrational or myopic behaviour is needed to be assumed to be able to get conclusive supportive results for fiscal action.

With rare exceptions, positive fiscal multipliers are observed across different time horizons and fiscal experiments. These exceptions refer to policy experiment 4 where, under certain parameter calibrations, negative multipliers are observed across all time horizons.[13] This was predicted in relationship (6.14) whereby government spending movements were observed to be more effective per unit than tax movements. Therefore, a policy which cuts taxes only to repay for this over the medium run through lower government spending is removing net demand within the economy. This occurs at lower levels of both λ and h and also at longer time horizons when the contractionary impact of repaying government debt is fully accounted for. The long run results in policy experiment 4 are in stark contrast to those of policy experiment 2, where to some extent, over long time horizons, these two experiments can be seen as the reverse of each other. In the former, negative or low multipliers are observed for most calibrations of λ and h, whereas the latter records high multipliers at modest calibrations of these

[13] Negative impact multipliers can also result in policy experiment 3 at both low levels of λ and high levels of h. This is due to the capital accumulation friction and does not occur for the smaller model in Section 6.3. Whereas the movement in private consumption is small at low levels of λ and slow to respond at high levels of h, investment initially falls as a result of the shock because there is a rise in interest rates that outstrips a rise in the rental rate of capital. This leads to an initial fall in investment as Ricardian households substitute investment in capital for investment in bonds which leads to an initial, but short lived, fall in output.

parameters, as the stimulating impact of government spending is much greater than the contractionary impact of future tax rises. In general, it is possible to observe that those multipliers for government spending led stimuli are greater than those for tax cut led measures over all time horizons and at any calibrations of λ and h.

Finally, it is possible to observe large fiscal multipliers, even over the long run, with all four policy experiments. This shows the power of habit persistence and non-Ricardian agents in increasing theoretical multipliers and moreover of the combination of the two. In effect, through introducing empirically appropriate interactions between heterogeneous agents, only a small fraction of agents who behave differently from the perceived optimal way are required in order to reproduce empirically appropriate results; we can obtain these results whilst still assuming a high degree of fully rational agents. For example, long run multipliers of 3 can be obtained in policy experiments 1 & 2 at $h = 0.7$ with $\lambda = 0.3$ and $\lambda = 0.05$ respectively. Moreover, the model can replicate values across the whole spectrum of empirical estimates with both positive and negative values over the short and long run, depending on the specific policy experiment and the individual calibrations of λ and h.

6.4.2 Sensitivity

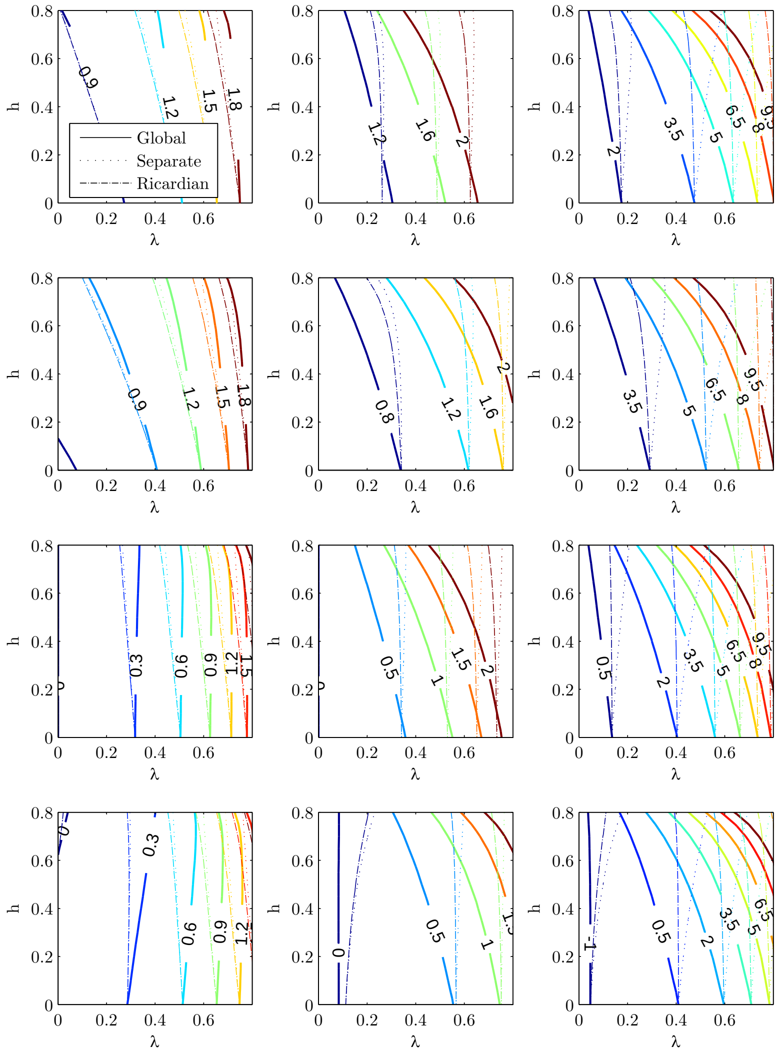
Different habit persistence assumptions

As discussed above, a global version of habit persistence where both agents form habits based on past levels of aggregate consumption is unusual in the DSGE literature. To see the significance of this, Figure 18 presents results under three separate assumptions on habit persistence: the global levels of habit persistence developed above; the typical assumption where only Ricardian households develop habits on past Ricardian consumption (see for example Coenen and Straub; 2005); and the less common concept that each agent forms habits based on their own disaggregate levels (see for example Furlanetto and Seneca; 2012). On impact, the result of a change in habit assumptions have a limited effect on multipliers because independent of the assumption $c^{R}_{t-1} = c^{NR}_{t-1} = 0$, and therefore lagged dynamics are not being accounted for. However, over the medium and long term the differences become more apparent. The two additional frameworks exclude herding behaviour, by assumption, and as such the interaction between λ and h is no longer present: the contours are seen to be inelastic. Over the long run under the assumption of purely Ricardian habits the relationship works in the opposite direction as discussed above: greater levels of (Ricardian) habit persistence results in lower long run multipliers for a given value of λ. This occurs because when $h = 0$, Ricardian households would respond to the fiscal stimulus through cutting consumption in all four experiments: this was seen in Figure 16. When acting independently of their rule-of-thumb neighbours therefore, higher levels of persistence in falling Ricardian consumption lead to lower fiscal multipliers over the long term. When both agents form separate habits based on disaggregate averages of past consumption, the impact of this persistence in Ricardian consumption is matched by the persistence of increasing non-Ricardian consumption and as as such the results for long run multipliers are insensitive to movements in h (assuming $h^R = h^{NR}$). Therefore, the assumption on who and how agents form habits is important to the dynamics of the model, and subsequently on the size of fiscal multipliers. It is argued that the concept of 'catching up with the Jones' is empirically relevant and the introduction of herding behaviour in DSGE models is an interesting innovation.

Distortionary taxation

The analysis above has been performed using lump sum taxation however, were distortionary taxes to be included similar results would be derived. From the structure of the model it is possible to include taxes on consumption, employment income, capital and employment by firms such that these rates perform an initial shock and react to the level of debt similar to (6.10); see Appendix E.5 for details of the structure of this model. If these are included similar results as those presented for lump sum taxes are derived: higher values of h require lower values of λ for a given multiplier over the medium and long term. As these fiscal actions involve movements in taxation, higher levels of habit persistence result in lower initial multipliers as consumption is slow to respond to the stimulus. There is more scope in this design for negative multipliers through those taxes which distort production decisions of firms: taxes on capital and labour. When an expansionary fiscal action is repaid through employer social security contributions or capital taxes the deflationary impact over the medium run can result in negative cumulative multipliers over longer horizons with low calibrations of λ and h. This occurs because the fiscal stimulus is now not only impacting demand within the economy but also the supply of firms. It is also observed that those fiscal instruments which specifically target the consumption function of non-Ricardian households (taxes on consumption and labour income) have larger multipliers than production taxes: government spending multipliers dominate all tax multipliers over all calibrations of λ and h. However, the results presented above are not sensitive to extending the range of tax instruments available to the government.

FIGURE 18: Fiscal experiments and multipliers at different calibrations of λ and h and different assumptions on habit persistence



The graphs presents contours representing different fiscal multipliers for different values of both λ and h. The different panes correspond to those used in Figure 17 and multipliers are calculated in the same way. 'Global' habit persistence represents the same results presented above whereas 'Ricardian' habit persistence represents the results under a model where only Ricardian agents form habits based on their own past levels of consumption, and 'Separate' habit persistence a model where both households form habits on their own past levels of consumption (and where $h^R = h^{NR}$).

Other parameters

Other parameter calibrations also impact the size of fiscal multipliers beyond those of asset market non-participation and habit persistence which have been the main focus of this chapter. Although these have a quantitative impact across the four fiscal experiments and across the three time horizons, these effects tend to be small and, and more importantly, they do not lead to qualitative changes in the results discussed above. Further, these quantitative changes tend to go in line with intuition. Table 12 presents fiscal multipliers across different calibrations and time horizons, the results of which are discussed below.

More conservative monetary policy leads to lower fiscal multipliers as the nominal interest rate is increased in order to dampen the economy. Higher degrees of price and wage stickiness increase the scope for fiscal policy because they represent larger real rigidities in the model, and therefore larger fiscal multipliers are associated with increased calibrations of θ and ϕ_w and smaller calibrations of ϵ_w. The preference parameters impact on the response of private agents to public policy, with greater values of σ and smaller values of φ leading to bigger fiscal multipliers. Increased adjustment costs in the capital accumulation process prohibits the productive sector responding quickly to the fiscal activity and therefore adds a lag to the full impact of the shocks to be felt: this corresponds with larger fiscal multipliers being associated with smaller calibrations of η. Reducing the persistence of the fiscal shocks, either by decreasing ρ_i or increasing $\varphi_{b,i}$ $(i = \{G, T\})$, fiscal multipliers increase in the short and medium run. This happens for two main reasons: first, through reducing the persistence of the shock the expected lifetime income of the Ricardian agents falls by less, subsequently reducing the initial fall in their private consumption; and second, through reducing the persistence of the shock, there is less debt to repay and less fiscal stimulus, making the denominator in any multiplier calculation smaller. However, despite all these small nuances, the quantitative results are not significantly altered and the qualitative results remain unchanged. Moreover, fiscal policy multipliers are observed to be most sensitive to the calibration of the two parameters λ and h.

6.5 Conclusions

The model presented above provides empirically appropriate values for fiscal policy multipliers which are reflective of the entire range of estimates in the literature. These results come from reasonable assumptions on consumption behaviour, which have been empirically tested, and further which have previously been included in theoretical models. The innovation of this chapter has been to acknowledge the importance of heterogeneous agents in unison with the assumption of external habit persistence of 'catching up with the Jones', and the subsequent impact this has on the actions of fiscal authorities.

In effect, the model has introduced an element of herding behaviour or animal spirits into the dynamics of various shocks. This Keynesian concept has been discussed at length, and the current downturn is no exception (see for example Akerlof and Shiller; 2010), however previously models have failed to produce this effect. In many respects

Table 12: Chapter 6 sensitivity

	Cumulative Multipliers					
	Policy experiment 1			Policy experiment 3		
	Impact	Two years	lifetime	Impact	Two years	lifetime
Benchmark	1.302	2.335	6.862	0.572	1.839	6.843
$\lambda = h = 0.0$	0.700	0.886	1.482	0.000	0.000	0.000
$\lambda = 0.0$	0.868	0.912	1.563	0.000	0.000	0.000
$h = 0.0$	1.180	1.545	3.670	0.590	0.841	2.825
Separate habits	1.451	1.701	3.905	0.756	0.973	3.003
Ricardian habits	1.420	1.599	3.060	0.713	0.836	1.951
$\varphi_\pi = 2.5$	1.029	1.826	5.353	0.320	1.341	5.587
$\varphi_y = 0.5$	0.878	1.413	3.679	0.306	1.070	3.440
$\theta = 0.85$	1.345	2.776	7.330	0.594	2.251	7.183
$\phi_w = 250$	1.358	2.584	6.865	0.623	2.074	6.671
$\sigma = 0.5$	1.167	2.017	4.853	0.469	1.575	4.941
$\varphi = 2$	1.195	2.295	6.661	0.466	1.743	6.061
$\eta = 0.75$	1.370	2.631	6.987	0.623	2.127	6.914
$\rho_i = 0.7$	1.432	3.077	5.553	0.678	2.529	5.376
$\varphi_{b,i} = 0.05$	1.160	1.834	6.407	0.442	1.382	6.973

'Benchmark' represents the calibration discussed in Section 6.4 with $h = 0.7$ and $\lambda = 0.5$. For brevity the results from policy experiments two and four are not presented: the results are not sensitive to this. In the final two rows $i = G$ for policy experiment 1, and $i = T$ for policy experiment 3.

the assumption of a representative household trivialises many of these consumption based issues and the introduction of heterogeneous agents provides scope for many further extensions such as those presented above.

Intuitively, similar results will be provided if different heterogeneity is introduced into the model, for example through regional differences, and further research into greater agent diversity may provide interesting results. Habit persistence that breaches national boundaries is a concept not discussed above but for which is potentially true of an ever more integrated and open global economy. Empirical research into the changing nature of both habit persistence and rule-of-thumb behaviour, and their cyclical properties, may also be of interest. The consumption behaviour of individuals in response to fiscal policy is clearly an important issue in order to reflect upon the impacts of any such policy actions. This chapter has suggested that previously this has been under-represented in the literature, focusing too frequently on representative agents, and has introduced herding behaviour into an otherwise standard New Keynesian DSGE model.

Chapter 7

On the consequences of procyclical fiscal policy

7.1 Introduction

The 2008-09 global financial crisis and the subsequent downturn in the world economy has prompted policymakers in a large number of countries to enact substantial fiscal stimulus packages. Most of these recovery packages entailed provisions for bailing out the financial sector that was subject to massive losses following the onset of the crisis in 2008, raising the overall fiscal cost of intervention to unprecedented levels in most industrialized countries, especially in the US and the UK. This, in turn, led many countries to reverse the course of policy and opt for fiscal retrenchment. Others such as Greece, Ireland, Italy and Spain were forced to follow suit due to sovereign risk considerations. Such policy actions in the form of fiscal stimulus followed by fiscal austerity revitalized the debate on the desirability of countercyclical fiscal policy.

A central question underlying this policy debate is whether countercyclical policy actions (expansionary in bad times and contractionary in good times), as was sought by the fiscal stimulus packages, are likely to be effective. Although there are counter arguments against the active use of fiscal policy as a stabilization tool, such as tax smoothing arguments based on Ricardian equivalence (see for example Barro; 1979), once fiscal policy is deemed to be among the policy tool box, the case for countercyclical policy is clear. A countercyclical fiscal policy stance with policy actions against the cycle aims to act as a stabiliser by reducing output volatility and keeping growth on a steady, non-fluctuating path.

Yet, the recent return to fiscal procyclicality - austerity during the severest downturn in the post-war era - is not an isolated case. Indeed, there is widespread evidence that procyclical fiscal policies have been the norm in many developing and emerging market countries (see for example Gavin and Perotti; 1997; Kaminsky et al.; 2004; Talvi and Végh; 2005; Woo; 2009). Such evidence has been considered puzzling and hence led to an active research agenda on the sources of procyclical fiscal policy. Potential explanations that have been put forward include: borrowing constraints that restrict policymakers ability to follow countercyclical fiscal policy in bad times (see for example Gavin and Perotti; 1997); the procyclicality of capital flows that also act as borrowing constraints in bad times (Kaminsky et al.; 2004); political constraints such that fiscal pressures from multiple power groups for higher public spending in good times resulting in contractionary fiscal policy in bad times due to insufficient savings (Lane and Tornell; 1998; Lane; 2003; Talvi and Végh; 2005; Woo; 2009); and political distortions such as corruption leading to public pressure for greater public spending in good times, in order to reduce the rents available to corrupt governments (Alesina et al.; 2008).

A key aspect of the observed cyclical pattern of fiscal policy is related to its consequences for economic outcomes. It is therefore surprising that, in contrast to the wealth of studies on the sources of procyclical policy, potential consequences of such seemingly sub-optimal policies have been largely ignored in the existing literature. Although procyclical fiscal policies are widely viewed to be detrimental to macroeconomic outcomes, to the best of our knowledge, there is no systematic study of the economic costs of following such policies.[1] Given the prevalence of procyclical fiscal policy in many countries this is clearly of key relevance for both policymakers and researchers.

Motivated by the current debate on fiscal stimulus versus fiscal austerity in response to the global downturn in economic activity, representing countercyclical versus procyclical policies respectively, this paper attempts to address the following important policy question: does the cyclicality of fiscal policy have any systematic impact on economic outcomes? Put differently, does it matter whether a country adopts a procyclical fiscal policy stance rather than a countercyclical one? In trying to answer this question, we move beyond the sources of fiscal procyclicality and examine the potential consequences of such policies. We utilize an annual dataset for a large sample of 114 countries over the period 1950-2010 to construct a comprehensive set of indicators to measure the cyclical properties of fiscal policies. After establishing the direction of fiscal cyclicality, we examine the implications of the cyclicality of fiscal policy on three important indicators: output growth, volatility of output growth, and inflation.

[1] Two exceptions to this are Aghion and Marinescu (2007) and Woo (2009) both of whom find a negative correlation between economic growth and fiscal procyclicality. However, for both of these papers this is not the main focus, and in the case of the former the analysis is performed only upon 19 OECD countries, and in the case of the latter the analysis is based on whole sample averages.

Our results are clear and compelling. First, we establish that procyclical fiscal policies have indeed been a norm for the majority of countries in our sample. We do not find much evidence for the so-called 'graduation hypothesis' (Frankel et al.; 2012) that many countries have 'graduated' from fiscal procyclicality recently, which only holds for a restricted set of observations in our sample. Furthermore, our findings clearly indicate that the cyclicality of fiscal policies matters. We find that fiscally procyclical countries have lower rates of economic growth, higher rates of output volatility and higher rates of inflation. Having formally linked inferior macroeconomic outcomes to fiscal procyclicality, our results point to the importance of moving from procyclical to countercyclical fiscal policy. When combined with the scale of observed fiscal procyclicality, our findings on the consequences of procyclical fiscal policy suggest that establishing fiscal institutions to ensure countercyclical fiscal policy should be a policy priority.

The rest of the paper is organized as follows. Section 7.2 discusses the methodology and the data, derives measures of fiscal cyclicality and presents descriptive statistics. Section 7.3 relates macroeconomic outcomes in the form of output growth, output volatility and inflation to the derived cyclicality measures. Robustness checks and extensions to the benchmark estimations are presented in Section 7.4. Section 7.5 concludes.

7.2 Methodology

7.2.1 Identifying fiscal procyclicality

This paper aims to explore the consequences of procyclical fiscal policy on macroeconomic outcomes. The first necessary step in any such study is to identify the cyclical properties of fiscal policy for individual countries. Although debate exists around the choice of fiscal procyclicality statistics, there is, in general, agreement on which fiscal variable should be used in calculations. The cyclicality of fiscal policy is commonly measured by fiscal instruments such as government consumption and tax rates rather than outcomes such as fiscal balances. For example, Kaminsky et al. (2004) demonstrate that only government consumption and tax rates provide unambiguous results on the cyclical properties of fiscal policy, and given the data availability issues regarding the latter (tax rates), the former (government consumption) has been the preferred choice in existing studies.

There are two country specific procyclicality statistics widely used in the literature: the first is a composite measure (henceforth referred to as CM) which detrends data in order to focus only on the cyclical components of both government consumption and output: the discretionary reaction of fiscal authorities to the business cycle. Using a Hodrick-Prescott filter to perform this detrending the following statistic can be obtained:

$$CM = \left(\frac{1}{2}HPCorr\right) + \left(\frac{1}{2}AMP\right) \tag{7.1}$$

where $HPCorr$ is the pairwise correlation of the cyclical components of real government consumption and real GDP, and AMP is the 'amplitude' of government consumption measured as the difference between the average growth rate of real government consumption in good and bad times, where good and bad times are defined as years with above and below trend growth, respectively.[2] The amplitude is converted into a $[-1, 1]$ measure by normalising both the positive and negative results separately; this keeps the two components of the composite measure on the same scale. This statistic is calculated using government consumption and GDP data over a number of years for an individual country and provides an average measure of fiscal procyclicality for that country over the given time horizon. A positive (negative) value illustrates procyclical (countercyclical) fiscal policy; discretionary government consumption is positively (negatively) correlated with trend levels of output and/or government consumption grows more (less) in good times than in bad.

The second procyclicality statistic widely used in the literature is based on estimating a fiscal policy response function, similar to Lane (2003) and Woo (2009):

$$\Delta\log(G_{i,t}) = \alpha_i + \beta_i \Delta\log(GDP_{i,t}) + \varepsilon_{i,t} \tag{7.2}$$

where $G_{i,t}$ and $GDP_{i,t}$ represent real government consumption and real gross domestic product respectively for country i in time t, α is a constant term and the estimate of β ($\widehat{\beta}$) provides the measure of cyclicality. Equation (7.2) is estimated using ordinary least squares with correction for first order serial correlation. As with the composite measure, this statistic is calculated using data over a number of years for an individual country and provides an average measure of fiscal procyclicality for that country over the given time horizon. A positive (negative) value of $\widehat{\beta}_i$ illustrates procyclical (countercyclical)

[2] This composite measure is adapted from Kaminsky et al. (2004) who give both $HPCorr$ and AMP an equal weight of 40 per cent and inflation tax a weight of 20 per cent in the calculation of their composite measure. Our measure excludes inflation tax in order to focus on those elements the government has direct control over. Sensitivity to this omission is tested and the statistic with an inflation tax component included is strongly correlated with one where it is not: a correlation coefficient of 0.97 is obtained.

fiscal policy; there is a positive (negative) correlation between government consumption and output.

Both of these two measures have their merits and drawbacks. The use of the Hodrick-Prescott filter has the benefit of only considering cyclical components: the discretionary element of fiscal policy. However, as highlighted by Forbes and Rigobon (2002), unadjusted correlation coefficients (which represent half of the composite measure) can generate misleading results when samples have different levels of volatility: a certainty when considering cross country GDP and government consumption figures. It is also the case that the resulting correlations only measure the strength and direction of the relationship but not the responsiveness of fiscal policy to the business cycle. Moreover, the composite measure combines two separate statistics with arbitrary weighting where one of these statistics (AMP) will be sensitive to the normalisation process involved in producing it. The $\hat{\beta}$ statistic obtained by estimating equation (7.2) does not have the benefit of using detrended data and therefore will implicitly include the trend in the analysis: this may lead to an upwards bias in the estimate assuming an upward trend in both real GDP and government spending. A significant advantage of this approach, however, is that it measures the elasticity between the two variables unlike the composite measure. However, the correlation (given by the individual statistical significance of the $\hat{\beta}$ estimate) is often ignored with this measure.

We therefore propose a new method which combines the positive features of both those above: its inclusion further tests the results and conclusions obtained in the paper. This new method uses a fiscal policy response function similar to (7.2) but uses the detrended data for both government consumption and GDP used in (7.1):

$$\Delta\log\left(G_{i,t}^{CYC}\right) = \tilde{\alpha}_i + \tilde{\beta}_i \Delta\log\left(GDP_{i,t}^{CYC}\right) + \tilde{\epsilon}_{i,t} \tag{7.3}$$

where superscript 'CYC' represents the cyclical component of a variable. Equation (7.3) is estimated using ordinary least squares with correction for first order serial correlation. This estimated procyclicality statistic, which will be notated as $\widehat{\tilde{\beta}}$, takes both elements of the above statistics and measures the elasticity of the cyclical (discretionary) element of government consumption to the cyclical element of real GDP.

It has been argued that fiscal procyclicality statistics obtained through methods similar to (7.2) (and therefore (7.3)) suffer from an endogeneity issue as output growth is not exogenous to fiscal actions. However, as Lane (2003) notes, there seems no good reason why this feedback between the two variables should not be included in the analysis.[3] Also, the method is the same for each country and therefore the measures can be used relative to each other. Moreover any such feedback is dependent on the size of the fiscal multiplier which is shown to be small in developing countries (see for example Ilzetzki et al.; 2013) who are also observed to be more procyclical. Nonetheless, this discussion points to the importance of using more than one method in measuring the conduct of fiscal procyclicality, a point also emphasized by Ilzetzki and Végh (2008) in their choice of multiple methodologies in measuring the cyclical properties of fiscal policy.

7.2.2 The consequences of procyclical fiscal policy

To assess whether there is a statistically significant link between the compiled fiscal cyclicality measures and macroeconomic outcomes we estimate the following cross country panel specification:

$$M_{i,t} = \alpha + \theta FP_{i,t} + \gamma X_{i,t} + z_{i,t} \tag{7.4}$$

where $M_{i,t}$ represents a macroeconomic indicator for country i during a time interval t, $FP_{i,t}$ denotes the relevant fiscal cyclicality statistic and $X_{i,t}$ is a set of appropriate control variables. In order to examine the effect of the cyclical properties of fiscal policy on macroeconomic outcomes the data needs to reflect all phases of the business cycle. A country experiencing good times would be expected to grow faster, all other things being equal, than a country in bad times independent of the actions of the fiscal authority. As a result, we estimate the above relationship for 15-year horizons starting from 1960, which yields three periods per country: 1960-74, 1975-89 and 1990-2005. This maximises the number of observations for regressions whilst at the same time allowing for appropriate intervals for variables to be measured over.[4] Regressions of specification (7.4) are performed applying Generalised Least Squares with random effects where time dummies for each period are included. Each of the fiscal procyclicality variables obtained by applying (7.1), (7.2) and (7.3) enter the specifications separately and are tested in isolation of one another. This paper is concerned with both real and nominal economic impacts as well as levels and volatilities of variables. Therefore, the dependent variables ($M_{i,t}$) in regression (7.4) will be average growth rates, growth volatility and average levels of inflation.

[3] Lane (2003) finds a strong correlation between the procyclicality statistics obtained from fiscal policy response functions similar to (7.2) and statistics which either instrument out GDP growth or attempt to measure the cyclical properties of fiscal policy in other ways.

[4] Alesina et al. (2008) also point to the importance of observing a full business cycle in the sample and thus include at least 16 years of data for each country. The robustness of our results with respect to the interval and the start date will be tested.

The main regressor of interest in these specifications is the fiscal procyclicality statistic which when compiled using (7.2) and (7.3) is estimated with an estimated error. In order to reflect this, weighted regressions will be applied when using both the $\widehat{\beta}$ and $\widehat{\widehat{\beta}}$ statistics where the weight is the inverse of the standard error on the procyclicality coefficients in (7.2) and (7.3): each country's procyclicality statistic is obtained with its own associated error. This means that those observations for which the fiscal procyclicality statistics are estimated more precisely obtain a greater weight: this is in line with Lane (2003) and Aghion and Marinescu (2007).

7.2.3 Data

In calculating the fiscal procyclicality statistics we utilize annual data from the IMF *International Financial Statistics* (IFS) for the period 1950 to 2010 where available; in total, information from 114 countries was collected. This data source provides the broadest dataset both with respect to the countries used and the time horizon.[5] Information for the dependent and control variables are collated from a wide range of sources: Appendix F provides details of both the methods applied to the raw numbers and the original sources.

7.2.4 Descriptive statistics

The prevalence of fiscal procyclicality Table 13 presents average fiscal procyclicality measures using all three methods of identification outlined above where the statistic has been based on data from all available years for each individual country; these figures have then been aggregated across income groups as defined by the World Bank. Results presented in Table 13 allow us to make three clear observations. First, fiscal procyclicality is heavily prevalent throughout the globe. This is not only true of developing countries, as is often found, but also in high income economies; for all three

[5] The government consumption measure from the IMF IFS includes all activities that decrease the net worth of the government as defined by the IMF, which consists of compensation of employees; use of goods and services; consumption of fixed capital; interest; subsidies and grants; and social benefits. Therefore, transfer payments to both households and enterprises are included in this measure. This, however, excludes government investment in gross capital formation: sensitivity to this on a smaller dataset is performed.

fiscal procyclicality statistics across all four income groups, procyclical policy is observed on average.[6] Second, there is a negative correlation between income and fiscal procyclicality; high income countries are less procyclical than middle income countries who themselves are less procyclical than low income countries. This is a common result found in the literature and is true for all fiscal procyclicality statistics utilised in this study. Interestingly, this relationship breaks down between upper-and-lower-middle income countries who are observed to have similar degrees of fiscal procyclicality but where the lower-middle income countries, on average, have lower statistics than their upper-middle income neighbours. Third, there is a strong degree of consistency across the three fiscal procyclicality statistics. This is confirmed when reviewing the pairwise correlations across the three procyclicality statistics which are all positive and strong.[7]

TABLE 13: Fiscal procyclicality statistics

	$\hat{\beta}$		$\hat{\hat{\beta}}$		CM
	Mean	Ave(SE)	Mean	Ave(SE)	Mean
High Income	0.390	0.230	0.253	0.251	0.184
Upper middle income	0.773	0.312	0.719	0.334	0.235
Lower middle income	0.738	0.397	0.672	0.456	0.197
Low income	1.158	0.634	1.177	0.724	0.238

Income groups relate to those as classified by the World Bank. Procyclicality statistics $\hat{\beta}$, $\hat{\hat{\beta}}$ and CM are calculated over all available information for each individual country. Ave(SE) represents the mean standard errors of the $\hat{\beta}$ and $\hat{\hat{\beta}}$ statistics: note that an equivalent value for CM is not applicable as this is not estimated in the same way.

Fiscal procyclicality over time The above results establish that fiscal procyclicality has been the norm rather than an exception in many countries, based on data from 1950-2010. This section deals with the issue of how procyclicality has changed over time.

Table 14 presents average values for $\widehat{\beta}$, $\widehat{\widehat{\beta}}$ and CM, where these statistics are calculated annually over an overlapping time horizon of 20 years throughout the sample period of

[6] Moreover, these results tend to be statistically significant for the estimated parameters of $\hat{\beta}$ and $\hat{\hat{\beta}}$ as demonstrated by the the average standard error statistics in parenthesis: individually 75 (66%) and 67 (59%) statistically significant results respectively are found at at least a 10% significance level. The aggregation process to find a mean value across income groups hides the number of individual country countercyclical observations. These are (4 (11%), 1 (4%), 2 (7%), 0 (0%)) for the $\widehat{\beta}$ statistic, (11 (30%), 2 (8%), 5 (17%), 1 (5%)) for the $\widehat{\widehat{\beta}}$ statistic and (4 (11%), 2 (8%), 3 (10%), 1 (5%)) for the CM statistic, where the four figures presented represent the four income categories in descending income order and the parenthesised percentage figures represent the ratio of countercyclical observations to total observations for that income category.

[7] The correlation between $\hat{\beta}$ and $\hat{\hat{\beta}}$ is 0.938 which is stronger than those between these two and the composite measure, 0.501 and 0.468 respectively. This suggests that the difference between using equations (7.1) and (7.2) is greater than the difference arising from whether the data are detrended or not.

Table 14: Fiscal procyclicality over time for high and middle income countries

	$\hat{\beta}$ (mean)		$\hat{\hat{\beta}}$ (mean)		CM (mean)	
	High	Middle	High	Middle	High	Middle
1970s	0.205	0.517	0.148	0.548	0.101	0.161
1980s	0.280	0.676	0.204	0.623	0.143	0.245
1990s	0.267	0.730	0.208	0.700	0.182	0.337
2000s	0.379	0.733	0.291	0.724	0.130	0.277

Income groups relate to those as classified by the World Bank. 'High' represents those classified as 'High Income' countries and 'Middle' represents those countries classified as 'Middle Income' countries. Procyclicality statistics are obtained by taking an overlapping 20 year time horizon annually for every country in the sample. The statistics are then sorted by income group and decade where the end year of the 20 year time horizon is taken for the decade classification.

the data; subsequently the figures are grouped by income category and mean averages taken every decade where the end of the 20 year horizon is taken for the decade categorisation. Results presented in Table 14 allow us to derive the following conclusions. First, procyclical fiscal policy has been prevalent for all income groups throughout the time period for which data is available: in all 24 examples presented in the table positive (procyclical) statistics are obtained. Second, at all time periods for each of the three fiscal procyclicality statistics the average value of middle income countries are higher than the average value of high income countries; levels of fiscal procyclicality are negatively correlated with income. This compares with other studies in the literature and is consistent with the overall results presented in Table 13. Third, the difference between high and middle income countries' average procyclicality statistics has remained relatively constant over the sample period, suggesting a degree of comovement between the two country groups. Finally, with the exception of three cases in Table 14, the average procyclicality statistic has increased from one decade to the next suggesting countries are becoming more procyclical over time, further stressing the importance of understanding the consequences of the cyclical properties of fiscal policy.

The results presented in Table 14 go against the graduation hypothesis proposed in Frankel et al. (2012) who suggest that some developing countries are 'graduating' from procyclical policy through a movement towards countercyclical policies. In contrast, our results imply that procyclicality has been on the increase. Disaggregating the mean averages from Table 14 to country specific observations over two periods, we find that only 16% of countries that were procyclical in the first period subsequently become countercyclical in the final period. This compares to 28% of countries in Frankel et al. (2012): fewer countries are observed to be 'graduating' from procyclical fiscal policy in our sample. The reason behind this discrepancy is because Frankel et al. (2012) use different time periods to ours, comparing procyclicality statistics obtained between 1960-99 to those for the period 2000-09; when we take similar time horizons we obtain results more in line with Frankel et al. (2012). However, observing the cyclical properties of fiscal policy over only a 10-year period is statistically problematic, as explained above. Also, the recent experience of governments adopting austerity measures in bad times is likely to result in this observation of graduation to be short lived.

7.3 The consequences of procyclical fiscal policy

This section presents empirical results on the macroeconomic consequences of procyclical fiscal policy. With the prevalence of fiscal procyclicality presented above this is a significant question. As discussed above, these effects will be tested along three dimensions: average growth per capita, volatility in economic growth, and levels of inflation.

7.3.1 Economic growth

The first effect to be tested is that between the cyclical properties of fiscal policy and economic growth. A natural hypothesis is that higher levels of fiscal procyclicality would lead to lower levels of economic growth. This could occur through many plausible channels and, if true, would result in a significant cost of following such policies.

Bivariate analysis To begin this discussion we perform a bivariate comparison between fiscal cyclicality in a country and its level of growth. The most fiscally procyclical countries and the most fiscally countercyclical countries are split into different groups by percentiles. The average growth rates of these two groups are then taken and the difference across them are presented in Table 15.

TABLE 15: Fiscal procyclicality and economic growth - bivariate analysis

	Difference		
Percentile	$\hat{\beta}$	$\hat{\hat{\beta}}$	CM
10	1.112	1.331*	0.217
20	1.253***	1.190***	0.651
30	0.968***	0.883***	0.272
40	0.932***	1.072***	0.269

'Difference' is the average growth rate of the x-percentile countercyclical countries minus the average growth rates of the x-percentile procyclical countries: a positive difference means countercyclical countries have a larger growth rate. We use the standard star convention; *** signifies that the difference is statistically significant to 1% significance, ** to 5% and * to 10%.

The results are intuitive and robust; fiscally countercyclical countries grow at faster average annual rates than fiscally procyclical countries. In all twelve separate tests (at four separate percentile levels for the three different measures of fiscal procyclicality) the expected sign is delivered and in seven of these the difference is statistically significant. Moreover, these differences are economically significant, at least with respect to the $\widehat{\beta}$ and $\widehat{\widehat{\beta}}$ statistics; even at the broadest measure the top 40% most procyclical countries in our sample are observed to grow at approximately 1 percentage point less per capita per year than the top 40% most countercyclical countries. Compounded over a number of years this has a significant impact.

Growth regression In estimating the role of fiscal cyclicality on economic growth, we adopt specification (7.4) where the control variables, $X_{i,t}$, are in line with Barro (2007) and therefore include the following. To control for convergence, the log of GDP per capita at the start of the period is taken ($InitialGDP$) from Heston et al. (2009). The log average number of years of education for the total population aged 15 or over for the start of the period ($Log(Edu)$) is taken from Barro and Lee (2001). Log levels of fertility ($Log(Fert)$), measured as the number of births per women, and life expectancy at birth ($Log(Life)$), are obtained from the World Bank. The size of the public sector (SPS) is calculated using data from the IMF IFS as the ratio of government consumption to GDP and the level of openness in the economy ($Open$) is obtained from Heston et al. (2009), measured as the ratio of total exports plus imports to GDP. For the variables $Log(Fert)$, $Log(Life)$, SPS and $Open$ the annual observations are averaged over the time period of each panel. Finally, as a measure of exchange rate volatility ($ExRateVol$) the standard deviation in the nominal exchange rate between the country and the US over the period in question is calculated from data obtained from the IMF IFS. The dependent variable is the average annual growth rate in GDP per capita ($GrGDP$) taken from Heston et al. (2009), averaged over the time period.

Table 16 presents estimation results for six specifications; two for each procyclicality statistic, one with a minimum number of control variables where the number of observations is maximised and a second which includes all control variables. In all six specifications the estimated coefficient of the procyclicality statistic is negative and significant to at least the 10 per cent level, and in the case of both $\hat{\beta}$ and $\hat{\hat{\beta}}$ to the 5 per cent level or stronger. Results presented in Table 16 point to an economically and statistically significant relationship between the level of fiscal procyclicality and average economic growth: higher levels of fiscal procyclicality lead to lower levels of economic growth. This is in line with what is commonly assumed, but not tested, in the fiscal procyclicality literature and is robust to the use of different measures of

Table 16: Fiscal procyclicality and economic growth

	1	2	3	4	5	6
InitialGDP	-0.701**	-1.831***	-0.765**	-1.892***	-0.477**	-1.710***
	(0.020)	(0.000)	(0.016)	(0.000)	(0.022)	(0.000)
Log(Edu)	0.843**	0.166	0.866**	0.158	0.693***	0.064
	(0.014)	(0.565)	(0.016)	(0.591)	(0.005)	(0.805)
$\hat{\beta}$	-0.502***	-0.515**				
	(0.006)	(0.016)				
$\hat{\hat{\beta}}$			-0.457***	-0.498**		
			(0.010)	(0.012)		
CM					–1.351**	-1.080*
					(0.013)	(0.063)
Log(Fert)		-2.984***		-2.969***		-2.842***
		(0.000)		(0.000)		(0.000)
Log(Life)		3.311*		3.652*		4.042**
		(0.083)		(0.058)		(0.017)
SPS		-1.544**		-1.505**		-0.371
		(0.048)		(0.027)		(0.785)
Open		0.485		0.553*		0.746**
		(0.104)		(0.061)		(0.022)
ExRateVol		0.007		0.005		-0.002
		(0.758)		(0.813)		(0.933)
Observations	181	139	181	139	179	136
R^2	0.262	0.469	0.227	0.482	0.233	0.458

Regression is a panel of three 15 year periods: 1960-74, 1975-89 and 1990-2004. The panel is a random effects panel weighted by the inverse of the standard errors of $\hat{\beta}$ in columns (1) and (2), and the inverse of the standard errors of $\hat{\hat{\beta}}$ in columns (3) and (4), and includes an overall constant and time period dummies, neither of which are presented in the table. If the volatility of economic growth (measured as the standard deviation in annual growth statistics) is included in the regression specification it is insignificant to any reasonable level of confidence whether the fiscal procyclicality statistic is included or not. The star convention is standard and is as stated in Table 15. P-values of t-statistics are in parentheses where heteroskedastic robust standard errors have been used. Definitions of all variables can be found in Appendix F.

fiscal procyclicality. Taking, for example, the results from specification (4) in Table 16, the difference between the average level of procyclicality for a low income country compared to that of a high income country (from Table 13) is the equivalent of 0.46 percentage points in average economic growth each year.[8]

These results are in line with those presented in Woo (2009) which tests whether social polarisation is correlated with the level of fiscal procyclicality and subsequently

[8]Using a panel that starts 5 years later (1965) but which still covers time horizons of 15 years at a time, the results are amplified; the point estimates are all increased and these results are significant to the 1 per cent confidence level. Further, using a panel starting in 1960 but covering 20 year horizons provides similar results as those presented in Table 16. Also, performing the regressions for specifications (1) to (4) without applying weights provides similar results.

whether the level of fiscal procyclicality is correlated with GDP growth, in a sample of 96 countries between 1960 and 2003. Woo (2009) also finds a negative relationship between growth rates in GDP per capita and the level of fiscal procyclicality which is both economically and statistically significant. However, these results are obtained by applying fewer control variables in the analysis than above, and further, by only considering procyclicality statistics obtained using equation (7.2). Moreover, the procyclicality statistic is not time varying and as such the time horizon for the regression used in Woo (2009) are an average over 43 years. Our evidence illustrates that these results are robust to these omissions. The results are also in line with those of Aghion and Marinescu (2007) who perform a similar analysis on a panel of 19 OECD countries between 1960 and 2007. Our findings illustrate that these results also hold when this sample is extended to those countries outside the OECD.

An instrumental variable approach With the specification used for the growth regressions in Table 16 there is a potential endogeneity issue arising from the use of GDP series in the calculations of the fiscal procyclicality statistic. One way to control for this would be to instrument out the procyclicality statistic in equation (7.4). We construct a dataset comprising of various variables which have been hypothesised in the literature to cause procyclical fiscal policy (see Section 7.1) and use these to select the best instruments for each procyclicality statistic in turn.[9]

Table 17 presents the estimation results from re-estimating Table 16 where $FP_{i,t}$ is instrumented for and where only the estimate of the variable of interest is presented: benchmark figures from Table 16 also shown for comparison. The expected direction of results are observed (higher levels of fiscal procyclicality lead to lower levels of growth) and these results are statistically significant for both the $\hat{\beta}$ and $\hat{\hat{\beta}}$. Moreover, the quantitative effect becomes larger with higher values of estimated coefficients being recorded. One issue with this approach is the restricted availability of information for the instruments used further reduces the number of observations involved in the regressions, especially for less developed countries for whom data availability is more of an issue. Nonetheless, estimation results are conclusive, with a slight qualification on the CM statistics for which the explanatory power of the instruments is not as strong as the $\hat{\beta}$ and $\hat{\hat{\beta}}$ statistics.

[9]The strategy applied was to use variables associated with borrowing constraints (*IIRating*, *NumDefault*, *YrsDefault* and *PDefault*) and political constraints (*POLCON*, *XCONST*, *Polity*, *Corruption*, *Accountability*, *PoliticalStability*, *GovernmentEffectiveness*, *RegulatoryQuality* and *RuleOfLaw*), as well as other factors hypothesised in the literature (*Gini* and *FiscalVol*) to identify which of these provided the best instruments from a first stage F-test: for detailed explanations of each variable see Appendix F. The best instruments for $\hat{\beta}$ were measures of government effectiveness and institutional investor ratings; for $\hat{\hat{\beta}}$ measures of regulatory quality and institutional investor ratings; and for CM those of government effectiveness, regulatory quality and the probability of default on sovereign debt.

TABLE 17: Fiscal procyclicality and economic growth - an instrumental variable approach

	1	2	3
Benchmark - Table 16			
FP	-0.515**	-0.498**	-1.080*
	(0.016)	(0.012)	(0.063)
Instrumental Variable Approach			
FP	-3.540***	-3.425***	-7.788
	(0.008)	(0.007)	(0.111)
F-test	18.57***	22.32***	5.36***
Overidentified	0.325	0.478	0.598

Regression is a random effects panel of three 15-year periods with weights as described above in both the first and second stages of the IV estimation. Only the estimates of the variables of interest are presented; the specifications of columns 1, 2 and 3 are otherwise identical to those of columns 2, 4 and 6 in Table 16. 'F-test' presents the p-value from a first stage F-test for each procyclicality statistic and 'Overidentified' presents the p-value of a Sargan-Hansen test for overidentification where the null hypothesis is that all instruments are jointly valid. The star convention is standard and is as stated in Table 15.

Despite the existing small literature on the detrimental impact of fiscal procyclicality on economic growth no research, to our knowledge, exists on other outcomes and channels for which this relationship may run. This is the subject of the following two subsections.

7.3.2 Volatility of economic growth

The second relationship we examine is the potential link between fiscal procyclicality and the volatility of economic growth. It is straightforward to postulate that, providing fiscal policy is effective, a country that conducts procyclical policy will exacerbate the business cycle and therefore increase the volatility of growth rates in the economy.

Growth volatility regression The specification in equation (7.4) is estimated by using the standard deviation of growth rates as the dependent variable ($GDPVol$, obtained from Heston et al.; 2009). Regressors used in this specification are $InitialGDP$, $Open$, SPS and $ExRateVol$, as defined earlier. We also include $Polity$, an annual statistic measuring the degree of democracy within a country, averaged over the period in question (obtained from Henisz; 2010), and $OpenVol$ which calculates the standard deviation of the $Open$ statistic. Table 18 presents the results from the analysis.

Again the relationship is tested through subjecting it to six different specifications; two each for the three procyclicality statistics. In all specifications, the expected direction is identified and is found to be statistically significant: higher rates of fiscal procyclicality leads to greater volatility in economic growth. Using specification (4) from Table 18, the

Table 18: Fiscal procyclicality and growth volatility

	1	2	3	4	5	6
InitialGDP	-0.506	-0.071	-0.484	-0.050	-0.378	-0.076
	(0.230)	(0.839)	(0.269)	(0.890)	(0.167)	(0.786)
Open	0.854*	-1.728	0.763	-1.731	1.051***	-0.774
	(0.096)	(0.176)	(0.126)	(0.185)	(0.010)	(0.297)
Polity	-0.107**	-0.134***	-0.111**	-0.139***	-0.085**	-0.115***
	(0.037)	(0.003)	(0.039)	(0.003)	(0.011)	(0.000)
$\hat{\beta}$	0.370**	0.461**				
	(0.025)	(0.016)				
$\hat{\hat{\beta}}$			0.318*	0.493**		
			(0.058)	(0.020)		
CM					2.364***	2.418***
					(0.000)	(0.001)
SPS		-0.811		-1.039		0.709
		(0.367)		(0.219)		(0.710)
OpenVol		0.207***		0.204**		0.147***
		(0.008)		(0.013)		(0.010)
ExRateVol		-0.020		-0.021		-0.031***
		(0.363)		(0.417)		(0.003)
Observations	189	147	189	147	186	143
R^2	0.209	0.304	0.215	0.310	0.250	0.349

Regression is a panel of three 15-year periods: 1960-74, 1975-89 and 1990-2004, as above. The panel is a random effects panel weighted by the inverse of the standard errors of $\hat{\beta}$ in columns (1) and (2), and the inverse of the standard errors of $\hat{\hat{\beta}}$ in columns (3) and (4), and includes an overall constant and time period dummies, neither of which are presented in the table. The star convention is standard and is as stated in Table 15. P-values of t-statistics are in parentheses where heteroskedastic robust standard errors have been used. Definitions of all variables can be found in Appendix F.

difference between the average level of procyclicality for low income countries compared to high income countries (from Table 13) is the equivalent of increasing the standard deviation of economic growth by 10%.[10]

An instrumental variable approach Similar to the average growth specification there is a potential endogeneity problem in these growth volatility regressions. It has been argued that the volatility in growth rates may lead to higher levels of fiscal procyclicality through increased variability in the tax revenue base (Talvi and Végh; 2005). Performing a similar instrumental variable approach as in Table 17, where the fiscal procyclicality statistic is instrumented for, we find similar results to those

[10] Using a panel starting 5 years later but which still covers time horizons of 15 years at a time provides similar results both in respect to point estimates and levels of significance. Taking a panel starting from 1960 but covering 20 year horizons provides similar results as to those presented in Table 18; however, these results will be weakened by the fewer number of observations in the sample. Also, performing the regressions for specifications (1) to (4) without applying weights provides similar results.

presented in Table 18. The expected direction is observed where point estimates double on average compared to Table 18, with similar levels of significance.

7.3.3 Inflation

The above evidence suggests that fiscal procyclicality impacts on the real economy. It therefore follows that through stimulating the economy in good times a procyclical government would be expected to raise price levels, as the economy is at its potential, resulting in higher inflation. We now turn to estimating this relationship by following the specification in equation (7.4) where the dependent variable is the average transformed GDP deflator for the period. The GDP deflator, π_t, is obtained from the World Bank *World Development Indicators*, and following Cukierman et al. (1992), is transformed using $\pi_t/(1+\pi_t)$ to remove the impact of high inflation outliers: using the raw inflation figures would give undue weight to a few outliers of very high inflation rates. For independent variables $InitialGDP$, $Open$ and $ExRateVol$ are used as above and these are combined with three measures of central bank independence that are established as important determinants of inflation performance in the existing empirical literature. $Turnover$, a measure of central bank governor turnover, and CBI, an overall measure of central bank independence, are both taken from Cukierman et al. (1992) for the period 1950 to 1989. An issue with these two measures is that they do not cover the whole time period and do not vary with time. To try and combat this a third measure, CBI', is used which is a further aggregate measure of central bank independence that uses data from both Cukierman et al. (1992) and Polillo and Guillén (2005). This aggregate measure is computed across different time periods using the same methodology and we match as best as possible these periods to the ones used in our study. Estimation results are presented in Table 19.

In all six specifications the expected relationship is observed and in four of the six this relationship is significant to at least the 5 per cent level. The sign and significance of the point estimates for the fiscal procyclicality measures indicate that higher levels of fiscal procyclicality lead to higher levels of inflation, all other things being equal. This is true also after controlling for the size of the country, proxied by initial GDP, where it is observed that more prosperous economies have lower levels of inflation. There is limited availability of data for central bank independence measures, particularly in developing countries, and therefore when these are included in the regressions the number of observations are significantly reduced, and the resulting samples are dominated by high income countries. As is seen from columns (2) and (4) in Table 19, despite this lack of variability, the estimated relationship between fiscal cyclicality and inflation is robust to including central bank independence measures. Of the independence measures only

Table 19: Fiscal procyclicality and inflation

	1	2	3	4	5	6
InitialGDP	-0.055***	-0.066***	-0.055***	-0.066***	-0.040***	-0.061***
	(0.003)	(0.000)	(0.003)	(0.000)	(0.003)	(0.000)
Open	-0.002	0.018	-0.005	0.016	0.020	0.041***
	(0.956)	(0.578)	(0.893)	(0.611)	(0.532)	(0.010)
ExRateVol	0.001	0.000	0.001	-0.001	-0.000	0.000
	(0.622)	(0.859)	(0.585)	(0.713)	(0.888)	(0.930)
$\hat{\beta}$	0.046***	0.035*				
	(0.007)	(0.054)				
$\hat{\hat{\beta}}$			0.046***	0.038**		
			(0.007)	(0.034)		
CM					0.133***	0.042
					(0.008)	(0.392)
CBI'		0.278		0.319		0.105
		(0.334)		(0.248)		(0.642)
Turnover		0.248**		0.276**		0.187**
		(0.014)		(0.015)		(0.011)
CBI		-0.315		-0.360		-0.166
		(0.322)		(0.235)		(0.620)
Observations	122	65	122	66	121	66
R^2	0.131	0.530	0.132	0.534	0.151	0.500

Regression is a panel of three 15 year periods: 1960-74, 1975-89 and 1990-2004. The panel is a random effects panel weighted by the inverse of the standard errors of $\hat{\beta}$ in columns (1) and (2), and the inverse of the standard errors of $\hat{\hat{\beta}}$ in columns (3) and (4), and includes an overall constant and time period dummies, neither of which are presented in the table. The star convention is standard and is as stated in Table 15. P-values of t-statistics are in parentheses where heteroskedastic robust standard errors have been used. Definitions of all variables can be found in Appendix F.

the turnover of the central bank governor is found to be significant and this is also true when each measure is included in the specification individually, which is in line with the findings in Cukierman et al. (1992). Using specification (4) from Table 19, the difference between the average level of procyclicality for low income countries compared to high income countries (from Table 13) is the equivalent of increasing inflation rates by 4 percentage points.[11]

[11] Using a panel starting 5 years later but which still cover time horizons of 15 years provides similar results as those presented in Table 19. Also, performing the regressions for specifications (1) to (4) without applying weights provides similar results.

7.4 Further extensions and robustness checks

7.4.1 The level of development

The results presented above are intuitive and conclusive: fiscal procyclicality has detrimental effects on macroeconomic outcomes. An interesting aspect of this relationship is related to whether this detrimental effect is stronger in some countries than others. This section looks to investigate this question by examining the results across different levels of development. It does this through including in all the specifications from Section 7.3 an additional interaction variable which is the product of the fiscal procyclicality statistic and the log of the initial GDP used to represent the level of development within a country.

Table 20 presents this analysis where only the estimate of the variables of interest in those specifications which include all control variables have been included. The data exhibits a high degree of collinearity between the fiscal procyclicality and this interaction variable which subsequently increases standard errors.[12] We therefore conduct a test to see whether both the coefficient attached to the procyclicality statistic and the interaction variable are jointly significant.

TABLE 20: Fiscal procylicality and the level of development

	1	2	3
Growth			
FP	-2.899*	-2.366	-6.385
	(0.070)	(0.128)	(0.203)
FP×InitialGDP	0.280	0.220	0.617
	(0.134)	(0.226)	(0.286)
Joint significance	0.008***	0.011**	0.105
Growth volatility			
FP	2.039	2.528	1.081
	(0.326)	(0.195)	(0.857)
FP×InitialGDP	-0.181	-0.234	-0.159
	(0.444)	(0.294)	(0.823)
Joint significance	0.131	0.069*	0.005**

Regression is a random effects panel of three 15 year periods with weights as described above. Only the estimates for the variables of interest are presented: the specifications of columns 1, 2 and 3 are otherwise identical to those of columns 2, 4 and 6 in Tables 16, 18 and 19. Joint significance relates to the p-value of a F-test of joint significance of both the nominal procyclicality statistic and the interaction statistic. The star convention is standard and is as stated in Table 15.

[12] This collinearity results because, as seen in Tables 1 and 2, lower income countries tend to have higher levels of fiscal procyclicality, resulting in a negative correlation between the two variables.

The results from Table 20 suggest that the detrimental effects of fiscal procyclicality on growth and growth volatility is diminishing the more developed the country is. This inference follows from the opposite coefficients attached to the interaction variables compared with the nominal variables in each case, suggesting that as the country gets richer, the impact of procyclical fiscal policies are diminished.[13] These results are similar in nature to Aghion and Marinescu (2007) who find in their sample of 19 OECD countries that countercyclical fiscal policy has a more beneficial impact on growth the lower the level of financial development in the country. This particular finding is of significant interest because it is the poorer countries who are observed to be the most procyclical (see Table 13) and therefore it is for these countries that such policy is suboptimal. Fiscal procyclicality in higher income countries is still estimated to have detrimental effects, albeit with a smaller impact.

7.4.2 Government investment

The variable used to derive fiscal procyclicality statistics was government consumption which includes all disbursements made by the government including transfers and debt interest servicing, but excluding those which contribute to gross capital formation (government investment). This was used in order to derive the broadest dataset possible both with respect to countries and time horizon. The OECD *Economic Outlook Database* provides detailed disaggregated data for government expenditure from 1970 including government investment in gross capital formation: this can be used as a sensitivity check for the above results. Government investment is seen to be procyclical on average in OECD countries and is also observed to be more procyclical than general government consumption: these two results are in line with Lane (2003). Including fiscal procyclicality statistics derived from government expenditure incorporating investment into the regression specifications from Section 7.3 provides similar significant results for the detrimental impact of procyclical fiscal policy on both economic growth and inflation. In general the coefficients attached to fiscal procyclicality increase but so too do the standard errors association with these statistics: this latter result is to be expected given the small sample size.[14]

[13] Performing the same analysis for inflation does not provide a similar interaction effect, although this may be driven by the restricted data on control variables in Table 19 resulting in the regression being limited to only high income countries.

[14] The compiled data set contains only 29 countries over a shorter time horizon. The results for the detrimental impact of fiscal procyclicality on the volatility of economic growth is not found in this small sample of developed countries.

7.5 Concluding remarks

The results presented above provide a clear narrative: procyclical fiscal policy is detrimental to economic growth, output volatility and inflation. These effects are larger in less developed economies, those countries which are found to be more fiscally procyclical. An interesting question these findings pose is what are the channels through which these results are observed? One possible interpretation is that the impact of fiscal policy is asymmetric over the course of the business cycle. Recent research has suggested that fiscal policy is more effective in downturns compared with good times (see for example Auerbach and Gorodnichenko; 2012). Under this hypothesis a government conducting countercyclical fiscal policy is using expansionary measures when they have their greatest impact on the aggregate economy: when multipliers are high (in a recession) expansionary effects are amplified. In the case of procyclical fiscal policy the results are reversed, expansionary policy is used when it's effectiveness is at its lowest. Under this policy the main impact of expansionary policy will be on prices as the economy is close to capacity and therefore cannot increase output, which further supports our empirical findings on inflation.

A second potential channel through which procyclical policies may influence the real economy is through their impact on the probability of financial crises. If fiscal procyclicality is found to raise the probability of a financial crisis, that would establish a negative relationship between the procyclicality of fiscal policies and economic growth, given the well-established unfavourable output consequences of financial crises (see for example Reinhart and Rogoff; 2014). It is commonly hypothesised in the literature that this causation works in other direction with procyclical policies being caused by higher probabilities of financial crisis, as those countries thought to be vulnerable find it hard to borrow in bad times: however this mechanism is likely to feedback on itself. From our data we found more evidence for the first stage of directional causality (increased probability of financial crises leading to higher levels of procyclicality) than of the second stage, but this is nevertheless another potential mechanism that may be at work.[15]

Another explanation of the results found is that fiscal countercyclicality is a proxy for good general macroeconomic management. As is observed in the empirical results, there are detrimental consequences to procyclical fiscal policy and therefore a government which conducts countercyclical policy is presenting a signal to agents that they are good stewards of the economy. Research has shown that democratic institutions play

[15]Granger causality tests were performed between our fiscal procyclicality statistics and measures used to proxy the probability of financial crises taken from Reinhart (2010): *IIRating*, *NumDefault*, *YrsDefault* and *PDefault*) definitions of which can be found in Appendix F.

a significant role in raising economic growth within a country (see for example Barro; 2007) and therefore it seems reasonable that the actions of these institutions, and not just their presence, is also of importance. Countercyclical governments are able to both state and credibly demonstrate a commitment to good fiscal and economic management. A government which conducts procyclical policy in good times loses this credibility and with it the advantages which come from it. A fiscal authority that provides the reputation of strong countercyclical measures would in time find that their reputation did the work for them as rational agents would expect the economy not to fluctuate as much and therefore their private actions will reinforce this. An economy in such a situation would feasibly have higher levels of trend growth, lower levels of fluctuations around this trend and steadier, lower rates of inflation.

Having formally linked inferior macroeconomic outcomes in the form of lower output growth, higher output volatility and higher inflation to fiscal procyclicality, our results point to the importance of moving from procyclical to countercyclical fiscal policy. When combined with the scale of fiscal procyclicality, as established in the first part of this chapter, our findings on the consequences of procyclical fiscal policy suggest that establishing fiscal institutions to ensure countercyclical fiscal policy should be a policy priority. Indeed, the recent global crisis experience has clearly indicated that countries with stronger fiscal institutions were also among those better able to avoid the worst effects of the crisis.

Chapter 8

Conclusions

This thesis has demonstrated that countercyclical fiscal policy can be used as an effective policy tool, achieving multiple objectives simultaneously. From a redistributive perspective, the thesis has presented theoretical results from a DSGE model with heterogeneous agents based on their access to capital markets, developed in Chapter 2. This chapter presented the empirical rational for such heterogeneity and subsequently developed a benchmark model from which both simulation and algebraic analysis can be performed. It was shown that such models have unique properties which are determined by the share of asset market non-participation.

This model was applied in Chapter 3 to demonstrate that exogenous shocks have different impacts on households depending on their access to credit: those who have access are able to smooth the impact of business cycles, whereas those without cannot. These results were derived through algebraic proof, dynamic simulation and through a derivation of disaggregated welfare criteria. The results from Chapter 3 also demonstrated how credit-constrained agents can insulate the unconstrained, and at times the aggregate economy, through their labour market decisions. These results reconcile with, and add to, the heterogeneous agent literature finding that business cycles disproportionately impact the poor, low skilled and unemployed, and an empirical investigation demonstrated that there is a negative correlation between growth in the economy and income inequality.

Chapter 4 demonstrated that countercyclical fiscal policy could be used to minimise the inequality across agents resulting from business cycles, a result again developed through both the derivation of algebraic properties and through dynamic simulation. Polarized preferences were observed between those agents with access to credit and those without, with the latter gaining from countercyclical policy at the expense of the former. The impact of policy was seen in a near zero sum game with the gains of one agent being (nearly) netted off against the losses of another: the polarized preferences across agents were observed both in respect to the responsiveness of the fiscal interaction and the speed with which resulting debt is repaid. These results were observed both specifically during a downturn and also over the course of the business cycle where, as in Chapter 3, the insulating affect of credit-constrained agents was observed.

The nature of the results from Chapter 4 were extended in Chapter 5 using a bigger model to specifically investigate the positive and normative consequences of austerity. A trade off was observed between the efficiency and equity of austerity, with policies focusing on government spending reductions having the smallest impact on output, average incomes and welfare, but having the greatest impact on the distribution of incomes and welfare. Tax based austerity, on the other hand, tends to be more detrimental to both output, income and welfare, but in a more equitable way. These impacts, when considering the lifetime of the fiscal consolidation, are sensitive to the composition of austerity but are largely unaffected by its speed; when considering shorter time horizons, faster austerity leads to bigger immediate impacts. These results were seen to be magnified when consolidation is performed at the monetary zero lower bound for those policies which are inflationary when expansionary: however, for those policies which increase taxes in production, the positive and normative consequences of austerity are improved at the zero lower bound as they generate inflationary pressure.

From an aggregate perspective Chapter 6 presented results demonstrating how large theoretical fiscal multipliers could be achieved through combing the two assumptions of credit-constrained consumers and external habit persistence. As hand-to-mouth consumers are more responsive to fiscal intervention, policy multipliers are increased as their behaviour is imitated by Ricardian agents. In effect, the combination of assumptions introduced an element of herding behaviour into the dynamics of various shocks in an otherwise standard DSGE model.

Finally, the empirical effectiveness of fiscal policy was addressed in Chapter 7 by considering the importance of the cyclicality of policy, in a panel of 114 countries over a 60 year time horizon. Countercyclical policy was seen to improve economic growth, growth volatility and inflation, and this improvement was stronger in developing countries. However, the empirical results in Chapter 7 also imply that most economies do not use countercyclical fiscal policy, a result supported by the existing literature. The most generous interpretation of Table 13, for example, would conclude that only 19 countries conducted countercyclical fiscal policy on average between the period of 1950 to 2010. Moreover, unlike the 'graduation' results of Frankel et al. (2012), this thesis suggests that fiscal procyclicality has been increasing over time. Fiscal procyclicality is just one of many demonstrations in the literature of how fiscal policy is conducted inappropriately, and the intuitive concept that political considerations dominate policy decisions made predominantly by elected officials poses problems for its future conduct.

Removing these political objectives from policy making would appear to be a priority and the successful results from the movement to central bank independence would support this. Indeed, actions in countries such as Canada, Hungary, Slovenia, Sweden and the United Kingdom in setting up 'Fiscal Councils' to oversee policy makers and forecasts which have been promoted by the IMF, the OECD and the European Council have gone some way to doing this. However, there still exists debate as appropriate conduct for policy and, although the results from this thesis would support arguments for active countercyclical policy, more research into these results are needed. Further, the improvements made in the conduct of monetary policy have made the use of fiscal policy somewhat obsolete, at least up until 2008, where it was commonly believed that controlling the interest rate was sufficient macroeconomic policy. Further research into when fiscal policy is most effective, when monetary policy becomes ineffective, and the interaction between these two would also appear warranted. The research literature on the monetary zero lower bound contributes to this, but there are still issues arising from the current downturn to warrant further analysis.

There exists critiques inherent to fiscal policy such as recognition, decision and implementation lags for which monetary policy is still less exposed. Perhaps the most imminent concern however is that fiscal policy is subject to a flow constraint which limits future potential use, at least for those countries with existing high levels of debt. Moreover, past conduct of fiscal policy would exert credibility problems on the future conduct of policy. The theoretical models used in this thesis would imply that a fiscal authority who could credibly commit to countercyclical policy would find some of their work done for them as rational agents would anticipate a downturn to be accompanied by expansionary policy, therefore expecting a smaller fall in output, which would subsequently be partially fuelled by the actions of private agents. Previously, politicians have tried to buy this credibility through setting fiscal rules, such as the Golden rule in the UK and the Stability and Growth Pact for those countries in the Eurozone, however, these have been shown to fail. A move towards more independent decision making on the conduct of fiscal policy, free from political motives, used when most needed and most effective would seem a logical next step in the evolution in macroeconomic policy. However, whether politicians would be willing to forgo this power, and whether the electorate would allow such decisions to be made by unelected officials, is a political question of importance: certainly the recent debates in Europe have suggested that fiscal sovereignty is highly valued. However, if discretionary fiscal policy is still applied in such a way that it is having a detrimental impact on both the aggregate and disaggregate economy, it would suggest that until this can be rectified it should not be used at all.

Appendix A

Appendices to Chapter 2

A.1 Log-linear conditions

The model is solved by deriving log-linear approximations of the key optimality conditions around the non-stochastic steady state with zero inflation and zero government debt. Log-linearising (2.4), (2.5), (2.6), (2.7), (2.9), (2.10), (2.11), (2.13), (2.17), (2.18) and (2.19) respectively provides the following conditions:

$$\varphi n_t^R + \sigma c_t^R = w_t - p_t \tag{A.1}$$

$$c_t^R = E_t \left\{ c_{t+1}^R \right\} - \frac{1}{\sigma} \left(r_t - E_t \left\{ \pi_{t+1} \right\} - E_t \left\{ \Delta \varepsilon_{t+1}^b \right\} \right) \tag{A.2}$$

$$c_t^{NR} = \frac{N^{NR} W}{C^{NR} P} \left(n_t^{NR} + w_t - p_t \right) - \frac{Y}{C^{NR}} \widehat{t}_t^{NR} \tag{A.3}$$

$$\varphi n_t^{NR} + \sigma c_t^{NR} = w_t - p_t \tag{A.4}$$

$$y_t = \varepsilon_t^a + (1 - \alpha) n_t \tag{A.5}$$

$$\pi_t = (1 - \theta) \left(p_t^* - p_{t-1} \right) \tag{A.6}$$

$$p_t^* - p_{t-1} = \left(1 - \theta\beta^R\right) \sum \left(\theta\beta^R\right)^k E_t \left\{ mc_{t+k|t}^r + \varepsilon_t^\mu + (p_{t+k} - p_{t-1}) \right\} \tag{A.7}$$

$$\widehat{b}_{t+1} = (1 + \rho_R) \left[\widehat{b}_t + \widehat{g}_t - \widehat{t}_t \right] \tag{A.8}$$

$$c_t = (1 - \lambda)\, c_t^R + \lambda c_t^{NR} \tag{A.9}$$

$$n_t = (1 - \lambda)\, n_t^R + \lambda n_t^{NR} \tag{A.10}$$

$$y_t = \gamma_c c_t + \widehat{g}_t \tag{A.11}$$

where $E_t \left\{ mc_{t+k|t}^r \right\}$ is the expected real marginal cost in period $t+k$ of a firm who last set their price in period t, and $\gamma_x = X/Y$ represents the share of variable X to steady state output Y. These equations combine with the log-linear policy rules for the path of the nominal interest rate, government spending and taxes, (2.12), (2.14) and (2.15) respectively, to close the system.

A.2 The non-linear model

The non-linear version of the model can be summarised with (2.4), (2.5), (2.6), (2.7), (2.9), (2.10), (2.13), (2.17), (2.18) and (2.19), with non-linear versions of the monetary and fiscal rules:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\Pi}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y}\right)^{\varphi_y} \varepsilon_t^r$$

$$\frac{\widehat{G}_t}{\widehat{G}} = \left(\frac{Y_t}{Y}\right)^{\varphi_g} \left(\frac{\widehat{B}_t}{\widehat{B}}\right)^{\varphi_{b,g}}$$

$$\frac{\widehat{T}_t}{\widehat{T}} = \left(\frac{Y_t}{Y}\right)^{\varphi_T} \left(\frac{\widehat{B}_t}{\widehat{B}}\right)^{\varphi_{b,T}}$$

and through decomposing the pricing problem of firms (2.11):

$$X_{1,t} = \Lambda_t MC_t Y_t + \beta^R \Pi_{t+1}^{\epsilon} X_{1,t+1} \tag{A.12}$$

$$X_{1,t} = \Lambda_t \Pi_t^* Y_t + \beta^R \theta \Pi_{t+1}^{\epsilon-1} \frac{\Pi_t^*}{\Pi_{t+1}^*} X_{2,t+1} \tag{A.13}$$

$$\epsilon X_{1,t} = (\epsilon - 1) X_{2,t} \tag{A.14}$$

where $X_{1,t}$ represents the first expression in (2.11) and $X_{2,t}$ the second expression, and where Λ_t represents the Lagrangian-multiplier attached to the first-order condition of Ricardian households with respect to bonds.

In order to find the steady state values in the non-linear model, prices can be normalised to one as can employment. From this, equations (A.12), (A.13) and (A.14) can be used to solve for marginal costs, which can subsequently be used to solve for real wages and consumption:

$$MC = \frac{\epsilon - 1}{\epsilon}$$

$$\frac{W}{P} = MC(1-\alpha)N^{-\alpha}$$

$$C = \left(\frac{W}{P} N^{-\varphi}\right)^{\frac{1}{\sigma}}$$

and where the normalisation of employment sets output to one, and where government spending (and therefore lump sum taxes) are given by the excess of output to consumption.

A.3 Deriving the aggregate demand condition with perfectly competitive labour markets

To derive the aggregate demand condition the household optimisation results and labour market conditions are combined to obtain a weighted average Euler equation that describes the path of aggregate private consumption in the economy. Note that (A.9) and (A.10) can be manipulated to provide:

$$c_t^{NR} = \frac{c_t - (1-\lambda)\, c_t^R}{\lambda}$$

$$n_t^{NR} = \frac{n_t - (1-\lambda)\, n_t^{NR}}{\lambda} \tag{A.15}$$

and through combining these two results with (A.4) gives:

$$w_t - p_t = \varphi\left(\frac{n_t - (1-\lambda)\, n_t^{NR}}{\lambda}\right) + \sigma\left(\frac{c_t - (1-\lambda)\, c_t^R}{\lambda}\right)$$

Which once simplified provides the condition that:

$$w_t - p_t = \varphi n_t + \sigma c_t \tag{A.16}$$

Combining the above and (A.15) provides:

$$n_t^{NR} = \frac{\varphi n_t + \sigma c_t - \sigma c_t^{NR}}{\varphi}$$

And substituting this into the non-Ricardian consumption function (A.3) gives:

$$c_t^{NR} = \frac{N^{NR}W}{C^{NR}P}\left(\frac{1+\varphi}{\varphi}\left(\varphi n_t + \sigma c_t\right) - \frac{\sigma c_t^{NR}}{\varphi}\right) - \frac{Y}{C^{NR}}\widehat{t}_t^{NR} \tag{A.17}$$

To simplify this expression, note that the model assumes $C = C^{NR} = C^R$ and therefore $Y/C^{NR} = Y/C = (\gamma_c)^{-1}$. Moreover, note that in steady state labour gets a return of its marginal product net of the monopolistically competitive firms' markup. Algebraically, $N^{NR}W/P = (1-\alpha)Y/(1+\mu)$ and therefore $N^{NR}W/C^{NR}P = (1-\alpha)Y/C^{NR}(1+\mu) = (1-\alpha)Y/C(1+\mu) = (1-\alpha)/(1+\mu)\gamma_c$. Substituting this into the above provides:

$$c_t^{NR} = \frac{(1-\alpha)}{(1+\mu)\gamma_c}\left(\frac{1+\varphi}{\varphi}\left(\varphi n_t + \sigma c_t\right) - \frac{\sigma c_t^{NR}}{\varphi}\right) - \frac{1}{\gamma_c}\widehat{t}_t^{NR}$$

Simplifying this by combining all like terms and rearranging provides:

$$c_t^{NR} = \frac{(1-\alpha)(1+\varphi)}{\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)}\left(\varphi n_t + \sigma c_t\right) - \frac{\varphi(1+\mu)}{\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)}\widehat{t}_t^{NR}$$

Finally, the Euler equation describes intertemporal consumption across time periods; therefore multiplying this expression by $\left(1 - L^{-1}\right)$ where L is the lag-operator, the following non-Ricardian intertemporal consumption function is obtained:

$$\begin{aligned}
\left[c_t^{NR} - E_t\left\{c_{t+1}^{NR}\right\}\right] &= \frac{(1-\alpha)(1+\varphi)}{\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)}\left[\sigma\left(c_t - E_t\left\{c_{t+1}\right\}\right) - \varphi E_t\left\{\Delta n_{t+1}\right\}\right] \\
&\quad + \frac{\varphi(1+\mu)}{\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)} E_t\left\{\widehat{t}_{t+1}^{NR}\right\} \qquad \text{(A.18)}
\end{aligned}$$

Combining (A.18) with the corresponding consumption function for Ricardian households (A.2) and the log-linear condition for aggregate consumption (A.9), and simplifying the resulting expression provides the aggregate Euler equation for the economy (under the assumption of perfectly competitive labour markets):

$$\begin{aligned}
c_t &= E_t\left\{c_{t+1}\right\} - \gamma_c^{-1}\Theta_A^{PC}\left(r_t - E_t\left\{\pi_{t+1}\right\} - E_t\left\{\Delta\varepsilon_{t+1}^b\right\}\right) \\
&\quad -\gamma_c^{-1}(1-\alpha)\Theta_B^{PC} E_t\left\{\Delta n_{t+1}\right\} + \gamma_c^{-1}\Theta_C^{PC} E_t\left\{\triangle\widehat{t}_{t+1}^{NR}\right\} \\
\Theta_A^{PC} &= \gamma_c\left(1-\lambda\right)\frac{1}{\sigma}\left(\varphi(1+\mu)\gamma_c + \sigma\left(1-\alpha\right)\right)\Gamma^{PC} \\
\Theta_B^{PC} &= \gamma_c\varphi\lambda\left(1+\varphi\right)\Gamma^{PC} \\
\Theta_C^{PC} &= \gamma_c\varphi\lambda(1+\mu)\Gamma^{PC} \\
\Gamma^{PC} &= \left[\varphi(1+\mu)\gamma_c + \sigma\left(1-\alpha\right)\left[1-\lambda\left(1+\varphi\right)\right]\right]^{-1}
\end{aligned}$$

Within this Euler equation, consumption can be substituted out using the goods market clearing condition (A.11), and employment can be substituted out using the production function (A.5). Performing this, and simplifying the resulting expression provides the result:

$$\begin{aligned}
y_t &= E_t\left\{y_{t+1}\right\} - \Phi^{PC} E_t\left\{\triangle\widehat{g}_{t+1}\right\} - \Phi^{PC}\Theta_A^{PC}\left(r_t - E_t\left\{\pi_{t+1}\right\} - E_t\left\{\Delta\varepsilon_{t+1}^b\right\}\right) \\
&\quad + \Phi\Theta_B E_t\left\{\Delta\varepsilon_{t+1}^a\right\} + \Phi^{PC}\Theta_C^{PC} E_t\left\{\triangle\widehat{t}_{t+1}^{NR}\right\} \\
\Phi^{PC} &= \frac{(\Gamma^{PC})^{-1}}{(\Gamma^{PC})^{-1} - \gamma_c\varphi\lambda\left(1+\varphi\right)}
\end{aligned}$$

A.4 Deriving the aggregate demand condition with imperfectly competitive labour markets

As above, an aggregate labour supply curve (in log-linear terms) can be derived and is given by:

$$w_t - p_t = \sigma c_t + \varphi n_t$$

As in Appendix A.3 this can be substituted into the non-Ricardian consumption function (A.3), noting that $n_t^{NR} = n_t$, which can be multiplied by $\left(1 - L^{-1}\right)$ and combined with the Ricardian Euler equation (A.2) to give an aggregate Euler equation. This in turn can be combined with the goods market clearing condition (A.11) to give aggregate demand:

$$\begin{aligned}
y_t &= E_t\left\{y_{t+1}\right\} - \Phi^{IC} E_t\left\{\triangle\widehat{g}_{t+1}\right\} - \Phi^{IC}\Theta_A^{IC}\left(r_t - E_t\left\{\pi_{t+1}\right\} - E_t\left\{\Delta\varepsilon_{t+1}^b\right\}\right) \\
&\quad + \Phi^{IC}\Theta_B^{IC} E_t\left\{\Delta\varepsilon_{t+1}^a\right\} + \Phi^{IC}\Theta_C^{IC} E_t\left\{\triangle\widehat{t}_{t+1}^{NR}\right\} \\
\Phi^{IC} &= \frac{\left(\Gamma^{IC}\right)^{-1}}{\left(\Gamma^{IC}\right)^{-1} - \gamma_c\lambda\left(1+\varphi\right)} \\
\Theta_A^{IC} &= \gamma_c^2\left(1-\lambda\right)\frac{1}{\sigma}(1+\mu)\Gamma^{IC} \\
\Theta_B^{IC} &= \gamma_c\lambda\left(1+\varphi\right)\Gamma^{IC} \\
\Theta_C^{IC} &= \gamma_c\lambda(1+\mu)\Gamma^{IC} \\
\Gamma^{IC} &= \left[(1+\mu)\gamma_c - \lambda\sigma\left(1-\alpha\right)\right]^{-1}
\end{aligned}$$

A.5 Deriving the New Keynesian Phillips curve

The New Keynesian Phillips curve can be derived by combining the log-linear equations for the production sector, (A.5), (A.6) and (A.7). The first step is to derive an expression that relates the individual firms real marginal cost, to the economy-wide average real marginal cost. Observe that the economy's average real marginal cost (MC_t^r) is given by:

$$MC_t^r = \frac{W_t/P_t}{MPN_t}$$

where MPN_t is the marginal product of labour at time t which once log-linearised provides:

$$mc_t^r = (w_t - p_t) - mpn_t$$

and, note that the marginal product of labour is given by:

$$MPN_t = \frac{\partial Y_t(j)}{\partial N_t(j)} = \frac{\partial (N_t(j))^{1-\alpha}}{\partial N_t(j)} = (1-\alpha)\varepsilon_t^a (N_t(j))^{-\alpha}$$

Which once log-linearised provides:

$$mpn_t = \varepsilon_t^a - \alpha n_t$$

Substituting these two expressions together gives:

$$mc_t^r = (w_t - p_t) + \alpha n_t - \varepsilon_t^a$$

Next, note that the log-linear production function (A.5) can be rearranged to provide:

$$n_t = \frac{y_t - \varepsilon_t^a}{1-\alpha}$$

And substituting this into the above gives:

$$mc_t^r = (w_t - p_t) + \frac{\alpha}{1-\alpha} y_t - \frac{1}{1-\alpha}\varepsilon_t^a \tag{A.19}$$

Performing the same task for the individual firm's real marginal costs provides:

$$mc_{t+k|t}^r = (w_{t+k} - p_{t+k}) + \frac{\alpha}{1-\alpha} y_{t+k|t} - \frac{1}{1-\alpha}\varepsilon_{t+k}^a$$

And therefore:

$$
\begin{aligned}
mc^r_{t+k|t} - mc^r_{t+k} &= \left[(w_{t+k} - p_{t+k}) + \frac{\alpha}{1-\alpha} y_{t+k|t} \right] \\
&\quad - \left[(w_{t+k} - p_{t+k}) + \frac{\alpha}{1-\alpha} y_{t+k} \right] \\
mc^r_{t+k|t} &= mc^r_{t+k} + \frac{\alpha}{1-\alpha} \left(y_{t+k|t} - y_{t+k} \right)
\end{aligned}
$$

Using (2.8) to derive the expected demand for the monopolistically competitive firm in period $t+k$ who last reset their price in period t, provides:

$$
y_{t+k|t} - y_{t+k} = -\epsilon \left(p^*_t - p_{t+k} \right)
$$

And substituting this into the above gives:

$$
mc^r_{t+k|t} = mc^r_{t+k} - \frac{\alpha\epsilon}{1-\alpha} \left(p^*_t - p_{t+k} \right)
$$

Substituting this expression into the log-linear price setting rule for the intermediate goods firms (A.7), simplifying the resulting expression, and subtracting p_{t-1} from both sides provides:

$$
\begin{aligned}
p^*_t - p_{t-1} &= \left(1 - \beta^R \theta\right) \Theta \sum_{k=0}^{\infty} \left(\theta \beta^R\right)^k E_t \left\{ mc^r_{t+k} + \varepsilon^\mu_t \right\} \\
&\quad + \left(1 - \beta^R \theta\right) \sum_{k=0}^{\infty} \left(\theta \beta^R\right)^k E_t \left\{ p_{t+k} - p_{t-1} \right\}
\end{aligned}
$$

where:

$$
\Theta = \frac{1-\alpha}{1-\alpha+\alpha\varepsilon}
$$

And note that through rearranging the above, the following difference equation can be derived:

$$
p^*_t - p_{t-1} = \beta^R \theta E_t \left\{ p_{t+1} - p_t \right\} + \left(1 - \beta^R \theta\right) \Theta \left(mc^r_t + \varepsilon^\mu_t \right) + \pi_t
$$

Next, the inflation dynamics expression (A.6) can be rearranged to provide:

$$p_t^* - p_{t-1} = \frac{\pi_t}{1-\theta}$$

and substituting this into the above, and simplifying the result provides the solution:

$$\begin{aligned}
\pi_t &= \beta^R E_t\left\{\pi_{t+1}\right\} + \omega\left(mc_t^r + \varepsilon_t^\mu\right) \\
\omega &= \Theta\frac{(1-\theta)\left(1-\beta^R\theta\right)}{\theta}
\end{aligned}$$

Finally, the expression for the real marginal cost can be calculated by combining (A.19) with the aggregate household labour supply (A.16) and simplifying the resulting expression to give:

$$mc_t^r = y_t\left[\frac{\sigma}{1-\gamma_g} + \frac{\varphi+\alpha}{1-\alpha}\right] - \widehat{g}_t\left[\frac{\sigma}{1-\gamma_g}\right] - \varepsilon_t^a\left[\frac{1+\varphi}{1-\alpha}\right]$$

A.6 Derivations for Proposition 2

Perfectly competitive labour markets

To aid notation, let $\Gamma^{\prime,PC} = \left(\Gamma^{PC}\right)^{-1} - \gamma_c\varphi\lambda\left(1+\varphi\right)$ which is the denominator of Φ^{PC}.

The first condition in the proof of Proposition 2: Differentiating Φ^{PC} with respect to λ provides:

$$\frac{\partial\Phi^{PC}}{\partial\lambda} = \frac{\left(\Gamma^{PC}\right)^{-1}\left[\sigma(1-\alpha)(1+\varphi) + \gamma_c\varphi(1+\varphi)\right]}{\left(\Gamma^{\prime,PC}\right)^2} - \frac{\sigma(1-\alpha)(1+\varphi)}{\Gamma^{\prime,PC}}$$

which is positive if:

$$\left(\Gamma^{PC}\right)^{-1}\left[\sigma(1-\alpha)(1+\varphi) + \gamma_c\varphi(1+\varphi)\right] > \sigma(1-\alpha)(1+\varphi)\Gamma^{\prime,PC}$$

which after cancelling and combining like terms provides:

$$\gamma_c\varphi(1+\varphi)\left[\left(\Gamma^{PC}\right)^{-1} + \lambda\right] > 0$$

which we know to be true for all possible calibrations, and provides the first condition in the proof of Proposition 2.

The second condition in the proof of Proposition 2: Differentiating $\Phi^{PC}\Theta_A^{PC}$ with respect to λ provides:

$$\begin{aligned}\frac{\partial \Phi^{PC}\Theta_A^{PC}}{\partial \lambda} &= \frac{(1-\lambda)\left[\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)\right]\left[\sigma(1-\alpha)(1+\varphi) + \gamma_c\varphi(1+\varphi)\right]}{\left(\Gamma^{\prime,PC}\right)^2\sigma} \\ &\quad - \frac{\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)}{\left(\Gamma^{\prime,PC}\right)\sigma}\end{aligned}$$

which is positive if:

$$\begin{aligned}(1-\lambda)\left[\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)\right]\left[\sigma(1-\alpha)(1+\varphi) + \gamma_c\varphi(1+\varphi)\right] \\ > \left(\varphi(1+\mu)\gamma_c + \sigma(1-\alpha)\right)\Gamma^{\prime,PC}\end{aligned}$$

which after cancelling and combining like terms provides:

$$\sigma(1-\alpha) + \gamma_c(1+\varphi) > (1+\mu)\gamma_c$$

which is true providing $\lambda < \lambda^*$, and provides the second condition in the proof of Proposition 2.

The third and fourth condition in the proof of Proposition 2: Finally differentiating Γ^{PC} with respect to λ provides:

$$\frac{\partial \Gamma^{PC}}{\partial \lambda} = \sigma(1-\alpha)(1+\varphi)\left(\Gamma^{PC}\right)^2$$

which we know to be positive providing $\lambda < \lambda^*$ and therefore the third and fourth conditions in the proof in Proposition 2 easily follow.

Imperfectly competitive labour markets

To aid notation, let $\Gamma^{\prime,IC} = \left(\Gamma^{IC}\right)^{-1} - \gamma_c\lambda\left(1+\varphi\right)$ which is the denominator of Φ^{IC}.

The first condition in the proof of Proposition 2: Differentiating Φ^{IC} with respect to λ provides:

$$\frac{\partial \Phi^{IC}}{\partial \lambda} = \frac{\left(\Gamma^{IC}\right)^{-1}\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]}{\left(\Gamma^{\prime,IC}\right)^2} - \frac{\sigma(1-\alpha)}{\Gamma^{\prime,IC}}$$

which is positive if:

$$\left(\Gamma^{IC}\right)^{-1}\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right] > \sigma(1-\alpha)\Gamma^{\prime,IC}$$

which after cancelling and combining like terms provides:

$$\gamma_c(1+\varphi)\left[\left(\Gamma^{IC}\right)^{-1}+\lambda\right] > 0$$

which we know to be true for all possible calibrations, and provides the first condition in the proof of Proposition 2.

The second condition in the proof of Proposition 2: Differentiating $\Phi^{IC}\Theta_A^{IC}$ with respect to λ provides:

$$\frac{\partial \Phi^{IC}\Theta_A^{IC}}{\partial \lambda} = \frac{\gamma_c^2(1-\lambda)(1+\mu)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]}{\left(\Gamma^{\prime,IC}\right)^2\sigma} - \frac{\gamma_c^2(1+\mu)}{\left(\Gamma^{\prime,IC}\right)\sigma}$$

which is positive if:

$$\gamma_c^2(1-\lambda)(1+\mu)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right] > \gamma_c^2(1+\mu)\Gamma^{\prime,IC}$$

which after cancelling and combining like terms provides:

$$\sigma(1-\alpha)+\gamma_c(1+\varphi) > (1+\mu)\gamma_c$$

which is true providing $\lambda < \lambda^*$, and provides the second condition in the proof of Proposition 2.

The third and fourth condition in the proof of Proposition 2: Finally differentiating Γ^{IC} with respect to λ provides:

$$\frac{\partial \Gamma^{IC}}{\partial \lambda} = \sigma(1-\alpha)\left(\Gamma^{IC}\right)^2$$

which we know to be positive providing $\lambda < \lambda^*$ and therefore the third and fourth conditions in the proof in Proposition 2 easily follow.

A.7 Derivations for Proposition 3

Perfectly competitive labour markets

The first condition in the proof of Proposition 3: Performing the second derivative of Φ^{PC} with respect to λ provide:

$$\begin{aligned}\frac{\partial^2 \Phi^{PC}}{\partial \lambda^2} \quad = \quad & \frac{2\left(\Gamma^{PC}\right)^{-1}\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right]^2}{\left(\Gamma^{\prime,PC}\right)^3} \\ & -\frac{2\sigma(1-\alpha)(1+\varphi)\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right]}{\left(\Gamma^{\prime,PC}\right)^2}\end{aligned}$$

which is positive when $\lambda < \lambda^*$ providing:

$$\left(\Gamma^{PC}\right)^{-1}\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right] > \sigma(1-\alpha)(1+\varphi)\Gamma^{\prime,PC}$$

which after cancelling and combining like terms provides:

$$\varphi\gamma_c(1+\mu)+\sigma(1-\alpha) > 0$$

which we know to be true and provides the first condition in the proof of Proposition 3.

The second condition in the proof of Proposition 3: Performing the second derivative $\Phi^{PC}\Theta_A^{PC}$ with respect to λ provides:

$$\begin{aligned}\frac{\partial^2 \Phi^{PC}\Theta_A^{PC}}{\partial \lambda^2} \quad = \quad & \frac{2(1-\lambda)\left[\varphi(1+\mu)\gamma_c+\sigma(1-\alpha)\right]\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right]^2}{\left(\Gamma^{\prime,PC}\right)^3\sigma} \\ & -\frac{2\left(\varphi(1+\mu)\gamma_c+\sigma(1-\alpha)\right)\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right]}{\left(\Gamma^{\prime,PC}\right)^2\sigma}\end{aligned}$$

which is positive when $\lambda < \lambda^*$ providing:

$$(1-\lambda)\left[\sigma(1-\alpha)(1+\varphi)+\gamma_c\varphi(1+\varphi)\right] > \Gamma^{\prime,PC}$$

which after cancelling and combining like terms provides:

$$(1+\varphi)(\sigma(1-\alpha)+\gamma_c\varphi) > \varphi(1+\mu)\gamma_c$$

which is true providing $\lambda < \lambda^*$, and provides the second condition in the proof of Proposition 3.

The third and fourth condition in the proof of Proposition 3: Finally Performing the second derivative Γ^{PC} with respect to λ provides:

$$\frac{\partial^2\Gamma^{PC}}{\partial\lambda^2} = 2\sigma^2(1-\alpha)^2(1+\varphi)^2\left(\Gamma^{PC}\right)^3$$

which we know to be positive providing $\lambda < \lambda^*$ and therefore the third and fourth conditions in the proof in Proposition 3 easily follow.

Imperfectly competitive labour markets

The first condition in the proof of Proposition 3: Performing the second derivative of Φ^{IC} with respect to λ provide:

$$\frac{\partial^2\Phi^{IC}}{\partial\lambda^2} = \frac{2\left(\Gamma^{IC}\right)^{-1}\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]^2}{\left(\Gamma^{\prime,IC}\right)^3} - \frac{2\sigma(1-\alpha)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]}{\left(\Gamma^{\prime,IC}\right)^2}$$

which is positive when $\lambda < \lambda^*$ providing:

$$\left(\Gamma^{IC}\right)^{-1}\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right] > \sigma(1-\alpha)(1+\varphi)\Gamma^{\prime,IC}$$

which after cancelling and combining like terms provides:

$$\varphi\gamma_c(1+\mu)+\sigma(1-\alpha) > 0$$

which we know to be true and provides the first condition in the proof of proposition 3.

The second condition in the proof of Proposition 3: Performing the second derivative $\Phi^{IC}\Theta_A^{IC}$ with respect to λ provides:

$$\begin{aligned}\frac{\partial^2\Phi^{IC}\Theta_A^{IC}}{\partial\lambda^2} &= \frac{2\gamma_c^2(1-\lambda)(1+\mu)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]^2}{\sigma\left(\Gamma^{\prime,IC}\right)^3} \\ &\quad -\frac{2\gamma_c^2(1+\mu)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right]}{\sigma\left(\Gamma^{\prime,IC}\right)^2}\end{aligned}$$

which is positive when $\lambda < \lambda^*$ providing:

$$(1-\lambda)\left[\sigma(1-\alpha)+\gamma_c(1+\varphi)\right] > \Gamma^{\prime,IC}$$

which after cancelling and combining like terms provides:

$$\sigma(1-\alpha)+\gamma_c(1+\varphi) > (1+\mu)\gamma_c$$

which is true providing $\lambda < \lambda^*$, and provides the second condition in the proof of Proposition 3.

The third and fourth condition in the proof of Proposition 3: Finally Performing the second derivative Γ^{IC} with respect to λ provides:

$$\frac{\partial^2\Gamma^{IC}}{\partial\lambda^2} = 2\sigma^2(1-\alpha)^2\left(\Gamma^{IC}\right)^3$$

which we know to be positive providing $\lambda < \lambda^*$ and therefore the third and fourth conditions in the proof in Proposition 3 easily follow.

Appendix B

Appendices to Chapter 3

B.1 Determinacy conditions when $\varphi_y > 0$

Section 3.2.3 discusses the impact on the determinacy conditions of the model when $\varphi_y > 0$: this section derives the algebra behind these discussions.

B.1.1 Determinacy when $\lambda < \lambda^*$

Following the conditions given in Woodford (2003) and detailed in Chapter 3, the following conditions for Case I are obtained for when $\lambda < \lambda^*$:

A1 $\Phi\Theta_A(\varphi_y + \omega_y\varphi_\pi) > \beta^R - 1$;

A2 $\Phi\Theta_A\varphi_y\left(\left(\beta^R\right)^{-1} - 1\right) + \left(\beta^R\right)^{-1}\omega_y\Phi\Theta_A(\varphi_\pi - 1) > 0$;

A3 $\Phi\Theta_A\varphi_y(1+\beta^R) + \Phi\Theta_A\omega_y\varphi_\pi > -\left[2(\beta^R + 1) + \omega_y\Phi\Theta_A\right]$.

Note that when $\lambda < \lambda^*$, Φ and Θ_A are positive and therefore all three conditions are satisfied providing $\varphi_\pi > 1$: the Taylor Principle. However, it is also observable that as φ_y increases, φ_π can be less than one (passive), the degree to which this is permitted depends on the size of φ_y.

B.1.2 Determinacy when $\lambda > \lambda^*$

Following the conditions given in Woodford (2003), the following conditions for Case I are obtained for when $\lambda > \lambda^*$:

A1 $\varphi_y + \omega_y \varphi_\pi < (\Phi\Theta_A)^{-1}(\beta^R - 1)$;

A2 $\varphi_y \left(\left(\beta^R\right)^{-1} - 1 \right) + \left(\beta^R\right)^{-1} (\varphi_\pi - 1) < 0$;

A3 $\varphi_y(1 + \beta^R) + \omega_y \varphi_\pi < -(\Phi\Theta_A)^{-1} \left[2(\beta^R + 1) + \Phi\Theta_A \omega_y \right]$.

As in the analysis in Section 3.2 these conditions set a higher limit on φ_π. Moreover, the introduction of $\varphi_y > 0$ leads to higher values of φ_y needing more passive values of φ_π to ensure determinacy. Considering Case II of Woodford (2003) gives the results:

B1 $\varphi_y(1 - \beta^R) + \omega_y(\varphi_\pi - 1) > 0$; and,

B2 $\varphi_y(1 + \beta^R) + \omega_y(\varphi_\pi + 1) > -(\Phi\Theta_A)^{-1} \left[(2(\beta^R + 1)) \right]$.

which are similar to those found in Section 3.2 where the monetary authority need to respond very aggressively to movements in inflation. The conditions here for when $\varphi_y > 0$ are less restrictive to those in Section 3.2 with respect to how high φ_π needs to be: in effect higher values of φ_y can compensate for φ_π.

B.2 Algebraic properties

Disaggregate relationships: perfectly competitive labour markets

The assumption that non-Ricardian households consume entirely their disposable income makes it possible to derive functions of their consumption and employment behaviour with respect to output. Log-linearising the non-Ricardian consumption function (2.6) provides, in the absence of tax changes:

$$c_t^{NR} = \frac{1 - \alpha}{1 + \mu} \left[n_t^{NR} + (w_t - p_t) \right] \tag{B.1}$$

where the steady state ratio has been substituted with $N^{NR}W/C^{NR}P = (1-\alpha)/(1+\mu)$ using the observation that employment gets paid its marginal product net of the markup charged by the monopolistically competitive firms. From Appendix A.3 the aggregate labour supply expression $(w_t - p_t) = \varphi n_t + \sigma c_t$ can be obtained and substituting this into (B.1) and deriving an expression for non-Ricardian employment, n_t^{NR}, in terms of aggregate consumption, employment and non-Ricardian consumption using both the aggregate and disaggregate labour supply functions provides (after manipulation):

$$c_t^{NR} = \frac{(1+\varphi)(1-\alpha)}{\varphi(1+\mu)+\sigma(1-\alpha)}\left[\varphi n_t + \sigma c_t\right]$$

Finally, using the aggregate log-linear production function (A.5) and market clearing condition (A.11) to substitute out for both employment and consumption provides:

$$c_t^{NR} = \frac{(1+\varphi)(\varphi+\sigma(1-\alpha))}{\varphi(1+\mu)+\sigma(1-\alpha)}y_t - \frac{(1+\varphi)\varphi}{\varphi(1+\mu)+\sigma(1-\alpha)}\varepsilon_t^a \tag{B.2}$$

From this it is possible to observe the complications made through productivity shocks.[1] Setting $\varepsilon_t^a = 0$, condition (C1) from Table 4 is trivial. Moreover, substituting out for non-Ricardian consumption using the market clearing condition (A.11) provides:

$$c_t^R = \left[\frac{\lambda}{1-\lambda}\frac{(1+\mu)\varphi+\sigma(1-\alpha)-\lambda(1+\varphi)(\varphi+\sigma(1-\alpha))}{1+\mu+\sigma(1-\alpha)}\varphi\right]y_t \tag{B.3}$$

Where condition (C2) from Table 4 can be obtained, providing $\lambda < \lambda^*$. Moreover, the above two conditions can combine to obtain condition (C3) from Table 4.[2]

Using the log-linear expressions for the aggregate and non-Ricardian labour supply functions, in conjunction with the production function and goods market clearing condition, one can obtain the result:

$$\varphi n_t^{NR} + \sigma c_t^{NR} = \left[\frac{\varphi+\sigma(1-\alpha)}{1-\alpha}\right]y_t$$

which can be used to substitute out c_t^{NR} from (B.2) to obtain a relationship between non-Ricardian employment and output (N2):

$$n_t^{NR} = \frac{1}{\varphi}\left[\frac{\varphi+\sigma(1-\alpha)}{1-\alpha} - \frac{\sigma(1+\varphi)(\varphi+\sigma(1-\alpha))}{(1+\mu)\varphi+\sigma(1-\alpha)}\right]y_t$$

Which can be used, once it has been observed that in the absence of technology shocks $\partial n_t/\partial y_t = 1/(1-\alpha)$, to obtain the first half of condition (N3) from Table 4 where the second half and condition (N3) are then logical extensions from this first result.

[1] Note that from these conditions we can substitute for ε_t^a using the conditions derived using the method of undetermined coefficients. When this is performed, however, ambiguous conditions are obtained.

[2] Another way of obtaining (C3) is to show that $\partial c_t^{NR}/\partial y_t > 1$ and $\partial c_t^R/\partial y_t < 1$ using the functions derived above.

Disaggregate relationships: imperfectly competitive labour markets

Performing similar procedures to those outlined above where $n_t^{NR} = n_t^R = n_t$ we can obtain the following conditions similar to (B.2) and (B.3) respectively:

$$c_t^{NR} = \frac{1+\varphi+\sigma(1-\alpha)}{1+\mu} y_t - \frac{1+\varphi}{1+\mu} \varepsilon_t^a \tag{B.4}$$

$$c_t^R = \frac{1}{1-\lambda} \left[1 - \frac{\lambda\left(1+\varphi+\sigma(1-\alpha)\right)}{1+\mu} \right] y_t \tag{B.5}$$

From these, conditions similar to (C1) and (C2) can be derived where the latter is true providing $\lambda < \lambda^*$ (the same condition as was required for perfectly competitively labour markets). Moreover, from these it is possible to derive (C3) from Table 4 providing $\mu < \varphi + \sigma(1-\alpha)$, the same condition as was required for perfectly competitive labour markets. With the assumption of imperfectly competitive labour markets both households work the same contracts and as such relationships similar to (N2) and (N3) in Table 4 break down.

B.3 Derivation of the disaggregated welfare functions

To derive the welfare functions for each household, a second order Taylor series expansion around steady state values of the period utility function (assumed to be identical across households) is performed, such as that performed in Woodford (2003). This provides:

$$\begin{aligned} U_t^i - U^i \quad \approx \quad & U_c\left(C_t^i - C^i\right) + U_n\left(N_t^i - N^i\right) + \frac{1}{2} U_{cc}\left(C_t^i - C^i\right)^2 \\ & + \frac{1}{2} U_{nn}\left(N_t^i - N^i\right)^2 \end{aligned}$$

Where $U_x = \partial U(\cdot)/\partial x$, and the separability of consumption and employment provides $U_{cn} = 0$. Following previous notation, upper case letters with no time subscripts represent steady state values. Manipulating the above provides:

$$\begin{aligned}\frac{U_t^i - U^i}{U_c C^i} \approx & \left[\left(\frac{C_t^i - C^i}{C^i}\right) + \frac{1}{2}\frac{U_{cc}}{U_c} C^i \left(\frac{C_t^i - C^i}{(C^i)^2}\right)^2\right] \\ & + \frac{U_n N^i}{U_c C^i}\left[\left(\frac{N_t^i - N^i}{N^i}\right) + \frac{1}{2}\frac{U_{nn}}{U_n} N^i \left(\frac{N_t^i - N^i}{(N^i)^2}\right)^2\right]\end{aligned}$$

With the assumptions made in Section (2.3.1), $C^i = C$ and $N^i = N$:

$$\begin{aligned}\frac{U_t^i - U}{U_c C} \approx & \left[\left(\frac{C_t^i - C}{C}\right) + \frac{1}{2}\frac{U_{cc}}{U_c} C \left(\frac{C_t^i - C}{(C)^2}\right)^2\right] \\ & + \frac{U_n N}{U_c C}\left[\left(\frac{N_t^i - N^i}{N^i}\right) + \frac{1}{2}\frac{U_{nn}}{U_n} N^i \left(\frac{N_t^i - N}{(N)^2}\right)^2\right]\end{aligned}$$

The presence of the monopolistically competitive intermediate firms creates a distortion in the employment market and subsequently in the general equilibrium, such that:

$$\frac{MPN}{1+\mu} = MRS$$

Where the marginal rate of substitution is given by $MRS = -U_n(\cdot)/U_c(\cdot)$, and from the production function (2.9) the marginal product of labour is given by, $MPN = (1-\alpha)\, Y/N$. Substituting these conditions into the Taylor series expansion above gives:

$$\begin{aligned}\frac{U_t^i - U}{U_c C} \approx & \left[\left(\frac{C_t^i - C}{C}\right) + \frac{1}{2}\frac{U_{cc}}{U_c} C \left(\frac{C_t^i - C}{(C)^2}\right)^2\right] \\ & - \frac{(1-\alpha)}{1+\mu}\frac{N}{C}\frac{Y}{N}\left[\left(\frac{N_t^i - N^i}{N^i}\right) + \frac{1}{2}\frac{U_{nn}}{U_n} N^i \left(\frac{N_t^i - N}{(N)^2}\right)^2\right]\end{aligned}$$

Which from the specified utility function provides:

$$\begin{aligned}\frac{U_t^i - U}{U_c C} &\approx \left[\left(\frac{C_t^i - C}{C}\right) - \frac{\sigma}{2}\left(\frac{C_t^i - C}{(C)^2}\right)^2\right] \\ &\quad - \frac{(1-\alpha)}{(1+\mu)\gamma_c}\left[\left(\frac{N_t^i - N^i}{N^i}\right) + \frac{\varphi}{2}\left(\frac{N_t^i - N}{(N)^2}\right)^2\right]\end{aligned}$$

The above can be written in terms of log deviations as:

$$\begin{aligned}\frac{U_t^i - U}{U_c C} &\approx \left[c_t^i + \frac{1}{2}\left(c_t^i\right)^2 - \frac{\sigma}{2}\left(c_t^i\right)^2\right] \\ &\quad - \frac{(1-\alpha)}{(1+\mu)\gamma_c}\left[n_t^i + \frac{1}{2}\left(n_t^i\right)^2 + \frac{\varphi}{2}\left(n_t^i\right)^2\right]\end{aligned}$$

And simplified to:

$$\frac{U_t^i - U}{U_c C} \approx \left[c_t^i + \frac{1-\sigma}{2}\left(c_t^i\right)^2\right] - \frac{(1-\alpha)}{(1+\mu)\gamma_c}\left[n_t^i + \frac{1+\varphi}{2}\left(n_t^i\right)^2\right]$$

Finally, welfare losses for each type of household can be defined as the sum of lifetime utility lost expressed as a fraction of steady state consumption as:

$$\begin{aligned}W^i &= E_0 \sum_{t=0}^{\infty} \beta^{i,t}\left(\frac{U_t^i - U}{U_c C}\right) \\ W^i &= E_0 \sum_{t=0}^{\infty} \beta^{i,t}\left(c_t^i + \frac{1-\sigma}{2}\left(c_t^i\right)^2\right) - \frac{(1-\alpha)}{(1+\mu)\gamma_c} E_0 \sum_{t=0}^{\infty} \beta^{i,t}\left(n_t^i + \frac{1+\varphi}{2}\left(n_t^i\right)^2\right)\end{aligned}$$

B.4 Agent specific levels of steady state consumption

If we relax the assumption that both agents consume the same amount in steady state (and therefore, by extension, work the same amount), note that the assumed identical utility function for the two agents will result in the same ratio of consumption to work. Maximisation of period utility (2.2) subject to either the budget constraint for Ricardian households (2.3) or non-Ricardian households (2.6) with respect to consumption and employment leads to the condition:

$$\frac{W_t}{P_t} = \left(N_t^i\right)^{\varphi}\left(C_t^i\right)^{\sigma}$$

and therefore if both households are subject to the same real wage they will both optimise at a constant ratio of N/C.

The only difference the relaxation of identical steady state consumption levels will have on the model is to change the log-linear aggregate consumption condition. Log-linearising (2.17) where $C^{NR} \neq C^R \neq C$ provides:

$$c_t = \lambda \frac{C^{NR}}{C} c_t^{NR} + (1-\lambda) \frac{C^R}{C} c_t^R$$

which can be simplified to:

$$c_t = \chi c_t^{NR} + (1-\chi) c_t^R$$

where $\chi = \lambda \left(C^{NR}/C\right)$.

Appendix C

Appendices to Chapter 4

C.1 The closed system

As stated in Chapter 4, the economy can be described by six equations in six unknowns. These six equations are the aggregate demand condition (2.20); the New Keynesian Phillips curve (2.24); the Taylor rule (2.12); the government spending and taxation rules (2.14) and (2.15); and the flow constraint for government debt (2.16). This can be simplified by substituting the Taylor rule in to the aggregate demand condition and the government spending and tax rules into the government flow constraint which results in the following system of three equations in three unknowns:

$$\mathbf{A}E_t\left\{u_{t+1}\right\} = \mathbf{B}u_t + \mathbf{B}\varepsilon_t$$

where $u_t = \left[y_t, \pi_t, \widehat{b}_t\right]'$ and $\varepsilon_t = \left[\varepsilon_t^r, E_t\left\{\Delta\varepsilon_{t+1}^b\right\}, \varepsilon_t^a, \varepsilon_{t+1}^a, \varepsilon_t^\mu\right]'$ and the matrices $\mathbf{A}$, $\mathbf{B}$ and $\mathbf{C}$ are given by:

$$A = \begin{bmatrix} 1+\Phi\left[\Theta_C\varphi_T - \varphi_g\right] & \Phi\Theta_A & \Phi\left[\Theta_C\varphi_{b,T} - \varphi_{b,g}\right] \\ 0 & \beta^R & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 1+\Phi\left[\Theta_A\varphi_y + \Theta_C\varphi_T - \varphi_g\right] & \Phi\Theta_A\varphi_\pi & \Phi\left[\Theta_C\varphi_{b,T} - \varphi_{b,g}\right] \\ \omega_g\varphi_g - \omega_y & 1 & \omega_g\varphi_{b,g} \\ (1+\rho_R)(\varphi_g - \varphi_T) & 0 & (1+\rho_R)(1+\varphi_{b,g} - \varphi_{b,T}) \end{bmatrix}$$

$$C = \begin{bmatrix} -\Phi\Theta_A & \Phi\Theta_A & -\Phi\Theta_B & \Phi\Theta_B & 0 \\ 0 & 0 & \omega_\varepsilon & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

where $\omega_y = \omega\left(\sigma/\gamma_c - (\varphi+\alpha)/(1-\alpha)\right)$, $\omega_g = \omega\left(\sigma/\gamma_c\right)$ and $\omega_\varepsilon = \omega(1+\varphi)/(1-\alpha)$.

C.2 Net discounted government spending in policy experiment 1

As was stipulated in Section 4.2, net discounted government spending will be negligible in policy experiment 1 because the interest which accrues on existing debt is the inverse of the rate at which Ricardian agents discount future transactions. Under the conditions of policy experiment 1, existing debt in any given period n will be equal to:

$$b_n = \sum_{t=1}^{t=n}\left\{\left(\frac{1}{\beta^R}\right)^{n-t} g_t\right\}$$

and given the solvency condition on government debt we know that $b_n \to 0$ as $n \to \infty$. Put another way we could separate all those increases in government spending from decreases to get the result:

$$\sum_{t=1}^{t=\infty}\left\{\left(\frac{1}{\beta^R}\right)^{t} g_t|_{g_t>0}\right\} = \sum_{t=1}^{t=\infty}\left\{\left(\frac{1}{\beta^R}\right)^{t} g_t|_{g_t<0}\right\}$$

That is, all reductions in government spending must pay back all the increases in government spending including the interest accrued on it. This means that were the government to temporarily increase spending the reductions over the medium term will be greater than the short term increases. However, when the households evaluate the welfare implications of such policy they discount future periods by the factor $\left(\beta^i\right)^t$ and substituting this into the above, the net discounted increases in government spending are exactly offset by the net discounted decreases, or algebraically:

$$\sum_{t=1}^{t=\infty}\{\bar{g}_t|_{g_t>0}\}=\sum_{t=1}^{t=\infty}\{\bar{g}_t|_{g_t<0}\}$$

where $\bar{g}_t$ represents discounted movements in government expenditure. This means that the assumptions made about whether government spending enters the utility function is trivial in policy experiment 1.

C.3 Steady state properties of fiscal policy

From the structure of the non-linear steady state model we can perform the following substitutions in order to get a relationship between public and private consumption:

$$\begin{aligned}
\frac{W}{P} &= MC(1-\alpha)N^{-\alpha}=\frac{\epsilon-1}{\epsilon}(1-\alpha)N^{-\alpha}\\
C &= \left[\frac{W}{P}N^{-\varphi}\right]^{\frac{1}{\sigma}}=\left[\frac{\epsilon-1}{\epsilon}(1-\alpha)N^{-(\varphi+\alpha)}\right]^{\frac{1}{\sigma}}\\
Y &= N^{1-\alpha}\Leftrightarrow N=Y^{\frac{1}{1-\alpha}}\\
C &= \left[\frac{\epsilon-1}{\epsilon}(1-\alpha)Y^{-\frac{\varphi+\alpha}{1-\alpha}}\right]^{\frac{1}{\sigma}}\\
C &= \left[\frac{\epsilon-1}{\epsilon}(1-\alpha)\left[C+G\right]^{-\frac{\varphi+\alpha}{1-\alpha}}\right]^{\frac{1}{\sigma}}\\
G &= \left[\frac{C^{\sigma}\epsilon}{(\epsilon-1)(1-\alpha)}\right]^{-\frac{1-\alpha}{\varphi+\alpha}}-C
\end{aligned}$$

from which it can be shown that:

$$\frac{\partial G}{\partial C}=\frac{-(1-\alpha)\sigma\left(\frac{C^{\sigma}\epsilon}{(1-\alpha)(\epsilon-1)}\right)^{-\frac{1-\alpha}{\varphi+\alpha}}}{C(\alpha+\varphi)}$$

with which we can perform the following substitutions:

$$\begin{aligned}
\frac{\epsilon}{(\epsilon-1)(1-\alpha)} &= N^{-\alpha}\left(\frac{W}{P}\right)^{-1}; \; C^{\sigma} = \frac{W}{P}N^{-\varphi} \\
\frac{C^{\sigma}\epsilon}{(1-\alpha)(\epsilon-1)} &= N^{-\alpha+\varphi} = Y^{-\frac{\alpha+\varphi}{1-\alpha}} \\
\frac{\partial G}{\partial C} &= -\frac{\sigma(1-\alpha)}{\alpha+\varphi}\frac{Y}{C} = -\frac{\sigma(1-\alpha)}{\gamma_c(\alpha+\varphi)} \\
\frac{\partial C}{\partial G} &= -\frac{\gamma_c(\alpha+\varphi)}{\sigma(1-\alpha)}
\end{aligned}$$

C.4 Adding distortionary taxation to the model

A tax on consumption can be included in the model such that the gross price paid for a good is $(1+\tau_t^c)P_t$. Similarly, a tax on wage income can be imposed such that take home pay for each unit of labour by households is given by $(1-\tau_t^l)W_t$ (note that an employee social security contributions would enter the model in the same way). These two would change the optimisation results (2.4) and (2.7), and (2.5) respectively:

$$\frac{W_t(1-\tau_t^l)}{P_t(1+\tau_t^c)} = \left(N_t^i\right)^{\varphi}\left(C_t^i\right)^{\sigma}$$

$$R_t^{-1} = \beta^R E_t\left\{\left(\frac{C_{t+1}^R}{C_t^R}\right)^{-\sigma}\left(\frac{P_t(1+\tau_t^c)}{P_{t+1}(1+\tau_{t+1}^c)}\right)\left(\frac{\varepsilon_{t+1}^b}{\varepsilon_t^b}\right)\right\}$$

Moreover, a tax can be imposed on firms employment, analogous to an employer social security (or national insurance) contribution, such that the gross amount paid for each unit of labour is equal to $(1+\tau_t^{er})W_t$ and therefore real marginal costs become equal to:

$$MC_t^r = \frac{W_t(1+\tau_t^{er})/P_t}{(1-\alpha)\varepsilon_t^a\left(N_t(j)\right)^{-\alpha}}$$

These three taxes will change the log-linear Ricardian Euler equation, non-Ricardian consumption function, the labour supply conditions and the marginal cost dynamics from the model presented in Chapter 2 to:

$$c_t^R = E_t\left\{c_{t+1}^R\right\} - \frac{1}{\sigma}\left(r_t - E_t\left\{\pi_{t+1}\right\} - E_t\left\{\Delta\varepsilon_{t+1}^b\right\} - \frac{\tau^c}{1+\tau^c}E_t\left\{\Delta\tau_{t+1}^c\right\}\right)$$

$$(1+\tau^c)\gamma_c\left(c_t^{NR}+\frac{\tau^c}{1+\tau^c}\tau_t^c\right)=(1-\tau^l)\frac{1-\alpha}{1+\mu}\left((w_t-p_t)+n_t^{NR}-\frac{\tau^l}{1-\tau^l}\tau_t^l\right)-\widehat{t}_t$$

$$w_t-p_t=\varphi n_t^R+\sigma c_t^R+\frac{\tau^l}{1-\tau^l}\tau_t^l+\frac{\tau^c}{1+\tau^c}\tau_t^c$$

$$w_t-p_t=\varphi n_t^{NR}+\sigma c_t^{NR}+\frac{\tau^l}{1-\tau^l}\tau_t^l+\frac{\tau^c}{1+\tau^c}\tau_t^c$$

$$mc_t^r=(w_t-p_t)-\varepsilon_t^a+\alpha n_t+\frac{\tau^{er}}{1+\tau^{er}}\tau_t^{er}$$

Moreover, the government flow constraint will be updated to reflect new sources of income:

$$\begin{aligned}\widehat{b}_{t+1} \quad = \quad & (1+\rho_R)\Bigg[\widehat{b}_t+\widehat{g}_t-\widehat{t}_t-\gamma_c\tau^c\left(\tau_t^c+c_t\right) \\ & -\frac{1-\alpha}{1+\mu}\tau^l\left(\tau_t^l+(w_t-p_t)+n_t\right)-\frac{1-\alpha}{1+\mu}\tau^{er}\left(\tau_t^{er}+(w_t-p_t)+n_t\right)\Bigg]\end{aligned} \tag{C.1}$$

Appendix D

Appendices to Chapter 5

D.1 First-order conditions of Ricardian households

The first order condition with respect to consumption results in:

$$C_t^{-1} = \lambda_t \left(1 + \tau_t^c\right)$$

where λ_t represents the Lagrange multiplier on the budget constraint. The first-order conditions with respect to bond holdings results in the standard Euler equation:

$$\lambda_t = E_t \left[\frac{R_t}{\Pi_{t+1}} \beta^R \lambda_{t+1} \right]$$

The left-hand side of the above represents the marginal utility cost of investing in bonds; the right-hand side implies that investing in bonds provides an ex ante real rate of return represented by R_t/π_{t+1}. The first-order condition with respect to the capital utilisation rate, presented below, indicates that the real rental rate net of capital taxes is equal to the marginal cost of capital utilisation:

$$\left(1 - \tau_t^k\right) r_{k,t} = a'(u_t)$$

A higher rate of return on capital or a lower capital tax implies a higher utilisation rate up to the point where extra benefits are equal to extra costs. The first-order condition with respect to capital links the shadow price of capital between two periods:

$$Q_t = \frac{E_t \pi_{t+1}}{R_t} E_t \left[Q_{t+1}(1-\delta_k) + \left(1-\tau^k_{t+1}\right)(r_{k,t+1}u_{t+1}) - a(u_{t+1}) \right]$$

The above implies that the price of capital is simply the present value of future net income from capital holdings. The price of capital depends positively on the expected real rental rate and the expected utilisation rate, and depends negatively on the real ex ante interest rate, capital taxes and the capital utilisation cost.

The first-order condition with respect to investment is given by:

$$\lambda_t = Q_t \lambda_t F'_t \left(I_t, I_{t-1}\right) + Q_{t+1}\beta^R \lambda_{t+1}\beta^R E_t F'_{t+1}\left(I_{t+1}, I_t\right)$$

where $F_t(\cdot) = [1 - s(\cdot)]$: the left-hand side represents the marginal utility cost of investment in physical capital, which is equal to the marginal utility cost of investment in bonds. An increase in investment by one unit at time t leads to an increase in the value of capital by $Q_t F'_t\left(I_t, I_{t-1}\right)$ in period t, and by $Q_{t+1}\beta^R F'_{t+1}\left(I_{t+1}, I_t\right)$ in period $t+1$.[1]

D.2 Derivation of the disaggregated welfare function

To derive the welfare function in this model the same procedures as used in Appendix B.3 can be applied where it is recognised that in steady state the marginal product of labour and the marginal rate of substitution are equating through the following:

$$MRS = \frac{MPL_t}{1+\tau^{er}} \frac{\nu - 1}{\nu} \frac{1 - \tau^l - \tau^{ee}}{1+\tau^c}$$

Thus leading to the welfare function:

$$\begin{aligned} W^i &= E_0 \sum_{t=0}^{\infty} \left(\beta^i\right)^t \left(\frac{U^i_t - U^i}{U_c C^i} \right) \\ W^i &= E_0 \sum_{t=0}^{\infty} \left(\beta^i\right)^t \left(c^i_t\right) - \frac{\nu-1}{\nu} \frac{1-\tau^l-\tau^{ee}}{1+\tau^c} \frac{(1-\alpha)}{(1+\tau^{er})} \frac{Y}{C^i} E_0 \sum_{t=0}^{\infty} \left(\beta^i\right)^t \left(l^i_t + \frac{1+\sigma_l}{2}\left(l^i_t\right)^2 \right) \end{aligned}$$

[1] Substituting for $F_t\left(I_t, I_{t-1}\right)$ results in:
$1 = Q_t \left[1 - \frac{\phi_k}{2} - \frac{3\phi_k}{2}\left(\frac{\varepsilon^I_t I_t}{I_{t-1}}\right)^2 + 2\phi_k \frac{\varepsilon^I_t I_t}{I_{t-1}} \right] + Q_{t+1}\frac{U_{c,t+1}}{U_{c,t}}\beta^R \left[\phi_k \left(\frac{\varepsilon^I_{t+1} I_{t+1}}{I_t}\right)^3 - \phi_k \left(\frac{\varepsilon^I_{t+1} I_{t+1}}{I_t}\right)^2 \right]$.
Therefore $F'_t(1) = 1$ and $F'_{t+1}(1) = 0$, thus the steady state does not depend on the parameter ϕ_k and $Q = 1$.

Appendix E

Appendices to Chapter 6

E.1 The log-linear model

The model as described in Chapter 6 once log-linearised, can be described in the following set of equations:

$$y_t = \gamma_c c_t + \gamma_i i_t + \widehat{g}_t \tag{E.1}$$

$$y_t = \alpha k_t + (1-\alpha) n_t \tag{E.2}$$

$$k_t - n_t = (w_t - p_t) - (r_t^k - p_t) \tag{E.3}$$

$$k_{t+1} = (1-\delta) k_t + \delta i_t \tag{E.4}$$

$$q_t = -\left(r_t - E_t\left\{\pi_{t+1}^P\right\}\right) + (1-\beta(1-\delta))\, E_t\left\{r_{t+1}^k - p_{t+1}\right\} + \beta E_t\left\{q_{t+1}\right\} \tag{E.5}$$

$$i_t - k_t = \eta q_t \tag{E.6}$$

$$c_t = (1-\lambda) c_t^R + \lambda c_t^{NR} \tag{E.7}$$

$$\pi_t = \beta E_t \left\{ \pi^P_{t+1} \right\} + \frac{(1-\beta\theta)(1-\theta)}{\theta} \left[(w_t - p_t) - (y_t - n_t) \right] \tag{E.8}$$

$$r_t = \varphi_\pi \pi^P_t + \varphi_y y_t \tag{E.9}$$

$$c^R_t - h \cdot c_{t-1} = E_t \left\{ c^R_{t+1} - h \cdot c_t \right\} - \frac{1-h}{\sigma}(r_t - E_t \left\{ \pi_{t+1} \right\}) \tag{E.10}$$

$$c^{NR}_t = \frac{1-\alpha}{\gamma_c(1+\mu)} \left[n_t + (w_t - p_t) \right] - \frac{1}{\gamma_c} \widehat{t}^{NR}_t \tag{E.11}$$

$$\pi^w_t = \beta E_t \left\{ \pi^w_{t+1} \right\} + \frac{\epsilon_w - 1}{\phi_w} \left[\frac{c_t - h \cdot c_{t-1}}{1-h} + \varphi n_t - (w_t - p_t) \right] \tag{E.12}$$

$$\widehat{g}_t = \varepsilon^G_t + \varphi_{b,g} \widehat{b}_t; \quad \varepsilon^G_t = \rho_g \varepsilon^G_{t-1} + \eta^G_t \tag{E.13}$$

$$\widehat{t}_t = \varepsilon^T_t + \varphi_{b,t} \widehat{b}_t; \quad \varepsilon^T_t = \rho_t \varepsilon^T_{t-1} + \eta^T_t \tag{E.14}$$

$$\widehat{b}_{t+1} = (1 + \rho_R) \left(\widehat{b}_t + \widehat{g}_t - \widehat{t}_t \right) \tag{E.15}$$

E.2 Deriving the aggregate demand condition

The aggregate demand condition is derived using a similar process that was used in Section A.3. First note that through combining individual labour supply conditions the following aggregate function can be derived:

$$(w_t - p_t) = \varphi n_t + \frac{\sigma}{1-h}(c_t - h \cdot c_{t-1})$$

which can be substituted into the non-Ricardian consumption function (E.11) to derive an aggregate Euler equation:

$$\begin{aligned}
c_t &= E_t\{c_{t+1}\} - X_1(r_t - E_t\{\pi_{t+1}\}) - X_2 E_t\{\Delta n_{t+1}\} + X_3 \Delta c_t + X_4 E_t\left\{\Delta \widehat{t}_t^{NR}\right\} \\
X_1 &= (1-\lambda)\frac{1}{\sigma}(1-h)\left[\gamma_c \varphi(1+\mu)(1-h) + \sigma(1-\alpha)\right] X_5^{-1} \\
X_2 &= \lambda(1-h)(1-\alpha)(1+\varphi)\varphi\Gamma^{-1} \\
X_3 &= \left[\lambda\varphi\sigma(1-\alpha)h - (1-\lambda)h\left[\gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\right]\right] X_5^{-1} \\
X_4 &= \lambda\varphi(1+\mu)(1-h)X_5^{-1} \\
X_5 &= \gamma_c\varphi(1+\mu)(1-h) + \sigma(1-\alpha)\left[1-\lambda(1+\varphi)\right]
\end{aligned}$$

Finally, this can be combined with the market clearing and production function in order to obtain the demand condition for the simplified model presented in Chapter 6, equation (6.12).

E.3 Proofs for conditions in (6.15)

The first condition in (6.15) Differentiating Φ' with respect to λ provides:

$$\begin{aligned}
\frac{\partial \Phi'}{\partial \lambda} = & \frac{\Gamma'\left[\gamma_c\varphi(1+\mu)(1-h)h + \sigma(1-\alpha)(1+\varphi)(1+h) + (1-h)(1+\varphi)\varphi\gamma_c\right]}{(\Gamma'')^2} \\
& - \frac{\gamma_c\varphi(1+\mu)(1-h)h + \sigma(1-\alpha)(1+\varphi)(1+h)}{\Gamma''}
\end{aligned}$$

which is positive providing:

$$\begin{aligned}
& \Gamma'\left[\gamma_c\varphi(1+\mu)(1-h)h + \sigma(1-\alpha)(1+\varphi)(1+h) + (1-h)(1+\varphi)\varphi\gamma_c\right] \\
& \quad > \gamma_c\varphi(1+\mu)(1-h)h + \sigma(1-\alpha)(1+\varphi)(1+h)\left(\Gamma''\right)
\end{aligned}$$

which, after cancelling and combining like terms, is true providing:

$$\sigma(1-\alpha)\left(1-(1+\mu)\lambda h\right) + \varphi\gamma_c(1+\mu)(1+\lambda h)) > 0$$

which is the condition as stated in main body: this is not a significant restriction at reasonable calibrations.

The second condition in (6.15) Differentiating Φ' with respect to h provides:

$$\begin{aligned}\frac{\partial \Phi'}{\partial h} = & \frac{\gamma_c \varphi(1+\mu)\left[(1-h)(1-\lambda)-1-(1-\lambda)h\right]+\sigma(1-\alpha)\left(1-\lambda(1+\varphi)\right)}{\Gamma''} \\ & -\frac{\Gamma'\left[\gamma_c\varphi(1+\mu)\left[(1-h)(1-\lambda)-1-(1-\lambda)h\right]\right]}{\left(\Gamma''\right)^2} \\ & -\frac{\Gamma'\left[\sigma(1-\alpha)(1-\lambda(1+\varphi))+\lambda(1+\varphi)\varphi\gamma_c\right]}{\left(\Gamma''\right)^2}\end{aligned}$$

which is negative providing:

$$\begin{aligned}& \Gamma'\left[\gamma_c\varphi(1+\mu)\left[(1-2h)(1-\lambda)-1\right]+\sigma(1-\alpha)(1-\lambda(1+\varphi))+\lambda(1+\varphi)\varphi\gamma_c\right] \\ & \quad > \gamma_c\varphi(1+\mu)\left[(1-2h)(1-\lambda)-1\right]+\sigma(1-\alpha)\left(1-\lambda(1+\varphi)\right)\left(\Gamma''\right)\end{aligned}$$

which, after cancelling and combining like terms, is true providing:

$$(1-h)^2\gamma_c\varphi(1+\mu)(1-\lambda)+2\sigma(1-\alpha)\left[1-\lambda(1+\varphi)\right]>0$$

which is the condition as stated in main body: this is not a significant restriction at reasonable calibrations.

The third condition in (6.15) Differentiating Θ_B with respect to λ provides:

$$\begin{aligned}\frac{\partial \Theta_B}{\partial \lambda} = & \frac{\gamma_c\varphi(1+\mu)(1-h)}{\Gamma''} \\ & +\frac{\gamma_c\varphi(1+\mu)(1-h)\lambda\left[\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)(1+\varphi)(1+h)\right]}{\left(\Gamma''\right)^2} \\ & +\frac{\gamma_c\varphi(1+\mu)(1-h)\lambda\left[(1-h)(1+\varphi)\varphi\gamma_c\right]}{\left(\Gamma''\right)^2}\end{aligned}$$

where everything above is positive, providing $\lambda > \lambda^*$, and therefore $\partial\Theta_B/\partial\lambda > 0$.

The fourth condition in (6.15) Differentiating Θ_B with respect to h provides:

$$\begin{aligned}
\frac{\partial \Theta_B}{\partial h} = & -\frac{\gamma_c \varphi(1+\mu)}{\Gamma''} \\
& -\frac{\gamma_c \varphi(1+\mu)(1-h)\left[\gamma_c \varphi(1+\mu)(1-h)(1-\lambda)\right]}{(\Gamma'')^2} \\
& -\frac{\gamma_c \varphi(1+\mu)(1-h)\left[\sigma(1-\alpha)(1-\lambda(1+\varphi))+\lambda(1+\varphi)\varphi\gamma_c\right]}{(\Gamma'')^2} \\
& +\frac{\gamma_c \varphi(1+\mu)(1-h)\left[\gamma_c \varphi(1+\mu)(1+(1-\lambda)h)\right]}{(\Gamma'')^2}
\end{aligned}$$

which is negative, when $\lambda < \lambda^*$, providing:

$$\begin{aligned}
& \frac{\Gamma'' + (1+h)\left[\gamma_c \varphi(1+\mu)(1-h)(1-\lambda)+\sigma(1-\alpha)(1-\lambda(1+\varphi))+\lambda(1+\varphi)\varphi\gamma_c\right]}{\Gamma''} \\
& \quad > \frac{(1+h)\left[\gamma_c \varphi(1+\mu)(1+(1-\lambda)h)\right]}{\Gamma''}
\end{aligned}$$

which, after cancelling and combining like terms, is true providing:

$$\frac{2(1+\varphi)}{1-h} > 1+\mu$$

which is the condition as stated in main body: this is not a significant restriction at reasonable calibrations.

E.4 Proofs for conditions in (6.16)

The first condition in (6.16) Partially differentiating Φ_A with respect to λ provides:

$$\begin{aligned}
\frac{\partial \Phi_A}{\partial \lambda} = & \frac{(\Gamma - \lambda(1-h)(1+\varphi)\varphi\gamma_c)\left[\gamma_c \varphi(1+\mu)+\sigma(1-\alpha)(1+\varphi)(1+h)\right]}{(\Gamma'')^2} \\
& +\frac{(\Gamma - \lambda(1-h)(1+\varphi)\varphi\gamma_c)\left[(1-h)(1+\varphi)\varphi\gamma_c\right]}{(\Gamma'')^2} \\
& -\frac{\sigma(1-\alpha)(1+\varphi)+\gamma_c(1-h)(1+\varphi)\varphi}{\Gamma''}
\end{aligned}$$

which is negative providing:

$$
\begin{aligned}
&[\sigma(1-\alpha)(1+\varphi)+\gamma_c(1-h)(1+\varphi)\varphi]\,\Gamma'' \\
&\qquad > (\Gamma-\lambda(1-h)(1+\varphi)\varphi\gamma_c)\,[\gamma_c\varphi(1+\mu)+\sigma(1-\alpha)(1+\varphi)(1+h)] \\
&\qquad\quad (\Gamma-\lambda(1-h)(1+\varphi)\varphi\gamma_c)\,[(1-h)(1+\varphi)\varphi\gamma_c]
\end{aligned}
$$

which, after cancelling and combining like terms, is true providing:

$$
(1+\varphi)(1+h)\,[(1+\mu)(\gamma_c\varphi(1-h)-1)+1]+\varphi\gamma_c(1-h)\,[\varphi(1+\varphi)-h(1+\mu)]>0
$$

which is certainly true when $\mu<\varphi$, which is not reasonably restrictive.

The second condition in (6.16) Partially differentiating Φ_A with respect to h provides:

$$
\begin{aligned}
\frac{\partial\Phi_A}{\partial h} \;=\; & \frac{\gamma_c\varphi\,(\lambda(1+\varphi-(1+\mu)}{\Gamma''} \\
& -\frac{[\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\gamma_c\varphi(1+\mu)(1-h)(1-\lambda))}{(\Gamma'')^2} \\
& -\frac{[\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\sigma(1-\alpha)(1-\lambda(1+\varphi))}{(\Gamma'')^2} \\
& -\frac{[\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\lambda(1+\varphi)\varphi\gamma_c-\gamma_c\varphi(1+\mu)(1+(1-\lambda)h))}{(\Gamma'')^2}
\end{aligned}
$$

which is negative providing:

$$
\begin{aligned}
&\gamma_c\varphi\,(\lambda(1+\varphi-(1+\mu)\,\Gamma'' \\
&\quad < [\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\gamma_c\varphi(1+\mu)(1-h)(1-\lambda)) \\
&\quad + [\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\sigma(1-\alpha)(1-\lambda(1+\varphi)) \\
&\quad + [\Gamma-\gamma_c\lambda(1-h)(1+\varphi)\varphi]\,(\lambda(1+\varphi)\varphi\gamma_c-\gamma_c\varphi(1+\mu)(1+(1-\lambda)h))
\end{aligned}
$$

which, after cancelling and combining like terms, is true providing:

$$(1+\varphi)\left[1+h+\varphi\gamma_c(1-h)\varphi\right]-(1+\mu)(1+h-\gamma_c\varphi(1-h)>0$$

which is certainly true when $\mu < 1+\varphi$, which is the restriction as in the main body and is not reasonably restrictive.

The third condition in (6.16) Partially differentiating Φ'' with respect to λ provides:

$$\begin{aligned}
\frac{\partial\Phi''}{\partial\lambda} &= \frac{\left[(1-\lambda)h\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right)-\lambda\varphi\sigma(1-\alpha)h\right]A_1}{(\Gamma'')^2} \\
&\quad -\frac{h\left[\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right]-\varphi\sigma(1-\alpha)h}{\Gamma''} \\
A_1 &= \gamma_c\varphi(1+\mu)(1-h)h+\sigma(1-\alpha)(1+\varphi)(1+h)+(1-h)(1+\varphi)\varphi\gamma_c
\end{aligned}$$

which is positive if:

$$\begin{aligned}
&\left[(1-\lambda)h\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right)-\lambda\varphi\sigma(1-\alpha)h\right]A_1 \\
&\quad > \left[\left[\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right]-\varphi\sigma(1-\alpha)h\right]\Gamma''
\end{aligned}$$

which, after cancelling and combining like terms, is true providing:

$$\gamma_c\varphi(1+\mu)(1-h)\left[(1-\lambda)A-\Gamma''\right]+\sigma(1-\alpha)\left[\left((1-\lambda)-\lambda\varphi\right)A-(1+\varphi)\Gamma''\right]>0$$

which is certainly true when $\mu < \varphi$, which is the restriction as in the main body and is not reasonably restrictive.

The fourth condition in (6.16) Partially differentiating Φ'' with respect to h provides:

$$\begin{aligned}
\frac{\partial \Phi''}{\partial h} &= \frac{(1-\lambda)\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)-h\gamma_c\varphi(1+\mu)\right)-\lambda\varphi\sigma(1-\alpha)}{\Gamma''} \\
&\quad -\frac{\left[(1-\lambda)h\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right)-\lambda\varphi\sigma(1-\alpha)h\right]A_2}{(\Gamma'')^2} \\
A_2 &= \gamma_c\varphi(1+\mu)(1-h)(1-\lambda)+\sigma(1-\alpha)\left(1-\lambda(1+\varphi)\right)+\lambda(1+\varphi)\varphi\gamma_c \\
&\quad -\gamma_c\varphi(1+\mu)\left(1+(1-\lambda)h\right)
\end{aligned}$$

which is positive if:

$$\begin{aligned}
&\left[(1-\lambda)\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)-h\gamma_c\varphi(1+\mu)\right)-\lambda\varphi\sigma(1-\alpha)\right]\Gamma'' \\
&\quad > \left[(1-\lambda)h\left(\gamma_c\varphi(1+\mu)(1-h)+\sigma(1-\alpha)\right)-\lambda\varphi\sigma(1-\alpha)h\right]A_2
\end{aligned}$$

which, after cancelling and combining like terms, is true providing:

$$\begin{aligned}
&\varphi(1+\mu)(1-h)\left[(1+\mu)\left[(1+\varphi)(1+(1-\lambda)h)-h(1-\lambda(1+h))\right]\right] \\
&\quad \varphi(1+\mu)(1-h)\left[(1+\varphi)(1+\lambda(\varphi-h))\right]+\sigma(1-\alpha)(1+\varphi)(1+h)\lambda(\varphi-h)>0
\end{aligned}$$

which is certainly true when $\lambda < 1/h(1+\varphi)$, which is the restriction as in the main body and is not reasonably restrictive, especially when we are restricting to where $\lambda < \lambda^*$.

E.5 Adding distortionary taxation to the model

Taxes on consumption, labour income and employers labour usage can be applied to the model using a similar procedure as performed in Appendix C.4. Moreover, a capital tax can be charged such that Ricardian agents' income from renting capital becomes $(1-\tau_t^k)r_t^k K_{t-1}$. Were these amendments to be included in the model the conditions (E.3), (E.5), (E.8), (E.10), (E.11), (E.12), (E.15), would become, respectively:

$$k_t - n_t = \left(w_t - p_t + \frac{\tau^{er}}{1+\tau^{er}}\hat{\tau}_t^{er}\right) - (r_t^k - p_t)$$

$$\begin{aligned} q_t &= -\left(r_t - E_t\left\{\pi^P_{t+1}\right\}\right) + \frac{1-\delta}{1-\delta+(1-\tau^k)r^k} E_t\left\{q_{t+1}\right\} \\ &\quad + \frac{(1-\tau^k)r^k}{1-\delta+(1-\tau^k)r^k}\left(r^k_{t+1} - p_{t+1}\right) - \frac{\tau^k r^k}{1-\delta+(1-\tau^k)r^k}\tau^k_{t+1} \end{aligned}$$

$$\pi_t = \beta E_t\left\{\pi_{t+1}\right\} + \frac{(1-\beta\theta)(1-\theta)}{\theta}\left[\left(w_t - p_t + \frac{\tau^{er}}{1+\tau^{er}}\hat{\tau}^{er}_t\right) - (y_t - n_t)\right]$$

$$c^R_t - h\cdot c_{t-1} = E_t\left\{c^R_{t+1} - h\cdot c_t\right\} - \frac{1-h}{\sigma}\left(r_t - E_t\left\{\pi_{t+1}\right\} + \frac{\tau^c}{1+\tau^c}\left(\hat{\tau}^c_t - E_t\left\{\hat{\tau}^c_{t+1}\right\}\right)\right)$$

$$(1+\tau^c)\,\gamma_c\left[c^{NR}_t + \frac{\tau^c}{1+\tau^c}\hat{\tau}^c_t\right] = \left(1-\tau^l\right)\frac{1-\alpha}{1+\mu}\left[w_t + n^{NR}_t - \frac{\tau^l}{1-\tau^l}\hat{\tau^l}\right] + \hat{t}_t$$

$$\pi^w_t = \beta E_t\left\{\pi^w_{t+1}\right\} + \frac{\epsilon_w - 1}{\phi_w}\left[\frac{c_t - h\cdot c_{t-1}}{1-h} + \varphi n_t + \frac{\tau^l}{1-\tau^l}\hat{\tau}^l_t + \frac{\tau^c}{1+\tau^c}\hat{\tau}^c_t - (w_t - p_t)\right]$$

$$\begin{aligned} \hat{b}_t &= (1+\rho_R)\left[\hat{b}_{t-1} + \hat{g}_t - \hat{t}_t - \tau^c\gamma_c\left(\tau^c + c_t\right) - \tau^l\frac{1-\alpha}{1+\mu}\left(\tau^l_t + w_t + n_t\right)\right. \\ &\quad \left. -\tau^{er}\frac{1-\alpha}{1+\mu}\left(\tau^{er}_t + (w_t - p_t) + n_t\right) - \tau^k r^k\frac{K}{Y}\left(\tau^k_t + r^k_t + k_{t-1}\right)\right] \end{aligned}$$

Appendix F

Appendices to Chapter 7

F.1 Data appendix

Table 21: Chapter 7 data appendix

Variable	Description and Source
G	Real annual government consumption converted from nominal figures, where possible, using a GDP deflator, otherwise using CPI inflation. The measure of government consumption includes all activities that decrease the net worth of the government as defined by the IMF which includes: expenses; compensation of employees; use of goods and services; consumption of fixed capital; interest; subsidies and grants; and social benefits. Data obtained from IMF *International Financial Statistics* (IFS).
GDP	Real annual GDP converted, where possible, using a GDP deflator, otherwise using CPI inflation. Data obtained from IMF IFS.
GrGDP	Average of the annual growth rate of real GDP per capita: units in percentage terms. Data obtained from Heston et al. (2009).
InitialGDP	Natural log of real GDP per capita, in PPP terms. Data obtained from Heston et al. (2009).
Log(Edu)	Natural log of average years of schooling for individuals above the age of 15. Data obtained from Barro & Lee (2001).
Log(Fert)	The log of the number of births per women, taken from the World Bank.

Log(Life)	The log of the life expectancy at birth, obtained from the World Bank.
SPS	Size of the public sector measured as the average annual proportion of government consumption (G) in real GDP (GDP). Units are measured in decimals. Authors' calculations based on the data obtained from IMF IFS.
Open	Average of annual exports plus imports over GDP in constant prices. Unit measured in decimals. Data obtained from Heston et al. (2009).
GDPVol	Standard deviation of the annual growth rates of real GDP per capita: data obtained from Heston et al. (2009).
ExRVol	Exchange rate volatility measured as the standard deviation in the growth rate of monthly nominal exchange rates between the country in question and the USA. Data used to calculate are from IMF IFS.
POLITY	Measure of democracy within a given country on a (-10,10) scale; higher values relating to higher degrees of democracy and lower values indicating greater degrees of autocracy. Data are obtained from Henisz (2010).
OPENVol	Standard deviation of the annual openness of a country measured using Open above. Data obtained from Heston et al. (2009).
π	Value of the GDP deflator in percentage terms. Data obtained from the World Development Indicators of the World Bank.
CBI	Measure of central bank independence obtained from Cukierman et al. (1992).
CBI'	Measure of central bank independence obtained from Cukierman et al. (1992) as well as Polillo & Guillen (2005), where the latter uses the same methodology as the former to update the statistics.
TURNOVER	Variable that measures turnover of the central bank governor between 1950 and 1989. Data obtained from Cukierman et al. (1992).
POLCON	Average 'POLCONIII' score using data obtained from Henisz (2010).
XCONST	Average 'XCONST' score using data obtained from Henisz (2010).

Gini	The average of available annual Gini coefficients in the relevant time period using data obtained from Deininger & Squire (1996).
IIRating	Average Institutional Investor Ratings for 1979-2002 obtained from Reinhart et al. (2003).
NumDefault	Number of periods of external default since 1945; data obtained from Reinhart (2010).
YrsDefault	Number of years spent in external default since 1945; data are obtained from Reinhart (2010).
PDefault	Probability of default on sovereign debt computed as the ratio of the number of years in default to the total number of years since independence for each nation: authors' calculations using data from Reinhart (2010).
FiscalVol	Standard deviation in the growth rates of government spending over the relevant period: authors' calculations using data from IMF IFS.

Corruption, Accountability, PoliticalStability, GovernmentEffectiveness, RegulatoryQuality and RuleOfLaw are all variables obtained from Kaufmann et al. (2009) where the variable names are matched in the source documentation.

References

Aghion, P. and Marinescu, I. (2007). Cyclical budgetary policy and economic growth: What do we learn from OECD panel data?, *NBER Macroeconomics Annual* **22**: 251–297.

Agnello, L., Mallick, S. K. and Sousa, R. M. (2012). Financial reforms and income inequality, *Economics Letters* **116**(3): 583–587.

Akerlof, G. and Shiller, R. (2010). *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism*, Princeton University Press, Princeton, NJ.

Alesina, A., Campante, F. and Tabellini, G. (2008). Why is fiscal policy often procyclical?, *Journal of the European Economic Association* **6**(5): 1006–1036.

Alesina, A. and Perotti, R. (1996). Fiscal adjustments in OECD countries: composition and macroeconomic effects, *NBER Working Papers No. 5730.*

Altig, D., Christiano, L. J., Eichenbaum, M. and Linde, J. (2011). Firm-specific capital, nominal rigidities and the business cycle, *Review of Economic Dynamics* **14**(2): 225–247.

Andrés, J., Domenech, R. and Fatas, A. (2008). The stabilizing role of government size, *Journal of Economic Dynamics and Control* **32**(2): 571–593.

Aschauer, D. (1993). Fiscal policy and aggregate demand: Reply, *American Economic Review* **83**(3): 667–669.

Auerbach, A. and Gorodnichenko, Y. (2012). Measuring the output responses to fiscal policy, *American Economic Journal: Economic Policy* **4**(2): 1–27.

Barnard, A., Howell, S. and Smith, R. (2011). The effects of taxes and benefits on household income, 2009/10; further analysis and methodology, *Economic and Labour Market Review* **5**(6): 1–95.

Barro, R. (1979). On the determination of the public debt, *Journal of Political Economy* **87**(5): 940–971.

Barro, R. (2007). *Determinants of Economic Growth: A Cross-Country Empirical Study*, The MIT Press.

Barro, R. and Lee, J. (2001). International data on educational attainment: Upadates and implications, *Oxford Economic Papers* **53**(3): 541.

Bhattarai, K. and Trzeciakiewicz, D. (2012). Macroeconomic impacts of fiscal policy shocks in UK: A DSGE analysis, *Technical report*, mimeo, University of Hull.

Bilbiie, F. (2005). Limited asset markets participation, monetary policy and (inverted) Keynesian logic, *Nuffield College, University of Oxford Economics Papers*.

Bilbiie, F. (2008). Limited asset markets participation, monetary policy and (inverted) aggregate demand logic, *Journal of Economic Theory* **140**(1): 162–196.

Bilbiie, F., Meier, A. and Müller, G. (2008). What accounts for the changes in US fiscal policy transmission?, *Journal of Money, Credit and Banking* **40**(7): 1439–1470.

Bilbiie, F. and Straub, R. (2004). Fiscal policy, business cycles and labor-market fluctuations, *Magyar Nemzeti Bank Working Papers*.

Blanchard, O. and Perotti, R. (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output, *Quarterly Journal of Economics* **117**(4): 1329–1368.

Boscá, J., Domenech, R. and Ferri, J. (2011). Search, Nash bargaining and rule of thumb consumers, *European Economic Review* **55**(7): 927–942.

Browning, M. and Collado, M. (2001). The response of expenditures to anticipated income changes: panel data estimates, *American Economic Review* **91**(3): 681–692.

Caldara, D. and Kamps, C. (2008). What are the effects of fiscal policy shocks? A VAR-based comparative analysis, *ECB Working Paper*.

Calvo, G. (1983). Staggered prices in a utility-maximizing framework, *Journal of Monetary Economics* **12**(3): 383–398.

Campbell, J. and Mankiw, N. (1989). Consumption, income, and interest rates: Reinterpreting the time series evidence, *NBER Macroeconomics Annual* **4**: 185–216.

Carbone, E. (2005). Demographics and behaviour, *Experimental Economics* **8**(3): 217–232.

Carbone, E. and Hey, J. (2004). The effect of unemployment on consumption: an experimental analysis, *Economic Journal* **114**(497): 660–683.

Carroll, C. D. (1997). Buffer-stock saving and the life cycle/permanent income hypothesis, *Quarterly Journal of Economics* **112**(1): 1–55.

Carroll, C. D. (2000). Requiem for the representative consumer? Aggregate implications of microeconomic consumption behavior, *American Economic Review* **90**(2).

Christiano, L., Eichenbaum, M. and Rebelo, S. (2011). When is the government spending multiplier large?, *Journal of Political Economy* **119**(1): 78–121.

Christiano, L. J., Eichenbaum, M. and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy, *Journal of Political Economy* **113**(1): 1–45.

Coenen, G. and Straub, R. (2005). Does government spending crowd in private consumption? Theory and empirical evidence for the Euro Area, *International Finance* **8**(3): 435–470.

Coenen, G., Straub, R. and Trabandt, M. (2013). Gauging the effects of fiscal stimulus packages in the euro area, *Journal of Economic Dynamics and Control* **37**(2): 367–386.

Cogan, J., Cwik, T., Taylor, J. and Wieland, V. (2010). New Keynesian versus old Keynesian government spending multipliers, *Journal of Economic Dynamics and Control* **34**(3): 281–295.

Colciago, A. (2011). Rule-of-thumb consumers meet sticky wages, *Journal of Money, Credit and Banking* **43**(2-3): 325–353.

Cukierman, A., Web, S. and Neyapti, B. (1992). Measuring the independence of central banks and its effect on policy outcomes, *World Bank Economic Review* **6**(3): 353–398.

Cushing, M. (1999). The indeterminacy of prices under interest rate pegging: The non-Ricardian case, *Journal of Monetary Economics* **44**(1): 131–148.

Daffin, C. (2009). Wealth in Great Britain, main results from the wealth and assets survey 2006/08, *Office for National Statistics*.

Deininger, K. and Squire, L. (1996). A new data set measuring income inequality, *The World Bank Economic Review* **10**(3): 565–591.

Eggertsson, G. (2011). What fiscal policy is effective at zero interest rates?, *NBER Macroeconomics Annual* **25**(1): 59–112.

Erceg, C. J., Guerrieri, L. and Gust, C. (2006). Sigma: A new open economy model for policy analysis, *International Journal of Central Banking* **2**(1).

Evans, P. (1993). Consumers are not Ricardian: evidence from nineteen countries, *Economic Inquiry* **31**(4): 534–548.

Evans, P. and Karras, G. (1996). Private and government consumption with liquidity constraints, *Journal of International Money and Finance* **15**(2): 255–266.

Flavin, M. (1981). The adjustment of consumption to changing expectations about future income, *Journal of Political Economy* **89**(5): 974–1009.

Forbes, K. and Rigobon, R. (2002). No contagion, only interdependence: measuring stock market comovements, *Journal of Finance* **57**(5): 2223–2261.

Frankel, J., Végh, C. and Vuletin, G. (2012). On graduation from fiscal procyclicality, *Journal of Development Economics* **100**(1): 32–47.

Furlanetto, F. and Seneca, M. (2009). Fiscal shocks and real rigidities, *BE Journal of Macroeconomics* **9**(1).

Furlanetto, F. and Seneca, M. (2012). Rule-of-thumb consumers, productivity, and hours, *The Scandinavian Journal of Economics* **114**(2): 658–679.

Galí, J., López-Salido, J. and Vallés, J. (2007). Understanding the effects of government spending on consumption, *Journal of the European Economic Association* **5**(1): 227–270.

Gavin, M. and Perotti, R. (1997). Fiscal policy in Latin America, *NBER Macroeconomics Annual* **12**: 11–61.

Graham, F. (1993). Fiscal policy and aggregate demand: Comment, *American Economic Review* **83**(3): 659–66.

Graham, L. (2008). Consumption habits and labor supply, *Journal of Macroeconomics* **30**(1): 382–395.

Granados, C. M. (2005). Fiscal adjustments and the short-term trade-off between economic growth and equality, *Hacienda Pública Española* (172): 61–92.

Hall, R. (1978). Stochastic implications of the life cycle-permanent income hypothesis: Theory and evidence, *Journal of Political Economy* **86**(6): 971–987.

Hall, R. (2011). The long slump, *American Economic Review* **101**(2): 431–469.

Hall, R. and Mishkin, F. (1982). The sensitivity of consumption to transitory income: Estimates from panel data on households, *Econometrica* **50**(2): 461–481.

Henisz, W. (2010). The political constraints index (polcon) database.
URL: *http://www-management.wharton.upenn.edu/henisz/*

Heston, A., Summers, R. and Aten, B. (2009). Penn World Table, *Center for International Comparisons at the University of Pennsylvania.*

Hey, J. and Dardanoni, V. (1988). Optimal consumption under uncertainty: An experimental investigation, *Economic Journal* **98**(390): 105–116.

Holden, T. and Paetz, M. (2012). Efficient simulation of DSGE models with inequality constraints, *School of Economics, University of Surrey Working Papers.*

Hsieh, C. (2003). Do consumers react to anticipated income changes? Evidence from the Alaska permanent fund, *American Economic Review* **93**(1): 397–405.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle, *American Economic Review* **95**(3): 739–764.

Ilzetzki, E., Mendoza, E. G. and Végh, C. A. (2013). How big (small?) are fiscal multipliers?, *Journal of Monetary Economics* **60**(2): 239–254.

Ilzetzki, E. and Végh, C. (2008). Procyclical fiscal policy in developing countries: Truth or fiction?, *NBER Working Paper No.14191.*

IMF (2012a). *Fiscal Monitor October 2012*, Vol. 3, International Monetary Fund, Washington, D.C.

IMF (2012b). *IMF Fiscal Outlook: Balancing Fiscal Policy Risks*, Vol. 4, IMF Publishing, Washington, D.C.

IMF (2013). *Fiscal Monitor October 2013: Taxing times*, Vol. 5, International Monetary Fund, Washington, D.C.

IMF (2014). *Fiscal Monitor October 2014: Public expenditure reform, making difficult choices*, Vol. 6, International Monetary Fund, Washington, D.C.

Ireland, P. N. (2011). A New Keynesian perspective on the great recession, *Journal of Money, Credit and Banking* **43**(1): 31–54.

Jappelli, T. and Pagano, M. (1989). Consumption and capital market imperfections: An international comparison, *American Economic Review* **79**(5): 1088–1105.

Kaminsky, G., Reinhart, C. and Végh, C. (2004). When it rains, it pours: Procyclical capital flows and macroeconomic policies, *NBER Macroeconomics Annual* **19**: 11–53.

Kaufmann, D., Kraay, A. and Mastruzzi, M. (2009). Governance matters VIII: aggregate and individual governance indicators, 1996-2008, *World Bank Policy Research Working Paper, No. 4978.*

Kiley, M. (2010). Habit persistence, nonseparability between consumption and leisure, or rule-of-thumb consumers: Which accounts for the predictability of consumption growth?, *The Review of Economics and Statistics* **92**(3): 679–683.

Krusell, P., Mukoyama, T., Sahin, A. and Smith, A. (2009). Revisiting the welfare effects of eliminating business cycles, *Review of Economic Dynamics* **12**(3): 393–404.

Krusell, P. and Smith, A. (1999). On the welfare effects of eliminating business cycles, *Review of Economic Dynamics* **2**(1): 245–272.

Lane, P. (2003). The cyclical behaviour of fiscal policy: evidence from the OECD, *Journal of Public Economics* **87**(12): 2661–2675.

Lane, P. and Tornell, A. (1998). Why aren't savings rates in Latin America procyclical?, *Journal of Development Economics* **57**(1): 185–199.

Lawrance, E. C. (1991). Poverty and the rate of time preference: Evidence from panel data, *Journal of Political Economy* **99**(1): 54–77.

Leeper, E. M., Plante, M. and Traum, N. (2010). Dynamics of fiscal financing in the United States, *Journal of Econometrics* **156**(2): 304–321.

Linnemann, L. (2006). The effect of government spending on private consumption: a puzzle?, *Journal of Money Credit and Banking* **38**(7): 1715.

Linnemann, L. and Schabert, A. (2003). Fiscal policy in the new neoclassical synthesis, *Journal of Money, Credit and Banking* **35**(6): 911–929.

Lucas, R. (2003). Macroeconomic priorities, *American Economic Review* **93**(1): 1–14.

Mankiw, N. (2000). The savers-spenders theory of fiscal policy, *American Economic Review* **90**(2): 120–125.

Monacelli, T. and Perotti, R. (2008). Fiscal policy, wealth effects, and markups, *NBER Working Papers.*

Mukoyama, T. and Şahin, A. (2006). Costs of business cycles for unskilled workers, *Journal of Monetary Economics* **53**(8): 2179–2193.

Muscatelli, V., Tirelli, P. and Trecroci, C. (2004). Can fiscal policy help macroeconomic stabilisation? Evidence from a New Keynesian model with liquidity constraints, *CESifo Working Paper Series.*

Nevitte, N., Blais, A., Gidengil, E. and Nadeau, R. (2009). Socio-economic status and non-voting, *The Comparative Study of Electoral Systems* pp. 85–108.

OECD (2009). *OECD Economic Outlook*, Vol. 2009, OECD Publishing, Paris.

OECD (2012). *OECD Economic Outlook*, Vol. 2012, OECD Publishing, Paris.

Parker, J. (1999). The reaction of household consumption to predictable changes in social security taxes, *American Economic Review* **89**(4): 959–973.

Paxson, C. (1993). Consumption and income seasonality in Thailand, *Journal of Political Economy* **101**(1): 39–72.

Polillo, S. and Guillén, M. (2005). Globalization pressures and the state: The worldwide spread of central bank independence, *American Journal of Sociology* **110**(6): 1764–1802.

Ramey, V. (2011). Identifying government spending shocks: It's all in the timing, *Quarterly Journal of Economics* **126**(1): 1–50.

Reinhart, C. (2010). This time is different chartbook: Country histories on debt, default, and financial crises, *NBER Working Paper No. 15815*.

Reinhart, C. M. and Rogoff, K. S. (2014). Recovery from financial crises: Evidence from 100 episodes, *American Economic Review* **104**(5): 50–55.

Reinhart, C., Rogoff, K. and Savastano, M. (2003). Debt intolerance, *Brookings Papers on Economic Activity* **1**(1): 1–74.

Romer, C. and Bernstein, J. (2009). The job impact of the American recovery and reinvestment plan, *Office of the President-Elect*.

Rotemberg, J. (1982). Monopolistic price adjustment and aggregate output, *The Review of Economic Studies* **49**(4): 517–531.

Rotemberg, J. J. and Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy, *NBER Macroeconomics Annual* **12**: 297–346.

Sarantis, N. and Stewart, C. (2003). Liquidity constraints, precautionary saving and aggregate consumption: an international comparison, *Economic Modelling* **20**(6): 1151–1173.

Schmitt-Grohe, S. and Uribe, M. (2006). Optimal fiscal and monetary policy in a medium-scale macroeconomic model, *NBER Macroeconomics Annual* **20**: 383–462.

Shapiro, M. and Slemrod, J. (2003). Consumer response to tax rebates, *American Economic Review* **93**(1): 381.

Shea, J. (1995). Union contracts and the life-cycle/permanent-income hypothesis, *American Economic Review* **85**(1): 186–200.

Smets, F. and Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the Euro area, *Journal of the European Economic Association* **1**(5): 1123–1175.

Souleles, N. (1999). The response of household consumption to income tax refunds, *American Economic Review* **89**(4): 947–958.

Souleles, N. S., Parker, J. A. and Johnson, D. S. (2006). Household expenditure and the income tax rebates of 2001, *American Economic Review* **96**(5): 1589–1610.

Straub, R. and Tchakarov, I. (2007). Assessing the impact of a change in the composition of public spending: A DSGE approach, *Technical report*, European Central Bank.

Sullivan, J. (2008). Borrowing during unemployment, *Journal of Human Resources* **43**(2): 383–412.

Talvi, E. and Végh, C. (2005). Tax base variability and procyclical fiscal policy in developing countries, *Journal of Development Economics* **78**(1): 156–190.

Walsh, C. E. (2010). *Monetary theory and policy*, MIT press.

Wolfers, J. (2003). Is business cycle volatility costly? Evidence from surveys of subjective well-being, *International finance* **6**(1): 1–26.

Woo, J. (2009). Why do more polarized countries run more procyclical fiscal policy?, *Review of Economics and Statistics* **91**(4): 850–870.

Woo, J., Bova, E., Kinda, T. and Zhang, Y. S. (2013). Distributional consequences of fiscal consolidation and the role of fiscal policy: What do the data say?, *Technical report*, International Monetary Fund.

Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*, Princeton University Press.

Woodford, M. (2011). Simple analytics of the government expenditure multiplier, *American Economic Journal: Macroeconomics* **3**(1): 1–35.

Zeldes, S. (1989). Consumption and liquidity constraints: An empirical investigation, *Journal of Political Economy* **97**(2): 305–346.