Fiscal consolidations and distributional effects: what fiscal austerity is least bad? *

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June 12, 2018

Abstract

Distributional consequences of fiscal austerity, while being increasingly recognized in the policy debate, have received little attention in the existing formal work. This paper proposes a medium scale New Keynesian DSGE model incorporating an appropriate dimension of household heterogeneity and a well-specified fiscal structure, allowing for a comprehensive analysis of losers and winners from austerity. Our results are as follows. First, cutting transfers and public employment and raising labour taxes are the most regressive forms of austerity, greatly raising income inequality. In contrast, raising capital taxes is progressive - the only such policy in our analysis- with also smallest output losses in the short run. Second, while credit-constrained agents lose out in the short to medium term following fiscal adjustment, there is a reversal of fortune over a longer horizon; the credit unconstrained suffer in the long-term. Finally, speedy austerity yields worst distributive and output effects irrespective of its composition.

JEL Classification: E65; H2; H3.

*Comments from the participants at The European Monetary Forum workshop at the University of Glasgow; Money, Macro and Finance Annual Conference at Queen Mary College; the Royal Economic Society Annual Conference at the University of Manchester, European Workshop on Political Macroeconomics at the University of Reading, and seminars at the University of Manchester and Koc University are gratefully acknowledged.

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1 Introduction

Populism has been on the rise in industrial democracies with unexpected consequences. For example, electoral surprises both in the UK’s referendum to leave the European Union and the US presidential election are widely seen as watershed moments, following from widespread discontent of the masses. Similarly, there has been strong support for anti-establishment parties in elections in France, Germany, Spain, and more recently in Italy. A prominent argument is that the 2008-09 global financial crisis and the wide-spread fiscal consolidation efforts from 2010 onwards hurt the most disadvantaged, creating resentment for the status quo (see for example [Broughton et al. 2015, Bell & Machin 2016]). The poorest with low skills and with no financial wealth, who had already suffered the consequences of globalization in the form of low wages and job losses, now witnessed their benefits and transfer payments dwindle in times of fiscal austerity.\footnote{Substantial fiscal stimulus packages that were put in place in response to the global financial crisis were swiftly reversed in favour of fiscal austerity, particularly in advanced economies due to serious fiscal sustainability issues. The size of fiscal consolidation as a proportion of GDP between 2009 and 2013 was as large as 3 per cent of GDP in France, 4.3 per cent in the US, 6.2 percent in the UK and 17.8 per cent in Greece (see [IMF 2013]).}

There is now mounting empirical evidence on the distributional effects of fiscal adjustment, in the form of increased income inequality ([Agnello et al. 2012, IMF 2012, Ball et al. 2013, Agnello & Sousa 2014]).\footnote{This line of work is separate from the well-established empirical literature on the output effects of fiscal consolidations (see for example [Alesina & Perotti 1995, Alesina et al. 2015, Guajardo et al. 2014] among many others).} It has also been documented that fiscal austerity that is viewed as ‘unfair’ is unlikely to succeed (see for example [Granados 2005, IMF 2012]) and that the distributional impacts of fiscal policy shocks matter (see, for example, [De Giorgi et al. 2012, Anderson et al. 2016]). Furthermore, in a comprehensive study of fiscal consolidation in the European Union, [Paulus et al. 2016] establishes significant variation in the distributional effects of austerity, calling for more disaggregated analysis of not just types of fiscal action but also of different income groups.

Despite its central role in policy discussions and the support from recent empirical studies, as noted above, the distributive consequences of fiscal austerity has received much less attention in formal work until recently. One exception is [Röhrs & Winter 2017] who show that in the presence of inequality, there are welfare costs of debt reduction in the short-run whereas reducing government debt is beneficial for aggregate welfare in the long-run, as previously discussed by [Forni et al. 2010] and [Clinton et al. 2011]. Other recent papers exploring distributional consequences of fiscal policy more broadly are [Drautzburg & Uhlig 2015] and [McManus 2015]. The former analyse the effectiveness of the 2009 American Recovery and Re-investment Act (ARRA) and find that policy intervention may lower the welfare of both constrained and unconstrained agents in the economy. In contrast, [McManus 2015] finds that countercyclical fiscal policy is to the benefit of credit-constrained agents and to the detriment of the unconstrained and hence with minimal aggregate welfare effects.

One common feature of this line of work has been the broad categorization of fiscal action as tax versus spending based consolidations. In contrast, austerity packages in practice varied
greatly in their composition. For example, both advanced an emerging economies employed a wide range of fiscal measures in designing fiscal consolidation from 2010 onwards (see for example [IMF] 2012). These included cuts in civil service, social benefits, public investment as well as public wage freeze on the spending side, and rises in income, capital and expenditure taxes and social security contributions on the revenue side, clearly with very different distributional implications.

In this paper, we propose a medium scale dynamic stochastic general equilibrium (DSGE) model, with a rich fiscal structure allowing a comprehensive analysis of consequences of each individual fiscal action. Given that distributional issues are our central focus, capturing the appropriate dimension of household heterogeneity is a key step in building our framework. The vast majority of the existing work on fiscal policy that feature heterogeneous agents within a DSGE framework adopts a standard setting with two types of consumers: a full-optimizing, consumption smoothing household who has access to financial markets, and a credit-constrained household whose consumption is tightly linked to disposable income. Yet, a sizeable proportion of households in advanced economies hold substantial wealth that is illiquid, forcing these households to act as constrained by consuming all of their period disposable income - referred to as the ‘wealthy hand-to-mouth’ (Kaplan et al. 2014). Similarly, data from the British Household Panel Survey clearly indicates that there is a separate group of households whose behaviour differs from both the full-optimizers and the credit-constrained consumers in the holdings of both illiquid wealth and borrowing.

In order to provide a realistic representation of household heterogeneity, our framework features three types of agents. In addition to the full-optimising Ricardian consumers and the credit-constrained rule-of-thumb ones (as standard) we incorporate the empirically relevant wealthy hand-to-mouth type. These households, whom we refer to as impatient agents, hold sizable wealth yet are also credit-constrained due to the illiquid nature of that wealth, capturing important characteristics established previously in the literature (see, for example, Iacoviello 2005, Kaplan et al. 2014). To the best of our knowledge, ours is the first paper considering this dimension of heterogeneity by differentiating between two types of credit constrained households - across holdings of wealth and access to borrowing - in analysing fiscal adjustment. This feature of our model allows us to link fiscal action to household borrowing, with important implications.

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3 An implication of the two-agents framework is that sensitivity of aggregate consumption to transitory income - widely observed to be high - should be closely linked with the proportion of such credit-constrained agents who have no access to financial markets. However, evidence from microeconomic data on household balance sheets suggests that the fraction of agents with near-zero wealth and no borrowing is too small (around 30 percent in both the UK and the US) to account for such consumption behaviour, suggesting that the standard setting with two types of households is too simplistic.

Cloyne & Surico (2017), by using data from the UK’s Family Expenditure Survey, find that households with mortgage debt hold very little liquid wealth in contrast to outright home-owners, while owning sizeable illiquid assets. Furthermore, the consumption response in the face of income tax changes of outright home owners, households with mortgage debt and renters are shown to be substantially different.

5 The importance of the concentration of wealth as a key issue underlying economic behaviour is now widely recognized. See, for example, Mankiw (2000) and the response to the influential work by Piketty (2014). The role of the housing market as an underlying source of difficulties preparing the ground for the 2008-2009 global financial crisis has also been widely discussed (see for example Yellen 2009).
for how the burden of austerity is shared.\footnote{The other two papers that incorporate housing investment and credit-constrained indebted households are Ratto et al. (2009) and Alpanda & Zubairy (2017) neither of whom explores fiscal consolidations. The former examines effectiveness of fiscal policy in a two-country model excluding distributional issues while the latter studies effects of housing-related tax policy.}

The resulting framework also features eight fiscal instruments (four separate distortionary taxes and four spending categories), enabling us to carry out a full examination of empirically relevant fiscal actions.\footnote{McManus et al. (2018) also utilizes a model with a rich set of fiscal measures but their interest is in examining the possibility of expansionary fiscal contractions and hence they do not consider the distributional issues.} By utilizing our proposed setting, we explore three sets of outcomes arising from fiscal consolidations. We first examine the impact on the aggregate economy, in particular on output. Given our interest in distributional effects, we then provide a comprehensive analysis of the impact on income distribution across agents; and, finally, on the distribution of welfare across agents.

Our main findings are as follows. We find that incorporating an appropriate level of household heterogeneity alongside an extensive range of fiscal instruments proves crucial in mapping individual consolidation packages to redistributive outcomes. For example, we show that those agents who are credit constrained are most exposed to austerity as opposed to the unconstrained who frequently gain from such fiscal action. In addition, although access to borrowing is typically beneficial for the impatient agents in the short run, in the medium run these households start to see increased interest costs (due to higher levels of borrowing) leading to lower consumption. Furthermore, while credit-constrained agents lose out in the short to medium term following fiscal adjustment, interestingly, there is a reversal of fortune over a longer horizon: the credit unconstrained suffer in the long-term. As the fully-rational patient agents own government debt, whilst this is being repaid their incomes are higher; when this is complete, lower levels of government bonds lead to lower interest income in steady state. Regarding the composition, tax based consolidations induce more favourable distributional consequences than those from the spending based ones in the form of less skewed welfare and income distribution. More specifically, we find that austerity based on cutting transfers and public employment and raising labour income taxes are most regressive, greatly raising income inequality; with limited access to credit, the constrained agents are more sensitive to movement in income made up of both government transfers and wages. In contrast, raising capital taxes is a progressive form of fiscal adjustment - the only one - also with smallest output costs in the short-run. Increases in capital taxes lead to a substitution from capital to labour, temporarily raising employment income; over the medium run, however, capital decumulation reduces the marginal product of labour and the capacity of the economy, leading to poor effects after a short lived boost. Finally, our results suggest that both the output and the distributional effects of fiscal austerity in the short-run are shaped by its speed much more than its composition.

The paper proceeds in the following way. Section 2 builds the model including durable and non-durable goods, three types of households, and eight fiscal instruments. Section 3 evaluates the macroeconomic impact of different fiscal consolidations, as well as the distributional outcomes in terms of both income and welfare. Section 4 considers further extensions, the impact...
of the monetary zero lower bound and other sensitivity checks. Finally, Section 5 concludes.

2 The model

We build a medium scale DSGE model which shares features with Smets & Wouters (2003), Iacoviello (2005), and Gali et al. (2007). The model economy is populated by three types of households: ‘patient’ (lenders), ‘impatient’ (borrowers), and ‘rule-of-thumb’ (RoT), two productions sectors and fiscal and monetary authority. Patient households consume the non-residential good, accumulate housing, provide the physical capital for firms, and lend to impatient households and the government. Impatient agents consume the non-residential good and discount the future more heavily than patient households. The higher rate of time discounting of these households implies that they are borrowers and do not invest in physical capital; however, they do gain utility from housing and as such, accumulate a stock of durable goods which acts as collateral against which they can borrow. Rule-of-thumb households neither engage with financial markets nor own housing stock. This behaviour is formalised through postulating that these households are also impatient and they obtain no utility from housing. As such, each period rule-of-thumb agents consume their income from labour (net of taxes and union fees) and lump sum government transfers.

All agents provide differentiated labour to unions who optimize wages every period subject to a fee. Subsequently, labour from the three types of households is combined with sector specific capital in the production of both the non-residential goods and housing via Cobb-Douglas technology. The production sector of the non-residential good features monopolistic competition and Calvo contracts, whereas the residential good sector is perfectly competitive, as is typically the case in the literature (see Iacoviello & Neri 2010). The fiscal authority imposes taxes on consumption, labour and capital income, and employer’s social security contributions and spends the proceeds on public consumption, investment, employment and transfers to impatient and RoT households. Monetary policy follows a standard Taylor type rule. In what follows, we present the details of the model economy.

2.1 Households

There is a continuum of measure 1 of households in each of the three groups: ‘patient’, ‘impatient’ and ‘rule-of-thumb’. The utility of households evolves according to:

$$E_0 \sum_{i=0}^{\infty} (\beta^m)^i \left( \ln (C_t^m(i)) + \sigma_h^m \ln (H_t^m(i)) - \frac{1}{1 + \sigma_l} (L_t^m(i))^{1+\sigma_l} \right)$$

(1)

where $m \in \{P, I, R\}$ refers to, respectively, patient, impatient and RoT households; $E_0$ is the expectations operator; $i$ indicates a particular household; $\beta^m$ is a subjective discount factor; $C_t(i)$, $H_t(i)$ and $L_t(i)$ denote, respectively, household $i$’s consumption of the non-residential good, housing and hours of work at time $t$; $\sigma_h^m$ denotes the weight on housing in utility and $\sigma_l$ is the inverse elasticity of labour supply with respect to real wages.
2.1.1 Patient households

Total real income of patient households consists of: after tax labour income \((1 - \tau_t^l) w_t^P(i)L_t^P(i)\), where \(\tau_t^l\) represents labour income taxes and \(w_t^P(i)\) is the real wage rate of patient agents; after tax capital income \((1 - \tau_t^k) [r_{c,k,t}K_{c,t-1}(i) + r_{h,k,t}K_{h,t-1}(i)]\), where \(\tau_t^k\) denotes a tax on capital income and \(r_{c,k,t}\) and \(r_{h,k,t}\) are the real rental rates of capital used in the non-residential and residential sector respectively; after tax dividend income \((1 - \tau_t^{div})div_t(i)\), where \(div_t(i)\) denotes dividend payments from monopolistic producers; interest from holdings of government debt \((B_{t-1}(i))\) and impatient households’ debt \((LO_{t-1}(i))\) given by \(((R_{t-1} - 1)/\pi_t)(B_{t-1}(i) + LO_{t-1}(i))\), where \(R_{t-1}\) is the gross nominal interest rate and \(\pi_t\) the gross inflation rate.

Patient household \(i\) spends her total real disposable income on: consumption of the non-residential \((1 + \tau_t^c)C_t(i)\), taxed at a rate of \(\tau_t^c\); net acquisition of residential property \(q_t[H_t(i) - (1 - \delta_h)H_{t-1}(i)]\), where \(q_t\) is the relative price of housing and \(\delta_h\) is the rate at which housing stock depreciates; net acquisition of government bonds \((B_t(i) - B_{t-1}(i)/\pi_t)\) and loans to impatient agents \((LO_t(i) - LO_{t-1}(i)/\pi_t)\); and investment in the physical capital in the non-residential \((I_{c,t}(i))\) and residential \((I_{h,t}(i))\) sector, which leads to the following law of motion for capital:

\[
K_{n,t}(i) = (1 - \delta_{n,k})K_{n,t-1}(i) + F_k(I_{n,t}(i), I_{n,t-1}(i))
\]

where \(n \in \{c, h\}\), capital depreciates at rate \(\delta_{n,k}\), and investment is subject to costly adjustment quantified such that \(F_k(I_{n,t}(i), I_{n,t-1}(i)) = \left[1 - (\phi_k/2)\left((I_{n,t}(i)/I_{n,t-1}(i)) - 1\right)^2\right]I_{n,t}(i)\) where \(\phi_k\) denotes the inverse elasticity of investment with respect to installed capital. Household \(i\) budget constraint is given by:

\[
LO_t(i) + B_t(i) + I_{c,t}(i) + I_{h,t}(i) - \frac{(B_{t-1}(i) + LO_{t-1}(i))}{\pi_t} + q_t[H_t^P(i) - (1 - \delta_h)H_{t-1}^P(i)]
\]

\[
+ (1 + \tau_t^c)C_t^P(i) = \left(1 - \tau_t^l\right) w_t^P(i)L_t^P(i) + \frac{(R_{t-1} - 1)}{\pi_t} (B_{t-1}(i) + LO_{t-1}(i))
\]

\[
+ \left(1 - \tau_t^k\right) [r_{c,k,t}K_{c,t-1}(i) + r_{h,k,t}K_{h,t-1}(i) + div_t(i)] - F_t^P(i)
\]

where \(F_t^P(i)\) denotes labour union membership fee.\(^8\) Patient households maximise utility (1) subject to (2) and (3).

2.1.2 Impatient households

Each impatient household \(i\) faces a budget constraint which states that expenditure on interest on loans, non-residential consumption and the net acquisition of housing must match labour income (net of taxes and union fees), new loans, and lump sum government transfers \((1 - \)

\(^8\)The labour union membership fee refers to the Rotemberg (1982) wage adjustment costs given by \(F_t^{\text{wu}}(i) = (\phi_w/2)\left((W_t^{\text{wu}}(i)/(W_{t-1}^{\text{wu}}(i)\pi)) - 1\right)^{\phi_w} W_t^{\text{wu}}N_t^{\text{wu}}\), where \(\phi_w\) is a wage adjustment cost parameter and \(\pi\) denotes an inflation target.
\( \mu TR_t^l(i) \), where \((1 - \mu)\) denotes a share of transfers that go to impatient households. 

\[
\frac{(R_t - 1)LO_{t-1}(i)}{\pi_t} + (1 + \tau_t^r) C_t^l(i) + q_t(H_t^l(i) - (1 - \delta_h)H_{t-1}^l(i)) = \left(1 - \tau_t^l\right) w_t^l(i)L_t^l(i) + (1 - \mu)TR_t(i) + LO_t(i) - \frac{LO_{t-1}(i)}{\pi_t} - F_t^l(i) \tag{4}
\]

The upper limit to which each impatient agent can borrow is their stock of housing net of a down-payment \((\tau)\). This implies the following constraint on the borrowing of impatient households:

\[
LO_t(i) \leq \rho_h \frac{LO_{t-1}(i)}{\pi_t} + (1 - \rho_h)(1 - \tau)q_tH_t^l(i) \tag{5}
\]

where \(\rho_h\) denotes the degree of persistence in the borrowing limit as in Guerrieri and Iacoviello (2017). Impatience of these agents, relative to the patient above, ensures that this borrowing constraint is binding in and around the steady-state. Impatient households maximise utility \((1)\) subject to constraints \((4)\) and \((5)\).[^9][^10]

### 2.1.3 Rule-of-thumb households

The budget constraint of rule-of-thumb households is given by:

\[
(1 + \tau_t^R) C_t^R(i) = \left(1 - \tau_t^R\right) w_t^R(i)L_t^R(i) + \mu TR_t^R(i) - F_t^R(i) \tag{6}
\]

These agents do not accumulate the residential good \((\sigma_t^R = 0)\). RoT households are also assumed to be impatient, and given the borrowing constraint \((5)\) and the lack of residential good consumption, these agents do not engage with credit or capital markets, and simply consume their disposable income each period.

### 2.1.4 Labour Aggregation and Labour Unions

There are three labour aggregators, one for each of the three types of households in the model. Each aggregator transforms the differentiated labour \((L_t^m(i))\) obtained from labour unions into composite labour \(N_t^m\) with CES technology \(N_t^m = \int_{0}^{1} (L_t^m(i))^{(\nu_w - 1)/\nu_w} di / \int_{0}^{1} (w_t^m(i))^{\nu_w/\nu_w} di\), where \(\nu_w\) denotes the elasticity of substitution among differentiated labour inputs. Subsequently, labour \(N_t^m\) is supplied to private firms and the government i.e. \(N_t^m = N_{t, t}^m + N_{h,t}^m + N_{g,t}^m\), where \(N_{t, t}^m\) denotes the demand for labour of household type \(m\) from the non-residential goods sector, \(N_{h,t}^m\) the residential good sector, and \(N_{g,t}^m\) from the government. Each aggregator choose \(L_t(i)\) to maximise profits defined as: \(profit_{t, t}^m = w_t^m N_t^m - \int_{0}^{1} w_t^m(i)L_t^m(i) di\), where \(w_t^m\) denotes a wage index. The first order condition yields the standard demand functions for differentiated labour:

\[
L_t^m(i) = (w_t^m(i)/w_t^m)^{-\nu_w} N_t^m.
\]

[^9]: We assume that the government provides lump-sum transfers only to impatient and RoT households. The labour income share of these households in total labour are given by \(b_2\) and \(1 - b_1 - b_2\) respectively (where \(b_1\) is the labour income share of patient households in total labour income) and therefore we set \(1 - \mu = b_1/(1 - b_1)\).

[^10]: It was reported that the proportion of such households with substantial holdings of wealth while facing tight liquidity constraints varies between approximately 20% and 30% in advanced economies (Kaplan et al. 2014).
The remaining part of the wage framework closely follows Furlanetto (2011). For a fee, each labour union sets wages for its members, by maximising the present value of average utility of its members subject to the budget constraints and demand for labour from labour aggregators each period.

2.2 Production sector

2.2.1 Production of non-residential good

A representative perfectly competitive producer of the homogeneous non-residential good purchases differentiated goods \(Y_t(j)\) from monopolistic producers and combines them into a single consumption good \(Y_t\) using a standard CES technology:

\[
Y_t = \left[ \int_0^1 Y_t(j)^{(v_p-1)/v_p} dj \right]^{v_p/(v_p-1)}
\]

where \(v_p\) denotes the elasticity of substitution. Profit maximisation of these firms provides standard demand functions for intermediate goods given by

\[
Y_t(j) = \left( \frac{P_t}{P_t(j)} \right)^{v_p} Y_t.
\]

Homogeneous output \(Y_t\) is subsequently demanded by households and the government i.e.

\[
Y_t = I_c,t + I_h,t + C_P, t + C_I, t + C_R, t + I_g,t + G_c,t + F_P, t + F_I, t + F_R, t
\]

where \(G_c,t\) and \(I_g,t\) denote, respectively, public consumption and investment.

The intermediate good production sector is populated by monopolistic firms indexed by \(j\) whose production technology is given by:

\[
Y_t(j) = (K_{c,t-1}(j))^{\alpha_h} \left[ \left( N_{c,t}^P(j) \right)^{b_1} \left( N_{c,t}^I(j) \right)^{b_2} \left( N_{c,t}^R(j) \right)^{1-b_1-b_2} \right]^{1-\alpha_h} (K_{g,t-1})^{\sigma_g} - \Phi
\]

where \(K_{g,t-1}\) represent public capital, \(\alpha_h\) denotes the share of private capital in production, \(b_1\) and \(b_2\) represent, respectively, the labour share of patient and impatient households in total labour used in production, \(\sigma_g\) denotes the elasticity of output with respect to public capital, and \(\Phi\) a fixed cost in production. As is standard in the new Keynesian framework, monopolistic competitors face three constraints: the production function, a demand constraint, and price rigidity governed by a Calvo (1983) mechanism where each period each firm faces a constant probability \((1 - \theta_p)\) of being able to re-optimise its prices. The remaining firms follow a simple indexation rule in price setting, \(P_{j,t} = \bar{\pi} P_{j,t-1}\), where \(\bar{\pi}\) denotes an inflation target.

Producers of the residential good

The competitive residential good producers use Cobb-Douglas technology to produce residential output \(HI_t\):

\[
HI_t = (K_{h,t-1})^{\alpha_h} \left[ \left( N_{h,t}^P(j) \right)^{b_1} \left( N_{h,t}^I(j) \right)^{b_2} \left( N_{h,t}^R(j) \right)^{1-b_1-b_2} \right]^{1-\alpha_h} K_{g,t-1}^{\sigma_g}
\]

where, \(\alpha_h\) denotes the share of private capital in the production of the residential good. Optimisation of the representative final good producer is performed through maximising profits subject to technology, where prices and wages are taken as given. The output of residential good producers is purchased by patient and impatient households, \(HI_t = H_t^P + H_t^I - (1 - \delta_h) \left( H_{t-1}^P + H_{t-1}^I \right)\).
2.3 Macroeconomic policy

2.3.1 Monetary policy

The monetary authority sets nominal interest rates \((R_t)\) following a Taylor rule which responds to movements in both output and inflation with some persistence \((\rho)\):

\[
R_t = R \left( \frac{R_{t-1}}{R} \right)^\rho \left[ \left( \pi_t^A \right)^{0.25} \pi \left( \frac{GDP_t}{GDP} \right)^{\rho_y} \right]^{1-\rho}
\]

where \(GDP_t = Y_t + qHI_t + (1 + \tau_{er}^t)(w_tP_{g,t}N_{g,t} + w_tI_{g,t}N_{I,t} + w_tR_{g,t}N_{R,t})\), \(\pi_t^A = P_t/P_t - 4\) is an annual inflation rate; \(\rho_\pi\) and \(\rho_y\) denote respectively, the policy maker’s aversion for the deviations of inflation and output from their respective steady-state values.\(^{11}\)

2.3.2 Fiscal policy

The government budget constraint is given by:

\[
\left( \frac{R_{t-1}}{\pi_t} \right) B_{t-1} + G_t + I_{g,t} + TR_t = \tau_c t \left( C_t + C_I + C_R \right) + (\tau^c + \tau^{er}_t) \left( w_t^P L_t^P + w_t^I L_t^I + w_t^R L_t^R \right) + \tau^k \left( r_{k,c,t} K_{c,t-1} + r_{k,h,t} K_{h,t-1} + div_1 \right) + B_t
\]

where \(G = G_{c,t} + (1 + \tau_{er}^t)(w_tP_{g,t}N_{g,t} + w_tI_{g,t}N_{I,t} + w_tR_{g,t}N_{R,t})\). Public investment induces the law of motion of public capital:\(^{12}\)

\[
K_{g,t} = (1 - \delta_{g,k})K_{g,t-1} + I_{g,t}
\]

where \(\delta_{g,k}\) represents depreciation of public capital. The eight fiscal instruments ensure that the level of debt converges to steady-state values:

\[
X_t = X \left( \frac{B_t}{B} \right)^{\phi_{B,X}}
\]

where \(X = \{ \tau^c, \tau^k, \tau^l, \tau^{er}, G_c, I_g, N_{g}, TR \} \). Variables with no time subscript represent their steady-state values and \(\phi_{B,X}\) denotes ‘debt aversion’ parameters. These fiscal rules ensure that debt converges to its steady-state level and the calibration of \(\phi_{B,X}\) determines if this is done either through tax increases and/or spending cuts and the speed in which this is performed.\(^{13}\)

\(^{11}\)Note that this formulation of GDP has three components: the output from the non-residential good sector \((Y_t)\); the output from the residential good sector \((qHI_t)\); and the wage cost of public sector employment \((1 + \tau_{er}^t)(w_t^P N_{g,t} + w_t^I N_{I,t} + w_t^R N_{R,t})\) which is equal to the output of the public sector. Following Iacoviello & Neri (2010) our definition of GDP uses steady-state house prices.

\(^{12}\)Equation (11) indicates that the accumulation of public capital is equivalent to the accumulation of private capital, but without adjustment costs, as is common in the literature (see for example Traum & Yang 2015).

\(^{13}\)The debt aversion parameters \(\phi_{B,X}\) take negative values for spending instruments and positive values for revenue instruments.
This form of fiscal action is motivated by the use of a rich set of spending and tax instruments in fiscal consolidation in practice, as was the case since 2010 (see for example IMF 2012).

3 The implications of fiscal austerity

3.1 Consumption, investment and labour

In order to understand the aggregate and disaggregate effects from fiscal austerity episodes, it is instructive to first consider the optimisation conditions facing different agents in the economy. The response of these agents (and the economy more broadly) to fiscal actions provide the intuition for the results from the fiscal experiments to follow.

3.1.1 Non-residential consumption

The first order conditions for patient and impatient households with respect to consumption are presented in the following Euler equations:

\[
\lambda_t^P = \frac{U_{c,t}^P}{(1 + \tau_c^P)} = \beta^P E_t \frac{R_t}{\pi_{t+1}} \frac{U_{c,t+1}^P}{(1 + \tau_c^{P,t+1})}
\]

\[
\lambda_t^I = \frac{U_{c,t}^I}{(1 + \tau_c^I)} = \beta^I E_t \frac{R_t}{\pi_{t+1}} \frac{U_{c,t+1}^I}{(1 + \tau_c^{I,t+1})} \left(1 - \lambda_t^b\right)
\]

where \(\lambda^b\) is the price of borrowing (the ratio of the Lagrange multiplier on the borrowing constraint of the impatient to the Lagrange multiplier on the budget constraint), and \(U_x = 1/C_x\) denotes marginal utility of consumption for \(x \in \{P,I\}\). The Euler equation for patient agents (13) is standard and illustrates that these households’ consumption responds to changes in expected discounted paths of real interest rates and consumption taxes: the movement of the latter is determined directly by the austerity itself; movements in real interest rates will occur as a result of the fiscal action as the Taylor rule (9) responds to movements in both output and inflation. Likewise patient households will respond to changes in expected discounted consumption such that consumption is smoothed over their lifetime; therefore, these forward looking agents internalise the movement in their consumption profile as a result of austerity, including the change in consumption that is expected after the austerity has been enacted.

In the fiscal experiments to follow, we maintain \(\lambda^b > 0\) which means that the constraint on the borrowing of impatient agents (5) is always binding in and around the steady-state; in this situation, any additional income in the current period (including any extra borrowings from the loosening of the borrowing constraint) is used for contemporaneous consumption. Changes

\[\text{[14]}\]

Similarly, by using US data to estimate fiscal rules, it has been shown that best fitting models are those with many fiscal instruments responding to debt (see for example Leeper 2010).

\[\text{[15]}\]

Note that for the borrowing constraint to not hold, there would need to be a large consumption boom for impatient households such that the marginal benefit from additional consumption is lower than the cost of borrowing. This is not likely in the presence of fiscal austerity, and therefore we always assume this borrowing constraint binds in our experiments.
in income for impatient agents as a result of the fiscal experiments can come from two main channels: first, the direct effect of policy on labour income and/or transfers; and second, the indirect effect that policy can have on impatient borrowing, both with respect to the value of housing (which influences the amount these agents can borrow) and with the rate of interest these agents repay on their borrowing. Similarly, rule-of-thumb households spend all additional income in the period on consumption, and their consumption function is given in (6). Therefore, austerity will impact the consumption of rule-of-thumb households both through their labour income and as a result of a movement in transfers.

3.1.2 Residential consumption

The first-order conditions for patient and impatient households with respect to housing are given respectively by:

\[ \lambda^P_t = \frac{U^P_{h,t}}{q_t} + \beta^P (1 - \delta_h) \frac{E_t [\lambda^P_{t+1} q_{t+1}]}{q_t} \]

\[ \lambda^I_t = \frac{U^I_{h,t}}{q_t} + \beta^I (1 - \delta_h) \frac{E_t [\lambda^I_{t+1} q_{t+1}]}{q_t} + (1 - \tau) (1 - \rho_h) \lambda^I_t \lambda^b_t \]

(15)

(16)

where \( U^x_h = \sigma^x_h / H^x_t \) for \( x \in \{P, I\} \). The left hand side of the above equations illustrate the marginal cost of spending a unit of income on housing (forgone consumption of the non-residential good) and the right hand side (RHS) the return on such action. By increasing expenditure on housing each household benefits from a direct increase in utility (the first term on the RHS), an expected rise in utility arising from the resale of the housing unit in the following period (the second term on the RHS), and in the case of impatient households, a direct increase in utility stemming from the possibility of utilising housing as collateral, thus increasing borrowing and subsequently consumption (the last term in equation (16)). The first order conditions with respect to housing can be re-arranged to show that:

\[ Z^x_t H^x_t = \sigma^x_h (1 + \tau^C_t) C^x_t \]

(17)

where \( Z^x_t \) denotes the user cost of a unit of housing for impatient (\( x = I \)) and patient (\( x = P \)) households. Equation (17) demonstrates that expenditure on the final consumption good is related to expenditure on housing; however, the above does not necessarily imply that consumption and housing always co-move as the user cost dynamics act as a wedge in the allocation of income by agents.

To investigate the dynamics of house prices we follow Barsky et al. (2007) and Monacelli (2009) by denoting the shadow value of a unit of the durable good for patient households as \( V^P_t = q_t \lambda_t^P \) which, using (15) above, can be derived as:

\[ V^P_t = q_t \lambda^P_t = E_t \sum_{j=0}^{+\infty} (\beta^P (1 - \delta_h))^j U^P_{h,t+j} \]

(18)
where $U_{h,t}^P$ is determined by the stock of durables $H_{P,t}^P$, which itself is related to housing investment $IH_t$. The ratio of accumulated housing stock to housing investment is high (in the steady-state $1/\delta_h = H_{P,t}^P/IH_t$), and thus even large changes in housing investment induce a small effect on the stock of housing, and subsequently on the utility stemming from housing services; this results in the RHS of (18) to be relatively invariant. Therefore, $V_{t}^P \approx V_{t}^P$ and thus $q_t$ and $\lambda_{P,t}^t = 1/(1 + \tau_c^t) C_{P,t}^t)$ tend to move in opposite directions which implies that the house price is positively related to the consumption of patient households. Taking this argument further, and observing that $\lambda_{P,t}^t = \prod_{l=0}^{\infty} (\beta_{P,t}^l \frac{R_t}{\pi_{t+1}^t} + \frac{l}{\pi_{t+1}^t} + 1 + \frac{\tau_{k,t+1}^t}{\pi_{t+1}^t})$, we get a clear link between the real interest rate and house prices; that is, holding everything else constant, expectations of lower real interest rates on bonds imply that investors shift resources to other markets to benefit from higher expected real returns. In equilibrium the return on housing needs to be equal to the return on investment in bonds; hence the RHS of (13) is equal to the RHS of (15) and the RHS of (14) is equal to the RHS of (16). It therefore follows that ceteris paribus, a lower real interest rate on bonds results in higher investment in housing and hence higher house prices.

### 3.1.3 Investment

Patient households have access to a broad range of assets; they can invest in bonds, housing and physical capital. Investment in physical capital is determined by:

$$\lambda_{t}^P = Q_{n,t} \lambda_{t}^P F_k'(I_{n,t}, I_{n,t-1}) + \beta^t E_t Q_{n,t+1} \lambda_{t+1}^P F'_k(I_{n,t+1}, I_{n,t}) \quad (19)$$

where $n \in \{c, h\}$, $Q$ denotes shadow value of capital (‘Tobin’s Q’ [20]), and $F_k'(I_{n,t}, I_{n,t-1})$ denotes the increase in physical capital at time $t$ generated by higher investment in $I_t$; therefore $Q_{n,t} \lambda_{t}^P F'_k(I_{n,t}, I_{n,t-1})$ represents the value of additional capital in consumption terms. The RHS of (19) is equal to the RHS of (13) and (15) such that the returns in the housing, investment and bonds markets are equal. Re-arranging equation (19) provides Tobin’s Q defined as:

$$Q_{n,t} = E_t \frac{\pi_{t+1}}{R_t} [Q_{n,t+1}(1 - \delta_{k,n}) + (1 - \tau_{k,t}^k) r_{k,n,t+1}] \quad (20)$$

which indicates that the key factors determining the price of capital are the expected real interest rate and the net return on capital $E_t (1 - \tau_{k,t+1}^k) r_{k,n,t+1}$. Therefore, similar to above, lower real interest rates result in higher demand for capital, an increase in the price of capital and subsequently higher investment in physical capital.

### 3.1.4 Labour

In order to provide more intuition for the labour market dynamics, we present the limiting case in which the wage adjustment cost is absent ($\phi_w = 0$). In this case, for all households, the wage is determined by the level of consumption and labour:

\[Note that consumption of impatient households is not always related positively with the house price because the shadow value of housing for these households depends on $U_{I,t}^I$, $X_{t}^I$ and $E_t R_t/\pi_{t+1}$; see Barsky et al. (2007) and Monacelli (2009) for more details.\]
\[ w_{t}^{m} = \frac{v_{w}}{v_{w} - 1} (N_{t}^{m})^{\sigma_{t}} C_{t}^{1 + \tau_{t}} \frac{1 + \tau_{t}}{1 - \tau_{t}} \]  

(21)

where \( m \in \{P, I, R\} \). Clearly, higher labour demand and consumption result in an increase of the wage rate. An increase in non-labour income puts upward pressure on the wage rate and downward pressure on labour supply as it results in higher consumption. Further, lower rates of interest serve a similar function to lower labour supply, increasing wages for patient and impatient households.

### 3.2 Fiscal experiments and calibration

#### 3.2.1 Fiscal experiments

For our fiscal consolidation experiments we consider the impact of repaying five percentage points of the debt-to-GDP ratio, moving between two different steady-states, which is motivated by the size of consolidation carried out by advanced economies in the aftermath of the Great Recession that was 5.6% on average (see for example [IMF 2013]). The initial steady-state is based on the benchmark calibration of the model (discussed below), and the closing steady-state reflects an economy in which the debt-to-GDP ratio is five percentage points lower; as a result, spending instruments are increased and tax revenue decreased by the same percentage. The two steady-states are discussed in more detail in Section 3.3.1.

Our fiscal experiments vary across two dimensions: the composition of fiscal adjustment and the speed of debt repayment. Regarding the composition, we examine fiscal adjustment through changing one instrument at a time yielding eight separate cases. In each separate case the government uses only one fiscal instrument to repay the debt whereas all the remaining instruments adjust steadily to the closing steady-state. For example, if government consumption is used to repay debt, fiscal policy is defined with the following two equations:

\[ G_{c,t} = G_{c}^{c} (B_{t}/B^{c})^{\phi_{B,G_{c}}} \]  

(22)

\[ \Xi_{t} = \Xi^{c} + \left( \frac{B_{t} - B^{c}}{B_{i} - B^{c}} \right) (\Xi^{i} - \Xi^{c}) \]  

(23)

where \( \Xi = \{\tau^{c}, \tau^{b}, \tau^{l}, \tau^{er}, I_{g}, N_{g}^{m}, TR\} \) and superscripts \( i \) and \( c \) refer respectively to initial and closing steady-states which are discussed in more details in Section 3.3.1.

In order to quantify the speed of repayment we introduce the concept of the ‘half-life’ of consolidation which represents the time (in quarters) for half of the total consolidation to take place. As a benchmark, we set this half-life at 20 quarters, and this is performed through the calibration of \( \phi_{B,X} \) in equation (12). We return to the issue of how varying the speed of

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17 Clearly, the lower steady-state level of debt implies that the government spends less money on interest payments on debt and therefore can increase spending and cut tax rates.

18 Comparing the scale and speed of post-crisis austerity programmes in developed economies after the financial crash, debt half-lives of 21 quarters (on average) are observed; see [IMF 2013]. Note that the ‘half-life’ of debt is endogenously determined in the model for a given calibration of \( \phi_{B,X} \), to maintain consistency, we report on
adjustment impacts the dynamics below.

### 3.2.2 Calibration

We calibrate the model as in Table 1 using data from the US between 1985 and 2016 and values adopted in previous literature (the period is consistent with Guerrieri & Iacoviello [2017] from whom we take many parameters). We set shares of fiscal spending instruments (government consumption, investment and employment) to output to match the averages in the data for the period 1985-2016. The resulting values are in line with Drautzburg & Uhlig (2015) who calibrate government consumption to output at 15.3%, and government investment to output at 4%. We set the closing level of government debt to (annual) GDP (after the fiscal austerity has been enacted in the model) at 60% which leaves transfers set by the model at approximately 11% of output. In setting the tax rates we rely on the dataset and methods used in Trabandt & Uhlig (2011). For the purpose of this paper we modify their work in two dimensions: first, we recalculate the tax rates so that our starting point is 1985 (their average tax rates are calculated for the period from 1995); and second, we include both labour income taxes and employers’ social security contributions (whereas Trabandt & Uhlig 2011 combine both in one tax rate).

For the majority of the remaining parameters we follow the calibration in Guerrieri & Iacoviello (2017), as outlined in Table 1. We set the elasticity of output with respect to public capital equal to 0.02 which is in line with the range of estimates discussed in Leeper, Walker & Yang (2010), and we set the depreciation of this capital \( \delta_g \) equal to 0.015 to match the ratio of public capital to GDP in the data. We calibrate the weight of housing in the utility function and the depreciation of housing to match the ratio of housing wealth to GDP and of residential investment to GDP; this implies a utility weight of 0.1321 and a housing depreciation rate of 0.0102, values very close to those used in Iacoviello & Neri (2010). Since, Guerrieri & Iacoviello (2017) do not use housing production, we use the share of physical capital in production from Iacoviello & Neri (2010). Given the shares of capital in production, the capital income tax rate and the patient households’ discount rate, we set the depreciation of both residential and non-residential capital to match the investment and capital to GDP ratios in the data. The depreciation rate of non-residential capital is set at 0.0145, similar to Drautzburg & Uhlig (2015) and Alpanda & Zubairy (2016), and the depreciation rate of residential capital (0.03) is in line with Iacoviello & Neri (2010). Finally, in order to calibrate the wage adjustment cost parameter \( \phi_w \) we use the following relationship

\[
(1 - \beta \theta_w)(1 - \theta_w)/\theta_w(1 - \nu_w \sigma_1) = (\nu_w - 1)(1 - \tau_l)/\phi_w,
\]

where the left hand side refers to the experiments with the same ‘half-life’ for our benchmark results.

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19 All the data used to calculate the steady-state shares are taken from the Bureau of Economic Analysis. Data on private consumption expenditure, non-residential investment, and residential investment are from Table 1.1.5. Data on public consumption, investment, and transfers are taken from Table 3.1. Data on public capital, private residential and non-residential capital are from Table 1.1. Data on physical capital in the residential production sector are taken from Table 3.1ESI. Data used to calculate the share of employees working in the public sector are taken from Table 6.4B.

20 Similar to Drautzburg & Uhlig (2015), Trabandt & Uhlig (2011), and Alpanda & Zubairy (2016) the level of transfers is set through the calibration of other parameters in the government budget constraint.
slope of the Wage Philips Curve derived with Calvo (1983) contracts, and the right hand side refers to the slope of the Wage Philips Curve derived with Rotemberg (1982) adjustment cost (as in this paper). Given the values of other parameters in Table 1, our calibration of \( \phi_w = 2718 \) implies that the probability of not being able to re-optimise wage (\( \theta_w \)) is slightly above 0.9, as in Guerrieri & Iacoviello (2017).

### 3.3 Fiscal austerity and macroeconomic outcomes

#### 3.3.1 The two steady-states

Before we start exploring the alternative consolidation packages underlying our fiscal experiments, we briefly discuss the properties of the two steady-states, the start and end point of our experiments. Given that we examine fiscal austerity, our policy analysis entails a move from an initial steady-state with a higher level of debt to the one with a lower level (debt-to-GDP ratio decreases from 65% to 60%). This reduction in debt implies that taxes are lower and spending is higher in the closing steady-state compared to the initial position as the government spends less money on debt interest rate payments; we construct experiments where these changes are equal across all fiscal instruments between the two states (a movement of 0.22%). Values for key variables are presented in Table 2.

With lower taxes and higher government spending (including higher public investment) output is higher in the lower-debt closing steady-state (by 0.11%). This subsequently leads to higher employment (0.09%) and investment (0.21%) in the economy. Lower labour taxes and higher labour demand in the closing steady-state lead to higher net labour incomes for all households. When combined with greater transfers, both impatient and RoT households enjoy

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**Table 1: Calibration**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value Data/ Source</th>
<th>Parameter</th>
<th>Description</th>
<th>Value Data/ Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Sigma C_m/GDP )</td>
<td>Aggregate consumption to GDP</td>
<td>0.640 0.645</td>
<td>( qH + H'/(4GDP) ) Housing wealth to output</td>
<td>1.84 1.034</td>
<td></td>
</tr>
<tr>
<td>( qH/GDP )</td>
<td>Residential investment</td>
<td>0.042 0.042</td>
<td>( (K_c + K_h)/(4GDP) ) Production capital to output</td>
<td>2.148 2.239</td>
<td></td>
</tr>
<tr>
<td>( (L, l + l)/(GDP) )</td>
<td>Capital investment</td>
<td>0.128 0.123</td>
<td>( K/G(4GDP) ) Public capital to output</td>
<td>0.678 0.678</td>
<td></td>
</tr>
</tbody>
</table>

**Fiscal policy**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value Data/ Source</th>
<th>Parameter</th>
<th>Description</th>
<th>Value Data/ Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( G/GDP )</td>
<td>Government consumption to GDP</td>
<td>0.149 0.149</td>
<td>( \alpha ) Capital in non-residential production</td>
<td>0.3 IN</td>
<td></td>
</tr>
<tr>
<td>( l/GDP )</td>
<td>Government investment to GDP</td>
<td>0.041 0.041</td>
<td>( \alpha_k ) Capital in residential production</td>
<td>0.3 IN</td>
<td></td>
</tr>
<tr>
<td>( TR/GDP )</td>
<td>Transfers to GDP</td>
<td>0.111 0.114</td>
<td>( \delta_{jk} ) Depreciation of non-residential capital</td>
<td>0.015 *</td>
<td></td>
</tr>
<tr>
<td>( Nm/N^m )</td>
<td>Share of public employment</td>
<td>0.147 0.147</td>
<td>( \delta_{chk} ) Depreciation of residential capital</td>
<td>0.03 *</td>
<td></td>
</tr>
<tr>
<td>( \tau_c )</td>
<td>Consumption taxes</td>
<td>0.05 TU</td>
<td>( \delta_h ) Depreciation of housing</td>
<td>0.01 *</td>
<td></td>
</tr>
<tr>
<td>( \tau_k )</td>
<td>Capital income taxes</td>
<td>0.36 TU</td>
<td>( \delta_g ) Depreciation of government capital</td>
<td>0.015 *</td>
<td></td>
</tr>
<tr>
<td>( \tau_l )</td>
<td>Labour income taxes</td>
<td>0.2 TU</td>
<td>( \phi_w ) Elasticity of substitution - goods</td>
<td>6 GI</td>
<td></td>
</tr>
<tr>
<td>( \tau_e )</td>
<td>Employer social security</td>
<td>0.07 TU</td>
<td>( \theta_p ) Price stickiness</td>
<td>0.906 GI</td>
<td></td>
</tr>
<tr>
<td>( \delta_{hk} )</td>
<td>Utility share of housing</td>
<td>0.144</td>
<td>( \phi_u ) Rottenberg wages</td>
<td>2718</td>
<td></td>
</tr>
<tr>
<td>( \beta_c )</td>
<td>Frisch elasticity of labour</td>
<td>1 GI</td>
<td>( \phi_{lw} ) Elasticity of substitution - labour</td>
<td>6 GI</td>
<td></td>
</tr>
<tr>
<td>( \beta^p )</td>
<td>Patient discount factor</td>
<td>0.995 GI</td>
<td>( \phi_{lw} ) Elasticity of substitution - labour</td>
<td>6 GI</td>
<td></td>
</tr>
<tr>
<td>( \beta^f )</td>
<td>Impatient discount factor</td>
<td>0.986 GI</td>
<td>( \chi_{lw} ) Output elasticity of public capital</td>
<td>0.02 LNY</td>
<td></td>
</tr>
<tr>
<td>( b_1 )</td>
<td>Share of patient agents</td>
<td>0.15 AZ</td>
<td>( \rho ) Monetary policy persistence</td>
<td>0.562 GI</td>
<td></td>
</tr>
<tr>
<td>( b_2 )</td>
<td>Share of impatient agents</td>
<td>0.54 AZ</td>
<td>( \rho_p ) Inflation Taylor rule weight</td>
<td>1.877 GI</td>
<td></td>
</tr>
<tr>
<td>( \tau )</td>
<td>Down-payment ratio</td>
<td>0.1 GI</td>
<td>( \rho_{lw} ) Output Taylor rule weight</td>
<td>0.096 GI</td>
<td></td>
</tr>
<tr>
<td>( \rho_h )</td>
<td>Borrowing persistence</td>
<td>0.618 GI</td>
<td>( \pi ) Inflation target</td>
<td>1.005 GI</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Opening and closing steady-state values

<table>
<thead>
<tr>
<th>Variable</th>
<th>Open</th>
<th>End</th>
<th>Change</th>
<th>Variable</th>
<th>Open</th>
<th>End</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate variables</td>
<td></td>
<td></td>
<td></td>
<td>Disaggregate variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(share of total)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.693</td>
<td>1.695</td>
<td>0.106</td>
<td>Patient cons.</td>
<td>0.235</td>
<td>0.234</td>
<td>-0.449</td>
</tr>
<tr>
<td>Consumption (agg)</td>
<td>1.084</td>
<td>1.084</td>
<td>0.059</td>
<td>Impatient cons.</td>
<td>0.490</td>
<td>0.491</td>
<td>0.138</td>
</tr>
<tr>
<td>Employment (agg)</td>
<td>2.421</td>
<td>2.423</td>
<td>0.086</td>
<td>Rule-of-thumb cons.</td>
<td>0.275</td>
<td>0.275</td>
<td>0.138</td>
</tr>
<tr>
<td>Housing (agg)</td>
<td>7.032</td>
<td>7.031</td>
<td>-0.012</td>
<td>Patient labour income</td>
<td>0.190</td>
<td>0.190</td>
<td>0.000</td>
</tr>
<tr>
<td>Capital investment</td>
<td>0.217</td>
<td>0.217</td>
<td>0.213</td>
<td>Impatient labour income</td>
<td>0.540</td>
<td>0.540</td>
<td>0.000</td>
</tr>
<tr>
<td>Housing investment</td>
<td>0.071</td>
<td>0.071</td>
<td>-0.000</td>
<td>Rule-of-thumb labour income</td>
<td>0.270</td>
<td>0.270</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Patient housing</td>
<td>0.339</td>
<td>0.337</td>
<td>-0.388</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Impatient housing</td>
<td>0.661</td>
<td>0.663</td>
<td>0.199</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Patient income</td>
<td>0.357</td>
<td>0.356</td>
<td>-0.209</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Impatient income</td>
<td>0.424</td>
<td>0.425</td>
<td>0.116</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rule-of-thumb income</td>
<td>0.219</td>
<td>0.22</td>
<td>0.116</td>
</tr>
<tr>
<td>Government spending</td>
<td></td>
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<td>Taxation rates</td>
<td></td>
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<td></td>
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<tr>
<td>(total expenditure)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Govt. consumption</td>
<td>0.070</td>
<td>0.070</td>
<td>0.217</td>
<td>Consumption taxes</td>
<td>0.050</td>
<td>0.050</td>
<td>-0.217</td>
</tr>
<tr>
<td>Govt. investment</td>
<td>0.069</td>
<td>0.069</td>
<td>0.217</td>
<td>Capital taxes</td>
<td>0.361</td>
<td>0.360</td>
<td>-0.217</td>
</tr>
<tr>
<td>Public employment</td>
<td>0.182</td>
<td>0.182</td>
<td>0.217</td>
<td>Employers’ taxes</td>
<td>0.070</td>
<td>0.070</td>
<td>-0.217</td>
</tr>
<tr>
<td>Transfers</td>
<td>0.188</td>
<td>0.188</td>
<td>0.217</td>
<td>Labour income taxes</td>
<td>0.200</td>
<td>0.200</td>
<td>-0.217</td>
</tr>
</tbody>
</table>

Values of steady-state variables in both the initial (‘Open’) and closing (‘End’) steady-states and percentage change (‘change’) between the two. Abbreviation ’agg’ represents aggregate; ‘cons.’ consumption; ‘Govt.’ government; and ‘cont.’ contributions. All disaggregate variables are presented as fractions of aggregate variables for the whole economy. All percentage changes calculations are based on the whole figure in each measure and not the number when rounded to three decimal places.

higher income in the new steady-state (0.12% for two types of agent agents). In contrast, the reduction in interest from bond holdings - given the lower level of government borrowing - more than offsets the rise in patient household’s labour and capital income resulting in a reduction in overall income for these agents by (0.21%). These movements mean that consumption for impatient and RoT households increase in the lower debt steady-state (0.14%), and fall for patient households (-0.45%). As such, employment falls for the former (0.01%) and rises for the latter (0.29%), as illustrated in Section 3.1.4.21

In the closing steady-state, patient households account for 23% of consumption and 36% of income, but only contribute 19% in production. As illustrated in equation (17), expenditure on housing has a strong positive relationship with expenditure on consumption. Given that the fall in the consumption of patient households is greater than the increase in that of impatient agents, aggregate demand for housing is lower (-0.01%), as is housing stock in the new equilibrium. In contrast, both the relative house price and the price level return to their initial steady-state levels.

21Note that the share of labour income (in total labour income) stays the same across households in the opening and closing steady-state as these parameters are calibrated in the model; patient households have the same labour income share in the closing steady-state, but are working longer at a lower wage than in the higher debt economy.
3.3.2 Dynamics during transition from a high debt to a low debt economy

Spending based fiscal consolidations

We now turn to individual fiscal consolidation packages made up of four spending and four tax instruments, respectively. Figure 1 illustrates the dynamics of an economy repaying five percentage points of government debt through reductions in government consumption, government investment, public employment and government transfers, separately in each case. For each individual fiscal experiment, the start and end points are the same and it is how the lower level of debt is reached which differs. As mentioned above, our benchmark speed of adjustment is a half-life of 20 quarters, using an appropriate calibration for $\phi_{B,X}$ in (12).

[Insert Figure 1 here]

Government consumption Figure 1 demonstrates that fiscal consolidation based on cuts in government consumption leads to a fall in aggregate demand and subsequently in output and prices. Lower government demand leads to a crowding in of private consumption and investment and after twenty quarters output is above the initial value as the benefits of lower government debt and lower interest rates are observed in the economy.

As illustrated in equation (13), the consumption of patient households is determined by the expected path of real interest rates and consumption taxes. With the exception of the austerity package which raises consumption taxes, all other episodes of consolidation lead to a slow decline in the consumption tax rate until the new steady-state is achieved, as lower debt level allows lower taxes (Table 2). Further, the fall in output and inflation lead to lower real interest rates, which increases patient household’s consumption (equation (13)). In contrast, the RoT agents’ consumption is determined by net labour income and government transfers (6); with the exception of the austerity experiment which cuts transfers, there will be a small increase in transfers until the new steady-state is reached (Table 2). On impact, the initial fall in aggregate demand in the economy leads to a fall in labour income; however, as private demand crowds in and as debt is repaid, RoT agents receive higher levels of income, which subsequently leads to a higher level of consumption in the longer horizon.

Impatient households are similar to RoT agents in that they consume their income; however, in addition to net labour income and government transfers, impatient agents also borrow against the value of their housing. Although impatient households observe similar movements in the first two sources of income as RoT agents, they experience an initial increase in consumption. The divergence between the two credit-constrained agents (a term we use to denote both the impatient and RoT) derives from movements in the price (and therefore value) of housing and lower interest rates which result in lower interest payments on the outstanding debt, therefore leaving more resources available for consumption. As interest rates decrease, the house price increases as discussed in Section 3.1.2. As such, the amount against which impatient agents can borrow increases which in turn raises impatient agents’ consumption; this initial rise in consumption is therefore in line with that of patient households rather than the RoT households.
Overall, the initial rise in both patient and impatient consumption more than outweighs the fall in the RoT consumption, leading to a rise in aggregate consumption on impact; a crowding in of consumption following the cut in government consumption. Importantly, after a period of approximately three years, consumption of impatient households falls below that of RoT households. The reason behind this is that given the initial increase in the value of housing, impatient households increase their level of borrowing, which subsequently results in higher interest payments on debt that weighs heavily on them when house prices decrease. This indicates the importance of the value of housing for the expenditure of impatient households and their relative position with respect to RoT households. An increase in the value of housing initially allow these households to mitigate the negative impact of austerity and suffer less than RoT households, whereas a decrease in the value of housing leads to stronger drops in the consumption subsequently.

Investment in physical capital used in the production of residential and non-residential goods increases due to lower interest rates and capital income taxes as indicated in Section 3.1.3. Aggregate employment initially falls and then rises following the path of aggregate demand in the economy. Differences in employment across agents tend to be muted due to the high level of wage rigidities and reflect the respective consumption paths, where agents are more willing to substitute labour for leisure as indicated in equation (21).

**Government investment** The key difference between fiscal consolidation based on government investment compared to government consumption is that the former has supply side effects. The decline in government investment triggers public capital decumulation, putting downward pressure on output in both the residential and non-residential sectors. This supply side effect means that, relative to the case of a cut in government consumption, the decline in inflation is smaller (*ceteris paribus*, public capital decumulation puts upward pressure on marginal cost and therefore inflation). The decumulation of public capital also implies that it takes longer than in other experiments for output to reach the final steady-state; the worst outcome in our austerity experiments in terms of output over the medium term horizon.

The lower decrease in inflation relative to cuts in government consumption means that the fall in expected real interest rates is smaller; this means that although patient households crowd in the cut in government expenditure, the rise in their consumption is the lowest of all spending instruments. This smaller increase in patient consumption leads to a lower rise in the value of housing and subsequently a smaller increase in impatient consumption. Depressed output leads to lower labour demand and wages which lead to lower RoT incomes and consumption. In general, however, there is only a small difference between the effects of cuts to government investment relative to cuts in government consumption, all driven by the the supply side effects of the policy.

**Transfers** Unlike the above two experiments, lowering transfers directly impacts impatient and RoT households’ incomes and henceforth expenditure. Lower aggregate demand puts downward pressure on output and prices, resulting in a fall in interest rates. As a result, patient
households increase their spending on consumption, housing and investment, which is in line with the discussion in Section 3.1. Impatient agents experience similar falls in labour income as RoT households; however, as there is an increase in house prices caused by the drop in the real interest rate (see Section 3.1.2), they are able to mitigate the impact of lower labour income by increasing borrowing, at least in the early stages of the austerity. Once the impatient households’ value of housing starts decreasing (due to the decreasing house price and lower housing expenditure) and interest rates start increasing, these agents spend more on the repayment of debt and interest payments and therefore their consumption profile worsens compared to that of RoT households. This also implies that in medium horizon, these households are much more willing to supply labour compared with RoT households as indicated in Section 3.1.4. Despite cuts in transfers leading to the most unequal outcomes of all spending based austerity, the aggregate effects are the lowest with output being consistently higher compared to all other cuts in government spending.

**Public employment** A cut in public labour demand results in a drop in the real wage rate in the economy and therefore has a positive impact on private firms which increase the demand for labour and increases output. Lower real interest rates lead to an increase in the consumption and investment of patient households as indicated in Sections 3.1.1 and 3.1.3. As illustrated in Figure 1, the investment response of patient households is the strongest of all spending based consolidations. House prices increase as the housing market offers higher rates of return than the bond market which attracts the investment of patient households (as indicated in Section 3.1.2). This tempers some of the impact on impatient agents compared to RoT agents initially, however, as house prices start decreasing, the outstanding loans weighs heavily on impatient households setting their consumption below and labour above that of RoT households.

**Tax based fiscal consolidations**

We now turn to tax based fiscal consolidation experiments. Figure 2 depict the four alternative scenarios where the reduction in debt is secured by raising capital, labour and consumption taxes and employers social security contributions, separately in each case.

[Insert Figure 2 here]

**Capital taxes** A rise in capital taxes implies reduced capital income for patient households, a higher rental rate of capital for firms and therefore reduced investment in physical capital in the economy. The higher rental rate of capital forces firms to substitute capital for labour, thereby putting upward pressure on labour incomes. The resulting higher marginal cost induces an increase in inflation and, in turn, in nominal interest rates. The initial increase in demand for labour does not persist; lower investment and subsequent capital decumulation lead to lower aggregate supply and lower demand for labour and hence consumption.

Although depressed economic activity puts a downward pressure on future expected real interest rates, the rise in the rental cost leads to increased production costs and therefore the
fall in real interest rates is small. Patient households’ consumption initially increases as agents sacrifice investment for consumption as in [Leeper, Plante & Traum (2010)], but less so compared to spending based austerity. The initial increased demand for labour increases labour incomes and therefore consumption of RoT and impatient agents. The initial rise in consumption of impatient households is the highest for any tax based austerity due to both increased wage income and to an increase in the price of housing as patient consumption increases (as they substitute investment for consumption). Similarly, RoT income and consumption initially increases, but capital decumulation in the economy reduce productive capacity and after twelve quarters output is at its lowest of all austerity packages.

Employers social security contributions A rise in employers’ social security contributions makes employees more expensive, resulting in lower demand for labour. This leads to the lowest wages of all fiscal experiments, with clear detrimental effects on the income and consumption of credit-constrained agents; output and employment experience sharp initial falls from both the decrease in supply (as a result of expensive labour) and demand (as a result of lower labour incomes). The raising of employers’ social security leads to an initial fall in patient consumption as higher inflation in the economy leads to an increase in real interest rates. As such, there is an initial small reduction of house prices in the economy, the only fiscal experiment where this is the case. This dynamic leads to the response of both impatient and RoT agents to be close to one another; further, due to the initial fall in house prices, impatient consumption is the worst in this austerity experiment.

Consumption taxes A rise in consumption taxes drive all three households to cut their consumption. As observed in Figure 2, patient households experience a long lasting fall in consumption; the only experiment where there are consistent consumption falls for these agents as the impact of higher consumption taxes more than outweighs that of lower real interest rates arising from depressed economic activity. There is a greater supply of capital as patient agents substitute consumption for investment which allows for a quick recovery in output. Higher taxes in non-residential consumption encourages spending on housing, hence the housing boom observed in Figure 2. The resulting increase in house prices is the largest among all the experiments and mitigates some of the effect of depressed wages on impatient households.

Labour tax Fiscal consolidation through higher labour taxes has a direct impact on the net income of households, forcing both RoT and impatient households to cut their consumption significantly. Patient households, on the other hand, experience a rise in expenditure on consumption and investment in physical capital and housing due to lower real interest rates, leading to a small increase in house prices.

3.4 Fiscal austerity and distributive outcomes

We now turn to an examination of the distributional consequences of fiscal consolidations in greater detail. We approach this issue by exploring the income and welfare implications of fiscal
adjustment. Within this analysis, we split outcomes between those experienced in the short run (defined as a 20 quarter period) and those over the lifetime of the consolidation experiments.

3.4.1 The distribution of income and utility

Figure 3 presents dynamics for both disposable income (including financial transactions) and utility arising from the fiscal consolidation experiments outlined above. The results for disposable income are in line with those discussed above. Credit-constrained agents suffer most from cuts in transfers and higher labour taxes and employers’ social security contributions; patient agents, on the other hand, see relatively consistent rises in their income over the medium term as government debt is repaid back to these agents. The main exception to this is the case of higher capital taxes which reduces income of patient agents substantially as these agents own all the capital in the economy.

Of the credit-constrained households, initially impatient agents tend to have higher utility profiles than RoT households, then the RoT overtake. As discussed above, house price and interest rate movements allow impatient households to insulate themselves from the short-run consequences of austerity relative to the RoT agents, with important implications for how the burden of austerity is shared. With higher house prices, impatient households can increase their level of borrowings and lower interest rates imply that interest payments on existing debt are smaller. Distinguishing between the RoT and impatient agents allows us to link fiscal action to household borrowing and its consequences for distributive outcomes, given impatient agents are the only ones who borrow in this framework. Moreover, given that both transfers and public employment are important sources of income for the RoT, these agents are more affected by spending cuts than tax rises, in line with the evidence provided by Paulus et al. (2016) from fiscal consolidation in the European Union, during 2008-2012. Over the longer horizon, however, as house prices fall and interest rates rise, higher level of debt weigh heavily on impatient households financial income, resulting in lower income relative to the RoT.

In aggregate, over the twenty quarter horizon patient agents observe improvements in income in all experiments apart from those raising capital taxes. The credit-constrained households tend to see negligible impacts on their short run income from spending based consolidations (with the exception of cuts in transfers) and they observe substantial loses from rising labour income taxes and employer’s social security contributions.

With respect to utility, patient agents observe improvements in all the experiments over twenty quarters (with the exception of increases in consumption taxes) due to falling interest rates and increased income from the repayment of government debt. These utility increases tend to be lower for the consolidation conducted with taxes as these put upward pressure on inflation and therefore tend to result in lower drops in expected real interest rates. The

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Savage et al. (2015) document that sharpest fall of income during Ireland’s austerity over 2008-2013 indeed fell on the bottom decile.
results are different for credit-constrained agents, who do not own government debt. On impact impatient agents tend to have higher utility profiles than RoT households, then the situation reverses as in the case of income. As discussed above, impatient households can initially increase their consumption (and therefore utility) as higher house prices allow them to borrow more and lower interest rates mean lower interest payments on existing debt. In the longer horizon, net income of impatient households decreases as they borrow less and higher interest rates result in increased interest payments on the higher stock of loans. Under these circumstances impatient households are more willing (than RoT agents) to supply labour which also puts downward pressure on their utility when compared to that of RoT households.

Fiscal consolidation through cuts in transfers has the greatest detrimental impact on the welfare of credit-constrained households who receive transfers, as expected. Both credit-constrained agents experience small short run gains from rising capital taxes as this leads to higher demand for labour (improving incomes of the credit-constrained) and encourage substitution of investment for consumption (providing temporary benefits to patient households). Other measures reducing the utility of the credit-constrained are labour taxes and employment social security contributions both of which reduce the income of these agents.

### 3.4.2 The speed versus composition of consolidation

The analysis above has been performed fixing the speed of consolidation at a half-life of 20 quarters. Figure 4 performs similar analysis as above now for varying speeds of adjustment (governed by the $\phi B, x$ parameter) as illustrated in the $x$-axis of each panel. For each fiscal instrument, we consider three statistics over the first 20 quarters of the adjustment: the change in the Gini coefficient as a result of discounted income movements (the first row of Figure 4); the change in the Gini coefficient as a result of discounted utility movements (the second row); and the change in discounted output (the third row).

These are calculated for all fiscal instruments, presenting all government spending instruments (the first column) and all taxation instruments (the second column).

Focusing on government spending instruments (the first column of Figure 4), it can be observed that the speed of consolidation has more influence on the effects of austerity, than the composition of the consolidation packages. This is observed in the higher degree of variation across different speeds of adjustment compared to the differences across different instruments. The austerity experiment where a cut in transfers moves the economy to a lower debt steady-state has the biggest impact of inequality for all speeds of adjustment; this is consistent with

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For income and utility movements we discount each household at their respective discount rate, where we apply the same rate for both types of credit constrained agents. In the case of the Gini coefficients, we use the discounted changes in income and utility summed over twenty quarters, and compute Gini coefficients based on the proportion of the population being equal to the share of labour income each type of households. Although the share of households in the population differ from their labour income share, this simplifying assumption provides results from which intuition can be developed; varying these shares have little effect on our results.
Figure 3, where it is observed that in this experiment incomes and utility fall the most for credit constrained agents and rise the most for patient households. At half-lives of more than 20 quarters, the difference across government spending instruments is small. The first column of Figure 4 also demonstrates that for all government spending instruments inequality is increased and output falls in the first 20 quarters of the austerity episodes when the consolidation is conducted quickly (where the half-life of adjustment is less than 20 quarters). Overall, of the four spending type consolidations, those based on cutting transfers and public employment raise income inequality most, hence are the most regressive, as seen in both Figures 3 and 4.

The second column of Figure 4 displays the profile of consolidation packages using distortionary taxes across the varying speeds of adjustment. As is clear, when half of the consolidation package is enacted in 20 quarters or more, the effects on both inequality and output are smaller, and the differences across instruments diminish; however, due to the distortionary nature of taxes, if austerity is conducted quickly, there can be more variation across the instruments. When consolidation is performed through raising capital taxes, there is a substitution from capital to labour temporarily supporting incomes of the RoT and impatient agents (as seen in Figure 3): this is the only progressive fiscal experiment for which both income and utility inequality is improved at all speeds of adjustment. Austerity conducted through increasing labour and consumption taxes have large demand side impacts, which leads to similar outcomes as government spending instruments.

Overall, our analysis points to the importance of how individual fiscal measures interact with income and liquidity constraints facing different agents, playing a key role in determining the distributive effects of fiscal austerity. For example, while all spending based consolidations lead to more skewed income distribution, cuts in transfers and public employment, with direct impact on the income of the constrained agents, raise inequality most sharply. This finding cautions against branding spending based consolidations as uniform and as good austerity that is most likely to succeed (see for example Alesina & Ardagna 1998). Consistent with our findings, recent evidence from consolidation in EU countries suggests that targeted public spending imposed the greatest burden on the liquidity constrained groups in Greece, Spain, Italy and Portugal (see for example Paulus et al. 2016).

3.4.3 The long run consequences of austerity

To consider the long run effects of fiscal consolidation, Table 3 presents discounted welfare movements from two fiscal austerity experiments (both with a debt half-life of 20 quarters), one with cuts to government consumption getting the economy to the new lower debt steady-state, and one with rises in capital taxes. These two are applied for brevity and results for all fiscal instruments are provided in Appendix A as in the long run the economy is returning to the same steady-state in all experiments, therefore the choice of instrument has more impact in the short run than when assessing a longer horizon.

Despite credit-constrained agents losing and patient agents gaining from consolidation packages in the short run (as discussed above), over longer horizons these fortunes reverse. As
demonstrated in Table 2, patient households’ income is lower in the new lower-debt steady-state as they receive smaller interest payments from government debt; further, impatient and RoT income is larger due to higher overall demand in the economy and lower taxes. As such, both types of credit-constrained agents experience a tailing off of effects as consolidation progresses and improvements in utility occur in the medium and long run; the impact for patient households get progressively worse as time goes on. Impatient households are seen to benefit over RoT agents in these experiments as the access to credit eases the impact of austerity.

Table 3: Discounted utility effects over the long run

<table>
<thead>
<tr>
<th>Qtrs</th>
<th>Government consumption</th>
<th>Capital taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patient</td>
<td>Impatient</td>
</tr>
<tr>
<td>20</td>
<td>0.106</td>
<td>0.128</td>
</tr>
<tr>
<td>50</td>
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<tr>
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<td>-0.386</td>
<td>0.548</td>
</tr>
</tbody>
</table>

Entries are the discounted sum of utility corresponding to different horizons of consolidation (as highlighted by the first column), with experiments with a half-life of 20 quarters where all fiscal instruments are utilised.

As debt is repaid the asset position of patient agents deteriorates, as it is the patient who own government debt. This, relative to permanent higher levels of debt, therefore stops the redistribution from the credit-constrained to the unconstrained as there is now less debt to service through interest payments. The debt servicing contributions are paid by all in the economy, however, they are only paid out to patient agents. Through speeding up the repayment of debt, the asset holders’ position is temporarily improved at the expense of longer term losses. Government debt is an asset of the patient households and hence fiscal consolidation increases their short run income at the expense of a long run annuity. Therefore, in the long run, patient agents lose the most, however this hides a large timing disparity: credit-constrained agents feel the cost of austerity in the short to medium run, whereas the unconstrained receive a small annuity cost over time.

4 Further extensions and sensitivity

The analysis above demonstrates that: the response of the interest rate to austerity is important in determining the impact on patient households; the interaction between the fiscal consolidation and the labour market is important in determining the impact on RoT agents; and, for impatient households, both monetary policy and wages play an important role. These observations form the bases of our robustness checks on the sensitivity of our results to different parameter calibrations and environments.
4.1 Monetary policy

A feature of the Great Recession which received much academic attention is that the monetary policy was operating at its lower bound where nominal interest rates reach, or are close to zero (see for example Eggertsson 2011, Christiano et al. 2011). Figures 5 and 6 repeat our earlier fiscal austerity experiments for a number of monetary policy extensions, including when the monetary zero lower bound (‘ZLB’) is binding for four quarters. For brevity, we present results for two fiscal instruments, that of capital taxes (Figure 5) and government consumption (Figure 6). In each experiment, the half-life of debt is fixed at 20 quarters, and the benchmark results from above are presented.

The impact of the ZLB on the benchmark results above is determined by the impact of fiscal consolidation on inflation. As indicated in Figure 1 and 2 this is inflationary for increases in capital income taxes and employers’ social security contributions and deflationary for the remaining fiscal instruments. When the consolidation is inflationary and the nominal interest rate remains at the ZLB, there is a lowering in the real interest rate with respect to the benchmark (Figure 7). Under such scenarios private consumption initially crowd in; however, the rise in capital taxes leads to a fall in investment, and once the ZLB has passed, consumption follows a similar path to that had the ZLB not occurred. The welfare of credit constrained households initially improves when compared to benchmark results due to higher expenditure on consumption and housing in the case of impatient agents; after the period over which the ZLB is binding, welfare for RoT households deteriorates as labour incomes fall due to lower investment.

When fiscal consolidation is deflationary lower inflation leads to a rise in the real interest rate and subsequently lower private demand. This is illustrated in Figure 6 which presents results for austerity through government consumption cuts where the opposite results from above prevail: lower output, lower income and lower welfare for credit constrained agents. The transmission mechanisms behind these results reconcile with those from Eggertsson (2011) and demonstrate that the impact of the ZLB on consolidation episodes is critically reliant on the fiscal instruments used in the consolidations.

The remaining monetary policy extensions presented in Figures 5 and 6 illustrate the impact of: higher monetary policy persistence ($\rho = 0.8$); and more adverse policy to deviations in output ($\rho_y = 0.25$) and inflation ($\rho_\pi = 2.5$). In general we observe a drop in output over the initial twenty quarters as a result of austerity, therefore a stronger response to GDP ($\rho_y$) results in a more negative real rate and higher output when compared to the benchmark. As a result we observe stronger expenditure of households and an increase in output, capital and labour income. Additionally, lower interest rates benefit impatient households due to the lower interest payments on debt and therefore disadvantage patient households. Given higher income, impatient households also increase their housing stock, whereas patient households invest more in physical capital. In general the utility of credit-constrained households increases whereas that of the patient decreases as increased hours of work and lower housing holdings prevail over the increased non-residential consumption. The implication of a stronger response to inflation
(\(\rho_\pi\)) is similar to the stronger response to output. When inflation decreases with the fiscal austerity, a stronger response to inflation results in more negative real interest rates, higher aggregate demand and therefore higher output and income of households. In contrast, when inflation increases, as in the case of employers social security contributions, a stronger response to inflation results in a higher real rate and therefore lower output and income of households. As indicated in Figure Figures 5 and 6 the results are not sensitive to the movements in the monetary policy persistence (\(\rho\)).

4.2 The labour market and other sensitivity checks

We further check the sensitivity of our benchmark results to changes in a number of other parameter calibrations. Figures 7 and 8 present results under different extensions (as indicated on the x-axis) presenting three statistics in each case: the movement in discounted income over twenty quarters for the three types of household (the top panel); the movement in discounted utility over twenty quarters for the three types of household (the middle panel); and discounted output over twenty quarters (applying the discount rate of the patient: the bottom panel). Again we present results for only capital taxes (Figure 7) and government spending (Figure 8) for brevity, and in each case we impose a half-life of debt of 20 quarters.

Austerity puts downward pressure on wages for the credit constrained agents. Therefore, reducing the adjustment cost in wage setting behaviour (\(\phi_w\)) quickens the fall in wages for impatient and RoT agents, reducing levels of utility for both agents. These agents therefore increase their labour supply relative to benchmark in order to supplement their falling incomes; this leads to higher labour and therefore increased output relative to benchmark and consequently better utility and income outcomes for patient households. Overall, these changes are quantitatively minimal (as illustrated in Figures 7 and 8) and the intuition for the dynamics is the same as from above.

We have also tested our results to changes in price stickiness, the persistence of the borrowing constraint for impatient agents and the investment adjustment process. Results in Figures 7 and 8 indicate small changes from the benchmark. We have further tested our results to different calibrations; our findings prevail in a wide variety of settings (not reported).

5 Conclusions

This paper presented a comprehensive analysis of distributional consequences of fiscal austerity by proposing a medium scale DSGE model with three types of households and a rich set of fiscal instruments. We examined the aggregate, welfare and the distributional outcomes arising from a variety of fiscal consolidation packages that vary with the composition and the speed of fiscal adjustment. The two features of our settings are incorporating the appropriate dimension of household heterogeneity - by including ‘wealthy hand-to-mouth’ households who hold sizeable assets yet are liquidity-constrained - and a rich fiscal structure, allowing a detailed examination of losers and winners from fiscal austerity.
We derived a set of results with important policy implications. First, we show that incorporating an appropriate level of household heterogeneity within a rich fiscal structure proves key in mapping individual consolidation packages to redistributive outcomes. For example, we find that austerity based on cutting transfers and public employment and raising labour income taxes are most regressive, greatly raising income inequality. In contrast, raising capital taxes is a progressive form of fiscal adjustment - the only one out of the eight experiments considered - and is also with smallest output costs in the short run, but substantial output losses follow after a decumulation of capital in the economy. In general, tax based consolidations induce more favourable distributional consequences than those from the spending based ones in the form of less skewed welfare and income distribution. We also find that while credit-constrained agents lose out in the short to medium term following fiscal adjustment, there is a reversal of fortune over a longer horizon with the credit unconstrained suffering in the long-term. Furthermore, the speed of fiscal adjustment plays a much greater role on both the output and the distributional effects especially in the short-run.

Overall, our results point to the importance of the interaction between individual fiscal measures and the constraints facing different income groups. We have identified a number of cases - defined both in terms of the composition and the speed of adjustment - with significant worsening in both the redistributive and output outcomes. As such our findings call for the judicious design of consolidation packages not just for aggregate outcomes but also for redistributive ones with potentially far-reaching consequences.

References


Bell, D. & Machin, S. (2016), Brexit and wage inequality, Technical report, VOX EU.


A Long run utility result

Table 4 presents long run discounted utility results similar to Table 3 now for the remaining six fiscal instruments.

Table 4: Discounted utility effects over the long run: further instruments

<table>
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<th>Qtrs</th>
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<th>Employers’ social security</th>
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Entries are the discounted sum of utility corresponding to different horizons of consolidation (as highlighted by the first column), with experiments with a half-life of 20 quarters.
Figure 1: Dynamics from government spending consolidation episodes

Dynamics from using government spending instruments to repay five percentage points of debt to GDP; in each experiment a fixed half-life of debt of 20 quarters is applied. In each pane the respective lines represent percentage deviations of variables from their opening steady-state values. Abbreviations are such that ‘Cons.’, ‘Inv.’, and ‘Trans.’ represent consumption, investment and transfers, respectively, and ‘Agg.’, ‘Pat.’, and ‘Impat.’ represent aggregate, patient and impatient, respectively.
Figure 2: Dynamics from tax based consolidation episodes

Dynamics from using tax instruments to repay five percentage points of debt to GDP; in each experiment a fixed half-life of debt of 20 quarters is used. In each pane the respective lines represent percentage deviations of variables from their opening steady-state values. Abbreviations are such that ‘Cons.’, ‘Cap.’, and ‘Ers.’ represent consumption, capital and employers social security contributions, respectively, and all others are as previously.
Dynamics of disaggregated disposable income (including cashflows from financial transactions) and utility based on experiments from Figures 1 and 2. The top two rows represent government spending based consolidations and the bottom two results from taxed based experiments.
Results for consolidation episodes for our eight fiscal instruments, varying the speed of adjustment (x-axis). For each instrument the following are presented: the change in the Gini coefficient as a result of discounted income movements in the first 20 quarters (the first row); the change in the Gini coefficient as a result of discounted utility movements in the first 20 quarters (the second row); and the sum of discounted output (the third row). When calculating Gini coefficients, we use the share of each type of household in labour income as the share of households in the economy.
Dynamics from similar experiments in the benchmark results (presented in Figure 1) with changes to the monetary policy framework. Dynamics illustrated as ‘Bench’ representing benchmark result from above; ‘ZLB’ when the monetary zero lower bound is binding for four quarters; when persistence in the Taylor rule is increased to $\rho = 0.8$; when aversion to deviations of output in the Taylor rule is increased to $\rho_y = 0.25$; and when aversion to deviations of inflation in the Taylor rule is increased to $\rho_\pi = 2.5$. 
Dynamics from similar experiments in the benchmark results (presented in Figure 1) with changes to the monetary policy framework. Legend of dynamics is the same as in Figure 5.
Results for a variety of different parameter calibrations illustrating the impact on short run income (first row), short run welfare (second row) and discounted short run output (the third row), where the short run is measured as the first twenty quarters of the experiments. The x-axis of each panel represents the change in calibration with: ‘Bench’ representing benchmark result from above; ‘ZLB’ when the monetary zero lower bound in binding for four quarters; when persistence in the Taylor rule is increased to $\rho = 0.8$; when aversion to deviation of output in the Taylor rule is increased to $\rho_y = 0.25$; when aversion to deviation of output in the Taylor rule is increased to $\rho_{\pi} = 2.5$; when the adjustment cost in wage setting is decreased to $\phi_w = 100$; when price stickiness is decreased to $\theta = 0.66$; when the persistence in the borrowing constraint is reduced to $\rho_h = 0.4$; and when the investment adjustment cost is reduced to $\phi_k = 6$. 

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Results for a variety of different parameter calibrations illustrating the impact on short run income (first row), short run welfare (second row) and discounted short run (20 quarters) output (the third row). The notation of the z-axis is the same as in Figure 7.