Why are fiscal multipliers asymmetric?
The role of credit constraints

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Abstract

Recent empirical evidence strongly points to the state-dependence of fiscal multipliers which are larger in recessions than in expansions. Yet, standard business cycle models face great difficulty in producing such asymmetric fiscal policy effects. By incorporating endogenously binding collateral constraints into a medium scale DSGE model, we find that fiscal effectiveness can vary substantially across the business cycle. The key to our framework is the state-dependent nature of collateral constraints; binding in bad times while slack in good times, amplifying the effectiveness of fiscal policy and hence generating fiscal multipliers that are larger during recessions.

Key words: fiscal policy; fiscal multipliers; housing market; collateral constraints; recessions.


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1 Introduction

Substantial fiscal stimulus packages adopted in response to the 2008-09 global financial crisis revived the interest in the effectiveness of fiscal policy, particularly in downturns. A key finding from the ensuing empirical work has been that fiscal multipliers are state-dependent: larger in recessions when there is spare capacity in the economy, and smaller in upturns. For example, Auerbach & Gorodnichenko (2012), Auerbach & Gorodnichenko (2013), Baum & Koester (2011) and Fazzari et al. (2015), find government spending multipliers in the range of near zero at the peak of the business cycle to 1.6 or greater during recessions. Similarly, Tagkalakis (2008) shows that fiscal policy has been more effective in expanding private investment during recessions compared to expansions in OECD countries. Bachmann & Sims (2012) also document the non-linearity in government spending multipliers and show that this is due to different types of policy governments pursue in upturns versus in downturns. Although other papers find smaller variation (Owyang et al. 2013, Ramey & Zubairy 2014) there is now significant empirical support for fiscal multipliers that vary across the cycle.

Despite such widespread evidence, formal work on state-dependence of fiscal effectiveness seriously lags behind. That is perhaps not surprising given the difficulty standard business cycle models face in generating asymmetries in dynamics. To the best of our knowledge, there are only two attempts in the existing literature to formally answer the question of why fiscal policy is more effective in bad times. In the first, Michaillat (2014) demonstrates that the effect of fiscal expansion varies across the stages of the business cycle by utilizing a simple New Keynesian framework with search and matching employment frictions. An increase in public employment increases the tightness of the labour market and crowds out private employment; this effect is stronger in expansions (when employment is already high and the labour market tight) than in recessions, leading to the public employment multiplier doubling (from 0.24 to 0.49) when the unemployment rate rises from 5 percent to 8 percent.

The second formal explanation for the asymmetric effects of fiscal policy is provided by Canzoneri et al. (2016) who base their state-dependent multipliers on costly financial intermediation. By incorporating countercyclical variation in bank intermediation costs into the model of Curdia & Woodford (2010), Canzoneri et al. arrive at fiscal multipliers that are strongly state-dependent. In the presence of financial frictions that are aggravated in recessions, an expansionary fiscal action facilitates more borrowing by reducing the interest rate spread, which is itself countercyclical. This, in turn, allows fiscal policy to be more effective in expanding output in bad times than in good times. While Canzoneri et al. (2016) get a significant state-dependence in the short run (the impact multiplier during expansions is approximately 1, as opposed to 2 during recessions), the difference disappears
In this paper, we propose an alternative explanation for the asymmetric effects of fiscal policy by developing a tractable model based on endogenously binding borrowing constraints. Building on Guerrieri & Iacoviello (2017), we incorporate collateral constraints that are tied to the value of housing wealth into a medium scale dynamic stochastic general equilibrium (DSGE) model. In this framework a share of households face borrowing constraints which are binding in normal times and recessions but become ‘slack’ during expansions, when their consumption is high. As a result, during recessions any additional income from fiscal expansion and associated loosening of their borrowing constraint is spent on consumption. During expansions, in contrast, when the marginal utility of consumption is low and the borrowing constraint is slack, additional income is smoothed across time, which results in lower output increases. Therefore, fiscal policies which raise household income when the marginal propensity to consume is higher (when the borrowing constraint is binding) will have a larger impact than when this is not the case.

While the fact that models with credit-constrained consumers produce higher fiscal multipliers is well-understood, these agents are permanently constrained in much of the existing work, at odds with state-dependency of responses to fiscal policy (see, for example, Gali et al, 2007, Kaplan & Violante 2014). A key advantage of our framework is the endogenous nature of the slackness in the credit constraint in our model, which allow us to establish the state-dependence of multipliers. In order to examine the potential asymmetries in fiscal policy, we construct a medium scale New Keynesian DSGE model with eight fiscal instruments. Our model economy is populated by two types of households: patient (lenders) and impatient (borrowers). Both households supply labour to firms and the government, consume the final good and accumulate housing; however, impatient households discount the future at a higher rate and as a result end up borrowing from patient households who also lend to the government and accumulate physical capital. Central to our framework is the explicit treatment of housing wealth, which has a key role in determining the value of the collateral constraints for impatient agents, and therefore the implications of the fiscal shocks. The model features nominal rigidities in price and wage setting and real frictions such as adjustment costs, and monopolistic competition in non-residential good sector and capital utilisation cost.

We find that fiscal policy is indeed state-dependent and fiscal effectiveness varies substantially across the cycle. Moreover, the rich fiscal structure we employ in our framework allows us to work out the state dependence of fiscal policy for a large number of fiscal instruments. For example, we find four quarter cumulative spending multipliers to be, on average, 50 percent lower during consumption booms compared to when the borrowing constraint is always binding; taxation multipliers for employers’ social security and consumption and labour tax
multipliers are (on average) 44 percent lower in booms. We find clear heterogeneity across fiscal instruments; targeted transfers are more effective in downturns relative to normal times by as much as 72 percent, as these policies strongly rely on the consumption dynamics of impatient households. Our consideration of such an extensive fiscal instruments set does not only allow us to generalize our results, but also throws up new results such as in the case of capital taxes, where expansionary policy (a cut in taxes) leads to a substitution from labour to capital, and subsequently lower incomes for credit-constrained agents. Under this scenario, having more access to borrowing in the boom allows these agents to mitigate the impact of the policy, increasing their consumption in addition to the expansionary effects from the policy of increasing the productive capacity of the economy. Our results further suggest that it is the credit conditions of agents which determine the asymmetry of fiscal multipliers and not the fiscal action itself, as the size and direction of the latter plays a limited role in the former. That is, only shocks to transfers and labour taxes can have a substantial effect on access to credit for impatient agents and therefore, for the majority of policy, the size and expansionary/contractionary nature of the fiscal action does not lead to asymmetries itself. The implication of this is that conducting ‘austerity’ or ‘stimulus’ is not important to determine the impact of policy, but the underlying economic climate, and for our model, the credit conditions of agents.

Moreover, the asymmetries in the effectiveness of fiscal policy persist in the long-run, in contrast to Canzoneri et al. (2016) who find the non-linearity of their state-dependent multipliers diminishing beyond ten quarters; this persistence better matches the empirical results which typically look at multipliers over the medium term (for example Auerbach & Gorodnichenko 2012, measure output multipliers over five years). Furthermore, our results suggest that higher fiscal multipliers are present in both normal times as well as in downturns, making them the rule rather than the exception; as consistent with the empirical estimates from Tagkalakis (2008) and Fazzari et al. (2015).

An additional advantage of our framework with its rich set of policy instruments is that we can explore the state-dependence of fiscal multipliers in nine separate cases: five government spending policies (government consumption, government investment, transfers, targeted transfers and public employment) and four tax instruments (employer social security contributions and labour, consumption and capital taxes). Given that the existing two theoretical studies employ one type of fiscal multiplier each (public employment in Michaillat (2014) and government consumption in Canzoneri et al. (2016)), it is important to establish whether the state-dependence of fiscal multipliers is limited to certain instruments or applies generally. Doing so also allows us to map our results to the estimated fiscal multipliers which varies substantially across different types of public spending (see, for example, Auerbach &
More importantly, our findings on the state-dependency of individual fiscal multipliers enable us to present policy prescriptions for disaggregated fiscal policy, with crucial implications for policy design, particularly in downturns.

The rest of the paper is organized as follows. Section 2 presents a detailed description of our model economy and the policy making structure. Section 3 provides a number of fiscal experiments towards uncovering the state-dependent nature of fiscal policy effectiveness. Some further extensions and robustness checks are presented in Section 4. Finally, main conclusions of our analysis are presented in Section 5.

2 The model

Our model builds upon that of Guerrieri & Iacoviello (2017) in two clear ways: first, we endogenise the production of the residential (durable) good; and second, we develop a full fiscal sector with eight policy instruments and nine policy experiments. In what follows, we present the key features of the model structure; the rest of the model description is presented in a supplementary technical Appendix.

2.1 Households

As in Iacoviello & Neri (2010) there is a continuum of measure 1 of households in each of the two groups: ‘patient’ and ‘impatient’. Both types of household consume residential and non-residential goods and supply labour to production. The key difference between the two types of households is that the patient discounts the future at a lower rate than the impatient and hence the former are lenders to the latter; the value of housing stock of the impatient agents acts as collateral against their borrowing, as in Iacoviello (2005).

Patient Households

The utility function for each patient household is given by:

$$E_t \sum_{t=0}^{\infty} \beta^t \left( \ln(C^P_t(i)) + \epsilon^P_t \sigma_h \ln(H^P_t(i)) - \frac{1}{1 + \sigma_l} (L^P_t(i))^{1+\sigma_l} \right)$$

where superscript $P$ is used for patient agents, $i$ indicates a particular household, and $t$ represents time; $\beta$ is a subjective discount factor; $\sigma_l$ is the inverse elasticity of labour ($L$); $\sigma_h$ denotes a weight on housing in utility and $\epsilon^P_t$ is a housing preference shock which follows an AR(1) process with persistence $\rho_B$; $C^P$ and $H^P$ represent consumption of the final good and housing, respectively. Each patient household receives income from the following sources:
their after tax labour income \((1 - \tau^c_t)(w^P_t(i)I^P_t(i))\), where \(\tau^c_t\) and \(w^P_t\) denote the labour tax and wage rate; the after tax capital income \((1 - \tau^k_t)[r_{n,k,t}u_{n,t}(i)K_{n,t-1}(i)]\), where \(\tau^k_t\) denotes the capital tax rate, and \(K_n, u_n\) and \(r_{n,k}\) \((n \in \{c, h\})\) denote the physical stock of capital, the utilisation and rental rate of capital in the production of the consumption good sector \((n = c)\) and the housing sector \((n = h)\); the after tax dividend income \((1 - \tau^k_t)div_t(i)\); interest income from holdings of government bonds \((B)\) and loans to the impatient agents \((LO), ((R_{t-1} - 1)/\pi_t)(B_{t-1}(i) + LO_{t-1}(i))\), where \(R_{t-1}\) is the gross nominal interest rate on one period bonds and \(\pi_t = P_t/P_{t-1}\) is gross inflation; and, lump sum transfers from the government \(\mu TR_t\), where \(\mu\) is the share of government transfers received by patient households.

Each patient household \(i\) spends: \((1 + \tau^c_t)C^P_t(i)\) on the final consumption good where \(\tau^c_t\) denotes the consumption tax rate; \(\sum_{n=c,h} I_{n,t}(i) = I_{c,t}(i) + I_{h,t}(i)\) on investment in the physical capital in the consumption and the housing producing sectors, respectively; \(q_t[H^P_t(i) - (1 - \delta_h)H^P_{t-1}(i)]\) on residential property where \(q_t = P_{h,t}/P_t\) denotes relative price of housing and \(\delta_h\) the depreciation of housing; \((LO_t(i) - LO_{t-1}(i)/\pi_t)\) on loans to impatient households and purchases of government’s bonds; and on costs arising from changes in the level of the capital utilisation rate in both the consumption and housing sectors, \(a(u_{n,t})K_{n,t-1}(i)\). Investment increases the stock of physical capital according to:

\[
K_{n,t}(i) = (1 - \delta_{n,k})K_{n,t-1}(i) + \left[1 - S \left( \frac{I_{n,t}(i)}{I_{n,t-1}(i)} \right) \right] I_{n,t}(i) \tag{2}
\]

The flow budget constraint of the patient household can then be represented in real terms by:

\[
\sum_{n=c,h} I_{n,t}(i) + (1 + \tau^c_t)C^P_t(i) + q_t[H^P_t(i) - (1 - \delta_h)H^P_{t-1}(i)] + LO_t(i) + B_t(i) = (1 - \tau^1_t)(w^P_t(i)L^P_t(i)) + \mu TR_t + A^P_t(i) + \frac{R_{t-1}}{\pi_t}(B_{t-1}(i) + LO_{t-1}(i)) + (1 - \tau^k_t) \left[ \sum_{n=c,h} r_{n,k,t} u_{x,t}(i) K_{c,t-1}(i) + div_t(i) \right] - \sum_{n=c,h} a(u_{n,t}(i)) K_{n,t-1}(i) \tag{3}
\]

where \(A^P_t\) denote state contingent securities the presence of which implies that households are homogeneous with respect to consumption and assets choices. Each patient household maximizes utility subject to the budget constraint, the capital accumulation equations and the demand for labour. Wages are set subject to Calvo (1983) frictions.
Impatient Households

The utility of impatient households evolves according to:

$$E_0 \sum_{t=0}^{\infty} \gamma_t \left( \ln(C_t^I(i)) + \epsilon_t^B \sigma_h \ln(H_t^I(i)) - \frac{1}{1 + \sigma_t} \right) (L_t^I(i))^{1+\sigma_t}$$

Each impatient household $i$ faces a flow budget constraint which states that net labour income $(1 - \tau_l^t)(w_t^I(i)L_t^I(i))$, transfers $(1 - \mu)TR_t$, and the net acquisition of new loans $LO_t(i) - (LO_{t-1}(i)/\pi_t)$ should match total expenditure made up of: interest payments on outstanding loans $((R_t - 1)/\pi_t)LO_{t-1}(i)$; the expenditure on consumption $(1 + \tau_c^t)C_t^I(i)$; and the net acquisition of housing $q_t(H_t^I(i) - (1 - \delta_h)H_{t-1}^I(i))$. The impatient agents’ budget constraint is therefore given by:

$$\frac{(R_t-1)LO_{t-1}(i)}{\pi_t} + (1 + \tau_c^t)C_t^I(i) + q_t(H_t^I(i) - (1 - \delta_h)H_{t-1}^I(i))$$

$$= LO_t(i) - \frac{LO_{t-1}(i)}{\pi_t} + (1 - \tau_l^t) w_t^I(i)L_t^I(i) + (1 - \mu)TR_t + A_t^I(i)$$

The maximum that an impatient agent can borrow is defined by the constraint:

$$LO_t(i) \leq (1 - \tau)q_t H_t^I(i)$$

where $\tau$ denotes the ratio of the down-payment to the value of housing. This constraint states that the value of the loan has to be less than or equal to the value of housing, adjusted by the down-payment $(1 - \tau)q_t H_t^I(i)$. Each impatient household maximizes utility subject to the budget constraint, the borrowing constraint and the demand for labour.

2.2 Non-residential good sector

Final good sector

The final good $Y$ is produced by combining differentiated intermediate products using CES technology, $Y_t = \int_0^1 Y_t(j)^{(\nu_p-1)/\nu_p} dj^{\nu_p/(\nu_p-1)}$, where $\nu_p \geq 1$ denotes the elasticity of substitution among the differentiated outputs of intermediate firms and $Y_t(j)$ denotes output of $j^{th}$ producer. The retail firm chooses $Y_t(j)$ and maximises profit of the form:

$$Profit_t = P_t Y_t - \int_0^1 P_t(j)Y_t(j) dj$$
where $P_t$ is the price of the composite good and $P_t(j)$ denotes the price of the intermediate firm $j$. The first order condition results in the demand equation for the output of intermediate producer $j$, $Y_t(j) = (P_t/P_t(j))^{u_p} Y_t$, and the zero profit condition implies a price index of $P_t = \int_0^1 P_t(j)^{1-u_p} dj]^{1/(1-u_p)}$.

**Intermediate good sector**

The production technology of the monopolistically competitive intermediate good producers is given by the Cobb-Douglas function:

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

where $K_{g,t-1}$ and $K_{c,t-1}(j)$ denote public and private capital services, respectively; $N_{c,t}^P(j)$ and $N_{c,t}^I(j)$ denote labour supplied by the patient and impatient households, respectively; $\alpha$ denotes the share of capital in production; $b_1$ stands for the share of patient households in total labour used in production; $\Phi$ is a fixed cost of production; and $\sigma_g$ denotes the elasticity of output with respect to public capital. Monopolistic producers choose $K_{c,t-1}(j)$, $N_{c,t}^P(j)$, and $N_{c,t}^I(j)$ to minimise total real costs of production subject to the available technology, where all prices of inputs are taken as given. Monopolistic producers are also price setters, and prices are subject to Calvo (1983) frictions. In particular, in each period a share of firms, $\theta_p$, are unable to re-optimalise their prices and they simply increase prices by the central bank’s target rate of inflation.

2.3 **Residential good sector**

The competitive residential good producers use capital, $K_h$, and labour of patient and impatient households, $N_{h}^P$ and $N_{h}^I$, to produce the residential output ($HI$) using Cobb-Douglas production function of the form:

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

where $\alpha_h$ is the capital share in the production of housing. Both producers of the non-residential and residential good are subject to employers’ social security contributions which adds a tax proportion to total labour costs of the firm ($\tau_{er}$).

2.4 **Monetary Policy**

We adopt a standard formulation of monetary policy where policy-makers follow a Taylor type rule through which the nominal interest rate responds to movements in both output
and inflation with some persistence ($\rho$):

$$R_t = \max \left\{ 1, R \left( \frac{R_{t-1}}{R} \right)^\rho \left[ \left( \frac{\pi_{t}}{\pi} \right)^{0.25} \left( \frac{GDP_t}{GDP} \right)^{\rho_n} \right]^{1-\rho} \varepsilon_t^R \right\} \quad (10)$$

where $\varepsilon_t^R$ is a monetary shock; GDP represents gross domestic product which is given by

$$GDP_t = Y_t + qHI_t + (1 + \tau_{t}^\text{er})(w^P_t N_{g,t}^P + w^I_t N_{g,t}^I)$$

where $N_{g,t}^P = \varphi_g N_t^P$ and $N_{g,t}^I = \varphi_g N_t^P$ represent public employment of patient and impatient agents; $\bar{\pi}$ is the central bank’s target rate of inflation and $\pi_{t}^A = P_{t}/P_{t-4}$ is annual inflation rate; $\rho_n$ and $\rho_y$, denote respectively, the policy maker’s aversion to deviations of inflation and output from their respective steady-state values. Variables with no time subscript represent steady-state values. As in Iacoviello & Neri (2010), the formulation in (10) maintains that the nominal interest rate does not respond directly to variation in house prices.

### 2.5 Fiscal policy

The government budget constraint requires that spending on consumption ($G_c$), investment ($I_g$), transfers ($TR$) and public employment ($N_{g,t}^P$ and $N_{g,t}^I$) as well as the repayment of previous period debt is equal to tax receipts from the four revenue sources and issuance of new government debt.

$$\left( \frac{R_{t-1}}{\pi_t} \right) B_{t-1} + G_t + I_{g,t} + TR_t = \tau_c^c (C_t^P + C_t^I) + \tau_{t}^I (w^P_t L_t^P + w^I_t L_t^I) + \tau_{t}^\text{er} (w^P_t N_t^P + w^I_t N_t^I) + \tau_k^k (r_{k,c,t} u_{c,t} K_{c,t-1} + r_{k,h,t} u_{h,t} K_{h,t-1} + \text{div}_t) + B_t \quad (11)$$

where $G_t = G_{c,t} + (1 + \tau_{t}^\text{er})(w^P_t N_{g,t}^P + w^I_t N_{g,t}^I)$. For transfers, we adopt two scenarios: one where transfers are spread evenly across patient and impatient households ($\mu = b_1$, where $b_1$ is the share of patient households in total labour used in production); and another where transfers are targeted to impatient agents who both have lower incomes and who respond more to changes in lump sum payments ($\mu = 0$).
instruments and nine fiscal experiments at the disposal of the government (including both targeted and general transfers).

Public investment augments public capital according to:

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

(12)

where $\delta_{k,g}$ denotes the depreciation of public capital. Fiscal policy rules are set similar to those used by Leeper et al. (2010). We assume that fiscal policy responds countercyclically to the movements in debt and GDP, which implies that:

$$X_t = \left( \frac{B_t}{B} \right)^{\phi_{B,x}} e_t^x$$

$$e_t^x = 1 + \eta_{x,t} + \eta_{x,t-1} + \eta_{x,t-2} + \eta_{x,t-3}$$

(13)

where $x = \{\tau_c, \tau_k, \tau_I, \tau^{er}, G_c, I_g, N_{P,g}, N_{g}, TR\}$ is the set of fiscal instruments, and where $\eta_{x,t} \sim N (0, \sigma_x^2)$ are i.i.d. normally distributed errors. Shocks to fiscal instruments, therefore, last for only four quarters, with no persistence; extensions to these shocks is conducted in Section 4.1.

2.6 Equilibrium in residential and non-residential markets

The homogeneous output of the residential good producer is purchased by patient and impatient households:

$$HI_t = H_{t}^P + H_{t}^I - (1 - \delta_h) \left( H_{t-1}^P + H_{t-1}^I \right)$$

(14)

The final goods market is in equilibrium when the aggregate supply equals the aggregate public and private demand in final consumption good, investment and housing. The resource constraint is given by:

$$K_{c,t-1}^\alpha \left[ \left( N_{c,t}^P \right)^{\frac{1}{b_1}} \left( N_{c,t}^I \right)^{(1-b_1)} \right]^{1-\alpha} K_{g,t-1}^{\sigma_g} - \Phi$$

$$= s_{1,t} \left[ I_{c,t} + I_{h,t} + C_{t}^P + C_{t}^I + G_{c,t} + I_{g,t} + a(u_{h,t})K_{h,t-1} + a(u_{c,t})K_{c,t-1} \right]$$

(15)

where

$$s_{1,t} = (1 - \theta_p) \left( \tilde{p}_t \right)^{-v_P} + \theta_p \left( \frac{\bar{\pi}}{\pi_t} \right)^{-v_P} s_{1,t-1}$$

(16)
where \( s_{1,t} \) is a term denoting price dispersion.

3 Are the effects of fiscal policy state-dependent?

3.1 Time preferences, borrowing constraints and consumption

To explore the asymmetries in the model, a full understanding of the consumption decisions of impatient households is crucial given that it is through the impatient agents that the non-linear effects of policy are transmitted into the economy. The first order conditions for impatient and patient households with respect to consumption are presented in the following Euler equations:

\[
(1 - \lambda^b_t) \begin{cases} 
\frac{U^I_{c,t}}{P_t(1 + \tau^c_t)} = \gamma R_tE_t \frac{U^I_{c,t+1}}{P_{t+1}(1 + \tau^c_{t+1})} \\
\frac{U^P_{c,t}}{P_t(1 + \tau^c_t)} = \beta R_tE_t \frac{U^P_{c,t+1}}{P_{t+1}(1 + \tau^c_{t+1})}
\end{cases}
\]  

(17)

(18)

where \( \lambda^b_t \) is the price of borrowing (the ratio of the Lagrange multiplier on the borrowing constraint to the Lagrange multiplier on the budget constraint), and \( U^m = 1/C^m \) denotes marginal utility of consumption for \( m \in \{P, I\} \).

Using equation (17), it is straightforward to show that when \( \lambda^b_t > 0 \) the following holds:

\[
\frac{U^I_{c,t}}{P_t(1 + \tau^c_t)} - \gamma R_tE_t \frac{U^I_{c,t+1}}{P_{t+1}(1 + \tau^c_{t+1})} > 0
\]

(19)

Put differently, when the constraint on borrowing is binding (when the left hand side of (19) is greater than the right hand side) impatient agents would rather borrow more than they are permitted. This, in turn, is when the marginal utility of additional consumption \( (U^I_{c,t}/(P_t(1 + \tau^c_t))) \) is greater than the expected cost of this borrowing \( (\gamma R_tE_tU^I_{c,t+1}/(P_{t+1}(1 + \tau^c_{t+1}))) \) to the impatient agent. 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. This suggests that when impatient consumption in the current period is sufficiently high the constraint on their borrowing is no longer binding \( (\lambda^b_t = 0) \) and the two Euler equations of patient and impatient households become similar. Intuitively, this is when the marginal utility of additional consumption from extra borrowing is equal to the expected cost of this borrowing. Put differently, when \( \lambda^b_t = 0 \) impatient agents smooth any additional increase in income over the period in which they expect the borrowing constraint
to be slack. In doing so, they reduce interest payments and this allows for a slightly higher consumption profile in the longer horizon.

Iterating forward the Euler equations in (17) and (18) provides:

\[
C_t^I = \prod_{l=0}^{i=\infty} E_t \left\{ \frac{1}{\gamma^l} \frac{\pi_{t+1+l} + \tau_{t+1+l}^c}{1 + \tau_{t+1+l}^c} \right\} - \prod_{l=0}^{i=\infty} E_t \left\{ \lambda_t^b \frac{1}{\gamma^l} \frac{\pi_{t+1+l} + \tau_{t+1+l}^c}{1 + \tau_{t+1+l}^c} \right\}
\]

(20)

\[
C_t^P = \prod_{l=0}^{i=\infty} E_t \left\{ \frac{1}{\beta^l} \frac{\pi_{t+1+l} + \tau_{t+1+l}^c}{1 + \tau_{t+1+l}^c} \right\}
\]

(21)

which confirms the intuition from above. When \( \lambda_t^b = 0 \) the two equations become similar, where the difference in discount rates mean that the impatient bring more consumption forward than the patient. In this situation, impatient households smooth any additional income over the horizon in which the borrowing constraint is not binding (\( \lambda_t^b = 0 \)) and their level of borrowing is lower than the constraint permits. The presence of \( \lambda_t^b \) in (20) implies that any loosening of the borrowing constraint results in higher consumption today, whereas a tightening of the constraint has the reverse effect.

### 3.2 Policy experiments

Provided that the constraint on borrowing for impatient agents is binding at all times (\( \lambda_t^b > 0 \)) these agents borrow all that is permitted and there are no asymmetries in the dynamics from the model; that is, the impact of shocks in the model is symmetric. Therefore, in order to identify non-linear effects of fiscal policy, this borrowing constraint needs to not bind for some time interval; this will happen when consumption today is so high that the marginal utility gained from further borrowing (and therefore further consumption) is equal to the marginal cost of borrowing, as stipulated by (19). In this environment, shocks of the same magnitude will have different effects depending on how long the borrowing constraint on impatient households does not bind, or is ‘slack’. In order to get the constraint to not bind, as in Guerrieri & Iacoviello (2017) we use a housing preference shock (\( \varepsilon^H \) in (1) and (4)) such that the stock and value of housing increases for impatient and patient agents therefore increasing the borrowing potential of these households and thus consumption; we then increase the size of this shock in order to increase the number of periods in which the

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4Note that in the steady-state the borrowing constraints of impatient households are binding: \( \lambda_t^b = 1 - \gamma/\beta > 0 \) as \( \gamma < \beta \). We impose the restriction \( \lambda_t^b \geq 0 \) implying that impatient agents either wish to borrow (\( \lambda_t^b > 0 \)) or are indifferent between borrowing and saving (\( \lambda_t^b = 0 \)); a similar restriction is also adopted in Guerrieri & Iacoviello (2017).
constraint does not bind.

To calculate the size of fiscal multipliers, we include a small fiscal shock on top of the housing preference shock such that the length of the period in which the borrowing constraint does not bind is not altered; this fiscal shock is spread equally over four quarters before it subsequently dies (as specified in (13)). We then calculate multipliers by looking at the difference in variables with the additional fiscal shock compared to the counterfactual of only including the housing preference shock in the economy. In this respect, we find what Erceg & Lindé (2014) call a ‘marginal’ multiplier as the fiscal intervention is not of sufficient size to change the state the economy; extensions to when this is not the case is presented in Section 4.1. From this perspective, the period when the borrowing constraint on impatient agents binds can be considered as the multiplier corresponding to both ‘normal’ and recessionary times, whilst when it does not bind the economy is experiencing good times or a ‘boom’; the longer the constraint does not bind, the longer the boom.

In order to quantify the impact of policy on output, we employ the following metric to calculate cumulative fiscal multipliers ($M$):

$$M_T = \frac{\sum_{j=0}^{T} (Y_{t+j} - Y_0)}{\sum_{j=0}^{T} (x_{t+j} - x_0)}$$ (22)

where $T$ is the time horizon over which the multiplier is measured, $x$ is the respective fiscal instrument, and variables with a subscript zero are outcomes corresponding to the counterfactual of no fiscal policy change. When $x$ is a government spending instrument, we use the monetary value of the change in spending as the denominator (throughout the paper, we use the expression ‘government spending’ to represent the four spending instruments in the model in total). To ensure consistency, for tax multipliers we use the change in tax revenues were all other variables (with the exception of the relevant tax rate) to remain the same.

In solving the model we apply the toolkit for solving dynamic models with occasionally binding constraints developed in Guerrieri & Iacoviello (2015).

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5 In order to get the borrowing constraint not binding for an increasing period of time, we increase the size of the housing preference shock. A two (eight) quarter period of slack in the borrowing constraint requires a shock leading to an on impact increase in the house price of 0.5 (2.3) per cent. Given that an estimated one standard deviation housing preference shock leads to an approximate increase of 2 per cent in the house price in Guerrieri & Iacoviello (2017), it is clear that the magnitude of the required shock to ensure the slackness of the borrowing constraint is well within the range observed in the data. Guerrieri & Iacoviello (2017), for example, in an estimated version of their model, find the borrowing constraint on impatient agents to have been slack between 1998 and 2006.

6 For government spending instruments ($G_C, I_G, N_g, TR$) we set each shock such that the change is equal to 0.01% of steady-state output. To ensure comparability of multipliers across fiscal instruments, we shock tax rates such that the change in the steady-state tax revenue is also equal to 0.01% of steady-state output. This size of shock ensures that the horizon over which the borrowing constraint on impatient agents is not binding is unaffected.
3.3 Calibration

We calibrate the model using the values adopted in the previous literature and data from the US between 1985 and 2016, as outlined in Table 1. We set the ratio of government consumption, investment, transfers to output and a share of public employment to total employment to match the averages in the data for the period 1985-2016 (we take 1985 as the starting point to be consistent with Guerrieri & Iacoviello 2017). This is in line with Trabandt & Uhlig (2011), Drautzburg & Uhlig (2015) and Alpanda & Zubairy (2016) who calibrate government consumption to 18%, 15.3% and 18% respectively, and Drautzburg & Uhlig (2015) calibrate government investment to 4% of GDP. 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. The exception to this is that our capital utilisation cost and investment adjustment cost are based on the estimated values in Iacoviello & Neri (2010). The elasticity of fiscal instruments to debt ($\phi_{B,t}$) is set to 0.2 which means that all instruments are used to ensure government solvency and respond slowly to bring debt to its steady-state; debt as a result of fiscal shocks is halved after 34 quarters, and sensitivity to this parameter is performed in Section 4.1. 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). We then set the depreciation rate of public capital 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 0.093 and a depreciation rate of 0.0101, values very close to the ones used in Iacoviello & Neri (2010). Since, Guerrieri & Iacoviello (2017) do not use housing production, we use the share of physical capital in

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7All 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 public sector are taken from Table 6.4B.

8None of these models include public employment, and in all three the level of transfers is fixed through the calibration of other parameters.

9The inclusion of either employers’ social security contributions or public employment are uncommon assumptions in the literature. Therefore we test the sensitivity of our results to a model which do not include these; see Appendix A for further details.
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 those used in Drautzburg & Uhlig (2015) and Alpanda & Zubairy (2016) and depreciation rate of residential capital (0.03) is in line with Iacoviello & Neri (2010).

To assess the reliability of our calibration, we compare four quarter output multipliers from our benchmark model specification (where borrowing constraints are binding) to those presented in Coenen et al. (2012). In general our multipliers fit very well with those presented in Coenen et al. (2012). The two exceptions are for labour income and consumption taxes, where we get higher multipliers, particularly in the case of the latter. The reason behind this is that our benchmark specification does not have habit formation in consumption, which allows for a strong immediate response of consumption to changes in labour and consumption taxes. As is seen in Section 4.3, including habit persistence in consumption brings our multipliers much closer to those presented in Coenen et al. (2012) but has a limited effect on the key findings from the analysis.

3.4 Dynamics

In order to explore the transmission mechanism through which fiscal policy impacts upon impatient agents’ consumption (and subsequently the broader economy), we present dynamics from two fiscal experiments involving a shock to transfers (Figure 1) and government consumption (Figure 2). In these plots the period over which the borrowing constraint on impatient agents is slack varies between zero and 18 quarters. As discussed in Section 3.2, we get this borrowing constraint to not bind by shocking housing preferences \( \varepsilon^B \) and then consider the impact of policy by including a further shock to the relevant fiscal instrument.

An increase in transfers increases both the income for impatient households and the level of government debt. In normal times, when \( \lambda^b > 0 \), impatient households convert increased incomes into increased consumption for the four quarters whilst the policy shock is active (this includes any additional borrowing arising from an increase in the value of the borrowing constraint). This is because the marginal utility of additional consumption for

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10 Coenen et al. (2012) compute fiscal multipliers across seven instruments for a number of models used by policy institutions. Following their work, we also distinguish between targeted and general transfers, where targeted transfers go only to impatient agents and general transfers are spread evenly across the two types of households.

11 This is in line with Guerrieri & Iacoviello (2017) who show that the borrowing constraints were slack in the USA between 1998 and 2006 and subsequent housing collapse lead to tightening of borrowing constraints which exacerbated the recession of 2008-2009.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Data/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_h )</td>
<td>Utility share of housing</td>
<td>0.093</td>
<td>*</td>
</tr>
<tr>
<td>( \sigma_l )</td>
<td>Frish elasticity of labour</td>
<td>1</td>
<td>GI</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Patient discount factor</td>
<td>0.995</td>
<td>GI</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>Impatient discount factor</td>
<td>0.9922</td>
<td>GI</td>
</tr>
<tr>
<td>( b_t )</td>
<td>Share of patient agents</td>
<td>0.5013</td>
<td>GI</td>
</tr>
<tr>
<td>( \tau )</td>
<td>Down-payment ratio</td>
<td>0.1</td>
<td>GI</td>
</tr>
<tr>
<td>( \rho_B )</td>
<td>Persistence in housing shock</td>
<td>0.9835</td>
<td>GI</td>
</tr>
<tr>
<td>( \alpha_c )</td>
<td>Share of capital in non-residential production</td>
<td>0.3</td>
<td>IN</td>
</tr>
<tr>
<td>( \alpha_h )</td>
<td>Share of capital in residential production</td>
<td>0.1</td>
<td>IN</td>
</tr>
<tr>
<td>( \delta_{k,c} )</td>
<td>Depreciation of non-residential capital</td>
<td>0.0145</td>
<td>*</td>
</tr>
<tr>
<td>( \delta_{k,h} )</td>
<td>Depreciation of residential capital</td>
<td>0.03</td>
<td>*</td>
</tr>
<tr>
<td>( \delta_h )</td>
<td>Depreciation of housing</td>
<td>0.0101</td>
<td>*</td>
</tr>
<tr>
<td>( \delta_{k,g} )</td>
<td>Depreciation of public capital</td>
<td>0.0151</td>
<td>*</td>
</tr>
<tr>
<td>( \sigma_g )</td>
<td>Elasticity of output w.r.t. public capital</td>
<td>0.02</td>
<td>*</td>
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<tr>
<td>( \phi_k )</td>
<td>Investment adjustment cost parameters</td>
<td>14.25</td>
<td>IN</td>
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<tr>
<td>( \kappa )</td>
<td>Capital utilisation adjustment parameter</td>
<td>2.2258</td>
<td>IN</td>
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<tr>
<td>( \theta_p )</td>
<td>Price stickiness</td>
<td>0.9182</td>
<td>GI</td>
</tr>
<tr>
<td>( \theta_w )</td>
<td>Wage stickiness</td>
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<td>GI</td>
</tr>
<tr>
<td>( \upsilon_p )</td>
<td>Steady state price markup</td>
<td>0.2</td>
<td>GI</td>
</tr>
<tr>
<td>( \upsilon_w )</td>
<td>Steady state wage markup</td>
<td>0.2</td>
<td>GI</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Monetary policy persistence</td>
<td>0.5509</td>
<td>GI</td>
</tr>
<tr>
<td>( \rho_{\pi} )</td>
<td>Inflation Taylor rule weight</td>
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</tr>
<tr>
<td>( \rho_{y} )</td>
<td>Output Taylor rule weight</td>
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<td>GI</td>
</tr>
<tr>
<td>( \phi_{B,x} )</td>
<td>Response of fiscal instruments to debt</td>
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<td></td>
</tr>
<tr>
<td>( \tau^c )</td>
<td>Consumption tax rate</td>
<td>0.05</td>
<td>TU</td>
</tr>
<tr>
<td>( \tau^l )</td>
<td>Labour tax rate</td>
<td>0.2</td>
<td>TU</td>
</tr>
<tr>
<td>( \tau^k )</td>
<td>Capital tax rate</td>
<td>0.36</td>
<td>TU</td>
</tr>
<tr>
<td>( \tau^{cr} )</td>
<td>Employers social security contributions rate</td>
<td>0.07</td>
<td>TU</td>
</tr>
<tr>
<td>( G/GDP )</td>
<td>Public consumption and employment to GDP</td>
<td>0.149</td>
<td>0.149</td>
</tr>
<tr>
<td>( IG/GDP )</td>
<td>Public investment to GDP</td>
<td>0.041</td>
<td>0.041</td>
</tr>
<tr>
<td>( TR/GDP )</td>
<td>Transfers to GDP</td>
<td>0.114</td>
<td>0.114</td>
</tr>
<tr>
<td>( \psi_g = N^f/g = N^p/g )</td>
<td>Share of public employment</td>
<td>0.147</td>
<td>0.147</td>
</tr>
<tr>
<td>( (C_p + C_l)/GDP )</td>
<td>Consumption to GDP</td>
<td>0.645</td>
<td>0.645</td>
</tr>
<tr>
<td>( (I_h + I_c)/GDP )</td>
<td>Non-residential investment to GDP</td>
<td>0.123</td>
<td>0.123</td>
</tr>
<tr>
<td>( qHI/GDP )</td>
<td>Residential investment to GDP</td>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>( (K_c + K_h)/(4 \times GDP) )</td>
<td>Business capital to GDP</td>
<td>2.107</td>
<td>2.239</td>
</tr>
<tr>
<td>( q(H_l + H_p)/(4 \times GDP) )</td>
<td>Housing value to GDP</td>
<td>1.038</td>
<td>1.033</td>
</tr>
<tr>
<td>( Kg/(4 \times GDP) )</td>
<td>Public capital to GDP</td>
<td>0.679</td>
<td>0.678</td>
</tr>
<tr>
<td>( Kh/(Kc + Kh) )</td>
<td>Share of residential capital in total capital</td>
<td>0.009</td>
<td>0.007</td>
</tr>
</tbody>
</table>

The abbreviations ‘GI’, ‘IN’ and ‘TU’ refers to Guerrieri & Iacoviello (2017), Iacoviello & Neri (2010) and Trabandt & Uhlig (2011) respectively. The symbol * represents a value implied by other calibrations to fix steady state shares to empirical values.
Dynamics from fiscal experiments where the borrowing constraint on impatient agents is slack for 0, 6, 12 and 18 quarters, as illustrated by the legend. In each instance, the results have been normalised to present the dynamics as a result of a shock to fiscal policy equal to one percentage of output; dynamics for each variable are presented as percentage deviations from the steady state. The results present marginal impacts as the length of time the borrowing constraint is not binding is unaffected by the policy; the normalisation is performed on shocks equal to one-hundredth of this, and is done for ease of presentation.

these households is higher than the marginal cost of borrowing, as discussed in Section 3.1. Higher demand from impatient agents brings about higher output, and inflationary pressures lead to an increase in the real interest rate which subsequently leads to a fall in consumption of patient households, as indicated in equation (21).

When the borrowing constraint on impatient agents is not binding, on the other hand, these agents smooth any additional income over the period in which they expect their borrowing constraint to be slack; this is when the marginal utility of additional consumption for these households is equal to the marginal cost of this consumption. This implies a smaller increase in impatient households’ consumption in the short run, and therefore a smaller increase in output. This can be seen in the first and second panels of Figure 1 (for output and impatient agents’ consumption, respectively) for differing periods over which the borrowing constraint is slack; a smoothing of impatient income leads to a smoothing of the effects of policy on output.

The smoothing actions of impatient households impacts the dynamics of patient agents in
two ways: first, when the impatient borrowing constraint is not binding for a period of time, their smoothing of consumption leads to more persistent levels of inflation and subsequently higher real interest rates following the fiscal shock; and second, a smoothing of consumption by impatient agents leads to a smaller response to output arising from the fiscal action, and as such lower tax revenue and higher debt. The combination of anticipated higher interest rates and taxes (needed to repay higher debt) lead patient agents’ to crowd out the expenditure more when impatient agents’ smooth their response to the policy, as is clear from (21). Therefore, the response of output to fiscal stimulus in the short run is determined by the actions of impatient agents which is influenced by whether they are constrained in their borrowing; over the medium-run, however, the dynamics of output are determined by the action of patient agents responding to the wealth outcomes of the policy.

Figure 2 presents dynamics as a result of a government spending shock, for differing horizons over which the constraint on impatient borrowing is not binding; as is illustrated in the first panel, output multipliers tend to be lower than one, suggesting a net crowding
out of private expenditure to the policy. Similar to above, an increase in government consumption leads to both increases in impatient incomes and government debt. Higher output and inflation result in an increase in the real interest rate which crowds out expenditure of patient households on impact, as indicated in equation \((21)\). In normal and recessionary times, when \(\lambda^b > 0\), impatient agents increase their consumption in the short run when government consumption is increased, as extra aggregate demand increases labour demand and subsequently income for these agents. When the borrowing constraint on the impatient is not binding, on the other hand, these agents smooth the additional expenditure over the period in which they expect the borrowing constraint to be slack. Therefore the mechanism determining the consumption path of impatient households is the same as in the case of transfers. The main difference between the two policy experiments, however, is the fact that transfers impact directly the income of impatient households, whereas government consumption does indirectly through higher labour income. Therefore, the increase in income and consumption is smaller in the case of government consumption (as shown in Figure 2), and the output effects of this policy come from public (and not private) demand. As the income being smoothed is smaller, the impact on the real economy resulting from this smoothing process is also smaller and therefore the difference in response of output between expansions and recessions is not as large as in the case of transfers. Given this, the subsequent influence of consumption smoothing of impatient agents on patient households expenditure via the channels discussed above (expected real interest rates and taxes) is also smaller as can be seen in Figure 2.

### 3.5 Fiscal multipliers

To extend the analysis to all nine fiscal experiments, the first column of Figure 3 presents four quarter cumulative output multipliers \((y\text{-axis})\) for differing periods for which the constraint on impatient households’ borrowing does not bind \((x\text{-axis})\). The intuition from above, that the longer the slack in the borrowing constraint the smaller the fiscal policy effect on output is maintained. As discussed above, in periods of slack, impatient agents are already consuming enough to not use their full credit capacity, and increases in their incomes during these periods lead to a lower consumption response of impatient agents compared to when their borrowing constraint binds. For example, average government spending multipliers are 50% lower when there is slack in the impatient borrowing constraint for 20 quarters compared to when this is always binding; similarly, employers’ social security and consumption and labour tax multipliers are lower by (on average) 44% between the two benchmarks. The largest non-linearity in multipliers are for targeted and general transfers and labour taxes.
which are 0.72, 0.34 and -0.43, respectively, in normal and recessionary times when the borrowing constraint binds, and nearly zero when there is slack for 20 quarters.

Cumulative multipliers for the nine fiscal experiments for differing horizons over which the borrowing constraint on impatient households does not bind; the first column presents output multipliers, the second column impatient non-residential consumption multipliers; and the final column patient non-residential consumption multipliers. The first row represents results for government spending instruments and the second row taxation instruments.

The one exception to the main result is for capital taxes which have a higher impact on the economy when the impatient borrowing constraint is not binding. In normal and recessionary times ($\lambda^b > 0$), a cut in capital taxes leads to a substitution from labour to capital, lowering labour income and therefore impatient consumption. In this situation, impatient households would prefer to borrow more ($\lambda^b$ increases) which they can do if the borrowing constraint is not binding. Therefore a decrease in capital taxes has a smaller negative effect on the consumption of impatient households during an expansion and as a result there is an additional improvement in output resulting in a higher multiplier. The distortionary nature of taxes can lead to the general intuition to brake, but only in our model for taxes on capital; for all other instruments, expansionary policy leads to higher incomes for impatient agents and as such, if their borrowing constraint is not binding at the time of the policy, output multipliers are lower.

The degree to which the effects of fiscal policy are non-linear is determined by the degree
to which the effectiveness of policy is influenced by the consumption movements of impatient agents. If these movements are small when the borrowing constraint binds (for example when the government increases spending on consumption, investment and employment or when it decreases employers social security contributions or taxes on capital), the non-linearity of the response to fiscal policy is smaller. Cumulative four quarter consumption multipliers presented in Figure 3 demonstrate that impatient consumption multipliers are largest when their borrowing constraint is binding for targeted and general government transfers, and labour and consumption taxes. As such, these instruments lead to the most non-linear of outcomes in both impatient consumption and output; note that the consumption of patient agents is largely unaffected by the actions of the impatient in the four quarter horizon. Patient agents have higher discount factors and their consumption is influenced by the path of expected future real interest rates and consumption taxes (as demonstrated in (21)); although the actions of the impatient influence these, the effects comes over the medium term and as a result four quarter consumption multipliers are not as volatile as for impatient households.

To examine further the role of binding versus non-binding borrowing constraints on fiscal outcomes, Figure 4 presents a decomposition of four quarter cumulative output multipliers for each of the nine fiscal experiments, separated between government spending and tax instruments. The movement of each component of GDP were examined to determine what was contributing to the movement in total output over the first four quarters of the fiscal intervention; for each fiscal experiment a pair of results are presented side-by-side to each other, one where the borrowing constraint on impatient agents is always binding (left hand bar) and another where it is slack for 20 quarters (right hand bar). These results illustrate that it is the movements in impatient agents’ consumption which is the biggest source of non-linearity in these multipliers; the bars which represent impatient spending are those which vary the most between the different scenarios. It follows, therefore, that when impatient spending is not a large contributor to the output multiplier, the difference in results relative to when the borrowing constraint is not binding is not as quantitatively large; that is, for those policies which do not require movements in impatient households’ consumption to change output, fiscal effects are less non-linear.

As highlighted in Figures 1 and 2, although the smoothing actions of impatient agents reduce the output response of policy in the short term, when their borrowing constraint is slack, over a longer period it improves output as consumption is spread over the longer horizon. This smoothing of actions by the impatient agents leads to less non-linearity in multipliers when measured over a long horizon; this is confirmed in the first column of Figure 5 which plots twenty quarter cumulative output multipliers. Non-linearity is still observed,
A decomposition of output multipliers for each instrument (along the x-axis) where each instrument has two bars, representing a pair of values: in the left hand bar the borrowing constraint on impatient agents is always binding; in the right hand bar it is slack for 20 quarters. The decompositions separate between those elements which contribute negatively and positively to the four quarter cumulative output multiplier, with the circle-point in each bar representing the value of the multiplier (the net of the positive and negative effects).

and although the percentage changes in output multipliers are similar, the absolute range of these values is smaller. Targeted and general transfers continue to be the most non-linear spending instruments and twenty quarter cumulative multipliers are now negative for general transfers when there is slack in the impatient borrowing constraint. These negative multipliers result from the rise in distortionary taxes to pay for the expansionary policy, and from the behaviour of patient households, as discussed in Section 3.4.

Over short time horizons, the non-linear response of fiscal multipliers is determined by the consumption of impatient agents; however, evaluating a period which nests the entire
Cumulative multipliers for the nine fiscal experiments for differing horizons over which the borrowing constraint does not bind; the first column presents output multipliers, the second column impatient non-residential consumption multipliers; and the final column patient non-residential consumption multipliers. The first row represents results for government spending instruments and the second row taxation instruments.

time in which borrowing constraints are slack (and therefore the period over which impatient consumption is smoothed), it is the response of patient agents which becomes more important. This can be seen in the second and third columns of Figure 5 which presents twenty quarter cumulative consumption multipliers for the two types of household for differing periods over which credit constraints are slack. Whereas in Figure 3 the non-linearity in four quarter cumulative consumption multipliers is driven by impatient agents, when the whole period over which these agents can smooth their consumption is considered, as in Figure 5, the non-linearity is driven by patient households. As discussed above, the difference in the four quarter output multipliers between expansions and recessions stems from the consumption smoothing of impatient households during expansions. Over the 20 quarter period the entire smoothing exercise is completed therefore there is limited volatility in the impatient households’ consumption multiplier. On the other hand, the smoothing process of impatient households results in more persistent real interest rates and larger increases in the present discounted value of taxes, which leads to greater crowding out of patients’ consumption and therefore a lower consumption multiplier for these households. There is
therefore both a short and long run non-linearity to fiscal policy. In this respect our results differ from those presented in Canzoneri et al. (2016) who use costly financial intermediation to produce asymmetric fiscal multipliers; in their paper, although the short run multipliers are different in recessions and expansions, there is limited non-linearity over a longer time horizon (beyond ten quarters).

4 Further extensions

4.1 Further fiscal experiments

The fiscal experiments in our benchmark specification above featured small temporary shocks spread over four quarters. To examine the non-linear effects of policy further, we now consider larger shocks, ones which can influence the time horizon over which the borrowing constraint on impatient households is not binding. Table 2 presents results across all nine experiments for expansionary fiscal shocks varying in size, where all shocks start from a benchmark position of when the impatient borrowing constraint is always binding, but is on the border between always binding and not binding (to get to this position we apply a housing preference shock)\textsuperscript{12}

<table>
<thead>
<tr>
<th>Shock</th>
<th>$G$</th>
<th>$I^C$</th>
<th>$TR$</th>
<th>$N_g$</th>
<th>$TR'$</th>
<th>$τ^c$</th>
<th>$τ^l$</th>
<th>$τ^k$</th>
<th>$τ^{cr}$</th>
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<tbody>
<tr>
<td>1</td>
<td>0.893</td>
<td>0.903</td>
<td>0.345</td>
<td>0.694</td>
<td>0.702</td>
<td>-0.918</td>
<td>-0.427</td>
<td>-0.118</td>
<td>-0.619</td>
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<tr>
<td>2</td>
<td>0.893</td>
<td>0.903</td>
<td>0.338</td>
<td>0.694</td>
<td>0.584</td>
<td>-0.918</td>
<td>-0.414</td>
<td>-0.118</td>
<td>-0.619</td>
</tr>
<tr>
<td>3</td>
<td>0.893</td>
<td>0.903</td>
<td>0.319</td>
<td>0.687</td>
<td>0.486</td>
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<td>-0.372</td>
<td>-0.118</td>
<td>-0.62</td>
</tr>
<tr>
<td>4</td>
<td>0.885</td>
<td>0.895</td>
<td>0.294</td>
<td>0.680</td>
<td>0.419</td>
<td>-0.911</td>
<td>-0.333</td>
<td>-0.118</td>
<td>-0.617</td>
</tr>
<tr>
<td>5</td>
<td>0.880</td>
<td>0.891</td>
<td>0.267</td>
<td>0.670</td>
<td>0.369</td>
<td>-0.906</td>
<td>-0.302</td>
<td>-0.118</td>
<td>-0.612</td>
</tr>
</tbody>
</table>

Table 2: Four quarter cumulative average fiscal multipliers

Average four quarter multipliers where the economy is subjected to a fiscal shock the size of which is given in the first column as a percent of GDP varying from one to five percent.

The multipliers in Table 2 confirm the intuition from above; expansionary fiscal shocks increase impatient incomes and subsequently consumption. Table 2 demonstrates that when fiscal shocks are large enough, the borrowing constraint on impatient agents becomes slack. The degree to which this happens follows the intuition from Section 3.5, where for those instruments which have the greatest impact on impatient incomes and consumption (targeted and general transfers and labour taxes) average multipliers are lower with larger shocks as

\textsuperscript{12}That is, small changes in the circumstances of impatient households can lead their borrowing constraint to no longer be binding.
these make the borrowing constraint on these agents no longer bind, and subsequently impatient agents start to smooth their consumption. For all other instruments, where impatient households play a less important role in the transmission mechanism of fiscal policy, there is a limited non-linear impact of the size of the shock on fiscal multipliers. Therefore, it can be concluded that even though fiscal multipliers are state-dependent, policy itself has a limited impact upon its own effectiveness. The implication of this is that whether conducting ‘austerity’ or ‘stimulus’ is not important to determine the impact of policy, but the underlying economic climate, and for our model, the credit conditions of agents.

Figure 6: Four quarter cumulative multipliers: fiscal policy extensions

Four quarter cumulative multipliers for transfers and labour taxes under a number of different extensions as labelled in the legend: ‘Benchmark’ represents the benchmark results above; ‘8 qtr shock’ represents where fiscal shocks last for eight quarters (in benchmark, fiscal shocks last for four quarters); ‘Higher $\phi_{b,x}$’ refers to $\phi_{b,x} = 0.4$ (as opposed to 0.2 in the benchmark), this change leads to debt being halved in 18 quarters on average instead of 34 quarters in the benchmark scenario.

We further consider experiments similar to those above in Section 3.5 but now including fiscal shocks lasting eight quarters (compared with four in the benchmark) and with higher levels of debt aversion ($\phi_{b,x}$ in (13)). Figure 6 presents results for both transfers and labour taxes; results are not sensitive to which fiscal instruments are considered and these two are chosen for ease of presentation. Although fiscal multipliers in these two extensions vary from those in the benchmark, the difference is limited. In the above two cases, longer lasting shocks lead to higher short run multipliers as impatient agents play an important role in the transmission mechanism in the case of labour income taxes and transfers. Higher

13For the remaining fiscal instruments, where impatient households play a relatively less important role
levels of debt aversion lead to lower multipliers as the government are now more aggressively responding to debt by lowering spending and raising taxes thus reducing demand. Despite these changes in the size of multipliers, however, the asymmetry and the state-dependence is maintained.

4.2 Monetary policy

In order to put the results on the non-linearity of fiscal policy into context, in this section we extend our analysis in two dimensions: first, we consider another source of non-linearity, that of monetary policy being at its ‘zero lower bound’ (ZLB); and second, similar to the framework above, we consider whether the impact of monetary policy shocks on the general economy are non-linear by varying the time over which the borrowing constraint on impatient agents is slack. In order to consider the former, we use an interest rate shock ($\varepsilon^R_t$) to get the nominal interest rate to be at its ZLB for up to five quarters and then apply the small fiscal shocks from above to get multiplier values, as in Section 3.5. To investigate potential non-linearities in monetary policy we use a framework similar to that of above, but now instead of applying a small fiscal shock for when the impatient borrowing constraint is slack for up to 20 quarters, we apply a small one-quarter monetary policy shock. The results are normalised to show a percentage change in output over a four quarter horizon to a one quarter change in the interest rate of 100 basis points. Results from these extensions are presented in Figure 7.

The first panel of Figure 7 demonstrates that fiscal policy multipliers are more non-linear with changes in the ZLB length than with the borrowing conditions of impatient households: for example, government spending (tax) multipliers are 60% (40%) larger than normal times with a ZLB length of five quarters. This is intuitive given that the non-linearity in the results presented in Section 3.5 derive from the actions of impatient households (which account for half the economy in our benchmark calibration), whereas the ZLB has an impact on the whole economy. Fiscal expansions can have an inflationary effect which, when combined with the ZLB, lowers real interest rates encouraging spending by both impatient and patient households. A period where the monetary ZLB is binding is likely to also be one of where the borrowing constraint on impatient households is also binding, as it is unlikely for the former to occur in a consumption boom. As such, the co-existence of the ZLB and a recession, would yield even greater state-dependence and hence asymmetries in fiscal multipliers than those presented above. That is, the ZLB provides one end of the spectrum where fiscal multipliers in the transmission mechanism, the negative wealth effect dominates and the more persistent action of the fiscal authority results in smaller multipliers, and the impact on the variability of these over the business cycle is very limited.

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Figure 7: Monetary policy extensions

The first two panels present fiscal multipliers for spending and tax instruments, respectively, for periods over which the ZLB is binding for between zero and five quarters. The third panel presents results from a one quarter monetary policy shock where the change in the interest rate lasts for one quarter and is equal to 100 basis points.

Weise (1999) and Lo & Piger (2005) find that monetary shocks have a bigger impact on output in a recession than in a boom, whereas Tenreyro & Thwaites (2016) show the reverse finding i.e. business investment and consumption on durables are less responsive to interest rate shocks during downturns. Our results (as illustrated in the third panel of Figure 7) are consistent with the former and suggest that monetary policy is less effective in expansions than in recessions. From the perspective of impatient households, monetary policy stimulus leads to higher labour income, lower interest payments and higher transfers (as the government budget constraint is relaxed with lower interest). In normal times and in recessions all this additional income is spent instantly, whereas in an expansion the expenditure is smoothed over the period in which borrowing constraints are expected to be slack, hence rendering monetary policy less effective in upturns.

We also consider different forms for the Taylor rule and different calibrations of its parameters. Figure 8 presents results for general transfers and labour tax multipliers under various Taylor rule specifications, where again these instruments are used as examples and the results are not sensitive to which fiscal instruments considered. In general, the results presented in Section 3.5 are robust with asymmetric responses to fiscal policy depending on the conditions of the impatient agents’ borrowing constraint. The non-linearity of fiscal policy is greater under two scenarios: first, when the response of the monetary authority

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Four quarter cumulative multipliers for transfers and labour taxes under a number of different extensions as
labelled in the legend: ‘Benchmark’ represents the benchmark results from above; ‘Output growth’ represents
where output growth, as opposed to the deviation of output from steady state, is in the Taylor rule (10);
‘TR: low $\rho_e$’ when the calibration of this parameter is 1 (1.7196 in the benchmark); ‘TR: low $\rho_y$’ when the
calibration of this parameter is 0.01 (0.0944 in the benchmark); ‘TR: higher $\rho$’ when the calibration of this
parameter is 0.85 (0.5509 in the benchmark).

to higher output is muted ($\rho_y = 0.01$); and second, where the Taylor rule responds to output
growth ($GDP_t/GDP_{t-1}$) instead of movements in output from the steady-state. When
the Taylor rule responds to output growth, multipliers are 59% and 49% smaller for gov-
ernment spending and taxation instruments, respectively, when the borrowing constraint is
slack for 20 quarters compared to when it is always binding (the corresponding differences
were 50% and 44% in the benchmark results). In both of these scenarios four quarter multi-
pliers increase significantly (with respect to the benchmark) when the borrowing constraint
is binding, or not binding for a relatively short period of time. When this is the case there
is a significant initial increase in output and a monetary policy that is unresponsive to out-
put ($\rho_y = 0.01$) means that the increase in the interest rate is smaller, leading to a smaller
crowding out of patient households’ consumption and as a result a greater multiplier. A
similar profile emerges when the Taylor rule responds to output growth, where changes in
the interest rate occur only in the period of growth, whereas there is no change when output
is steadily above the steady-state value. With respect to the benchmark this also implies a
smaller response of interest rates and a lower crowding out of patients’ consumption. For
other changes analysed in Figure 8 there are small variations in the size of multipliers under
different calibrations, but not to the variability of these multipliers as a result of slack in the

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Figure 8: Four quarter cumulative multipliers: Taylor rule extensions
impatient borrowing constraint.

4.3 Further sensitivity

Following the discussion of the size of our benchmark multipliers in Section 3.3, we now include habit formation in non-residential consumption in our model. In particular, it was observed that multipliers resulting from the calibration of the model were in line with those from Coenen et al. (2012) with the exception of labour and consumption taxes, for which the absence of habit persistence has an important influence on model dynamics. We now set this parameter to 0.7 for both households, in line with Guerrieri & Iacoviello (2017). The implication of this exercise is that households’ consumption responses take a hump-shaped form, rather than adjusting instantly. This affects the transmission mechanism in two ways: first, for fiscal instruments which result in a positive (negative) response of a particular household’s consumption, habit formation decreases this response in absolute values, resulting in smaller consumption multipliers and therefore lower (higher) output multipliers; and second, habit formation affects the consumption dynamics of the unconstrained more than the constrained households.

Figure 9: Robustness checks: habit persistence

Four quarter cumulative multipliers in nine fiscal experiments for differing horizons over which the borrowing constraint on impatient household does not bind. For each experiment, two sets of results are presented: those with thinner line are those from the benchmark above; those with thicker lines are those where agents’ utility functions feature habit persistence with parameter 0.7.

Results for a model with habit persistence in consumption are presented in Figure 9 including benchmark results from above. The impact of introducing habit persistence in
the model is particularly visible for instruments with a direct and significant impact on consumption: consumption and labour taxes and transfers. For these instruments we can observe a decrease in the multiplier; the presence of habit persistence for consumption taxes, for example, reduce the response of both households, and therefore significantly lower the output multiplier. While the introduction of habit persistence has not qualitatively altered the non-linearity of our fiscal multipliers, our results are now in line with those presented in Coenen et al. (2012).

In addition to above, we also performed sensitivity tests to other parameter values, including (but not limited to): price and wage stickiness; the proportion of impatient households in the economy; and the exclusion of employers’ social security contributions and public employment in the model. Despite quantitative shifts in the size of multipliers, the non-linearity of fiscal impacts remains similar to those presented above; the results are robust to further sensitivity tests. Further results can be found in Appendix A.

5 Discussion and concluding remarks

We have developed and calibrated a medium scale DSGE model which, through the use of occasionally binding borrowing constraints on impatient agents, provides substantial non-linearities in fiscal multipliers. We show this across nine fiscal experiments demonstrating heterogeneity in the asymmetry of multipliers across fiscal instruments. For eight of the nine experiments, we find that policy has larger effects when borrowing constraints bind, and this is strongest where the consumption of impatient agents is most predominant in the transmission mechanism of the policy. The only exception is the case of capital taxes where we find stronger effects when the borrowing constraint does not bind due to lower wages arising from the cut in capital taxes as a result of substitution from labour to capital. We also find that these asymmetries are stronger when the ZLB on nominal interest rates are binding.

It is not possible to directly compare our results to those in the empirical literature for two main reasons: first, this literature typically only looks at a broad category of government spending and not at the full nine experiments we consider in our theoretical model; and second, the empirical literature typically considers the change of multipliers over the business cycle, and not credit constraints directly. There is also some disagreement over the degree of asymmetry in fiscal multipliers. While Owyang et al. (2013) and Ramey & Zubairy (2013) find government spending multipliers to be larger in times of ‘tight’ credit market conditions in the US, measured by the spread between BAA-rated corporate bond yield and 10-year Treasury constant maturity rate, which is consistent with our findings.
(2014) find limited asymmetries in government spending multipliers with respect to slack in the economy, Baum & Koester (2011) find more volatility in spending multipliers using a threshold VAR to estimate a range of 0.36 in good times and 1.04 during recessions. Auerbach & Gorodnichenko (2013), Auerbach & Gorodnichenko (2012) and Fazzari et al. (2015), on the other hand, find the greatest range in results with government spending multipliers statistically insignificant from zero at the peak of the business cycle, and 1.6 or greater during recessions.\(^{15}\)

Our estimates are in middle of the range of findings in this literature, with differences in fiscal multipliers varying by an average of 50%. It should be noted, though, that we present one mechanism of potentially many in which multipliers may be non-linear. Indeed, we have shown that through combining non-linearities in the form of the ZLB on interest rates, one can get a larger variation of results. Michaillat (2014), for example, identifies that government employment multipliers can double when unemployment is at 8% compared to 5% using a slack in the search and matching employment mechanism, and Canzoneri et al. (2016) demonstrate through the use of costly financial intermediation that impact spending multipliers can vary between 0.9 and 2.1, but this difference disappears for 20 quarters multipliers in their work.

Importantly, our results suggest that higher multiplier values are observed during ‘normal’ times when the borrowing constraint on impatient households always binds; that is, it is not rare to have more effective policy and this is not limited to times of crisis. This is indeed documented by Tagkalakis (2008) and Fazzari et al. (2015); the latter find that the US experienced high multipliers in most periods between 1967 and 2012, and the former present evidence for heightened effects of fiscal policy for 19 OECD countries between 1970 and 2001 for half of this period. Furthermore, our results suggest that the non-linearity in spending instruments is approximately equal to the non-linearity of tax instruments.

We also find that there is a high degree of heterogeneity in the impact of slack in the borrowing constraint on fiscal multipliers across instruments; a subtlety on which the empirical literature is largely silent. This has important interpretations when considering potential non-linearities and subsequent policy recommendations. In our results, transfers - and especially targeted transfers - can have a large non-linear effect depending on the presence of slack in the impatient’s borrowing constraint as it is these agents who respond to movements in transfers. On the other hand, direct government spending and investment has lower non-linear effects as impatient consumption has less influence on the effectiveness of these policies.

\(^{15}\)Ramey & Zubairy (2014) suggest that the results from Auerbach & Gorodnichenko (2013) are sensitive to the way in which impulse response functions are derived, something which is less straightforward in non-linear models. When using a different method to derive these impulse responses, lower levels of asymmetries are found in Ramey & Zubairy (2014).
The degree and source of state-dependent multipliers are important because they offer more scope to countercyclical fiscal policy; stimulus in a downturn would be less costly in terms of output relative to contractionary policy during booms, when multipliers are smaller. This provides an additional dimension to policy making, with crucial implications for the optimal policy design.

References


A Appendix: further robustness tests

A.1 Model without public employment and employers social security contributions

As highlighted in Section 3.3 it is uncommon for DSGE models to contain both employers’ social security contributions and public employment, especially one calibrated to the US economy. This subsection presents results from two separate iterations from the benchmark model above: one with public employment but without social security contributions; and another without both public employment and employer social security contributions. Figure 10 presents results for the eight remaining fiscal instruments.

Figure 10: Four quarter cumulative output multipliers: models without public employment and social security contribution

Four quarter cumulative output multipliers for eight fiscal instruments with models which include: the benchmark from above; the benchmark without public employment; and, the benchmark without public employment and employers social security contributions.

A.2 Further sensitivity checks

Figures 11 and 12 presents results from a set of further sensitivity checks, changing calibrations of price and wage stickiness and other parameters, respectively.
Figure 11: Robustness checks: price and wage stickiness

Four quarter cumulative multipliers for the nine fiscal experiments under a number of different extensions as labelled in the legend.

Figure 12: Robustness checks: other parameters

Four quarter cumulative multipliers for the nine fiscal experiments under a number of different extensions as labelled in the legend.