Dynare Working Papers Series
http://www.dynare.org/wp/

The Keynesian multiplier, news and fiscal policy rules in a DSGE model

George Perendia
Chris Tsoukis

Working Paper no. 25

December 2012

CEPREMAP
CENTRE POUR LA RECHERCHE ECONOMIQUE ET SES APPLICATIONS
142, rue du Chevaleret — 75013 Paris — France
http://www.cepremap.ens.fr

The Keynesian multiplier, news and fiscal policy rules in a DSGE model

George Perendia[§]
London Metropolitan University, UK

and

Chris Tsoukis*
London Metropolitan University, UK

November 2012

Abstract

We extend the standard Smets-Wouters (2007) medium-sized DSGE model in two directions, namely to analyse the effects of news and the Keynesian multiplier, and secondly to incorporate a fiscal policy rule. We show that both the news channel and the government spending fiscal policy rule significantly improve the model fit to data. News shows up significantly, but most of its contribution comes from the fiscal rule as opposed to consumption. We then calculate the fiscal multipliers which appear more Keynesian (with a higher effect on output and a positive effect on consumption, more persistent) than argued in much preceding literature.

JEL Classification Numbers: E120, E620, O230

Keywords: DSGE model, news, fiscal policy, Taylor rule, Keynesian multiplier.

*Corresponding author. Address for correspondence: Economics, LMBS, London Metropolitan University, Calcutta House, Old Castle Street, London E1 7NT, UK. e-mail: c.tsoukis@londonmet.ac.uk
§: Perendia's email: george@perendia.orangehome.co.uk

1. Introduction

Fiscal policy activism is rising to prominence at least for two reasons: because of the limited effectiveness of monetary policy in dealing with business cycle instability (due to 'zero bound' problems, Christiano, Eichenbaum and Rebelo, 2011; Eggertsson, 2011); secondly, in Europe, because of the loss of monetary sovereignty by individual countries. But debate continues to surround the desirability and effectiveness of fiscal policy, witness the controversy surrounding the 'Obama stimulus plan' (American Recovery and Reinvestment Act, ARRA 2009) in both policy and academic circles (see e.g. Ramey, 2011, and other contributions to Vol. 3, Issue 3 of *The Journal of Economic Literature*; Barro, 2010; and the debate between Taylor, 2011 and C. Romer, 2011). The effectiveness of fiscal policy, particularly government spending, has crystallised around the notion of the 'Keynesian multiplier': the notion of a virtuous circle of government spending generating incomes-consumption-output-further incomes, etc., giving a powerful rationale for fiscal policy. The notion remains much debated (among a booming recent literature see e.g. Corsetti *et al.*, 2012; Denes *et al.*, 2012; Ilzetzki, 2010, in addition to the references above); but a better understanding of the multiplier remains essential for a number of reasons, including understanding the effects of discretionary fiscal policy, and because the multiplier affects the efficacy of automatic stabilisers (Blanchard, 2000; Fatas and Mihov, 2001).

In recent years, the macroeconomic effects of government spending have been analysed by various strands of the macroeconomic literature. A first, static strand of literature is purely neoclassical (Hall, 2009, Woodford, 2011, Mulligan, 2011). The key idea there is that rational agents realise that government spending increases will be accompanied by tax increases (as the framework is static, all rises in government spending are permanent). As a result, (rational consumer's) consumption declines ('crowded out'). Total output rises because a poorer consumer will work harder (will 'buy less leisure'); but the output rise is less than the government spending increase. Hence, government spending crowds out private spending, something which is questionable from a welfare point of view. There is thus a positive multiplier here, but lower than unity, and with a heavy welfare price, which are very un-Keynesian features. Another static variety of models seeks to re-discover and analyse the Keynesian multiplier in static monopolistic setups with optimising households (Mankiw, 1988; Starz, 1989; Dixon, 1987; Dixon and Lawler, 1996; Heijdra, 1998, Heijdra, Ligthart and van der Ploeg, 1998; Sylvestre, 1993). This literature derives multipliers because of the virtuous circle of higher spending generating higher company profits, which then feed on to higher spending through consumption; the multipliers vanish in the long run, though, because free entry eliminates all profits and breaks the virtuous circle. In general, the logic of these models is not much removed from the neoclassical one, as are several key conclusions and typical features of the multipliers of this literature. A third strand of literature builds on intertemporal optimisation by households and firms (Aschauer, 1985, 1988; Barro, 1989; Aiyagari *et al*., 1990; Christiano and Eichenbaum, 1992; Baxter and King, 1993; Gali, Lopez-Salido and Valles, 2002). While they share some neoclassical features (e.g., the lack of involuntary unemployment and the often negative response of consumption), this strand is able to ask more diverse questions (e.g., a point of contention is the relative magnitudes of short- and long-run multipliers, as well as the size of either). A further strand, the closest precursor to this work, aims to embed the intertemporally optimising approach into a Dynamic Stochastic General Equilibrium (DSGE) model of the business cycle (Cogan *et al.*, 2010; Drautzburgh and Uhlig, 2011). Perhaps not surprisingly, though, this strand, too, fails to reach uniform conclusions. Thus, the quest for a clearer understanding of the effects of fiscal policy is far from over.

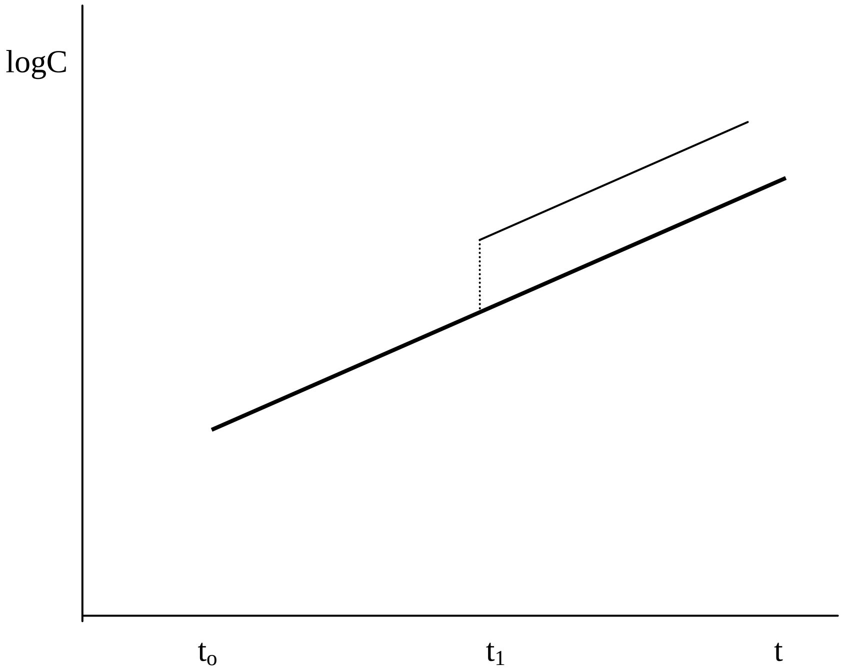
This paper seeks to enhance our understanding of the workings of fiscal policy in the context of the business cycle, and its potential for stabilisation. Our innovation is twofold. Firstly, we incorporate a Keynesian multiplier into a standard New Keynesian DSGE model of the business cycle, drawing on elements from the neoclassical and the intertemporal approaches. To do so, we employ a variant of the Euler equation for consumption that accounts for unexpected developments in output and the interest rate ('news'). Unexpected developments due to fiscal policy, in particular, fuel consumption, which then add up to output via national income accounting, and then further affect consumption, and so on. In other words, a Keynesian multiplier structure arises around the backbone of intertemporal evolution, the Euler equation. As we analyse in the next Section, such a structure is absent in standard formulations, hampering a true understanding of the workings of fiscal policy. Our second innovation accounts for the evolution of fiscal policy, which may follow a rule akin to that of Taylor (19993) for monetary policy. This is motivated by the fact that fiscal policy is not random (as would have been the case if it had been modelled as a shock, as is customary) but shows patterns of association with the business cycle. None of these features, a news-based Keynesian multiplier or a fiscal rule seems to have received much attention, in DSGE models of the business cycle or elsewhere. As our results show, both contribute substantially to the modelling of the business cycle and to the understanding of the effects of fiscal policy, government spending in particular, and the multiplier. Another preamble worth making is that the 'news channel' considered here allows the strengthening of the Keynesian features of the multipliers.

The remainder of this paper is structured as follows: Section 2 incorporates 'news' into the Euler equation underpinning all DSGE models and derives a testable augmentation to a standard DSGE model like that of Smets and Wouters (2007). Section 3 introduces our second innovation, the fiscal rule. Section 4 discusses the empirical implementation and presents the main results, Section 5 shows the resulting multipliers, while Section 6 concludes.

2. News and the Keynesian multiplier

The DSGE 'canonical model', as exemplified e.g. in Smets and Wouters (2007) (henceforth SW07) and Drautzburg and Uhlig (2010) (henceforth DU10) is not in a position, we argue, to contribute usefully to the lively current debate on the size of the fiscal multiplier. This is because the Euler equation, a central pillar of all such models, is unable to accommodate the logic of the Keynesian multiplier. Any discussion of the multiplier should begin with how consumption responds to lifetime incomes (and how government spending impacts those). The former question can conceptually be broken down into two types of decision by the individual, namely the position and the slope of the lifetime consumption profile (the bold line of Figure 1). Its position reflects the lifetime resources anticipated at t_0 (the beginning of the planning period) and is decided only once (at t_0); its slope is determined by the standard Euler equation every period. The key problem is that the standard Euler equation is silent on the position of the profile - how consumption responds to changes in lifetime resources. To be sure, the position of the entire consumption profile does take into consideration the anticipated lifetime resources at the beginning of the planning period but only implicitly, as explicit solutions are not available; furthermore, any subsequent revisions of those are not reflected in the path of consumption. Referring to Figure 1, both the position and slope of the bold profile marked 'Euler eq.' is determined at t_0. However, if at t_1, say, there is 'news', i.e. a revision of lifetime fortunes (unanticipated at t_0) that might warrant a shift to a higher profile with the same slope (thinner line), this development will be lost in the Euler equation. This is a crucial omission, as at the core of the multiplier is the virtuous circle: fiscal expansion – higher incomes over the lifetime – higher consumption – higher output and lifetime incomes. The error term that any estimable Euler equation contains is entirely exogenous and random, hence unrelated to the logic of the multiplier. One might counter that the interest rate should also reflect some of the 'news', but this channel is much too indirect and uncertain to support a Keynesian multiplier. In a nutshell, the key element in any multiplier, the response of consumption to lifetime resources, is missing in all Euler-based models of the business cycle, including the DSGE ones.

Figure 1: Consumption and 'news'



The way we propose to restore the multiplier is by drawing on the 'permanent theory of consumption' (Friedman, 1956). The individual is assumed to plan at t_0 (so optimisation is involved). In the original formulation of the theory, there is a strong bias (due to quadratic utility) of maintaining a flat consumption profile; in more general formulations, growth in consumption is allowed. In other words, the 'permanent income' model of consumption lets the position of the profile respond readily to revisions of lifetime resources, and is therefore much better suited to an analysis of the multiplier. Against this advantage, one should note that the slope of the profile (growth of consumption) is exogenous. Thus, our strategy is to create a version of the Euler equation in which the slope of the consumption profile responds endogenously to the real interest rate but that allows, additionally, for consumption to be explicitly related to lifetime resources. The advantage of this formulation is that previously unanticipated revisions in lifetime resources produce unexpected evolution in consumption, alongside all the standard features of the Euler equation.

We adopt a variant of the 'permanent income theory of consumption', following Obstfeld and Rogoff (1996, Ch. 2) among others[1]. Consumption at time t is given by:

$$C_t = \frac{r-\gamma}{1+r-\gamma}\left[A_t + E_t \sum_{s=0}^{\infty} X_{t+s} / R_t^s\right] \tag{1}$$

Where

$$R_t^s \equiv \prod_{v=1}^{s}(1+r_{t+v}), \qquad R_t^t = 1$$

is the inverse of the discount factor. The essence of this formulation is that consumption is an annuity that exhausts total lifetime resources, made up of current wealth (at the beginning of the period, A_t, plus discounted labour earnings and monopoly profits over the lifetime (net of tax), X_t.[2] γ is the trend real growth rate. In the classic formulation of the theory, the fraction of intertemporal resources that is permanently sustainable and exhausts resources over the

[1] See in particular their equation (2.16).

[2] Monopoly profits exclude a 'normal' profit rate equal to the competitive interest rate. The underlying assumption here is that the financial valuation of assets (A_t) anticipates lifetime normal profits. This allows us to relegate monopoly profits to X_t, and therefore explicitly consider the virtuous circle monopoly profits-consumption-monopoly profits, which is at the core of the New Keynesian formulation of the multiplier as analysed in the Introduction.

lifetime is r/(1+r). Allowing for a balanced-growth path growth rate $\gamma>0$ modifies the above to $(r-\gamma)/(1+r-\gamma)$.[3]

Log-linearising (1) around steady-state (balanced growth path) values, we get:

$$c_t = \frac{X}{C}\frac{r-\gamma}{1+r-\gamma}\left[\frac{\mathrm{A}}{\mathrm{X}}a_t + E_t\sum_{s=0}^{\infty}\frac{x_{t+s}}{(1+r-\gamma)^s} - \frac{1}{1+\tilde{r}}E_t\sum_{s=0}^{\infty}\frac{(1+\gamma)r_{t+s+1}/(1+r)-\Delta y_{t+s+1}}{(1+r-\gamma)^s}\right] \quad (2)$$

Consumption (in log-deviations form) responds positively to variations in wealth (α_t) and labour income and monopoly profits (x_t), negatively to variations in the real interest rate as these reflect revisions of the discount factor and thereby of lifetime resources, and positively to the growth rate of output as this reflects changes in the growth rate of resources. We now introduce 'news': Following Deaton (1990, Ch. 3), we proceed to use the period budget constraint in a beginning-of-period formulation:

$$A_t = (1+r_t)\left[A_{t-1} + X_{t-1} - C_{t-1}\right] \quad (3)$$

The notational convention is that r_t is the interest rate accruing between periods t-1 and t. In a linearised form:

$$a_t = (1+r-\gamma)\left[a_{t-1} + \frac{X}{A}x_{t-1} - \frac{C}{A}c_{t-1}\right] + r_t \quad (3')$$

Inserting (3') into the consumption equation (2), we get:

$$c_t = \frac{X}{C}\frac{r-\gamma}{1+r-\gamma}\left[\begin{array}{l} \frac{\mathrm{A}}{\mathrm{X}}\left\{(1+r-\gamma)\left[a_{t-1} + \frac{X}{A}x_{t-1} - \frac{C}{A}c_{t-1}\right] + r_t\right\} + \\ \\ + E_t\sum_{s=0}^{\infty}\frac{x_{t+s}}{(1+r-\gamma)^s} - \frac{1}{1+r}E_t\sum_{s=0}^{\infty}\frac{(1+\gamma)r_{t+s+1}/(1+r)-\Delta y_{t+s+1}}{(1+r-\gamma)^s} \end{array}\right] \quad (4)$$

[3] Various other reasons that are not accounted for in the classic formulation of the theory (durable goods,

The first row in the square brackets is assets, A, as they have evolved from last period (weighted by A/X to show the importance of assets relative to human wealth). Lagging (2) once, we get:

$$c_{t-1} = \frac{X}{C}\frac{r-\gamma}{1+r-\gamma}\left[\frac{A}{X}a_{t-1} + E_{t-1}\sum_{s=0}^{\infty}\frac{x_{t+s-1}}{(1+r-\gamma)^s} - \frac{1}{1+r}E_{t-1}\sum_{s=0}^{\infty}\frac{(1+\gamma)r_{t+s}/(1+r) - \Delta y_{t+s}}{(1+r-\gamma)^s}\right] \tag{2'}$$

If we multiply (2') by $(1+\tilde{r}-\gamma)$ and subtract from (4), we get:

$$\Delta c_t = \frac{X}{C}\frac{r-\gamma}{1+r-\gamma}\left[\begin{array}{l}\frac{A}{X}r_t + \sum_{s=0}^{\infty}\frac{(E_t - E_{t-1})x_{t+s}}{(1+\tilde{r}-\gamma)^s} - \frac{r_t/(1+r) - \Delta y_t/(1+\gamma)}{1+r-\gamma} - \\ -(E_t - E_{t-1})\sum_{s=0}^{\infty}\frac{r_{t+s+1}/(1+r) - \Delta y_{t+s+1}/(1+\gamma)}{(1+r-\gamma)^s}\end{array}\right] \tag{5}$$

Our definition of 'news' (at t) is the revisions in expectations between times t-1 and t, $(E_t - E_{t-1})x_{t+s} \equiv E_t x_{t+s} - E_{t-1}x_{t+s}$, and similarly with all the other variables. According to (5), the evolution of consumption is due to the interest rate (as is standard) plus news about labour earnings and monopoly profits (x), and the future path of the real interest rate, which affects discount factors, and of the growth rate, which affects the growth of future resources; apart from the real interest rate, anything else anticipated at t-1 would have been reflected on the level of consumption then (t-1) and not on its subsequent evolution. Thus, 'news' co-determines the evolution of consumption. When positive (say) shocks hit the system and current output rises, this will create news about future earnings, which will affect current consumption, thus raising output further, and so on, generating a multiplier effect.[4] If the

adjustment costs, habits, to name a few) may cause further deviations from the basic formulation. For tractability, such considerations have been ignored.

[4] Note that (5) involves taking expectations at different times, so it cannot be deduced from the aggregate resource constraint minus the government budget constraint.

original shock was due to fiscal policy, the final effect is essentially a Keynesian multiplier. This structure is absent in a standard Euler equation, where the fiscal shock would have a weaker effect.

To close the model, we need:

$$X_t \equiv W_t L_t + \Pi_t^M = W_t L_t + Y_t(1 - MC_t / P_t) = W_t L_t + Y_t(1 - 1/(1 + m_t)) \tag{6}$$

Π^M_t: Real monopolistic ("supernormal") profits, i.e. that share of capital over the competitive market real interest rate – it is assumed that all such profits are remitted directly to households.

Therefore in linearised form:

$$x_t = y_t + lshare(w_t + l_t) + \mu_t^p \tag{6'}$$

Where *lshare* (labour share) is parameter – commonly thought to be around 0.65. Thus, total output, wage and employment increases, and monopoly power (fuelling supernormal profits) will have an impact on profits. Introducing (6') into (5), we get:

$$\Delta c_t = \frac{\mathrm{X}}{C}\frac{r-\gamma}{1+r-\gamma}\left[\frac{\mathrm{A}}{\mathrm{X}}r_t + (E_t - E_{t-1})\Omega_t - \frac{r_t/(1+r) - \Delta y_t/(1+\gamma)}{1+r-\gamma}\right] \tag{7a}$$

$$\Omega_t \equiv \frac{\Omega_{t+1}}{1+\tilde{r}-\gamma} + x_t - \frac{r_{t+1}}{1+r} + \frac{\Delta y_{t+1}}{(1+\gamma)} \tag{7b}$$

Ω_t is the present value of labour earnings plus monopoly profits (in deviations from trend).

Equation (7a with b) should be contrasted with the standard Euler equation which in SW07 takes the form:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt}) \tag{8}$$

This equation includes a consumption lag as well as a lead (with a homogeneity restriction) motivated by habits in utility. It also includes the disutility of labour, which under habits again becomes a forward-looking labour difference. In addition to the inclusion of news, there are important differences between equations (7a, b) and (8). Except for news, (7a) is entirely backward-looking (and with a fixed coefficient of unity), whereas the Euler equation is mostly forward-looking. The latter motivates the consumption lag (if any) as a way of capturing habit formation in consumption, whereas in (7a) consumption growth is attributed to news and revisions in the discount rate and trend growth rate. This equation includes the real interest rate but with a different coefficient than the intertemporal elasticity of substitution, as is the case in the Euler equation. Finally, the real interest rate and output growth enter here with a forward-looking MA structure, essentially in order to capture the revision in the estimated lifetime earnings.

In view of the differences between our approach (7a) and the standard Euler equation (8), the best strategy in empirical estimation may be to blend the two, and let the data determine the importance of news. In order to follow the standard formulation but allow for news, we augment (8) with a news term to obtain:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt}) \qquad (8')$$

This ‘hybrid Euler’ equation will be an important element in the models we estimate below. Finally, in order to keep the element of interest (news) in a tractable backward-looking specification, we simplify (7a, b) to:

$$c_t = \theta c_{t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_t \ , \qquad \theta>0 \qquad (9a)$$

$$\Omega_t \equiv \frac{\Omega_{t+1}}{1+\tilde{r}-\gamma} + x_t - \frac{r_{t+1}}{(1+\tilde{r})} + \frac{\Delta y_{t+1}}{(1+\gamma)} \qquad (9b)$$

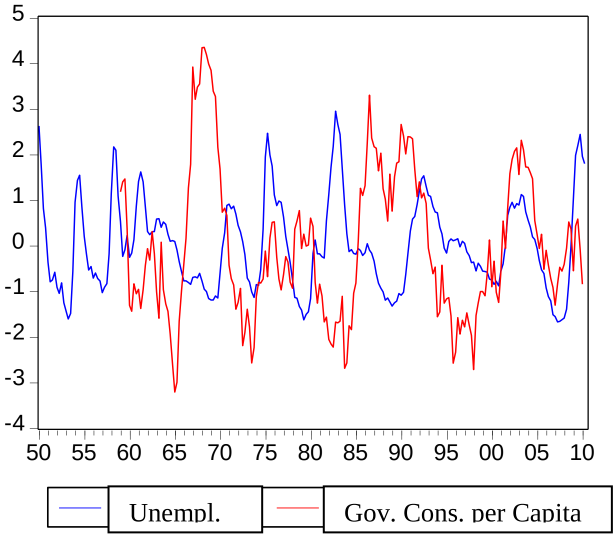
This formulation has also been tried in estimation as explained in Section 4.

3. Government spending and a fiscal policy rule

In common with SW07, we allow government spending to be determined by an AR(1) process which is affected by technology shocks in addition to exogenous government spending shocks.[5] We extend this government spending AR(1) process with two additional elements: the news channel (Ω_t) and a labour market-related variable like the unemployment rate or the change in employment. The rationale for both is that government spending (as a ratio over GDP) is affected by the state of the business cycle. A 'news channel' on fiscal policy then relates public expenditures (in particular non-transfer ones, like government consumption as a share over GDP) to revisions of expectations about future GDP, whereas a labour market index, like the unemployment rate, relates it to the current state of the cycle.

Both channels suggest that the government pursues an activist stabilisation policy via its consumption expenditures. Figure 2 provides support for this thesis with US data:

Figure 2: US Government consumption and unemployment (HP filtered)



[5] As in SW07, taxation plays no role in the subsequent analysis; fiscal policy will be assumed to take the form of variations in expenditure only. As can be easily checked, a flat tax rate across all incomes would drop out of the ensuing linearisations. The tax rate is assumed to be such that it balances the government books along the baseline trend path and over the cycle when business-cycle deviations are allowed. The fiscal multiplier that will be considered below is effectively a bond-financed one, such that government solvency is not jeopardised.

Granger causality test for government per-capita consumption (GC) and unemployment rate (U) (both US).

Pairwise Granger Causality Tests	No of observations: 201	
Null Hypothesis:	F-Statistic	Probability
GC does not Granger Cause U	0.48387	0.74757
U does not Granger Cause GC	2.53113	0.04184

Government consumption shows a consistent unemployment-related pro-cyclical behaviour, suggesting an activist counter-cyclical policy. We can see large surges of spending reacting to the periods of high unemployment and its reductions: 1964-70, 1985-90, early 1990s, the crisis in 2001 and a further spending increase jump (and unemployment drop) starting in early 2003. The associated results of the Granger causality test (see above table), which effectively fails for government per-capita spending (Granger) causing unemployment but succeeds in the reverse direction, is indicative that the US government has been following an overall reactive spending policy in relation to the unemployment rate (though, since the early 1990s, this stance seems to have been softened).

These considerations lead us to extend the SW07 equation characterising government with two additional elements: the news channel and the expected unemployment change. This forms a new rule for government spending analogous to the monetary policy interest rate rule of Taylor (1993). Accordingly, the government pursues an activist stabilisation policy via its spending, which is informed by the state of the economic cycle and the future outlook. The form of this fiscal rule is:

$$g_t = \rho_g g_{t-1} + g_u \eta_t + g_w (E_t - E_{t-1}) \Omega_t + g_y \varepsilon_{at} + \varepsilon_{gt} \tag{10}$$

Where η_t is a labour market-related indicator of the state of the business cycle: In empirical implementation, we have investigated a number of variants of (10), depending on the exact definition of η_t; specifically, whether it is the level of unemployment (u_t), or a forward- or backward-looking change in unemployment or in the hours supplied (l_t):

$$\eta_t \equiv u_t \tag{11a}$$

$$\eta_t \equiv E_t u_{t+1} - u_t \tag{11b}$$

$$\eta_t \equiv u_t - u_{t-1} \tag{11c}$$

$$\eta_t \equiv E_t l_{t+1} - l_t \tag{11d}$$

$$\eta_t \equiv l_t - l_{t-1} \tag{11e}$$

where g_t.=log(G_t/G) and the unemployment (u) is defined as a ratio (log difference) of hours worked in the flexible and the sticky-price economy (lf_t and l_t, resp.):

$$u_t = (lf_t - l_t) + \varepsilon_{ut} \tag{12}$$

To preamble, the estimated parameters lend support to this rule and to the notion that government spending evolves in an endogenous fashion at least partially, rather than as a purely exogenous random shock as modelled so far. Note that the labour market-related variable in this rule (g_u) may be of either sign, depending on its exact nature; throughout our estimated models, it has a consistently counter-cyclical effect on government spending.

The empirical support this activist fiscal rule receives indicates that it operates in parallel with the standard Taylor rule for monetary policy. There is complementarity in stabilisation with a difference in focus between the two, with monetary policy more geared towards inflation and less towards the output gap, and fiscal policy more towards unemployment and the state of the cycle. It is sometimes claimed that there is no equilibrium for a situation when both fiscal and monetary policy are active (Bhattarai et al., 2012). That may not be the case especially when monetary policy is restricted by zero lower bound on the interest rate policy instrument; but further analysis of this is beyond the scope of this paper.

4. Empirical implementation

4.1: Estimated models

In empirical estimation, we have tried a number of models, based on our simplified backward-looking consumption with news (9a, b) and the hybrid Euler equation with news (8’). We also differentiate the estimable models according to whether news and/or unemployment affect the ‘Taylor rule’ of government expenditures. We mark the estimated variants of the model as M1, M2, ..., going from the parsimonious to the more general. The standard SW07 model as programmed by Dynare is indicated as M0; except for the consumption equation and/or the fiscal rule, the models are otherwise identical to SW07/M0. A summary of the features of the models that are of interest to this paper are presented in Table 1, together with their empirical performance; Appendix A presents the models in more detail.

4.2: Data

The data used in estimation is as in Smets and Wouters (2007), and freely available together with their Dynare model file from the Internet. These are 7 series, all related to the US: i. Real GDP, y; ii. Real wage w; iii. investment i; iv. consumption, c; v. inflation π; vi. short-term Federal reserve base interest rate r; vii. hours worked. In the case of trending variables, they are all log-deviations from trend. For more details, see the SW07 Data Appendix. In simulations, we take r=3%, γ=1.6% (annualised rates). $\overline{X}$ is the X/C ratio in the steady state, assumed equal to 1.5. This arises as follows: X is all output minus normal profits, so since assets are all real and productive, they effectively equal the real capital stock. This is roughly three times GDP, so that $X/Y=(Y-rK)/Y\approx 0.9$. Since C/Y is roughly 0.6, X/C $X/C\approx 0.9/0.6=1.5$. $A/X=K/X=K/(Y-Y(rK/Y))=3/0.9=3.333...$

4.3: Results

Estimation was carried out by Dynare's[6] full-information DSGE estimation.[7] The benchmark model estimated by Dynare, which we call M0, is the SW07 model; the results are close, but not identical, to the results in Table 1 of SW07.[8] In terms of the features that concern us here, SW07/M0 has an Euler (8) without news and a fiscal rule (10) without any news term of labour market-related variable. Its LL (the approximate log data density) when estimated by Dynare is -924.956 using the csminwel algorithm based estimation and -925.115 when estimated using 100,000 draws in the MCMC Metropolis-Hastings based posterior maximisation, and these form natural benchmarks against which the results for the other models we estimate can be compared. The focus in what follows is on how the models that incorporate news and the fiscal policy rule compare with the benchmark M0 model.

The empirical performance of the models is shown in Table 1. The models with news generally perform better than similar models without news. This is obvious in the comparison between the pairs of M0 and M6, M1 and M7, and M5 and M8, where the latter member of the pair involves news in the fiscal rule. But comparison between models M3 and M4 (the latter with a hybrid Euler equation 8') shows the improvements realised by augmenting the

[6] See S. Adjemian, H. Bastani, M. Juillard, F. Mihoubi, G. Perendia, M. Ratto and S. Villemot (2011), "Dynare: Reference Manual, v4," Dynare Working Papers 1, CEPREMAP; http://www.dynare.org

[7] Estimation is mostly carried out via Log Likelihood maximisation using Chris Sims's 'csminwel' algorithm (see the Dynare manual). In reporting the results, we indicate by LL (Log-likelihood) the Laplace approximation of log-data density obtained by this method. This is the first stage of posterior maximisation often followed by the MCMC Metropolis-Hastings sampling-based estimation; wherever this has been carried out, we indicate by MCMC the resulting Laplace approximation of log-data density.

[8] Though the parameter estimates results are similar, there are two marginal log-likelihood values reported by SW07: In their Table 4, a value of –923 is reported; whilst in Table 2, the value reported is the much higher –905.8, however, a training sample 1956:1 – 1965:4 was used to obtain this estimate. As we do not use such training in any of the models we estimate, the -905.8 value is discarded for comparison purposes. The benchmark value against which we measure the performance of the models we estimate is the LL of M0/SW07 of -924.956, obtained by estimating the SW07/M0 model by Dynare (from estimation based on the 'scminwel' algorithm by Chris Sims, see the preceding Footnote). Tables C2.1 and C2.2 in Appendix C show the results from estimation of M0 in more detail.

Euler equation by a news term. On the whole, however, it is fair to say that the improvement in the fit comes mainly from the incorporation of news in the fiscal rule rather than the consumption part of the model. A model with news in consumption but not in the fiscal rule was also estimated, with LL=-918.478, and MCMC=-917.616 (more details available on request), showing a non-trivial improvement in fit by the news in consumption, but not comparable with the results obtained by our preferred model M12, to which we now turn.

Our preferred in terms of empirical fit model is M12, involving news in an augmented Euler equation (8') and in the fiscal rule, and a backward-looking labour difference in the latter. It behaves in a comparable manner to SW07 (see the detailed parameter estimates and the Impulse Response Functions – IRFs – shown in the Appendices). But with a sizeably higher likelihood, our model provides a much improved fit to data than SW07: LL=–910.513 and MCMC log data density =-910.213, to be contrasted with SW07/M0 LL=-924.956 and its MCMC Log data density of –925.115 respectively. Table 2 presents the estimates of the new parameters in the model of best fit M12 as well as the key differences in the estimated parameters between that model and the M0/SW07 benchmark model; a full list of estimated parameters with their descriptions is given in Table B.1 in Appendix B.

Table 1: Summary of estimated models

Rank	Model	Features of consumption	Features of the fiscal rule	β	g_w	g_u	LL	MCMC 100,000 draws
1	M12	Euler augmented by news (8')	News; (11e)	0.1463	-0.26	-0.1732	-910.513	-910.213
2	M11	Euler augmented by news (8')	News; (11a)	0.1634	-0.298	0.0265	-911.493	
3	M9	Euler augmented by news (8')	News; (11b)	0.151	-0.281	0.164	-911.918	
4	M7	Euler (8)	News and (11c)		-0.259	0.1592	-911.926	
5	M8	Euler augmented by news (8')	Only news; (g_u=0)	0.1569	-0.295		-912.057	
6	M6	Euler (8)	Only news; (g_u=0)		-0.316		-912.079	
7	M10	Euler (8) augmented by news	News; (11c)	0.1544	-0.265	0.1154	-912.331	
8	M4	Hybrid Euler (8) with news and bk-looking (9a) with news	News and (11a)	0.269	-0.261	0.0257	-912.352	
9	M13	Euler eq. (8)	No news (g_w=0); (11e)			-0.4711	-913.115	-917.586 (10,000 draws)
10	M3	Hybrid Euler (8) and bk-looking (9a) with news	News and (11a)	0.4602	-0.318	0.0218	-915.805	
11	M1	Euler eq. (8)	No news (g_w=0); (11c)			0.4802	-917.623	-921.946 (10,000 draws)
12	M0	SW07 estimated by Dynare – Euler eq. (8)	No news (g_w=0); g_u=0				-924.956	-925.115
13	M5	Euler augmented by news (8')	No news (g_w=0); g_u=0	-0.024			-929.619	
14	M2	Bk-looking (9a) with news	Only news (g_u=0)				Fails BK (1980)	

Notes: LL is Log-likelihood (Laplace approximation of log-data density using Sims's 'csminwel' log-likelihood maximisation algorithm); MCMC is the Laplace approximation of the log-data density obtained by the second-stage MCMC Metropolis-Hastings algorithm with 100,000 draws (unless stated otherwise, see Footnote 6).

Table 2: The main differences between best-fit M12 and M0/SW07 models

	Description	M12	M0/SW07
g_u	Employment difference (11e) in the government spending rule	-0.1732	N/A
β	News in consumption	0.1463	N/A
g_w	News in the government spending rule	-0.26	N/A
ρ_b	Consumption shock AR1 process coefficient	0.476	0.1623
σ_1	Labour substitution risk aversion	1.1582	1.6706
z	Elasticity of the capital utilisation	0.3994	0.4687
Φ/Y_0	Fixed cost in production relative to output	0.5279	0.7054
H	Habit	0.7889	0.739
	Long-term labour	0.3773	0.2284
g_y	Technology shock on government spending	0.7363	0.6045
η_b	Std. error of consumption shock	0.0833	0.2469

Notes: The results are derived using Sims's 'csminwel' algorithm; see the Table in Appendix B for more details.

The t-statistics of the parameters introduced in this paper (shown by N/A for the M0/SW07 estimation) are in general strong. News features strongly and positively in the consumption equation (t-stat.=5.35). The labour market-related parameter (g_w) in the fiscal rule is negative; in general, it produces somewhat weaker t-statistics in models when estimated in conjunction with the news effect (-1.9 in M12) but shows up rather more significantly when estimated without the news effect (these estimates are available on request). The effect of news on government spending in the context of the fiscal rule (g_w) is negative and significant (t-stat=-3.89). Thus, both the change in employment and the news term cushion the government spending effect of the exogenous spending shock, so that only about 61% of the initial spending shock manifests itself into an actual change of government spending. This is also evidenced in an IRF of g of about 0.33 out of a shock of about 0.56 (equal to its standard error); IRFs will be discussed shortly. This cushioning is to be contrasted with an IRF of the spending shock on g of about 0.52 in M0/SW07, roughly equal to the shock; so the shock translates almost one-to-one into a change in government spending in that model. The interpretation of this cushioning effect in M12 is that the spending shock elicits a change in the state of the cycle and expectations about the overall future outlook; such developments then reduce the impact of the exogenous shock on actual government spending. This may be either because of a direct effect on the fiscal rule (relating spending to the state of the economy), or because of political economy reasons: a calculating government may realise that it will probably not need to spend the full amount of the exogenous stimulus in order to achieve a certain effect, but may retain the remaining funds for other use.

In terms of other parameters, estimates show a much higher persistence of the consumption shock (0.476 vs. 0.162) and, relatedly, lower labour risk aversion (1.16 vs. 1.17), a higher habit level (0.79 vs. 0.74), lower Φ, and a much higher level of long term labour. We also observe a much lower standard error for the consumption shock, as a substantial part of the previously unexplained variance of consumption is now explained by the news; e.g., even the best fit model without news, model M13, also has as standard error of a consumption shock similar to that of M0/SW07). The higher habit level is also significant as it implies a greater weight on lagged consumption in relation to the lead (see parameter θ in M12 and other models in Appendix A), and hence a more backward-looking consumption. A smaller Φ/Y_0 shows up whenever we do not have an extended fiscal rule with news or a labour market-related variable. It may be due to the stabilising effect of the fiscal rule which increases fixed capital utilisation (cf. the higher elasticity of capital utilisation of 0.47 vs. 0.4 in SW07) and therefore reduces the overall level of capital requirement and the share of required fixed cost (i.e., investment) relative to total output.

We next review the Impulse Response Functions (IRFs) for M12 (see Figures C.1 in Appendix C). As mentioned, the overall outlook of the IRFs is quite similar to that of M0/SW07. Notable differences concern the effects of the exogenous spending shock (εg_t) on consumption which is positive here and remains so for a number of quarters (as will be discussed in the context of the multipliers in the next Section), in sharp contrast to the M0/SW07 IRFs. Moreover, the same shock has a smaller contemporaneous effect on total government spending here, as discussed (about 0.45 vs. about 0.5 in M0/SW07) as it is cushioned by other variables (news and the employment change). The effect of the news is shown in Table C.1.b. Positive news affects consumption, investment and the wage in a positive way, but reduces the overall government spending. As a result, the total effect on output is negative and fairly persistent. This, somewhat counterintuitive result is due to the strong and overriding effect of news on government spending. We next turn to the multipliers.

5. Multipliers

As mentioned, the Impulse Response Functions (IRF) are shown in Appendix B below. Below, we show the economically more meaningful multipliers; to this end, we next describe briefly how we transform the IRFs into multipliers. The multipliers that theory and policy-makers are interested in are given as:

$$(Y_t - Y_0)/dG_0,$$

where capitals are the variables in levels, and 0 is the time of the shock. Various types of adjustment should be done to this formula to render it more meaningful, shown below:

Firstly, following SW, our model is structured as follows:

$$y_t = c_y\, c_t + i_y\, i_t + g_t$$

and

$$g_t = \rho_g g_{t-1} + \varepsilon_{gt} + g_y \varepsilon_{at} + \text{labour market-related variables (possibly)} + \text{news (possibly)}$$

where y, c, i are percentage deviations from (own) trend and c_y (=0.5991) and i_y are the mean consumption-GDP and investment-GDP ratios in the data, respectively. In contrast, g_t is the deviation from the steady-state spending-GDP ratio. ε_{gt} (η_{gt} in SW07 notation) is the truly exogenous part of government spending (that may account for other exogenous shocks, e.g. shocks to exports, if g is assumed to be a catch-all variable for all other spending other than consumption and investment). Therefore, if we wish to convert the consumption deviation from trend into a percentage of GDP (as opposed to percentage of C itself) so that it makes more economic sense, we need to multiply the raw IRFs of consumption by c_y – all the consumption responses presented below have been transformed in this way, so they are readily interpretable as percentages of GDP.

Secondly, there is a question of what is exactly 'the' exogenous part of fiscal spending. While in our model this is clearly ε_{gt}, there is an argument that the government will have a target for overall fiscal spending, g_t, and if that shows any signs of changing dramatically because of 'truly exogenous spending shocks' (the ε_{gt}), then government will take corrective action. Under this reasoning, g_t may be more 'exogenous' than is hypothesised above, so that it is worth presented multipliers cast in terms of that, too.

Table 3 presents the multipliers with these two types of adjustment. Output, consumption and government spending responses are presented for selected horizons: for the first 8 quarters (contemporaneous to the shock up to and including the end of the second year), and at the end of the 3rd, 4th, and 5th years (11, 15 and 19 quarters after the shock). For each model, 6 sets of numbers are given, in two sets of three: The first set of three are the IRFs normalised by the exogenous part of the spending shock (εg_0 – where 0 is shorthand for t_0, the time of the shock); the latter three are the IRFs normalised by the total spending shock (g0). In each set of 3, the first line concerns consumption, the second (bold line) concerns the output multiplier, and the third one concerns government spending. Specifically, the first set are the consumption ($c_t/\varepsilon g0$), output ($y_t/\varepsilon g0$) and government spending ($g_t/\varepsilon g0$) responses divided by the exogenous part of government spending (assumed to be one estimated standard deviation of the error term in the fiscal rule); the second set of three has the same responses (consumption – $c_t/g0$, output – $y_t/g0$ and government spending – $g_t/g0$) divided by the government spending of quarter 0, the time of the shock. (As a consistency check, the government spending response in quarter 0 is identically one as $g_0/g0 \equiv g_0/g_0$.)

The models are presented in groups so as to facilitate comparison and conclusions on the role of news.

- The first pair, M12 and M13 consists of the best equation in terms of data fit, while the latter equation is identical except that it omits news in both the consumption equation and the fiscal rule.
- The second group should perhaps be reviewed from the last (base) model, M0, the SW07 model estimated by Dynare; M5 adds news only to the Euler equation of M0, while M11 adds both news and unemployment to the fiscal rule.

The key point to emerge is that the consumption multipliers without news terms are negative. While news can change this sign, comparison between M11 and M5 (and also M8 and M7) suggests that it is the combination of news term in the Euler equation together with the presence of the fiscal rule of some kind (i.e. either with news only or unemployment only or with both), that is responsible for the positive profile of consumption multipliers; i.e. a positive consumption effect is also evident in model M8 with news in both consumption Euler and the fiscal rule but without unemployment, whilst it is negative in M7 with news and unemployment in the fiscal rule but no news in the Euler equation.

In terms of output multipliers (in bold), comparison between M12 and M13 shows the output multiplier in the former to be higher and more persistent, as one would also expect from the positive consumption response. But comparison among the output profiles in the second group does not reveal a straightforward relation between the news term and the strength of the output multipliers.

In terms of the normalisation, when that is by the total government spending (g0, as opposed to the exogenous portion of it εg_0) the multipliers are higher and generally above unity making them ‘truly Keynesian’ (a fuller discussion will be given shortly). This is not true, however, in the last two models shown in which there is no labour market indicator or news in the fiscal rule; as a result, the exogenous spending impacts one-for-one on total government spending without any cushioning by any other variable, and the two sets of 3 rows are practically identical. These features are evident in the graphical presentation of the multipliers of the best model (M12) and its no-news counterpart (M13) shown in Figures 3 (a,b).

Table 3: Multipliers without trend

Quarter after shock	0	1	2	3	4	5	6	7	11	15	19
1a. Model M12 (best)											
$c_t/\varepsilon g0$	0.16	0.10	0.05	0.01	-0.03	-0.05	-0.08	-0.10	-0.14	-0.16	-0.17
$y_t/\varepsilon g0$	**0.80**	**0.69**	**0.60**	**0.53**	**0.47**	**0.41**	**0.37**	**0.33**	**0.23**	**0.18**	**0.15**
$g_t/\varepsilon g0$	0.60	0.60	0.59	0.59	0.58	0.57	0.56	0.55	0.51	0.46	0.42
$c_t/g0$	0.26	0.17	0.08	0.01	-0.04	-0.09	-0.13	-0.16	-0.24	-0.27	-0.28
$y_t/g0$	**1.34**	**1.16**	**1.01**	**0.88**	**0.78**	**0.69**	**0.61**	**0.55**	**0.39**	**0.30**	**0.24**
$g_t/\varepsilon g0$	1.00	1.00	0.99	0.98	0.97	0.95	0.94	0.92	0.84	0.77	0.69
1b. Model M13											
$c_t/\varepsilon g0$	-0.03	-0.07	-0.10	-0.12	-0.14	-0.16	-0.17	-0.18	-0.20	-0.21	-0.20
$y_t/\varepsilon g0$	**0.74**	**0.66**	**0.59**	**0.54**	**0.48**	**0.44**	**0.40**	**0.37**	**0.27**	**0.21**	**0.17**
$g_t/\varepsilon g0$	0.74	0.74	0.74	0.74	0.73	0.72	0.71	0.70	0.63	0.57	0.51
$c_t/g0$	-0.05	-0.09	-0.13	-0.16	-0.19	-0.21	-0.23	-0.24	-0.27	-0.28	-0.27
$y_t/g0$	**0.99**	**0.89**	**0.80**	**0.72**	**0.65**	**0.59**	**0.54**	**0.49**	**0.36**	**0.28**	**0.22**
$g_t/\varepsilon g0$	1.00	1.00	1.00	1.00	0.99	0.97	0.96	0.94	0.86	0.77	0.68
2a. Model M11											
$c_t/\varepsilon g0$	0.20	0.14	0.09	0.05	0.01	-0.02	-0.05	-0.07	-0.13	-0.15	-0.16
$y_t/\varepsilon g0$	**0.86**	**0.72**	**0.60**	**0.51**	**0.43**	**0.36**	**0.30**	**0.26**	**0.15**	**0.09**	**0.07**
$g_t/\varepsilon g0$	0.62	0.60	0.57	0.55	0.53	0.51	0.49	0.48	0.42	0.37	0.33
$c_t/g0$	0.33	0.23	0.15	0.08	0.02	-0.03	-0.07	-0.11	-0.20	-0.24	-0.26
$y_t/g0$	**1.39**	**1.16**	**0.97**	**0.81**	**0.68**	**0.58**	**0.49**	**0.42**	**0.24**	**0.15**	**0.11**
$g_t/\varepsilon g0$	1.00	0.96	0.92	0.88	0.85	0.82	0.79	0.76	0.67	0.59	0.52
2b. Model M5											
$c_t/\varepsilon g0$	-0.14	-0.21	-0.26	-0.31	-0.34	-0.37	-0.39	-0.40	-0.41	-0.43	-0.42
$y_t/\varepsilon g0$	**0.95**	**0.82**	**0.71**	**0.61**	**0.54**	**0.47**	**0.42**	**0.37**	**0.33**	**0.23**	**0.17**
$g_t/\varepsilon g0$	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.77	0.67	0.59
$c_t/g0$	-0.14	-0.21	-0.26	-0.31	-0.34	-0.37	-0.39	-0.40	-0.41	-0.43	-0.42
$y_t/g0$	**0.95**	**0.82**	**0.71**	**0.61**	**0.54**	**0.47**	**0.42**	**0.37**	**0.33**	**0.23**	**0.17**
$g_t/\varepsilon g0$	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.77	0.67	0.59
2c. Model M0 (SW07)											
$c_t/\varepsilon g0$	-0.09	-0.18	-0.25	-0.30	-0.34	-0.38	-0.40	-0.42	-0.43	-0.44	-0.44
$y_t/\varepsilon g0$	**0.97**	**0.84**	**0.72**	**0.62**	**0.54**	**0.48**	**0.42**	**0.38**	**0.34**	**0.24**	**0.18**
$g_t/\varepsilon g0$	1.00	0.97	0.94	0.91	0.88	0.85	0.83	0.80	0.78	0.68	0.60
$c_t/g0$	-0.09	-0.18	-0.25	-0.30	-0.34	-0.38	-0.40	-0.41	-0.43	-0.44	-0.44
$y_t/g0$	**0.97**	**0.84**	**0.72**	**0.62**	**0.54**	**0.48**	**0.42**	**0.38**	**0.34**	**0.24**	**0.18**
$g_t/\varepsilon g0$	1.00	0.97	0.94	0.91	0.88	0.85	0.83	0.80	0.78	0.68	0.60

Please refer to main text for details.

Figure 3a: multipliers (normalised by e_{g0} – no trend) from M12

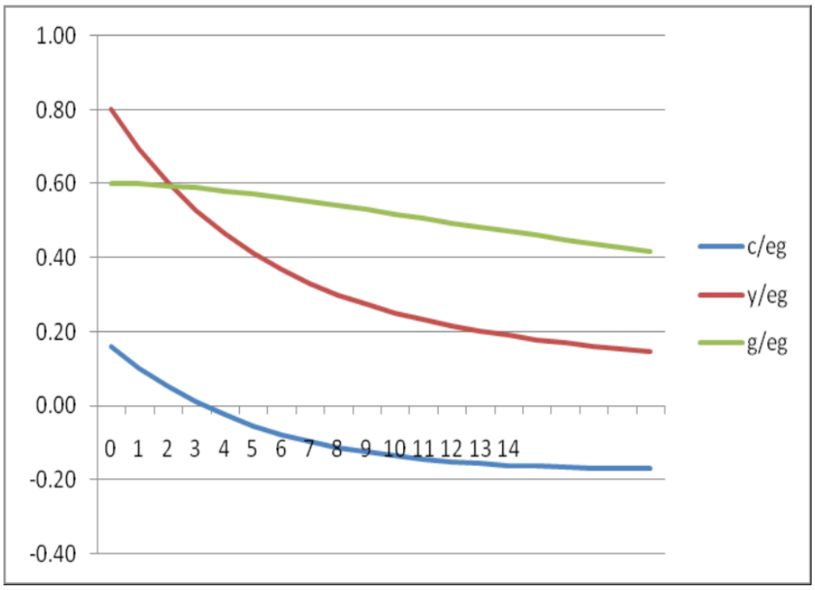
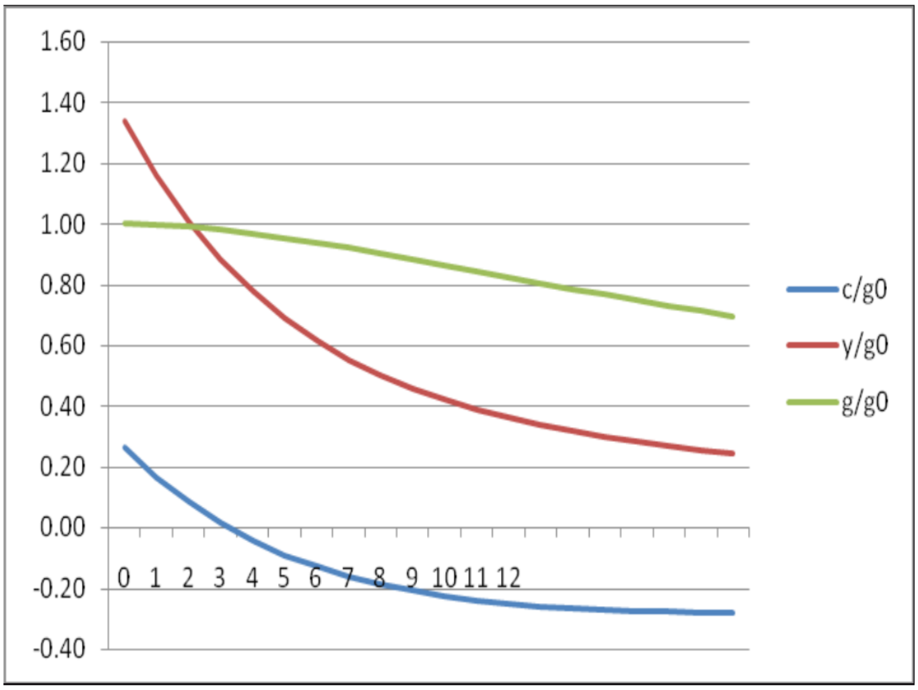


Figure 3b: multipliers (normalised by g_0 – no trend) from M12



A third type of adjustment concerns the treatment of trend. Recall that the theoretical multiplier is $(Y_t-Y_0)/dG_0$, where capitals are the variables in levels and dG_0 is government expenditure change at time t=0. In a trend growth environment like a DSGE model, Y_t-Y_0

may be decomposed into two parts, a change alongside the trend, plus a deviation from trend. Now, the change alongside the trend should not be properly considered as a 'multiplier' effect because it is exogenous and (by assumption) entirely supply-side; hence, it bears no relation to government spending (unless one assumes that government spending includes spending that enhances an economy's long-term production possibilities, such as infrastructural spending; but this is beyond the scope of this). To make essentially the same point from another angle, the change alongside the trend will increase geometrically across time, so if the multiplier is the ratio presented above, it will tend to infinity asymptotically.

We proceed under the assumption that the trend is entirely unrelated to government spending, hence it should not be considered as a response to it. Hence, the multipliers should be presented as

$$(Y_t - \overline{Y}_t) / dG_0$$

Where the overbar indicates a trend value. Since y_t represents a % deviation from trend, we have $y_t = (Y_t - \overline{Y}_t)/\overline{Y}_t$, therefore $Y_t - \overline{Y}_t = y_t \overline{Y}_t$. As mentioned, the government spending shock, g_0, is a deviation of the government spending-GDP ratio from its steady-state value (log-additive to y_t, and so is its exogenous part ε_{g0}, therefore they both are expressed as percentages of GDP). Hence, we have $dG_0 = \varepsilon_{g0} \overline{Y}_0$. Thus, the correct multiplier is related to the quantities given in the IRFs by:

$$\frac{Y_t - \overline{Y}}{dG_0} = \frac{y_t \overline{Y}_t}{\varepsilon_{g0} \overline{Y}_0}$$

In other words, the IRF of consumption, output and government spending should be multiplied by $\frac{\overline{Y}_t}{\overline{Y}_0}$, as well as being scaled by the size of the exogenous government spending shock (ε_{g0}). So, the six rows we present in Table 4 are:

$$\frac{c_t \overline{Y}_t}{\varepsilon_{gt_0} \overline{Y}_0}, \frac{y_t \overline{Y}_t}{\varepsilon_{gt_0} \overline{Y}_0}, \frac{g_t \overline{Y}_t}{\varepsilon_{gt_0} \overline{Y}_0}, \frac{c_t \overline{Y}_t}{g_0 \overline{Y}_0}, \frac{y_t \overline{Y}_t}{g_0 \overline{Y}_0}, \text{ and } \frac{g_t \overline{Y}_t}{g_0 \overline{Y}_0}.$$

The models presented in Table 4 are the same as the first two of Table 3. The latter two Models of Table 3 are omitted here as the relevant IRFs do not converge to zero in the long run, or do not converge fast enough, so that that the multipliers that incorporate the trend adjustment described above explode over time. The multipliers of the best-fit model (M12) are shown graphically in Figures 4 (a,b). Comparison with Table 3 reveals that there is now more persistence in the multipliers; otherwise the same messages as before apply: the variable of normalisation (εg_0 or g_0) matters, as does the introduction of the news term.

Table 4: Multipliers with trend

Quarter after shock	0	1	2	3	4	5	6	7	11	15	19
1a. Model M12 (best)											
c_eg/eg	0.16	0.10	0.05	0.01	-0.03	-0.06	-0.08	-0.10	-0.15	-0.17	-0.18
y_eg/eg	**0.80**	**0.70**	**0.61**	**0.54**	**0.47**	**0.42**	**0.38**	**0.34**	**0.24**	**0.19**	**0.16**
g_eg/eg	0.60	0.60	0.60	0.60	0.59	0.58	0.58	0.57	0.53	0.49	0.45
c_eg/g0	0.26	0.17	0.08	0.01	-0.04	-0.09	-0.13	-0.17	-0.25	-0.29	-0.31
y_eg/g0	**1.34**	**1.16**	**1.02**	**0.89**	**0.79**	**0.70**	**0.63**	**0.57**	**0.41**	**0.32**	**0.26**
g_eg/g0	1.00	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.88	0.82	0.75
1b. Model M13											
c_eg/eg	-0.03	-0.07	-0.10	-0.12	-0.14	-0.16	-0.18	-0.19	-0.21	-0.22	-0.22
y_eg/eg	**0.74**	**0.67**	**0.60**	**0.54**	**0.49**	**0.45**	**0.41**	**0.38**	**0.28**	**0.22**	**0.18**
g_eg/eg	0.74	0.75	0.75	0.75	0.75	0.74	0.73	0.72	0.67	0.61	0.55
c_eg/g0	-0.05	-0.09	-0.13	-0.17	-0.20	-0.22	-0.24	-0.25	-0.28	-0.30	-0.30
y_eg/g0	**0.99**	**0.90**	**0.81**	**0.73**	**0.66**	**0.60**	**0.55**	**0.51**	**0.38**	**0.30**	**0.24**
g_eg/g0	1.00	1.01	1.01	1.01	1.00	0.99	0.98	0.97	0.90	0.82	0.74

Please refer to main text for details.

As mentioned, the size of the fiscal expenditures multiplier is fiercely debated. Echoing a neoclassical line of reasoning, Hall (2009) estimates it to be between 0.5 and 1. Kwok *et al.* (2010) re-estimate the effects of ARRA 2009 by extending the SW07 model in two directions, including non-Ricardian consumers and specifying a path for taxes. They show that the effects of increased government spending result in a more or less contemporaneous rise in GDP by about 0.5% and will peak with a rise in GDP of about 0.8% in the 6-8 quarters ahead. Clearly, the implied multiplier is less than unity – but somewhat higher than the one produced by the SW07 model. In a more Keynesian spirit, the wide-ranging review of empirical studies by Ramey (2012) leads her to suggest a plausible range of 0.8 to 1.5. Using international evidence on forecast errors, Blanchard and Leigh (2012) argue that the multipliers that have been used in recent years in generating growth forecasts have been systematically too low; and that actual multipliers may be higher, in the range of 0.9 to 1.7.

It is fair to say that our results fall in the range of parameters suggested by the more Keynesian analyses and reviews. The output response is nowhere below 0.75; when news is introduced and the normalisation is carried out by means of the total shock (suggesting that it is that that the fiscal authorities pay attention to rather than the 'truly exogenous' portion of fiscal spending, as suggested above), then the multiplier is well above unity. In line with that, the consumption multipliers are positive when news is introduced; in the models with news, consumption rises initially and stays above normal for about 4 periods and only then does it start decreasing below trend. This is quite important, as one key criticism of the fiscal multiplier by the neoclassical models and some New Keynesian models reviewed above, is that it crowds out private consumption, so that it is 'expensive' from the consumer's welfare point of view (see e.g. Barro, 2010). Our preferred model M12 suggests that more than half of the output effect (of a one-period shock) persists 4 quarters after the shock has ended, and will linger on years afterwards; a substantial portion of it will not have died even 3 years after the shock. This remarkable persistence is shared by most models, and is also shared by the consumption multipliers. Allowing for the effect of a secular trend increases somewhat this persistence. This is shown graphically in Figures 4 (a,b).

Figure 4a: multipliers (normalised by e_{g0} – with trend) from M12

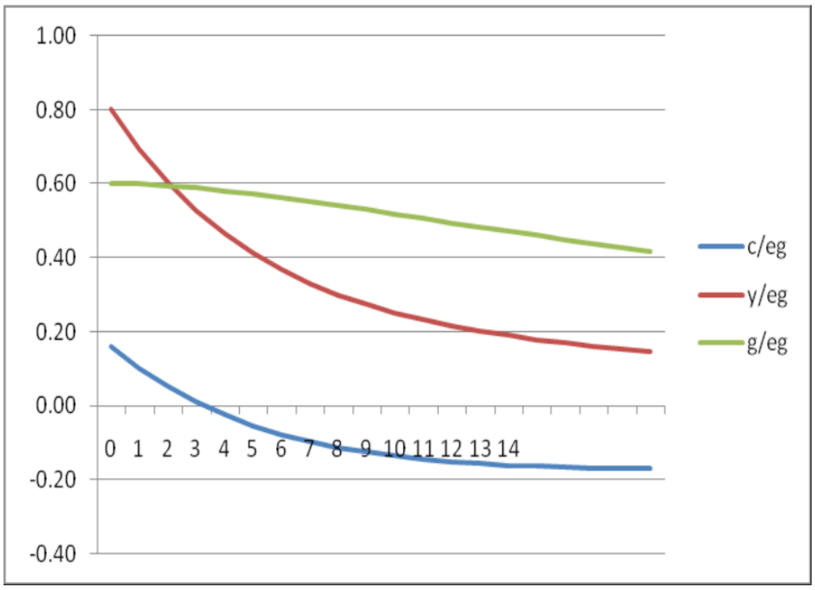
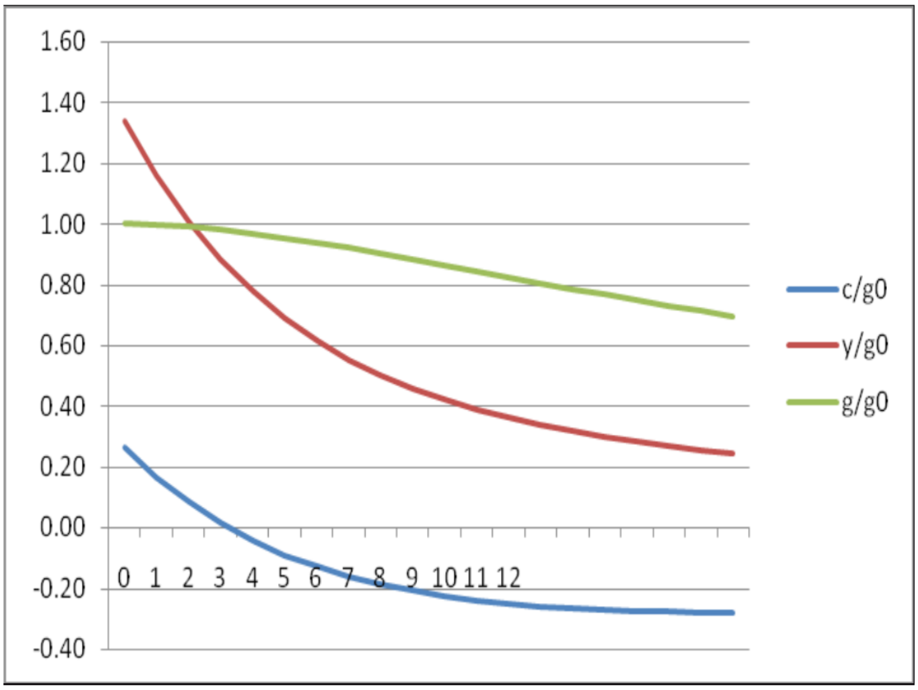


Figure 4b: multipliers (normalised by g_0 – with trend) from M12



5. Conclusions

Understanding the effects of fiscal policy on aggregate output is increasingly important in an era of business cycle instability, when the stabilisation potential of monetary policy appears rather limited for a variety of reasons. This paper has sought to enhance our understanding of the aggregate effects of government spending and the nature of the associated multiplier. It does so by building and estimating a medium-sized DSGE model which incorporates 'news' and a formulation of fiscal policy, particularly spending, as following a rule akin to the Taylor (1993) rule for monetary policy. The former is motivated as a way of better understanding the fiscal multiplier, which the Euler equation of dynamic models is not in a good position to capture, for the reasons explained in Section 2; the news term is essentially revisions of the discounted sum of future incomes, inspired by the permanent theory of consumption. The fiscal rule concerns spending on goods and services (the 'G' of elementary macroeconomics) and is motivated as a way of formalising the stabilisation role of fiscal policy. Furthermore, we combine the two features and add news as an additional term in the fiscal rule. These features are innovations of this paper; the rest is a standard New Keynesian DSGE model such as the SW07 model which is rapidly achieving 'canonical' status in this literature (and to which reference should be made for further details).

We show that adding the news channel and the extended government spending fiscal policy rule framework all significantly improve the model fit to data and its forecasting quality. Both these features therefore are supported by the data. It is fair to say, though, that much of the improvement in the model fitness comes from the news in the context of the fiscal rule, more so than the news channel in consumption; but the importance of the news channel is unambiguous. Furthermore, an augmented government spending rule of a countercyclical nature that formalises the government's stabilisation policy working in conjunction with the standard monetary policy rule may be a more realistic assumption than adding a random, exogenous spending shock. The other strong message of this work concerns the fiscal multipliers that appear rather more 'Keynesian' than much neoclassical, and indeed some New Keynesian literature has suggested.

While both the news channel and an endogenous fiscal rule merit further investigation, so do some limitations and important omitted features: Our framework has abstracted from interactions between fiscal and monetary policy (as alluded to in the Introduction), consumer heterogeneity (the existence of non-Ricardian consumers a la Drautzburg and Uhlig, 2010, or spenders a la Mankiw, 2010), and the effects of budget constraints, government deficits and debt. Incorporation of these features is on the agenda, as is the inclusion of optimistic and pessimistic ('animal spirits'-driven) agents along the lines of DeGrauwe (2009), and the imperfect (partial) information solution framework with the adaptive behaving agents on the lines of Levine, Pearlman, Perendia and Yang (2010).

References

Aiyagari, S.R. and L.J. Christiano, (1992): The output, employment and interest rate effects of government consumption, *Journal of Monetary Economics*, 30, pp 73-86.

Aschauer, D.A. (1985): Fiscal Policy and Aggregate Demand, *American Economic Review*, 75, 1 (March), pps. 117-127.

____________ (1988): The Equilibrium Approach to Fiscal Policy, *Journal of Money, Credit and Banking*, 20, 1 (February), pps. 41-62.

Barro, R.J. (1989a): *Modern Business Cycle Theory*, Oxford: Basil Blackwell.

________ (1989b): The Neoclassical Approach to Fiscal Policy, Chapter 5 in Barro (1989a).

________ (2010): The Stimulus Evidence One Year On, *The Wall Street Journal*, 23/2; http://online.wsj.com/article/SB10001424052748704751304575079260144504040.html

Baxter, M. and R. King (1993): Fiscal Policy in General Equilibrium, *American Economic Review*, 83, 2 (June), pps. 315-334.

Bhattarai, S., Lee, J.W., Woong Yong Park (2012) Policy Regimes, Policy Shifts, and U.S. Business Cycles, 8th Dynare Conference, Zurich, September 2012

Blanchard, O.J. (2000): Commentary on Automatic Stabilisers, *Federal Reserve Bank of New York Economic Policy Review*, April, pp. 69-74.

_____________ C.M. Khan, (1980): The Solution of Linear Difference Models Under Rational Expectations, *Econometrica*, 48, 5 (July), pp. 1305-11.

____________ and D. Leigh (2012): Are We Underestimating Short-term Fiscal Multipliers? Box 1.1, Chapter 1 of the World Economic Outlook, October 2012, IMF.

____________ and R. Perotti (2002): An empirical characterisation of the dynamic effects of changes in government spending and taxes on output, *Quarterly Journal of Economics*, 117, 4 (November), pp. 1329-68.

Christiano, L.J. and M. Eichenbaum (1992): Current Real Business Cycles Theories and Aggregate Labour Market Fluctuations, *American Economic Review*, 82, 3 (June), pps. 430-450.

Cogan, J.F., T. Cwik, J.B. Taylor and V. Wieland (2010): New Keynesian versus old Keynesian government spending multipliers, *Journal of Economic Dynamics and Control*, 34, pp. 281-95

Collard, F. and Dellas, H. (2009). Imperfect Information and the Business Cycle, *Journal of Monetary Economics*.

Corsetti, G., A. Gernot, and J. Muller (2012): What Determines Government Spending Multipliers?, mimeo, May; available on: http://www.bruegel.org/fileadmin/bruegel_files/Events/Event_materials/2012/Giancarlo_Corsetti_multipliers.pdf

Coto-Martinez, J. and H.D. Dixon (2003): Profits, Mark ups and Entry: Fiscal Policy in an Open Economy, *Journal of Economic Dynamics and Control*, 7, 4, pp. 573-97.

DeGrauwe, P. (2009). Animal Spirits and Monetary Policy. Mimeo, University of Leuven.

Denes, M., G.B. Eggertsson, and S. Gilbukh (2012); Deficits, Public Debt Dynamics, and Tax and Spending Multipliers, Federal Reserve Bank of New York, Staff Report No. 551, Revised September 2012; http://www.newyorkfed.org/research/staff_reports/sr551.pdf

Devereux, M.B., A.C. Head, and B.J. Lapham (1996): Monopolistic Competition, Increasing Returns, and the Effects of Government Spending, *Journal of Money, Credit and Banking*, 28, 2 (May), pp. 233-54.

Dixon, H.D. (1988): A simple model of imperfect competition with Walrasian Features, *Oxford Economic Papers*, 39, pps. 134-160.

__________ and P. Lawler (1995): Imperfect Competition and the Fiscal Multiplier, *Scandinavian Journal of Economics*, 98 (2), pps. 219-231.
Drautzburg, T. and H. Uhlig (2011): Fiscal Stimulus and Distortionary Taxation, NBER Working Papers 17111.
Gauti B. Eggertsson (2011): What Fiscal Policy is Effective at Zero Interest Rates?, NBER Chapters, in: NBER Macroeconomics Annual 2010, Volume 25, pages 59-112 eds. Daron Acemoglu and Michael Woodford (2011).
Fatas, A. and I. Mihov (2001): Government Size and Automatic Stabilisers: International and Intranational Evidence, *Journal of International Economics*, October.
Friedman, M., (1956): A Theory of the Consumption Function, Princeton: Princeton University Press.
Gali, J., J.D. Lopez-Salido and J. Valles (2002): Understanding the Effects of Government Spending on Consumption, mimeo, CREI.
Hall, R.E. (2009): By How Much Does GDP Rise If the Government Buys More Output?," *Brookings Papers on Economic Activity*, vol. 40(2 (Fall)), pages 183-249.
Heijdra, B.J. (1998): Fiscal policy multipliers: The role of monopolistic competition, scale economies, and intertemporal substitution in labour supply, *International Economic Review*, 39, 3 (August), pps. 659-96.
___________, J.E. Ligthart, and F. van der Ploeg (1998): Fiscal policy, distortionary taxation, and direct crowding out under monopolistic competition, *Oxford Economic Papers*, 50, pps. 79-88.
Ilzetzki, E., E.G. Mendoza, and C.A. Végh (2010): How Big (Small?) are Fiscal Multipliers?, NBER Working Paper No. 16479, October 2010.
Levine, P., Pearlman, J., Perendia, G. and Yung, B. (2011): Endogenous Persistence in an Estimated DSGE Model under Imperfect Information, forthcoming in EJ.
Mankiw, N.G. (1988): Imperfect Competition and the Keynesian Cross, *Economics Letters*, 26, pps. 7-14.
_____________ (2000): The Savers-Spenders Theory of Fiscal Policy, *American Economic Review*, 90, 2 (May), pp. 120-5.
Mulligan, C.B. (2010): Simple Analytics and Empirics of the Government Spending Multiplier and Other "Keynesian" Paradoxes, NBER Working Paper No. 15800, March
Obstfeld, M. and K. Rogoff (1996): *Foundations of International Macroeconomics*, Cambridge, MA: MIT Press.
Ramey, V.A. (2011): Can Government Purchases Stimulate the Economy? *Journal of Economic Literature 2011*, 49:3, 673–685
Romer, C. (2011): What Do We Know About The Effects Of Fiscal Policy? Separating Evidence From Ideology, mimeo; http://emlab.berkeley.edu/~cromer/Written%20Version%20of%20Effects%20of%20Fiscal%20Policy.pdf
Starz, R. (1989): Monopolistic competition as a foundation for New Keynesian Macroeconomics, *Quarterly Journal of Economics*, November, pps. 737-752.
Taylor, J.B. (2011): An Empirical Analysis of the Revival of Fiscal Activism in the 2000s, *Journal of Economic Literature* 49:3, 686-702.
Woodford, M. (2011): Simple Analytics of the Government Expenditure Multiplier, *American Economic Journal: Macroeconomics*., Vol. 3, 1 (January), pp. 1-35.

Appendix A: Estimated models

This Appendix presents the features of the estimated models in detail (summaries of which have been presented in Table 1). Except for the equations presented below, the rest of each model is exactly as the Dynare version of SW07. The benchmark SW07 model as programmed and estimated by Dynare (without any of the features we add in this paper) is termed M0. Ω_t is defined in (9b). Before describing the models in more detail, Table A.1 shows the connections between them.

Table 1.A: Estimated models

Features of consumption	**Features of the fiscal rule**											
	None		11a		11b		11c		11d		11e	
	No news	news	No news	news	No news	news	No news	news	No news	news	No news	news
Euler eq. (8)	M0 925.0	M6 912.1					M1 917.6	M7 911.9			M13 913.1	
Euler with news (8')	M5 929.6	M8 912.1		M11 911.5		M9 911.9		M10 912.3				M12 910.5
Bk-looking (9a)		M2 Fails										
Hybrid (8) and (9a)				M3 913.1								
Hybrid (8') and (9a)				M4 912.4								

M0: The standard SW07 (as programmed by Dynare).

LL=-924.956

M1: A standard Euler equation (8) as in SW, without news in either the Euler equation or the government spending 'Taylor rule', but with the backward-looking unemployment rate difference (11c) in the latter, as follows:

$$g_t = \rho_g g_{t-1} + g_u(u_t - u_{t-1}) + \varepsilon_{gt} + g_y \varepsilon_{at}$$

LL=-917.623

M2: This specification combines our backward-looking consumption with news (9a); a government spending 'Taylor rule' with news but no unemployment or labour supply:

$$g_t = \rho_g g_{t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

It is worth noting that a unitary coefficient for the lagged θ is not admitted by estimation (the estimate is significantly less than unity). Anyway, for either an imposed θ=1 or an estimated θ, this model failed the Blanchard-Kahn (1980) test due to an insufficient number of forward looking variables.

M3: A hybrid model of the Euler equation (8) combined with the backward consumption function (9a), with news and the unemployment rate in levels (11a) in the fiscal rule:

$$c_t = (1-\kappa)c_{1t} + \kappa c_{2t}, \qquad 0 < \kappa < 1$$

$$c_{1t} = \theta_1 c_{1t-1} + (1-\theta_1)E_t c_{1t+1} + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$c_{2t} = \theta_2 c_{2t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_t \ ,$$

$$g_t = \rho_g g_{t-1} + g_u u_t + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Partly motivated by the failure of M2, this model nests two specifications (with weights 0<1-κ<1 and κ, respectively) a standard SW Euler equation without any news effects, and a backward consumption equation (with an estimated coefficient θ_2=0.4602) with news in both the backward-looking consumption equation and the government spending rule, as well as the unemployment rate in the latter. The rationale is that there may be individuals who follow either pattern of behaviour; the estimated $\kappa \approx 0.45$ reflects the share of those following this paper's formulation of consumption equation (9a) as opposed to the Euler equation (8).

LL=-913.1

M4: As M3, with the addition of a news term in the Euler equation in the fiscal rule equation:

$$c_t = \rho c_{1t-1} + (1-\rho) c_{2t}$$

$$c_{1t} = \theta c_{1t-1} + (1-\theta) E_t c_{1t+1} + \beta (E_t - E_{t-1}) \Omega_t + c_2 u_t - c_3 (r_t + \varepsilon_{bt})$$

$$c_{2t} = \theta c_{2t-1} + \beta (E_t - E_{t-1}) \Omega_t + \varepsilon_t \ ,$$

$$g_t = \rho_g g_{t-1} + g_u u_t + \beta (E_t - E_{t-1}) \Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

This is a richer nested model; the estimated LL(=-912.4) as opposed to -913.1 for M3 shows the importance of news in the Euler equation.

M5: Euler equation augmented by news (8'), and a basic government spending rule (without news or unemployment):

$$g_t = \rho_g g_{t-1} + \varepsilon_{gt} + g_y \varepsilon_{at}$$

The change in employment is also part of the standard SW07 Euler equation. This is essentially another reference specification, but with an estimated LL=-929.6, not high on the pecking order.

M6: A standard Euler equation (8), with a government spending rule featuring news but no unemployment:

$$g_t = \rho_g g_{t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

The estimated LL=-912.079 shows a marked improvement with the addition of the news term to the government spending rule.

M7: As M6 with the addition of the backward-looking change in the unemployment rate in the government spending rule, as follows:

$$g_t = \rho_g g_{t-1} + g_u(u_t - u_{t-1}) + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Estimated LL=-911.926.

M8: As M5 (Euler equation with news) with the addition of news (but no unemployment) in the fiscal 'Taylor rule'.

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$g_t = \rho_g g_{t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

This effectively augments both the Euler equation and the fiscal rule with news. Estimated LL=-912.057.

M9: As M8 with the addition of the forward-looking difference in unemployment in the fiscal rule:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$g_t = \rho_g g_{t-1} + g_u(u_{t+1} - u_t) + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Estimated LL=-911.918

M10: As in M9 with backward-looking (instead of forward-looking) change in unemployment in the fiscal rule:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$g_t = \rho_g g_{t-1} + g_u(u_t - u_{t-1}) + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Estimated LL=-912.331; estimated θ=0.4395.

M11: As in M10 with the simple unemployment rate (instead of its difference) in the fiscal rule:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$g_t = \rho_g g_{t-1} + g_u u_t + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Estimated maximum likelihood is LL=-911.493.

M12: As in M11 but with the backward looking employment rate change (instead of u) in the fiscal rule:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt})$$

$$g_t = \rho_g g_{t-1} + g_u(l_t - l_{t-1}) + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_{gt} + g_y \varepsilon_{at}$$

The M12 is the best model in terms of estimated maximum likelihood (-910.513). The estimated θ=0.45 shows an essentially forward-looking Euler equation, in line with standard formulations. In Tables 2 and 3 in the text, we report results (IRFs) based on this specification.

M13: As in M1 but with the backward looking employment rate change (instead of u) in the fiscal rule:

$$g_t = \rho_g g_{t-1} + g_u(l_t - l_{t-1}) + \varepsilon_{gt} + g_y \varepsilon_{at}$$

Estimated log-LL: -913.115

Appendix B: Summary estimates of the parameters in M12

Parameter		Point estimates		M12 estimates		
SW07 Label	Description	M0/SW07	M12	Distribution	Mean	Std. error
ρ_a	Technology shock AR1 coefficient	0.9585	0.9426	BETA	0.5	0.20;
ρ_b	Consumption preference shock AR1 coefficient	0.1623	0.476	BETA	0.5	0.20;
ρ_g	Government spending shock AR1 coefficient	0.9688	0.9741	BETA	0.5	0.20;
ρ_I	Investment cost shock AR1 coefficient	0.7038	0.7122	BETA	0.5	0.20;
ρ_r	Interest rate shock AR1 coefficient	0.1311	0.1285	BETA	0.5	0.20;
ρ_p	Mark-up disturbance AR1 coefficient	0.9405	0.9351	BETA	0.5	0.20;
ρ_w	Wage shock AR1 coefficient	0.9771	0.9785	BETA	0.5	0.20;
μ_p	Price markup	0.7861	0.798	BETA	0.5	0.2;
μ_w	Wage markup	0.8683	0.878	BETA	0.5	0.2;
φ	Steady-state elasticity of the capital adjustment cost	5.3508	5.4984	NORMAL	4	1.5;
σ_c	Consumption risk aversion	1.3027	1.333	NORMAL	1.50	0.375;
H	Habit	0.739	0.7889	BETA	0.7	0.1;
ζ_w	Probability of wage adjustment in period	0.7002	0.7056	BETA	0.5	0.1;
σ_l	Labour risk aversion	1.6706	1.1582	NORMAL	2	0.75;
ζ_p	Probability of price adjustment in period	0.6225	0.6782	BETA	0.5	0.10;
i_w	Wage indexation	0.5894	0.5661	BETA	0.5	0.15;
i_p	Price indexation	0.2447	0.2497	BETA	0.5	0.15;
z	Elasticity of the capital utilisation	0.4687	0.3994	BETA	0.5	0.15;
Φ/Y_0	Fixed cost in production relative to output	0.7054	0.5279	NORMAL	0.25	0.125;
r_π	Inflation coefficient in Taylor rule	2.0619	2.0298	NORMAL	1.5	0.25;
r_r	Interest rate coefficient in Taylor rule	0.8148	0.806	BETA	0.75	0.10;
r_y	Output coefficient in Taylor rule	0.0846	0.0842	NORMAL	0.125	0.05;
$r_{\Delta y}$	Lagged output difference coefficient in Taylor rule	0.2125	0.219	NORMAL	0.125	0.05;
	Long term inflation (constant)	0.6107	0.6155	GAMMA	0.625	0.1;
β	Discount factor	0.21	0.21	GAMMA	0.25	0.1;
	Long term labour	0.2284	0.3773	NORMAL	0.0	2.0;
γ	Growth Trend	0.4258	0.4217	NORMAL	0.4	0.10;
g_y	Technology shock effect on government spending	0.6045	0.7363	NORMAL	0.5	0.25;
α	Capital weight production function	0.2957	0.3202	NORMAL	0.3	0.05;
g_u	Employment difference (11e) in the government spending rule	N/A	-0.1732	NORMAL	0.01	0.2;
β	News in consumption	N/A	0.1463	NORMAL	0.1	2.0;
g_w	News in the government spending rule	N/A	-0.26	NORMAL	0.01	0.2;

	Std. error of AR1 shocks:					
η_a	Technology shock	0.4239	0.4433	INV_GAMMA	0.1	2;
η_b	Consumption shock	0.2469	0.0833	INV_GAMMA	0.1	2;
η_g	Government spending shock	0.5349	0.5566	INV_GAMMA	0.1	2;
η_q	Investment shock	0.4597	0.4575	INV_GAMMA	0.1	2;
η_r	Monetary (interest rate) shock	0.2410	0.2442	INV_GAMMA	0.1	2;
η_π	Inflation shock	0.1372	0.1376	INV_GAMMA	0.1	2;
η_w	Wage shock	0.2469	0.24	INV_GAMMA	0.1	2;
	AR1 shock to consumption propensity - normal economy	N/A	1.463	INV_GAMMA	0.1	2;
	AR1 shock to consumption propensity - frictionless economy	N/A	0.046	INV_GAMMA	0.1	2;

Notes: The results are based using Sims's 'scminwel' algorithm; see the Table in Appendix B for more details.

Appendix C: Estimation Results

Table C1.1: Results From Posterior Maximization of model M12

Parameter	prior mean	mode	s.d.	t-stat	prior	pstdev
crhoa	0.500	0.9426	0.0173	54.3515	beta	0.2000
crhob	0.500	0.4760	0.1533	3.1057	beta	0.2000
crhog	0.500	0.9741	0.0099	98.8695	beta	0.2000
crhoqs	0.500	0.7122	0.0604	11.7875	beta	0.2000
crhoms	0.500	0.1285	0.0654	1.9656	beta	0.2000
crhopinf	0.500	0.9351	0.0392	23.8339	beta	0.2000
crhow	0.500	0.9785	0.0109	90.0613	beta	0.2000
cmap	0.500	0.7980	0.0833	9.5815	beta	0.2000
cmaw	0.500	0.8780	0.0597	14.6987	beta	0.2000
csadjcost	4.000	5.4984	1.2150	4.5253	norm	1.5000
csigma	1.500	1.3330	0.1376	9.6871	norm	0.3750
chabb	0.700	0.7889	0.0430	18.3444	beta	0.1000
cprobw	0.500	0.7056	0.0819	8.6163	beta	0.1000
csigl	2.000	1.1582	0.6474	1.7890	norm	0.7500
cprobp	0.500	0.6782	0.0579	11.7217	beta	0.1000
cindw	0.500	0.5661	0.1364	4.1517	beta	0.1500
cindp	0.500	0.2497	0.0976	2.5577	beta	0.1500
czcap	0.500	0.3994	0.0926	4.3154	beta	0.1500
cfc	1.250	1.5279	0.0845	18.0896	norm	0.1250
crpi	1.500	2.0298	0.1741	11.6575	norm	0.2500
crr	0.750	0.8060	0.0259	31.0963	beta	0.1000
cry	0.125	0.0842	0.0245	3.4298	norm	0.0500
crdy	0.125	0.2190	0.0292	7.5069	norm	0.0500
constepinf	0.625	0.6155	0.0662	9.2912	gamm	0.1000
constebeta	0.250	0.2100	0.0917	2.2913	gamm	0.1000
constelab	0.000	0.3773	1.1682	0.3229	norm	2.0000
ctrend	0.400	0.4217	0.0206	20.4430	norm	0.1000
cgy	0.500	0.7363	0.1315	5.6010	norm	0.2500
calfa	0.300	0.3202	0.0402	7.9600	norm	0.0500
cgu	0.010	-0.1732	0.0916	1.8914	norm	0.2000
crhowcp	0.100	0.1463	0.0274	5.3461	norm	2.0000
cgw	0.010	-0.2600	0.0669	3.8853	norm	0.2000

Standard deviation of shocks:

Parameter	prior mean	mode	s.d.	t-stat	prior	pstdev
ea	0.100	0.4433	0.0289	15.3196	invg	2.0000
eb	0.100	0.0833	0.0425	1.9568	invg	2.0000
eg	0.100	0.5566	0.0525	10.5989	invg	2.0000
eqs	0.100	0.4575	0.0485	9.4243	invg	2.0000
em	0.100	0.2442	0.0151	16.1573	invg	2.0000
epinf	0.100	0.1376	0.0169	8.1252	invg	2.0000
ew	0.100	0.2414	0.0223	10.8292	invg	2.0000
ewcp	0.100	1.4627	0.2288	6.3922	invg	2.0000
ewcpf	0.100	0.0461	0.0188	2.4503	invg	2.0000

Note: Estimation is based on the ‘scminwel’ algorithm by Chris Sims (see the Dynare manual).
Log-likelihood [Laplace approximation of log-data density] is -910.513

Table C1.2: MCMC Based Estimation of Model M12

Parameters	prior mean	post. mean	conf. interval		prior	pstdev
crhoa	0.500	0.9400	0.9119	0.9693	beta	0.2000
crhob	0.500	0.4226	0.2034	0.6346	beta	0.2000
crhog	0.500	0.9728	0.9563	0.9891	beta	0.2000
crhoqs	0.500	0.7264	0.6270	0.8254	beta	0.2000
crhoms	0.500	0.1447	0.0467	0.2400	beta	0.2000
crhopinf	0.500	0.9158	0.8480	0.9913	beta	0.2000
crhow	0.500	0.9687	0.9427	0.9939	beta	0.2000
cmap	0.500	0.7428	0.5835	0.9094	beta	0.2000
cmaw	0.500	0.8338	0.7306	0.9411	beta	0.2000
csadjcost	4.000	5.7790	3.7027	7.7414	norm	1.5000
csigma	1.500	1.3656	1.1409	1.5954	norm	0.3750
chabb	0.700	0.7820	0.7120	0.8519	beta	0.1000
cprobw	0.500	0.6953	0.5817	0.8148	beta	0.1000
csigl	2.000	1.2428	0.2984	2.0643	norm	0.7500
cprobp	0.500	0.6802	0.5872	0.7745	beta	0.1000
cindw	0.500	0.5539	0.3573	0.7732	beta	0.1500
cindp	0.500	0.2579	0.1025	0.4100	beta	0.1500
czcap	0.500	0.3999	0.2502	0.5510	beta	0.1500
cfc	1.250	1.5267	1.3884	1.6671	norm	0.1250
crpi	1.500	2.0613	1.7732	2.3539	norm	0.2500
crr	0.750	0.8084	0.7674	0.8494	beta	0.1000
cry	0.125	0.0902	0.0488	0.1314	norm	0.0500
crdy	0.125	0.2190	0.1711	0.2682	norm	0.0500
constepinf	0.625	0.6258	0.5018	0.7393	gamma	0.1000
constebeta	0.250	0.2482	0.0922	0.3991	gamma	0.1000
constelab	0.000	0.1925	-1.8486	2.3080	norm	2.0000
ctrend	0.400	0.4217	0.3868	0.4563	norm	0.1000
cgy	0.500	0.7478	0.5175	0.9890	norm	0.2500
calfa	0.300	0.3214	0.2537	0.3878	norm	0.0500
cgu	0.010	-0.1939	-0.3481	-0.0452	norm	0.2000
crhowcp	0.100	0.1366	0.0873	0.1844	norm	2.0000
cgw	0.010	-0.2770	-0.3973	-0.1544	norm	0.2000

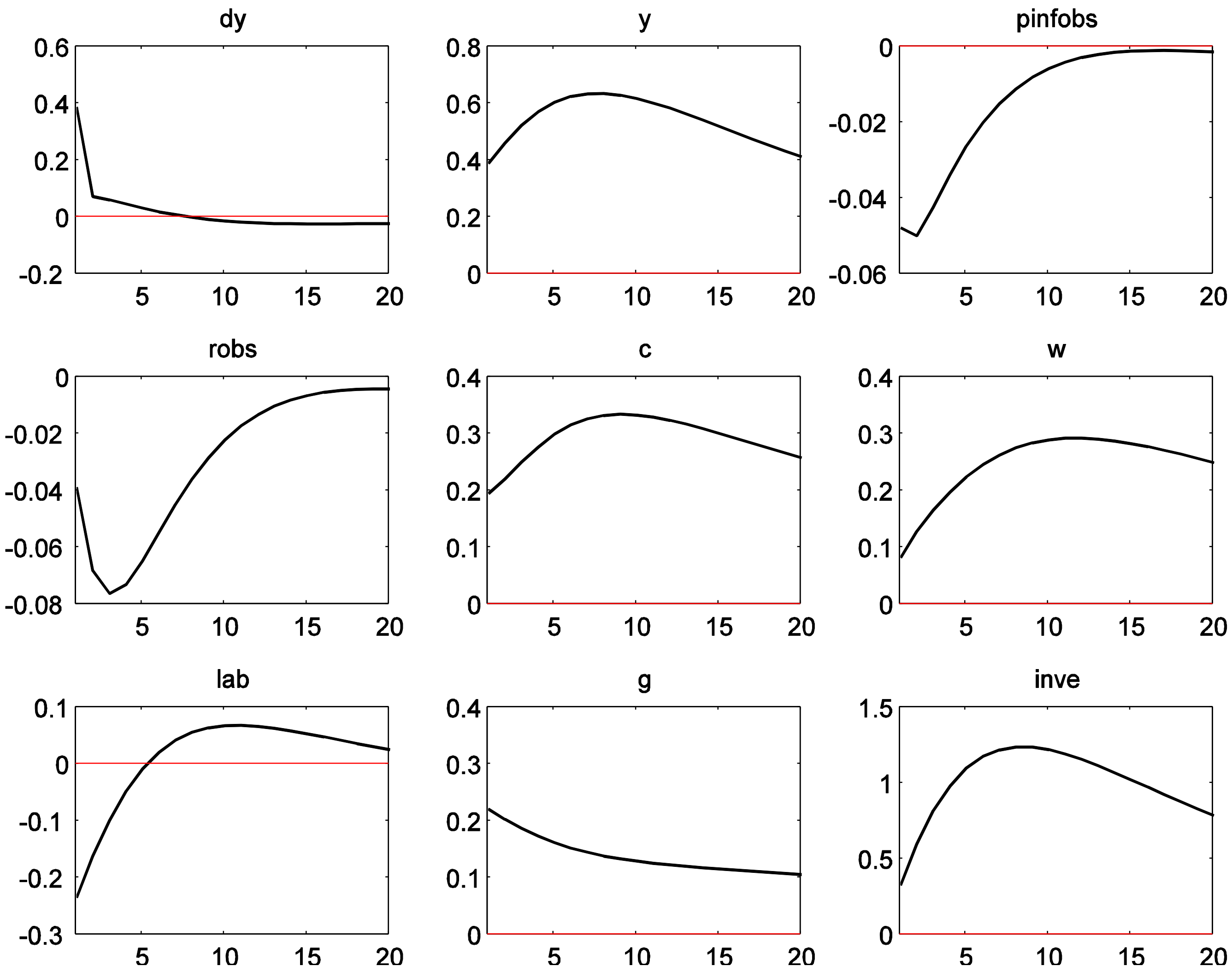
standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
ea	0.100	0.4516	0.4017	0.4993	invg	2.0000
eb	0.100	0.1081	0.0409	0.1689	invg	2.0000
eg	0.100	0.5772	0.4818	0.6802	invg	2.0000
eqs	0.100	0.4566	0.3717	0.5368	invg	2.0000
em	0.100	0.2482	0.2229	0.2731	invg	2.0000
epinf	0.100	0.1355	0.1049	0.1656	invg	2.0000
ew	0.100	0.2397	0.1978	0.2823	invg	2.0000
ewcp	0.100	1.5062	1.0683	1.9358	invg	2.0000
ewcpf	0.100	0.0873	0.0240	0.1670	invg	2.0000

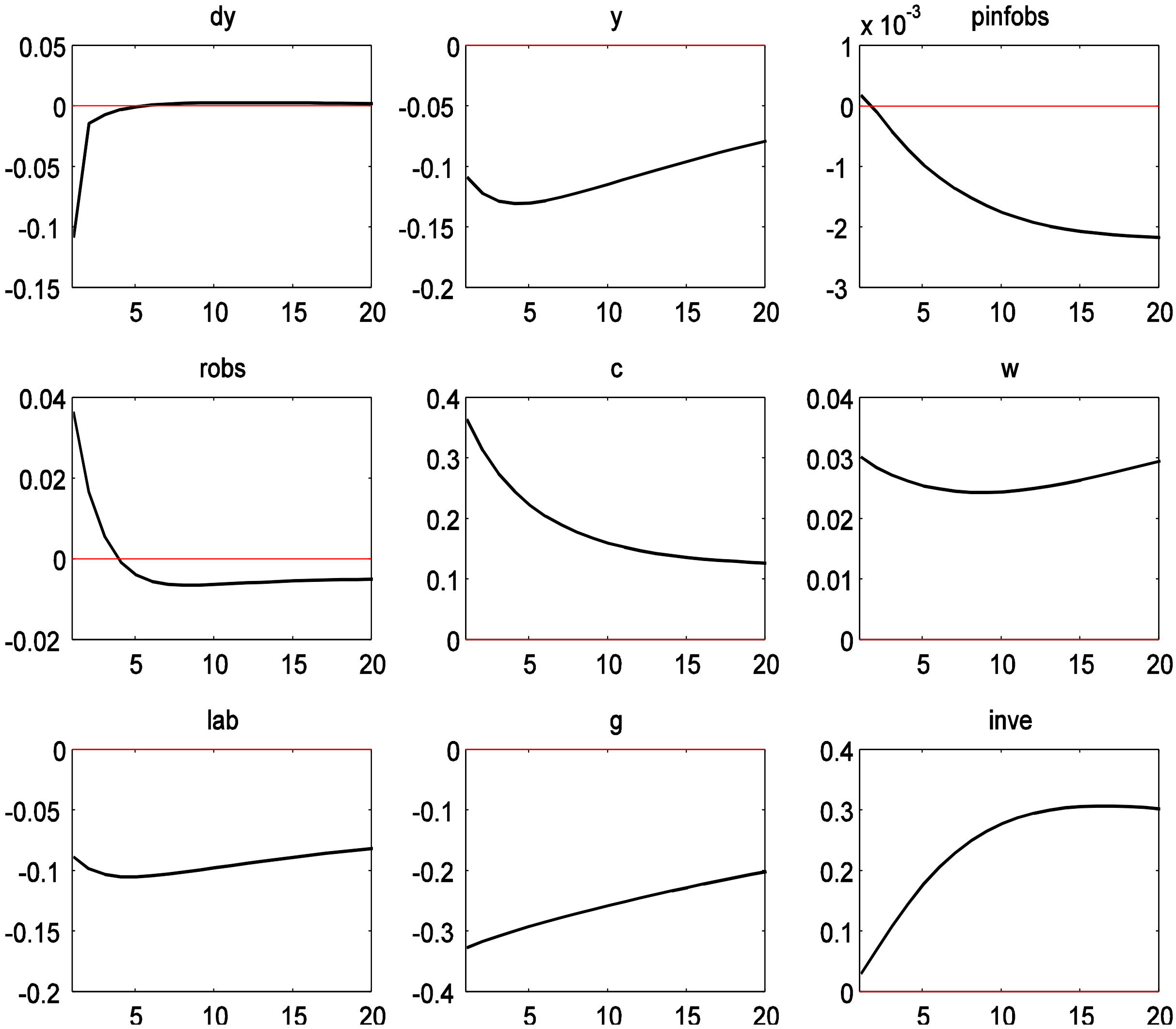
Note: This is the M12 model estimated by Dynare using the second stage of the estimation, based on 100,000 draw MCMC posterior maximisation. Log-likelihood (Laplace approximation of the log-data density) is -910.213

Figures C.1: IRFs of model M12

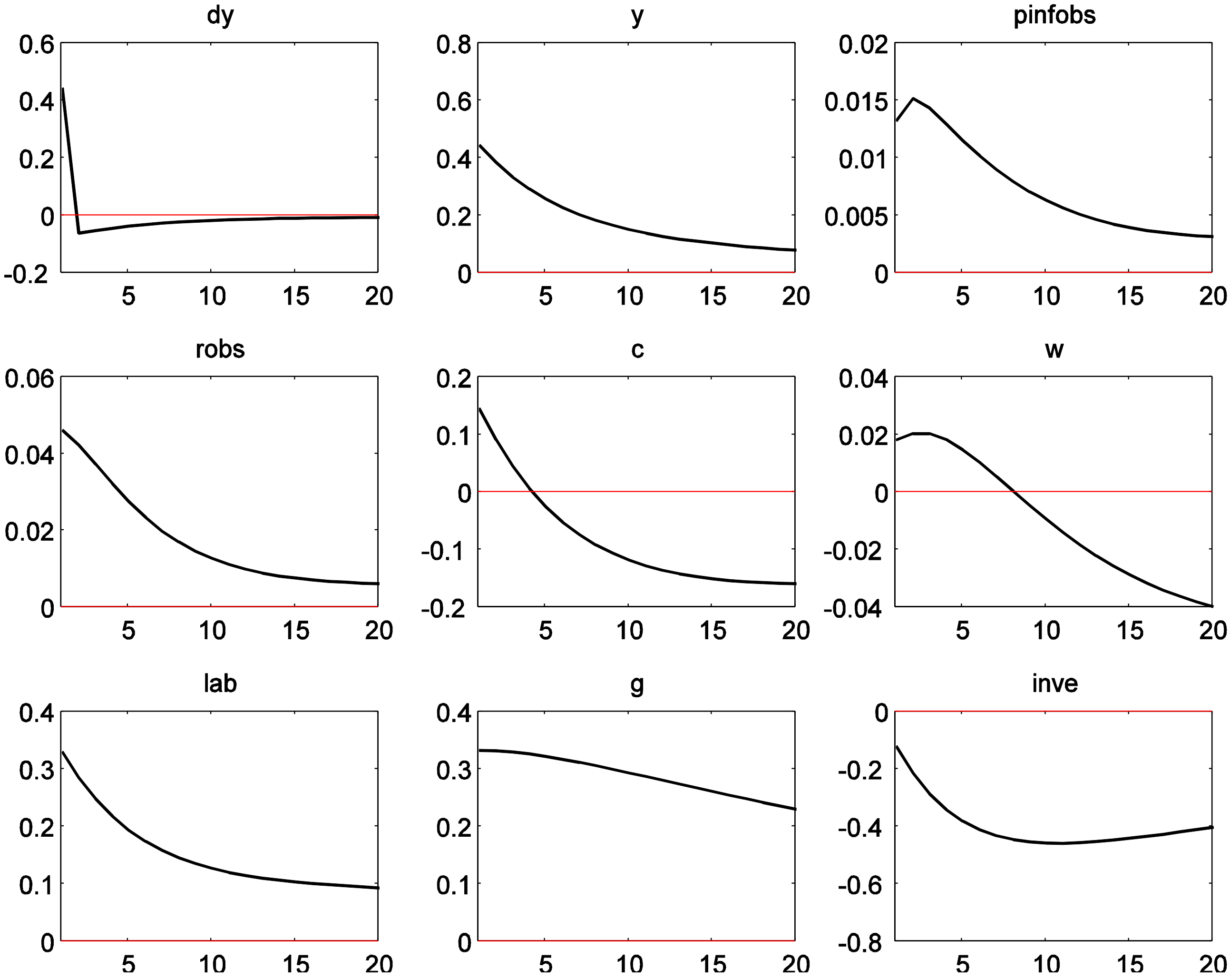
Figures C.1.a: Shock to technology:



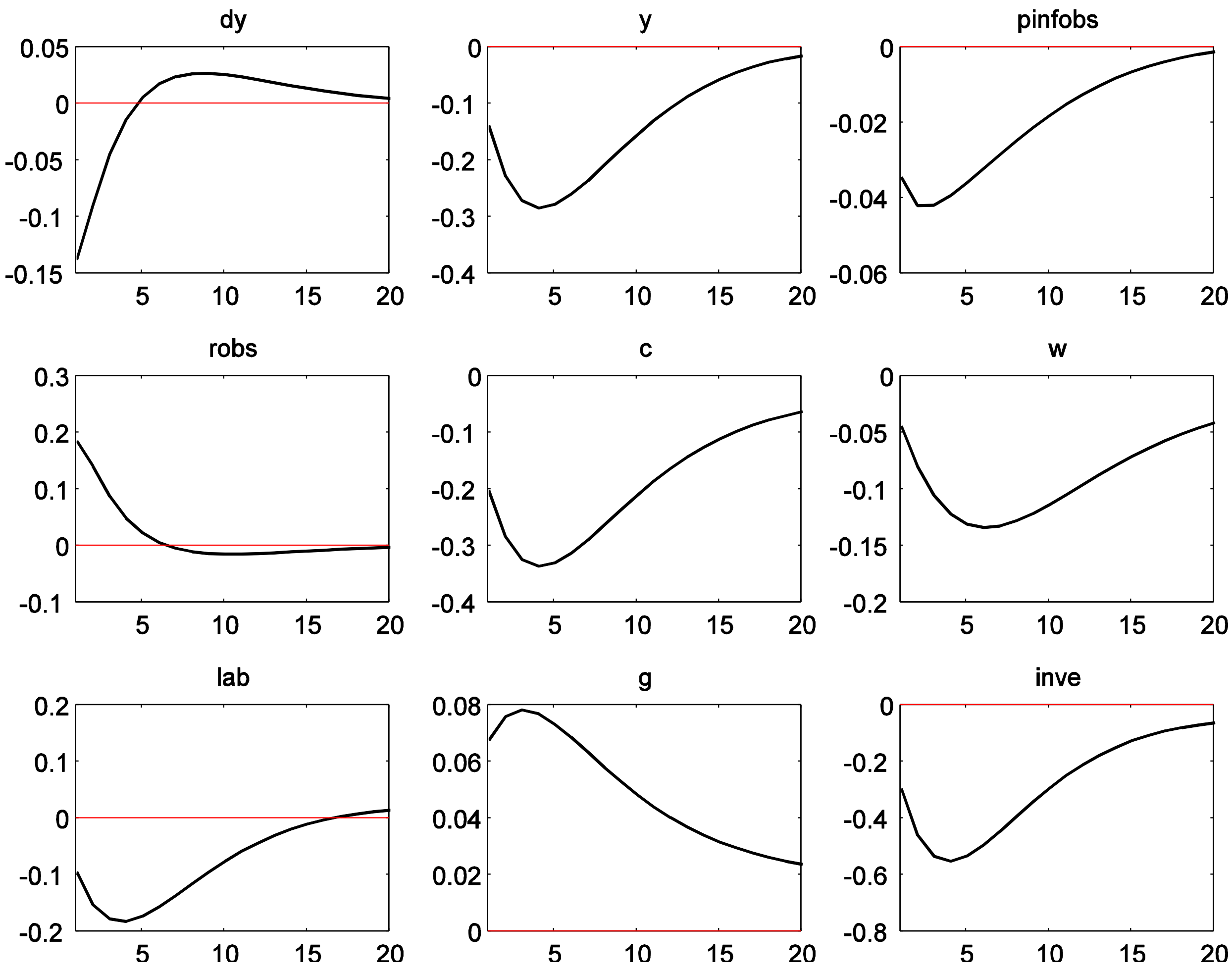
Figures C.1.b: Shock to news



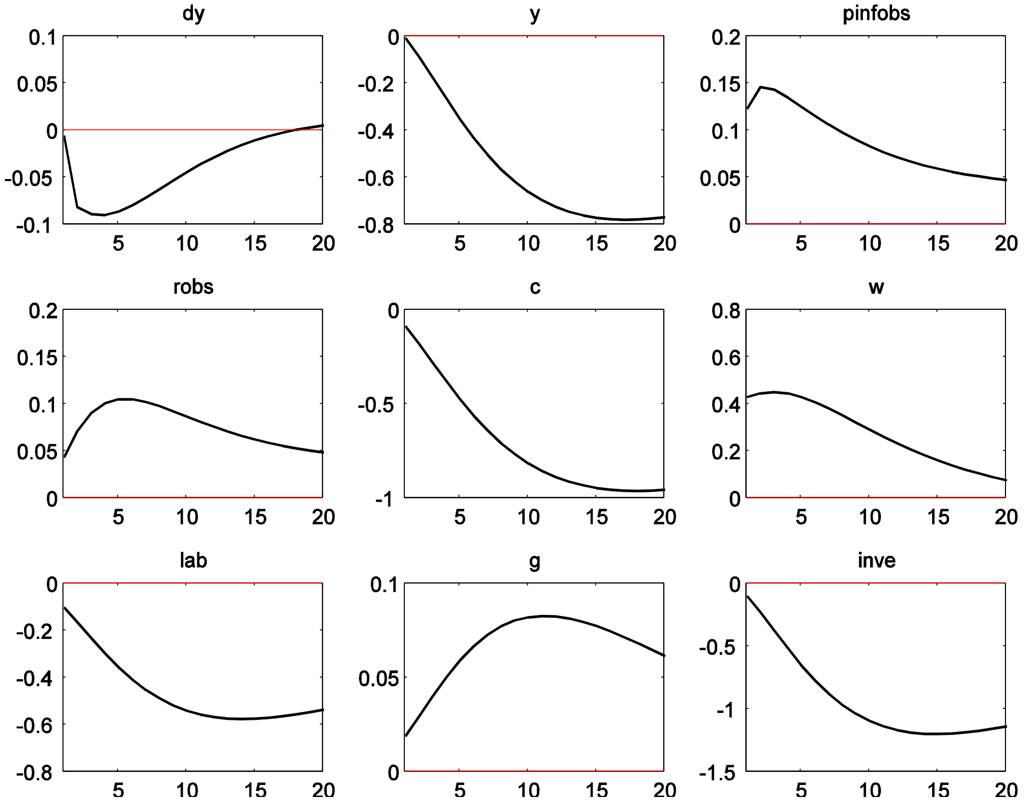
Figures C.1.c: Shock to the government spending



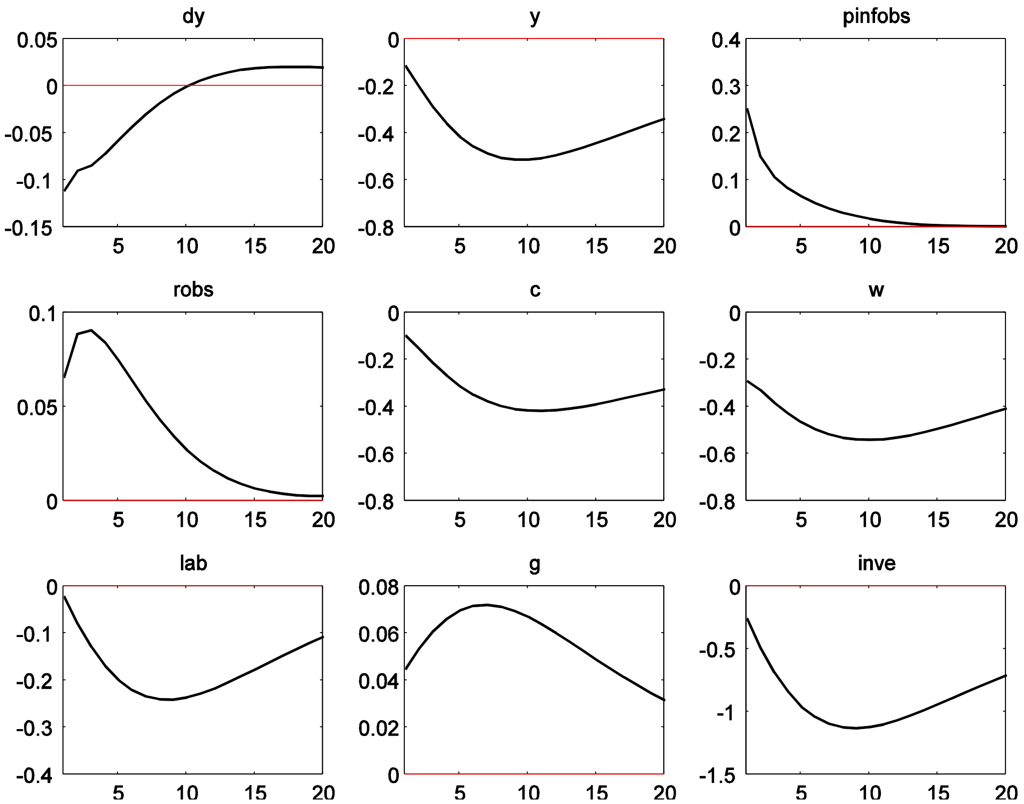
Figures C.1.d: Shock to monetary policy rate r



Figures C.1.e: Shock to the wage w



Figures C.1.f: Shock to inflation



Appendix C: Estimation results (cont.'d)

Table C2.1: Results from posterior maximisation for M0 (SW07)

Parameter	prior mean	mode	s.d.	t-stat	prior	pstdev
crhoa	0.500	0.9585	0.0106	90.2220	beta	0.2000
crhob	0.500	0.1623	0.0779	2.0839	beta	0.2000
crhog	0.500	0.9688	0.0092	105.6310	beta	0.2000
crhoqs	0.500	0.7038	0.0603	11.6642	beta	0.2000
crhoms	0.500	0.1311	0.0665	1.9737	beta	0.2000
crhopinf	0.500	0.9405	0.0380	24.7624	beta	0.2000
crhow	0.500	0.9771	0.0098	100.1353	beta	0.2000
cmap	0.500	0.7861	0.0869	9.0460	beta	0.2000
cmaw	0.500	0.8683	0.0674	12.8896	beta	0.2000
csadjcost	4.000	5.3508	1.0149	5.2724	norm	1.5000
csigma	1.500	1.3027	0.1331	9.7838	norm	0.3750
chabb	0.700	0.7390	0.0442	16.7268	beta	0.1000
cprobw	0.500	0.7002	0.0795	8.8038	beta	0.1000
csigl	2.000	1.6706	0.6229	2.6819	norm	0.7500
cprobp	0.500	0.6225	0.0576	10.8135	beta	0.1000
cindw	0.500	0.5894	0.1359	4.3373	beta	0.1500
cindp	0.500	0.2447	0.0959	2.5521	beta	0.1500
czcap	0.500	0.4687	0.1049	4.4676	beta	0.1500
cfc	1.250	1.7054	0.0762	22.3797	norm	0.1250
crpi	1.500	2.0619	0.1755	11.7454	norm	0.2500
crr	0.750	0.8148	0.0245	33.2613	beta	0.1000
cry	0.125	0.0846	0.0225	3.7636	norm	0.0500
crdy	0.125	0.2125	0.0270	7.8551	norm	0.0500
constepinf	0.625	0.6107	0.0667	9.1598	gamm	0.1000
constebeta	0.250	0.2100	0.0917	2.2913	gamm	0.1000
constelab	0.000	0.2284	1.0173	0.2245	norm	2.0000
ctrend	0.400	0.4258	0.0214	19.9343	norm	0.1000
cgy	0.500	0.6045	0.0970	6.2298	norm	0.2500
calfa	0.300	0.2957	0.0442	6.6882	norm	0.0500

Note: This is the original SW07 model estimated by Dynare; this is the first stage of the estimation, based on the 'scminwel' algorithm by Chris Sims (see the Dynare manual). Log-likelihood (Laplace approximation of log-data density) is -924.956.

Table C2.2: MCMC Estimation results for M0 (SW07)

parameters	prior mean	post. mean	conf. interval		prior	pstdev
crhoa	0.500	0.9550	0.9373	0.9740	beta	0.2000
crhob	0.500	0.1963	0.0672	0.3235	beta	0.2000
crhog	0.500	0.9682	0.9532	0.9836	beta	0.2000
crhoqs	0.500	0.7166	0.6223	0.8162	beta	0.2000
crhoms	0.500	0.1568	0.0483	0.2625	beta	0.2000
crhopinf	0.500	0.9232	0.8634	0.9873	beta	0.2000
crhow	0.500	0.9724	0.9549	0.9909	beta	0.2000
cmap	0.500	0.7401	0.5961	0.8916	beta	0.2000
cmaw	0.500	0.8132	0.6957	0.9297	beta	0.2000
csadjcost	4.000	5.5701	3.9947	7.1887	norm	1.5000
csigma	1.500	1.3067	1.0844	1.5231	norm	0.3750
chabb	0.700	0.7358	0.6651	0.8096	beta	0.1000
cprobw	0.500	0.6712	0.5634	0.7827	beta	0.1000
csigl	2.000	1.6349	0.6820	2.5482	norm	0.7500
cprobp	0.500	0.6208	0.5259	0.7076	beta	0.1000
cindw	0.500	0.5794	0.3797	0.7843	beta	0.1500
cindp	0.500	0.2601	0.1095	0.4019	beta	0.1500
czcap	0.500	0.4774	0.3096	0.6463	beta	0.1500
cfc	1.250	1.7077	1.5810	1.8260	norm	0.1250
crpi	1.500	2.0861	1.7866	2.3598	norm	0.2500
crr	0.750	0.8103	0.7675	0.8511	beta	0.1000
cry	0.125	0.0840	0.0471	0.1203	norm	0.0500
crdy	0.125	0.2142	0.1685	0.2579	norm	0.0500
constepinf	0.625	0.6221	0.5116	0.7312	gamma	0.1000
constebeta	0.250	0.2544	0.0926	0.4103	gamma	0.1000
constelab	0.000	0.1147	-1.6136	1.8897	norm	2.0000
ctrend	0.400	0.4239	0.3885	0.4576	norm	0.1000
cgy	0.500	0.5962	0.4362	0.7612	norm	0.2500
calfa	0.300	0.2954	0.2235	0.3652	norm	0.0500

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
ea	0.100	0.4290	0.3841	0.4713	invg	2.0000
eb	0.100	0.2444	0.2064	0.2808	invg	2.0000
eg	0.100	0.5407	0.4891	0.5905	invg	2.0000
eqs	0.100	0.4575	0.3818	0.5311	invg	2.0000
em	0.100	0.2467	0.2221	0.2730	invg	2.0000
epinf	0.100	0.1373	0.1092	0.1662	invg	2.0000
ew	0.100	0.2450	0.2059	0.2839	invg	2.0000

Note: This is the original SW07 model estimated by Dynare; this is the second stage of the estimation, based on 100,000 draw MCMC posterior maximisation. Log-likelihood (Laplace approximation of the log-data density) is -925.115320.