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News, Fiscal Rules and the Keynesian Multiplier in a DSGE Model

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Abstract: We extend the standard Smets-Wouters (2007) medium-sized DSGE model to analyse the effects of news and the Keynesian multiplier. News is modelled in a novel way compared to the literature, as revisions of expectations regarding future fundamentals. News-driven expectations changes augment both the consumption Euler equation and a fiscal rule, which is a secondary innovation of the paper. This news channel significantly improves the model fit to data. We 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.

1. INTRODUCTION

Following the lead of Beaudry and Portier (2004, 2007), an expanding literature analyses the role of news as drivers of business cycles. In much of this literature, 'news' refers to new information about future productivity-related shocks. Or, as in Christiano *et al*. (2008) and Gunn and Johri (2011), news refers to information about a process that governs the evolution of some financial friction (cost of default by financial intermediaries). In much of this literature, news is synonymous to advance signals about exogenous drivers before these actually take effect (Karnizova, 2010; Khan and Tsoukalas, 2012; Milani and Treadwell, 2012). Often, the connection of

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these signals to the fundamentals is imperfect or implicit (Jaimovich and Rebelo, 2009; Schmitt-Grohe and Uribe, 2008). The common theme in all of these contributions is that 'news' is conveyed by additional exogenous error terms which augment the processes that govern the external drivers or fundamentals. Yet, it is not clear how these additional error terms are differentiated from the other exogenous terms in the fundamentals; moreover, this approach has been criticised on identification grounds (Kurmann and Mertens, 2014).

This paper introduces news into a DSGE model and relates this to the Keynesian multiplier. Our contribution is that we take a different approach to news, by modelling it as the revision of expectations about future endogenous variables. One inspiration for this approach is the vintage random walk model of consumption (see Deaton, 1992) in which all currently available information about future consumption is embodied in current consumption. Consumption evolution happens therefore only as expectations about lifetime resources are gradually updated, causing 'surprises' (Muellbauer, 1983). In this spirit, 'news' should be everything that contributes towards revising those expectations, and not just a particular set of error terms. By modelling news in this way, our approach generalises the existing models; by not involving additional exogenous processes, it is immune to questions about their nature or identification. Additionally, our approach is better suited to the analysis of a 'Keynesian multiplier' process, which is a further objective of the paper.

The issue of the government spending ('Keynesian') multiplier has come under renewed attention in line with the increased emphasis on fiscal activism. The notion remains much debated both conceptually and empirically, without any consensus in sight as yet (see e.g. Hall, 2009; Woodford, 2011; Mulligan, 2011; Ramey, 2011; Barro, 2010; the debate between Taylor, 2011 and Romer, 2011; Corsetti *et al.*, 2012; Denes *et al.*, 2012; Ilzetzki, 2010; Blanchard and Leigh, 2012). More broadly, a better quantitative understanding of the effects of fiscal policy remains elusive (see Blanchard and Perotti, 2002; Gali, Lopez-Salido and Valles, 2010). Our modelling of news is a fruitful approach to the multiplier as it encompasses its logic: News feeds into changes of expectations, consumption, then output, which generates further revisions of expectations (i.e., news), and so on. This patterns applies also to unexpected developments in fiscal policy. Such a structure is absent in standard formulations as the news there is captured by exogenous terms that are uncorrelated with fiscal policy. Thus, our approach contributes to a better understanding of the workings of fiscal policy.

A third strand of literature to which the paper is related is Dynamic Stochastic General Equilibrium (DSGE) models of the business cycle. In particular, apart from the modelling of news, we follow quite closely Smets and Wouters (2007; henceforth SW07) which has by now achieved benchmark status. Within that strand, our work is related more specifically to analyses of the Keynesian multiplier in Cogan *et al.* (2010) and Drautzburgh and Uhlig (2009; henceforth DU09) and Zubairy (2013). Our approach innovates in this respect because of the news-related multiplier structure referred to above. A fourth strand of literature to which the paper is related concerns the endogenous evolution of fiscal policy. A number of papers have pointed out the association of fiscal policy with the business cycle (Leeper *et al.*, 2010; Fernandez-Villaverde *et al.*, 2011; Traum and Yang, 2013; and Zubairy, 2013). A subsidiary objective and contribution of this paper is to consider such a fiscal (spending) rule, in particular to augment it with a news effect as an indicator of the state of the business cycle. Much of this literature lets the output gap inform the fiscal rule; an additional contribution we make is that we replace output gap with unemployment (or employment change) and show that this further improves the empirical fit of the model.

The remainder of this paper is structured as follows: Section 2 augments the standard Euler equation with 'news' as described above; the resulting equation describing consumption dynamics is a testable addition to a DSGE model like that of Smets and Wouters (2007). Section 3 briefly introduces fiscal rules. Section 4 discusses the empirical implementation and presents the main results, Section 5 shows the resulting multipliers, while Section 6 concludes. Appendices A1, A2 and B present more information on various aspects of estimation. To preamble, news and the fiscal rule we consider enhance the empirical fit of the model and strengthen the Keynesian features of the multipliers.

2. EXPECTATIONS, 'NEWS' AND CONSUMPTION DYNAMICS

In this Section, we present a model of 'news' as revisions in expected lifetime resources, based on all new information. As mentioned, this approach presents a number of advantages over the usual modelling of news: It does not rely on any extra error processes, with all the questions that those may raise; it is more in line with the Rational Expectations approach of 'looking at everything' rather than particular error processes; it captures unexpected innovations of lifetime resources that the standard Euler equation is unable to capture (except indirectly via the interest rate); and it links more naturally with the Keynesian multiplier. The rest of the model is essentially the standard Smets and Wouters (2007) setup, which is not reproduced here for economy of space.

Our point of departure is the following decomposition of consumption:

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

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

Consumption (C_t) is a product of the marginal propensity to consume out of lifetime wealth, Φ_t, times lifetime wealth (in square brackets). $1/R_t^s$ is the relevant discount factor; r_t is the period real interest rate. Lifetime wealth is made up of assets (at the beginning of the period), A_t, plus discounted labour earnings and monopoly profits over the lifetime (net of tax), X_t.[1] Variables without subscripts indicate steady-state values. γ is the trend real growth rate. Equation (1) presents a decomposition of consumption into the slope and the position of its intertemporal profile: Φ_t is the Euler equation-determined slope of this profile, as Φ_t/Φ_{t-1} gives the (gross) consumption growth rate when the lifetime wealth is constant.

General solutions to Φ_t are not available; important special cases are: i. the random walk model of consumption when $\Phi_t = \Phi = r/(1+r)$ (e.g., Obstfeld and Rogoff, 1996, Ch. 2, eq. 2.10); ii. trend consumption growth under an iso-elastic utility in a non-stochastic environment, in which case we may write $_t = \Phi = (r-\gamma)/(1+r-\gamma)$, where γ is the (constant) growth rate of consumption (cf. Obstfeld and Rogoff, 1996, eq. 2.16).[2] We shall follow the latter case, but will allow for deviations of Φ_t from its steady-state of value of $\Phi \equiv (r-\gamma)/(1+r-\gamma)$; these will correspond to Euler equation-derived deviations of consumption from its trend path.

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

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

Consumption (in log-deviations form – lower-case letters) responds positively to short-run deviations of Φ_t from Φ, $\phi_t \equiv \log \Phi_t - \log \Phi$, deviations in wealth ($\alpha_t$) and labour income and monopoly profits (x_t), negatively to deviations 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. Furthermore, following Deaton (1992, Ch. 3), we proceed to use the period budget constraint in a beginning-of-period formulation:

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

The notational convention is that r_t is the interest rate accruing between periods t-1 and t. In a log-linearised form, along the steady-state path, we have:

$$a_t = (1+r-\gamma)\left[a_{t-1} + \frac{X}{A}x_{t-1} - \frac{C}{A}c_{t-1}\right] + r_t \tag{4}$$

Inserting (4) into the consumption equation (2), and using liberally, we get:[3]

$$\Delta c_t = \varphi_t - \varphi_{t-1} + \frac{X}{C}\Phi \begin{bmatrix} \frac{A}{X}r_t + \sum_{s=0}^{\infty}\frac{(E_t - E_{t-1})x_{t+s}}{(1+\tilde{r}-\gamma)^s} - \frac{r_t/(1+r) - \Delta y_t/(1+\gamma)}{1+r-\gamma} - \\ -(E_t - E_{t-1})\sum_{s=0}^{\infty}\frac{r_{t+s+1}/(1+r) - \Delta y_{t+s+1}/(1+\gamma)}{(1+r-\gamma)^s} \end{bmatrix} \tag{5}$$

Δ is the difference operator (e.g., $\Delta c_t \equiv c_t - c_{t-1}$). The $(E_t - E_{t-1})(.)$ terms refer to revisions in expectations from t-1 to t of the relevant discounted sums; this is our definition of 'news'.

To close the model, we need:

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

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

m_t: The monopoly power of the typical monopolistic firm.

Therefore in linearised form:

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

Where *lshare* (labour share) is a parameter, commonly thought to be around 0.65. μ^p_t is the monopoly power as a deviation from the steady state. Thus, total output, wage, employment and monopoly power (fuelling supernormal profits) increases will have an impact on profits. Introducing (6') into (5), we get more compactly:

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

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

Consumption evolution, in deviations, is now the sum of two parts: ϕ_t-ϕ_{t-1} is the evolution of optimal consumption governed by the Euler equation (the slope of the consumption profile in the earlier terminology), while the latter part is the evolution of lifetime wealth. In particular, Ω_t (defined recursively in 7b) is the present value of labour earnings plus monopoly profits (in deviations from trend).

As mentioned, our definition of 'news' (at t) is the revisions in expectations between times t-1 and t, $(E_t - E_{t-1})\Omega_{t+s} \equiv E_t\Omega_{t+s} - E_{t-1}\Omega_{t+s}$, and similarly with all the variables that make up the composite W_t. Our key innovation is to let this term be embedded into a more traditional Euler equation and be estimated freely. According to (7a), 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 original shock was due to fiscal policy, the final effect is essentially a Keynesian multiplier. As argued, this structure is absent in a standard Euler equation, where the fiscal shock would have a weaker effect.

Finally, it is worth emphasising that, through f_t-f_{t-1}, (7a) incorporates the standard Euler equation, which in SW07 takes the simpler form:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt}),\ 0 < \theta < 1 \qquad (8)$$

The mixed lead-lag structure is due to the presence of habits; (8) also includes the disutility of labour, which under habits again becomes a forward-looking labour difference. To maintain tractability, our strategy will be to use the Euler equation (8) and augment it with news in the spirit of (7a). Thus, we get:

$$c_t = \theta c_{t-1} + (1-\theta)E_t c_{t+1} + \beta(E_t - E_{t-1})\Omega_t + c_2(l_t - E_t l_{t+1}) - c_3(r_t + \varepsilon_{bt}) \qquad (9)$$

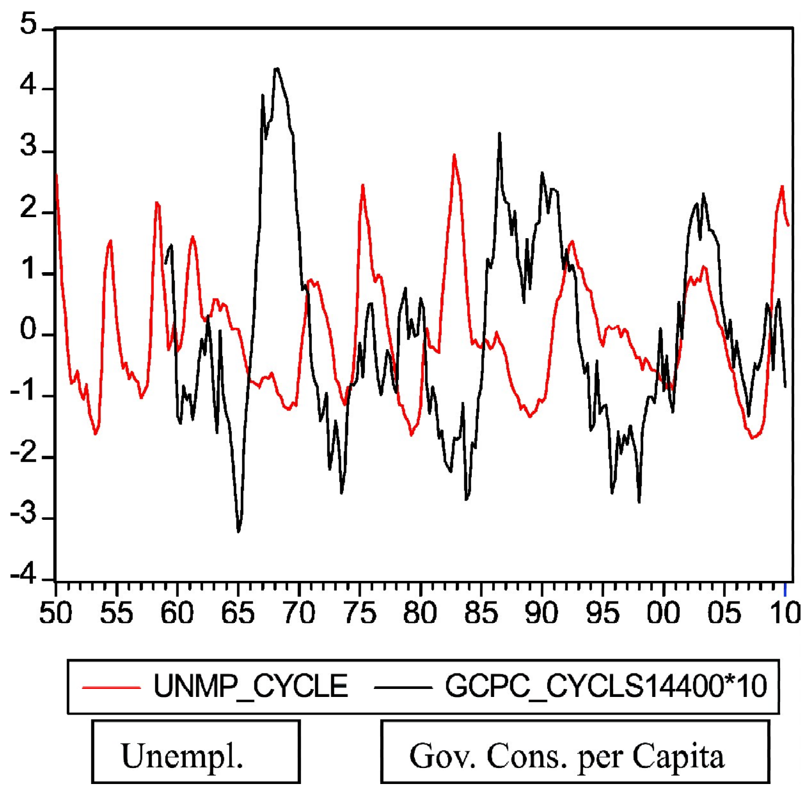
Equation (9) is a simpler version of (7a) and is our main estimable equation.[5] It is worth emphasising that our innovation is the news term $((E_t - E_{t-1})\Omega_t)$, whose importance will be gauged by the estimable parameter b. We shall also introduce this news term into the fiscal rule, to be discussed next. ε_{bt} is one of seven error terms, ε_{zt}, z = 1, 2, …, 7; we comment on them in Section 4.

3. GOVERNMENT SPENDING AND A FISCAL POLICY RULE

In addition to the consumption equation, news also enters a fiscal rule. Fiscal rules have been considered by some recent contributions: Leeper *et al.* (2010) estimates a DSGE model that incorporates a rich description of fiscal policy with several fiscal rules. Fernandez-Villaverde *et al.* (2011), Zubairy (2013) and Traum and Yang (2013) also consider fiscal rules in DSGE models. Fiscal rules are motivated by the fact that fiscal policy is not random but correlated with the state of the economy. This may be the case because of endogenously changing public finances, and because fiscal policy may follow an activist stabilisation rule akin to that of a Taylor (1993) rule for monetary policy. We consider these possibilities with the help of US data on consumption and employment, 1955-2010 (both HP detrended); see Figure 1 below.

The endogeneity of fiscal policy is confirmed by a Granger causality test (not shown) that shows causality firmly going from the state of the cycle (here: the unemployment rate) to government consumption, and not the other way around.

Figure 1: US Government consumption and unemployment



The more interesting question is the interpretation of this result. The two possible reasons for endogeneity of fiscal policy, i.e. constraints on public finances that depend on the state of the economy, or a fiscal stabilisation rule, imply correlations of opposite signs. The former would suggest a procyclical fiscal policy (spending is higher in good times) but the latter a countercyclical one (spending rises in bad times to stimulate the economy). In US data, the correlation coefficient of government spending and unemployment is -0.142109 for the entire sample (1959-2010), consistent with public finances stabilisation, but +0.265167 for 1980-2011, indicating a shift toward a countercyclical fiscal policy in the latter part of the sample. Thus, the data seems to point towards a fiscal rule that embodies an activist stabilisation stance, a feature that we build into our model.

More specifically, in common with SW07, we allow government spending to be determined by an AR(1) process augmented by technology shocks in addition to exogenous government spending shocks.[6] We extend this 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 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 are motivated by the fact that the government pursues an activist stabilisation policy analogous to the Taylor rule (1993).[7] Augmenting the fiscal rule with news and unemployment (instead of the more usual output gap), as indices of the state of the economy, is an additional contribution of this paper.

These considerations lead us to extend the SW07 equation characterising government spending to incorporate an activist stabilisation policy via government spending (see Dixit and Lambertini, 2003). 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; ε_{at} and ε_{gt} are error terms (see Section 4). The two additional elements discussed above are incorporated here: the news channel and the labour market indicator. We experimented with a number of variants of (10), with different definitions of η_t; specifically, we have experimented with 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, respectively), with the addition of an error term, ε_{ut}:

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

To preamble, the estimated parameters lend support to this rule. 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.[8]

4. ESTIMATION

4.1. Estimated models

We estimate a number of variants of the main estimable equation (9). We differentiate the estimable models according to whether news and/or unemployment affect the 'Taylor rule' of government expenditures. The standard SW07 model as programmed by Dynare is indicated as M0; in terms of the features that concern us here, M0/SW07 has an Euler equation (8) without news and a fiscal rule (10) without any news term or any labour market-related variable. A summary of the other estimated models with their essential features is presented in Table 1; a fuller list of models used in robustness checks, is given in Appendix A2. The models are marked as M1, M2, ..., M13, going from the parsimonious to the more general. Apart from news and the fiscal rule, in other respects the models are identical to M0/SW07.

4.2. Data

In order to assess the significance of our formulation of news, we make our framework directly comparable to Smets and Wouters (2007). To this end, we use the same data and their Dynare-based estimation code, all available from the Internet. There are 7 US data series: i. Real GDP (y); ii. Real wage (w); iii. Gross fixed capital formation (investment, i); iv. Private consumption (c); v. Inflation rate (π); vi. Federal

Reserve base interest rate (r); and vii. Hours worked (h). 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% and the balanced-growth-path growth rate 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≈0.9. Since C/Y is roughly 0.6, X/C X/C»0.9/0.6=1.5. A/X=K/X=K/(Y-Y(rK/Y))=3/0.9=3.333...

In line with SW07 (p. 17), seven exogenous, AR(1) error terms drive the dynamics, defined as follows: i. total factor productivity (ε_{at}); ii. investment-specific technology (ε_{it}); iii. risk premium (ε_{bt}); iv. exogenous spending (ε_{gt}), which is also affected by the productivity shock via: $\varepsilon_{gt} = \rho_g \varepsilon_{gt-1} + \omega_{gt} + \rho_a \omega_{at}$, where ω_{gt} and ω_{at} are the i.i.d. drivers of the AR(1) of the productivity and spending shocks; v. price mark-up (ε_{pt}); vi. wage mark-up (ε_{wt}); and vii. monetary policy shocks (ε_{rt}). In addition, the definition of unemployment (12) contains an additional mean-zero error term, ε_{ut}.

4.3. Results

Estimation was carried out by Dynare's[9] full-information DSGE estimation.[10] The results of the benchmark model estimated by Dynare, M0/SW07, are almost identical to the results in Table 1 of SW07.[11] Its LL (the approximate log data density) when estimated by Dynare is -924.956 using the csminwel algorithm 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 of the models that incorporate news and the fiscal policy rule can be compared.

The empirical performance of the best 6 models is shown in Table 1, alongside the reference M0/SW07 model. The models with news generally perform better than similar models without news; while the LogLikelihood of the best 5 models shows little differentiation, all models are significantly better than the baseline M0/SW07 model which shows LL=-924.956 (compared to LL≈-911 for the best models). This order of difference is clearly significant (see Rabanal and Rubio-Ramirez, 2005). A model without news in either the consumption equation or the fiscal rule is M13 with LL≈913, worse than the best models (with news), but also significantly better than M0/SW7, testifying to the importance of unemployment in the fiscal rule.

Table 1: Summary of estimated models

Rank	*Model*	*Features of consumption*	*Features of the fiscal rule (10) and state of the economy (11)*	β	g_w	g_u	*LL*	*MCMC 100,000 draws*
1	M12	Baseline (9)	News; (11e)	0.1463	-0.26	-0.1732	-910.513	-910.213
2	M11	Baseline (9)	News; (11a)	0.1634	-0.298	0.0265	-911.493	
3	M9	Baseline (9)	News; (11b)	0.151	-0.281	0.164	-911.918	
4	M7	Euler (no news) (8)	News; (11c)		-0.259	0.1592	-911.926	
5	M8	Baseline (9)	Only news; (g_u=0)	0.1569	-0.295		-912.057	
6	M13	Euler (no news) (8)	No news (g_w=0); (11e)			-0.4711	-913.115	-917.586 (10,000 draws)
7	M0/ SW07	SW07 estimated by Dynare – Euler (no news) (8)	No news (g_w=0); g_u=0				-924.956	-925.115

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 10).

Our preferred in terms of empirical fit model is M12, involving news-driven changes of expectations in both the consumption equation (9) and in the fiscal rule, and a backward-looking labour difference in the latter (11e). It behaves in a comparable manner to SW07 (see the detailed parameter estimates in Appendix A1 and the Impulse Response Functions in Appendix B). But with a sizeably higher likelihood, our model provides a much improved fit to data than SW07: M12 has 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 our preferred model M12, the model of best fit, as well as a comparison with those of the M0/SW07 benchmark; a full list of estimated parameters with their descriptions is given in Appendix A1.

Comparing M12 with M0/SW7, we note that the t-statistics of the parameters introduced in this paper (shown by N/A for M0/SW07) are in general strong. News features strongly and positively in the consumption equation (t-stat.=5.35). The labour

Table 2: The main differences between the 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_l	Labour substitution risk aversion	1.1582	1.6706
Z	Elasticity of the capital utilisation	0.3994	0.4687
Ψ/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: See Table 1 for the key features of the models and Appendix A1 for more details.

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 as modelled here 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 Impulse Response Functions (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 fiscal activism (the improved state of the economy exerts a negative effect on government spending), 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 fixed costs in production (Ψ/Ψ_0) and a much higher level of long-term labour.[12] 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 (q in equation 9 and M12 and other models in Appendices A1 and A2), and hence a more backward-looking consumption. Another motivation for such fiscal rule is that a smaller Y/Y_0 shows up whenever we 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 share of required fixed cost (i.e., investment) relative to total output.

We next review the Impulse Response Functions (IRFs) for our preferred model M12, shown in Appendix B. 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 (eg_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). 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 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

While the IRFs are shown in Appendix B, we show the economically more meaningful multipliers here; to this end, we describe briefly how we transform the IRFs into multipliers. The multipliers that theory and policy-makers are interested in are given as:

$$(Y_t\text{-}Y_0)/dG_0,$$

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. Output demand is given by (in obvious notation):

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

and

$g_t = \rho_g g_{t-1} + \varepsilon_{gt} + g_y \varepsilon_{at}$ + labour market-related variables (possibly) + 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 this might be taken to mean 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 presenting multipliers cast in terms of that, too.[13]

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 two 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 (M12), while the latter equation is identical except that it omits news in both the consumption equation and the fiscal rule.
- The second group presents the base model (M0/SW07) and M11. In M0, as there is no labour market indicator or news in the fiscal rule in this model, 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. M11 presents a contrast by adding news and labour market indicators to both the Euler equation and the fiscal rule.

The key point to emerge is that the consumption multipliers without news terms are negative (cf. M13 and M0) but positive in the presence of news. Correspondingly, the output multipliers (in bold) are higher and more persistent with news, as one would also expect from the positive consumption response. In terms of the normalisation, when that is by the total government spending (g0, as opposed to the fully exogenous portion of it eg_0) the multipliers are higher and generally above unity making them 'truly Keynesian' (a fuller discussion will be given shortly). 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). A second conclusion, drawn from comparing pair 1 (with a labour market indicator in the fiscal rule) and pair 2 (without) is that the output multipliers are marginally strengthened in the presence of a labour market indicator.

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 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.

A third type of adjustment concerns the treatment of trend. Recall that the theoretical multiplier is $(Y_t\text{-}Y_0)/dG_0$, 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, $Y_t\text{-}Y_0$ may be decomposed into two parts, a change alongside the trend, plus a deviation from trend. Now, the change alongside the trend should

Figure 3a: Multipliers (normalised by eg0 – no trend) from M12

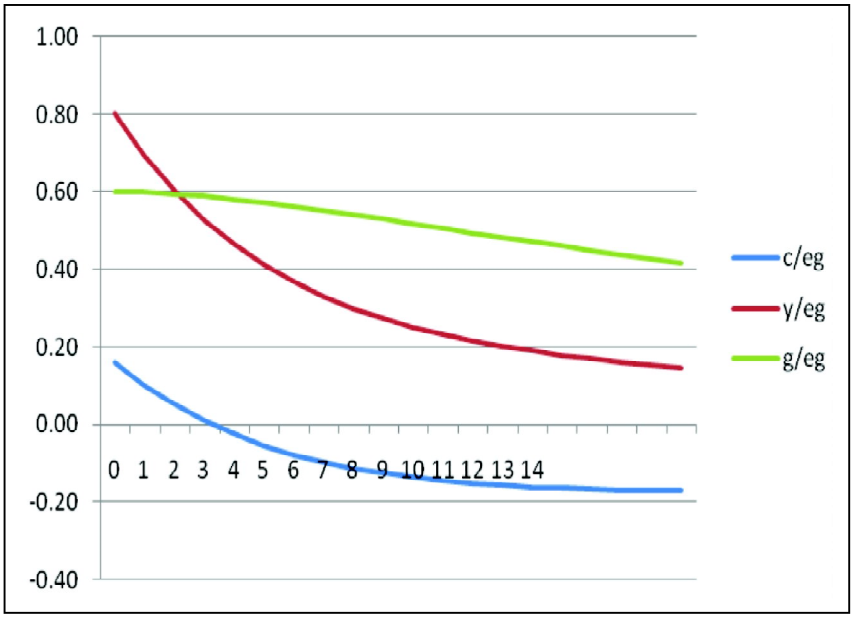
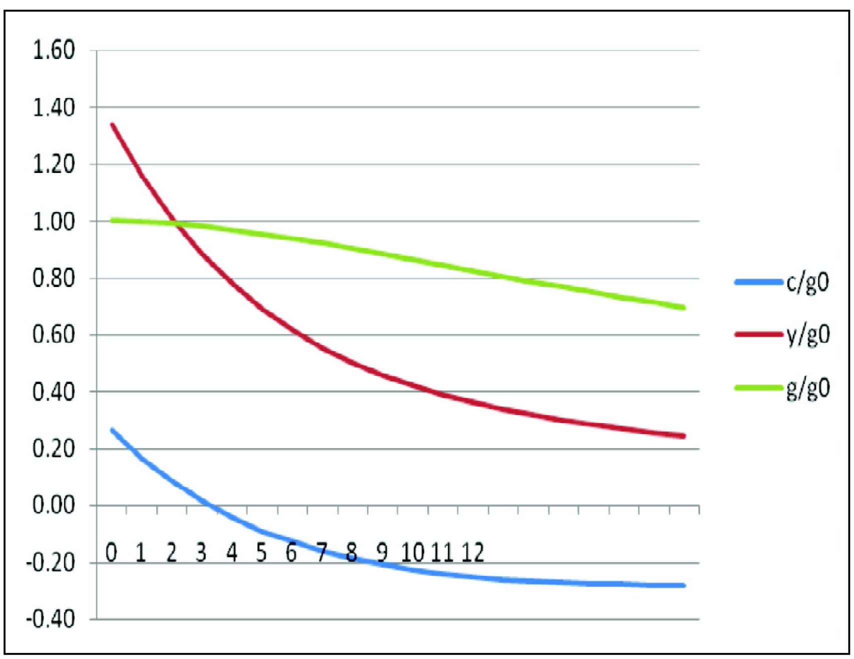


Figure 3b: Multipliers (normalised by g0 – no trend) from M12



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:

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

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 (e_{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) find an 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, while Blanchard and Leigh (2012) argue that they are plausibly between 0.9 to 1.7. Zubairy (2013) finds the government spending multiplier to be marginally above unity (1.07), largest on impact.

Our estimated parameters 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

Figure 4a: multipliers (normalised by eg0 – with trend) from M12

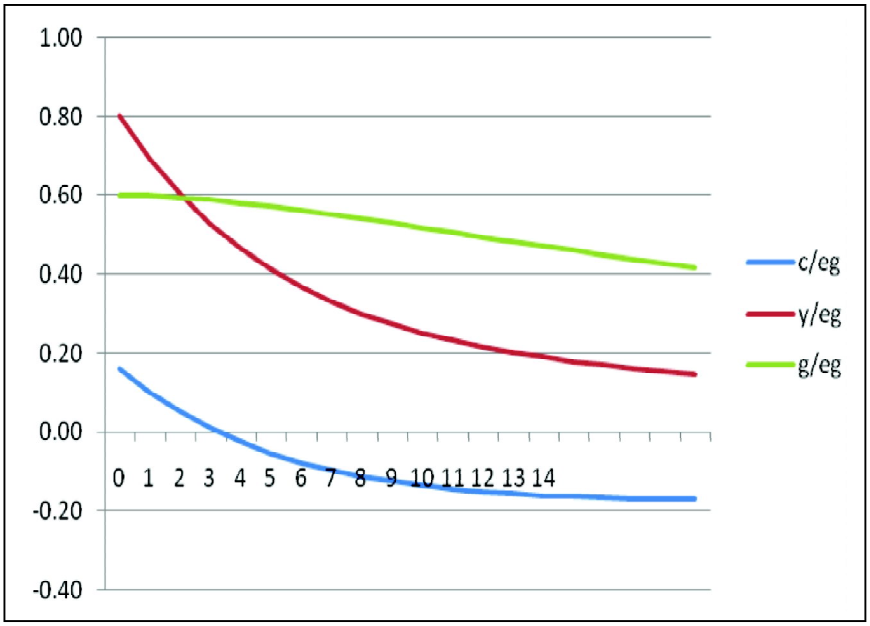
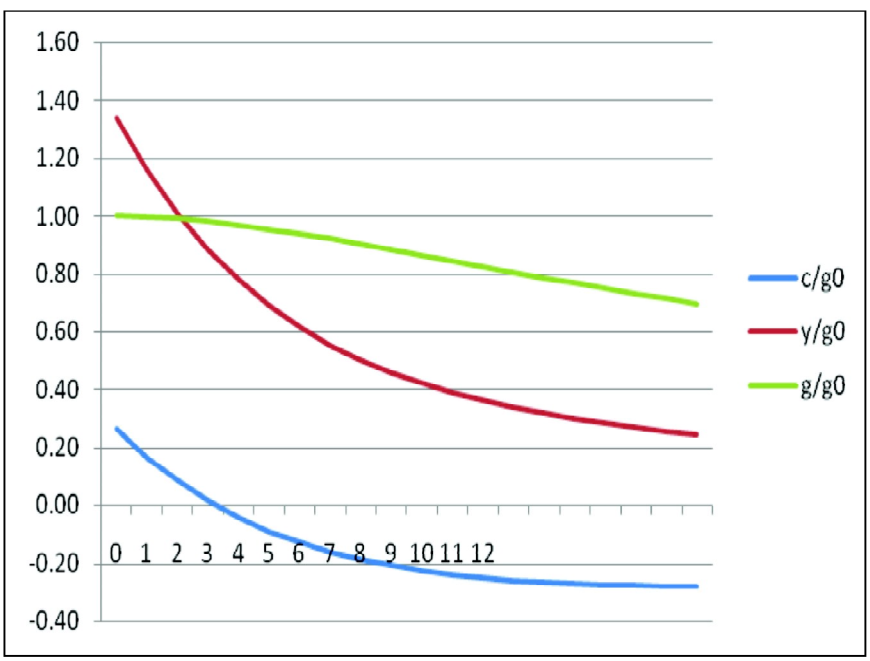


Figure 4b: multipliers (normalised by g0 – with trend) from M12



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 that it 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 of our estimated models with news, and is also exhibited in the consumption multipliers. Allowing for the effect of a secular trend increases somewhat this persistence. This is shown graphically in Figures 4 (a,b).

6. CONCLUSIONS

This paper's main objective is to estimate a medium-sized DSGE model which incorporates a novel formulation of 'news' and relate this to the fiscal multiplier. 'News' is modelled in a way that arguably presents an advance over previous literature and comes closer to the logic of a multiplier. The news term is essentially revisions of expectations about all future fundamentals. We augment the consumption Euler equation with that term as a way of capturing the notion of news as revision of the discounted sum of future incomes. An additional contribution of the paper, in line with some recent literature, is to consider a fiscal rule related to spending on goods and services (the 'G' of elementary macroeconomics); this rule formalises the stabilisation role of fiscal policy. We augment this rule by news and unemployment, which are innovations of this paper. The rest of the model is a standard New Keynesian DSGE model such as the SW07 model which has achieved 'canonical' status in this literature.

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 ability. Both these features therefore are supported by the data. The final strong message of this work concerns the fiscal multipliers that appear rather more 'Keynesian' than much neoclassical literature (Hall, 2009; Mulligan, 2010), and indeed some vintage New Keynesian literature (Dixon, 1988; Mankiw, 1988; Starz, 1989), has suggested. In all, our approach shows that both the news channel and an endogenous fiscal rule merit further investigation. The next step may be to extend this approach in various directions, e.g. by incorporating fiscal-monetary interactions (Kirsanova, Leith and Wren-Lewis, 2009), heterogeneity (the existence of non-Ricardian consumers as e.g. in Drautzburg and Uhlig, 2009; Mankiw, 2010), or information-related agent heterogeneity (see Levine, Pearlman, Perendia and Yang, 2012).

Notes

1. Monopoly profits exclude a 'normal' profit rate equal to the competitive interest rate. The underlying assumption here is that the financial valuation of assets (At) anticipates lifetime normal profits. This allows us to relegate monopoly profits to Xt, 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 (Dixon, 1988; Mankiw, 1988; Starz, 1989).
2. In the Obstfeld-Rogoff formulation, the gross growth rate of consumption (our $1+\gamma$) equals $(1+r)^{\sigma}\beta^{\sigma}$, where β is the discount factor and s the intertemporal elasticity of substitution. Determinants of consumption growth other than those accounted for in the standard iso-elastic utility case, such as the existence durable goods, adjustment costs, habits, to name a few, can also in principle affect g and F. For tractability, such considerations are ignored here.
3. To be accurate, the coefficient of ϕ_t is $1+r-\gamma\approx 1$; for simplicity, and because it is empirically possibly indistinguishable from a truly unit root, it has been set to unity.
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.
5. In particular, because (leads of) r_t and Δy_t are part of Ω_t, in order to avoid collinearity, they are dropped.
6. 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.
7. This activist fiscal rule operates in parallel with the standard Taylor rule for monetary policy; indeed, there may be fiscal-monetary policy interactions which are however outside the scope of this paper (see Dixit and Lambertini, 2003; Kirsanova *et. al.*, 2009).
8. As mentioned, using the output gap in (10) instead of any of (11a-e) gave inferior results; these are available on request.
9. 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*
10. 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.

11. 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, see the preceding Footnote).
12. Note that in SW07 notation, lower fixed costs in production are denoted F, rather than Y as here.
13. In other words, the fiscal rule (10) gt is analytically endogenous but (at least partly) exogenous as a policy instrument.

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Appendix A1: Estimates of the parameters in M12

Parameter		*M0/SW07*	*Posterior estimates*		*Priors*		
Label	*Description*	*Post. mean*	*Mean*	*St. err.*	*Distribution*	*Mean*	*St. err.*
ρ_a	Technology shock AR1 coefficient	0.9585	0.9426	0.0173	BETA	0.5	0.20;
ρ_b	Consumption preference shock AR1 coefficient	0.1623	0.476	0.1533	BETA	0.5	0.20;
ρ_g	Government spending shock AR1 coefficient	0.9688	0.9741	0.0099	BETA	0.5	0.20;
ρ_I	Investment cost shock AR1 coefficient	0.7038	0.7122	0.0604	BETA	0.5	0.20;
ρ_r	Interest rate shock AR1 coefficient	0.1311	0.1285	0.0654	BETA	0.5	0.20;
ρ_p	Mark-up disturbance AR1 coefficient	0.9405	0.9351	0.0392	BETA	0.5	0.20;
ρ_w	Wage shock AR1 coefficient	0.9771	0.9785	0.0109	BETA	0.5	0.20;
μ_p	Price markup	0.7861	0.798	0.0833	BETA	0.5	0.2;
μ_w	Wage markup	0.8683	0.878	0.0597	BETA	0.5	0.2;
φ	Steady-state elasticity of thecapital adjustment cost	5.3508	5.4984	1.2150	NORMAL	4	1.5;
σ_c	Consumption risk aversion	1.3027	1.333	0.1376	NORMAL	1.50	0.375;
H	Habit	0.739	0.7889	0.0430	BETA	0.7	0.1;
ζ_w	Probability of wage adjustment in period	0.7002	0.7056	0.0819	BETA	0.5	0.1;
σ_l	Labour risk aversion	1.6706	1.1582	0.6474	NORMAL	2	0.75;
ζ_p	Probability of price adjustment in period	0.6225	0.6782	0.0579	BETA	0.5	0.10;
i_w	Wage indexation	0.5894	0.5661	0.1364	BETA	0.5	0.15;
i_p	Price indexation	0.2447	0.2497	0.0976	BETA	0.5	0.15;
z	Elasticity of the capital utilisation	0.4687	0.3994	0.0926	BETA	0.5	0.15;
Ψ/Y_0	Fixed cost in production relative to output (F/Y_0 in SW07)	0.7054	0.5279	0.0845	NORMAL	0.25	0.125;
r_p	Inflation coefficient in Taylor rule	2.0619	2.0298	0.1741	NORMAL	1.5	0.25;
r_r	Interest rate coefficient in Taylor rule	0.8148	0.806	0.0259	BETA	0.75	0.10;
r_y	Output coefficient in Taylor rule	0.0846	0.0842	0.0245	NORMAL	0.125	0.05;
r_{Dy}	Lagged output difference coefficient in Taylor rule	0.2125	0.219	0.0292	NORMAL	0.125	0.05;
	Long term inflation (constant)	0.6107	0.6155	0.0662	GAMMA	0.625	0.1;
	Discount factor (b in SW07)	0.21	0.21	0.0917	GAMMA	0.25	0.1;
	Long term labour	0.2284	0.3773	1.1682	NORMAL	0.0	2.0;
γ	Growth Trend	0.4258	0.4217	0.0206	NORMAL	0.4	0.10;

g_y	Technology shock effect on government spending	0.6045	0.7363	0.1315	NORMAL	0.5	0.25;
α	Capital weight production function	0.2957	0.3202	0.0402	NORMAL	0.3	0.05;
g_u	Employment difference (11e) in the government spending rule	N/A	-0.1732	0.0916	NORMAL	0.01	0.2;
β	News in consumption	N/A	0.1463	0.0274	NORMAL	0.1	2.0;
g_w	News in the government spending rule	N/A	-0.26	0.0669	NORMAL	0.01	0.2;
	Std. error of AR1 shocks:						
η_a	Technology shock	0.4239	0.4433	0.0289	INV_ GAMMA	0.1	2;
η_b	Consumption shock	0.2469	0.0833	0.0425	INV_ GAMMA	0.1	2;
η_g	Government spending shock	0.5349	0.5566	0.0525	INV_ GAMMA	0.1	2;
η_q	Investment shock	0.4597	0.4575	0.0485	INV_ GAMMA	0.1	2;
η_r	Monetary (interest rate) shock	0.2410	0.2442	0.0151	INV_ GAMMA	0.1	2;
η_p	Inflation shock	0.1372	0.1376	0.0169	INV_ GAMMA	0.1	2;
η_w	Wage shock	0.2469	0.24	0.0223	INV_ GAMMA	0.1	2;
	AR1 shock to consumption propensity - normal economy	N/A	1.463	0.2288	INV_ GAMMA	0.1	2;
	AR1 shock to consumption propensity - frictionless economy	N/A	0.046	0.0188	INV_ GAMMA	0.1	2;

Notes: The results are based on Sims's 'scminwel' algorithm. On the whole, the labels conform to the notation of SW07.

APPENDIX A2: ROBUSTNESS CHECKS

In this Appendix, we show the results of estimation of a greater set of models to check robustness; in a nutshell, they corroborate the basic finding that news significantly improves the model's fit with the data. In addition to (9), we also estimate backward-looking consumption equation with news, essentially a flexible version of (7a):

$$c_t = \theta c_{t-1} + \beta(E_t - E_{t-1})\Omega_t + \varepsilon_t, \quad \theta>0 \tag{A2.1}$$

We estimate a number of variants of both the main estimable equation (9) and of the simplified backward-looking consumption with news (A2.1). As before, M0/SW07 is the baseline Smets-Wouters (2007) model and the variants here are labelled M1, M2, …, M12 in increasing order of complexity. The main message again is the improvement of the fit when news is incorporated, something that is obvious from 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 13) shows the improvements realised by augmenting the Euler equation by a news term. On the whole, the improvement in the fit comes from the incorporation of news in the fiscal rule and the consumption part of the model almost in equal measure. 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), compared with LL≈-925 from M0/SW07 and LL≈-910.5 from our model of best fit M12.

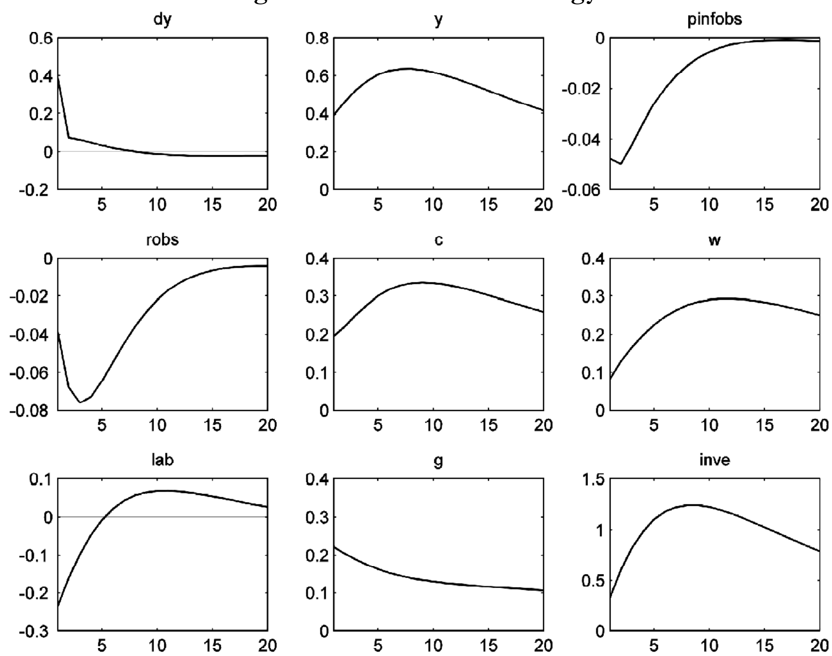
Table A2: Summary of estimated models

Rank	*Model*	*Features of consumption*	*Features of the fiscal rule*	β	g_w	g_u	*LL*	*MCMC 100,000 draws*
1	M12	Baseline (9)	News; (11e)	0.1463	-0.26	-0.1732	-910.513	-910.213
2	M11	Baseline (9)	News; (11a)	0.1634	-0.298	0.0265	-911.493	
3	M9	Baseline (9)	News; (11b)	0.151	-0.281	0.164	-911.918	
4	M7	Euler (8)	News; (11c)		-0.259	0.1592	-911.926	
5	M8	Baseline (9)	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	Baseline (9)	News;(11c)	0.1544	-0.265	0.1154	-912.331	
8	M4	Hybrid: Baseline (9) and bk-looking (13) 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: Baseline (9) and bk-looking (13) 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	Baseline (9)	No news (g_w=0); g_u=0	-0.024			-929.619	
14	M2	Bk-looking (13) with news	Only news (g_u=0)				Fails BK (1980)	

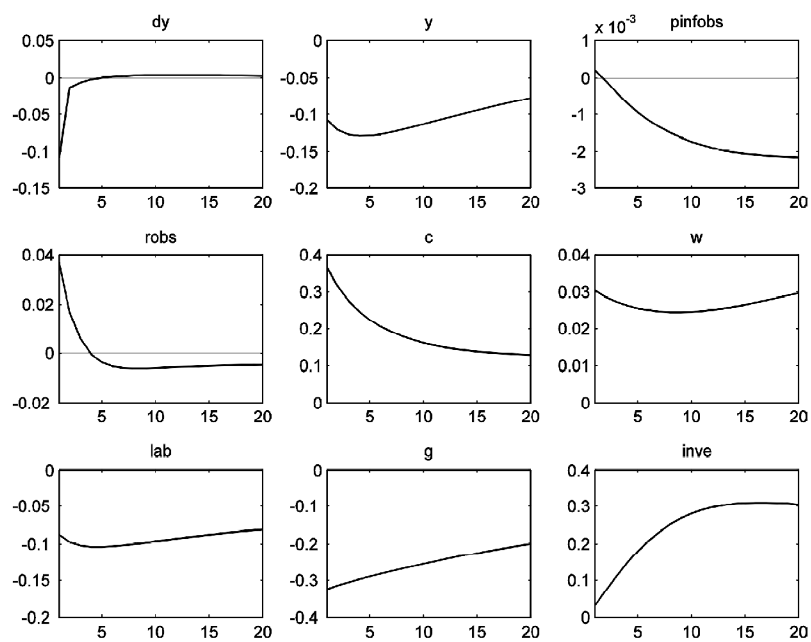
Notes: LL is Log-likelihood (Laplace approximation of log-data density using Sims's 'csminwel' log-likelihood maximisation algorithm); MCMC is the Laplace approximation of the log-data density obtained by the second-stage MCMC Metropolis-Hastings algorithm with 100,000 draws (unless stated otherwise,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

APPENDIX B: IRFS OF PREFERRED MODEL M12

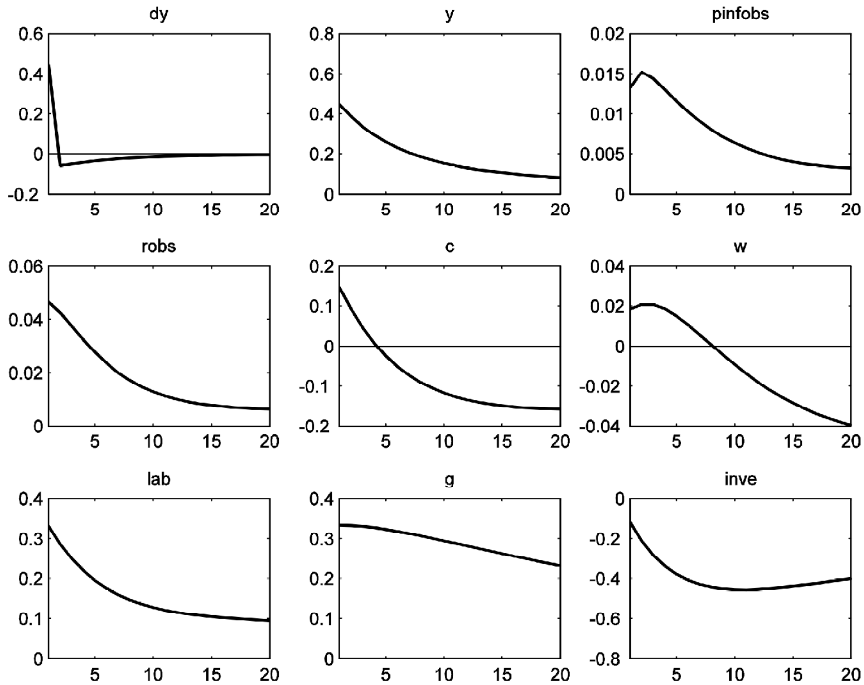
Figures Ba: Shock to technology:



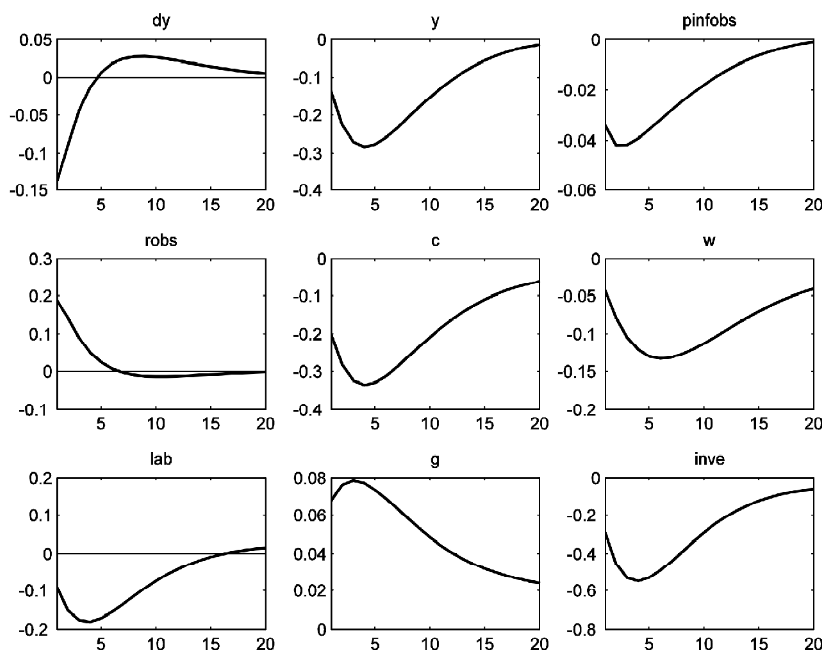
Figures Bb: Shock to news



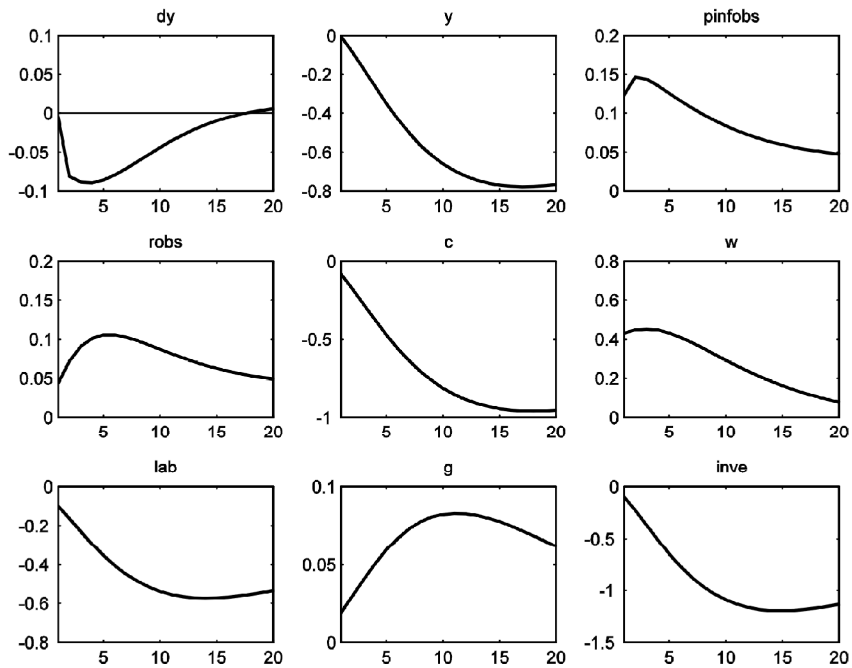
Figures Bc: Shock to the government spending



Figures Bd: Shock to monetary policy rate r



Figures Be: Shock to the wage w



Figures Bf: Shock to inflation