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Fiscal trade-offs: the relationship between output and debt in policy interventions

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Abstract

Implicit in fiscal policy debates is that there is a trade-off between output and debt outcomes; stimulus is at the expense of debt, and austerity at the expense of output. This paper theoretically and empirically investigates this trade-off through analysing the relationship between traditional output multipliers and 'debt multipliers' (the impact of policy on government debt). Theoretically the elasticity between the two is the marginal tax rate from movements of output in response to policy. This leads to two further hypotheses: first, if the marginal tax rate in the private sector is higher than that in the public sector, changes in government spending will result in a larger impact on debt than changes in taxes; and second, 'fiscal free lunches' are possible with recent estimates of the output multiplier. Indeed, empirically we find that tax revenues increase from exogenous tax cuts when the response of output is high.

1 Introduction

Fiscal policy has received much attention since the global financial crisis as many governments used stimulus packages in the face of depressed demand. Much of this academic and political attention has been in the form of debating the fiscal policy multiplier; the impact of changes in government spending and taxes on output. As budget deficits persisted, policy moved towards austerity as rising levels of debt became a key political narrative. Since then, debate has continued over best policy in a changing macroeconomic environment, with discussions largely concerned with the trade-off between output and debt objectives.

Implicit in these debates is that whereas austerity is bad for economic growth, stimulus is at the expense of higher government debt. There are two main objections to this: first, the relationship between policy and debt is not frequently analysed in the literature, where discussions tend to centre around the impact of policy on output; and second, there is a small literature suggesting that such trade-offs may not exist under certain circumstances. For example, some find empirical evidence that fiscal contractions can be expansionary to output (see for example Alesina et al. 2014), with theoretical transmission mechanisms coming from private agents' expectations about future government policy (see for example Blanchard 1990, McManus et al. 2017). Others find the potential for 'fiscal free lunches' where the economic environment is so conducive to fiscal stimulus that tax bases are increased to such a magnitude that there is no increase in debt as a result of fiscal stimuli (see for example Erceg & Lindé 2014, McManus et al. 2017).[1] These literatures investigate two outcomes where the trade-off between output and debt with respect to fiscal policy does not exist.

[1] In this paper, we use the expression 'expansionary fiscal contractions' to represent a fiscal contraction (cut in spending

The implicit assumption of a fiscal trade-off between output and debt objectives further requires investigation given high estimates of output multipliers in the recent empirical literature. Intuition suggests that a large response of output to policy would lead to large movements in the tax base of the economy, alleviating the financing constraint of any fiscal expansions; multipliers in excess of two have been recently estimated in many papers (see for example Romer & Romer 2010, Mertens & Ravn 2013, Cloyne 2013, Acconcia et al. 2014, among others). Further, there is a growing empirical literature estimating the impact of fiscal policy to be asymmetric over the business cycle, with larger output multipliers estimated during recessions, when there is slack in the economy (see for example Auerbach & Gorodnichenko 2012, Bachmann & Sims 2012, Caggiano et al. 2015). Asymmetric responses of output to fiscal interventions would suggest a varying degree of trade-off to policy over the course of the business cycle, providing scope for innovations to the design of optimal policy.

This paper develops a deeper understanding of the relationship between output and government debt as a result of fiscal actions to further consider the presence of the perceived trade-off between these two macroeconomic outcomes. It does this through applying three different methodologies; first, a simple government budget constraint is analysed to build benchmark intuition on the relationship between the two macroeconomic outcomes. This intuition is then tested and developed in a medium scale dynamic stochastic general equilibrium (DSGE) model, with a rich fiscal sector. Finally, the theoretical results are empirically tested applying datasets which have previously estimated large output multipliers.

The theoretical results hypothesise that in response to fiscal policy the elasticity of debt with respect the output multiplier is the negative of the marginal tax rate of the economy; that is, expansionary policy will increase government debt by the size of the policy less additional tax revenues as a result of increased output. This marginal tax rate is determined by both the sources and the level of taxes within an economy, and rigidities which influence transmission mechanisms of policy. Two implications arise from this theoretical hypothesis: first, with low levels of fiscal multipliers, changes in government spending will influence government borrowing more than changes in taxes, if the public sector pays taxes at a lower rate than the private sector. With low output multipliers, changes in government spending shift resources between the public and private sectors which has significant impacts on the budgetary consequences of policy. This result is complimentary with that which finds government spending cuts more likely to lead to 'expansionary fiscal contractions' compared to tax rises (see for example Alesina et al. 2014); although our result cannot talk to the empirical regularity of this distinction, it provides a theoretical framework through which this can occur, and further, through which these outcomes might be more discernible in the data. The second result derived from the theoretical intuition is that at levels of tax to GDP observed in OECD countries, potential 'fiscal free lunches' are possible with output multipliers recently estimated in the literature, and discussed above. Indeed, there is strong support for our theoretical model when it is tested against empirical data, and therefore, support for potential fiscal free lunches. Specifically, applying data from Romer & Romer (2010) - where output multipliers in excess of 3 were estimated - results suggest that total tax revenues increase in response to a tax rate decrease, when the output effects of the policy are large.

In addition to the contributions to both the 'expansionary contractions' and 'fiscal free lunches' literature, we further contribute to the growing body of papers finding asymmetric fiscal multipliers through quantifying

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or rise in taxes) which is met with a reduction in debt and no fall in output. Ee use 'fiscal free lunches' to represent a fiscal stimulus (a rise in spending or cut in taxes) which is met with lower in government debt. In both cases the outcomes are similar (favourable output and debt dynamics) but the initial policy action is different.

the corresponding influence this will have on policy trade-offs. A unit change in the output multiplier over the course of the business cycle (a change conservatively within the range of estimates, see for example Caggiano et al. 2015) reduces the trade-off of expansionary policy on government debt by 0.3 - 0.5 at current OECD tax rates; that is, deficit financed expansionary policy during recessions will come at a smaller trade-off if future contractionary policy is performed during economic expansions.

The paper proceeds in the following way. Section 2 builds a simple theoretical model with which to derive intuition of the relationship between output and debt in response to fiscal policy; this intuition is then tested through simulations of a medium scale DSGE model with a rich fiscal sector in Section 3. Section 4 empirically tests these theoretical relationships using narrative tax data for the US and UK. Section 5 discusses the results and Section 6 concludes.

2 Benchmark results

This section develops a set of benchmark results for the relationship between output and debt dynamics as a result of fiscal policy. A single equation approach is applied, analysing a government budget constraint to derive intuitive results; these results are then tested in the next section in a medium scale DSGE model with a rich fiscal sector.

Consider a simple government budget constraint where the level of debt (B_t) is the difference between government spending (G_t) and tax revenue (T_t) plus the interest and capital from previous debt ($R_{t-1}B_{t-1}$), where R_{t-1} is one plus the real interest rate, and where tax revenue is a proportion of national output ($\tau_t Y_t$):[2]

$$B_t = G_t - T_t + R_{t-1}B_{t-1} = G_t - \tau_t Y_t + R_{t-1}B_{t-1} \tag{1}$$

If this expression is totally differentiated with respect to G one gets:

$$\frac{\mathrm{d}B_t}{\mathrm{d}G_t} = \frac{\partial B_t}{\partial G_t}\frac{\mathrm{d}G_t}{\mathrm{d}G_t} + \frac{\partial B_t}{\partial \tau_t}\frac{\mathrm{d}\tau_t}{\mathrm{d}G_t} + \frac{\partial B_t}{\partial Y_t}\frac{\mathrm{d}Y_t}{\mathrm{d}G_t} + \frac{\partial B_t}{\partial B_{t-1}}\frac{\mathrm{d}B_{t-1}}{\mathrm{d}G_t} + \frac{\partial B_t}{\partial R_{t-1}}\frac{\mathrm{d}R_{t-1}}{\mathrm{d}G_t} \tag{2}$$

and noting that $\partial B_t/\partial G_t = 1$, $\partial B_t/\partial \tau_t = -Y_t$, $\partial B_t/\partial Y_t = -\tau_t$, $\mathrm{d}B_{t-1}/\mathrm{d}G_t = 0$ and $\mathrm{d}R_{t-1}/\mathrm{d}G_t = 0$ leaves:

$$\frac{\mathrm{d}B_t}{\mathrm{d}G_t} = 1 - Y_t\frac{\mathrm{d}\tau_t}{\mathrm{d}G_t} - \tau_t\frac{\mathrm{d}Y_t}{\mathrm{d}G_t}$$

Allow $\mathrm{d}\tau_t/\mathrm{d}G_t = 0$, that is, tax rates do not respond contemporaneously to changes in government spending; this simplifying assumption is temporary, and analysis from a fuller model will occur in the next section. Finally, letting the government spending output multiplier ($\mathrm{d}Y_t/\mathrm{d}G_t$) be represented by m_G one obtains:

$$\frac{\mathrm{d}B_t}{\mathrm{d}G_t} = 1 - \tau_t m_G \tag{3}$$

[2]Note that implicitly the assumption that output coincides with income is only true in a closed economy. The sensitivity of the results to a model with an open economy is studied further in Section 3.4 below.

Following a similar process totally differentiating (1) with respect to tax revenue:

$$
\begin{aligned}
\frac{\mathrm{d}B_t}{\mathrm{d}T_t} &= \frac{\partial B_t}{\partial G_t}\frac{\mathrm{d}G_t}{\mathrm{d}T_t} + \frac{\partial B_t}{\partial \tau_t}\frac{\mathrm{d}\tau_t}{\mathrm{d}T_t} + \frac{\partial B_t}{\partial Y_t}\frac{\mathrm{d}Y_t}{\mathrm{d}T_t} + \frac{\partial B_t}{\partial B_{t-1}}\frac{\mathrm{d}B_{t-1}}{\mathrm{d}T_t} + \frac{\partial B_t}{\partial r_t}\frac{\mathrm{d}R_{t-1}}{\mathrm{d}T_t} \\
&= \frac{\mathrm{d}G_t}{\mathrm{d}T_t} - Y\frac{\mathrm{d}\tau_t}{\mathrm{d}T_t} - \tau_t\frac{\mathrm{d}Y_t}{\mathrm{d}T_t}
\end{aligned}
$$

and noting that $\mathrm{d}\tau_t/\mathrm{d}T_t = 1/Y$, setting $\mathrm{d}G/\mathrm{d}T_t = 0$, and denoting the tax revenue output multiplier ($\mathrm{d}Y_t/\mathrm{d}T_t$) by m_τ one obtains:

$$
\frac{\mathrm{d}B_t}{\mathrm{d}T_t} = -1 - \tau_t m_\tau \tag{4}
$$

which is analytically similar to the result with respect to government spending. Taken together (3) and (4) state that the response of debt to changes in government spending and taxation are functions of how these two influence output, the tax base of the economy; higher output multipliers (m_G and m_τ) lead to smaller debt multipliers. When output responds strongly to policy, tax bases change which alleviates the government's budget constraint (1). In this respect, τ represents the marginal elasticity of tax revenue with respect to output; a unit increase in the output multiplier leads to τ additional (less) revenue from expansionary (contractionary) policy. Considering 'expansionary contractions', when output multipliers are zero ($m_G = m_\tau = 0$) the response of debt to changes in fiscal policy are one-for-one; that is, there is no movement in the tax base as a result of policy and as such government borrowing increases one-for-one with the fiscal change. On the other hand, when output multipliers reach a critical value ($m_G = m_\tau = 1/\tau_t$) changes in fiscal instruments have no contemporaneous impact on debt (potential 'fiscal free lunches').[3]

The above analysis assumes that the tax base is the whole economy and the government pays taxes on their transactions at the same rate as those in the private sector. Changing this assumption and taking it to the other extreme, we can assume that no taxes are paid in the public sector. Representing the output and the tax rate of the private sector by Y' and τ' respectively, and substituting these into (1), the equivalent of (3) and (4) become:

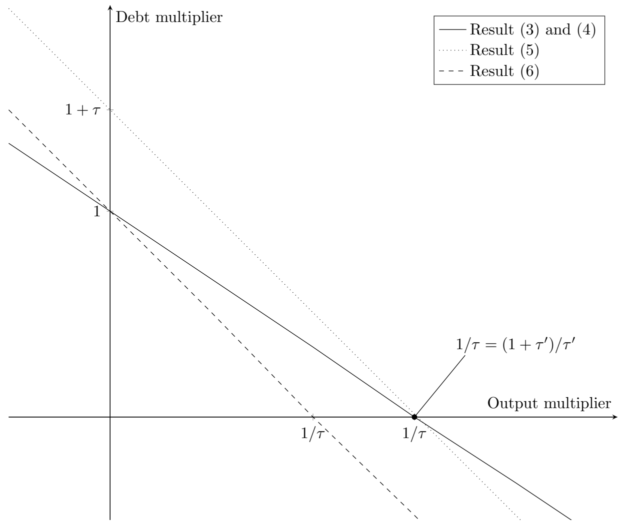
$$
\frac{\mathrm{d}B_t}{\mathrm{d}G_t} = (1+\tau'_t) - \tau'_t m_G \tag{5}
$$

$$
\frac{\mathrm{d}B_t}{\mathrm{d}T_t} = -1 - \tau'_t m_\tau \tag{6}
$$

These results are similar to those of (3) and (4) with two key exceptions. First, note that the constant on the impact of government spending changes on debt has increased from 1 to $1+\tau'$. This states that were

[3]The Haavelmo Theorem (Haavelmo 1945) suggests that a balanced budget government spending expansion can occur with an output multiplier of just one. To derive this result, a balanced budget is imposed such that $G = T$ and $\Delta G = \Delta T$, and therefore all additional economic activity must be taxed by the government. This reconciles with the result above as it is in effect imposing that $\tau_t = 1$. The Haavelmo Theorem states that balanced budget fiscal expansions can occur, although disposable incomes in the economy remain fixed as all additional activity is collected in tax revenues. DeLong & Summers (2012) use a model with hysteresis to demonstrate fiscal expansions can be self-financing with small output multipliers in a depressed economy, providing that they are accompanied by modest improvements in medium to long run growth.

Figure 1: Output and debt multipliers: single equation model



Graphical representation for the results identified in equations (3)-(6) where tax output multipliers have been multiplied by negative one in order to make them comparable to spending multipliers (therefore, a positive tax output multiplier in the graph represents the case where tax cuts lead to higher output). Note that if we let Y' and G represent output in the private and public sector (and therefore $Y = G + Y'$), and we let γ represent the share of private sector to total output ($\gamma = Y'/Y$) then if there were no debt in steady state, $T = G$ and $T/Y = \tau = 1 - \gamma$. Under these conditions, the ratio of tax revenue to the tax base (τ') is given by $(1-\gamma)/\gamma$. In this scenario, it is straight forward to demonstrate $1/\tau = (1+\tau')/\tau'$.

there to be no impact on output from policy ($m_G = 0$) an increase (decrease) in government spending would lead to a shift in activity from the private sector to the public sector leading to lower (higher) tax revenues; an output multiplier of one ($m_G = 1$) would lead to a one-for-one impact of policy on debt, as this is where there is no crowding in or out of the tax paying private sector. Note that this change in the constant is not present for the relationship between debt and tax based fiscal policy (6), as tax based policy does not experience the same issue of changing the share of the non-tax paying public sector.

The second difference in (5)-(6) from (3)-(4), is the elasticity of the debt multiplier to the output multiplier has changed from τ to τ'. Note that $\tau' \geq \tau$ ($T/Y' \geq T/Y$) because at the extreme the tax base of the economy is limited to total output ($Y \geq Y'$). This means that the elasticity between output and debt multipliers is higher in an economy where the tax base is less than total output, because tax rates are higher for a given level of revenue. As such, an increase in economic activity increases tax revenue at a higher marginal rate.

These results are presented in Figure 1 which is constructed under the assumption of no steady state debt in the economy and where the public sector pays no tax.[4] It is clear that the elasticity of debt multipliers to output multipliers is stronger when less tax is taken from the public sector. Further, it is illustrated that for a given output multiplier, the response of debt to a change in taxes is lower than of the response of debt to a change in government spending; if the public sector pays less taxes than the private sector, increasing the former at the expense of the latter will reduce tax revenues, all other things being equal. This

[4]These simplifying assumptions play no qualitative role in the relationships and allows for the identification of values in Figure 1 without needing to assume steady state debt levels and interest rates.

result is complimentary with the literature which finds that expansionary fiscal contractions are more likely with government spending cuts than tax rises (see for example Alesina et al. 2014); although the results in Figure 1 cannot talk to the empirical likelihood of a specific result, they do suggest that cuts in government spending will lead to higher reductions in debt compared to tax rises, all other things being equal.

To put these results in context, the average level of tax-revenue-to-GDP in OECD countries between 1965 and 2014 was 31.4%, with the country with the highest and lowest average over the period being Sweden (43.4%) and Mexico (13.8%). Over this period, average tax rates have increased decade-on-decade, with 26% of GDP taxed between 1965-69 compared with 33.6% between 2010 and 2014; the highest tax-revenue-to-GDP during the period was in Denmark in 2014 (49.6%) and the lowest in Turkey in 1970 (9.3%). At the mean average tax rate for 2010-2014, this would put an upper bound for potential 'fiscal free lunches' being possible with output multipliers of 3.0 using (3) and (4).

From this analysis, three intuitive results can be taken for further investigation: first, the elasticity of the response of debt to fiscal intervention with respect to the output multiplier is the negative of the marginal tax rate from additional output; second, providing the government pays taxes at a lower rate on their activities than the private sector, movements in government spending lead to larger responses of public debt compared to tax policy, for a given level of output multiplier; and finally, using empirical tax rates for OECD countries, fiscal free lunches are plausible with output multipliers recently estimated in the literature (see Section 1 above and Table 2 below). These results are tested in a fuller DSGE model in the next section.

3 General equilibrium analysis

The results from analysing a simple government budget constraint are clear and intuitive; this section builds upon these by extending the analysis to a medium-scale DSGE model. A fiscal authority with a rich set of instruments is embedded into an otherwise workforce DSGE model similar to that of Smets & Wouters (2003). The model contains: nominal rigidities in prices and wages; investment adjustment costs; a proportion of agents who consume hand-to-mouth ('non-Ricardian' households) and others who have full access to credit and capital in order to smooth consumption ('Ricardian' households); and a monetary authority following a Taylor rule. The model is then simulated over a number of calibrations using a Monte Carlo process and output and debt multipliers are calculated to determine if the relationship between these two identified above is consistent with this fuller model.

3.1 The model

The model applied is a Smets & Wouters (2003) framework with extensions of the inclusion of non-Ricardian households and a richer fiscal authority; a full description of the model equations can be found in Appendix A.1.[5] The conduct of fiscal policy is important to the results, and as such is discussed in more detail here. The fiscal authority allocates spending to public purchases of goods, investment, employment and transfers (G_t^C, I_t^G, N_t^G and TR_t, respectively) and collects revenue from taxes on consumption, labour income, capital income and employers' social security contributions (τ_t^c, τ_t^l, τ_t^k and τ_t^{er}, respectively). Thus, the government budget constraint is given by:

[5]'Non-Ricardian' households are increasingly common in the literature and agents who consume hand-to-mouth provide for models to generate a bigger range of fiscal multipliers; something important for the exercises to follow.

$$G_t^C + I_t^G + (1+\tau_t^{er})\, w_t N_t^G + TR_t = B_t - \frac{R_{t-1}B_{t-1}}{\pi_t} + \tau_t^c C_t + \tau_t^l w_t L_t + \tau_t^k r_t K_{t-1} + \tau_t^{er} w_t N_t \qquad (7)$$

where w_t and N_t represent the wage and quantity of labour in private production; R_t and π_t the nominal interest rate and inflation; and where C_t, L_t, r_t and K_t represent the level of consumption, total labour supply, the return on capital and the level of capital respectively.

A simple rule is applied for the evolution of each fiscal instrument ($x = \{G^C, I^G, N^G, TR, \tau^c, \tau^l, \tau^k, \tau^{er}\}$) where spending and taxes respond to: the business cycle (governed by the parameter $\varphi_{y,x}$); the level of debt (governed by the parameter $\varphi_{b,x}$); and by their own shock component (ε_x):

$$x_t = x\left(\frac{B_{t-1}}{B}\right)^{-\varphi_{b,x}}\left(\frac{Y_{t-1}}{Y}\right)^{-\varphi_{y,x}}\varepsilon_{x,t} \qquad (8)$$

$$\varepsilon_{x,t} = \rho_x \varepsilon_{x,t-1} + \eta_{x,t}$$

From the analysis above, the difference in results between (3)-(4) and (5)-(6) was the extent to which governments pay taxes similar to the private sector. A review of (7) identifies that: governments do not pay taxes on consumption, unlike the private sector; neither the public nor private sector pay taxes on investment, but whereas the private sector pays taxes on the income from this investment, the public sector does not; employees and employers of both the public and private sector pay the same taxes; and, the extent to which transfers relate to additional tax revenue (at least in the first instance) is determined by the actions of households on how to allocate these transfers. All these assumptions are common in the literature (see for example Coenen et al. 2012) and provide a range of scenarios against which to test the intuition of the difference between (3)-(4) and (5)-(6).

The model is simulated under different calibrations of parameters and cumulative multipliers as a result of fiscal shocks ($\eta_{x,t}$) are recorded through the following equation:

$$m_k^n = \frac{\sum_{j=0}^n (k_{t+n} - k_0)}{\sum_{j=0}^n (x_{t+n} - x_0)} \qquad (9)$$

where n is the time horizon over which multipliers are calculated, k is the macroeconomic variable of interest, x is the fiscal instrument in question, and where both k_0 and x_0 represent their respective steady state values. When $k = Y$ output multipliers prevail whereas when $k = B$ debt multipliers are achieved. In the case of government spending instruments, the monetary value of the changes in spending are used in the denominator of (9); for tax instruments, the denominator in (9) is the change in tax revenue that would prevail in an economy where all other variables are at their steady state, apart from the tax rate in question. This way, changes in output as a result of fiscal policy only impact the the numerator of (9) which allows multiplier values to be comparable between those coming from changes to government spending and those from changes in taxation; this is the approach taken in McManus et al. (2017).[6]

[6]Note that if ex-post tax revenues were to enter the denominator of (9) to measure tax multipliers, both the numerator and denominator will change as a result of differing impacts on output. As this would not occur for changes in government spending, where the shock in spending is fixed but the impact this has on the economy will effect tax revenues, it is preferable to have a measure where tax multipliers and government spending multipliers are comparable.

3.2 Calibration and simulations

In order to consider the relationship between output and debt responses to fiscal policy in this DSGE framework, a number of calibrations of the above model are applied to derive a range of output and debt multipliers over different time horizons. For benchmark results, the economy is calibrated to the US for which the existing literature provides substantial guidance, and which is consistent with the empirical work in Section 4 which uses data from both the US and UK; the results are robust to other calibrations, including to calibrating the model to the UK, as demonstrated in Section 3.4. For these calibrations, a Monte Carlo simulation is run calling values from distributions for each parameter in the model. Each parameter is modelled to come from a distribution which is calibrated to have the same first and second moments of the posterior distribution for these parameters estimated in Smets & Wouters (2007). The distributions used for each parameter can be found in the Appendix A.2. Using this Monte Carlo method, the intuition derived from Section 2 can be tested in this richer macroeconomic model.

For the calibration of steady state fiscal values, we use Trabandt & Uhlig (2011); specifically, the share of government consumption, investment, and public employment to GDP is set at 0.15, 0.04 and 0.10 respectively, and taxes on consumption, labour, capital and employers' social security contributions are set at 0.05, 0.2, 0.36 and 0.07, respectively. With debt to (annual) GDP calibrated to 60%, this leaves the ratio of transfers to GDP being set by the model at 0.10.[7] For benchmarks results we fix the calibration of those parameters in the fiscal rules: debt aversion ($\varphi_{b,x} = |0.1|$) is set low which is both consistent with empirical observations (fiscal instruments respond slowly to debt) and calibrations in other estimated models; policy is set to be mildly counter-cyclical ($\varphi_{y,x} = |0.2|$); and fiscal persistence is calibrated in line with estimates from the literature ($\rho_x = 0.85$).

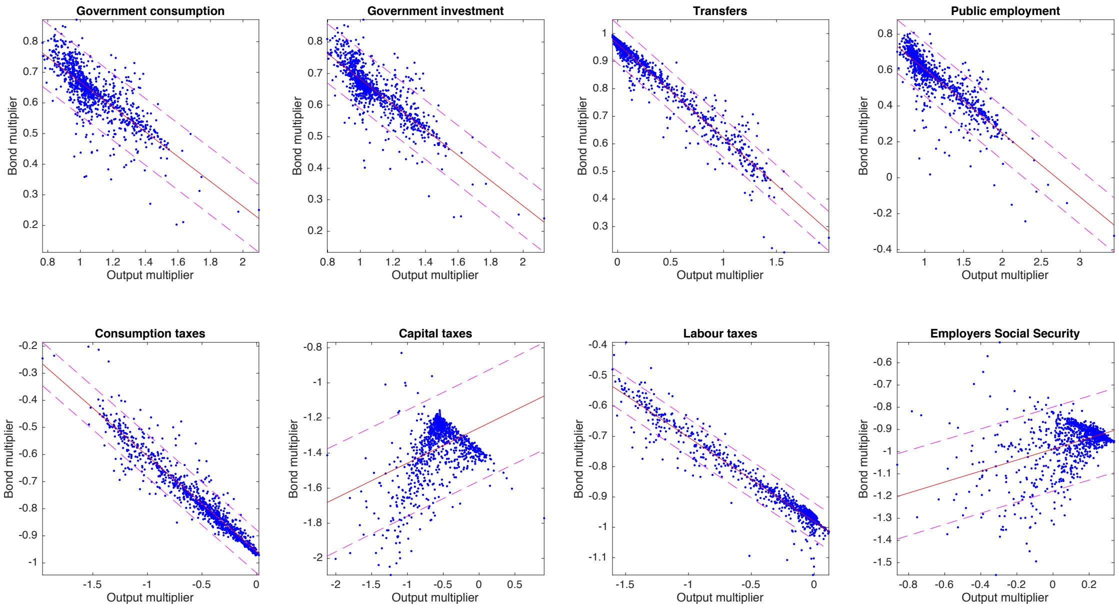
3.3 Results

Intuitively, there are two main differences between the DSGE model and the analysis performed in Section 2, that will influence the relationship between debt and output movements: first, the presence of distortionary taxes means that fiscal revenue is now derived from a number of sources, and movements in tax rates change incentives in the economy; and second, the DSGE model includes other rigidities within its transmission mechanisms which can provide a further wedge in the relationship between output and tax revenues. For example, both revenue from labour income taxes and employer social security contributions are a function of wages, which are themselves subject to stickiness. Further, whereas capital taxes have a direct impact on the investment decisions of agents, capital income taxes are taken from the stock of capital in (7) and not the flow of investment.

Figure 2 presents results from the Monte Carlo exercise calibrating the DSGE model over a 1,000 different simulations and deriving output and debt multipliers for the eight fiscal instruments in the model. In each panel: a point represents results for four quarter cumulative output (x-axis) and debt multipliers (y-axis); the solid line represents an estimated line of best fit across these multiplier coordinates; and the dashed lines represents 95% confidence intervals for this line of best fit. Considering the first row in Figure 2, that which refers to government spending instruments, the main relationship found in (3)-(6) is obtained; that is, higher output multipliers lead to lower debt multipliers as movements in the tax base reduces the trade-off between

[7] Data from the World Bank gives the average ratio of government debt to GDP in the US between 1990 and 2016 at 59.4%.

Figure 2: Four quarter cumulative output and debt multipliers in DSGE simulations



Figures illustrating four quarter cumulative output and debt multipliers in DSGE simulations for the eight fiscal instruments. For each iteration of the model a new calibration of parameters is randomly assigned from distributions set to match those estimated in Smets & Wouters (2007). A line line of best fit is plotted with 95% confidence bounds.

financing and GDP as a result of fiscal policy.[8] In general, there is a strong correlation between output and debt multipliers for government spending instruments: correlation coefficients of -0.78, -0.81, -0.97 and -0.86 are recorded for the four instruments as laid out in Figure 2.

The relationship between output and debt multipliers is less consistent for tax instruments, as illustrated in the bottom row of Figure 2. The difference in results is due to the fact that distortionary taxes change incentives and this is further compounded by the rigidities in the model. Whereas the relationship predicted in Section 2 is present for consumption and labour taxes, it is absent for capital taxes and employer social security contributions.[9] These latter two taxes influence the first order conditions of producers and the allocation between capital and labour in the economy. As discussed above, changes in allocations between labour and capital can create distortions between output in the economy and the tax base; whereas capital taxes influence investment decisions (and expenditure on investment goods directly contributes to GDP), taxes are taken on the stock (and not flow) of capital. For example, an increase in capital taxes leads to an increase in labour and consumption tax revenue (as resources are allocated away from capital and into labour), with only modest short run reductions in capital income taxes as the stock of capital is slow to respond to investment. Therefore, distortions which result in different allocations between capital and labour drive a wedge between output and tax bases in this economy. Over the short run, the immediate

[8]Different fiscal policies stimulate different sources of tax revenue: increases in government consumption and investment lead to more revenues from labour and capital taxes; increases in transfers and public employment lead to increases in revenue from consumption and labour income taxes.

[9]Employer social security contributions have positive multiplier estimates on average leading from a crowding out of investment as a result of a cut in these taxes (as labour becomes relatively cheaper) and the fact that the cost of public employment (including taxes) is included in the GDP calculation.

impact of changes of these distortionary taxes can lead to the intuitive relationship between output and budgetary outcomes from changes in tax rates to break down. This, therefore, means that there is less consistent results between output and debt multipliers for tax instruments in general in the model compared to spending instruments: correlation coefficients of -0.96, 0.39, -0.97 and 0.42 are recorded across the four tax instruments as presented in Figure 2.

In order to better evaluate the consistency of results from Section 2 to the DSGE model, Table 1 presents metrics on different lines of best fit for the relationship between output and debt multipliers (similar to those in Figure 2) over four different time horizons: one, four, ten and twenty quarters.[10] The first result from Section 2 was that the elasticity of the debt multiplier with respect to the output multiplier will be the negative of the tax share in the economy. In the calibration of the model, this tax share is 0.32 and for spending instruments the elasticity is stronger than this, especially in the short run (an average of -0.37 for ten quarter cumulative multipliers). This result is driven by the fact that the government does not pay taxes on its activity as much as the private sector, and therefore this result is consistent with (5)-(6). For tax instruments, the estimated elasticity is lower than predicted, and this is driven by the distortionary nature of taxes in the economy leading to a weaker relationship between output and tax revenues. Note also that as the time horizon over which multipliers are being measured increases, the results from all four tax instruments converge. This demonstrates that as time extends over a longer horizon, giving the distortionary consequences of tax policy scope to work through the economy, the intuitive relationship between output and debt is present for all four instruments (and not just labour and consumption taxes).

Table 1: The relationship between debt and output multipliers over time

	Elasticities			Constant			Free lunches			Correlations		
Qrt	Spend	Tax	Tax^{c,l}	Spend	Tax	Tax^{c,l}	Spend	Tax	Tax^{c,l}	Spend	Tax	Tax^{c,l}
1	-0.38	0.21	-0.38	1.01	-1.13	-1.00	2.68	-0.38	-2.65	-0.87	-0.29	-0.98
4	-0.38	-0.05	-0.32	1.02	-1.05	-0.97	2.72	1.00	-3.12	-0.86	-0.28	-0.96
10	-0.37	-0.25	-0.26	1.00	-0.92	-0.9	2.74	-4.26	-3.61	-0.86	-0.87	-0.92
20	-0.32	-0.26	-0.21	0.91	-0.88	-0.83	2.85	-3.51	-4.06	-0.87	-0.91	-0.87

Key statistics on the relationship between debt and output multipliers over time from DSGE simulations, aggregated by government spending instruments ('Spend'), tax instruments ('Tax') and just consumption and labour taxes ('Tax^{c,l}'), those two taxes which display the expected relationship in Figure 2. 'Elasticities' relates to the mean average debt multiplier elasticity with respect to the output multiplier across the fiscal instruments; 'Constant' the mean average value of the debt multiplier when the output multiplier is zero across the instruments; 'Free lunches' the mean average value of the output multiplier where it is estimated that the debt multiplier is zero; and 'Correlations' the mean average correlation coefficient between debt and output multipliers across the fiscal instruments in the simulations. These are taken over one, four, ten and twenty quarters, as displayed in the first column.

The second relationship predicted in Section 2 is that, all other things being equal, a change in government spending will have a bigger impact on debt than a similar change in taxes. This result is only moderately supported in the DSGE analysis. At low values of the output multiplier, Table 1 illustrates that spending based instruments have a higher (in absolute terms) 'constant' than tax based instruments (when $m_G = m_T = 0$). This is consistent with the relationship predicted in (5) and (6). Moreover, the policies where

[10]Note that Table 1 only presents information on the relationship between output and debt multipliers, and not the value of these multipliers themselves. These are in line with the existing literature (see for example Coenen et al. 2012) and are available on request.

these constants are larger (government consumption and investment) are those where the government pays no taxes on their activities, unlike the private sector; this further supports the intuition from (5) and (6). The higher elasticity of the debt multiplier with respect to the output multiplier for government spending instruments, however, means that when output multipliers are higher, spending based policy will have a smaller impact on debt than tax based policy. This is demonstrated in lower levels of output multipliers estimated to result in fiscal free lunches for government spending instruments in Table 1. The rigidities in the model, and specifically the presence of distortionary taxation, makes this part of the intuition derived from the difference in results from (3)-(4) to (5)-(6) to break down.

The final relationship predicted in Section 2 is that fiscal free lunches would be possible within the range of recent estimates of output multipliers. For both government spending and tax based instruments, short run multipliers in excess of 2.5 are predicted to lead potential fiscal free lunches, which are towards the higher end of some recent multiplier estimates, but not outside the range of estimates (see Section 5 below). In general, although there are some differences deriving from the presence of distortionary taxes in the economy, the results from the DSGE model are broadly consistent with those from Section 2.

3.4 Sensitivity

The relationship between output and debt multipliers is dependent on the calibration of fiscal parameters in the model. A higher steady state tax share in the economy leads to a lower (larger in absolute terms) elasticity of debt multipliers, as predicted in Section 2.[11] Further, a lower elasticity is experienced when policy is more counter-cyclical ($\varphi_{y,x}$) and is more adverse to debt ($\varphi_{b,x}$); these two results come from the fact that under both conditions other fiscal instruments respond quicker to the initial fiscal shock and therefore debt is moved more quickly to steady state levels.[12] Finally, a higher level of fiscal persistence (ρ_x) leads to a lower elasticity of debt multipliers with respect to output multipliers. This is driven by the latter being lower with higher shock persistence as more of the fiscal intervention is anticipated as it prolongs in the economy; debt multipliers, however, remain similar independent of fiscal persistence.

Beyond fiscal policy calibrations, monetary policy parameters have the next most importance in determining the relationship between output and debt as a result of fiscal intervention. Higher levels of monetary policy persistence (ρ) and lower aversions of the Taylor rule to deviations in inflation (ρ_π) and output (ρ_y) lead to lower movements in debt for a given multiplier, on average, across the eight fiscal instruments.[13] In each case, monetary policy is less responsive to the fiscal action leading to lower interest rates and thus, both lowering interest obligations for the government and less crowding out by private agents. Beyond fiscal and monetary policy calibrations, movements in other parameters are of less importance for the relationship between output and debt multipliers. Of the remaining non-policy calibrations, the stickiness in both prices and wages are the most important parameters. Higher levels of stickiness tend to increase output multipliers, especially for government spending based policies but have little impact on budgetary outcomes. Beyond this, individual parameter calibrations can effect the average multiplier values, but have a limit impact on

[11] Note, however, that differences in the level of steady state government debt (calibrated at 60% of GDP) has limited impact on those results presented above.

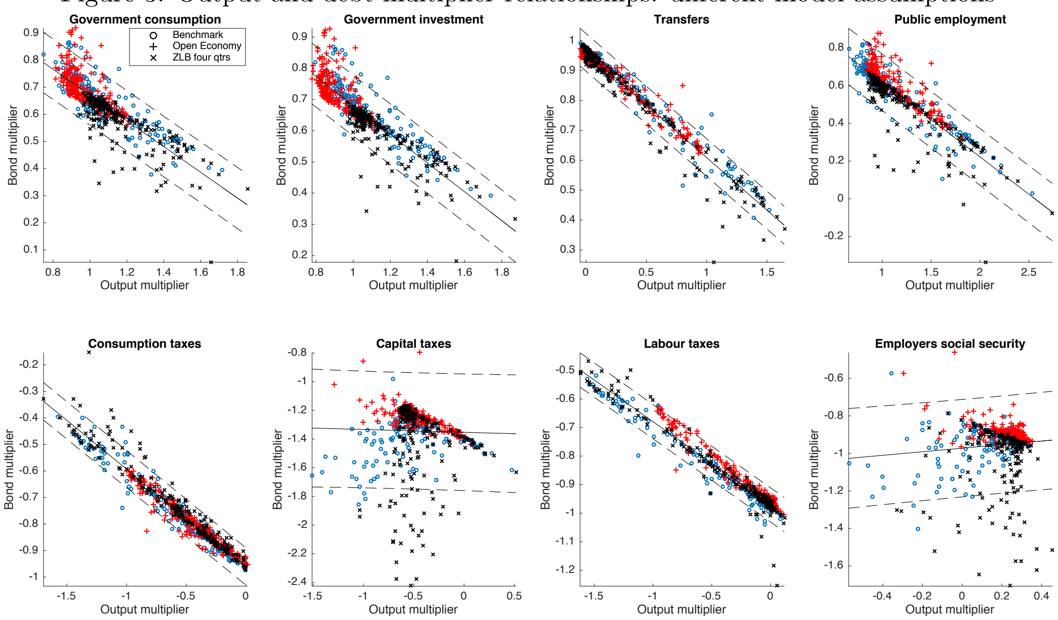
[12] Notice these parameters will influence $\mathrm{d}\tau_t/\mathrm{d}G_t$ and $\mathrm{d}B_{t-1}/\mathrm{d}G_t$ in (2), the automatic stabilisers of other fiscal instruments to movements in both output and debt.

[13] Notice these parameters will influence $\mathrm{d}R_{t-1}/\mathrm{d}G_t$ in (2), that is, the impact of fiscal policy on the interest payments on debt.

the relationship between output and debt multipliers.[14]

Despite the above analysis providing a theoretical framework with which to consider the relationship between output and debt, the variation in output multipliers is not in line with the extremes in both the empirical and theoretical literature. Figure 3 presents similar results as above containing: simulations from the benchmark model; a model which is extended to include a four quarter monetary policy zero lower bound; and an open economy model. These latter two extensions represent models which are commonly found in the literature to lead to both higher and lower fiscal output multipliers respectively. The results for government spending output multipliers follow the established intuition with those in the open economy being smaller than benchmark (as imports are a withdrawal from the system) and higher than benchmark when the monetary zero lower bound is binding (as unresponsive monetary policy limits crowding out and additional inflation lowers real interest rates). This intuition does not uniformly follow to tax output multipliers as fiscal expansion at the zero lower bound can have deflationary impacts which can lead to a rising real interest rate; these results are in line with Eggertsson (2010) and McManus et al. (2017).

Figure 3: Output and debt multiplier relationships: different model assumptions

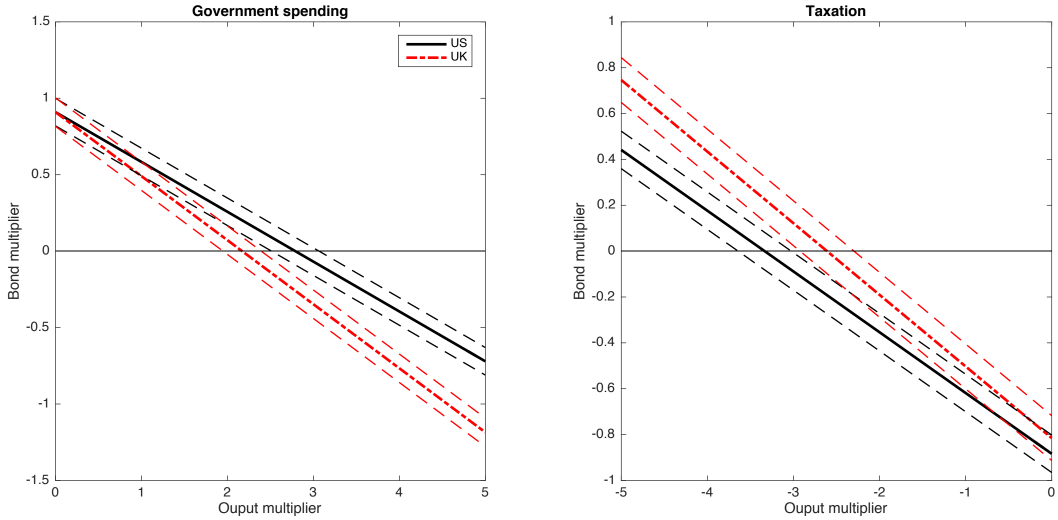


Results similar to those presented in Figure 2 now extended to include: the benchmark results; a model with international trade; and a model with the monetary zero lower bound binding for four quarters. Results for each are represented by a different symbol, as indicated in the legend.

These extensions, however, have little effect on the relationship between output and debt multipliers with similar elasticities being observed in all instruments; the results are robust to these extensions. Stronger elasticities between debt and output multipliers at the monetary zero lower bound are observed (which is consistent with Erceg & Lindé 2014, McManus et al. 2017, who find fiscal free lunches at output multipliers

[14]For example, a higher share of non-Ricardian households leads to higher output multipliers (most noticeably in the case of changes in transfers and labour taxes) and therefore lower debt multipliers; however, the relationship between output and debt remains consistent, independent of the calibration of these agents. Hayo & Neumeier (2017) present results from a survey of households to suggest rule-of-thumb behaviour is prevalent in Germany.

Figure 4: Twenty quarter cumulative output and debt multipliers in DSGE simulations: aggregation



Figures illustrating twenty quarter cumulative output and debt multipliers in DSGE simulations aggregating both 'government spending' and 'taxation' instruments by giving equal weights to each of the instruments from Figure 2. A line of best fit is plotted and extrapolated with 95% confidence bounds. Results presented for a model calibrated to the US and UK economy.

of approximately 2) which is as a result of lower interest rates arising from (for example) expansionary policy, as interest rates are temporary fixed to zero. Although lower average output multipliers are observed in an open economy where some of domestic incomes are spent on imports, the elasticity between output and debt multipliers remains consistent with those observed in Figure 2. The fiscal authority in the open economy still collects revenue from the same sources and therefore the mechanisms are similar to those from the closed economy, the difference now only comes from the higher marginal propensity to withdraw from the domestic economy leading to lower output multipliers (and correspondingly, higher debt multipliers).

Finally, the DSGE model was calibrated to the UK economy, and a similar Monte Carlo simulation performed using the posterior estimates for parameters from Smets & Wouters (2003).[15] Figure 4 presents results for twenty quarter cumulative multipliers where the four government spending and four tax based fiscal instruments have been aggregated (similar to Table 1). The results from a model calibrated to the UK are consistent with those from the US, with similar relationships between output and debt in response to fiscal policy, and similar confidence ranges. A higher elasticity between output and debt multipliers is observed for the UK, and this is consistent with the theory from Section 2 as the UK is calibrated to have higher levels of tax in the economy than the US (37.6% tax revenues to GDP for the UK compared to 31.9% in the US).

In all, the theoretical results and intuition form (3)-(6) is maintained in this bigger general equilibrium framework where higher output multipliers are associated with lower debt multipliers as increases in tax bases leads to more muted revenue responses to fiscal expansions. Variation in this relationship comes from both

[15] We use Bhattarai & Trzeciakiewicz (2017) to calibrate the fiscal parameters in the UK economy; namely, the shares of government consumption, investment, public employment and transfers to GDP are calibrated to 0.2, 0.02, 0.10 and 0.16, and taxes on consumption, labour, capital and employer social security contributions are calibrated at 0.2, 0.18, 0.29 and 0.07, respectively. This leaves an average tax revenue to GDP ratio of 37.6% in steady state, which is close to the EU average between 1965 and 2014 37.1%, using data from the OECD.

distortions in taxation and rigidities in the model, and this variation is seen to diminish when multipliers are measured over longer time horizons. The next section tests the relationship between output multipliers and tax revenues empirically to see if the theoretical results are robust to observed dynamics.

4 Empirical analysis

4.1 Identification strategy

As frequently discussed in the empirical literature (see for example Blanchard & Perotti 2002), there is an endogeniety concern when identifying the consequences of fiscal actions because were policy to be counter-cyclical (expansionary in bad times and contractionary in good times), there would be a downward bias on estimates of the output effects of policy. In response to this, Romer & Romer (2010) develop a dataset for classifying US tax changes between those which are endogenous to the business cycle (those which seek to influence short term growth) and those which are exogenous (performed for reasons beyond short run growth) by analysing announcements about the policies (for example, presidential speeches, executive-branch documents and congressional reports); this data was extended to UK tax changes by Cloyne (2013).

These datasets are used to analyse the theoretical relationships developed above for two main reasons: first, the exogenous nature of the data allows for robust inference of these policy changes; and second, output multipliers in excess of 2.5 are found in both Romer & Romer (2010) and Cloyne (2013) which the theoretical results above suggest would lead to a limited response of debt to fiscal interventions. Although the magnitude of these results are not unique in the literature (see Table 2 below) this additional element of the data is beneficial in testing the robustness of theoretical relationships identified above. That is, conditional on the model above being quantitatively accurate, the application of the same data and processes which finds output multipliers in excess of 2.5 should lead to limited movements in government debt in response to changes in tax policies.

The effects of a tax shock are estimated utlising the following VAR:

$$X_t = A_0 + A_1 t + B(L)X_{t-1} + C(L)d_t + e_t \tag{10}$$

where d_t are the exogenous tax shocks whose size, timing and motivation is determined from narrative records and where X_t is a vector of macroeconomic variables; $B(L)$ and $C(L)$ are lag polynomials with P and $Q+1$ lags respectively, and t is time. The tax shocks d_t from these narrative studies are scaled by their projected impact on tax liabilities as a fraction of total output; these projections are based on official calculations assuming that the tax base remains the same. Specification (10) is line with that of Cloyne (2013) and similar to that of Romer & Romer (2010). As a benchmark, Romer & Romer (2010) include only quarterly output growth in X_t and set $P = 0$. Cloyne (2013), on the other hand, include output, consumption and investment in X_t for their benchmark set of results. In both papers $Q = 12$ and both test their results to the inclusion of other control variables in the specification. Our benchmark specification is to include a VAR with output, consumption and investment as well as a measure of budgetary outcomes; however, sensitivity will be conducted to cover a number of separate specifications applied in the literature.

Where possible, we apply the same data used in the original studies of Romer & Romer (2010) and Cloyne (2013). The exception to this is a measure of the budgetary consequences of policy, which Romer &

Romer (2010) and Cloyne (2013) do not consider. This is our key focus, and the inclusion of these outcomes is the empirical contribution of the paper. For benchmark results, we use quarterly tax revenue to measure the impact of exogenous tax changes on debt for two main reasons: first, it is the impact that fiscal policy has on the tax base through which the theoretical dynamics above work, and therefore using tax revenues can test this relationship directly; and second, quarterly data on tax revenues for the US and UK is available for a longer time horizon than data on government debt.[16]

4.2 Results

The first column of Figure 5 illustrates the cumulative output impact of a one percentage point increase in tax to GDP in the US (the top row) and the UK (the bottom row) respectively. In the case of the former, a peak fall in GDP of 2.4% is observed after ten quarters, with similar effects for the UK. This figure is slightly lower than that of Romer & Romer (2010) who estimate a peak multiplier of over 3; however, Romer & Romer (2010) use a single equation version of (10), and once control variables are included, VAR estimates are in line with ours (see Cloyne 2013). As is illustrated in the third and fourth columns of Figure 5, both consumption and investment are estimated to fall in response to an exogenous tax rate increase, where the latter is seen to respond more strongly; this is consistent with the results identified in both Romer & Romer (2010) and Cloyne (2013) where investment is seen to respond more to exogenous tax shocks compared to consumption.

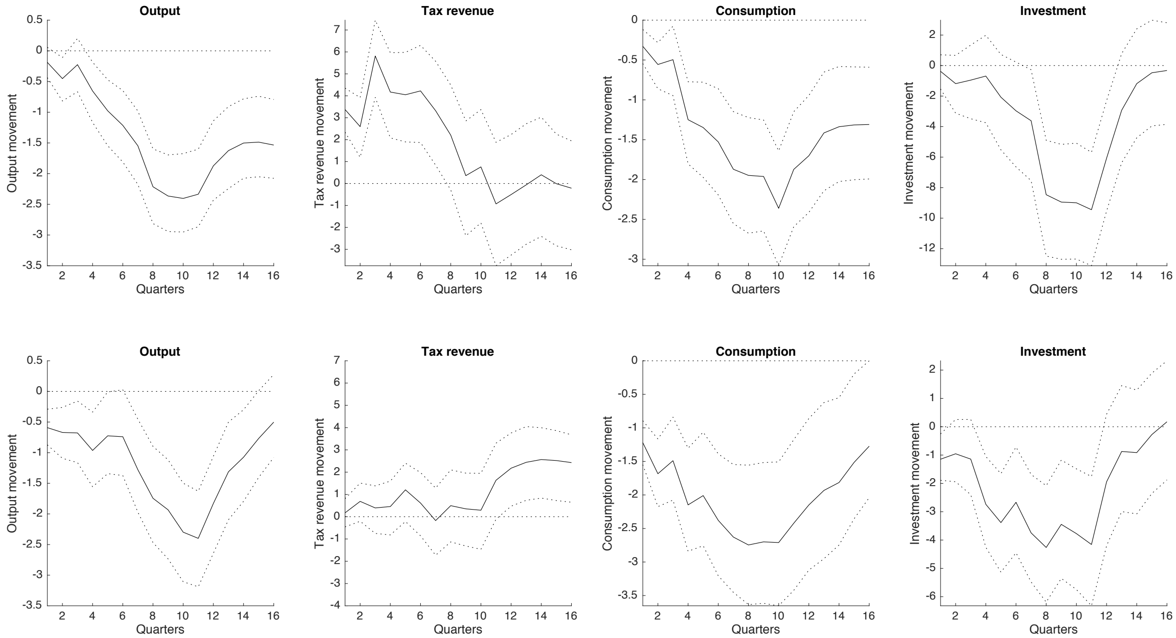
The response of tax revenue to tax shocks is illustrated in the second column of Figure 5. In the case of the US an increase in tax rates is predicted to increase tax revenues on impact; when output multipliers are low (insignificant from zero), the tax base is unchanged and an increase in the tax rate leads to higher overall revenues. As output multipliers increase, however, the impact of tax changes on tax revenues decreases; this confirms the results predicted in the theoretical analysis above. As can be seen in Figure 5, the path of tax revenues and output growth after an exogenous tax shock is similar; as cumulative output multipliers increase, tax revenue responses decrease, both reaching extreme values after ten and eleven quarters respectively. It is estimated that there is a neutral impact of tax rate changes on tax revenues after eleven quarters, where output multipliers exceed 2.3. This result is in line with the estimates from Figure 4. Indeed, the trade-off between output and debt in fiscal policy, as discussed in Sections 2 and 3, maps well to these empirical estimates.

Examining the results for the UK, the second row in Figure 5 provides similar results as the US with respect to supporting the theoretical analysis above. Although a similar path of cumulative output multipliers is estimated for the UK, these are lower (especially during the first two years of the shock) than the US and as such, the path of tax revenues is different. Here, tax revenues are not estimated to fall as a result of a tax increase; that is, when output multipliers are not sufficiently high, the conventional result prevails that higher tax rates lead to higher tax revenues. It should be noted, however, that the increase in tax revenues resulting from tax rate rises is only statistically significant after twelve quarters, when cumulative output multipliers are estimated to decrease.

Despite being common in the literature, it should highlighted that using one standard error confidence

[16] In the US, quarterly data on government debt is available from 1966 and for the UK from 1997. Whereas data on tax receipts is available for the whole sample in both the US and UK from the St Louis Fed and Office for National Statistics, respectively.

Figure 5: Cumulative output, tax revenue, consumption and investment movements from an exogenous tax increase



Results from vector-autoregression estimations of (10) from an exogenous tax increase equal to one percentage point of GDP, with growth in output (results in first column), tax revenue (results in second column), consumption (results in third column) and investment (results in fourth column) in X_t. Both point estimates are presented as well as one standard error confidence bands. The first row presents results when using data from the US, and the second row data from the UK.

bounds is the equivalent to a test probability of 68%. Although the results for the peak output multipliers are statistically significant from zero at 95% confidence, this is not the case for the result with respect to tax revenues. Two elements are noteworthy here: first, the intuition of the models developed in Section 2 and 3 are supported in this analysis, from the mapping of the point estimates for both output and debt multipliers. Moreover, the fact that the results suggest an insignificant from zero change in tax revenues from an increase in tax rates when the output effects are large (and after an initial statistically significant increase in revenues) is compelling; debates typically implicitly assume an unambiguous positive association between tax rates and tax revenues. Second, were a single equation approach taken as in Romer & Romer (2010) providing more degrees of freedom in the estimation process, statistically significant falls in tax revenue two years after an exogenous increase in tax rates would be observed in the US (these results are available in Figure A2 in the online appendix); similarly, more conclusive results are found using a two variable VAR with only output and tax revenues (these results are available in Figure A1 in the online appendix). This result is also consistent with Mertens & Ravn (2013) who use the underlying data from Romer & Romer (2010) and empirical estimates of changes in tax rates and tax bases to *infer* that cuts in tax rates have either an insignificant from zero or positive impact on tax revenues; our results demonstrate this also the case when analysing tax revenues directly.

4.3 Sensitivity

As discussed above, when following the approach of Romer & Romer (2010) and applying a single equation approach, stronger results are found both with respect to the size of output multipliers and the movement in tax rates; peak output multipliers of three and over one are achieved for the US and UK respectively after ten quarters and the dynamics of tax revenues follows that of output multipliers as the theoretical models predict. Further, more conclusive results are found when applying a two variable VAR with only growth in output and tax revenues. Results can be found in the online appendix for the single equation approach without (Figure A2) and with (Figure A3) a lagged dependent variable in the specification, and including both a linear (Figure A4) and polynomial (Figure A5) time trend. Further, the two variable VAR results are presented in Figure A1.

When considering the impact of those tax movements identified by Romer & Romer (2010) and Cloyne (2013) as endogenous to the business cycle, a rise in the tax rate is estimated to reduce output and increase tax revenues, and these effects are smaller than those from exogenous changes (peak output multipliers of one in a VAR estimation); see Figures A6 and A7 in the online appendix. This is consistent with the concept that fiscal policy endogenous to the business cycle is countercyclical and rises in tax rates occur mainly during periods of economic expansion.

Using data on exogenous tax changes in Germany from Hayo & Uhl (2014) provides similar results to those presented above; output multipliers reach a peak in excess of 2.5 and at this peak tax revenues are estimated to fall in response to a tax rise. Quarterly data on German total tax revenue is only available from 1991, and therefore the number of observations and statistical significance of the results are limited. Finally, using changes to total government debt in the analysis (and not changes in tax revenue) provides supportive, but statistically insignificant, results to those presented above. As discussed, UK quarterly data on debt is only available from 1997 which provides insufficient observations for analysis. Using US data, a rise in taxes is predicted to have an impact on debt insignificantly different from zero; however, after nine quarters, the point estimates are for a rise in taxes to lead to a rise in debt, consistent with a fall in tax revenues.[17]

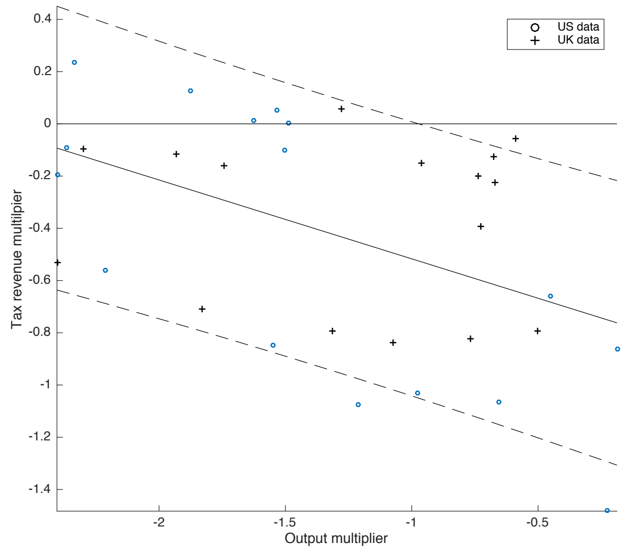
5 Discussion

There is a strong similarity in the relationship between debt and output multipliers derived in the empirical analysis compared to those found in the theoretical models of Sections 2 and 3, with support for two of the three results first established in Section 2.[18] Conditional on output multipliers in excess of 2.5, the theoretical models predict that fiscal free lunches are possible; applying data and techniques which finds such high output multipliers confirms this theoretical result. Figure 6 illustrates the similarity between the

[17] In addition to the above, the results were also tested to the additional procedures performed in both Romer & Romer (2010) and Cloyne (2013). In the case of the former, specifications which include control variables for government spending and monetary policy independent of the business cycle deliver quantitatively similar estimates for output and tax revenue movements in response to exogenous tax movements; this is expected given that similar processes performed in Romer & Romer (2010) also provide similar results to their benchmark estimates. In the case of Cloyne (2013), including inflation and the nominal interest rate in the VAR specification too delivers similar estimates for output and tax revenue movements in response to exogenous tax changes; again, this is as expected as these additional checks had limited impact on multiplier estimates in Cloyne (2013).

[18] Note that with empirical results only performed on tax changes, no support (or otherwise) can be provided for the theoretical result that government spending changes will influence debt more than tax changes, all other things being equal.

Figure 6: Estimated output and tax revenue multipliers from empirical results



Output and tax revenue multipliers from Figure 5 where in the case of tax revenue movements, the point estimates from the empirical work are multiplied by the average tax revenue to GDP for the US (25.5%) and UK (32.6%) to create multipliers. Further, these multipliers are multiplied by minus one in order to get results visually similar to those from the theoretical analysis (which were based on government debt multipliers: note a positive tax revenue multiplier would translate to a negative debt multiplier, all other things being equal). A line of best fit is plotted with 95% confidence bounds.

theoretical and empirical results through a scatter plot where each point represents output and tax revenue multipliers from the empirical results in Figure 5; tax revenue movements are used for proxies for debt multipliers by multiplying these by the negative of the fraction of tax revenue to GDP. Although there is more variation in these results compared to the theoretical analysis, the elasticity of the debt multiplier to the output multiplier is similar to those identified in Figure 2.

This suggests that there is a lack of a trade-off between fiscal stimulus and debt at output multipliers of 2.5. Table 2 highlights a number of empirical and theoretical papers which estimate multipliers within (or close to) this value.[19] By extension, therefore, there is a growing literature estimating high output multipliers, and the results of this paper combined with this literature suggests that fiscal policy trade-offs are not present (or are limited) in these scenarios. A natural question arising from this, therefore, is when are these scenarios most likely? That is, when is it possible that fiscal trade-offs are minimised? A review of Table 2 suggests answers to this question.

There is a considerable literature estimating that the impact of fiscal policy is asymmetric, with higher multipliers in recessionary times; the middle section of Table 2 presents the range of multiplier estimates from some of this literature. If debt is the trade-off for expansionary fiscal policy, the results from this paper suggests that a unit increase in the output multiplier leads to a decrease in this trade-off of the marginal tax rate (between 0.3 and 0.5 for most OECD countries). This would suggest significant arbitrage conditions whereby deficit financed expansions during recessionary periods can be 'repaid' at a lower cost during periods

[19]It should be noted that Table 2 selectively highlights those papers finding results with large multipliers. Studies using a structural VAR approach (see for example Blanchard & Perotti 2002) typically find smaller multipliers.

Table 2: Multiplier estimates from the empirical and theoretical literature

Paper	Multiplier	Notes
	Empirical literature	
Acconcia et al. (2014)	1.9	As a result from spending cuts
Cloyne (2013)	2.5	After eleven quarters
Guajardo et al. (2014)	3.1	After two years, with consolidations based on taxes
Hayo & Uhl (2014)	2.4	After eight quarters
Mertens & Ravn (2013)	2.2	After eight quarters
Romer & Romer (2010)	3.0	After ten quarters
	Asymmetric fiscal multipliers literature	
Auerbach & Gorodnichenko (2012)	0 - 1.7	Output multiplier estimates in expansions and recessions, respectively
Bachmann & Sims (2012)	0.8 - 3.1	
Caggiano et al. (2015)	0.3 - 3.1	
	Theoretical literature	
Christiano et al. (2011)	3.7	With the zero lower bound on monetary policy
Romer & Bernstein (2009)	1.6	Government spending multiplier after 8 quarters

Estimates of multipliers from both the empirical and theoretical literature. In the case of the literature finding asymmetric impacts of policy over the business cycle, a range of estimates is provided; the smallest value for estimated multipliers are for those during economic expansions, and the largest values for those in recessions.

of economic growth.[20] Moreover, given the size of fiscal multiplers estimated during a recession, potential fiscal free lunches may be possible.

The findings of Acconcia et al. (2014) suggest that local fiscal multipliers (those measured for a specific region) may be higher than national multipliers (those measured across a whole country) as the budgetary and monetary policy effects are experienced nationally whereas the initial fiscal shock are local. As such, if local output multipliers are larger than national ones, there may also be more scope for localised fiscal free lunches.[21]

Mertens & Ravn (2013) estimate that the movement of durable goods is more responsive to personal tax changes than the movement of non-durable expenditure. This suggests that policies which target specifically private consumption of durable goods are more likely to lead to fiscal free lunches; however, Berger & Vavra (2014) estimate that the response of durable consumption to fiscal shocks is conditional on the state of the economy, with smaller movements during recessionary periods as there is a cost to adjusting this type of consumption. These two results suggest, therefore, that policies which target durable spending in booms, and non-durable spending in recessions are more likely to be associated with lower fiscal trade-offs.

Considering the other side of the debate, the absence of fiscal trade-offs during debt consolidations (expansionary fiscal contractions) could result from the estimates in Auerbach & Gorodnichenko (2012) and Caggiano et al. (2015) in Table 2 (among others) who estimate that government spending multipliers may

[20]When we estimate multipliers using the non-linear approach applied in Auerbach & Gorodnichenko (2013), we further find support for asymmetric fiscal multipliers; output multipliers are estimated to be statistically insignificant from zero during expansions, whereas during recessions they are estimated to be larger than those found in Figure 5. Correspondingly, there is estimated to be an increase in tax revenues from tax rate cuts during a recession, and the opposite during expansions.

[21]It should be noted that Dupor & Guerrero (2017) find local and national output multipliers are good approximations for one another, and do not considerably diverge.

be close to zero during expansion. This is consistent with the results from Alesina et al. (2014) who estimate that expansionary fiscal contractions are more likely from government spending cuts (compared to tax rises) which has theoretical support from equations (5) and (6) above. Moreover, Alesina et al. (2014) estimate that persistent reductions in government spending have a greater positive effect on business confidence and private investment, and these longer-term changes are more associated with potential expansionary fiscal contractions.[22]

6 Conclusions

This paper has developed a theoretical framework with which to analyse the impact of fiscal policy on both debt and output; the results from this framework were then subsequently tested empirically. The results from the paper can be applied to consider trade-offs from potential fiscal policy actions. Indeed, the empirical results suggest that such trade-offs might not be present with output multipliers recently estimated in the literature. That is, potential 'fiscal free lunches' are possible, with tax revenues rising (or at least not falling) in response to tax cuts.

The results from this paper are striking, but to confidently rely on these, further research is required. Our results suggest that conditional on output multipliers in excess of 2.5, fiscal free lunches are possible. Further, empirically applying data which finds output multipliers in the region of 2.5 provides support for this conclusion; however, there is some scepticism in the literature over recent high estimates for output multipliers (see for example Favero & Giavazzi 2012, Perotti 2012, Hebous & Zimmermann 2017, among others). If fiscal free lunches require high output multipliers, which is supported by both the theoretical and empirical results in this paper, and if this magnitude of effects is not accepted as a fair and consistent result, it puts doubt on the inference that fiscal trade-offs may not occur. One direct way to consider this formally would be for those papers which find high output multipliers to directly test for the impact on budgetary outcomes. In particular, the empirical results of this paper do not consider the impact of government spending shocks, and extensions in this dimension would further contribute to our results. If potential fiscal free lunches are restricted only to the case of cuts in tax rates, this may signal that the results above derive from the distortionary nature of taxes, which could provide evidence of a Laffer curve (see for example Trabandt & Uhlig 2011). Moreover, extensions to the literature which finds fiscal multipliers to be asymmetric (see for example Auerbach & Gorodnichenko 2012, Bachmann & Sims 2012, Caggiano et al. 2015, discussed above) to consider how the budgetary outcomes of policy differ with this asymmetry would be a significant contribution. Even in the absence of free lunches, potential fiscal arbitrage opportunities through deficit financed counter-cyclical policy may be present with such asymmetric effects.

The key objective of this paper was to reflect further on fiscal policy trade-offs between output and debt, and to test the implied assumption that this trade-off is prevalent. When combined with recent literature on the effects of policy on output, the results suggest that expansionary contractions are possible (with literature that estimates low multipliers), that fiscal free lunches are possible (with literature that estimate high multipliers), and that there are considerable benefits to counter-cyclical policy in the presence

[22]Indeed, when performing simulations similar to those in Section 3 in Figures 2 and 3, we find that more persistent fiscal shocks are associated with expansionary fiscal contractions where debt is cut faster compared to less persistent fiscal shocks. Further, expansionary fiscal contractions are more likely in these simulations with more persistent fiscal shocks as output multipliers are on average estimated to be lower, and therefore, closer to zero.

of asymmetric fiscal multipliers. This naturally implies highly desirable policy implications, which would benefit from further empirical and theoretical research in the areas outlined above.

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A The model and calibration

A.1 Model equations

The model is a Smets & Wouters (2003, 2007) model extended to include both an extended fiscal section (as discussed in Section 3.1) and non-Ricardian, or 'hand-to-mouth', consumers. Please see Table A1 for a full list of model equations.

Table A1: Model equations

Households	
Ricardian consumption:	$\frac{1}{C_t^R - hC_{t-1}^R} = E_t\left[\beta \frac{R_t}{\pi_{t+1}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{1}{C_{t+1}^R - hC_t^R}\right]$
Capital adjustment:	$Q_t = \frac{E_t \pi_{t+1}}{R_t} E_t\left[Q_{t+1}(1-\delta) + \left(1-\tau_{t+1}^k\right) r_{t+1}\right]$
Investment:	$1 = Q_t\left[1 - \frac{\phi}{2} - \frac{3\phi}{2}\left(\frac{I_t}{I_{t-1}}\right)^2 + \frac{2\phi I_t}{I_{t-1}}\right] + \phi E_t\left\{\frac{Q_{t+1}\pi_{t+1}}{R_t}\left[\left(\frac{I_{t+1}}{I_t}\right)^3 - \left(\frac{I_{t+1}}{I_t}\right)^2\right]\right\}$
Capital accumulation:	$K_t = (1-\delta)K_{t-1} + \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t$
Non-Ricardian consumption:	$(1+\tau_t^c)\, C_t^{NR} = \left(1-\tau_t^l\right) w_t L_t^{NR} + TR_t$
FOC w.r.t. $\tilde{w}$:	$f_{1,t} = f_{2,t}$
	$f_{1,t} = \frac{(\nu_w - 1)}{\nu_w} \tilde{w}_t \frac{1-\tau_t^l}{(1+\tau_t^c)\left(C_t^R - hC_{t-1}^R\right)} \left(\frac{\tilde{w}_t}{w_t}\right)^{-\nu_w} N_t + \beta\theta_w \left(\frac{\tilde{w}_t}{\tilde{w}_{t+1}} \frac{\pi_t^\gamma}{\pi_{t+1}}\right)^{1-\nu_w} f_{1,t+1}$
	$f_{2,t} = \left(\frac{\tilde{w}_t}{w_t}\right)^{-\nu_w(1+\sigma_L)} N_t^{1+\sigma_L} + (\beta\theta_w)\left(\frac{\tilde{w}_t}{\tilde{w}_{t+1}} \frac{\pi_t^\gamma}{\pi_{t+1}}\right)^{-\nu_w(1+\sigma_L)} f_{2,t+1}$
Wage index:	$w_t^{1-\nu_w} = (1-\theta_w)\, \tilde{w}_t^{1-\nu_w} + \theta_w \left(\frac{\pi_{t-1}^{\gamma w} w_{t-1}}{\pi_t}\right)^{1-\nu_w}$
Firms	
Private output:	$Y_t = K_{t-1}^\alpha \left(N_t^P\right)^{1-\alpha} \left(K_{t-1}^G\right)^{\alpha_g} - \left(\frac{1}{\nu_p - 1}\right) Y$
Wage-rental ratio:	$(1-\alpha)\, r_t K_{t-1} = \alpha\,(1+\tau_t^{er})\, w_t N_t^P$
Real marginal cost:	$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^\alpha \left[(1+\tau_t^{er})\, w_t\right]^{1-\alpha} r_t^\alpha \left(K_{t-1}^G\right)^{-\alpha_g}$
Prices:	$\nu_p d_{1,t} = (\nu_p - 1)\, d_{2,t}$
	$d_{1,t} = mc_t \tilde{p}_t^{-(\nu_p+1)} Y_t + \beta\theta_p \frac{\left(C_t^R - hC_{t-1}^R\right)(1+\tau_t^c)}{\left(C_{t+1}^R - hC_t^R\right)\left(1+\tau_{t+1}^c\right)} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}}\right)^{-\nu_p - 1} \left(\frac{\pi_t}{\pi_{t+1}}\right)^{-\nu_p} d_{1,t+1}$
	$d_{2,t} = \tilde{p}_t^{-\nu_p} Y_t + \beta\theta_p \frac{\left(C_t^R - hC_{t-1}^R\right)(1+\tau_t^c)}{\left(C_{t+1}^R - hC_t^R\right)\left(1+\tau_{t+1}^c\right)} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}}\right)^{-\nu_p} \left(\frac{\pi_t^\gamma}{\pi_{t+1}}\right)^{1-\nu_p} d_{2,t+1}$
	$1 = (1-\theta_p)\, p_t^{1-\nu_p} + \theta_p \left(\frac{\pi_{t-1}^\gamma}{\pi_t}\right)^{1-\nu_p}$
Monetary policy	
Taylor rule:	$R_t = R\left(\frac{R_{t-1}}{R}\right)^\rho \left[\left(\frac{\pi_t}{\pi}\right)^{\rho\pi} \left(\frac{GDP_t}{GDP}\right)^{\rho y}\right]^{1-\rho}$
Market clearing definitions	
Goods market clearing:	$Y_t = C_t + I_t + G_t^C + I_t^G$
Total consumption:	$C_t = \lambda C_t^{NR} + (1-\lambda)\, C_t^R$
Labour market clearing:	$N_t = N_t^P + N_t^G$
GDP:	$GDP_t = Y_t + (1+\tau_t^{er})\, w_t N_t^G$

Note that the fiscal sector was discussed in Section 3.1. C^R, C^{NR}, h, λ and β represent Ricardian and non-Ricardian consumption, habit persistence, the share of non-Ricardian households and the discount factor, respectively. Q, δ and r^k represent is the shadow price of capital, depreciation and the rental rate. K and ϕ represent private capital and an investment adjustment cost, respectively. W, P, θ and γ represent wages, prices, stickiness in both and indexing in both, respectively, and ν represents the elasticity of substitution across goods (ν_p) and labour (ν_w). mc, α and σ_G represent marginal costs and the elasticity of capital and public capital in the production function, respectively, and d_1 and d_2 are expressions that allow us to present the first-order condition for $\tilde{p}_t$ (the price which maximises profits for intermediate firm producers at time t) in a recursive form; f_1 and f_2 are expressions that allow us to present the first-order condition for $\tilde{w}_t$ (the wage which maximises profits for trade unions at time t) in a recursive form. All other variables are as defined in the main body of the paper.

A.2 Calibration and simulations

In the benchmark simulation results certain parameters are fixed and do not change in each iteration. These include those parameters which are commonly fixed in the literature: $\delta = 0.025$, $\delta_G = 0.02$, $\nu_w = 6.67$, $\beta = 0.99$, $\alpha = 0.31$ and $\sigma_g = 0.02$. Further, to simplify the analysis, the benchmark results are obtained holding fiscal parameters fixed, as outlined in Section 3.3.

The simulations are conducted varying other parameters, the distributions for which are based on those from the literature which estimates these parameters; specifically, the distribution over which the parameters are randomised are modelled to closely resemble estimates of the first and second moments for these parameters in Smets & Wouters (2007) when the model is calibrated to the US, and Smets & Wouters (2003) when the model is calibrated to the UK. Details of which are in Table A.2.

Table A2: Random distribution for parameters in DSGE simulations

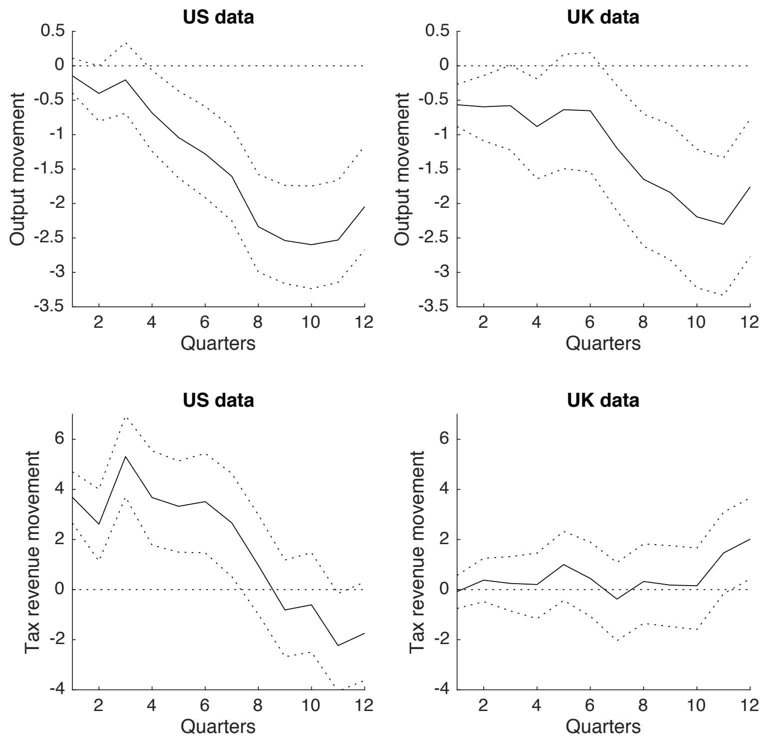
	US simulations			UK simulations		
Parameter	Distribution	Mean	StdDev	Distribution	Mean	StdDev
ϕ	N(6.40,1.01)	6.40	1.01	N(6.05,1.01)	6.05	1.01
κ	N(0.29,0.06)	0.29	0.06	N(0.18,0.08)	0.18	0.08
σ_l	N(2.09,0.60)	2.09	0.60	N(1.27,0.82)	1.27	0.82
σ_c	N(1.69,0.28)	1.69	0.28	N(1.61,0.29)	1.61	0.29
γ^p	N(0.44,0.11)	0.44	0.11	N(0.43,0.10)	0.43	0.10
γ^w	N(0.33,0.11)	0.33	0.11	N(0.66,0.20)	0.66	0.20
θ^p	B(4.66,0.49)	0.91	0.01	B(5.93,0.59)	0.91	0.01
θ^w	B(3.06,0.71)	0.81	0.03	B(2.82,0.91)	0.76	0.04
h	B(1.81,0.92)	0.66	0.06	B(1.22,0.99)	0.55	0.08
Φ	N(1.60,0.07)	1.60	0.07	N(1.50,0.21)	1.50	0.21
λ	B(0.25,0.63)	0.29	0.11	B(0.25,0.63)	0.29	0.11
ρ	B(3.04,0.42)	0.88	0.02	B(3.21,0.25)	0.93	0.02
ρ_π	N(1.50,0.11)	1.50	0.11	N(1.67,0.10)	1.67	0.10
ρ_y	N(0.07,0.03)	0.07	0.03	N(0.14,0.04)	0.14	0.04

Distributions and their first and second moments, as determined by Smets & Wouters (2007) for the US, and Smets & Wouters (2003) for the UK. Where the parameter is theoretically bounded by zero and one, a beta ('B') distribution was applied.

B Sensitivity plots

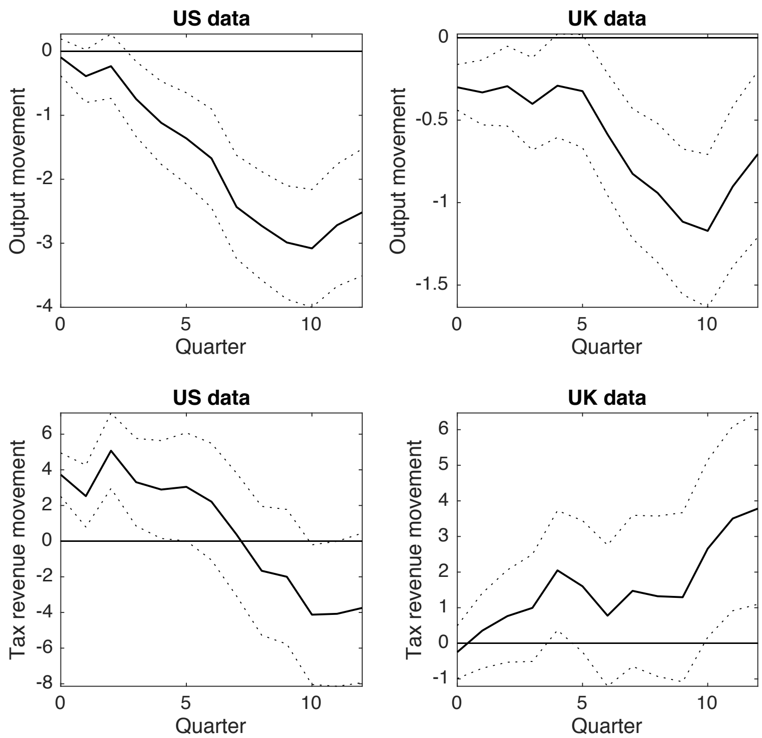
The following are figures testing the robustness of results from Section 4.

Figure A1: Cumulative output multipliers and tax movements from an exogenous tax increase: two variable VAR results



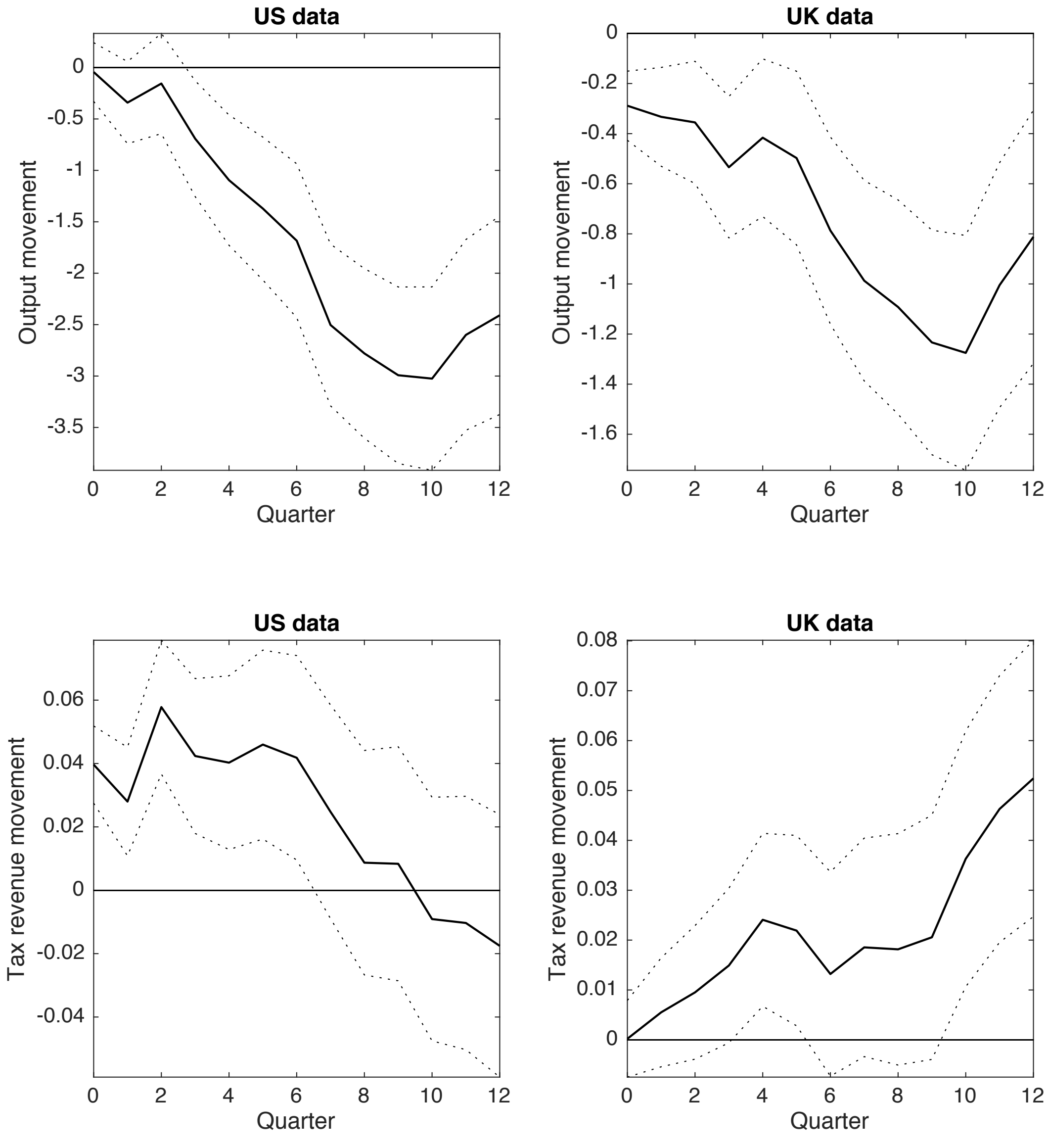
Results from vector-autoregression estimations of (10) from an exogenous tax increase equal to one percentage point of GDP, with both output growth and tax revenue growth in X_t. Both point estimates are presented as well as one standard error confidence bands.

Figure A2: Cumulative output multipliers and tax movements from an exogenous tax increase: single equation results



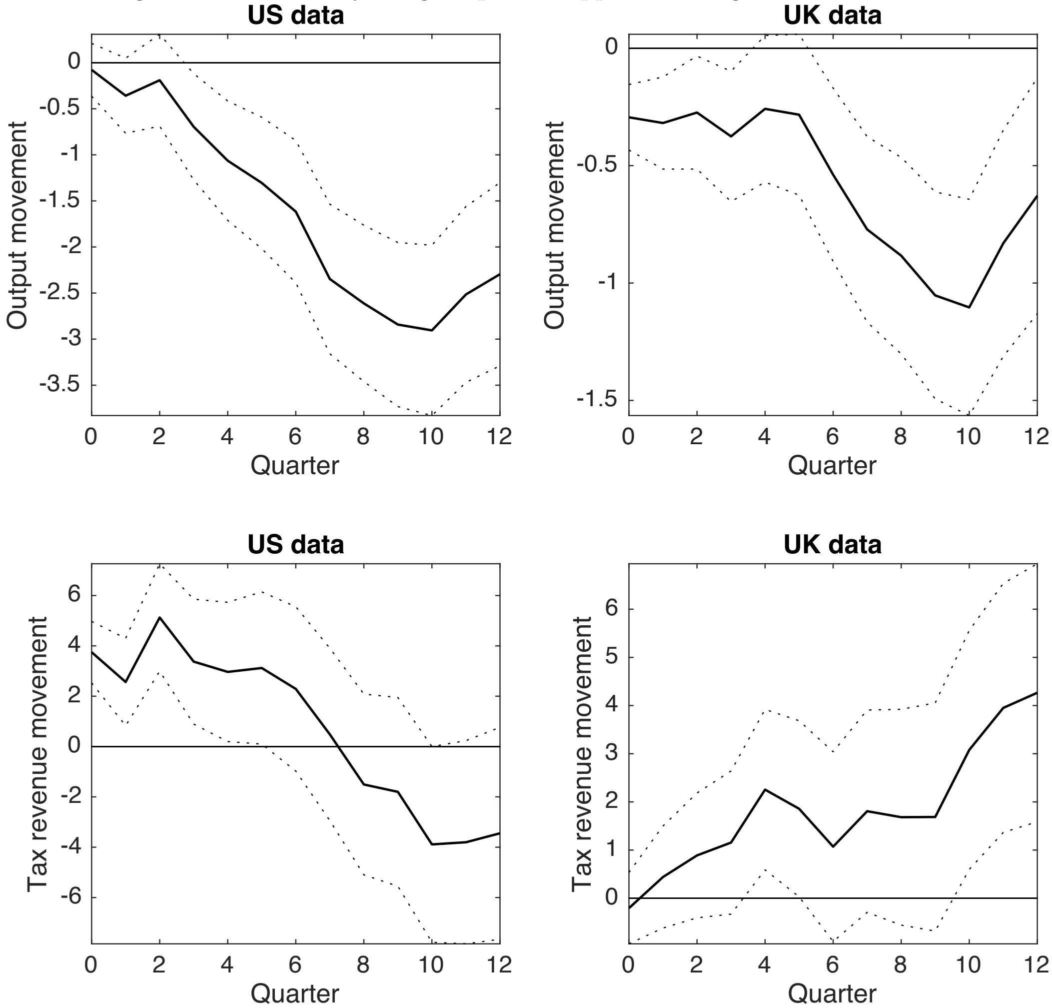
Results from estimations of (10) from an exogenous tax increase equal to one percentage point of GDP, with output growth as the only variable of interest in the top row, and tax revenue growth in the bottom row. Both point estimates are presented as well as one standard error confidence bands. Note all graphs present percentage changes in the variable of interest and therefore to obtain tax revenue multipliers, one would need to multiply by the tax share in the economy, 0.255 for the US and 0.326 for the UK in the sample period.

Figure A3: Sensitivity: single equation approach using lagged dependent variable



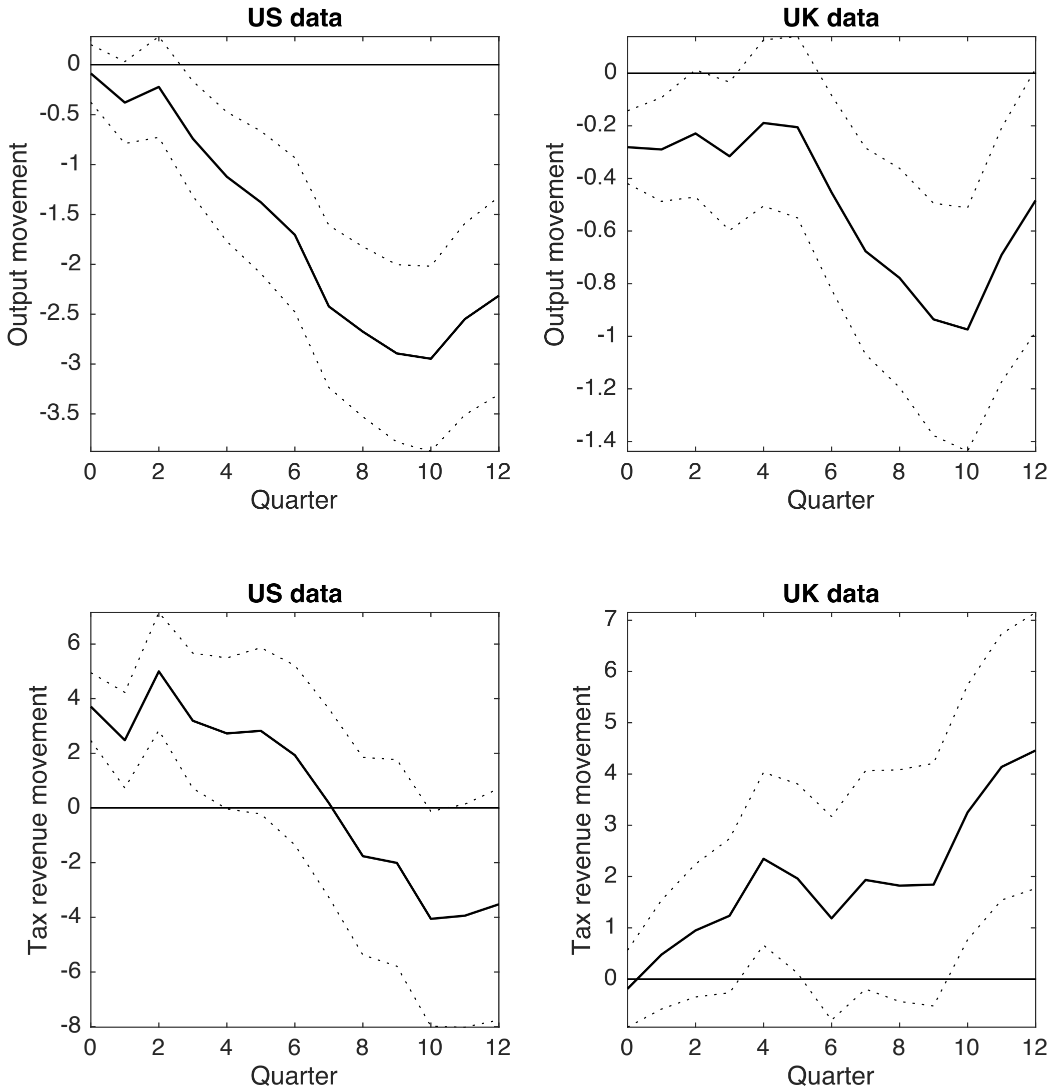
Results applying the same process as in Figure A2 now including 12 lags of the dependent variable in the specification ($P = 12$ in (10).

Figure A4: Sensitivity: single equation approach using linear time trend



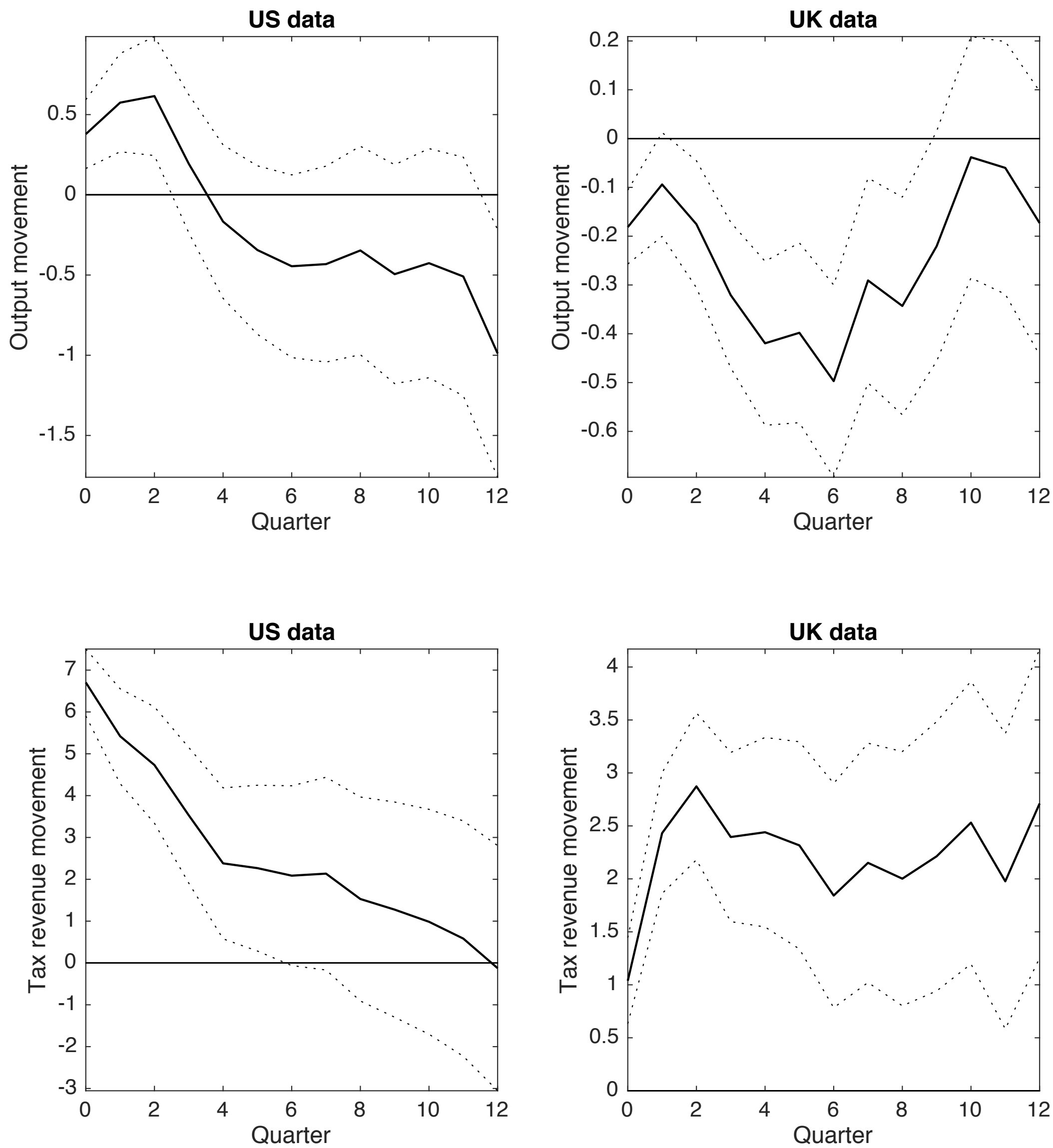
Results applying the same process as in Figure A2 now including a linear time trend in the specification.

Figure A5: Sensitivity: single equation approach using polynomial time trend



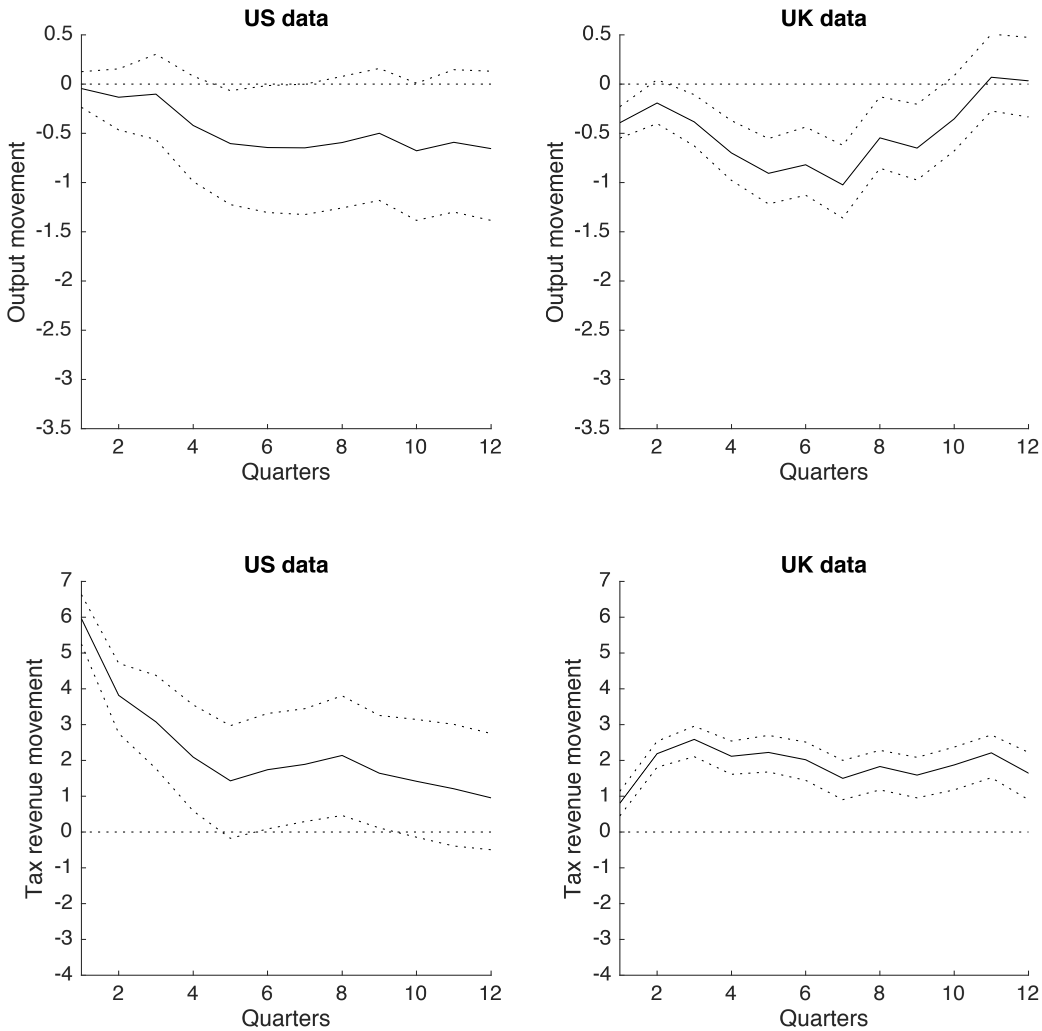
Results applying the same process as in Figure A2 now including a second order polynomial time trend in the specification.

Figure A6: Cumulative output multipliers and tax movements: single equation approach using endogenous shocks



Results applying the same process as in Figure A2 now using those shocks identified in Romer & Romer (2010) and Cloyne (2013) as endogenous to the business cycle.

Figure A7: Cumulative output multipliers and tax movements: VAR approach using endogenous shocks



Results applying the same process as in Figure A1 now using those shocks identified in Romer & Romer (2010) and Cloyne (2013) as endogenous to the business cycle.