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Self-defeating austerity at the zero lower bound

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Abstract

Fiscal consolidation programmes have been adopted almost universally in the developed world since 2011 in an effort to reverse the substantially worsened fiscal outlook in the aftermath of the global financial crisis. Prolonged stagnation combined with increasing debt levels over this period led many to question whether fiscal austerity can be self-defeating. This paper attempts to answer this question by presenting a comprehensive examination of fiscal policy when the nominal interest rates are at the zero lower bound (ZLB). In doing so, we propose an alternative measure of fiscal policy effectiveness in the form of bond multipliers that are based on the evolution of debt to GDP ratios. We show that, in contrast to the normal times, when interest rates are at their ZLB paths of government debt arising from different fiscal instruments could be very different, leading to self-defeating austerity in certain combinations of fiscal adjustment programs. Our findings, therefore suggest that self-defeating austerity, while a likely outcome with some instruments, can be avoided by judicious choice of the composition of fiscal action.

Key word: fiscal austerity, zero lower bound, composition of fiscal adjustment

JEL Classification: E65; H2; H3

1 Introduction

Policy makers across the globe embraced active fiscal policy as a key tool in responding to the recent global financial crisis. Substantial fiscal rescue packages that were enacted in response to the 2008-09 financial turmoil led to huge deterioration in fiscal balances in a large number of countries. Debt to GDP ratios around 90-100 per cent have become common place, forcing most countries to embark on serious fiscal consolidation from 2011 onwards (see, for example, IMF Fiscal Outlook, January 2012).[1]

A key issue surrounding the fiscal austerity programs since 2011 has been the effectiveness of such fiscal consolidations. As well as being a major policy concern, the question of whether fiscal austerity is likely to be effective has also created much interest in academic circles. Efforts towards a better understanding of fiscal policy dynamics have already led to a substantial and growing literature. Given the seriousness of the downturn in global economic activity since 2008, much of recent work has primarily focussed on the output implications of fiscal policy and thus on the size of fiscal multipliers. This line of work has identified a wide range of fiscal multipliers, varying from 1.6 (Romer and Bernstein; 2009) to much smaller figures that are close to zero (Cogan et al.; 2010). It was also shown that fiscal multipliers are larger when monetary policy is accommodative (Coenen et al.; 2013); when the zero lower bound (ZLB) on interest rates binds (Christiano et al.; 2011; Eggertsson; 2011; Erceg and Lindé; 2014); under fixed exchange rate regimes (Ilzetzki et al.; 2013; Born et al.; 2013); and when the share of credit constrained consumers is high (Cogan et al.; 2010).[2]

This paper attempts to answer the question of when fiscal austerity is likely to be self-defeating. Whether a fiscal austerity program succeeds or not in improving fiscal balances will clearly depend upon its impact on output and thus on fiscal revenues through automatic stabilizers. As a first step towards answering this question, therefore, we start by examining the real effects of different fiscal policy actions when the interest rates are at the ZLB. In doing this, we utilize a dynamic stochastic general equilibrium model (DSGE) with real and nominal frictions, as well as heterogeneity of agents regarding access to capital markets. We first explore the impact of fiscal policy on macroeconomic outcomes, with special emphasis on present values of output changes under each fiscal experiment, studying a large set of fiscal multipliers in each case.

We then turn to the budgetary implications of each fiscal action. Although it is straightforward to work out the implications of a given change in output on fiscal balances in normal times, this relationship breaks down

[1]See, for example, IMF World Economic Outlook, October 2009.

[2]This range of multipliers is in line with the empirical literature which has also established that the economic circumstances fiscal policy is conducted in plays a key role on its impact; see, for example, Auerbach and Gorodnichenko (2012) and Corsetti et al. (2012).

when nominal interest rates are at the ZLB. This is because paths of government debt arising from using different fiscal instruments at the ZLB could be very different compared to normal times. We, therefore, propose an alternative measure of fiscal policy effectiveness which takes the form of bond multipliers that are based on the evolution of debt to GDP ratios. Doing so allows us to present an explicit treatment of the dynamics of government bonds, which, in turn, enables us to consider the value for money of fiscal policy at the ZLB by considering the impact of different fiscal actions on the level of borrowing in the economy.

Our analysis points to a number of important policy implications. First, we show that, when interest rates are at the ZLB, as has been the case in a number of advanced economies since 2009 - a much longer period than initially anticipated - fiscal austerity can be self-defeating. This situation emerges when contractionary fiscal adjustment results in increased government borrowing. We find that this is more likely to emerge in the case of fiscal adjustment based on government consumption, government investment, public employment, transfers and consumption taxes. We also show that the paths of government debt vary greatly across fiscal instruments under the ZLB, as opposed to during normal times. This, therefore, implies that self-defeating austerity, while a likely outcome with some instruments, can be avoided by judicious choice of the composition of fiscal action. Existing empirical evidence provides strong support for the importance of the composition of fiscal adjustment programs for their consequences on macroeconomic outcomes. Our analysis indicates that the composition of fiscal consolidation plays an even greater role when fiscal action is taken at the ZLB.[3]

The rest of the paper is organised as follows. Section 2 presents a brief description of our model and sets out our policy formulation. Section 3 explores a set of traditional fiscal multipliers, as well as our proposed measure of bond multipliers in and out of ZLB. A set of robustness checks and further extensions are presented in Section 4. Finally, Section 5 provides concluding remarks.

2 Model

We utilize a medium scale DSGE model along the lines of Smets and Wouters (2003) and Christiano et al. (2005), featuring nominal rigidities in price and wage setting, real frictions such as adjustment costs, monopolistic competition and distortionary taxation on labour, capital and consumption. Our model also allows for the heterogeneity of consumers by incorporating the distinction between those with financial wealth and access to capital markets

[3]The composition of fiscal adjustment is also shown to play a major role in its redistributive consequences (McManus et al.; 2014).

(Ricardian) and those without (non-Ricardian). Nominal wages are set in a staggered price mechanism á la Calvo (1983). Monopolistic firms combine public and private capital with labour in producing intermediate goods that are then sold on to the competitive final goods sector that combines them into one single consumption good. Finally, fiscal and monetary policy decisions are taken by two separate authorities with well defined policy rules. The Appendix sets out the structure of our model in more detail.

As explained above, our main focus is on the real and budgetary consequences of fiscal policy actions. The scope of our benchmark model enables us to make use of a rich set of fiscal instruments in our analysis: taxes to consumption, τ^c, capital, τ^k, labour income, τ^l, and employee and employer social security, τ^{ee} and τ^{er}, as well as government spending, G^C, public investment, I^G, public employment, L^G, and lump sum taxes or transfers, T(nine in total).

Each instrument is assumed to follow a log linear rule responding to the previous period's debt and a shock process, similar to Forni et al. (2009) and Leeper et al. (2010):

$$x_t = \phi_{b,x}\hat{b}_{t-1} + e_{x,t} \tag{1}$$

where $x = \{\tau^c, \tau^k, \tau^l, \tau^{er}, \tau^{ee}, G^C, I^G, L^G, T\}$. In equation (1) hatted variables represent log deviations of variables from steady state values. In what follows, we consider lump sum taxes as transfers from the government to households. All shocks to fiscal variables follow an $ARMA(p, q)$ process where $p \in \{0, 1\}$ represents persistence in the fiscal action, and q is the length of time the ZLB is anticipated to last.

3 Fiscal policy at the zero lower bound

This section explores the impact of fiscal policy when monetary policy is at its ZLB. In what follows, we use the abbreviation 'binding period' to describe the horizon over which the ZLB is binding; when the nominal interest rate is zero, and the expression 'normal times' to describe when it is not. We use the expression 'government spending' to represent all the fiscal instruments which represent expenditure to the government (consumption, investment, employment and transfers).

For our benchmark results, we consider the case where active fiscal policy is only employed for the binding period, where agents are aware of this policy, the policy is deemed credible, and where rational expectations allow agents to know both the binding period and by extension the horizon for active fiscal policy. As a result, the only source of movement in fiscal instruments derives from repayment of debt resulting from the initial stimulus. This type of experiment is typical in the literature with the exception of the resulting repayment of bonds where frequently a fully Ricardian economy is assumed where all fiscal stimulus is repaid through lump sum taxation. In Section 4, our results will be tested against less clinical fiscal policy allowing for both time lags in the adoption of policy, and persistence in stimulus after the binding period has ended.

3.1 Calibration

We follow a calibration procedure in line with the existing literature with common parameters fixed in a standard way. Steady state tax rates on consumption, capital, labour income and employee and employer social security contributions (τ^c, τ^k, τ^l, τ^{ee} and τ^{er}) are set at 0.2, 0.4, 0.18, 0.05 and 0.07 respectively and the level of government debt in steady state is set at 60 per cent of output. We select a slightly lower value of the depreciation of public capital compared to private capital with $\delta_k^G = 0.02$, and we fix the share of public employment in total employment at 0.15. The elasticity of public capital in the production function, σ_G, is set at 0.02 which is slightly higher than the value calibrated by Straub and Tchakarov (2007) for the US and the euro area. We fix the share of public investment in GDP at 0.02, whereas the share of public consumption at 0.2. This calibration implies the ratio of private investment to GDP is 0.13 whereas private consumption to GDP is 0.65.

To obtain benchmark results, the persistence of fiscal shock parameters are all set equal to 0, such that discretionary policy is only performed when the ZLB is binding. The debt aversion parameters are set such that the half-life of existing government debt is equal to three and a half years, a prudent parameter within the context of the existing literature (see, for example, Leeper et al.; 2010), where this burden is shared equally by all fiscal parameters.[4] Finally, the share of credit-constrained non-Ricardian consumers is set equal to 0.3 in line with those in the existing literature. All other calibrated values are listed in Table 1.

3.2 Dynamics

We begin by exploring the implications of active fiscal policy when the ZLB is binding, as compared to when it is not. Each fiscal instrument is considered in turn and in isolation leading to eight separate unique policy experiments (labour income taxes and employees social security contributions enter the model in the same way and therefore analysis of one is equivalent to the other). In each case we maintain that, for each period the ZLB is binding, the government responds with the specific fiscal instrument with a shock the equivalent of one percent of steady state output. Our benchmark specification adopts a binding period of six quarters. For comparability, dynamics

[4]In practice this means normalising the debt aversion parameters to correct for the different importance of each fiscal instrument in steady state.

Table 1: Calibration

Share/parameter	Description	Value
Preferences		
β	Discount factor	0.99
σ_l	Inverse Frisch elasticity	2
θ	Share of non-Ricardian households	0.3
Technology		
δ_k	Depreciation rate: private capital	0.025
δ_k^G	Depreciation rate: public capital	0.02
α	Share of capital in production	0.35
ϕ_k	Investment adjustment cost parameter	5
κ	Capital utilisation adjustment parameter	0.6
ϖ	Stickiness in prices	0.75
ϖ_W	Stickiness in wages	0.5
γ_p	Price indexation	0.15
γ_w	Wage indexation	0.15
s	Elasticity of substitution in consumption	7.67
ν	Elasticity of substitution in labour	7.67
Φ	Fixed costs in production	0.15
Monetary policy		
ρ_π	Inflation Taylor rule weight	1.5
ρ_y	Output Taylor rule weight	0.125

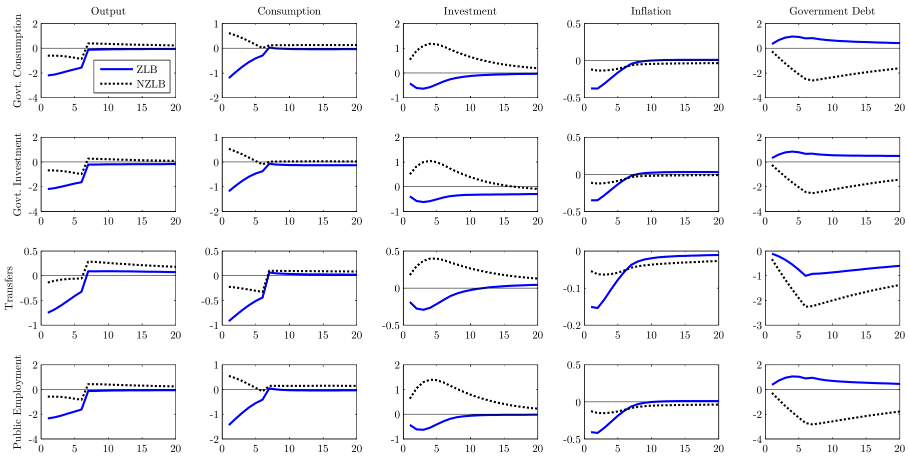
are also presented for the same type of fiscal policy in normal times.

Given that our focus is on fiscal austerity, these shocks take the form of cuts in public spending and rises in taxes. Our simulation results for discretionary government spending and for taxation are displayed in Fig.1 and Fig.2, respectively.

Government spending shocks

As is seen in Fig.1, when monetary policy is at the ZLB the impact of public spending shocks on the aggregate economy is amplified, as expected. In normal times, a fall in government spending directly reduces aggregate demand and subsequently output. This, in turn, leads to a fall in inflation and hence a reduction in interest rates, which crowds in private consumption as Ricardian households bring forward consumption. Similarly, in normal times the fall in nominal interest rates also crowd in private investment. However, when the nominal interest rates are at zero this compensating monetary impact does not occur as both consumption and investment fall, and hence the impact of the shock is greater at least over the short run. This is most predominant for the evolution of consumption where the reduction in inflation, combined with zero nominal interest rates lead Ricardian households

Figure 1: Dynamics from government spending shocks



Dynamics achieved through a shock from each fiscal instrument equivalent to one percent of steady state output under two separate scenarios: one where the ZLB binds (for six quarters) and one where it does not. Each column represents a different variable of interest highlighted by the top of each column, and each row a different fiscal instrument.

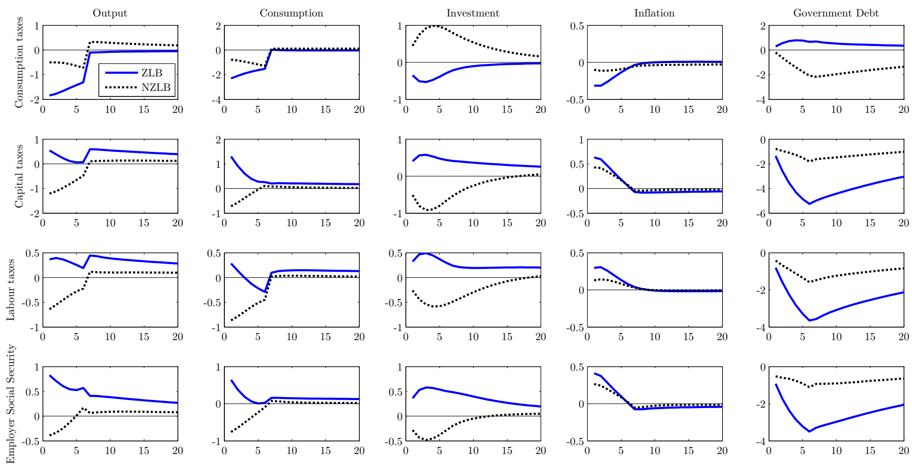
delay their consumption. Further, the deterioration in the economy reduces non-Ricardian disposable income and this feeds back into a further fall in consumption and thereby in output.

In terms of the real effects of the austerity package, the most damaging policy when the ZLB is binding, at least in the short run, is a fall in public employment closely followed by government consumption and investment. This contrasts with fiscal policy conducted when the ZLB is not binding when government investment is the most effective policy particularly in the short term. This, in turn, is due to the fact that government investment impacts on demand as well as the productive capacity of the economy, hence reducing output supply following fiscal austerity. When nominal interest rates are stuck at the ZLB, this latter effect creates an upward pressure on prices resulting in a fall in real interest rates, which dampens the initial impact of the fiscal contraction.

3.2.1 Tax shocks

Fig.2 presents impulse responses to increases in four types of taxes; consumption taxes, capital taxes, labour taxes and employer social security contributions where each is raised by the equivalent of one percentage point of steady state output. Fig.2 exhibits sharp differences in impacts in and out of the ZLB. Interestingly, rises in capital and labour taxes as well as in

Figure 2: Dynamics from taxation shocks



Dynamics achieved through a shock from each fiscal instrument equivalent to one percent of steady state output under two separate scenarios: one where the ZLB binds (for six quarters) and one where it does not. Each column represents a different variable of interest highlighted by the top of each column, and each row a different fiscal instrument.

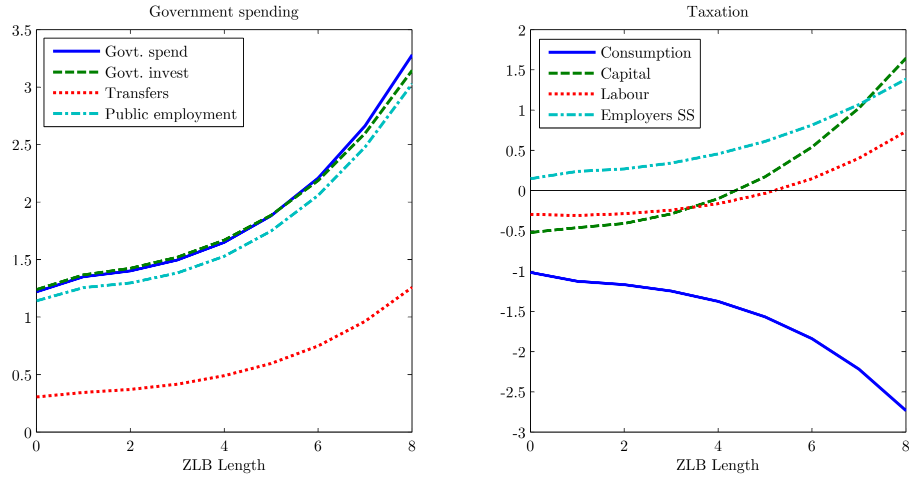
employers social security contributions lead to increases in output when the ZLB is binding, as is also suggested by Eggertsson (2011). When nominal interest rates are at the ZLB, the rise in inflation as a result of the rise in production taxes (capital and labour taxes and social security contributions) results in lower real interest rates. The outcome is, therefore, an increase in both consumption and investment and hence a rise rather than a fall in output.

A rise in consumption taxes, however, has a similar effect to that of a reduction in public expenditure. In normal times, fiscal contraction through higher consumption taxes depresses the economy through reducing private consumption as households delay purchases when faced with higher after tax prices. This, in turn, reduces output and creates deflation which subsequently leads to a fall in the nominal interest rate. When interest rates are bounded by zero, however, this does not happen and the additional deflationary pressure results in higher real interest rates further depressing private consumption. As a result, the contraction in output under the ZLB is greater than that under in normal times.

3.3 Cumulative versus impact multipliers

The dynamics presented in the previous section are based on impact multipliers for a given ZLB duration. We now generalize this analysis by in-

Figure 3: Impact multipliers and the length the zero lower bound is binding



Results obtained from shocking each of the fiscal instruments in turn and varying the length of the ZLB: note that the length of the shock is determined exactly by the length of the ZLB. Calibration is as set out in Table 1.

corporating cumulative multipliers for different duration of binding periods. Cumulative present value multipliers are calculated using the discounted sum of changes in output and the discounted sum of movements in the relevant fiscal instrument:

$$M^n = \frac{\sum_{j=0}^{n} \left(\Pi_{i=0}^{j} R_{t+i}^{-1} \right) \Delta Y_{t+j}}{\sum_{j=0}^{n} \left(\Pi_{i=0}^{j} R_{t+i}^{-1} \right) \Delta X_{t+j}} \tag{2}$$

where M^n denotes the cumulative multiplier over n periods, R_t denotes the gross nominal interest rates, Y_t is aggregate output, and X_t is the fiscal instrument in question: we use *ex ante* changes in tax income for tax multipliers and changes in the relevant spending category for spending multipliers.[5]

Results for the eight fiscal instruments at different binding horizons are presented in Fig.3 and Fig.4 for impact and cumulative multipliers, respectively. In both Fig.3 and 4, negative values for tax instruments represent a tax rise leading to a fall in output.

As is found elsewhere in the literature, fiscal multipliers are amplified exponentially with the length of the binding period, as can be seen from

[5] *Ex ante* changes in tax income are calculated as the change in tax revenue that would occur with the given change in the tax rate were all other parameters held at their steady state values.

Fig.3. With respect to the spending instruments and consumption taxes this amplification makes the fiscal action more effective, whereas for production taxes the reverse occurs: over a range of ZLB lengths, rises in production taxes lead to rises in output. The instrument with the largest multipliers at the ZLB is government spending, which differs from normal times when it is government investment. However, the former has a stronger link with inflation than the latter which both increases demand and supply within the economy. For a similar reason transfers experiences high amplification of multipliers as a result of the ZLB as this policy leads to the highest movement of inflation.

During normal times cumulative multipliers over longer horizons tend to fall as other instruments repay debt resulting from the fiscal interventions which causes output to fall: this is illustrated in Figure 4 showing five year cumulative multipliers, when the ZLB duration is zero, as at origin. However, at the ZLB this effect is smaller, especially over longer binding periods, as the movements in government debt differ as highlighted in Figures 1 and 2. Therefore, cumulative multipliers experience a great amplification of multipliers at the ZLB than impact multipliers.

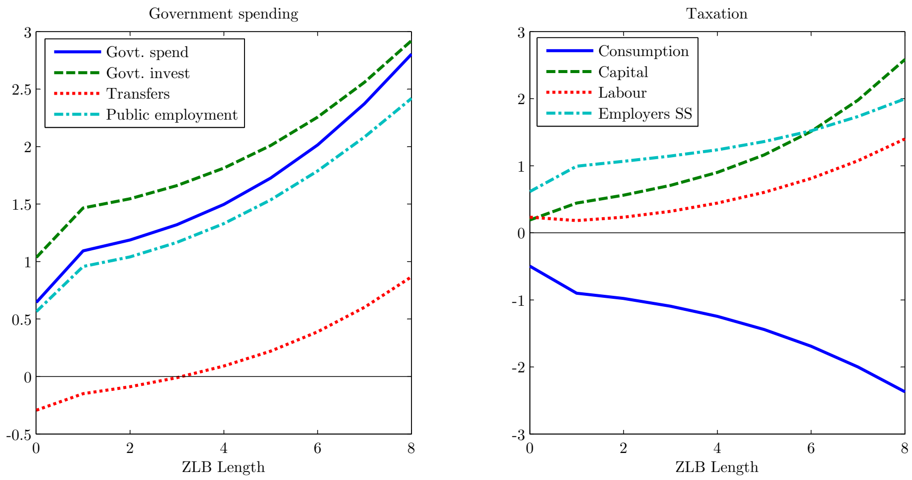
It should be noted that these fiscal multipliers under the ZLB are derived under the restrictive assumptions that the fiscal authority responds immediately to the ZLB being reached, knows how long this period will last, and announces that a similar fiscal shock will occur for the length of the binding period. This is significant because it is not just the immediate fiscal intervention which are generating these multipliers, but also the expectation of future policy, and its impact on inflation.

We will turn to exploring the role of these assumptions in our benchmark results in Section 4.

3.4 Bond multipliers at the ZLB

As argued above, the traditional multipliers as calculated in (2) provide only partial information to policy makers, and more so under the ZLB, for the following reasons. First, the government is stimulating with one instrument while it is contracting with others as it looks to repay the debt, with the design and the speed of this repayment playing a key role in both the real and the budgetary consequences of the initial fiscal action. As can be seen in Fig.1 and 2, government debt takes a different path when the economy is in the ZLB compared to when it is not. Traditional multipliers as presented above do not address this question as they do not explicitly take into account such dynamics of debt. Secondly, in a time of severe recession and austerity, policy makers are concerned with value for money of each fiscal action not only on efficiency grounds but also to allow for political feasibility. A true valuation of the cost of a fiscal action is not the changes in the stimulating fiscal action but the changes in government borrowing

Figure 4: Five year cumulative multipliers and the length the zero lower bound is binding



Results obtained from shocking each of the fiscal instruments in turn and varying the length of the ZLB: note that the length of the shock is determined exactly by the length of the ZLB. Calibration is as set out in Table 1.

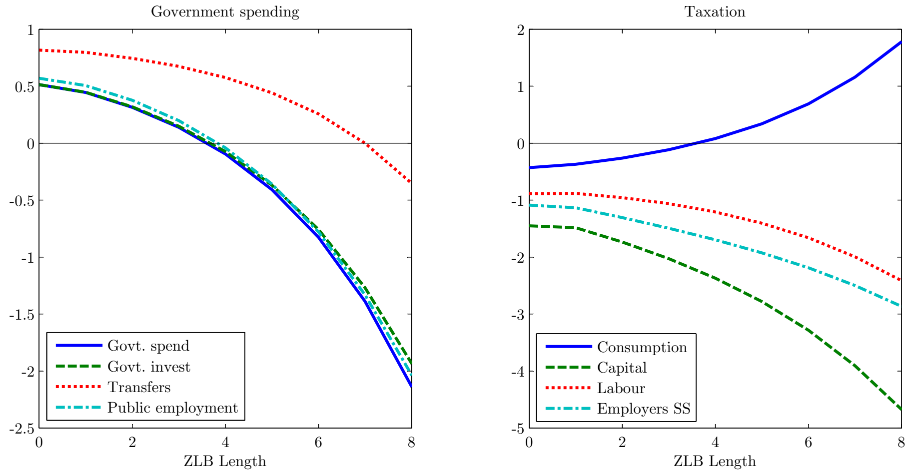
as a result of the policy. Based on these considerations, in this section we propose an alternative metric to evaluate fiscal action through the following:

$$B^n = \frac{\Pi_{i=0}^{n} R_{t+i}^{-1} \left(B_{t+n} - B_0\right)}{\sum_{j=0}^{n} \left(\Pi_{i=0}^{j} R_{t+i}^{-1}\right) \Delta X_{t+j}} \tag{3}$$

where B^n is used for 'bond multiplier' representing the change in the value of government borrowing arising from individual fiscal action calculated over horizon n and as such addresses both the objections with traditional multiplier calculations, stated above.

As is highlighted in Fig.1 and 2 the impact of austere fiscal actions when the economy is at the ZLB is to increase debt, at least whilst the ZLB is binding, in the policies which increase government spending and those which cut consumption taxes. This is driven by depressed tax revenues resulting from lower output due to deflationary fiscal actions. Likewise, for those policies which have an inflationary impact (rises in production taxes) the path of debt is lower than when the ZLB is not binding. In normal times, the dynamics of government debt are similar across experiments and therefore the ranking of the bond multipliers of fiscal experiments is in line with those of using traditional multipliers. However, when the economy is at the ZLB it is possible to obtain self defeating austerity: debt increases as a result of some austere policy measures. As can be seen from Fig. 5, with

Figure 5: Bond multipliers and the ZLB horizon



Results obtained from shocking each of the fiscal instruments in turn and varying the length of the ZLB: note that the length of the shock is determined exactly by the length of the ZLB. Calibration is as set out in Table 1.

a binding period of four quarters, spending cuts in consumption, investment and employment, and rises in consumption tax will result in increasing debt.

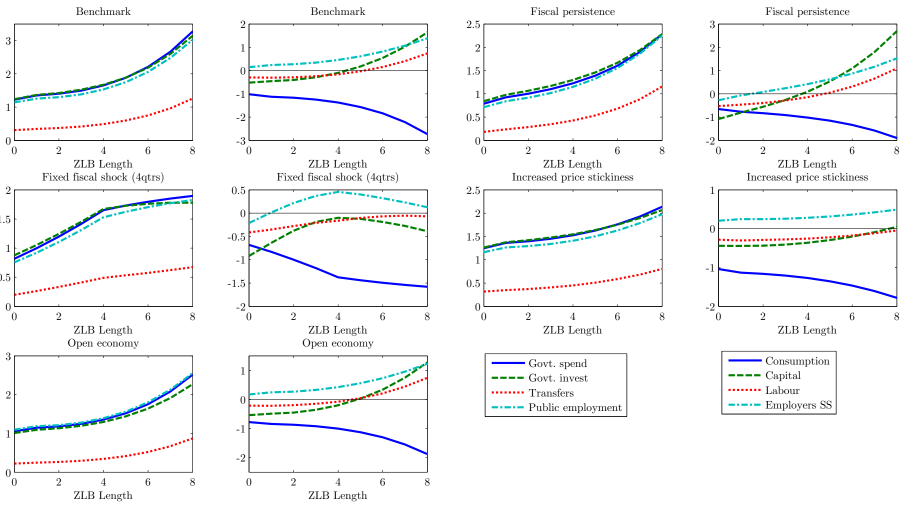
4 Robustness checks and further extensions

4.1 Sensitivity analysis

The benchmark results presented above are from highly stylised fiscal experiments that make strong assumptions about government reactions and agent expectations. Our benchmark framework maintains that the government is able to respond immediately to the fiscal action when the ZLB is binding, and subsequently to stop the intervention when nominal interest rates are positive; and that the fiscal action does not change the profile of the ZLB period.

In this section, we present an extensive set of robustness checks regarding our benchmark results. We start by examining the persistence of fiscal interventions after the initial shock, as is highlighted in Christiano et al. (2011). In Fig.6 the two panes on the first row labelled as 'fiscal persistence' present the revised spending and tax multipliers on the basis of a persistence of 0.85 of fiscal policy after the ZLB period. As is seen from these figures, our impact multipliers would reduce by about less than a third. We also examine the case of a fixed four-period shock to fiscal instruments, multipliers associated with these shocks vary little with the binding period beyond the

Figure 6: Sensitivity analysis



Results from a range of sensitivity checks for traditional multipliers for both government spending fiscal instruments (the first and third column) and tax instruments (the second and forth column). 'Benchmark' relates to those results presented in Figure 3; 'Increased price stickiness' to those results when setting price stickiness to 0.85; 'Fiscal persistence' adds persistence equal to 0.85 in the fiscal instrument after the binding period has ended; 'Fixed fiscal shock' maintains a four period shock to respective fiscal instruments, independent of the ZLB horizon, whilst varying the ZLB length; finally, 'Open economy' illustrates results from extending the model to an open economy.

fourth period (as illustrated in the second row of Fig.6). As can be seen from these it is the complete response of the fiscal authority that are providing large multipliers.[6]

Another important mechanism our benchmark results rely upon is the impact of fiscal instruments on inflation. However, as highlighted by Canova and Pappa (2011) this is empirically limited in the case of government spending shocks. When we increase the value of price stickiness in our model in order to slow the response of inflation to demand shifts, our above results are dampened; for example, an increase in the price stickiness from 0.75 in our benchmark calibration to 0.85 leads to a fall in traditional multipliers on average of a fifth, with an increasing effect at higher lengths of the ZLB (as illustrated in the second row of Fig.6). Moreover, this increase in stickiness leads to the point at which self defeating austerity is effective for government

[6]In many respects this demonstrates the importance of the policy formulation and reconciles the results from the smaller tractable models used in Christiano et al. (2011) and Eggertsson (2011) against those derived from medium scale DSGE models such as Cogan et al. (2010).

spending instruments and consumption taxes to six quarters of ZLB instead of four in the above results. However, it is still the case that fiscal austerity becomes less effective at the ZLB for these instruments.

We also extend our model to an open economy framework using a model similar to Adolfson et al. (2007).[7] In general, in an open economy the multipliers are lower as a fraction of the austerity is diverted to the rest of the world through higher levels of imports. As can be seen in the third row of Fig.6 the impact multipliers decrease in the case of government spending and consumption taxes, whereas in the case of consumption and labour taxes and employers' social security contributions the effects are negligible. Therefore, for the five instruments mentioned above it takes longer in an open economy to achieve the decrease in the bond multiplier. However, self defeating austerity is still observed, and the usual amplification of traditional multipliers is also maintained.

We have also explored the implications of different solution methods on the main results (not reported). Braun et al. (2013) suggest that under certain calibrations linear approximations of the non-linear model can have large effects on the estimated results at the ZLB. We applied both a second and third order approximation to our model with limited impacts on traditional and bond multipliers; the difference between these and the results from the log-linear model are negligible. Although it is not possible to derive a global solution to our model given its size, our findings point to political constraints underlying the speed and the duration of policy package rather than estimation techniques as determinants of the effectiveness of fiscal actions in our analysis.

We have also performed experiments testing our results to other calibrated parameters in the model; wage stickiness, capital utilization and investment adjustment costs (not reported). Those which the results are most sensitive to are the stickiness in prices (as outlined above) and the perceived persistence of the shock after the period of the ZLB. For all other parameters tested, no changes in the qualitative nature of our benchmark results are observed.

4.2 International experiments

In order to consider these discussions in an empirical setting, actual austerity packages as reported by the International Monetary Fund (2013, 2014),

[7] The only difference with respect to Adolfson et al. (2007) stems from the fact that apart from the import of private consumption and investment we allow for import of public consumption and investment goods. The calibration is in line with that of our benchmark results, where we set the elasticity of substitution between foreign and domestic goods to 1.5 and the risk premium parameter related to net foreign assets equals 0.05, both set as in Adolfson et al., and the imports' shares in aggregate public and private consumption and public and private investment to match the data in the input-output analytical tables for UK: 22, 32, 11 and 16 per cent, respectively.

displayed in Table 2, are simulated through our model. The figures in Table 2 represent the actual adjustments enacted in these countries between the period of 2009 to 2013. For simplicity, we assume that these changes are phased in over six quarters, are expected to last 20 quarters, when they diminish with persistence equal to 0.8: we assume a ZLB binding period of six quarters for these simulations. Results for both output and government debt are presented in Fig.7.

Table 2: International austerity packages

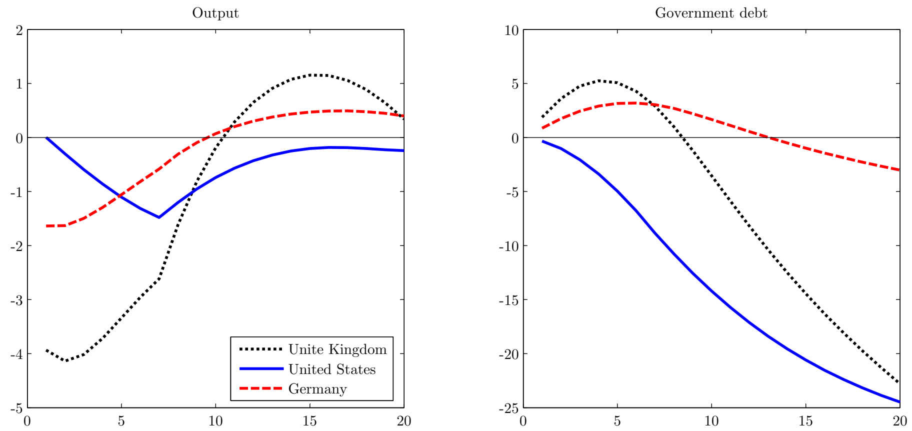
	Fiscal consolidation		
	Revenue	Expenditure	Total
Germany	-0.7	1.6	0.9
UK	2.5	3.7	6.2
USA	2.6	1.7	4.3

Data obtained from IMF Fiscal Monitor (2013: Figure 2) and (IMF; 2014a, Figure 2.2).

The UK with the biggest net austerity package has the largest initial fall in output of the three countries sampled, while the US, despite its austerity being of a similar size is simulated to have a much lower impact on output. This is driven by the fact that the US has relied more upon tax rises than spending cuts, that are beneficial to output at the ZLB, as established earlier. The evolution of output in Germany is simulated to be closer to that of the US despite the former having a much smaller austerity. This is because Germany has cut spending (in employment, consumption and transfers) in order to cut taxes (income and social security). However, over a longer time horizon, UK output dominates those of the other two countries due to cuts in capital taxes increasing the productive capacity in the economy. Therefore, whereas the UK austerity package appears to cause the most harm initially during the ZLB, the long term impact when the nominal interest rate is not bound is more favourable. This ranking of output performance is broadly consistent with the data such that US GDP growth dominated both that of Germany and the UK in the first two years of fiscal consolidation, whilst latest figures suggest that the most recent UK growth has fared better than those of the other two countries (IMF World Economic Outlook, October 2014).

Despite similar paths for output, those of government debt for the three countries are visibly different. The spending-led consolidation of the UK has led to simulated 'self-defeating austerity' initially with a similar result in Germany due the combination of both spending and tax cuts. US austerity is simulated to cut government debt both over the short and long term, predominantly driven by the inflation impact of rises in taxes during the

Figure 7: Simulated international austerity packages



Simulated figures for both output and government debt applying the austerity packages illustrated in Table 2. The calibration is as that of Table 1 but where the fiscal parameters are calibrated differently for Germany (where we use Coenen et al.; 2013), the UK (where we use Bhattarai and Trzeciakiewicz; 2012) and the US (where we use Leeper et al.; 2010).

ZLB period, and subsequently the cuts in government spending.

5 Concluding remarks

Our analysis points to a number of important policy implications. First, we show that, when interest rates are at the ZLB, as has been the case in a number of advanced economies since 2009, fiscal austerity can be self-defeating. This situation emerges when contractionary fiscal adjustment results in increased government borrowing. We find that this is more likely to emerge in the case of fiscal adjustment based on government consumption, government investment, public employment, transfers and consumption taxes. We also show that the paths of government debt vary greatly across fiscal instruments under the ZLB, as opposed to during normal times. This, therefore, implies that self-defeating austerity, while a likely outcome with some instruments, can be avoided by judicious choice of the composition of fiscal action. Existing empirical evidence provides strong support for the importance of the composition of fiscal adjustment programs for their consequences on macroeconomic outcomes. Our analysis indicates that the composition of fiscal consolidation plays an even greater role when fiscal action is taken at the ZLB.

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A Appendix: Benchmark Model

A.1 Households

There is a continuum of households a share, $(1-\theta)$, of which have access to capital markets (Ricardian households) and the remainder, θ, do not (non-Ricardian households).

Each Ricardian household, h, seeks to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t U \left(\ln\left(C_t(h)\right) - \frac{1}{1+\sigma_l} \left(L_t(h)_t\right)^{1+\sigma_l} \right) \tag{A1}$$

where E_0 denotes the expectation operator, $\beta \in (0,1)$ the discount factor, C_t consumption, L_t labour an σ_l the inverse of the Frisch labour supply elasticity.

The household's total expenditure on consumption, C_t^R, investment in physical capital, I_t, and accumulation of a portfolio of riskless one-period contingent claims, b_t, must equal the household's total disposable income:

$$\begin{aligned} \left(1+\tau_t^c\right) C_t^R(h) + I_t(h) + b_t(h) &= \left(1-\tau_t^l-\tau_t^{ee}\right) w_t\left(h\right) L_t^R\left(h\right) \\ &\quad + div_t + \left[\left(1-\tau_t^k\right) r_{k,t} u_t - a(u_t)\right] \bar{K}_{t-1} \\ &\quad + \frac{(1+i_{t-1}) b_{t-1}(h)}{\pi_t} - T_t \end{aligned} \tag{4}$$

where superscript R denotes the Ricardian household, τ_t^c a consumption tax, τ_t^l labour income tax, τ_t^{ee} an employee social security tax, w_t the real wage; div_t dividends paid out of firms profits; τ_t^k capital tax, $r_{k,t}$ the real return on capital services, u_t the capital utilisation rate where the cost of capital utilization is given by $a(u_t)\bar{K}_{t-1}$, $\bar{K}_{t-1}$ the stock of physical capital; i_{t-1} the nominal interest rate on one-period bonds, π_t the gross inflation rate, and the gross nominal interest rate is given by $R_t = 1 + i_t$; and T_t represents a lump sum tax (or transfer). We assume that $a''(u_t)/a'(u_t) = \kappa$, thus the dynamics of the model depend only on parameter κ. In the steady state, there is no unused capital such that $u = 1$. Due to the complete markets assumption for the state contingent claims in consumption and in capital, consumption and capital holdings are the same across households: $C_t^R(h) = C_t^R$, $K_t^R(h) = K_t$.

As standard in the existing literature, physical capital accumulates in accordance with:

$$\bar{K}_t = (1-\delta_k)\bar{K}_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t \tag{A3}$$

where the cost of investment adjustment function is defined as $S\left(I_t/I_{t-1}\right) = [(\phi_k/2)(I_t/I_{t-1}-1)^2]$ with $S\left(1\right) = S'\left(1\right) = 0$, and $S''\left(1\right) = \phi_k > 0$. Hence, the steady state does not depend on parameter ϕ_k(Schmitt-Grohe and Uribe (2006)).

Non-Ricardian households simply consume current after-tax income which consists of after-tax labour income net of lump sum taxation or transfers. The budget constraint of non-Ricardian households is therefore:

$$(1+\tau_t^c)\, C^{NR} = \left(1-\tau_t^l-\tau_t^{ee}\right) w_t L_t^{NR} - T_t \tag{A4}$$

where C^{NR} and L_t^{NR} denote consumption and employment of non-Ricardian households.

Each non-Ricardian household sets its wage equal to the average wage of optimising households. Given that all households face the same labour demand, the labour supply and total labour income of each rule of thumb household are equal to the average labour supply and average labour income of forward-looking households.

A.2 Wage-setting behaviour

A competitive labour union transforms households' differentiated labour into composite labour which is, in turn, supplied to private intermediate firms and the public sector. The technology used in the transformation is defined by:

$$L_t = \left[\int_0^1 (L_t(h))^{\frac{\nu-1}{\nu}}\, di\right]^{\frac{\nu}{\nu-1}} \tag{A5}$$

where ν is the elasticity of substitution among the differentiated labour inputs and L_t the aggregate labour index. The union takes every household's wage, $W_t(h)$, as given and maximises profit Π_t^U:

$$\Pi_t^U = W_t L_t - \int_0^1 W_t(h) L_t(h) di \tag{A6}$$

where $L_t(h)$ denotes the amount of labour supplied by household h to the union, and $W_t(h)$ is the corresponding wage rate for the labour; W_t is the aggregate wage index. Setting the profits of labour unions to zero, due to the prevailing perfect competition in the composite labour market, results in the aggregate wage index: $W_t = \left[\int_0^1 (W_t(h))^{1-\nu}\, di\right]^{1/(1-\nu)}$.

Nominal wages are set in a staggered-price mechanism as in Calvo (1983). Every period, each Ricardian household faces a probability $(1-\varpi_W)$ of being able to adjust the nominal wage. The household then sets nominal wages to maximize expected future utility subject to labour demand from firms. Those who cannot reoptimize set wages in accordance with the indexation rule, $W_t = \pi_t^{\gamma_w} W_{t-1}$, where $\gamma_w \in \langle 0, 1\rangle$ is a parameter that measures the degree of wage indexation.

A.3 Final good sector

The final good, Y_t^P, is produced by aggregating the intermediate goods, $Y_{j,t}^P$, with technology:

$$Y_t^P = \left[\int_0^1 \left(Y_{j,t}^P \right)^{\frac{s-1}{s}} dj \right]^{\frac{s}{s-1}} \tag{A7}$$

Standard demand functions for intermediate goods and a zero profit condition for prices can be derived as was performed for labour unions.

A.4 Intermediate goods sector

Monopolistic firms indexed by j use the following production function in producing the intermediate good $Y_{j,t}^P$:

$$Y_{j,t}^P = \left(K_{j,t-1} \right)^{\alpha} \left(L_{j,t}^P \right)^{1-\alpha} \left(K_{j,t-1}^G \right)^{\alpha_G} - \Phi \tag{A8}$$

where K_G is used for public capital and Φ represents a fixed cost of production. Firms pay a nominal rental rate $(R_{k,t})$ to rent capital services $K_{j,t-1}$. The cost of labour to each firm equals $(1 + \tau_t^{er}) W_t$ where τ_t^{er} denotes employers social security contributions. Intermediate-good sector firms face three constraints: the production function, a demand constraint, and price rigidity determined by a Calvo (1983) mechanism. Intermediate goods producers act to minimise total costs, $(1 + \tau_t^{er}) W_t L_{j,t}^P + R_{k,t} K_{j,t-1}$, subject to the production function (A8). Each firm acts as a price setter where each period a given firm faces a constant probability, $(1 - \varpi)$, of being able to reoptimise its nominal price. Those firms that are able to change prices maximize expected future profits at these prices. Those who are unable to reoptimise set prices subject to an indexing rule, $P_{j,t} = \pi_t^{\gamma_p} P_{j,t-1}$, where $\gamma_p \in \langle 1, 0 \rangle$.

A.5 Macroeconomic policy

Total expenditure on government consumption of final goods, G_t^C, public investment, I_t^G, and public employment, L_t^G has to be paid through either taxes or transactions in the bond market:

$$\begin{aligned} G_t^C + I_t^G + (1 + \tau_t^{er}) w_t L_t^G &= \left(b_t - \frac{(1 + i_{t-1}) b_{t-1}}{\pi_t} \right) + \tau_t^c C_t + T_t \\ &+ \left(\tau_t^l + \tau_t^{ee} + \tau_t^{er} \right) w_t L_t + \tau_t^k r_{k,t} u_t K_{t-1} \end{aligned} \tag{5}$$

where $G_t = G_t^C + (1 + \tau_t^{er}) w_t L_t^G$.

Public capital accumulates according to:

$$K_t^G = (1 - \delta_k^G) K_{t-1}^G + I_t^G \tag{A10}$$

where δ_k^G represents depreciation specific to public capital.

The monetary authority sets nominal interest rates (R_t) by following a Taylor rule which responds to both output and inflation:

$$\hat{R}_t = \rho_\pi \hat{\pi}_t + \rho_y \hat{Y}_t \tag{A11}$$

where, as above, hatted values are used for deviations from steady state and ρ_π and ρ_y, respectively, denote the response of interest rates to inflation and output deviations from their steady state values.

A.6 Market clearing

Total output is the sum of private and public sector output where the equilibrium conditions are given by:

$$Y_t = C_t + G_t + I_t + I_t^G + a(u_t)\bar{K}_{t-1} - (1 + \tau_t^{er})\, w_t L_t^G \tag{A12}$$

$$L_t = L_t^P + L_t^G \tag{A13}$$

where C_t and L_t denote total consumption and employment which are given by the weighted averages of the consumption and employment of Ricardian and non-Ricardian households. Similarly, the market for capital and bonds are in equilibrium when demand equals supply.