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Fiscal Multipliers in Policy–Focused Models with Financial Sector Risk

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Abstract

We analyze government expenditure and tax multipliers in three New Keynesian models with and without financial frictions and estimated for the Euro Area. The extent to which the combination of financial frictions and a binding zero lower bound increases multipliers temporarily above unity depends on how strongly monetary policy responds when the zero lower bound period ends. Refinancing additional government expenditure is not considerably cheaper in a liquidity trap. Output effects of tax rate decreases are generally lower than those based on direct government expenditure changes. Fiscal consolidation at the zero lower bound succeeds in reducing debt–to GDP and providing stimulus if it combines a reduction of government expenditure and transfers with a decrease of labor tax rates.

Keywords: Fiscal multipliers, tax multipliers, fiscal consolidation, financial frictions.

JEL Classification: E62, E63, G01, H61, H62, H63.

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1 Introduction

During the financial turmoil of the Great Recession in 2008 and 2009, governments across the world attempted to stabilize economic activity with higher public spending or tax rebates. In the Euro Area (EA), the main initiative was the European Economic Recovery plan (EERP) by the European Union, encompassing around 2% of EA GDP in the course of 2008 and 2009 (Cwik and Wieland, 2011). At the same time, national governments implemented own fiscal stimulus packages. From the viewpoint of Keynesians, these expansionary fiscal policy measures are highly effective not just in the very short run. The additional aggregate demand - either directly from the government or from households - is conjectured to lead to higher economic activity. Due to multiplier effects, the overall increase in output should exceed the size of government spending itself.

Proponents of this view argue that fiscal multipliers are particularly large in financial crises and under a binding zero lower bound on nominal interest rates (Eggertsson, 2011; Eggertsson and Krugman, 2012). On the one hand, the presence of financial frictions leads to a heightened sensitivity of macroeconomic activity to any policy or shocks. On the other hand, the central bank may not react to the additional fiscal stimulus by increasing interest rates as downward pressure on inflation and output prevails. As a consequence, the usual crowding–out of consumption and investment following fiscal stimulus - via an increase of real interest rates - is absent. Quite to the contrary, the absence of a nominal interest rate response and rising inflation lead to a decrease of real interest rates, thus increasing consumption and investment. In a scenario where both of these effects are present simultaneously, a fiscal stimulus is thus supposed to be highly effective, making it a natural policy tool in stabilizing the economy.

Notwithstanding elevated policy relevance, quantitative uncertainty about these fiscal multipliers remains high. Despite numerous contributions and model comparison exercises, the size of fiscal multipliers reported in the literature is not within a narrow range, a situation which Leeper et al. (2015) label as “fiscal multiplier morass”. In particular, evidence from policy–focused medium–sized New Keynesian models - which are able to fit empirical business cycle properties relatively well - is mixed. For models without financial frictions and considering "normal times" scenarios, initial output multipliers are usually found to be below unity, in a range of 0.7 - 0.9, and even lower medium– to long–run effects tend to be reported. However, results on the impact of the zero lower bound are highly heterogeneous, with some studies finding small amplifications of the multiplier only (Cogan et al., 2010; Kilponen et al., 2015), while others suggest multipliers well above unity in a liquidity trap scenario (Coenen et al., 2012).

The "fiscal multiplier morass" already present in New Keynesian models without financial frictions suggests that investigating the latter as an additional dimension constitutes a challenge. In the class of medium–scale models, this issue has so far received limited attention. One important contribution by Carrillo and Poilly (2013) analyzes a calibrated medium–scale New Keynesian model with financial frictions à la Bernanke et al. (1999). While the benchmark model of Carrillo and Poilly (2013) features a long–run multiplier of 0.59 only, adding financial frictions leads to a substantial amplification of the long–run multiplier to 1.37. Under a binding zero lower bound, the long–run multiplier is even 3.74. These results suggest that financial frictions substantially increase multipliers, in particular when coupled with a liquidity–trap regime, and are thus in line with the reasoning of fiscal stimulus proponents.

However, quantitative results from medium–scale New Keynesian models are generally highly sensitive to calibrated parameter values. Calibrated exercises are furthermore subject to the Lucas critique: A model without financial frictions is likely to feature different deep parameter values relative to a model with financial frictions. Moreover, in the present context, the exact type and formalization of financial frictions, the assumed economic environment - such as the duration of a binding liquidity trap - and the fiscal policy measure under investigation as well as the definition of the fiscal multiplier is of crucial importance for the results.

To fully assess the impact of financial frictions on fiscal multipliers - and put the contribution by Carrillo and Poilly (2013) into perspective - hence calls for a comparison across various estimated medium–scale New Keynesian models. To date, there is to the best of our knowledge no study specifically concerned with fiscal multipliers in such estimated models with financial frictions. It will hence be a principal aim of this paper to investigate the size of fiscal multipliers in estimated models for the EA with various types of financial frictions, with and without a zero lower bound scenario. We focus explicitly on estimated models; as the parameter estimates tie the model's behavior closely to observed business cycles, their quantitative results provide an important yardstick for policy considerations.

This paper also adds government debt as additional dimension to the analysis of fiscal multipliers. This issue has received surprisingly little attention in previous quantitative studies on fiscal multipliers. However, the EA sovereign debt crisis unfolding in 2010/2011 constitutes a reminder that fiscal indebtedness is of potentially high importance for business cycles and policy effectiveness. In the presence of high public sector debt, any fiscal policy measure should not only be evaluated with respect to its direct effect on output, but as well be subject to close investigation of associated implications for sovereign debt. In order to address this issue, we enhance the original model frameworks by a richer fiscal policy setup, allowing for distortionary taxation and the accumulation of government debt. Any fiscal multiplier will hence also be connected to a respective change in government debt.

What is more, making explicit the connection between the fiscal multiplier and government debt dynamics enables us to shed light on the likely effects of recent austerity measures introduced in the wake of the sovereign debt crisis. Against the backdrop of high public debt levels, the fiscal consolidation started in times of financial sector turmoil and European Central Bank (ECB) interest rates essentially at the zero lower bound. Following the Keynesian reasoning, these fiscal consolidation measures are hence supposedly associated with substantial contractionary effects. If governments cut on consumption or increase taxes to reduce debt levels while financial frictions prevail and monetary policy is not able to counteract by decreasing interest rates, the high multiplier effect on these measures will lead to an amplified downward pressure on output.[1] This may even prolong the recession or lead to a reverse, unintended effect on debt sustainability because output plummets such that debt–to–GDP increases. This raises the question how to best design a fiscal consolidation with prevailing financial system risk. In such a scenario, the (implicit) benefits of lower government debt such as higher financial and fiscal stability must be compared with potential short–run output costs.

To summarize, this paper contributes to the literature in at least four ways. First, it provides a model comparison exercise investigating the impact of financial frictions on fiscal multipliers within the class of medium–sized New Keynesian models estimated for the EA. We use the model by Smets and Wouters (2003) as benchmark model without financial frictions and contrast it to one model with firm–side financial frictions à la Bernanke et al. (1999), namely the model by De Graeve (2008), and one model with bank–side financial frictions introduced by Gertler and Karadi (2011). We use parameter values resulting from Bayesian estimations using EA data.

Second, we augment the models under consideration by a richer fiscal policy setup, allowing for distortionary taxation and government debt. On the one hand, this allows us to investigate tax multipliers in financial frictions models, a subject which has received limited attention so far. On the other hand, we are able to connect fiscal multipliers to associated changes in government debt and evaluate the fiscal policy measures jointly on two dimensions. Similar to fiscal policy, monetary policy across models is harmonized by employing a common interest rate rule or a common monetary policy accommodation, i.e. zero nominal interest rates for a specific duration.

Third, we analyze fiscal consolidation scenarios defined as the combined use of various single policy instruments with the primary goal of reducing debt–to–GDP levels. We quantify

[1] This abstracts from potential unconventional monetary policy measures such as quantitative easing, which could possibly unfold a similar effect as a decrease of nominal interest rates and therefore reduce the multiplier in this setting. As a consequence, successful unconventional monetary policy might be able to offset part of associated output costs of fiscal consolidation.

the resulting output and debt implications with and without a binding zero lower bound. We also suggest how fiscal consolidations can be designed in order to mitigate contractionary effects, which is in particular relevant during recessions.

Fourth, we use a piecewise first–order pertubation approach to analyze the effects of the zero lower bound. Previous studies approximated the zero lower bound simply by imposing constant nominal interest rates for an exogenously specified duration, which may produce misleading results. As outlined by Guerrieri and Iacoviello (2015), the accuracy of results obtained by piecewise linear pertubation methods is close to a fully nonlinear solution, therefore reducing approximation errors.

Our results can be summarized as follows. In the baseline scenario of a government consumption stimulus, all multipliers are below unity and decrease over time due to a persistent undershooting of output below steady state after the fiscal stimulus ends. A binding zero lower bound increases the multiplier just above unity on impact. The relative increase in the multiplier resulting from a liquidity trap is higher for financial frictions models. However, overall multipliers remain relatively small near unity over the medium– and long–run, unless parametrizations of the monetary policy rule are considered that lead to a relatively aggressive monetary policy reaction after the zero lower bound period ends. Moreover, refinancing additional government consumption is not considerably cheaper in a liquidity trap in terms of debt–to–GDP. Stimulus packages consisting solely of government spending cuts hence do not seem appropriate in a scenario of financial frictions and a binding zero lower bound.

Output effects of tax rate reductions are generally lower than those based on direct government expenditure and imply similar increases of government debt. In a liquidity trap, the multiplier effect of a labor tax rate decrease is substantially lowered. However, if labor tax rates decreases are gradually smoothed out, the associated multiplier increases under a binding zero lower bound and prevailing financial frictions. We show that these effects can be used to reduce real output costs resulting from fiscal consolidation, even at the zero lower bound and under prevailing financial frictions. In such a scenario, fiscal consolidation is highly effective if it combines a reduction of government consumption and transfers with a decrease of labor tax rates. This policy mix simultaneously achieves a substantial reduction of the debt–to–GDP ratio over the medium–term and provides stimulus for the real economy.

The remainder of the paper is structured as follows. Section 2 provides a short overview of related literature. Section 3 describes the chosen models, the enhanced fiscal policy setup and our methodology for calculating multipliers and simulating the zero lower bound. Sections 4 to 6 analyze fiscal multipliers for government consumption, consumption taxes and labor taxes, respectively. In Section 7, we investigate the effectiveness of fiscal consolidation packages. Section 8 concludes.

2 Literature

This section provides a short review of existing literature concerned with fiscal multipliers. For small–scale models without capital, Woodford (2011) and Christiano et al. (2011) find that a binding liquidity trap substantially increases government expenditure multipliers well above unity. In contrast, Cogan et al. (2010) show that medium–scale New Keynesian models feature government spending multipliers typically smaller than those of old (static) Keynesian models. In particular, they find that the canonical model of Smets and Wouters (2007) features multipliers below unity following a permanent increase of government expenditure. Even a binding zero lower bound for two years yields a multiplier only barely above one.

Cwik and Wieland (2011) compare 5 models for the EA and show that all four models with New Keynesian features imply a significant crowding–out of consumption and investment following an announcement of planned expansionary government spending. The forward–looking behavior of households and firms implies an anticipation of higher future tax burdens and interest rates. Cwik and Wieland (2011) argue that announced government savings packages and spending cuts provide significant short–run stimulus and crowding–in of consumption and investment.

Coenen et al. (2012) investigate 9 models and find significant agreement across models on the absolute and relative importance of various fiscal multipliers. They report a quite narrow range for the government consumption multiplier of 0.8 to 0.9 after one year for the Euro Area, confirming the findings of Cogan et al. (2010). A binding zero lower bound for two years leads to a significant increase of the average multiplier to 1.52 for the Euro Area. Decreases of consumption tax rates are associated with lower multipliers. Changes in labor tax rates feature even lower multipliers, in particular at the zero lower bound, but are still positive. This is in contrast with Eggertsson (2011), who argues that tax cuts at the zero lower bound can cause recessions, equivalent to negative multipliers.

Kilponen et al. (2015) report results from a model comparison exercise of fiscal multipliers using 15 multi–country and small–country models of specific EA countries with a harmonized monetary policy rule. For government consumption cuts, the multiplier is between 0.7 and 0.9 for most models. The introduction of a binding zero lower bound in the aggregate EA increases multipliers only moderately, as the spill–overs of national output to other countries and aggregate inflation is rather weak. However, the zero lower bound has a strong impact on fiscal multipliers if expansionary fiscal policy is implemented simultaneously in all countries. Similar to Coenen et al. (2012), they find that multipliers on labor income taxes and consumption tax rates are lower than the one on government consumption.

Cogan et al. (2013) model fiscal consolidation using the New Area Wide Model (NAWM) of the ECB. They show that a consolidation package consisting of a gradual decrease of government spending and labor tax rates, combined with a cut of transfers is highly effective. It is expansionary in the sense of stimulating output and reduces the debt–to–GDP ratio over the medium– and long–run. This suggests that the decrease of labor taxes and the associated lower distortions on labor supply is particularly suited to foster growth. Clinton et al. (2011) evaluates fiscal consolidation in the IMF's global dynamic general equilibrium model GIMF. They show that fiscal consolidation which is successful in reducing budget deficits can also be expansionary, in particular if it involves an increase of consumption taxes at the expense of labor taxes.

While some previous fiscal policy model comparison exercises include a limited number of models with financial frictions, they do not explicitly account for the effect of financial frictions or investigate the impact of these in closer detail. Similarly, the existing literature concerning fiscal consolidation in structural models does not investigate specific fiscal consolidation scenarios in the presence of financial frictions. The paper at hand thus contributes to the literature by conducting a model comparison exercise on fiscal multipliers and an analysis of fiscal consolidation in structural models with a particular focus on the impact of financial frictions.

On the empirical side, there is a vast array of studies investigating fiscal multipliers in different settings. Cogan et al. (2010) report a range of 0.6 - 1.7 for the government expenditure multiplier in the empirical literature employing Vector Autoregressive Models (VARs). For single countries within the EA, the findings are even more heterogeneous and range from 0.23 to 1.60 in the short–run (as outlined in Boussard et al., 2012 and Kilponen et al., 2015). For the Euro Area as a whole, Burriel et al. (2010) employ a time–varying VAR and find that short–run multipliers range between 0.7 and 1.0, while medium–run multipliers are between 0.7 and 1.7.

For tax rate multipliers, VAR–based studies display largely heterogeneous results for single Euro Area countries (again compare Boussard et al., 2012 and Kilponen et al., 2015). They find different signs of tax multipliers over the short– and the medium–run. However, the absolute magnitude of tax multipliers is mostly estimated to be smaller than the one for government expenditure. Burriel et al. (2010) report a short–term multiplier of 0.63 and a medium–term multiplier of 0.49 for the Euro Area.

Concerning the empirical effects of fiscal consolidation, Alesina and Ardagna (2009), Alesina et al. (2012) and Alesina and Ardagna (2013) investigate OECD countries and find that tax cuts are particular suitable to increase growth, in particular relative to increases of spending. With regard to the reduction of debt–to–GDP, direct government spending cuts are more effective than tax increases. This suggests that the success of fiscal consolidations largely depends on the exact design in term of used fiscal policy instruments and their persistence. More exactly, these studies support the finding of Cogan et al. (2013) that fiscal consolidation can be successful in reducing both debt–to GDP and boosting economic performance if it combines a decrease of labor taxes with a decrease of government spending. In particular, Alesina and Ardagna (2013) provide empirical evidence that some fiscal consolidations were even expansionary on impact.

3 Models, Fiscal Policy and Multipliers

3.1 Models

We compare fiscal multipliers across medium–scale New Keynesian models, which are a subset of Dynamic Stochastic General Equilibrium (DSGE) models featuring capital as production factor and sticky prices. The canonical model of Smets and Wouters (2003) (henceforth SW) serves as a benchmark for our simulations. This model, along with the similar model by Christiano et al. (2005) and its later US version (Smets and Wouters, 2007), provides the basic framework for a large strand of subsequent research. Relative to a small–scale New Keynesian variant, the model features habit formation, wage stickiness, capital adjustment cost and variable capital utilization as well as price and wage indexation. This set of frictions leads to a relatively good fit of theoretical impulse responses to empirical ones obtained by VAR methods.

While SW consider several frictions influencing business cycles, their model does not feature financial frictions. Several papers extend the baseline framework by adding some form of financial sector with associated distortions. De Graeve (2008) (henceforth DG) incorporates the canonical financial accelerator mechanism by Bernanke et al. (1999) (henceforth BGG) in the SW model. In this setup, entrepreneurs need to obtain loans to purchase capital as they do not own sufficiently high own net worth. However, in the spirit of Townsend (1979), idiosyncratic returns are observable by the entrepreneurs themselves only, while lenders need to pay a fixed auditing cost in order to observe the returns. The contract between lenders and entrepreneurs ties the external finance premium - the expected return on capital minus the risk–free rate - to entrepreneur's net worth. The higher the entpreneur's net worth, the lower the associated moral hazard and thus the lower the required external finance premium.[2] As entrepreneur net worth is pro–cyclical, this gives rise to a counter–cyclical external finance premium acting as a financial accelerator during business cycles. In our analysis, we use the parameter estimates for the EA by Gelain (2010).[3]

Models following Bernanke et al. (1999) introduce financial frictions between the financial sector and firms. In contrast, Gertler and Karadi (2011) (henceforth GK) provide a framework where agency problems exist between banks and households. Bank operations are subject to potential moral hazard; in each period, a fraction of household deposits can be diverted by bankers. The resulting incentive–compatible contract between depositors and banks generates an endogenous leverage constraint for banks, linking the volume of intermediated loans to bank net worth. As bank net worth is pro–cyclical, commercial bank intermediation of loans is pro–cyclical as well, leading to an acceleration of business cycles by the financial frictions. As the model is originally calibrated to US data, we use the estimation by Villa (2016) for the EA. This version also adds wage stickiness as well as wage and price indexation to the original model, such that it shares the same set of non–financial frictions as the other models.

Table 1 provides an overview of the models used for our analysis. In total, we consider three medium–scale New Keynesian models; one benchmark model without financial frictions, one variant with firm–based financial frictions and one model with banking–based financial frictions. All of the models are estimated using EA data and feature the same set

[2]In equilibrium, the expected return to capital equals the cost of external finance, such that $E_t\left[\widehat{R}^K_{t+1}\right] - \widehat{R}_t = -\epsilon E_t\left[\widehat{N}_{t+1} - \widehat{Q}_t - \widehat{K}_{t+1}\right]$ where ϵ is the elasticity of the external finance premium entrepreneur's net worth relative to the project size. $\epsilon = 0$ implies the absence of financial frictions.

[3]In the appendix, we consider a second model featuring the BGG mechanism put forward by Carlstrom et al. (2014).

of non–financial frictions.[4]

Table 1: Models

Model	Shortcut	Financial Friction	EA Estimation
Smets and Wouters (2003)	SW	None	SW
De Graeve (2008)	DG	Firm Costly State Verification	Gelain (2010)
Gertler and Karadi (2011)	GK	Bank Moral Hazard	Villa (2016)

For our analysis, we explicitly focus on models which are estimated on EA data using Bayesian techniques. We believe that this approach is likely to provide sensible quantitative yardsticks which are directly applicable to the EA, as these models are estimated including the financial frictions elements from the start. Previous literature investigating the impact of financial frictions on fiscal multipliers largely relied on calibrated models. The contribution of financial frictions is then obtained by means of counterfactual analysis, i.e. enabling or disabling the financial frictions, while keeping the rest of the model unchanged. This approach is subject to the Lucas critique, in that a change the underlying model structure should lead to an adjustment of (estimated) deep model parameters. From a Bayesian perspective, adding financial frictions thus requires a re–estimation of the whole model. Villa (2016) estimates three variants of the SW framework - without financial frictions, with BGG frictions and GK frictions - and shows that the estimates of core parameter values differ across models. This implies differences in the dynamic behavior aside from the mere effect of financial frictions. Thus, it seems appropriate to compare fiscal multipliers across models estimated with and without financial frictions, instead of a counterfactual analysis which artificially enables or disables financial frictions.

3.2 Government Sector

Most medium–scale models with financial frictions do not place a special focus on fiscal policy. It is hence unsurprising that they usually feature a skeleton government sector only.

[4]We also present key results when using US data in the appendix.

Government consumption is modeled as an exogenous shock process, financed by equivalent lump–sum taxes in the same period, i.e. in nominal terms

$$P_t G_t = T_t. \tag{1}$$

where P_t is the price level, G_t is real government consumption, and T_t denotes nominal lump–sum taxes. While this allows for an analysis of the dynamic responses of macroeconomic variables following government consumption expenditures, it precludes any considerations of distortionary taxation and government debt. To be able to analyze these issues, we enhance the original setups by explicitly tracking public debt and distortionary taxes. More specifically, the government is assumed to obey the following government budget constraint each period:

$$P_t G_t + TR_t + B_t = \tau_t^C P_t C_t + \tau_t^N W_t N_t + T_t + \frac{B_{t+1}}{R_t} \tag{2}$$

The expenditure side is given by government consumption G_t, transfers TR_t and interest payments on outstanding government debt in the form of one–period zero–coupon bonds B_t. Expenditures are financed by consumption taxes at a rate τ_t^C, labor taxes at a rate τ_t^N, lump–sum taxes T_t or issuance of new debt B_{t+1} at rate R_t. In other words, in the enhanced setup, the government is able to raise taxes from consumption and labor and can accumulate debt. The cost of new government debt is governed by the prevailing risk–free nominal interest rate set by the central bank. As such, any business cycle movements involving endogenous adjustments of the interest rates (via the Taylor rule) simultaneously affect government debt.

In our setup, the degree to which financing of government spending by lump–sum taxation is possible is limited. We follow Galí et al. (2007) and Cogan et al. (2010) by assuming that those are set according to a fiscal policy rule depending on government debt and government consumption:

$$T_t = \phi_b B_t + \phi_g G_t \tag{3}$$

where $0 < \phi_b < 1$, $0 < \phi_g < 1$, i.e. the government increases lump–sum taxes whenever debt or consumption increases, but not one–for–one. After accounting for changes in distortionary tax income, the fiscal policy rule thus also implicitly determines the extent to which lower government consumption lead to lower debt. The availability of lump–sum taxation is necessary to rule out explosive paths for government debt (compare Galí et al., 2007). Yet, their quantitative size is limited, such that the evolution of government debt is mainly determined by consumption, employment as well as interest rates and inflation. Following Kilponen et al. (2015), the government keeps lump–sum taxes constant for two years after a given fiscal stimulus.

Government consumption, labor and consumption tax rates are set exogenously. The parametrization of the fiscal policy setup follows estimates by Cogan et al. (2010) and Cogan et al. (2013) for the EA. The initial debt–to–GDP ratio is set to 90%, closely mirroring prevailing levels and making the results of our analysis applicable to the recent austerity measures in the EA.[5] Table 2 provides an overview.

Table 2: Parametrization of Fiscal Policy

Parameter	Symbol	Value	Source
Elasticity of lump–sum taxes w.r.t. debt	ϕ_b	0.043	Cogan et al. (2010)
Elasticity of lump–sum taxes w.r.t. spending	ϕ_g	0.124	Cogan et al. (2010)
Consumption tax rate	τ^C	0.122	Cogan et al. (2013)
Labor tax rate	τ^N	0.183	Cogan et al. (2013)
Initial debt–to–GDP ratio	$\frac{B}{Y}$	0.900	Eurostat

The enhanced models are obtained by appending (2) and (3) alongside exogenous processes for tax rates to the original model. Labor and consumption tax rates enter the original model block by altering the intertemporal and intratemporal optimality conditions of households. More specifically, the introduction of the consumption tax induces a distortion of household consumption behavior in their Euler equation:

$$u_{c,t} = E_t \left[\beta \frac{R_t}{\pi_{t+1}} u_{c,t+1} \frac{1+\tau_t^C}{1+\tau_{t+1}^C} \right]$$

where u_c is marginal utility, β is the discount factor, and $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ denotes gross inflation. As the marginal utility of consumption $u_{c,t}$ also enters the labor supply or wage–setting opti-

[5] The debt–to–GDP ratio ranged from 89.3 to 92.0% between 2012 and 2015 according to Eurostat.

mality condition, the consumption tax furthermore distorts these decisions. In the standard case of households choosing optimal labor supply, this would be equivalent to

$$w_t \frac{(1+\tau_t^N)}{1+\tau_t^C} = \frac{u_{n,t}}{u_{c,t}}$$

The labor tax is distortionary in the sense of reducing incentives to work, thus leading households to supply less labor.

Notably, our modeling approach to enrich the fiscal policy setup does not alter the model's dynamic features, and in particular does not change original fiscal multipliers on government consumption. As long as the exogenous tax rates remain at their steady state levels, any given change in government consumption will have the same effect on real allocations and prices as before. Lump–sum taxes ensure that government debt gradually returns to initial levels without distorting household decisions as all models feature Ricardian households only. An advantage of our approach is that the government budget constraint now provides information about the implied movement of government debt given the dynamic responses of macroeconomic variables following the shock.

3.3 Government Multipliers

As identified by Leeper et al. (2015), the "fiscal policy morass" manifests itself not only in terms of quantitative results, but also with respect to the term fiscal multiplier. In general terms, the fiscal multiplier is understood as the ratio of the output change relative to the change in the fiscal instrument. Existing literature has put particular emphasis on the deviation of output from steady state in the first period - a quarter usually - after the fiscal stimulus relative to the deviation of government consumption from steady state. This is a special case of the cumulative multiplier following Uhlig (2010)

$$M = \frac{\sum_{i=0}^{N} \widehat{y}_i}{\sum_{i=0}^{N} \widehat{g}_i} \tag{4}$$

where $\widehat{y}$ and $\widehat{g}$ denote percentage deviations of output and government consumption from their steady states, respectively, with $N = 1$.[6] With $N > 1$, this cumulative measure allows to capture the full dynamic time path of fiscal stimulus; potential persistent long–run effects of government stimulus may be neglected when focusing on short–run effects. We will discuss the cumulative multiplier at different horizons, namely after one quarter ($N = 1$), one year ($N = 4$), in the medium–run ($N = 20$) and in the long–run ($YN = 40, N = 100$).

Regarding fiscal policy instruments, we will pay particular attention to exogenous changes in government consumption, both temporary and permanent and with or without a binding zero lower bound. The initial size of the stimulus amounts to 1% of steady state GDP. We also consider exogenous temporary changes to labor tax rates and consumption tax rates. The size of a given tax stimulus is chosen to generate a decline in revenues equal to 1% of baseline GDP, hence comparable to the expenditure–based stimulus from an equivalent increase in spending.

Except for the fiscal consolidation, the policy experiments conducted vary one policy instrument at a time only, while keeping all other instruments fixed. In this way, we are able to capture the pure multiplier and debt effects of a single, isolated government action.

3.4 Simulated scenarios and solution method

In all our scenarios, the fiscal policy measure under consideration starts in period 0. Any policy action constitutes an exogenous deviation from steady state government behavior and is thus not anticipated by households and firms. However, given that all models feature rational expectations and perfect foresight, households and firms are assumed to know the full dynamic path of government policies upon implementation.[7]

As discussed above, monetary policy is a key driving force of fiscal multipliers, as the

[6] An alternative cumulative discounted multiplier proposed by Leeper et al. (2010) is given by $M_c = \frac{\sum_{i=0}^{N} \beta^{-i} \widehat{y}_i}{\sum_{i=0}^{N} \beta^{-i} \widehat{g}_i}$. As quantitative differences are negligible, we will focus on the undiscounted multiplier.

[7] We focus explicitly on exogenous fiscal policies only. For studies investigating the optimality of given fiscal policy under debt considerations, see for example Schmitt-Grohe and Uribe (2004), Adam (2011), Leith and Wren-Lewis (2013) and Burgert and Schmidt (2014).

adjustment of nominal interest rates to output (and inflation) affects consumption and investment through the real interest rate channel and asset prices. To harmonize the central bank stance to fiscal shocks, we follow previous model comparison exercises by replacing the original monetary policy rules by a common rule throughout all models.[8] Specifically, the harmonized rule employed is

$$R_t = \rho R_{t-1} + (1-\rho)\left[\phi_\pi \pi_t + \phi_q q_t\right]$$

with $\rho = 0.7$, $\phi_\pi = 1.5$, $\phi_q = 0.5$. All variables are in percentage deviations from steady state, where R is the gross nominal interest rate, π is annual gross inflation and $q = y - y^f$ denotes the output gap relative to a flexible–price version of the model. The functional form and parameter values of this Taylor rule are standard and similar to the estimated rules in the original models.[9]

We use a piecewise first–order pertubation approach to analyze the effects of the zero lower bound. Previous studies approximated the zero lower bound simply by imposing constant nominal interest rates for an exogenously specified duration. This approach neglects that economic decisions, and more generally business cycle behavior, may be very different at the zero lower bound. The single linearized solution is, strictly speaking, only valid in the close neighborhood of the steady state, which does not apply to the zero lower bound. The piecewise first–order pertubation approach calculates a second set of linearized policy functions for the zero lower bound scenario. As outlined by Guerrieri and Iacoviello (2015), the performance and accuracy of combining these two linearized solutions is close to a fully nonlinear solution, therefore avoiding approximation errors.

An exogenous contractionary shock is selected that sends the economy to the zero lower

[8]Model–specific estimated monetary policy rules differ in their functional form and parameter values and thus imply distinct central bank reactions to the fiscal stimulus. Comparing fiscal multipliers following a harmonized fiscal policy measure, but varying monetary policy reaction can lead to misleading results. As the monetary policy rule is not a part of the core model block, it is appropriate to harmonize it in the same way as fiscal policy. In the appendix, we discuss the results obtained by using model–specific Taylor rules.

[9]We perform several sensitivity results with respect to functional form and parameter choices in the appendix.

bound.[10] The size of the shock is chosen such that the zero lower bound binds for six quarters. As argued by Benhabib et al. (2001), a longer duration may generate sunspot equilibria. Chosing a duration of six quarters makes the results furthermore directly comparable to those of Carrillo and Poilly (2013).

In the case of a binding liquidity trap, the government stimulus starts in period zero, the first period where the zero lower bound is binding. The size of the government stimulus is chosen such that the duration of the ZLB is unchanged, i.e. we are focusing on the marginal government stimulus. In this way, we abstract from any endogenous adjustments of the length of the liquidity trap to the government stimulus. We then compute partial impulse responses, defined as

$$M_P = \frac{\sum_{i=0}^{N} \widetilde{y}_i}{\sum_{i=0}^{N} \widetilde{g}_i}$$

where $\widetilde{x}_t$ is the partial effect of government stimulus on variable x in percentage points, defined as $\widetilde{x}_t = \widehat{x}_t^f - \widehat{x}_t^0$ with $\widehat{x}_t^f$ being the percentage deviation response to the contractionary shock and fiscal stimulus, while $\widehat{x}_t^0$ is the response to the contractionary shock only. We thus compare the scenario of a binding zero lower bound and accompanied fiscal stimulus to a scenario of a liquidity trap only.

4 Government Consumption Multipliers

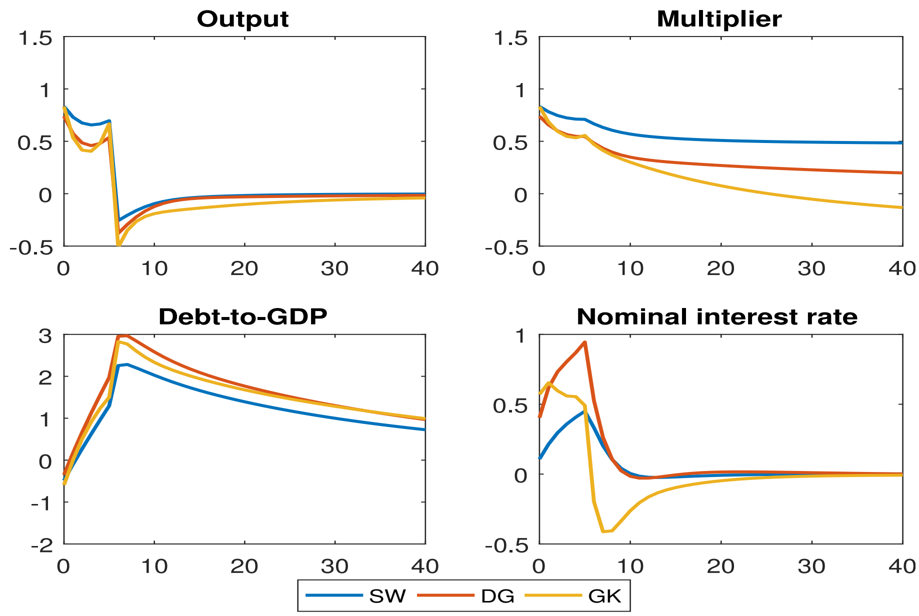
4.1 Baseline

As a baseline scenario, we consider an exogenous increase of government consumption by 1% of steady state GDP which lasts for six quarters, after which it returns to its steady state level.[11] Figure 1 shows the corresponding impulse responses.

[10]The shocks considered differs across models. As we compute partial impulse responses, the type of the selected contractionary shock is irrelevant for the results.

[11]In the appendix, we show that our results hold irrespective of the considered type of government stimulus, i.e. we conduct the same experiments using fiscal stimulus for eight quarters or following an AR(1) process.

Figure 1: Government Consumption Stimulus Baseline



Note: Impulse responses following an increase of government consumption by 1 percent of steady state GDP for six periods. Output and nominal interest rates are shown in percentage deviations from steady state, debt–to–GDP in percentage point differences and the multiplier in levels.

Initial multipliers are within a relatively close range of 0.74 to 0.83, well in line with the findings by previous model comparison exercises for the EA. Notable differences across models manifest only over time; the multipliers after one year range from 0.55 to 0.72. The financial frictions models predict a gradual decrease of the multiplier effect to zero, which results from a persistent undershooting of output below the steady state after the fiscal stimulus ends. In GK, the multiplier even turns negative eventually. In contrast, the SW model features a long–run multiplier of 0.47. While all models thus predict that government consumption can provide some short–run stimulus, they also shed doubt on the long–run efficiency in normal times.[12]

Multipliers are below one because the central bank reacts to the inflationary pressure induced by the fiscal stimulus. The tightening of monetary policy implies an increase of

[12]Coenen et al. (2012) argue that these small, but persistent long–run contractionary effects should be disregarded because the main goal of government stimulus is to counter short–run contractions and stop potential downward spirals. We would argue that, in addition to immediate effects, the full dynamic path of multipliers is important as well, since it potentially has long–lasting effect on debt–to–GDP.

Table 3: Government Consumption Multipliers Baseline

	Q1	Y1	Y5	Y10	Y25
SW	0.83	0.72	0.51	0.49	0.47
DG	0.74	0.56	0.27	0.20	0.11
GK	0.83	0.55	0.09	-0.13	-0.30

Note: Cumulative multiplier effects on output at different horizons following an increase of government consumption by 1 percent of steady state GDP for six periods. $Q1$ denotes the first quarter, Y denotes years after impact.

real interest rates, thus crowding–out consumption and investment. While government consumption thus contributes positively to output, there is a counteracting movement by private GDP components. In DG and GK, the more pronounced increase of inflation in these models induce the central bank to hike nominal interest rates relatively more (compared to the other two models), such that the crowding–out is stronger.[13]

In terms of debt considerations, the government stimulus implies a very short–lived small reduction of debt–to–GDP initially. However, debt–to–GDP increases persistently after the positive output effects end, up to 2–3 percentage points. The elevated debt levels prevail even after 10 years. This result stems from three different factors. First, the higher output is partially produced with labor, thus increasing the tax basis for labor taxes. Second, the crowding–out of private consumption amounts to a simultaneous decrease of the tax basis for consumption taxes. Third, the increase of government spending directly leads to an upward pressure on debt via the government budget constraint.

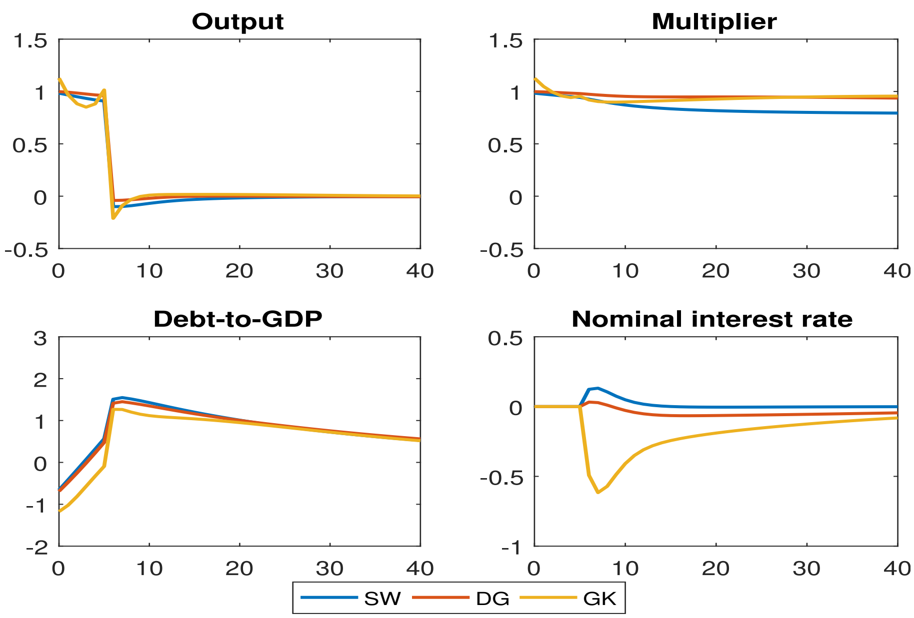
The baseline scenario clearly does not show (substantially) higher government consumption multipliers in models featuring financial risk. If anything, medium– and long–run multipliers are lower compared to the SW model. There are no clear–cut differences across the models with financial frictions. One should therefore conclude that financial frictions alone do not alter fiscal multipliers significantly. This is in stark contrast to monetary policy or technology shocks, which are typically substantially accelerated by financial frictions.

[13]Compared to SW, DG and GK are characterized by a combination of lower price stickiness and price indexation.

4.2 Zero Lower Bound

It should be noted that the findings from the previous section do not contradict the existing literature. Fernández-Villaverde (2010), Eggertsson and Krugman (2012) and Carrillo and Poilly (2013) argue that financial frictions increase government spending multipliers in particular if the economy is in a liquidity trap, i.e. at the zero lower bound. Figure 2 shows the effects of a binding zero lower bound on government consumption multipliers.

Figure 2: Government Consumption Stimulus at the ZLB



Note: Impulse responses following an increase of government consumption by 1 percent of steady state GDP for six periods with the zero lower bound binding for six quarters. Output, nominal interest rate and debt–to–GDP are in percentage points, the multiplier is in levels. All responses are partial, relative to a scenario with the zero lower bound only.

The top left panel shows the partial impulse response of increasing government consumption, i.e. the difference between a scenario of a liquidity trap and government consumption to a scenario without government stimulus. Multipliers across models are remarkably similar: Initial partial multipliers are between 0.98 and 1.13, multipliers after one year range from 0.96 to 0.99. Differences manifest over time only; in the long–run, the GK and DG feature multipliers at 0.95 and 0.88, respectively, while the SW model implies a multiplier of 0.78 only.

Table 4: Government Consumption Multipliers at the ZLB

	Q1	**Y1**	**Y5**	**Y10**	**Y25**
SW	0.98	0.96	0.82	0.79	0.78
DG	1.00	0.99	0.95	0.94	0.88
GK	1.13	0.96	0.92	0.96	0.95

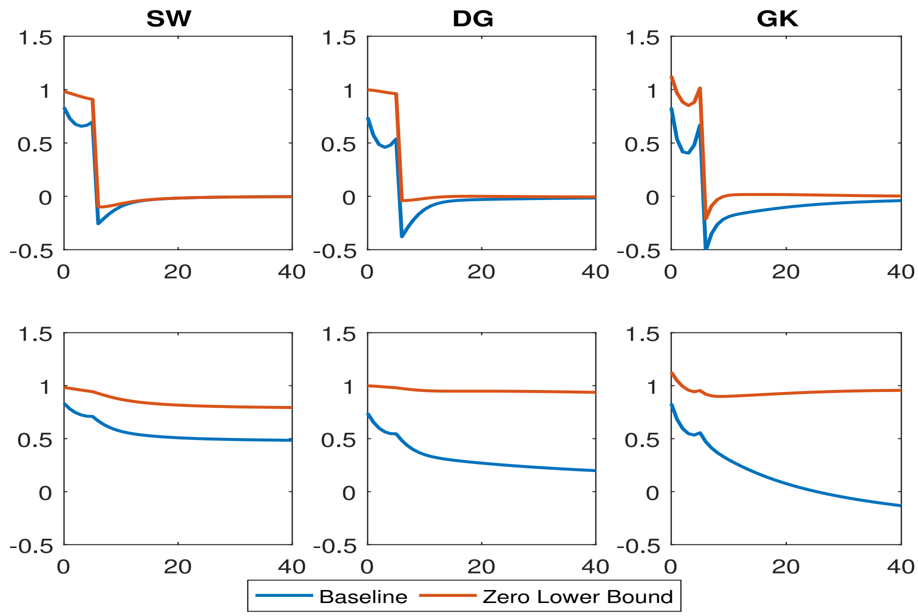
Note: Cumulative multiplier effects on output at different horizons following an increase of government consumption by 1 percent of steady state GDP for six periods under a binding zero lower bound for six quarters. $Q1$ denotes the first quarter, Y denotes years after impact.

For ease of comparison, Figure 3 plots partial output effects and multipliers for the baseline scenario and the zero lower bound scenario. The binding zero lower bound leads to an increase of multipliers across all models, thus confirming the findings by Christiano et al. (2011). The increase in the multiplier is particularly strong on impact and during the time the fiscal stimulus is actually in place. What is more, under a binding zero lower bound, the undershooting of output after the fiscal stimulus ends is substantially mitigated. In turn, this translates into an increase of medium– and long–run multipliers. For GK and DG, the relative effect of a binding zero lower bound is notably higher compared to the model by SW without financial frictions. Thus, the financial frictions contribute substantially to the multiplier in a liquidity trap.

However, the overall multiplier effect under a binding zero lower bound is still relatively small, a result similar to the ones by Cogan et al. (2010), Coenen et al. (2012) and Kilponen et al. (2015). In SW, the multiplier is below unity on impact and decreases monotonically thereafter, implying that consumption and investment are crowded out from the start of the fiscal stimulus. Agents anticipate that the additional government demand will lead to higher real interest rates eventually as soon as the zero lower bound ends and the central bank operates according to its Taylor rule again. Due to perfect foresight, they already adjust in the short–run where the liquidity trap is still in place.

In DG and GK, the initial multiplier is above unity, while long–run multipliers are fairly stable just below unity. The small, yet persistent overshooting of output above the baseline scenario in the medium–run implies that there is some crowding–in of consumption and in-

Figure 3: Government Consumption Stimulus Baseline versus ZLB Scenario



Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

vestment, a phenomenon coined capital–accumulation channel by Carrillo and Poilly (2013). The additional aggregate demand, induced by the government, increases the price of capital and accordingly - for a BGG–type financial frictions model - entrepreneurs collateral value. The associated decrease in leverage and credit frictions imply a decrease of the external finance premium, thus stimulating investment demand and capital accumulation. A higher capital stock further increases entrepreneur collateral, giving rise to a positive feedback loop and a persistent multiplier effect on investment. For the banking frictions model, the increase in the capital price raises asset demand of intermediaries through the endogenous leverage constraint. In turn, the higher asset demand by banks further increases the price of capital, triggering a similar upward spiral inducing a rise in investment.

The overall strength of this channel is closely linked to the central bank reaction. As the nominal interest rates stays constant for six periods, this amounts to elevated incentives to accumulate capital. Moreover, the forward–looking nature of the models also implies that the expected path of nominal interest rates after the economy leaves the zero lower bound is crucial for the magnitude of the multiplier. With the common monetary policy rule - which is standard in both functional form and parameter values - the capital–accumulation channel appears to be limited in strength and is far weaker than in Carrillo and Poilly (2013). Here, even the largest (long–run) multiplier in GK is still below unity.[14]

The increase of debt–to–GDP is less pronounced in the liquidity trap scenario. This largely reflects the cheaper refinancing of existing and new government debt due to zero nominal interest rates. Yet, the short–lived fiscal stimulus is associated with a persistent increase of debt–to–GDP of around 2% in most models.

The results from this exercise thus constitute a mixed message for fiscal stimulus in the form of higher government consumption in times of a liquidity trap. Indeed, as conjectured by the literature, government consumption multipliers are higher in a liquidity trap. However, the magnitude of the multiplier remains below unity for the considered medium–scale models estimated for the EA. The contribution of financial frictions to the multipliers is non–negligible, yet occur only in the course of time and barely keep multipliers around unity in the long–run. Ample multiplication of initial government stimulus is thus absent. Moreover, the associated increase in debt–to–GDP is similar to the case without a binding zero lower bound, implying that refinancing costs are not substantially lower.

5 Consumption Tax Multipliers

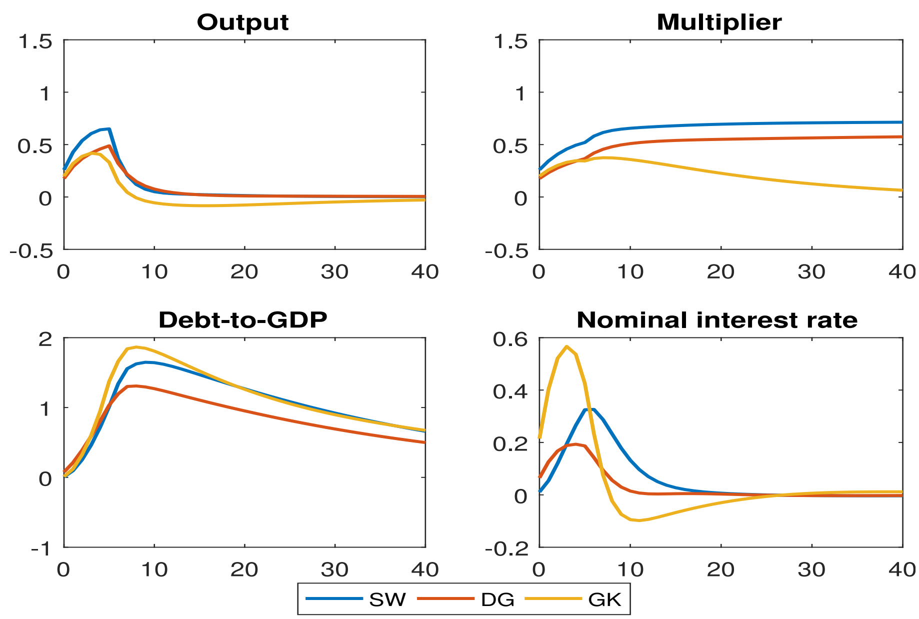
5.1 Baseline

In this section, we analyze an exogenous decrease of consumption tax rates for six periods. The magnitude is chosen such that the fiscal stimulus corresponds to a decline in revenues equal to 1% of baseline GDP. It is thus comparable with the increase in spending resulting from elevated government consumption, and also in line with the size considered by previous

[14]We present sensitivity analyses with respect to functional form and parameter values of the Taylor rule in the appendix. We also reproduce the finding by Carrillo and Poilly (2013) and discuss the relation to our finding.

model comparisons. Figure 4 plots the impulse responses.

Figure 4: Consumption Tax Stimulus Baseline



Note: Impulse responses following a decrease of consumption tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods. utput and nominal interest rates are shown in percentage deviations from steady state, debt–to–GDP in percentage point differences and the multiplier in levels.

Compared to government consumption, the consumption tax multipliers are substantially smaller. Initially, they range from 0.18 to 0.26, only. The decrease of consumption tax rates decreases the tax burden faced by households associated with contemporaneous consumption. In the Euler equation, this amounts to a decrease in the price of current consumption relative to future consumption, thus crowding in consumption. From an intra–temporal viewpoint, it furthermore provides incentives for additional labor supply. Multipliers increase slightly over time as the outlined effects are persistent.

Interestingly, consumption tax multipliers are lower in the financial frictions models relative to the SW model. In absence of financial frictions, a consumption tax rate cut is associated with a moderate increase of investment over the short– and medium–run. The higher aggregate demand stemming from consumption increases the price of capital, in turn increasing investment. In contrast, financial frictions models feature a reverse capital–accumulation–

Table 5: **Consumption Tax Multipliers Baseline**

	Q1	Y1	Y5	Y10	Y25
SW	0.26	0.46	0.69	0.71	0.72
DG	0.18	0.31	0.55	0.57	0.60
GK	0.20	0.33	0.24	0.07	-0.04

Note: Cumulative multiplier effects on output at different horizons following a decrease of consumption tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods. $Q1$ denotes the first quarter, Y denotes years after impact.

channel as counteracting effect. In the DG framework, the increase in real interest rates associated with the higher aggregate demand decreases entrepreneurial net worth. Via the financial frictions, this is equivalent to an increase in the external finance premium, which leads to a decrease in capital price and a corresponding decline of investment. Similarly, in the GK model featuring banking frictions, the decline in real interest rates weakens the accumulation of bank net worth, thus tightening the endogenous leverage constraint and reducing bank asset demand. This, in turn, reduces the price of capital and investment.

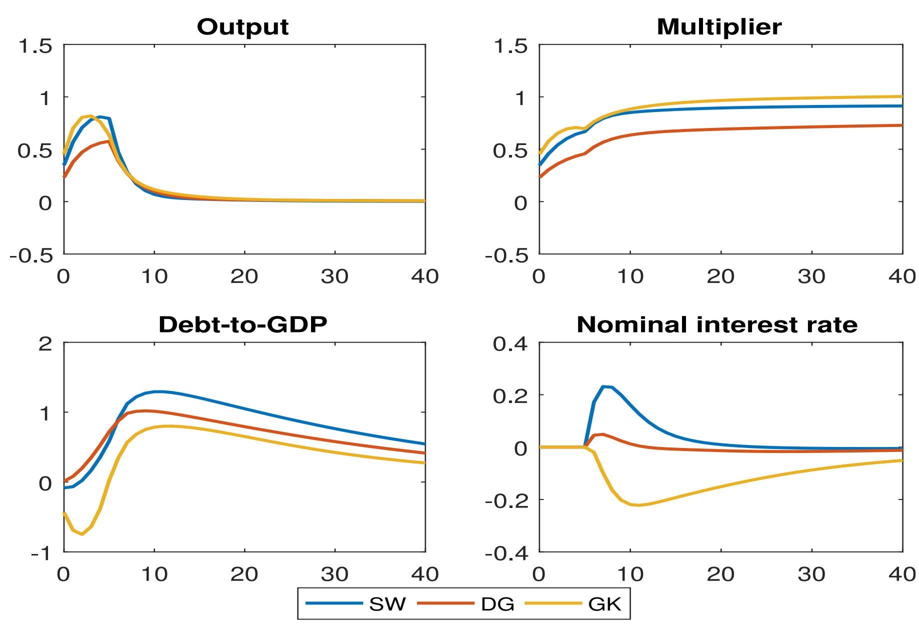
This reverse capital–accumulation–channel is strongest in the GK model over the medium– to long–run. The persistent decrease of investment also generates a prolonged drop of consumption below steady state levels, eventually even turning the multiplier negative. Notably, this effect is present even without a binding zero lower bound.

Regarding government debt, a cut in the consumption tax rate implies a larger tax basis for consumption taxes, which is however subject to a lower tax rate. Despite the moderate increase in output, debt–to–GDP increases right from the start of the fiscal stimulus. This implies that the lower tax rate effect dominates the larger tax basis channel, equivalent to the steady state being located on the left branch of the Laffer curve. Overall, for a given debt accumulation, the consumption tax policy is less favorable than the government consumption stimulus.

5.2 Zero Lower Bound

Figure 5 shows the consumption tax stimulus with a binding zero lower bound. Compared to the no–liquidity–trap scenario, multipliers are higher, ranging from 0.23 to 0.45 on impact and 0.40 to 0.69 after one year. In the long–run, the smallest multiplier is still at 0.76, while the largest effect is featured by the GK model at 1.03. With nominal interest rates constant for six quarters, the increase in inflation from higher consumption triggers a reduction of real interest rates, thus further stimulating consumption. At the same time, the central bank accommodation provides sufficiently high incentives for additional investment, weakening the reverse capital–accumulation channel observed without a liquidity trap. As a consequence, multipliers do not decrease or even turn negative over the medium– and long–run as it was the case before the GK model. The increase of multipliers when going from the baseline scenario to a liquidity trap is most pronounced in the GK framework. SW and DG feature smaller amplification effects.

Figure 5: Consumption Tax Stimulus at ZLB



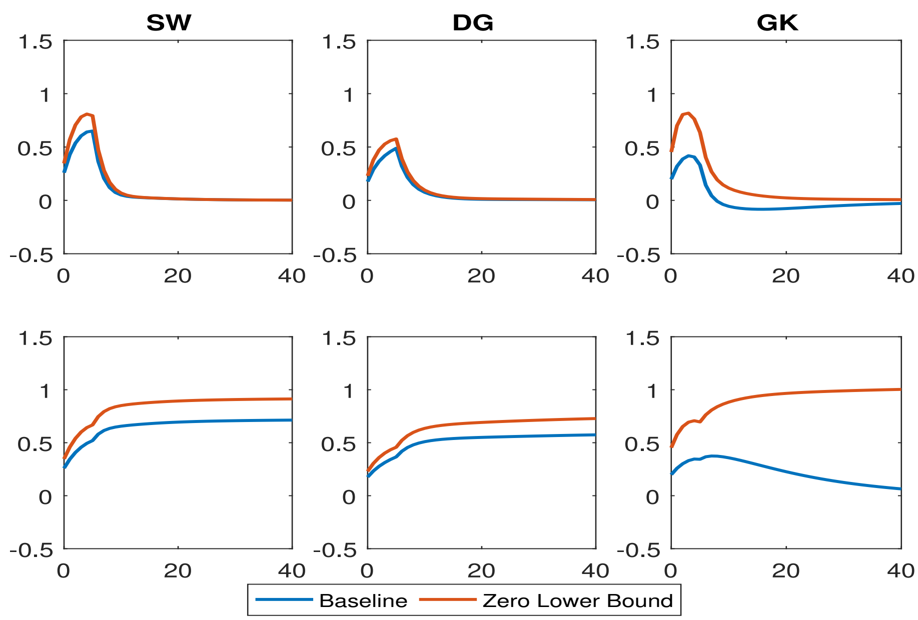
Note: Impulse responses following a decrease of consumption tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with the zero lower bound binding for six quarters. Output, nominal interest rate and debt–to–GDP are in percentage points, the multiplier is in levels. All responses are partial, relative to a scenario with the zero lower bound only.

Table 6: **Consumption Tax Multipliers at ZLB**

	Q1	Y1	Y5	Y10	Y25
SW	0.35	0.60	0.89	0.91	0.92
DG	0.23	0.40	0.69	0.73	0.76
GK	0.45	0.69	0.96	1.00	1.03

Note: Cumulative multiplier effects on output at different horizons following a decrease of consumption tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with the zero lower bound binding for six periods. $Q1$ denotes the first quarter, Y denotes years after impact.

Figure 6: Consumption Tax Stimulus Baseline versus ZLB Scenario



Note: Upper panels show output effects following a decrease of consumption tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

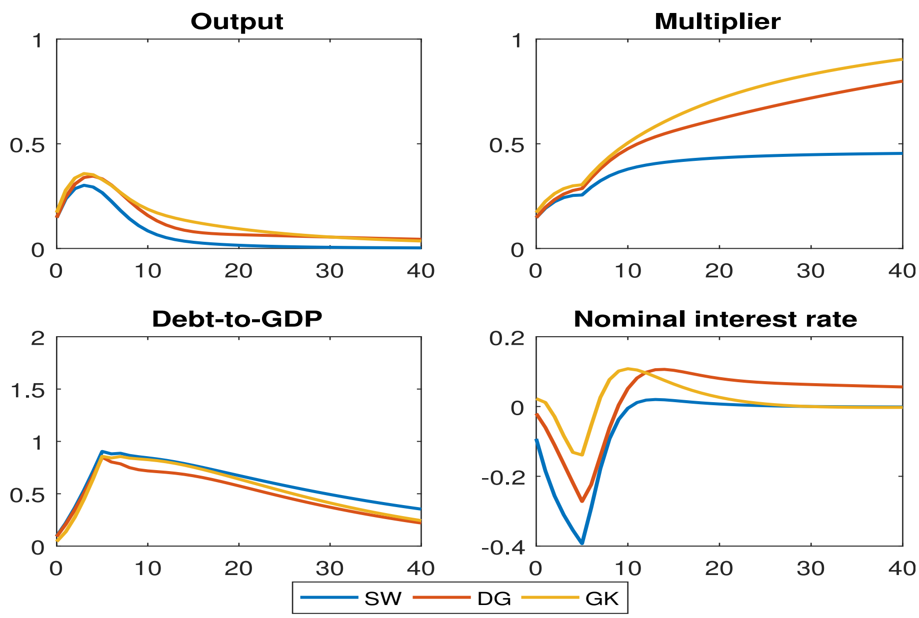
The time path of debt–to–GDP resembles the one implied by the government consumption stimulus at the zero lower bound, where all models predict an increase of approx. one percent. Given that consumption tax rate multipliers are initially lower than government consumption multipliers, however, a consumption tax rate cut seems to be less favorable in terms of a debt–output trade–off at the zero lower bound. The results from this exercise hence advocate the use of direct government spending instead of indirect tax cuts in a scenario where financial frictions are present and the zero lower bound is binding, while fiscal consolidation motives prevail.

6 Labor Tax Multipliers

6.1 Baseline

In this section, we analyze an exogenous decrease of labor tax rates. The magnitude is again chosen such that the fiscal stimulus corresponds to a decline in revenues of 1% of baseline GDP for six periods. Figure 7 plots the dynamic impulse responses.

Figure 7: Labor Tax Stimulus Baseline



Note: Impulse responses following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods. Output and nominal interest rates are shown in percentage deviations from steady state, debt–to–GDP in percentage point differences and the multiplier in levels.

Baseline multipliers are remarkably low, even lower than consumption tax multipliers, at 0.15 - 0.17 initially and 0.24 - 0.29 after one year. The decrease in labor tax rates amounts to an increase of permanent household income and higher incentives for additional labor supply. In contrast to government consumption and consumption taxes, the effect on aggregate demand is indirect and thus rather small. However, multipliers increase over time, amounting to 0.46 to 1.06 in the long–run, mirroring that the substitution effect on aggregate demand manifests over time only. The additional labor supply leads to lower wages and marginal costs of production and thus deflationary pressure. This counteracts the upward pressure on price induced by higher aggregate demand. At the same time, the output gap is negative, such that the central bank decreases nominal interest rates, crowding–in consumption and investment over time.

The effect is particularly strong in the DG and GK framework, where real interests remain persistently below steady state levels. The higher demand activates the capital–accumulation channel over time, leading to high long–run multipliers, at 1.05 for the DG model and 1.06 for the GK model.

Table 7: Labor Tax Multipliers Baseline

	Q1	**Y1**	**Y5**	**Y10**	**Y25**
SW	0.15	0.24	0.43	0.45	0.46
DG	0.15	0.26	0.61	0.79	1.06
GK	0.17	0.29	0.70	0.90	1.05

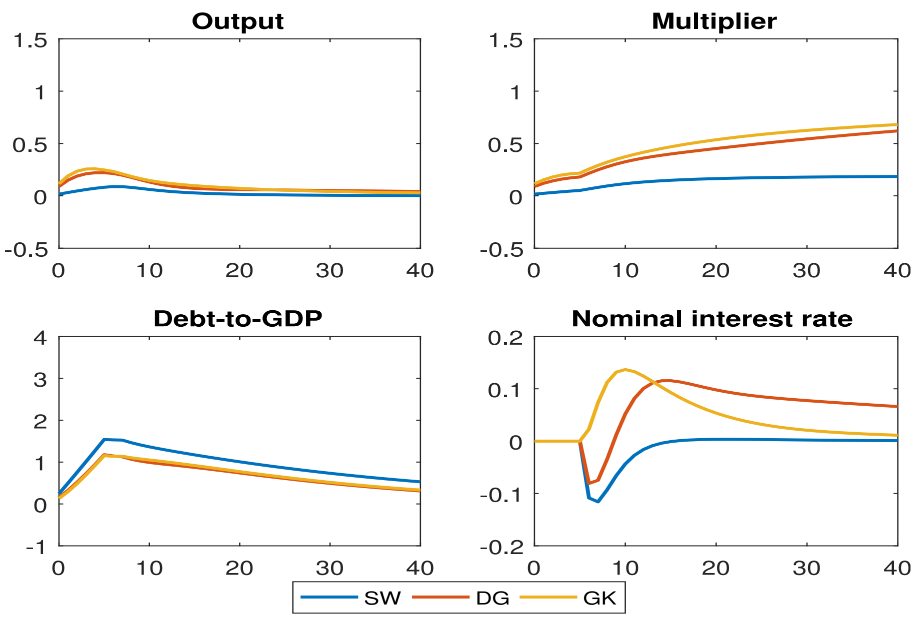
Note: Cumulative multiplier effects on output at different horizons following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods. $Q1$ denotes the first quarter, Y denotes years after impact.

The associated increase in government debt is substantially smaller than the one implied by government consumption stimulus or consumption tax decreases for the baseline scenario. The additional labor supply and higher consumption lead to a larger tax basis, but due to the reduction in labor tax rates, the tax income decreases. However, the deflationary pressure and associated decrease of nominal interest rates also lead to lower refinancing costs of government debt, thus limiting the implied debt accumulation.

6.2 Zero Lower Bound

Figure 8 plots labor tax multipliers at the zero lower bound. Under a binding zero lower bound, labor tax multipliers are lower than in the baseline scenario. These findings are in line with those of Coenen et al. (2012) and Kilponen et al. (2015), who also find that a binding zero lower bound decreases labor tax multipliers. They range from 0.02 to 0.11 initially and from 0.04 to 0.20 after one year. The lower labor tax leads to higher labor supply, in turn inducing a fall in wages, marginal costs of production and lastly also a drop in inflation. With a constant nominal interest rate, the central bank can not react further, such that the decrease of real interest rates is smaller relative to the baseline scenario. Thus, the associated crowding–in of consumption is limited as well. The lower rise of aggregate demand also weakens the capital–accumulation channel over time, such that the long–run effect is smaller than in a liquidity trap. The range is 0.20 to 0.87, where the highest values are again featured by DG and GK.

Figure 8: Labor Tax Stimulus at ZLB



Note: Impulse responses following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with the zero lower bound binding for six quarters. Output, nominal interest rate and debt–to–GDP are in percentage points, the multiplier is in levels. All responses are partial, relative to a scenario with the zero lower bound only.

In the appendix, we show that this result is sensitive to the dynamic time path of the labor tax rate adjustment. In particular, if the labor tax rates follow an AR(1) process, their associated multiplier increases slightly at the zero lower bound in the two financial frictions models. Thus, the amplification effect of the zero lower bound for labor tax stimulus depends crucially on its particular dynamic character. For the discussion of labor tax multiplier, we will continue to focus on the case of a compressed six periods stimulus package, while the latter analysis on fiscal consolidation will use a labor tax rate cut which is gradually smoothed out over time.

Table 8: Labor Tax Multipliers at ZLB

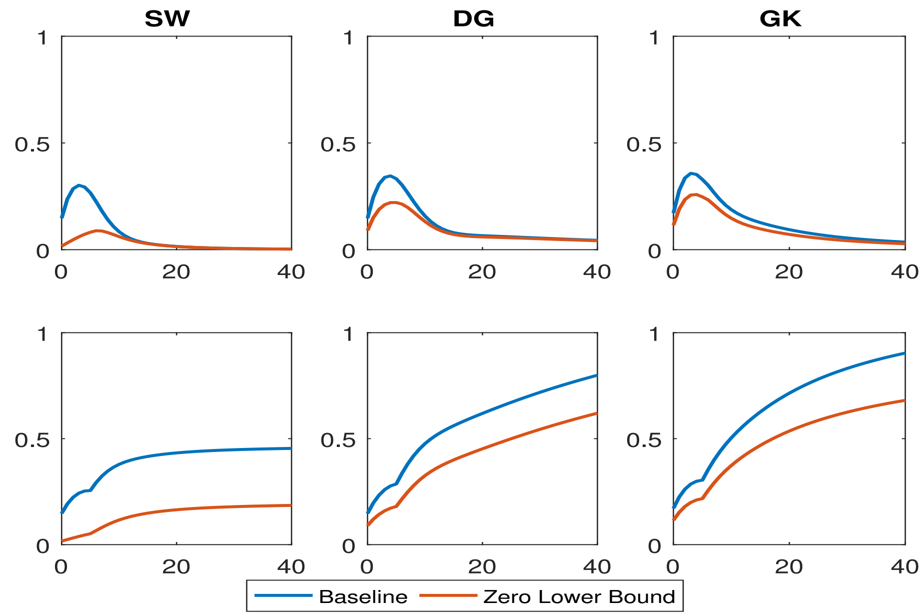
	Q1	**Y1**	**Y5**	**Y10**	**Y25**
SW	0.02	0.04	0.16	0.18	0.20
DG	0.09	0.16	0.44	0.61	0.87
GK	0.11	0.20	0.52	0.68	0.79

Note: Cumulative multiplier effects on output at different horizons following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with the zero lower bound binding for six periods. $Q1$ denotes the first quarter, Y denotes years after impact.

In contrast to Eggertsson (2011) and Carrillo and Poilly (2013), the labor tax decreases are not contractionary at the zero lower bound, as the (relative) crowding–out of consumption is too weak to overcompensate the increased labor supply. Moreover, the active capital–accumulation channel - although weakened relative to the baseline scenario - guarantees positive multipliers. Yet, the contribution of a binding zero lower bound for the multiplier effects on labor tax rates is negative, as shown in Figure 9. In particular, the short–run stimulus of a compressed six periods labor tax cut is substantially smaller under a binding zero lower bound, and the shortfall of cumulative multipliers widens over time.

The lower multiplier also translates into less favorable implications for government debt. In contrast to the baseline scenario, the associated increase in debt–to–GDP is higher in a liquidity trap. However, the increase debt–to–GDP is minimal for the financial frictions models and still lower than the one implied by government expenditure and consumption tax stimulus in a liquidity trap. This makes the labor tax stimulus still relatively cheap under a binding zero lower bound. Although the labor tax multipliers are lower in times of a binding zero lower bound, they might hence still be useful to stimulate the economy, in particular when fiscal debt is a prevailing concern.

Figure 9: Labor Tax Stimulus Baseline versus ZLB Scenario



Note: Upper panels show output effects following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

7 Fiscal Consolidation

At the prevailing levels of debt in the EA - averaging 90.7 percent at the end of 2015 - a reduction of sovereign debt is a primary concern. A high level of government debt is associated with higher risk premia and refinancing costs, possibly giving rise to an upward spiral. As such, it is reasonable to consider fiscal policy measures reducing public debt back to sustainable levels.

At the same time, the implied consequences on the real economy of such consolidation strategies are crucial. If the fiscal policy induces contractionary effects, a downward pressure on tax income due to a lower tax basis and a decrease of output could emerge. In particular when the economy is on the verge of a weak recovery and faces financial turmoil, such consolidation packages can easily be self–defeating in that they fail to reduce debt–to–GDP ratios. In such a scenario, the (implicit) benefits of lower government debt such as higher financial and fiscal stability must be compared with potential short–run output costs.

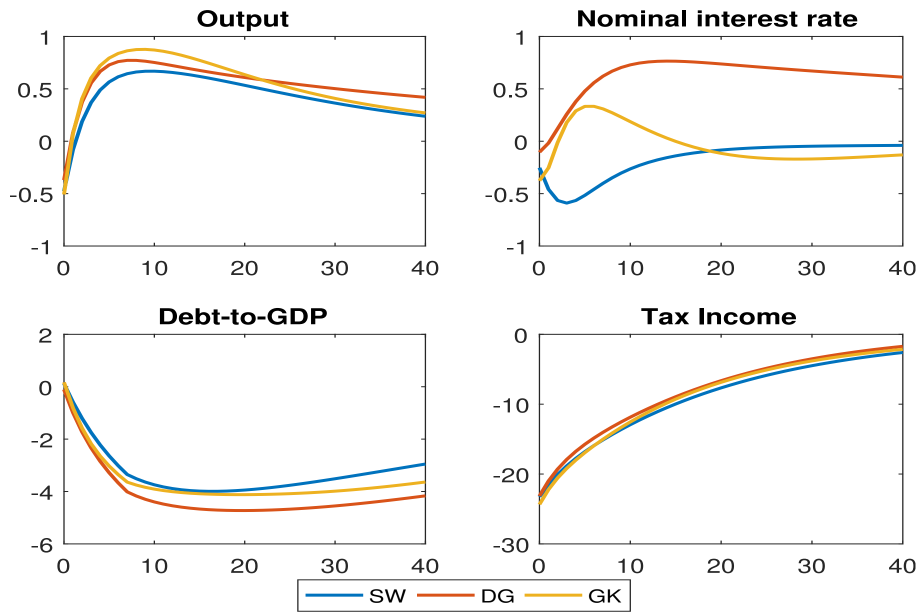
This raises the question how to best design a fiscal consolidation with prevailing financial frictions. Cogan et al. (2013) use the New Area Wide Model (NAWM) of the ECB to assess the effects of the 2013 US fiscal consolidation plan. They show that a combined decrease of government consumption, government transfers and labor tax rates is successful in reducing debt–to–GDP by more than ten percentage points over the course of fifteen years. At the same time, the fiscal consolidation package is expansionary immediately upon implementation. A similar finding is provided by Clinton et al. (2011) using the IMF's model GIMF. This section is devoted to analyze whether these findings carry over to financial frictions models with and without a binding zero lower bound.

7.1 Baseline

The results from the previous analysis on fiscal multipliers suggests that government consumption multipliers are somewhat higher under a binding zero lower bound and refinancing costs are not considerably lower. Consumption tax rate multipliers are lower, but imply similar increases of government debt. Labor tax rate multipliers are high over the medium– and long–run and are associated with mild increases of debt–to–GDP. Combining these findings suggest to use a cut of government spending with the goal of reducing government debt–to–GDP directly. At the same time, this measure should be accompanied by a decrease of labor tax rates to provide comparably cheap stimulus to the economy. We hence consider a similar fiscal consolidation scenario as Cogan et al. (2013), i.e. a cut of direct government spending coupled with a decrease of labor tax rates. This is also in line with Alesina and Ardagna (2009), Alesina et al. (2012) and Alesina and Ardagna (2013) who find that tax cuts are particular suitable to increase growth while direct government spending cuts are most effective in reducing debt–to–GDP.

In period zero, the government announces a simultaneous decrease of government consumption and transfers by 1 and 2 percent of steady state GDP, respectively. This part of the consolidation is intended to directly reduce government debt via a reduction of spending. It is complemented by a stimulative component to counteract the associated downward pressure on output by lower government consumption. The expansionary part is a reduction of labor tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. Lower labor tax rates are equivalent to lower distortions in the intra–temporal labor–consumption decision by households. They thus provide (possibly long–term) incentives for higher labor supply and output growth. All policies follow AR(1) processes with $\rho = 0.95$, mirroring a rather persistent consolidation motive. Figure 10 shows the impulse responses.

Figure 10: Fiscal Consolidation Baseline



Note: Impulse responses in a fiscal consolidation scenario: A simultaneous decrease by government consumption and transfers by 1 and 2 percent of steady state GDP, respectively, coupled with a decrease of labor tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. All policies follow an AR(1) process with $\rho = 0.95$. All variables are shown in percentage deviations from steady state, except for debt–to–GDP which is percentage point differences.

The combined reduction of government consumption, transfers and labor tax rates is successful in reducing debt–to–GDP levels in all models by roughly four percentage points over the medium–run. Tax income decreases substantially by over twenty percent on impact and only gradually reaches pre–consolidation levels over the course of more than ten years. However, the implied reduction in government spending is sufficiently high to outweigh the decline in revenues.

The reduction of government consumption triggers a decrease of output in the immediate short–run as it amounts to a direct reduction in aggregate demand. However, the reduction of labor tax rates and associated increased labor supply make the fiscal consolidation package expansionary, at the latest after one year. The stimulative effect on output is persistent and prevails over the course of more than ten years. This mirrors the time path of labor tax multipliers analyzed above; they are low initially, but increase over time as the substitution effect on aggregate demand unfolds. Ceteris paribus, the higher labors supply leads to deflationary pressure and a negative output gap. Associated lower interest rates crowd in consumption and investment over time. Eventually, this stimulative part of the consolidation package dominates the contractionary effect of lower government consumption.

From a central bank's perspective, the initial drop in output and inflation warrants a reduction of nominal interest rates in the first periods after the fiscal consolidation package is implemented. Over the medium–term, deflationary pressures remain, yet output rises above steady state. The total effect on the monetary policy stance differs across models. In DG and GK, the higher output increase and lower inflation lead to an increase of interest rates above steady state in the second year after implementation. In SW, nominal interest rates remain persistently below steady state.

The financial frictions models by DG and GK imply both a higher effect on output and stronger reduction in debt–to–GDP levels compared to the SW model. Again, this reflects the higher labor tax multipliers found in these models, in particular over the medium– to long–term. Overall, the picture emerging from this exercise suggest that the findings by Cogan et al. (2013) carry over to financial frictions models estimated for the EA. In these models, a fiscal consolidation package - consisting of a combined reduction of government consumption, transfers and distortionary labor tax rates - is expansionary and successful in reducing debt–to–GDP levels over the medium–term. The particular high multiplier for labor taxes in models with financial frictions makes the consolidation even more powerful than in the model without financial frictions.

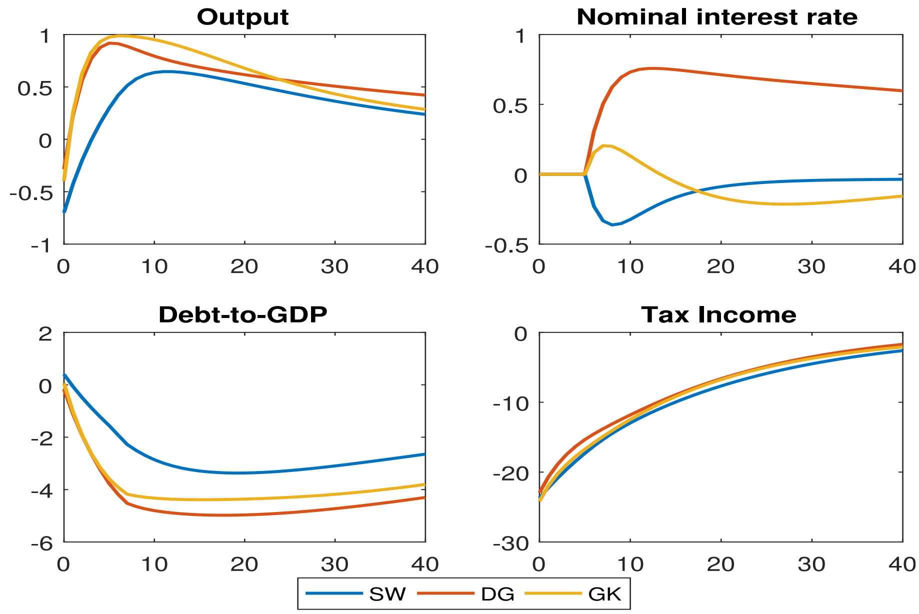
7.2 Zero Lower Bound

In the EA, governments implemented fiscal austerity measures in light of the sovereign debt crisis. The fiscal consolidation started in times where substantial frictions still prevailed and ECB interest rates were practically at the zero lower bound. Our previous findings on multipliers potentially shed doubt on the effectiveness of such policies. On the one hand, the consolidation package considered features a reduction in government consumption. As the corresponding multiplier is amplified in times of a liquidity trap and prevailing financial frictions, the direct downward pressure on output is higher. On the other hand, labor tax multipliers are not substantially higher or even lower under a binding zero lower bound. The fiscal policy instrument intended to stimulate the economy is thus potentially less effective. Overall, this raises concerns whether the fiscal consolidation package considered is appropriate in a liquidity trap. The combination of higher (negative) multipliers on government consumption and only mildly higher or even lower (positive) multipliers on labor tax cuts may even lead to a reverse, unintended effect on sovereign debt because output plummets such that debt–to–GDP increases.

In order to analyze this issue, we simulate the same fiscal consolidation package under a binding zero lower bound. The consolidation is announced and implemented in period zero, after which the liquidity trap still prevails for six periods. We consider partial impulse responses relative to a scenario without fiscal consolidation but with the binding zero lower bound, shown in Figure 11.

Despite the binding zero lower bound, the fiscal consolidation package considered is successful in simultaneously reducing debt–to–GDP and providing stimulus for the real economy in all models. Figure12 reveals that the effectiveness is close to the scenario without a binding zero lower bound in the SW model. The short–run output costs are minimally higher, as the central bank is not able to counteract the initial downward pressure on aggregate demand via lower government consumption by decreasing interest rates. However, over the medium–term, associated output stimulus is only slightly below baseline. Considering the

Figure 11: Fiscal Consolidation at the ZLB

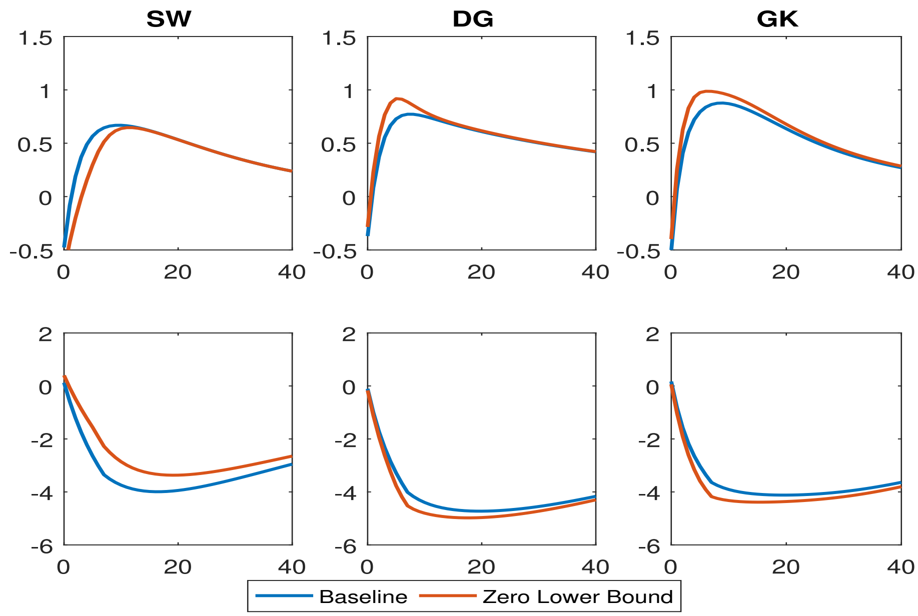


Note: Impulse responses in a fiscal consolidation scenario: A simultaneous decrease by government consumption and transfers by 1 and 2 percent of steady state GDP, respectively, coupled with a decrease of labor tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. All policies follow an AR(1) process with $\rho = 0.95$. The zero lower bound is binding for six periods. All variables are in percentage point differences. All responses are partial, relative to a scenario with the zero lower bound only.

reduction of sovereign debt, the effect of a binding zero lower bound is slightly unfavorable. The lower stimulative effect translates into a less pronounced decrease of debt–to–GDP. On top, the absent reduction of nominal interest rates makes refinancing costs of government debt more expansive relative to the baseline case. However, the overall reduction in debt–to–GDP achieved by fiscal consolidation under a binding zero lower bound is quantitatively very similar.

In contrast, in the financial frictions models, the fiscal consolidation is more expansionary under a binding zero lower bound and correspondingly also leads to a stronger reduction of debt–to–GDP. The main reason is that labor tax rate multipliers are slightly amplified under the zero lower bound if they follow an AR(1) process. We do not want to overemphasize this result that fiscal consolidation is stronger at the zero lower bound in financial frictions models. Yet, this suggests that even with prevailing financial frictions, a binding zero lower bound does not necessarily reduce the power of fiscal consolidation substantially.

Figure 12: Fiscal Consolidation Baseline versus ZLB Scenario



Note: Upper panels show output effects following fiscal consolidation scenario with (red) and without) a binding zero lower bound. The consolidation is given by a simultaneous decrease of government consumption and transfers by 1 and 2 percent of steady state GDP, respectively, coupled with a decrease of labor tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. All policies follow an AR(1) process with $\rho = 0.95$. Lower panels display the respective implications for debt–to–GDP ratios.

Overall, the results from these exercises suggest that fiscal consolidation at the zero lower bound and prevailing financial frictions need not be associated with substantial output costs. Financial frictions models feature higher government consumption multipliers at the zero lower bound relative to models without financial frictions. However, the same applies to labor tax rate multipliers if the tax rate decreases are gradually smoothed out. Hence, despite unfavorable implications of the liquidity trap for government consumption multipliers, a well–designed fiscal consolidation package can stabilize or even reduce debt–to–GDP levels persistently over the medium–term. In particular, the policy mix is characterized by a decrease of direct government spending (both consumption and transfers) and combined with a decrease of labor tax rates to stimulate economic activity. If sovereign debt is one of the primary concerns, such measures are suitable to reduce public debt back to sustainable levels, while at the same time providing some stimulus to the economy. As such, it is also implementable in recessions or during a period of weak economic recovery as the zero lower bound on nominal interest rates still prevails.

8 Conclusion

In wake of the sovereign debt crisis in the EA unfolding in 2010/2011, EA governments implemented fiscal consolidation packages with the aim of reducing public debt back to sustainable levels. These austerity measures were conducted in times of prevailing financial frictions and a binding zero lower bound on nominal interest rates. From a Keynesian reasoning, the reduction of government demand is associated with substantial contractionary effects in such a scenario due to higher fiscal multipliers. Fiscal consolidation is thus conjectured to prolong the recession and lead to a reverse unintended increase of debt–to–GDP.

We assess the impact of such consolidation policies by investigating fiscal multipliers in three different medium–sized New Keynesian models with and without financial frictions. We focus explicitly on estimated models to be able to provide quantitatively sensible yardsticks for EA policy considerations. In the light of high public sector debt, we evaluate fiscal policy measures not only with respect to their expansionary effect on output, but as well the associated implications for sovereign debt. In order to make the connection between fiscal multipliers and government debt dynamics explicit, we augment the models under consideration by a richer fiscal policy setup, allowing for distortionary taxation and government debt. The monetary policy stance across models is harmonized by employing a common interest rate rule and a common length of the liquidity trap. We use a piecewise first–order perturbation approach to analyze the effects of the zero lower bound and minimize approximation errors relative to the fully nonlinear solution.

Our results can be summarized as follows. In the baseline scenario of a government consumption stimulus, all multipliers are below unity and decrease over time due to a persistent undershooting of output below steady state after the fiscal stimulus ends. A binding zero lower bound increases the multiplier just above unity on impact. The relative increase in the multiplier resulting from a liquidity trap is higher for financial frictions models. However, overall multipliers remain relatively small near unity over the medium– and long–run, unless parametrizations of the monetary policy rule are considered that lead to a relatively aggressive monetary policy reaction when the zero lower bound period ends. Moreover, refinancing additional government consumption is not considerably cheaper in a liquidity trap in terms of debt–to–GDP. Stimulus packages consisting solely of government spending cuts hence do not seem appropriate in a scenario of financial frictions and a binding zero lower bound.

Output effects of tax rate reductions are lower than those based on direct government expenditure and imply similar increases of government debt. In a liquidity trap, the multiplier effect of a compressed labor tax rate decrease is substantially lowered. However, if labor tax rates decreases are gradually smoothed out, the associated multiplier increases under a binding zero lower bound and prevailing financial frictions. We show that these effects can be used to reduce real output costs resulting from fiscal consolidation, even at the zero lower bound and under prevailing financial frictions. In such a scenario, fiscal consolidation is highly effective if it combines a reduction of government consumption and transfers with a decrease of labor tax rates. This policy mix simultaneously achieves a substantial reduction of debt–to–GDP over the medium–term and provides stimulus for the real economy.

We conclude that fiscal consolidation at the zero lower bound and prevailing financial frictions need not be associated with substantial output costs. Despite unfavorable implications of the liquidity trap for government consumption multipliers, a well–designed fiscal consolidation package can stabilize or even reduce debt–to–GDP levels persistently over the medium–term. If sovereign debt is one of the primary concerns, such measures are suitable to reduce public debt back to sustainable levels, while at the same time providing some stimulus to the economy. As such, it is also implementable when financial frictions are binding, in recessions or during periods of weak economic recovery as the zero lower bound binds.

Appendix

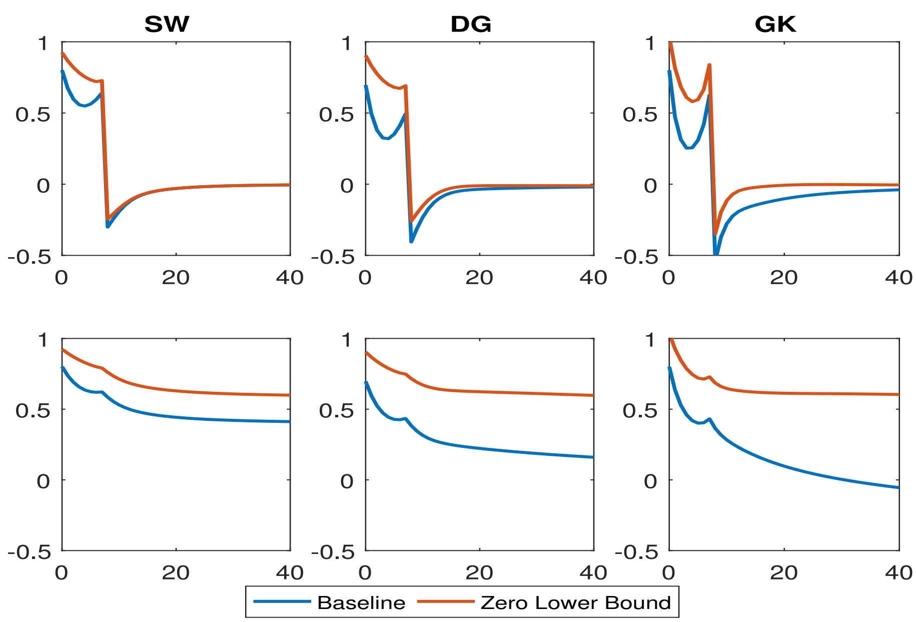
A Robustness Checks

We perform a number of robustness checks, i.e. by varying the dynamic path of fiscal stimulus and assuming a different monetary policy rule. We also present key results of an additional model with financial frictions, and results obtained when using US instead of EA data. Lastly, we consider a fiscal consolidation package using consumption tax rate cuts.

A.1 Fiscal Stimulus for eight periods

This section shows the results if the fiscal stimulus lasts for eight instead of six periods. As the stimulus is less compressed relative to the benchmark case, associated multipliers are lower. In particular, the fiscal stimulus lasts longer than the zero lower bound, such that the central bank partly offsets the direct stimulative effect.

Figure A1: Fiscal Stimulus for eight periods

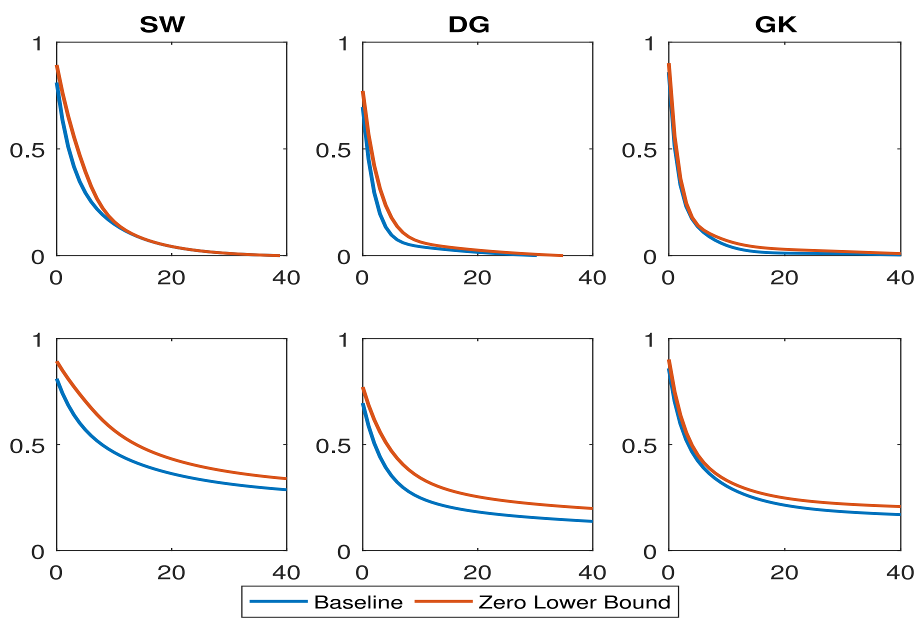


Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for eight periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

A.2 Government Consumption Stimulus as AR(1) process

This section shows the results if the fiscal stimulus is assumed to follow an autogressive process of order one with coefficient $\rho = 0.95$. Similar to the case of stimulus for eight periods, this is equivalent to a less compressed fiscal policy measure and thus associated with even lower multipliers - in particular as a non–negligible part of the stimulus occurs after the zero lower bound ends.

Figure A2: Government Consumption Stimulus as AR(1) process

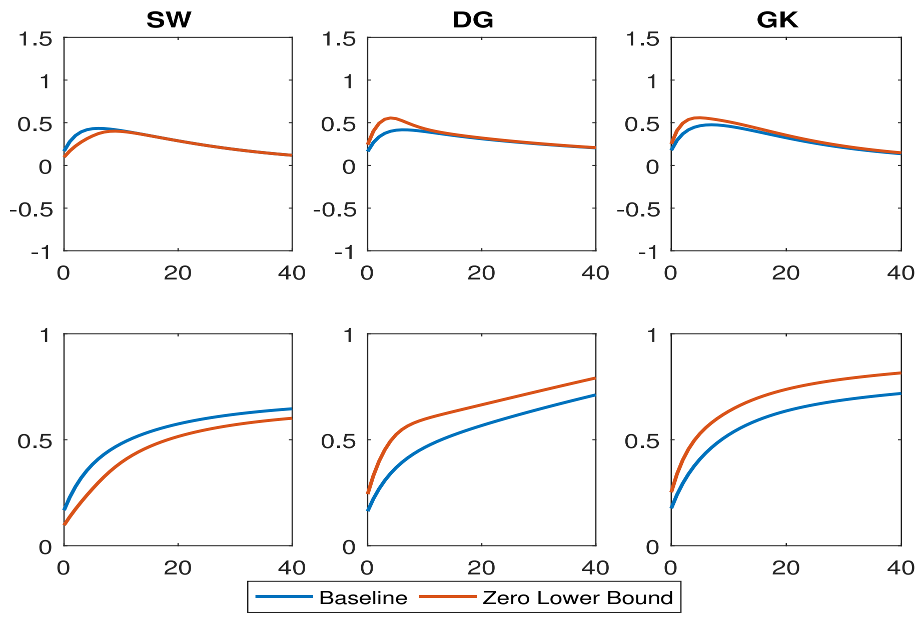


Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers. The policy follows an AR(1) process with $\rho = 0.95$.

A.3 Labor Tax Stimulus as AR(1) process

Figure A3 shows the results of a labor tax rate decrease, which is gradually smoothed out following an AR(1) process with $\rho = 0.95$. The associated multiplier increases in the two financial frictions models at the zero lower bound. This is in contrast to the case of a concentrated decrease of labor tax rates for six periods, where the zero lower bound lead to lower labor tax rate multipliers in all models. The higher persistence of the decrease of labor tax rates is equivalent to prolonged downward pressure on inflation through real marginal costs. After the zero lower bound ends, the central bank counteracts this by relatively lower nominal interest rates. As a consequence, agents rationally anticipate lower real interest rates for a prolonged duration after the zero lower bound ends. This amounts to elevated incentives to consume already when the zero lower bound is binding. The downward pressure on inflation is absent in the case of a compressed fiscal policy measure as the end of the fiscal stimulus coincides with the end of the zero lower bound.

Figure A3: abor Tax Stimulus as AR(1) process

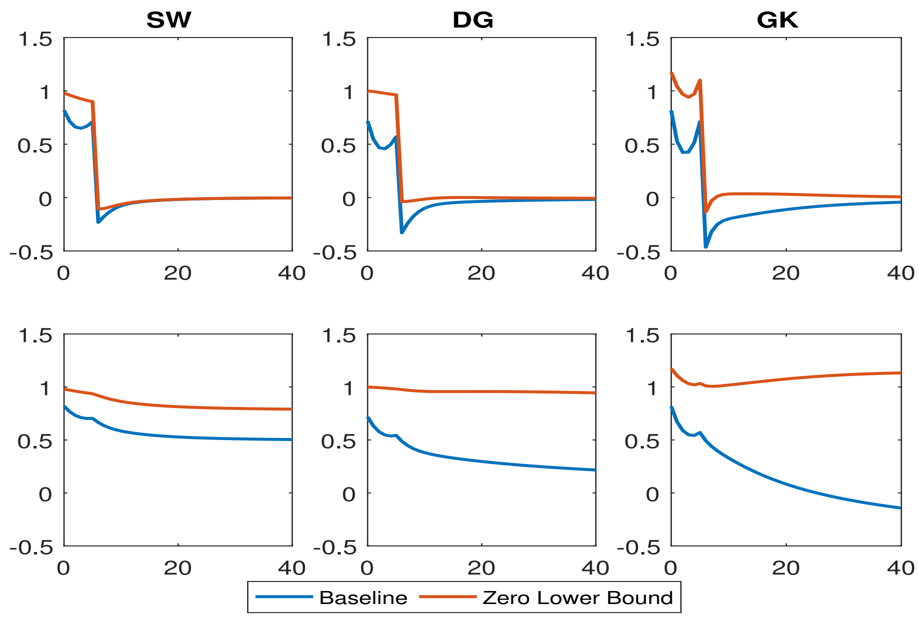


Note: Upper panels show output effects following a decrease of labor tax rates equivalent to a decline in revenues of 1 percent of steady state GDP, gradually smoothed out according to an AR(1) process with $\rho = 0.9$, with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

A.4 Different Policy Rule: Lower Smoothing

This section shows the results if the monetary policy rule features lower smoothing relative to the baseline harmonized rule, i.e. $\rho = 0.5$ instead of $\rho = 0.7$ such that $R_t = 0.5R_{t-1} + (1 - 0.5) \cdot 1.5\pi_t + (1 - 0.5) \cdot 0.5q_t$. The lower smoothing implies a more aggressive monetary policy stance after the zero lower bound ends, such that nominal interest rates are higher relative to the baseline case. The forward–looking agents anticipate these higher real interest rates and thus increase consumption. As emphasized by Carrillo and Poilly (2013), investment is further stimulated due to the capital–accumulation channel.

Figure A4: Different Policy Rule: Lower Smoothing

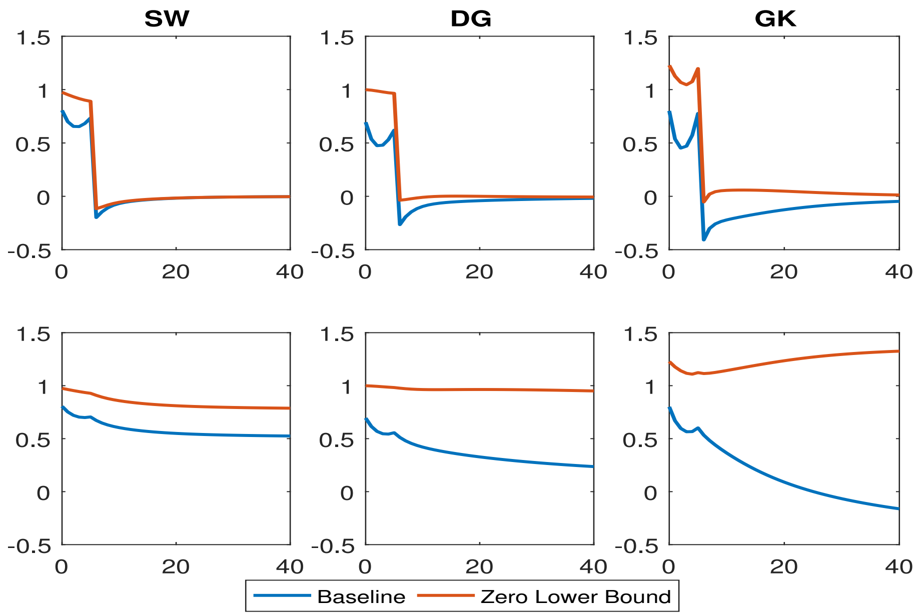


Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

A.5 Different Policy Rule: No Smoothing

This section shows the results if the monetary policy rule features no smoothing, i.e. $\rho = 0$ instead of $\rho = 0.7$ such that $R_t = 1.5\pi_t + 0.5q_t$. This rule is equivalent to the original Taylor (1993) rule. The absense of smoothing implies a strong aggressive monetary policy stance after the zero lower bound ends, such that nominal interest rates are higher relative to the baseline case and even higher than in the case of $\rho = 0.5$. Hence, both consumption and investment (the latter via the capital–accumulation channel) are encouraged. The effect of a binding zero lower bound on the multiplier is thus more pronounced.

Figure A5: Different Policy Rule: No Smoothing



Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

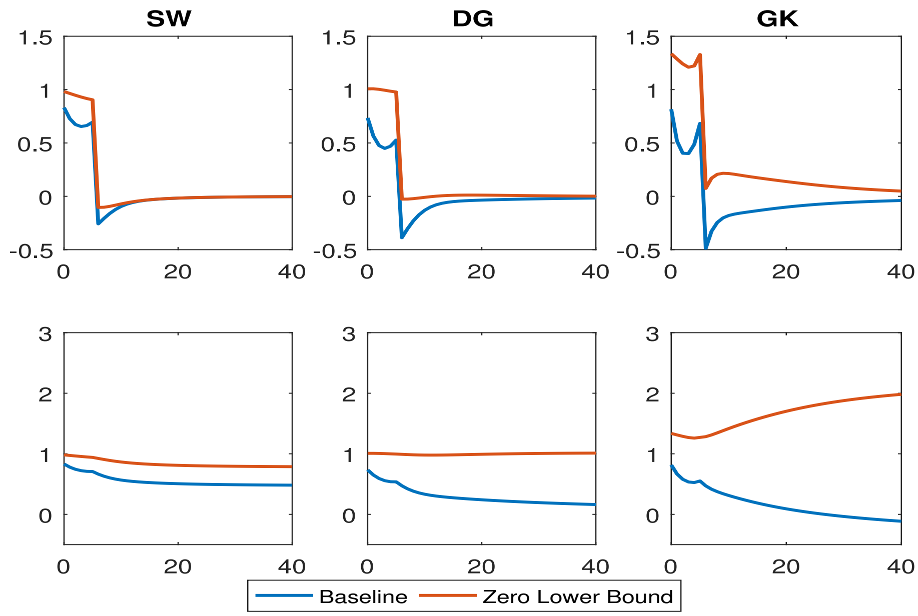
A.6 Different Policy Rule: Higher Inflation Weight

This section shows the results if the monetary policy rule features a higher weight on inflation relative to the baseline harmonized rule, i.e. $\phi_\pi = 2$ instead of $\phi_\pi = 1.5$ such that $R_t = 0.7R_{t-1} + (1-0.7)\cdot 2\pi_t + (1-0.7)\cdot 0.5q_t$. This policy rule generates higher multipliers at the zero lower bound, in particular in the GK model. A more aggressive response to inflation is equivalent to higher real interest rates after the zero lower bound ends. As a consequence, the same incentives to increase consumption and investment are present as before. Here, the strength of the capital–accumulation channel is particularly strong as the real interest rate within the zero lower bound is dragged down.

A.7 Different Policy Rule: Higher Output Gap Weight

This section shows the results if the monetary policy rule features a higher weight on the output gap relative to the baseline harmonized rule, i.e. $\phi_q = 0.75$ instead of $\phi_q = 0.5$ such

Figure A6: Different Policy Rule: Higher Inflation Weight



Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for eight periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

that $R_t = 0.7R_{t-1} + (1 - 0.7) \cdot 1.5\pi_t + (1 - 0.7) \cdot 0.75q_t$. The intuition is the same as in the previous cases. A higher weight on output gap implies more aggressive monetary policy, increasing real interest rates in the future, which provides incentives for higher consumption and investment during the zero lower bound period.

A.8 Different Policy Rule: Model–original rules

This section shows the results if the the model–original rules with associated estimated parameters are used instead of a harmonized common rule.

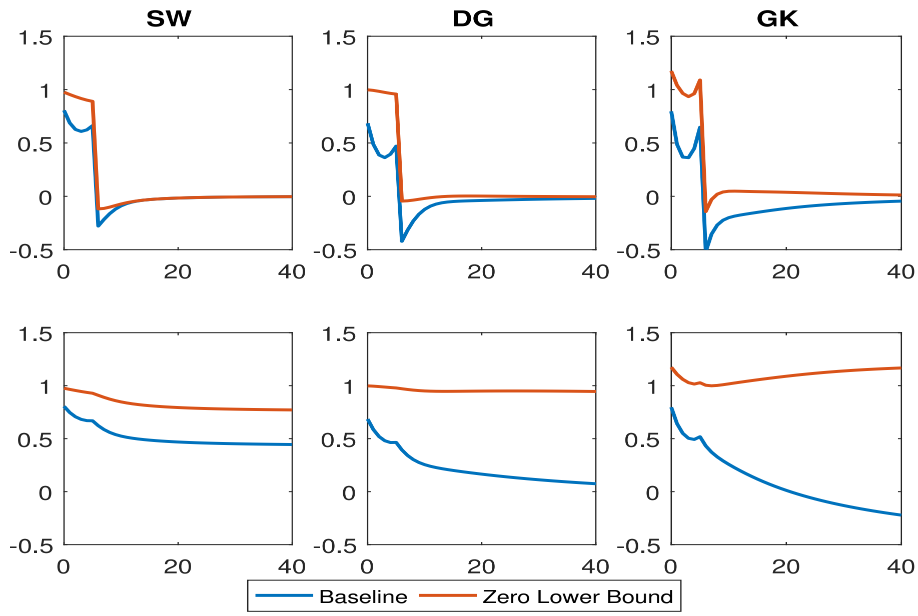
$$\text{SW: } R_t = 0.96R_{t-1} + 0.07\pi_t \quad + 0.14\Delta\pi_t + 0.02q_t + 0.63\Delta q_t$$

$$\text{DG: } R_t = 0.97R^n_{t-1} + 0.15\pi_{t-1} + 0.14\Delta\pi_t + 0.04q_t + 0.82\Delta q_t$$

$$\text{GK: } R_t = 0.89R_{t-1} + 0.19\pi_t \quad + 0.00\Delta\pi_t + 0.04q_t + 0.32\Delta q_t$$

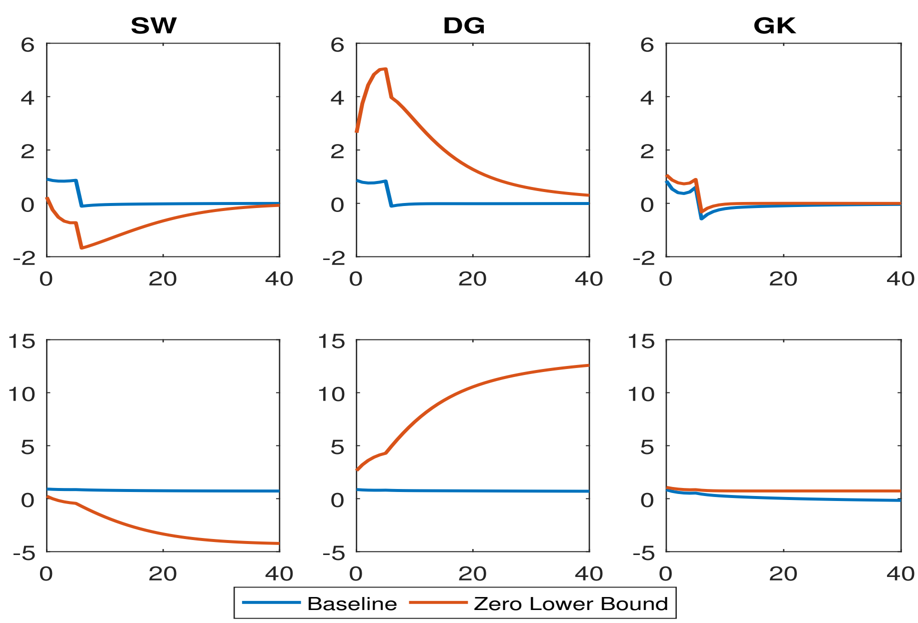
Figure A8 showcases the importance of using a harmonized monetary policy rule. The estimated model parameter rules imply various degrees of monetary policy aggressiveness. A

Figure A7: Different Policy Rule: Higher Output Gap Weight



Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for eight periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

Figure A8: Different Policy Rule: Model–original rules



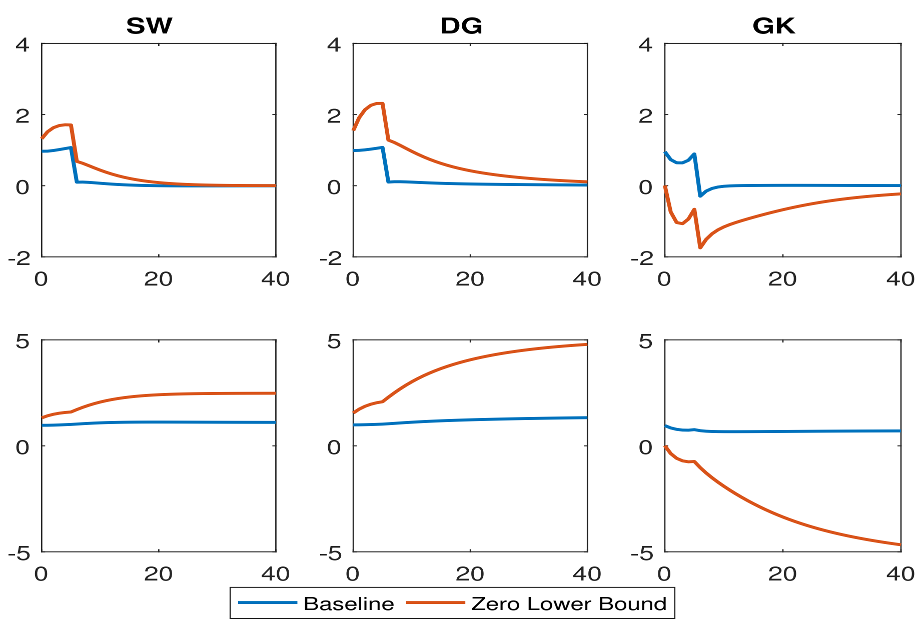
Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for eight periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

harmonized fiscal policy stimulus is thus transmitted to the real economy via quite distinct adjustments of nominal interest rates. Here, the fiscal multipliers of SW and DG are very different from the ones under the baseline rule. The SW model features negative multipliers at the zero lower bound, which results from a persistently lower nominal interest rate after the zero lower bound ends. The case is exactly the opposite for the DG model; its monetary policy rule implies very high real interest rates after the zero lower bound ends, such that consumption and investment are stimulated substantially during the zero lower bound. We believe that these results, implied by distinct central bank reactions to the fiscal stimulus, are misleading. As outlined in the main text, it seems more appropriate to harmonize the monetary policy rule as it is not a part of the core model block.

A.9 Different Policy Rule: Carrillo and Poilly (2013) rule

This section shows the results if the baseline rule by Carrillo and Poilly (2013) is used: $R_t = 0.8R_{t-1} + (1 - 0.8) \cdot 1.5\pi_t + (1 - 0.8) \cdot 0.5\Delta Y_t$

Figure A9: Different Policy Rule: Carrillo and Poilly (2013) rule



Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for eight periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

Figure A9 shows that fiscal multipliers are sensitive to the functional form of the monetary policy rule. Instead of the output gap, Carrillo and Poilly (2013) assume the central bank to react to output growth. In the DG model, under our benchmark rule, output growth is non–negative at the zero lower bound, as evidenced by Figure 2. The central bank then reacts aggressively to the drop of output implied after the zero lower bound ends, by decreasing interest rates (partially with respect to the no–fiscal–stimulus scenario). Due to persistence in the Taylor rule, the interest rates are very low for a prolonged period of time, thus activating the capital–accumulation channel substantially and increasing incentives for consumption.

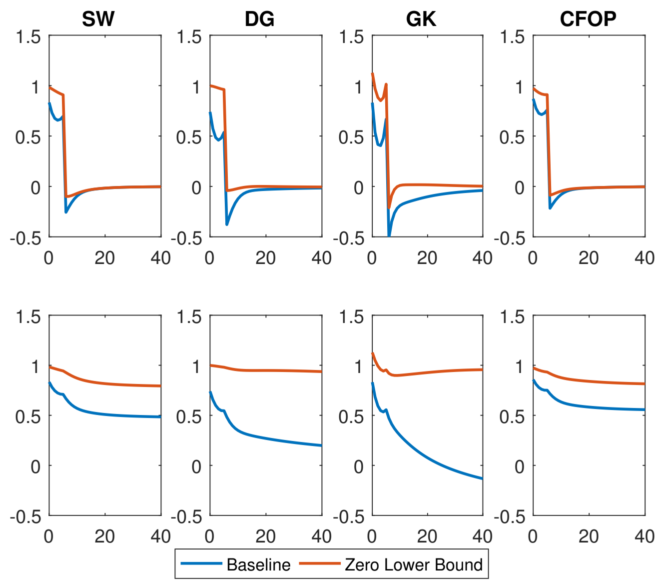
In the GK model, output features a small, yet persistent undershooting below the benchmark scenario after a fiscal policy stimulus (again compare Figure 2). This amounts to positive output growth, thus leading the central bank to set relatively high interest rates for a prolonged period of time. The contractionary effect of monetary policy is so high that it produces a significant downturn in economic activity relative to the scenario without the fiscal policy stimulus, and a negative cumulative multiplier.

Again, we believe that these results are misleading. The piecewise linear solution method seems to be particularly sensitive to the functional form and parameter values of the Taylor rule. In the case of the Carrillo and Poilly (2013) rule, the negative multipliers in the GK model shed considerable doubt on the validity of the high multiplier in the DG framework.

A.10 Additional model: Carlstrom et al. (2014)

This section shows the results of an additional model featuring financial frictions a la Bernanke et al. (1999), namely the model with contract indexation suggested by Carlstrom et al. (2014). They argue that the standard risky debt contract considered in the BGG framework is not optimal. As aggregate variables are not subject to asymmetric information, it is advantageous for both parties to enhance the loan contract by indexation to aggregate states, more exactly to the aggregate return to capital. Using US data, CFOP show that a model with indexation fits the data significantly better. We use the estimated EA version by Afanasyeva et al. (2016) for this analysis.

Figure A10: Additional model: Carlstrom et al. (2014)



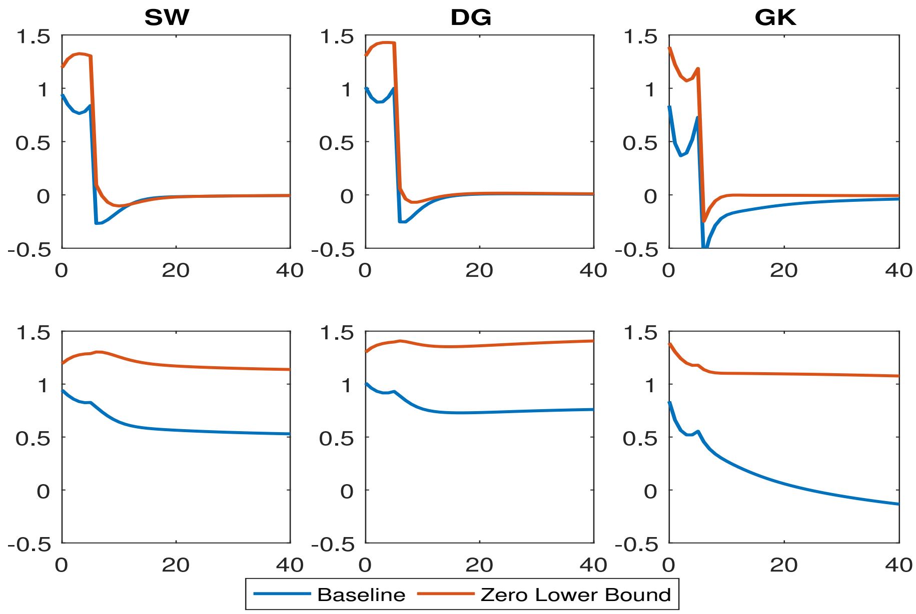
Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for six periods, with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

The increase of the multiplier under a binding zero lower bound is weaker in CFOP relative to the other two financial frictions models, and resembles the amplification by SW. This suggests that the contractionary part of a fiscal consolidation package may not necessarily be substantial when financial frictions prevail.

A.11 US Data

This section shows the results using US data. We use the Smets and Wouters (2007) model, the original De Graeve (2008) model and the US estimation by Villa (2016) for the GK model. All multipliers of government consumption stimulus are slightly higher than those obtained for the estimated EA models. In particular, all three models feature long–run multipliers above unity at the zero lower bound. The amplification effect of a binding zero lower bound is stronger than in the EA models, and again relatively stronger in the two financial frictions models. Overall, quantitative differences are notable, but not substantial and do not alter our main findings.

Figure A11: Government Consumption Stimulus with US data



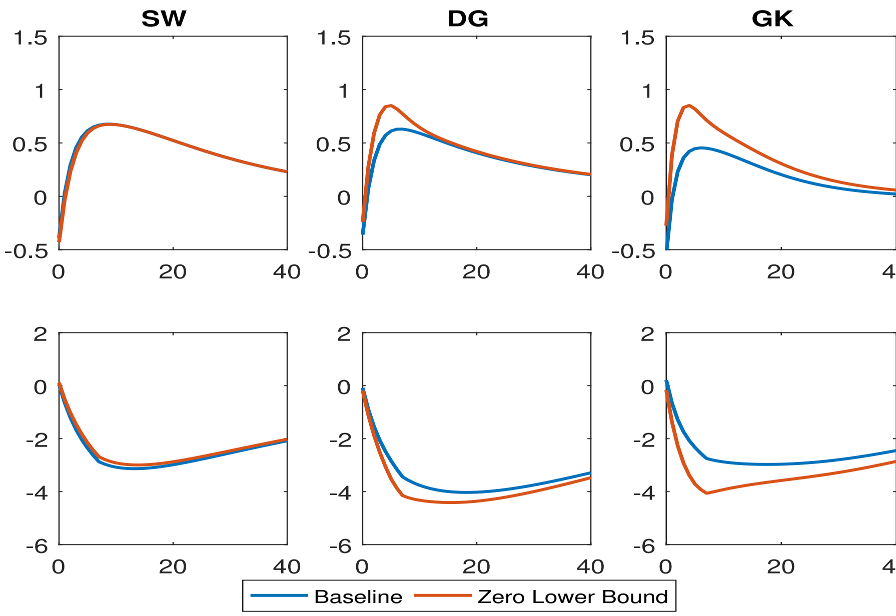
Note: Upper panels show output effects following an increase of government consumption by 1 percent of steady state GDP for six periods with (red) and without) a binding zero lower bound. Lower panels display the respective cumulative multipliers.

A.12 Fiscal Consolidation Using Consumption Taxes

We consider a fiscal consolidation scenario which uses consumption tax rate cuts instead of labor tax rate cuts. The rest of the fiscal policy mix is equivalent to the main scenario investigated: In period zero, the government announces a simultaneous decrease of government consumption and transfers by 1 and 2 percent of steady state GDP, respectively, and a reduction of consumption tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. All policies follow AR(1) processes with $\rho = 0.95$, mirroring a rather persistent consolidation motive. Figure A12 shows the impulse responses.

Fiscal consolidation using consumption taxes is slightly less effective than when using labor tax rates, in particular in normal times. Medium– to long–term expansionary effects are smaller, resulting in lower reductions of debt–to–GDP. However, at the zero lower bound, the fiscal consolidation package is more effective, mainly due to the relatively stronger increase of

Figure A12: Fiscal Consolidation with Consumption Taxes



Note: Upper panels show output effects following fiscal consolidation scenario with (red) and without) a binding zero lower bound. The consolidation is given by a simultaneous decrease of government consumption and transfers by 1 and 2 percent of steady state GDP, respectively, coupled with a decrease of consumption tax rates equivalent to a decline in revenues of 2 percent of steady state GDP. All policies follow an AR(1) process with $\rho = 0.95$. Lower panels display the respective implications for debt–to–GDP ratios.

consumption tax rate multipliers in comparison to the increase of government consumption multipliers. The overall fiscal consolidation success at the zero lower bound is close to the one using labor tax rates. For the model without financial frictions, differences between normal times and a binding liquidity trap are minuscule.

B Government Sector

This section outlines how the original models are augmented with the richer fiscal policy setup. The government budget constraint reads:

$$G_t + TR_t + B_t = \tau_t^C C_t + \tau_t^N W_t N_t + T_t + \frac{B_{t+1}}{R_t}$$

where G is government consumption, TR are lump–sum transfers and B is government debt in the form of one–period zero–coupon bonds. τ^C and τ^N are net tax rates on consumption and labor, respectively. T are lump–sum taxes or transfers and R denotes the gross interest rate $(1+r)$ paid on government bonds. The log–linear version of the government budget constraint is:

$$\frac{G}{Y}\widehat{g}_t + \frac{B}{Y}(\widehat{b}_t - \widehat{\pi}_t) = \tau^c \frac{C}{Y}\left(\frac{1+\tau^c}{\tau^c}\widehat{tax}_t^c\right) + \tau^N \frac{wN}{Y}\left(\frac{\tau^N - 1}{\tau^N}\widehat{tax}_t^N\right) + \frac{T}{Y}\widehat{t}_t + \beta\frac{B}{Y}(\widehat{b}_{t+1} - \widehat{R}_t)$$

where lower–case letters are real variables and $\widehat{x} \approx \frac{x_t - x}{x}$ denotes deviations from the respective steady state in percent. Furthermore, we define $tax^c = 1 + \tau^c$ and $tax^N = 1 - \tau^N$ with

$$\widehat{\tau}_t^C = \frac{1+\tau^c}{\tau^c}\widehat{tax}_t^c$$
$$\widehat{\tau}_t^N = \frac{\tau^N - 1}{\tau^N}\widehat{tax}_t^N$$

As all households are Ricardian, lump–sum taxes and transfers do not alter the original model equations. In contrast, consumption and labor taxes introduce distortions of household optimality equations. For the Euler equation:

$$u_{c,t} = E_t\left[\beta\frac{R_t}{\pi_{t+1}}u_{c,t+1}\frac{tax_t^c}{tax_{t+1}^c}\right]$$

where u_c denotes the derivative of utility with respect to consumption. In log–linear terms:

$$\widehat{u}_{ct} = E_t\left[\widehat{u}_{ct+1} + \widehat{R}_t - \widehat{\pi}_{t+1} + \widehat{tax}_t^C - \widehat{tax}_{t+1}^c\right]$$

For the intratemporal choice of labor and consumption:

$$w_t \frac{tax_t^N}{tax_t^C} = \frac{u_{n,t}}{u_{c,t}}$$

or in log–linear terms:

$$\widehat{w}_t + \widehat{tax}_t^N - \widehat{tax}_t^C = \widehat{u}_{nt} - \widehat{u}_{ct}$$

Lump–sum taxes are set according to a variant of the fiscal policy rule by Cogan et al. (2010) with:

$$\frac{T}{Y}\widehat{t}_t = \phi_b \frac{B}{Y}\widehat{b}_t + \phi_g \left(\frac{G}{Y}\widehat{g}_t + \frac{X}{Y}\widehat{x}_t \right)$$

Distortionary taxes are set exogenously. As they remain constant after a given government consumption shock, they are hence irrelevant for real dynamics of the economy. Only the path of government debt and lump–sum taxation is affected by the presence of distortionary taxation, allowing for a discretionary ceteris paribus analysis.

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