

The short- and long-run effects of fiscal consolidation in dynamic general equilibrium

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December 9, 2013

Very preliminary, work in progress!

Abstract

We provide a systematic analysis of fiscal consolidation in a dynamic general equilibrium model with a detailed government sector and a share of credit-constrained households. We simulate permanent cuts in government consumption, government investment, and transfer payments and we also simulate permanent increases in the labor, capital and consumption tax rate. Ordering these consolidation strategies by multiplier size or their welfare consequences leads to very different rankings. With respect to welfare gains cuts in government consumption rank highest because they yield the largest increase in private consumption in the short- and long-run, which however comes at the cost of large temporary reductions in output. Cutting transfers has the largest positive effects on output, yet the welfare consequences rank lowest since labor input does not decrease so that there is no increase in leisure. Cuts in government investment and capital tax increases have detrimental effects on output in the short- and long-run. But from a welfare perspective they do not rank lowest because slow convergence to the final steady state leads to substantial discounting of the implied long-run drop in consumption. We analyze the short- and long-run transmission channels of the different consolidation instruments to explain these different outcomes. Furthermore, we study how the transmission of fiscal consolidation changes in the case of a binding zero lower bound on nominal interest rates.

Keywords: fiscal consolidation, fiscal multiplier, government debt,
distortionary taxes, zero lower bound, welfare

JEL-Codes: E62, E63, H61, H62, H63

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1 Introduction

The global financial crisis of 2008/2009 has led to two waves of strong fiscal policy actions. First, countries facing deep recessions tried to counteract these with massive fiscal stimuli. The second wave of fiscal policy actions—fiscal consolidation—started as public debt in many countries spiralled upwards resulting in sovereign debt crises and the need to bring down debt-to-GDP ratios.

Regarding the first wave, the effectiveness of fiscal expansion has been widely debated and a large literature has evolved. The dependence of the fiscal multiplier on the following items is now well understood: the mix of spending instruments, the share of credit constrained consumers, the length of a binding zero lower bound on interest rates, usage of lump-sum or distortionary taxes to return the debt ratio to its initial level, and whether government consumption provides utility to households or not. Cogan et al. (2010) were the first to analyze implications of the American Recovery and Reinvestment Act (ARRA) using a DSGE model. Drautzburg and Uhlig (2011) extended the analysis to a variety of fiscal instruments. Christiano et al. (2011) focused on the dependence of the government spending multiplier on monetary policy reactions and Coenen et al. (2012) studied the robustness of fiscal stimulus implications in seven models used by policy institutions.

In contrast, the literature analyzing the consequences of fiscal consolidation in DSGE models is still in its early stage. The effects of fiscal consolidation are not just the mirror picture of fiscal stimulus. First, fiscal stimulus is a temporary policy change that leads to a return to the initial steady state in the long-run. The purpose of fiscal consolidation is, however, to bring down government debt indefinitely, i.e. to arrive at a new steady state with a lower debt-to-GDP ratio. Permanent changes in fiscal policy can have very different implications than temporary changes. Baxter and King (1993) show using a neoclassical model that permanent changes in government purchases induce larger effects than temporary changes. Secondly, the zero lower bound on interest rates works differently for fiscal stimulus, where an increase in interest rates is delayed, than for fiscal consolidation, where a decrease of interest rates is fully prevented.

Existing papers come to different and sometimes opposing conclusions regarding the short-run costs of fiscal consolidation. Some empirical analyses (see e.g. Giavazzi and Pagano, 1990, 1996) find that consolidation works expansionary even in the short-run. An important channel for this effect is most likely an anticipation effect of increases in future income and a consumption smoothing motive. Others (see e.g. Perotti, 2012) are more cautious and find that a fall in output has in some cases only be prevented because of currency depreciation.

In theoretical models the effects depend predominantly on the mix of consolidation instruments used, the assumption about the usage of additional long-run fiscal space and the credibility of announced consolidation plans. Baxter and King (1993) studied permanent change of fiscal policy in a neoclassical growth model, but did not consider fiscal consolidation, but directly adjusted each period taxes to balance the government budget. Several recent papers have studied the effect of fiscal consolidation directly. Coenen et al. (2008) simulate the effects of a permanent reduction in the targeted government debt-to-GDP ratio using a two-country DSGE model and analyse both, the reduction of expenditures and the increase of revenues. They find positive

long-run effects on key macroeconomic aggregates, but large short-run adjustment costs. While in this paper only one instrument is used at a time, Cogan et al. (2013) study a consolidation plan that combines expenditure reductions by means of government consumption and transfer payment cuts with reductions in distortionary taxes relative to a baseline scenario of no consolidation. Incentives to work increase so that hours and income increase in the long-run. Consumption already increases in the short-run because households anticipate these developments and smooth consumption over time. Similarly Forni et al. (2010) find that consolidation combined with permanent tax cuts are optimal because it has expansionary effects in the short- and long-run. To ensure a decrease in the debt-to-GDP ratio such a scenario requires, however, much larger expenditure cuts than a scenario without accompanying tax cuts. Erceg and Lindé (2013) study the effects of fiscal consolidation in a currency union and when the zero lower bound on interest rates binds. In both cases monetary policy cannot freely adjust the interest rate downwards and negative short-run implications of fiscal consolidation increase.

All these papers use complex open-economy DSGE models with many frictions. We complement these analyses by studying a simpler closed economy model. We study the transmission mechanisms of consolidative permanent changes of government consumption, government investment, transfer payments, the consumption tax rate, the labor tax rate and the capital tax rate. We change each of these instruments to achieve savings of 1% of initial GDP and phase in the change in the respective instrument over one year. Simulations are run under perfect foresight so that households and firms anticipate future developments. They take consolidation plans as fully credible and adjust their decisions accordingly. The debt-to-GDP ratio falls endogenously to fulfill the structurally improved government budget constraint. So, in contrast to most of the above mentioned studies, we simulate directly the change in the fiscal policy instruments and study how the debt-to-GDP ratio adjusts, rather than changing a debt-to-GDP target and letting fiscal instruments adjust via some fiscal feedback rule. We think that this setting reflects actual fiscal consolidation plans better. After five years of a falling debt-to-GDP ratio, finally, a fiscal feedback rule kicks in to stabilize the debt-ratio towards a new long-run equilibrium. Here, we consider two possibilities to use the additional available fiscal space: first, transfers increase to a new long-run debt-neutral level or, second, the labor tax rate is reduced. We think that using one instrument for fiscal consolidation and another instrument to stabilize the debt-ratio in the long-run is a more realistic description of actual consolidation than the scenarios used in some of the above mentioned studies where the same instrument is first used to consolidate the government budget and later on the change in the instrument is reversed and the instrument is even used to expand the government budget by the additional fiscal space available due to lower interest rate payments.

Using a closed economy model is useful to understand the above cited open-economy model results better. For example, there are many cases, where the real wage, the rental rate of capital and thus the capital-labor ratio are not affected at all by fiscal consolidation. So, movements in these variables which happen in almost all consolidation scenarios in open economy models are due to additional terms-of-trade movements.

To provide realistic short-run dynamics our closed economy model includes a number of frictions. Important features that affect the long-run impact of fiscal consolidation are the share

of credit constrained households, the labor supply elasticity, the degree of habit formation, the productivity of public capital and whether public consumption provides utility to households or not. Regarding the short-run the same features are important and in addition we include investment adjustment costs, capital utilization adjustment costs and price and wage rigidities.

After an understanding of consolidation scenarios under a benchmark calibration has been developed, we analyse the sensitivity of the consolidation effects with respect to the strength of these different features and a binding zero lower bound on the short-term nominal interest rate. This exercise is helpful on the one hand to understand the details of the transmission mechanism of the different instruments as even the closed economy model is quite complex. On the other hand, with this strategy we can provide ranges of the variations of important macroeconomic variables that are to be expected under various realistic calibrations. Thus, we do not use extreme parameter values, but draw on the existing fiscal policy literature and use for each parameter the maximum and minimum number that has been considered in baseline calibrations of other relevant papers. Using this strategy we are able to identify some key implications of fiscal consolidation that are robust to the specific calibration of the model and also identify which implications are sensitive to the exact modeling choices.

We find that a ranking of consolidation instruments based on output multipliers can be very different from a ranking based on a welfare criterion. In addition, we show that a welfare analysis of fiscal consolidation measures can be very misleading if one only focuses on steady state comparisons. Thus, the transition from the initial to the final steady state is important because agents discount developments in the far future considerably. Furthermore, are able to explain the long-run transmission of fiscal consolidation and the consequences for key macroeconomic variables, such factor prices and factor inputs using some steady state relations. Finally, we show that the zero lower bound on interest rates can generate adverse economic outcomes, depending on the length of the period and the choice of the long-run debt stabilization instrument.

The remainder of the paper is structured as follows. Section 2 provides a description of the model. Section 3 shows the steady state or long-run effects of the consolidation scenarios. Section 4 studies the transmission of fiscal consolidation in the short-run. Both sections include a variety of robustness checks and the short-run analysis also includes effects of a binding zero lower bound on interest rates. Finally, section 6 concludes.

2 A New Keynesian model with a fiscal sector

In this section we give an overview about the main model features. The model is a closed economy medium scale DSGE model. In addition to standard features like nominal and real rigidities and supply side driven long run developments the model includes a detailed fiscal sector and some additional elements that are crucial for the transmission of fiscal policy. The introduction of credit constrained households and a variety of distortionary taxes leads to non-Ricardian effects of fiscal policy. Further, we model a number of different fiscal expenditure instruments. The model consists of two types of households, intermediate goods producers, final goods producers, a central bank and a fiscal authority. The decision problems of these are described in the following.

2.1 Households

There is a continuum of households indexed by $j \in [0, 1]$. A share of $1 - \zeta$ of these households indexed by $o \in [0, 1 - \zeta]$ are optimizing households. They make forward looking decisions and have access to capital markets. The lifetime utility function of each of the optimizing households o is given by:

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\ln(\tilde{C}_{o,t+s} - h\tilde{C}_{o,t+s-1}^*) - \chi_o \frac{N_{o,t+s}^{1+\eta}}{1+\eta} \right]. \quad (1)$$

As in Coenen et al. (2012) $\tilde{C}_{o,t+s}$ is a household specific consumption bundle,

$$\tilde{C}_{o,t} = \left[\kappa_c^{\frac{1}{\nu}} C_{o,t}^{\frac{\nu-1}{\nu}} + (1 - \kappa_c)^{\frac{1}{\nu}} C_{G,t}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \quad (2)$$

where $C_{o,t}$ is consumption of private goods and $C_{G,t}$ is government consumption. κ_c is a share parameter and $\nu > 0$ measures the degree of substitution between private and public consumption. The parameter h determines the degree of external habit formation with respect to the aggregate peer group consumption bundle $\tilde{C}_{o,t+s-1}^*$.¹ The weight parameter χ_o is used to pin down the steady state level of labor supply $N_{o,t+s}$. Optimizing households face the following period t budget constraint

$$\begin{aligned} (1 + \tau_t^c)C_{o,t} + I_{o,t} + \frac{B_{o,t}}{P_t} &= (1 - \tau_t^n) \frac{W_{o,t}}{P_t} N_{o,t} + \left[(1 - \tau_t^k) [r_t^k u_t - a(u_t)] + \tau_t^k \delta \right] K_{o,t-1} \\ &+ R_{t-1} \frac{B_{o,t-1}}{P_t} + TR_{o,t} + Div_{o,t} \end{aligned} \quad (3)$$

and the capital accumulation equation

$$K_{o,t} = (1 - \delta)K_{o,t-1} + \left[1 - S_t \left(\frac{I_{o,t}}{I_{o,t-1}} \right) \right] I_{o,t}. \quad (4)$$

Following Christiano et al. (2005), we assume that it is costly to adjust gross investment. The adjustment cost function takes the form:

$$S_t \left(\frac{I_{o,t}}{I_{o,t-1}} \right) = \frac{\kappa}{2} \left[\frac{I_{o,t}}{I_{o,t-1}} - 1 \right]^2. \quad (5)$$

Optimizing households decide on the holdings of nominal government bonds $B_{o,t}$, the accumulation of physical capital $K_{o,t}$, and the amount of consumption $C_{o,t}$ and investment $I_{o,t}$. Furthermore, optimizing households choose the degree of capacity utilization u_t , which is subject to the cost $a(u_t)$. They receive wage income $W_{o,t}N_{o,t}$, dividend payments from the firms $Div_{o,t}$ and lump-sum transfers from the government $TR_{o,t}$. Households need to pay taxes on consumption, labor and capital, τ_t^c , τ_t^l , τ_t^k . Capital income taxes are levied on capital income net-of-depreciation as in Prescott (2002, 2004) and Trabandt and Uhlig (2011). Maximizing the

¹Marginal utility of income is identical across Ricardian households, because household members pool their wage income. Therefore, $\tilde{C}_{o,t+s} = \tilde{C}_{o,t+s-1}^*$ holds in equilibrium

utility function with respect to the above constraints leads to the following first order conditions:

$$\lambda_{o,t} = \kappa_{\tilde{c}}^{\frac{1}{\nu}} \left(\frac{\tilde{C}_{o,t}}{C_{o,t}} \right)^{\frac{1}{\nu}} \frac{(\tilde{C}_{o,t} - h\tilde{C}_{o,t-1}^*)^{-1}}{(1 + \tau_t^c)}, \quad (6)$$

$$\lambda_{o,t} = \beta E_t \lambda_{o,t+1} \frac{R_t}{\Pi_{t+1}}, \quad (7)$$

$$Q_t = \beta E_t \frac{\lambda_{o,t+1}}{\lambda_{o,t}} \left[(1 - \tau_{t+1}^k) [u_{t+1} r_{t+1}^k - a(u_{t+1})] + \tau_{t+1}^k \delta + Q_{t+1} (1 - \delta) \right], \quad (8)$$

$$1 = Q_t \left[1 - S_t \left(\frac{I_{o,t}}{I_{o,t-1}} \right) - \frac{\partial S_t}{\partial I_{o,t}} I_{o,t} \right] - \beta E_t \frac{\lambda_{o,t+1}}{\lambda_{o,t}} Q_{t+1} \frac{\partial S_{t+1}}{\partial I_{o,t}} I_{o,t+1}, \quad (9)$$

$$r_t^k = a'(u_t), \quad (10)$$

where $\lambda_{o,t}$ is the Lagrange multiplier on the budget constraint, Q_t is Tobins's Q and Π_{t+1} is the gross inflation rate. The effective amount of capital services which is rent out to the firms is:

$$K_{eff,o,t} = u_t K_{o,t-1}, \quad (11)$$

and the functional form of the adjustment cost function $a(u_t)$ is:

$$a(u_t) = \frac{1}{2} r^k \sigma_a u_t^2 + r^k (1 - \sigma_a) u_t + r^k \left(\frac{1}{2} \sigma_a - 1 \right), \quad (12)$$

where σ_a is the adjustment cost parameters and r^k is the steady state rental rate for capital services.

A share ζ of the households indexed by $r \in [1 - \zeta, 1]$ are 'rule-of-thumb' households, which do not have access to capital markets so that the budget constraint involves less terms than for unconstrained households:

$$(1 + \tau_t^c) C_{r,t} = (1 - \tau_t^n) \frac{W_{r,t}}{P_t} N_{r,t} + T R_{r,t}. \quad (13)$$

'Rule-of-thumb' households have the same utility function as unconstrained households. Their optimization problem, however, leads to fully consuming each period their current income, consisting of after tax labor income and transfer payments.

2.2 Wage setting

As in Erceg et al. (2000), we assume that each household is a monopolistic supplier of differentiated labor services $N_{i,t}$. The household sells this labor service to a representative firm that bundles all labor services into an aggregate labor service N_t using:

$$N_t = \left(\int_0^1 N_{i,t}^{\frac{\theta_w - 1}{\theta_w}} di \right)^{\frac{\theta_w}{\theta_w - 1}}. \quad (14)$$

The demand curve for $N_{i,t}$ is given by:

$$N_{i,t} = \left(\frac{W_{i,t}}{W_t} \right)^{-\theta_w} N_t. \quad (15)$$

In this equation W_t is the the aggregate wage index, which is defined as:

$$W_t = \left(\int_0^1 W_{i,t}^{1-\theta_w} di \right)^{\frac{1}{1-\theta_w}}. \quad (16)$$

Optimizing households set nominal wages in staggered contracts. Every period, there is a probability of $1 - \omega_w$ that each household member is allowed to re-optimize its wage. If a household member is not allowed to set the wage optimally it simply adjusts the wage to past periods inflation

$$W_{o,t} = W_{o,t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w}, \quad (17)$$

where γ_w is the parameter defining the degree of indexation.

When an optimizing household is allowed to reset the wage it chooses $W_{o,t}$ to maximize the intertemporal utility functional (1) subject to the intertemporal budget constraint (3) and the labor demand equation (15). The resulting first order condition reads

$$E_t \sum_{k=0}^{\infty} (\beta \omega_w)^k \left[(1 - \tau_{t+k}^n) \frac{W_{o,t}^*}{P_{t+k}} \left(\frac{P_{t+k-1}}{P_{t-1}} \right)^{\gamma_w} - \frac{\theta_w}{\theta_w - 1} (1 + \tau_{t+k}^c) MRS_{o,t+k} \right] \lambda_{o,t+k} N_{o,t+k} = 0, \quad (18)$$

where $W_{o,t}^*$ denotes the optimal wage set in period t and $MRS_{o,t+k} \equiv -\frac{\partial U_{o,t+k}/\partial N_{o,t+k}}{\partial U_{o,t+k}/\partial C_{o,t+k}}$ denotes the marginal rate of substitution between consumption and hours worked.

As in Erceg and Lindé (2013) we assume, that 'rule-of-thumb' households set their wage equal to the average wage rate of the optimizing households. Because both household types face the same labor demand schedule this assumption implies that the demand for labor is equally distributed between household types, $N_{o,t} = N_{r,t} = N_t$.

The definition of the aggregate wage index in equation (16) implies, that the law of motion for the wage index is given by:

$$W_t^{1-\theta_w} = (1 - \omega_w) (W_t^*)^{1-\theta_w} + \omega_w \left(\left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{t-1} \right)^{1-\theta_w}. \quad (19)$$

2.3 Firms

2.3.1 Final goods sector

A representative retail firm bundles intermediate products $y_{j,t}$ into a composite final good Y_t using a CES aggregator:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}. \quad (20)$$

Given the price $p_{j,t}$ of the intermediate inputs, the retail firm chooses factor inputs $y_{j,t}$ to minimize the costs of producing Y_t . The demand for each variety of the intermediate input can be written as:

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{-\theta} Y_t. \quad (21)$$

Perfect competition in the final goods market implies that the retail firm sells each unit of output at price P_t :

$$P_t = \left(\int_0^1 p_{j,t}^{1-\theta} dj \right)^{\frac{1}{1-\theta}}. \quad (22)$$

2.3.2 Intermediate goods sector

There is a continuum of differentiated intermediate goods producers, indexed by $j \in [0, 1]$. Each firm j produces output with a Cobb-Douglas production function,

$$y_{j,t} = z_t K_{G,t-1}^{\kappa_k} K_{eff,j,t}^{\alpha} N_{j,t}^{1-\alpha} - \Phi, \quad (23)$$

where $K_{eff,j,t}$ and $N_{j,t}$ respectively denote effective capital and labor employed by the firm, with the parameter α defining the elasticity of output with respect to private capital. Following Baxter and King (1993), $K_{G,t-1}$ is the public capital stock available in period t , and κ_k is the elasticity of public capital with respect to output. Φ are fixed cost of production. Finally, z_t is aggregate total factor productivity. Intermediate goods firms buy factor inputs in perfectly competitive markets. Let w_t and r_t^k denote the real wage rate and the rental rate of capital. Cost minimization implies that real marginal cost are given by

$$mc_t = \frac{1}{z_t K_{G,t-1}^{\kappa_k}} (r_t^k)^{\alpha} w_t^{1-\alpha} \frac{1}{(1-\alpha)^{1-\alpha} \alpha^{\alpha}}, \quad (24)$$

which are identical across firms.

Intermediate goods firms sell their products under monopolistic competition. As in Calvo (1983), in every period each firm faces the constant probability, $(1 - \omega)$, of being allowed to re-optimize its price $p_{j,t}$. If a firm is not allowed to set its price optimal in period t we follow Smets and Wouters (2003) and assume that a firm index its price to past period inflation $p_{j,t} = \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma} p_{j,t-1}$, with the parameter γ defining the degree of indexation. If a firm is allowed

to set the optimal price in period t it maximizes

$$E_t \sum_{k=0}^{\infty} (\omega\beta)^k \frac{\lambda_{o,t+k}}{\lambda_{o,t}} \left[\frac{p_{j,t}}{P_{t+k}} \left(\frac{P_{t+k-1}}{P_{t-1}} \right)^{\gamma} - mc_{t+k} \right] y_{j,t+k}, \quad (25)$$

taking the demand for its products as given. The resulting first order condition is

$$E_t \sum_{k=0}^{\infty} (\omega\beta)^k \frac{\lambda_{o,t+k}}{\lambda_{o,t}} \left[\frac{p_{t,j}^*}{P_{t+k}} \left(\frac{P_{t+k-1}}{P_{t-1}} \right)^{\gamma} - \frac{\theta}{\theta-1} mc_{t+k} \right] y_{j,t+k} = 0, \quad (26)$$

where $p_{t,j}^*$ is the optimal price set in period t .

The definition of the aggregate price index in equation (22) implies, that the law of motion for the price index is given by:

$$P_t^{1-\theta} = (1-\omega)(p_{t,j}^*)^{1-\theta} + \omega \left(\left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma} P_{t-1} \right)^{1-\theta}. \quad (27)$$

2.4 Monetary Policy

We assume that the central bank follows a Taylor rule to set the nominal interest rate R_t :

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_R} \left[\left(\frac{\Pi_t}{\Pi} \right)^{\delta_{\pi}} \left(\frac{Y_t}{Y_{f,t}} \right)^{\delta_y} \right]^{(1-\rho_R)}. \quad (28)$$

$Y_{f,t}$ is the flex-price output level. The parameter ρ_R determines the degree of interest rate smoothing, whereas the parameters δ_{π} and δ_y determine the response to the deviations of inflation from its steady state value and the output gap.

2.5 Fiscal policy

The government budget constraint in real terms is:

$$b_t + \tau_t^n w_t N_t + \tau_t^c C_t + [u_t r_t^k - a(u_t) - \delta] \tau_t^k K_{t-1} = C_{G,t} + I_{G,t} + TR_t + \frac{R_{t-1}}{\Pi_t} b_{t-1}. \quad (29)$$

In this equation, $b_t = \frac{B_t}{P_t}$ denotes the end of period t stock of government debt. Government spending consists of consumption $C_{G,t}$, public investment $I_{G,t}$ and transfers TR_t to households. On the revenue side the government raises taxes on private consumption as well as on labor and capital income.

The public capital stock evolves as

$$K_{G,t} = (1 - \delta_G) K_{G,t-1} + \left[1 - S_{G,t} \left(\frac{I_{G,t}}{I_{G,t-1}} \right) \right] I_{G,t}, \quad (30)$$

where δ_G is the depreciation rate and $S_{G,t}(I_{G,t}/I_{G,t-1})$ is an adjustment cost function, which has the same functional form as the adjustment cost function for the accumulation of physical

private capital.

All government instruments except for one are set exogenously. One instrument needs to be determined endogenously via a fiscal feedback rule to balance the budget and determine how the debt ratio bY_t is brought in line with the debt-to-GDP target $bY_{target,t}$. In principle one could choose any of the government instruments to adjust endogenously. To limit the number of simulations we focus on two cases: first, we study fiscal consolidation where transfer payments, TR_t , are adjusted endogenously and second, we study scenarios where instead the income tax rate, τ_t^n , is adjusted endogenously. We assume the following two fiscal rules for the two scenarios, respectively:

$$\frac{TR_t}{TR_{t-1}} = e_{aux,t}e_{TR}^{path} + (1 - e_{aux,t}) \left(\frac{bY_{t-1}}{bY_{target,t}} \right)^{-\Phi_{TR1}} \left(\frac{bY_{t-1}}{bY_{t-2}} \right)^{-\Phi_{TR2}}, \quad (31)$$

$$\frac{\tau_t^n}{\tau_{t-1}^n} = e_{aux,t}e_{\tau_n}^{path} + (1 - e_{aux,t}) \left(\frac{bY_{t-1}}{bY_{target,t}} \right)^{\Phi_{\tau_1}} \left(\frac{bY_{t-1}}{bY_{t-2}} \right)^{\Phi_{\tau_2}}. \quad (32)$$

$e_{aux,t}$ denotes a dummy variable that can be set to one for a number of periods to eliminate the endogenous adjustment of TR_t or τ_t^n and set these instruments exogenously as specified in e_{TR}^{path} and $e_{\tau_n}^{path}$, respectively. In this case debt adjusts endogenously to balance the budget each period. To ensure determinacy which requires a constant long run debt ratio, finally, e_{aux} needs to be set equal to zero so that TR_t or τ_t^n adjust endogenously to the debt neutral level where the debt ratio equals the debt target. The parameters Φ_{TR1} and Φ_{TR2} determine how fast the debt ratio converges to the debt target. These parameters enter equation (31) negatively to ensure that when debt is above the target expenditures transfers are reduced. The parameters Φ_{τ_1} and Φ_{τ_2} enter equation (32) positively to ensure that if debt is above target the income tax rate τ_t^n is increased until the debt ratio equals the debt target.

2.6 Calibration

In calibrating the model we use mainly the estimates from Drautzburg and Uhlig (2011). They estimate a similar closed economy DSGE models with many frictions and a rich fiscal sector on US data from 1947 to 2009 using Bayesian techniques. We use estimates for the US as our simulation exercise mirrors the US case more closely than for example consolidation efforts of countries in the Euro area. Some of these countries have experienced high increases in risk premia which might decrease along with fiscal consolidation. This might have additional positive effects on GDP which are not captured by our model. While the US debt ratio is increasing and thus fiscal consolidation is an important topic, risk premia have not risen substantially yet, so that our model framework is appropriate.

Initial steady state tax rates and the initial steady state debt-GDP ratio are taken from Trabandt and Uhlig (2011). They use the methodology from Mendoza et al. (1994) to calculate average effective tax rates. Based on data from 1995 to 2007 the consumption tax rate is set to 5%, the labor tax rate to 28%, the capital tax rate to 36% and the debt ratio to 64%. The calibration of the tax rates is important for the results with respect to Laffer curve effects. Trabandt and Uhlig (2011) show that the chosen tax rates are at least for the US on the left

hand side of the peak of the labor and capital tax Laffer curves in a neoclassical growth model with roughly similar steady state characteristics as the models used in this paper. An increase in these tax rates will therefore increase tax revenues. For the consumption tax rate they do not find a peak of the Laffer curve so that also increase in the consumption tax rate will lead to rising tax revenues. The slope of the Laffer curves does not change much for a range of about 20 to 40% for the labor tax rate and about 0 to 50% for the capital tax rate so that the results should also give some indication for the effects of fiscal consolidation for somewhat different initial steady state tax rates.

Drautzburg and Uhlig (2011) obtained time averages of government spending components from NIPA table 3.1. Accordingly, we calibrate spending on government consumption to 15.22% (this includes the value for net exports) and spending on government investment to 4% of GDP. The initial steady state transfer to GDP ratio is implied by the government budget restriction in equation (29) and other steady state values and yields 7.44% of GDP which is close to the actual value of 8.47% in the sample used by Drautzburg and Uhlig (2011). The share of credit constrained households is set to $\zeta = 25\%$. Overall transfers are split up between household types according to their share in the population. In consequence, consumption levels differ in steady state. In our setup consumption of credit constrained households is about 81 % of unconstrained households.

The parameters of the fiscal policy rule are set to $\Phi_{TR1} = 0.25$ and $\Phi_{TR1} = 5$ if equation (31) is used, i.e. transfers are used to stabilize the debt ratio, and to $\Phi_{\tau 1} = 0.1$ and $\Phi_{\tau 2} = 2$ if equation (32) is used, i.e. the labor tax rate is used to stabilize the debt ratio. These parameter values lead to a smooth transition of the stabilizing instrument and the debt ratio to the long run equilibrium. Using different values hardly impacts the consolidation phase in $t = 1, \dots, 20$, where $e_{aux,t} = 1$ and the debt ratio adjusts endogenously, but only the periods afterwards where the economy converges to the long-run equilibrium. The efficiency of public capital is set to $\kappa_k = 0.05$ as in Baxter and King (1993). The depreciation rate of public capital is equal to the depreciation rate of private capital ($\delta_G = 0.0145$) as in Drautzburg and Uhlig (2011).

The inverse of the labor supply elasticity equals 2.16 which is consistent with microeconomic estimates (Chetty et al., 2011) and the intratemporal elasticity of substitution is set to one so that we have a log utility specification. Steady state gross inflation is $\Pi = 1$ so that there is no price dispersion in steady state. There are adjustment costs for private capital, $\kappa = 4.51$, and for public capital, $\kappa_G = 7.11$, as estimated by Drautzburg and Uhlig (2011). An overview about all parameters can be found table 1.

2.7 Consolidation Scenario

To analyze the transmission channels of the different fiscal instruments we run consolidation scenarios where we vary one instrument at a time. Expenditure instruments $C_{G,t}$, $I_{G,t}$ and TR_t are reduced by one percent of initial steady state GDP. The reduction is phased in linearly over one year. Instruments on the revenue side are the tax rates τ_t^c , τ_t^n and τ_t^k . They are increased so that revenues for the initial steady state tax base would rise by 1% of initial steady state GDP.

Table 1: Calibrated parameters

Parameter	Value
Discount factor β	0.99
Intratemporal elasticity of substitution σ	1
1 minus weight of public consumption in the utility function κ_c	1
Inverse of Frisch labour elasticity η	2.16
Degree of habit formation h	0.80
Share of 'rule-of-thumb' households ζ	0.25
Steady state labor share N/Y	0.30
Investment adjustment cost private capital κ	4.51
Private capital depreciation rate δ	0.0145
Capital utilization adjustment cost σ_a	0.7544
Investment adjustment cost public capital κ_G	7.11
Public capital depreciation rate δ_G	0.0145
Efficiency of public capital in private production κ_k	0.05
Capital share α	0.24
Price mark-up parameter θ	2.06
Wage mark-up parameter θ_w	3.00
Government consumption share C_G/Y	0.1522
Government investment share I_G/Y	0.04
Transfer share TR/Y	0.0744
Consumption tax rate τ^c	0.05
Labor tax rate τ^n	0.28
Capital tax rate τ^k	0.36
Debt ratio bY	0.64
Responsiveness of transfers to debt changes (eq (31)) Φ_{TR2}	0.25
Responsiveness of income tax to debt changes (eq (32)) Φ_{TR2}	5
Responsiveness of transfers to debt changes (eq (31)) Φ_{τ_1}	0.1
Responsiveness of income tax to debt changes (eq (32)) Φ_{τ_2}	2
Steady state gross inflation Π	1
Calvo price ω	0.81
Calvo wage ω_w	0.83
Price indexation γ	0.28
Wage indexation γ_w	0.41
Taylor rule inflation reaction δ_π	1.63
Taylor rule output gap reaction δ_y	0.13
Taylor rule interest rate smoothing ρ_R	0.92

This increase is again phased in linearly over one year.² The fiscal-feedback rules are shut-off for the first five years by setting the dummy variable $e_{aux,t} = 1$, for $t = 1, \dots, 20$. Thus, the debt-to-GDP ratio is reduced endogenously for five years. Afterwards, the fiscal-feedback rule in equation (31) or (32) kicks in by setting $e_{aux,t} = 0$ and stabilizes the debt-to-GDP ratio at the level that is reached after five years by increasing transfer payments or decreasing the income tax rate to the new debt-neutral level. An iterative procedure is used to set the debt-to-GDP target $bY_{target,t}$ for periods $t = 21, \dots, \infty$ to the value of the debt ratio, bY_t that is reached after

²The timing of fiscal consolidation is quite important for the short run dynamics. A direct consolidation of 1% of initial steady state GDP in the first quarter via government consumption reductions yields an increase in the debt-to-GDP ratio over the first few quarters due to a larger decrease of GDP than in the case of gradually decreasing government consumption. Analysing the effects of the timing of fiscal consolidation is beyond the scope of this paper. We chose a linear phase in over a short period of time to simulate consolidations that should start right away, but might include some short term implementation lags.

five years ($t = 20$).

3 Long run effects of fiscal consolidation

The effectiveness of different consolidation instruments in reducing the debt-to-GDP ratio and the multiplier effects on output, consumption and investment are shown in Table 2. The different columns show multipliers for the different consolidation instruments. The upper part of the table refers to the scenarios where in the long run transfers increase to stabilize the debt-to-GDP ratio, while the lower part refers to the cases where in the long run the income tax rate is lowered to balance the structurally improved government budget. The multipliers shown denote changes from the initial to the final steady state. The multiplier shown refer to the impact of a consolidative change in the different instruments on the different macroeconomic variables. Those entries where the same instrument is used for short run consolidation and long run budget balancing, i.e. transfers in the upper part of the table and the income tax rate in the lower part of the table, are not shown. While these instruments are used to increase the structural government balance in the short run, in the long run lower interest rate payments allow even larger transfer payments or an even lower income tax rate, respectively, thus leading to a policy reversal. Therefore, multipliers for these cases are not comparable to the other entries of the table where the change in the fiscal instrument used for consolidation is permanent and a different fiscal instrument is used to balance the budget in the long run.

Table 2: Effectiveness of different consolidation instruments

$\Delta G =$	$-\Delta C_G/Y$	$-\Delta I_G/Y$	$-\Delta TR_G/Y$	ΔT^c	ΔT^n	ΔT^k
long run balancing via transfer adjustment						
$\Delta B_y/\Delta G$	-4.23	-3.98	-	-4.19	-4.32	-2.48
$\Delta Y/\Delta G$	-0.38	-2.11	-	-0.37	-0.59	-1.89
$\Delta C/\Delta G$	0.96	-1.25	-	-0.47	-0.75	-1.49
$\Delta I/\Delta G$	-0.38	-2.11	-	-0.37	-0.59	-7.45
long run balancing via income tax adjustment						
$\Delta B_y/\Delta G$	-4.20	-3.98	-4.83	-4.02	-	-2.41
$\Delta Y/\Delta G$	0.31	-1.72	0.76	0.30	-	-1.42
$\Delta C/\Delta G$	1.84	-0.76	0.98	0.38	-	-0.91
$\Delta I/\Delta G$	0.31	-1.72	0.76	0.30	-	-6.88

Notes: The table shows the steady state effects of fiscal consolidation via different instruments. Multipliers for the debt ratio, output, consumption and investment are reported. $G \in \{-C_{G,t}/Y, -I_{G,t}/Y, -TR_t/Y, T^c = -\tau_t^c C_t/Y, T^n = -\tau_t^n w_t N_t/Y, T^k = -(r_t^k - \delta)\tau_t^k K_t/Y\}$ denotes the different fiscal instruments in percent of initial GDP. For better comparability the sign of the expenditure multipliers is reversed so that the table shows how much a specific variable changes in response to a consolidative change of a fiscal instrument. Entries where the same instrument is used for short run consolidation and long run budget balancing are not shown as due to the reversal of the consolidation instrument these are not comparable to the other entries.

The results show that the long-run assumption is crucial for the effects on GDP and its components, but not for the size of the debt-to-GDP reduction. If the additional fiscal space is used to reduce tax distortions instead of increasing transfers than consolidation becomes expansionary in the long-run for several consolidation scenarios.

The relative ranking of the effectiveness of consolidations via government consumption, gov-

ernment investment, transfers, the consumption tax rate, the income tax rate and the capital tax rate is, however, not altered by the long run assumption. A transfer based consolidation has the most positive effect on output, and investment. The multiplier is positive for output, consumption and investment leading to expansionary effects in the long-run. In turn the debt-to-GDP ratio decreases most. A 1% of initial steady state GDP decrease in transfers reduces the debt-ratio by up to 4.8 percentage points. Government consumption based and consumption tax based consolidations are the second most effective way to reduce the debt ratio without causing a large contraction. A government consumption based consolidation has, however, much more expansionary effects on private consumption than a consolidation based on increases in the consumption tax rate. The effects of consolidations via government investment, the income and capital tax rate have least favorable effects. Both tax rates increase distortions and lower potential output. A reduction in government investment reduces the public capital stock which is used as an input in the production function and lowers via interactions with private capital and labor potential output, too. A consolidation via government investment yields the most negative impact on output. In terms of debt-ratio reductions, a consolidation via the capital tax rate is least efficient. An increase in capital tax revenues leads to a decrease of the debt ratio of only about 2.4 percentage points and thus about half as much as via the other consolidation instruments. Debt-reduction via government investment is larger despite the higher contraction of output. Government investment is one of the demand components of GDP and leads to a direct reduction of GDP, while the negative effects on GDP from increases in the capital tax rate fully work through reductions in consumption and investment, which reduces the tax base and the efficiency of debt reduction. While a consolidation via increases in the income tax rate also reduce potential output, the effects on output, consumption and investment are much less negative than those of consolidations via the capital tax rate or government investment.

In the following the specific transmission mechanisms of the six consolidation instruments will be analysed. Table 3 shows the long run effects of fiscal consolidation for the different instruments on the relevant macroeconomic variables. To understand these effects it is useful to look at the key steady state relations. Households set wages in the monopolistic labor market as a mark-up over the marginal rate of substitution (MRS). The consumption tax and income tax rate are a further wedge between the real wage and the MRS:

$$\frac{1 - \tau^n}{1 + \tau^c} w = \frac{\theta_w}{\theta_w - 1} \text{MRS} \quad (33)$$

The optimality condition for capital shows that the steady state rental rate of capital depends only on the capital tax rate, but not on the other fiscal instruments:

$$r^k = \frac{\frac{1}{\beta} + \tau^k \delta - 1 + \delta}{1 - \tau^k} \quad (34)$$

Finally, the optimal factor input for the monopolistic intermediate firms yields that mark-up

adjusted factor prices equal their respective marginal products:

$$w = \frac{\theta - 1}{\theta} MPL, \text{ with } MPL = (1 - \alpha)zK_G^{\kappa_k} \left(\frac{K}{N}\right)^\alpha \quad (35)$$

$$r^k = \frac{\theta - 1}{\theta} MPK, \text{ with } MPK = \alpha zK_G^{\kappa_k} \left(\frac{K}{N}\right)^{\alpha-1} \quad (36)$$

3.1 Transmission of a government consumption based consolidation

Government consumption does not show up in these steady state relations, but in the resource constraint. A permanent reduction of government consumption adds otherwise lost resources to the economy. The strength of this channel depends on the trade-off between partially utility-enhancing public consumption and the misallocation of resources induced by its production. In the baseline calibration government consumption does not provide utility to private households so that misallocation of resources is reduced without any disadvantages. These additional resources can be used to adjust one of the other fiscal instruments. If transfers are increased, this changes households' lifetime income. This *wealth channel* does not change the MRS, but leads to an increase in private consumption and induces an incentive for households to enjoy more leisure for a given wage rate because consumption and leisure are normal goods. Still output decreases as government consumption is one of the demand components of GDP and a decrease has direct negative impact on output. Output, however, decreases less than one for one, because of the increase in private consumption. Lower steady state output forces firms to adjust factor inputs of production. The composition of that reduction depends on relative factor prices, which the firm takes as given. In equilibrium the real wage rate returns according to equation (33) to its pre-consolidation level as there is no change in the MRS. The rental rate for capital is not affected by the change in government consumption and transfers either as can be seen from equation (34). In consequence firms reduce factor inputs in equal proportions according to equations (35) and (36).

For the long run assumption of a decrease in the labor tax rate, consolidation is expansionary. The reduction in government consumption is more than compensated by private demand, because in addition to the *wealth channel* an additional *substitution channel* is present. Income tax distortions decrease, so that households are according to equation (33) willing to supply more labor for a given wage rate. The reasoning behind this is, that opportunity costs for one additional unit of leisure increase. In equilibrium factor prices are again unaffected by fiscal consolidation, so that firms meet the additional demand by an increase of factor inputs in equal proportions as implied by equation (35) and (36). The resulting increase in hours worked leads to a rise in the tax base compared to the scenario with long run transfer increases. Therefore, a relatively large decrease in tax rates is necessary to balance the budget in the new steady state.

For both long run scenarios consumption of 'rule-of-thumb' consumers increases more than that of fully optimizing consumers. One reason is that the lower debt-to-GDP ratio leads to lower interest income of unconstrained households from holding government bonds. A second reason is that in the initial steady state 'rule-of-thumb' consumers' consumption is lower than consumption of unconstrained households. The same absolute increase in consumption

therefore leads to a larger percentage change for 'rule-of-thumb' consumers. For the long run scenario with increasing transfers, the first effect is most important as transfers are fully used to increase consumption by 'rule-of-thumb' consumers. Changes in capital income for unconstrained households are quantitatively negligible for changes in consumption and income differences between the two household types.

Table 3: Long run effects of fiscal consolidation for various consolidation instruments

	Y	C	I	N	w	C_o	C_r	ΔBy	ΔTR	$\Delta \tau_t^n$
long run balancing via transfer adjustment										
C_G	-0.38	0.96	-0.38	-0.38	0.00	0.82	1.46	-4.23	1.12	0.00
I_G	-2.11	-1.25	-2.11	-0.24	-1.87	-1.36	-0.85	-3.98	0.62	0.00
TR	0.03	0.03	0.03	0.03	0.00	-0.05	0.35	-4.86	0.20	0.00
τ^c	-0.36	-0.46	-0.36	-0.36	0.00	-0.59	0.02	-4.11	1.06	0.00
τ^n	-0.52	-0.66	-0.52	-0.52	0.00	-0.72	-0.44	-3.82	1.01	1.32
τ^k	-2.30	-1.81	-9.06	-0.06	-2.24	-2.12	-0.67	-3.01	0.84	0.00
long run balancing via income tax adjustment										
C_G	0.31	1.84	0.31	0.31	0.00	1.70	2.38	-4.20	0.00	-1.71
I_G	-1.72	-0.76	-1.72	0.16	-1.87	-0.87	-0.34	-3.98	0.00	-0.98
TR	0.76	0.98	0.76	0.76	0.00	0.88	1.33	-4.83	-1.00	-1.84
τ^c	0.30	0.38	0.30	0.30	0.00	0.25	0.89	-4.09	0.00	-1.64
τ^n	0.12	0.15	0.12	0.12	0.00	0.08	0.41	-3.81	0.00	-0.25
τ^k	-1.77	-1.13	-8.57	0.48	-2.24	-1.45	0.04	-3.01	0.00	-1.33

Notes: The table shows the steady state effects of a 1% of initial GDP consolidation via different fiscal instruments. C_G , I_G and TR denote decreases in government consumption, government investment and transfers. τ^c , τ^n and τ^k denote increases in tax rates. Tax rates are increased by as much as is necessary to yield a 1% increase in tax revenues based on the initial steady state tax base. All variables are denoted in percentage changes except for ΔBy and $\Delta \tau_t^n$ which are denoted in percentage point changes. ΔTR is expressed as percentage change relative to initial steady state .

3.2 Transmission of a government investment based consolidation

A permanent decrease in government investment has more complex effects than a decrease of government consumption. There is again a *wealth channel* at work that leads to increases in consumption and reductions in hours worked and if in the long run the income tax rate is lowered also the *substitution channel* is in effect. In addition there is a direct cost for the private sector as government capital is a production factor. A reduction in government capital makes the private capital stock and labor input less productive. Equations (35) and (36) show that a decrease of K_G works like a productivity shift. The strength of this *productivity channel* depends on the productivity parameter of the public capital stock κ_K and the initial steady state share of public investment. In case of $\kappa_K = 0$ a permanent decrease in government investment would work exactly as a permanent decrease in government consumption. In any other case, $\kappa_K > 0$, the effect on output is more negative. Private capital decreases to the point where its marginal product equals the pre-consolidation value. In turn, private steady state investment falls more than in the case of a consolidation via government consumption. The marginal product of labor decreases which leads to a change in the MRS. The wage adjusts accordingly. As equation (34) shows there is no change in the rental rate of capital. As the marginal product of capital in equation (36) decreases, the capital-labor ratio must decrease. Investment falls more than hours worked.

If in the long run transfers are increased, for the baseline calibration the *productivity channel* is stronger than the *wealth channel* as consumption decreases. If the labor tax rate is reduced then the *substitution effect* mitigates the negative effects on output and consumption to some extent and hours worked increase. Still, overall the effect on output and consumption is negative. The decrease in potential output by the reduction in government investment is stronger than the increase by the reduction of the distortionary income tax rate. The negative effects on consumption for unconstrained households are larger than for 'rule-of-thumb' consumers for the same reasons as for a government consumption based consolidation.

3.3 Transmission of a transfer based consolidation

A reduction of transfers and also increases of tax rates have in contrast to government consumption and government investment no direct effect on GDP as they are not demand components of output. They have, however, effects on consumption and investment and impact GDP indirectly through these. For the first long-term scenario transfers increase by the additional fiscal space created by lower interest rate payments due to the temporary decrease of transfers. The long-run increase in transfers is lower than if other instruments are used for consolidation as there are no permanent decreases in government expenditure or increases in tax revenues. Transfers do not show up in the above steady state equations and therefore do not alter any equilibrium prices or ratios. If there would be no 'rule-of-thumb' consumers then for the long run transfer adjustment scenario Ricardian equivalence would hold and there would be no change in output or consumption. The increase in transfers paid to households would exactly offset the decrease in interest income from holding government bonds. Due to the introduction of 'rule-of-thumb' consumers who do not suffer from reduced interest rate income and consume the increase in transfers, consumption of these households increases and Ricardian equivalence does not hold. Consequently, output increases slightly to satisfy additional demand. The MRS is unaffected so that the wage set by households does not change and firms demand a little more labor to produce more output. Consumption of unconstrained households falls slightly due their reduction in income from holding government bonds. The rental rate of capital stays constant according to equation (34) so that capital adjusts upwards until the pre-consolidation capital-labor ratio is restored.

In case of a long-run decrease of the income tax rate the decrease of transfers becomes permanent and the above effects are reversed. A reduction of the income tax rate leads via the *substitution channel* to a positive effect on hours worked. A change in the income tax rate leads to changes of the opportunity cost of leisure relative to consumption. This changes the MRS without affecting equilibrium factor prices. Firms meet changes in demand by an increase of factor inputs in equal proportions according to equations (35) and (36). These positive effects of the *substitution channel* dominate the negative effects from the *wealth channel* caused by decreased transfers. Hence, output and consumption of both household types increase.

3.4 Transmission of a consumption tax based consolidation

An increase of the consumption tax rate makes consumption relative to leisure more expensive shifting the MRS downwards without affecting the wage or the rental rate of capital as can be seen from equations (33) and equation (34). Consumption decreases through this *purchasing power channel* leading to a decrease in output. According to equations (35) and (36) labor and capital decrease proportionally. If transfers are increased then at the same time the *wealth channel* mitigates the decrease in consumption which leads to upward pressure on output and factor inputs. Overall, the increase in the consumption tax dominates the increase in transfers so that consumption, output and hours decrease.

If in addition to the increase in the consumption tax rate in the long-run the labor tax rate is reduced, then the *substitution channel* works against the negative effects of the *purchasing power channel* and dominates it. The effect on output, consumption, investment and hours becomes expansionary. For both long-run assumptions the difference in the percentage change in consumption of 'rule-of-thumb' and unconstrained households is again mainly explained by the lower initial steady state consumption level of 'rule-of-thumb' consumers.

3.5 Transmission of an income tax based consolidation

An increase in the income tax rate leads to a lower post-tax income and lowers incentives to work. The *substitution channel* changes the MRS reflecting the changes of the opportunity cost of leisure relative to consumption without altering the pre-tax wage or the rental rate of capital. Therefore, the capital intensity does not change. Labor, capital and therefore output decrease by the same amounts and consumption decreases. If in the long-run transfers increase the *wealth channel* works in the opposite direction for consumption and mitigates the decrease in consumption, but amplifies the decrease of labor.

If in the long-run instead the labor tax is reduced this reverses the potential negative effects from the consolidation and the reversal is stronger than the initial increase in the labor tax rate as there is additional fiscal space available due to lower interest rate payments. Therefore, this scenario is in the long-run a scenario where distortions are reduced via the *substitution channel* and output, consumption and investment increase.

3.6 Transmission of a capital tax based consolidation

An increase in the capital tax rate raises via equation (34) the rental rate of capital. The usage of capital becomes more expensive. This *capital tax distortion channel* leads to a reduction of capital in production and decreases the capital-labor ratio according to equation (36). The marginal product of labor decreases according to equation (35), too. In response the real wage and the MRS adjust via equation (33). Output, consumption, investment and hours worked decrease. The decrease of investment is much larger than the decrease of hours worked. For the baseline calibration it is quite dramatic: investment decreases by more than 8%. If the additional fiscal space is used to increase transfers then the *wealth channel* mitigates the decrease in consumption somewhat, but puts further downward pressure on hours worked. If instead the la-

bor tax rate is lowered, than the *substitution channel* mitigates the decrease in consumption and hours worked. The effect on hours worked turns positive. However, the effect of the *capital tax distortion channel* on output is very strong because of the dramatic decline of investment leading to a large permanent reduction in output. The differences in the developments of consumption of 'rule-of-thumb' consumers and unconstrained consumers are in the case of an increase in the capital tax rate mainly explained by the loss of capital income for unconstrained households.

4 Short run transmission of fiscal consolidation

For the analysis of the short-run effects we distinguish between three consolidation phases. During the *implementation phase* the fiscal instrument adjusts according to the consolidation plan. This phase lasts from period $t = 1$ to $t = 4$. The periods from $t = 5$ to $t = 20$ we call the *transition phase*. In this phase all fiscal instruments are held constant and the debt-to-GDP ratio adjust endogenously to its new level. The period thereafter, when the fiscal rule kicks in at period $t = 21$, we name the *debt stabilization phase*. During this phase, one fiscal instrument is stabilize the debt-to-GDP ratio at its new level.

4.1 Transmission of a government consumption based consolidation

The transmission of a government consumption based consolidation is shown in figure 1. The solid line shows the long-run transfer adjustment scenario and the dashed line shows the long-run income tax adjustment scenario.

Government spending is a component of aggregate demand. Therefore, the reduction in government spending during the *implementation phase* has a direct negative effect on output. The drop in output at the end of the *implementation phase* is less than the overall reduction in government spending, because the *wealth effect* leads to a rise in private consumption. The immediate expansion in consumption is solely due to the behavior of unconstrained households, who want to smooth their consumption path due to anticipated higher lifetime income. They finance this increase in consumption with the inflow of funds stemming from the repayment of government debt holdings, whereas their labor income decreases. The decrease in labor income, which is identical for unconstrained and 'rule-of-thumb' households forces the latter to consume less; their consumption falls by almost 1% during the *implementation phase*. On the production side of the economy firms react to the lack of demand by reducing labor input as well as the amount of capital services. Labor input is reduced more than capital input because unconstrained households want to consume more and work less due to the *wealth effect* and therefore demand a hire wage. Overall, the wage variation is, however, small. Most of the adjustment in capital services is done via a reduction of capital utilization as households anticipate that consumption of rule-of-thumb consumers will expand strongly once transfers increase or the income tax is decreased from period $t = 21$ onwards so that more consumption goods need to be produced and thus a high capital stock will be needed. The rental rate of capital decreases as the large reduction in hours worked reduces the marginal product of capital services. Due to price and wage rigidities, potential output falls slower than actual output

leading to a negative output gap at the end of the *implementation phase*; the movements in the output gap are, however, very small because the perfect foresight assumption implies that firms that are able to adjust their prices in a given period, incorporate all future developments in setting an optimal price so that inefficiencies due to price rigidities are small. Marginal costs decrease as the rental rate of capital decreases more than the increase in wages. This puts downward pressure on inflation and leads via the monetary policy rule to a lower interest rate. The changes in inflation and the interest rate are, however, with about 2 basis points very small. They are even smaller for the long-run income tax adjustment scenario as firms take into account when setting the price that the output gap will turn positive between $t = 15$ to $t = 25$. The debt-to-GDP ratio stays more or less constant during the *implementation phase* despite the cuts in government expenditures because GDP decreases and labor and capital tax revenues fall, too, because of a reduced tax base.

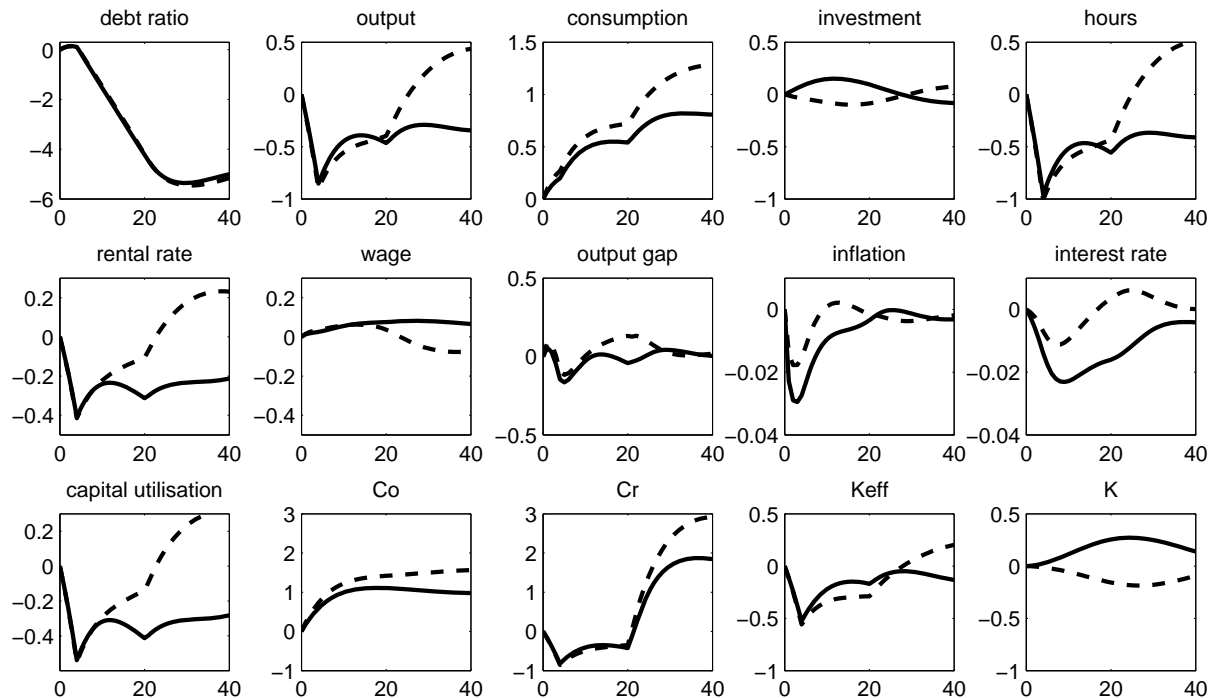


Figure 1: Transmission of government consumption reduction (long-run transfer adjustment: solid line; long-run income tax adjustment: dashed line)

Notes: Most variables are plotted as percentage changes. Debt-to-GDP ratio, inflation and the interest rate are denoted in percentage point changes. Consumption and investment are weighted with their initial share of output. For the output gap level values are plotted.

During the *transition phase* consumption of unconstrained households continues to increase towards the new steady state. Due to the consumption smoothing motive, the increase starts on impact, but it takes a while and continues through the *transition phase* because of consumption habits and the availability of additional funds due to debt-repayment during the *transition phase*. The increase is larger for the long-run tax reduction scenario as households anticipate that potential output will increase and consumption will be permanently higher than in the long-run transfer adjustment scenario. The hump in output is mainly driven by the increase of consumption and investment increases only little. Accordingly hours worked, capital utilization

and effective capital increase somewhat. Tax revenues therefore do not decrease further and the reduced level of government consumption leads during the *transition phase* to a continuously declining debt-to-GDP ratio. The increase in hours worked leads also to somewhat more wage income for rule-of-thumb households and their consumption increases a little.

For the long-run transfer adjustment scenario we observe an increase in investment, while we observe a decrease in investment for the long-run tax adjustment scenario. These differences are reflected in the output path. The differences in investment mirror the different developments in the rental rate of capital and the level of consumption during the *transition phase*. For the long-run transfer adjustment scenario the rental rate of capital is depressed for a longer time before returning to its initial steady state value. Agents anticipate this fall in the rental rate and react by increasing investment immediately. This even temporarily increases output above the scenario where in the long-run the income tax rate is reduced though in the new steady state output will be lower. It should be mentioned here, that the assumption of rule-of-thumb consumers is crucial for this investment boom. Without rule-of-thumb consumers investment would decrease much quicker towards the new steady state as there is no sudden consumption boom from period $t = 21$ onwards. For the long-run tax adjustment scenario consumption increases more than for the long-run transfer adjustment scenario due to the higher long-run consumption level and the consumption smoothing motive. Investment decreases because agents anticipate the persistent rise in the rental rate for capital beginning around period ten. The slow adjustment in investment in both cases is due to investment adjustment costs. The output gap, inflation and the interest rate reflect the different developments of current and future marginal cost due to the different development of the rental rate of capital. If the rental rate of capital is depressed longer, than this puts downward pressure on marginal cost and the output gap and inflation and the interest rate are lower.

During the *debt-stabilization phase* the economy improves mainly because of a large increase in consumption of rule-of-thumb consumers. Consumption of rule-of-thumb consumers increases quickly as they fully consume all additional income available due to higher transfers or a lower labor tax rate. While the output dynamics during the *implementation phase* and the *transition phase* are roughly similar for both long-run scenarios, during the *debt-stabilization phase* large differences emerge. The up-turn in economic conditions is more pronounced if labor taxes are used as a stabilization instrument, because the reduction in distortionary taxes increases incentives to work and in consequence fosters a large and quick increase in hours worked. We also observe some downward pressure on wages. Households are willing to demand lower wages, because the reduction in the labor tax rate in fact leads to an increase in the after-tax rate. If instead, stabilization is done via transfers, output is not lifted above the initial steady state level. Wages slowly return their initial steady state, the rental rate of capital slowly increases again. The differences between the two long-run scenarios reflect the differences in the development of hours worked. If hours worked increase more quickly this leads also to a quicker increase in the marginal product of capital and a quickly rising rental rate of capital. Inflation and the interest rate return to their long-run values. The debt-ratio decreases further for a while as tax revenues increase due to the upturn of the economy. After this overshooting the debt ratio is finally stabilized at the value reached at the beginning of the *debt-stabilization phase*.

4.2 Transmission of a government investment based consolidation

Figure 2 shows the short-run transmission of cuts in government investment. Again the solid black line refers to the long-run transfer adjustment scenario and the dashed black line refers to the long-run income tax adjustment scenario. The grey lines show for comparison the effects of a government consumption based consolidation as discussed above. There are some similarities for these two scenarios, especially during the *implementation* and *transition phase*. With the start of the *debt stabilization period* finally larger differences in the strength of the impact on different variables clearly appear.

A consolidation via government investment would have exactly the same effects as a cut in government consumption for the case of $\kappa_k = 0$. But even if $\kappa_k > 0$ - and in particular $\kappa_k = 0.05$ as in the baseline calibration - the impact of a change in government investment is not directly different from the impact of a change in government consumption. Only the induced change in the public capital stock leads to differences. The red line in the graph on the lower right shows the change in the public capital stock. The public capital stock decreases gradually over time and therefore the impact of changes in government investment via public capital on other variables are zero on impact except for anticipation effects about the decline in public capital. Only over time the productivity of private capital and labor input are reduced substantially through the decrease of public capital.

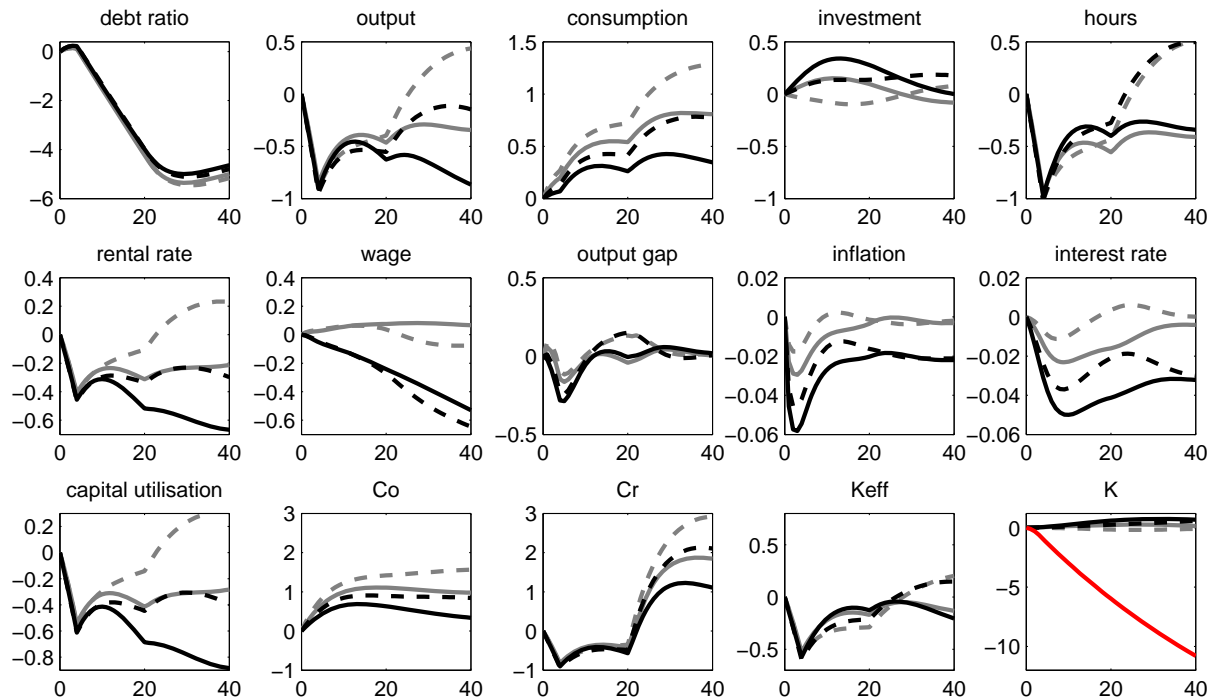


Figure 2: Transmission of government investment reduction (long-run transfer adjustment: solid line; long-run income tax adjustment: dashed line)

Notes: see figure 1. Grey lines show for comparison the simulation results from figure 1 (government consumption reduction). The red line in the bottom right picture denotes the public capital stock.

Government investment is a demand component of GDP as government consumption and therefore, a cut leads during the *implementation phase* to a similar negative effect on output.

The negative effects are somewhat more pronounced because unconstrained households are less willing to increase consumption compared to a government consumption based consolidation as they anticipate that potential output will be lower in the new steady state. In addition, the real wage falls rather than increases. This reduces labor income for both households and mutes consumption, in particular for rule-of-thumb households. Their consumption drops on impact as hours worked are reduced due to lower demand by the government. The debt-to-GDP ratio increases marginally more than in a government consumption based consolidation over the course of the *implementation phase*.

With the beginning of the *transition phase* the debt-to-GDP ratio starts to decline as output is boosted by an investment cycle and the continued increase in consumption of unconstrained households so that the tax base does not deteriorate further. The effect on private investment is more positive than for the government consumption based consolidation as a part of it is used as temporary substitute for public investment. Firms react to the investment boom and the increase in consumption by increasing labor and capital inputs. The increase in labor income leads to a slight increase of consumption of rule-of-thumb consumers during the *transition phase*. In contrast to the above scenario, we observe a persistent decrease in the real wage. This is due to the lower factor productivity induced by the fall in the public capital stock. As one can see in the bottom right graph the public capital stock (red line) deteriorates rapidly. At the end of the *transition phase* it is about six percent lower than in the initial steady state. Still a productivity parameter of $\kappa_k = 0.05$ leads to limited declines in the productivity of labor and private capital during the *transition phase*. Furthermore, the boom in investment and the increase in hours worked offset some of the negative effects from the reduction of the public capital stock. Overall, consumption is quite a bit lower due to the lower long-run level, but the differences of a government investment and a government consumption based consolidation for output are not very large during the *transition phase*. The output gap, inflation and the interest rate fall more than before and stay below their long run steady state persistently as marginal cost decrease more due to the decrease in the rental rate of capital and the real wage.

At the beginning of the *debt stabilization period* economic conditions start to temporarily improve because of either the increase in transfer payments or the decrease in the income tax rate. Accordingly, consumption of rule-of-thumb households rises for a while. Unconstrained households, however, smooth consumption so that their consumption slowly starts to decrease as the public capital stock and therefore potential output continue to drop. A larger decrease is only prevented by the very slow convergence of the public capital stock towards the new steady state so that the very long-run developments are substantially discounted. In the new steady state the public capital stock is reduced by 25%. Half of this adjustment is reached after 12 years and it takes 19 years until two thirds of the convergence are obtained. So, despite the long-run reduction in output, consumption and investment documented in table 3, consumption of both household types is above the initial and the final steady state during the first years of the *debt stabilization period*. Due to anticipation of the negative long-run developments, the increase in aggregate consumption is, however, lower than for a government consumption based consolidation and the stimulating fiscal policies do not lift output above the initial steady state level even if the income tax rate is lowered. Finally, consumption turns negative after 19 years

and 33 years for the long-run transfer and long-run income tax adjustment scenario, respectively.

4.3 Transmission of a transfer based consolidation

Figure 3 shows the impact of a transfer based consolidation strategy. The grey lines show again for comparison the effects of a government consumption based consolidation. A transfer based consolidation strategy does not lead to such a strong decline in output as the other expenditure based consolidations because output is not directly affected by the transfer cuts, but only indirectly via the impact on consumption and investment. Accordingly, the debt ratio starts to drop on impact. The movements in output are small during the *implementation phase* and mainly due to the drop in consumption of rule-of-thumb consumers. They must reduce consumption directly, because of lower transfer payments. Their consumption drops more than in the aforementioned scenarios, where the reduction in consumption was solely due to lower wage income. As the overall fall in production is lower than in the previous scenarios, hours worked, and the capital utilization rate fall less and in turn the rental rate of capital drops less sharply and wages increase only slightly during the *implementation phase*. Further, the drop in inflation and the interest rate is lower than in the previous scenarios and they even increase for long-run tax cuts as the rental rate of capital increases after a while, which leads to increasing marginal costs. Consumption of unconstrained households barely moves at all. For them Ricardian equivalence applies and the reduction in transfers and the debt repayment offset each other. Only in case of long-run tax cuts potential output increases in the long-run and due to consumption smoothing consumption of unconstrained households starts to increase on impact. While the long-run reduction of the income tax rate is the highest for all considered consolidation scenarios the implied increase in income is, however, partly offset by the permanent reduction of transfers by 1 percent of GDP in this scenario leading to a modest increase in consumption only.

During the *transition phase* consumption of rule-of-thumb consumers stabilizes at the level reached at the end of the *implementation phase* as there are no further transfer cuts. Consumption of unconstrained consumers remains more or less constant for the long-run transfer adjustment scenario because of Ricardian equivalence, while it continues to increase slightly for the long-run tax cut scenario because of consumption habits. The dynamics of output during the *transition phase* are driven by the investment dynamics which are very similar to the government consumption based consolidation. In case of long-run transfer adjustments investment increases temporarily as the rental rate of capital remains below steady state for a long time and thus using capital in production is cheap. In case of long-run tax cuts, the rental rate of capital starts to increase above steady state during the *transition phase*, the usage of capital becomes more expensive and in addition the increase in consumption of unconstrained households prevents larger amounts of investment. Compared to the former scenarios the economy as a whole is not so much depressed, which further promotes the reduction in the debt-to-GDP ratio. A transfer based consolidation achieves the largest reduction in the debt-to-GDP ratio at the end of the *transition phase* of all considered fiscal instruments. As output does not move

much during the *transition phase*, capital utilization and hours worked do not drop much, the variation in the rental rate of capital and wages are small so that the movements in inflation and the interest rate are even smaller than in the previous scenarios.

During the *debt-stabilization phase* the adjustment in fiscal instruments leads to an overall increase in economic activity. The speed of convergence to the new steady state is similar to the government consumption based consolidation. The long-run effect on output is more positive than for a government consumption based consolidation as there is no permanent reduction of government demand. The long-run effect on consumption is less positive as there are no additional resources usable for the private sector as is the case if government consumption is reduced. In the case of a transfer based long-run stabilization of the debt-to-GDP ratio the long-run increase of transfers as a share of GDP is only 1/5 compared to other consolidation strategies. Furthermore, unconstrained households interest income from holding government bonds is reduced. Consumption in the initial and final steady state are almost exactly the same. Only rule-of-thumb households' consumption is slightly higher in the new steady state as the reduction in interest rate payments is used to increase transfers which benefits rule-of-thumb households. For the long-run tax cut scenario output and hours worked increase substantially, but the effects on income and thus consumption are partly offset by permanent transfer cuts.

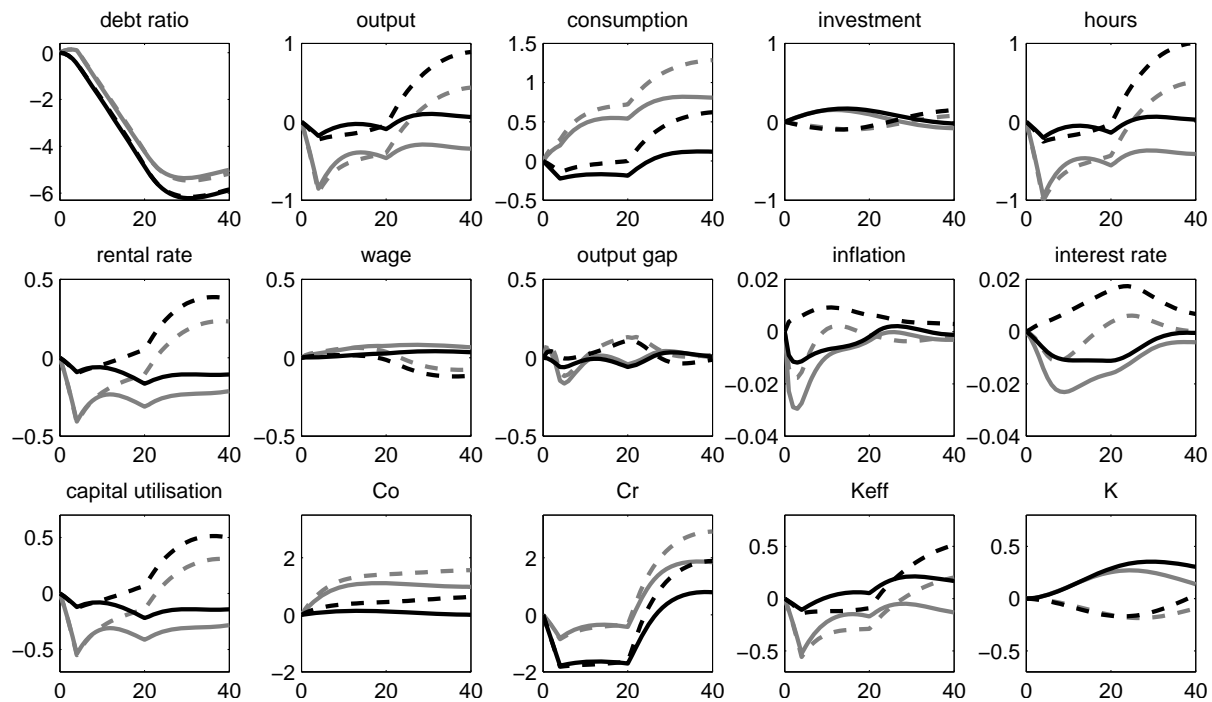


Figure 3: Transmission of transfer reduction (long-run transfer adjustment: solid line; long-run income tax adjustment: dashed line)

Notes: see figure 1. Grey lines show for comparison the simulation results from figure 1 (government consumption reduction).

4.4 Transmission of a consumption tax based consolidation

Figure 4 shows the effects of a consumption tax based consolidation (black lines) again compared to a government consumption based consolidation (grey lines). The decrease in output during the *implementation phase* is as for a transfer based consolidation smaller than for a government consumption based consolidation as the government demand component of GDP is not affected. The decline in output during the *implementation phase* is, however, slightly larger than for a transfer based consolidation as the effects on consumption of unconstrained households and on investment are more negative. Unconstrained households anticipate the increase in the consumption tax rate over the first four quarters and bring consumption forward to the first two quarters before it becomes more expensive leading to a small increase in consumption of unconstrained households on impact. If there would be no phase-in of the consumption tax increase over four quarters than consumption would drop on impact. Thereafter, they start to reduce consumption smoothly because of the anticipated lower long-run consumption level caused by loss of purchasing power. The reduction for rule-of-thumb households is more rapid as the increase in the consumption tax rate directly leads to a smaller amount of consumption goods bought each period. Firms respond to the lack in aggregate demand by employing less labor and capital services, which lowers income for households. The reduction in income forces rule-of-thumb consumers to consume less. The debt-to-GDP ratio starts to decline on impact as consumption tax revenues increase. The increase in consumption tax revenues is muted by the declining consumption tax base.

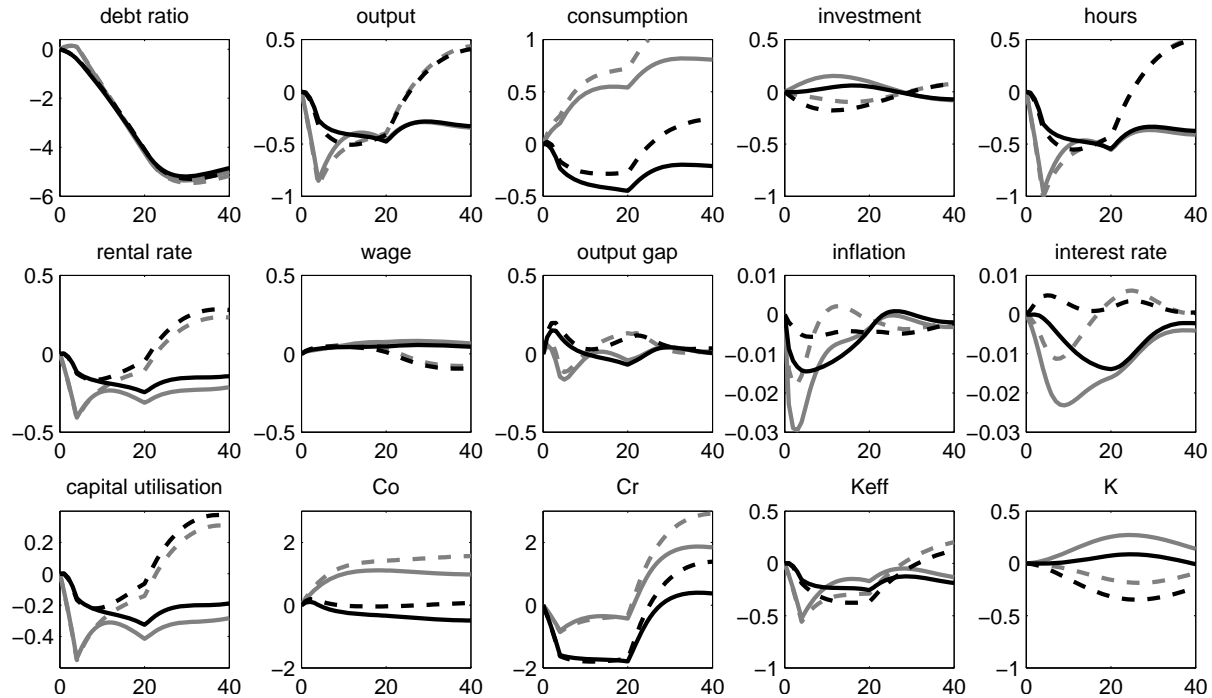


Figure 4: Transmission of a consumption tax increase. (long-run transfer adjustment: solid line; long-run income tax adjustment: dashed line)

Notes: see figure 1. Grey lines show for comparison the simulation results from figure 1 (government consumption reduction).

During the *transition phase* consumption of unconstrained households continues to converge to the new steady state. Consumption of rule-of-thumb households stabilizes at a low level as there is no further increase in the consumption tax and the decline in hours worked is small and partly offset by the increase in the real wage. Investment dynamics are similar to the government consumption and transfer based consolidations and are induced by the same transmission channels discussed above. In response to the smaller movements in hours worked, capital utilisation and effective capital, the movements in the rental rate of capital and wages are less volatile than for a government consumption based consolidation. Accordingly the movements of inflation and the interest rate are also muted.

When the fiscal rule kicks in at period $t = 21$ output picks up rapidly. An increase in transfers stimulates consumption of rule-of-thumb households directly. Firms hire more labor to produce the additional demand, which leads to an increase in income for both household types; the consumption path of unconstrained households continues, however, the same path as in the *transition phase* as they fully anticipated the income increase from period $t = 21$ onwards. Even more effective in increasing output is the reduction in the labor tax rate. One reason is that lower distortionary taxes increase incentives to work. Hours worked increase a lot, leading to higher wage income. After-tax income is further increased by the labor tax cuts. The convergence of output, hours worked, capital utilization, capital, prices, wages, inflation, the interest rate and the debt ratio is almost exactly the same as for the government consumption based consolidation. In the long-run all variables except for private and public consumption converge to almost exactly the same levels. Public consumption is lower for the government consumption based consolidation and private consumption is lower for the consumption tax based consolidation. The differences in public and private consumption between these two scenarios almost exactly offset each other so that output follows the same dynamic adjustment path throughout the *debt-stabilization phase* towards the new steady state for both consolidation scenarios.

4.5 Transmission of an income tax based consolidation

Figure 5 shows the transmission of an income tax based consolidation (black lines) again compared to the government consumption based consolidation (grey lines). The increase in the labor tax rate leads on impact to a fall in aggregate consumption, albeit household types are effected differently. In general, the fall in consumption is due to the reduction in after tax income and the higher tax distortions on the labor market which reduce incentives to work. Moreover, this reduction in work incentives is permanent if in the long-run the debt-to GDP ratio is stabilized via transfers. Unconstrained households are able to smooth out the reduction in consumption over time so that the decline during the *implementation phase* is very small, while 'rule-of-thumb' households need to adjust their consumption immediately. As less output needs to be produced, capital utilization falls and effective capital used in production is reduced. The increase in labor taxes triggers a rise in the real wage because households want to be partly compensated for the implied reduction in after-tax real wage. The drop in hours worked reduces the productivity of capital, so that the rental rate of capital falls. Due to the large drop in output, the debt-to-GDP

ratio does respond only little during the *implementation phase*.

In the course of the *transition phase* private consumption remains more or less flat. Consumption of unconstrained households does not move much because of consumption smoothing. Consumption of rule-of-thumb households is stabilized as there are no further changes in the income tax rate and therefore in post-tax income. The dynamics for investment are again similar to the government consumption based consolidation, albeit on a lower level because the long-run capital stock will be lower. As output and the tax base do not deteriorate further, the debt-to-GDP ratio falls continuously over the *transition phase*. The debt ratio reduction reached at the end of this phase is, however, smaller than for a government consumption based consolidation as the reduction of the tax base prevents a one-to-one increase of labor tax revenues in response to the increase of the labor tax rate. Movements in the output gap inflation and the interest rate are again very small.

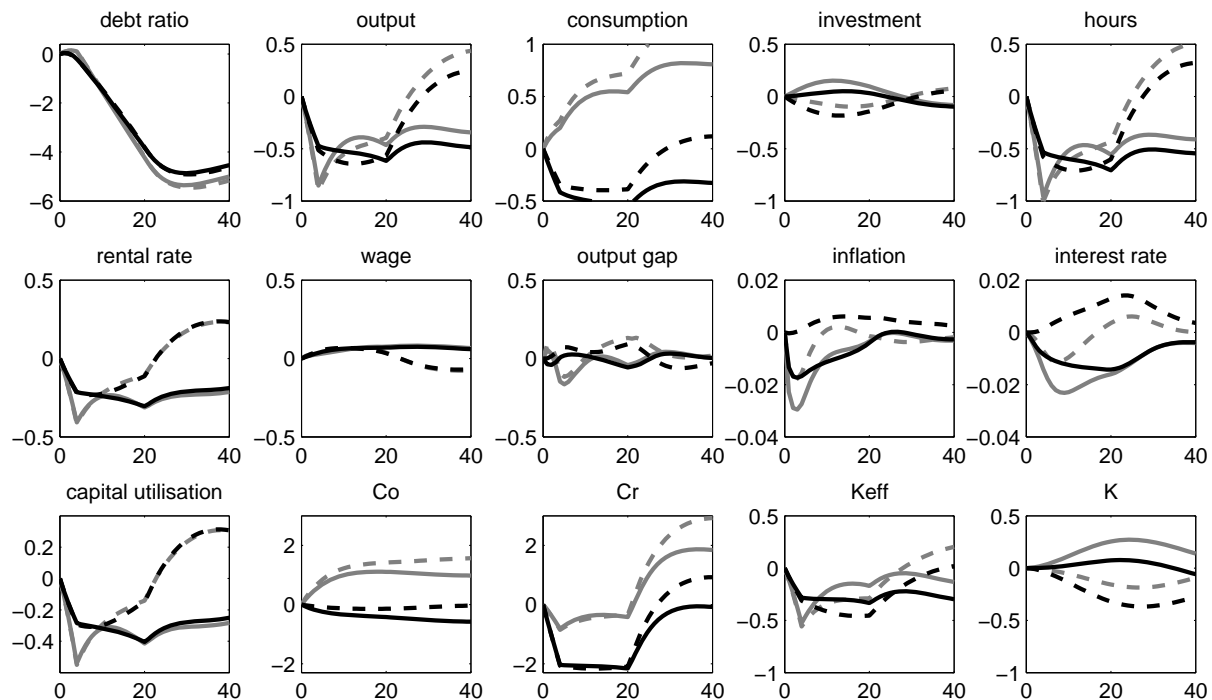


Figure 5: Transmission of an income tax increase. (long-run transfer adjustment: solid line; long-run income tax adjustment: dashed line)

Notes: see figure 1. Grey lines show for comparison the simulation results from figure 1 (government consumption reduction).

During the *debt-stabilization phase* the increase in transfers leads directly to an increase in consumption of rule-of-thumb consumers, while consumption of unconstrained households continues to converge smoothly towards the new steady state. The increase in aggregate consumption is, however, smaller than for the government consumption, transfer or consumption tax based consolidations as the distortionary effects of the permanent increase in the labor tax reduce incentives to work and thus potential output in the new steady state. If instead the labor tax rate is reduced in the long-run, this leads to a gradual reversal of the negative effects of the labor tax increases in the short run. Still, the increase in output is smaller than in the aforementioned scenarios as the labor tax rate is only decreased by the additional fiscal space

available due to lower interest rate payments, but not by additional other fiscal space due to reductions of one of the government expenditure or government revenue components. Further, convergence towards the new steady state is slower as households postpone the increase in hours worked partly until the major reduction of the labor tax rate has taken place.

4.6 Transmission of a capital tax based consolidation

Figure 6 shows the effects of a capital tax based consolidation (black lines) compared to a government consumption based consolidation (grey lines).

A capital tax based consolidation strategy has by far the strongest impact on economic activity among all considered consolidation strategies. While the consolidation strategies discussed above showed qualitatively roughly similar dynamics the government consumption based consolidation, the differences to the capital tax rate consolidation are striking. On impact GDP declines by more than one percent compared to the initial steady state and drops further to -2.5% during the *implementation phase*. On the demand side of the economy this drop in GDP is to a large extent attributed to the costs associated with capacity utilization which is reduced by around four percent on impact. A permanent increase in the capital tax rate increases the equilibrium rental rate for capital services permanently. On impact the rental rate increases by 4%. Because of this instantaneous increase in the rental rate of capital and the anticipation of the permanent increase households react by reducing capital utilisation and investment considerably. Firms reduce in addition labor input to decrease production. The reduction in capital input leads to a lower marginal product of labor and, hence, wages fall. The drop in hours worked and wages leads on impact to less income for rule-of-thumb consumers and their consumption falls. Consumption of unconstrained households even increases slightly as households have more money to spend on consumption as the payments for investment are reduced. The debt-to-GDP ratio increases on impact and stays above the initial steady state level during the whole *implementation phase* because of the extreme contraction of output.

During the *transition phase* GDP declines even more, but the debt-to-GDP ratio starts to come down as the deterioration of the tax base slows down. The further drop in output is mainly caused by the decrease in investment which started relatively slowly and is increased slowly over time to minimize investment adjustment costs. Investment falls more than in the new steady state to decrease the capital stock towards the lower new steady state capital stock. Capital utilisation which dropped sharply during the *implementation phase* slowly starts to increase as investment continues to fall. Consumption of unconstrained households temporarily continues to increase due to additional available funds because of reduced investment. Complete consumption smoothing is prevented as the new steady state is approached very slowly because of slow convergence of the capital stock. Therefore, the strong long-run decrease in consumption is discounted substantially. While the reduction in investment leads to a further drop in hours worked, from the middle of the *transition period* the stabilization of investment and the increase in consumption of unconstrained households stop the decrease in hours worked and lead to a partial reversal. Consumption of rule-of-thumb households therefore is stabilized. The drop in the real wage and the rise in the rental rate lead firms to shift to a more labor intensive

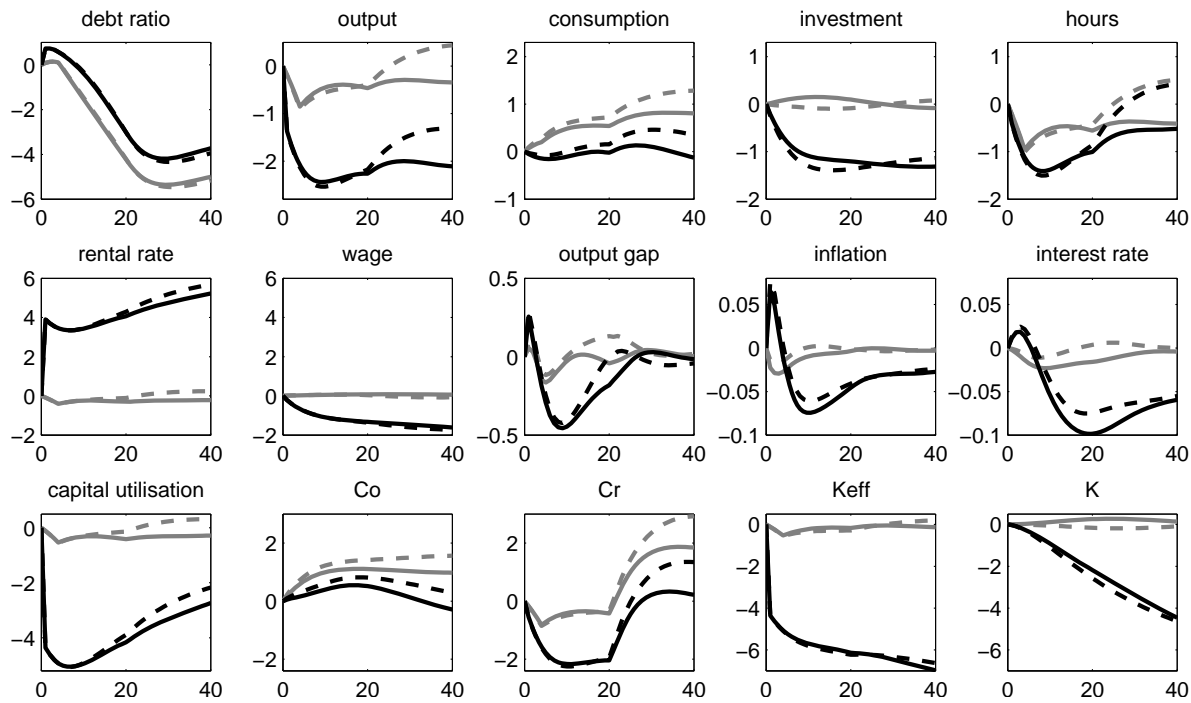


Figure 6: Transmission of a capital tax increase. Solid line: long-run transfer adjustment, Dashed line: long-run income tax adjustment

production. While capital and effective capital continue to decrease towards the new steady state the drop of hours worked is reversed to some extent to substitute for the capital input. The movements in the output gap, inflation and the interest rate are much larger than in the previous scenarios. Inflation increases on impact because of the large increase in the rental rate of capital and thus in marginal costs. Afterwards the output gap and inflation turn negative as potential output adjusts somewhat slower to the new steady state than actual output because of price and wage rigidities. While the movements in inflation and the interest rate are larger than in the previous scenarios they are with 10 basis points still modest. The reduction in the debt-ratio is smaller than for the other scenarios as output contracts a lot.

During the *debt stabilization phase* consumption of rule-of-thumb consumers picks up as they consume all additional transfer payments or income tax reductions. Wages continue to decline and the rental rate of capital continues to rise. In consequence, hours worked continue to increase as production becomes more and more labor intensive. This further increases consumption of rule-of-thumb households temporarily. As capital continues to decline towards the new steady state, but the level of investment is stabilized, consumption of unconstrained households starts to decrease. The capital utilization rate increases towards its steady state level so that effective capital decreases more slowly. Output is stabilized in case of long-run transfer adjustments and even increases relative to the *transition phase* in case of a long-run income tax reduction which spurs hours worked.

4.7 Fiscal consolidation at the zero lower bound on interest rates

In the long-run the nominal interest rate must return to its initial steady state value, but the short run transmission simulations have showed that in many cases the drop in output leads to a temporary drop of marginal cost and inflation so that the nominal interest rate decreases via the monetary policy rule. The accommodating monetary policy responses to fiscal consolidation are in all cases small and reach a maximum of -10 basis points for the capital tax based consolidation combined with a long-run adjustment of transfer payments. Nevertheless, if the consolidation starts close to zero interest rates, such a fiscal-monetary policy interaction might become infeasible. In this case a prevention of lower nominal interest rates leads to rising real interest rates if inflation drops, which reduces consumption and output putting further downward pressure on inflation increasing the real interest rate further. These movements can potentially be so strong that the debt-ratio might even increase rather than decrease.

To analyse whether such a situation is realistically to be expected we approximate a binding zero lower bound by repeating the above simulations but holding the nominal interest rate constant for either two or four years. Holding the interest rate constant for a longer time prevents in many cases the simulation algorithm to find a feasible path to the new long-run equilibrium. Letting the fiscal feedback rule kick in earlier would make these simulations feasible as well. While it turns out that even in the case of holding the interest rate constant for four years, a drop in the interest rate is not fully prevented, but just postponed until the interest rate is not hold constant anymore, we think that this is still a reasonable approximation of the zero lower bound situation. Our simulation setup abstracts from all macroeconomic shocks except for the deterministic changes in fiscal policy variables. After a period of a four year long zero interest rate induced by adverse shocks at least a slight increase in the nominal interest rate caused by positive macroeconomic shocks that is sufficient to allow a decrease of the nominal interest rate by up to 10 basis points is not too unlikely.

Figure 7 shows the simulation results for a government consumption based consolidation. The black lines refer to the long-run transfer adjustment scenario, while the blue lines denote the long-run income tax adjustment scenario. The solid lines show the baseline case of no restrictions on monetary policy. The dashed lines show the case of holding the interest rate constant for two years at its initial steady state value and the dotted lines the case of holding the interest rate constant for four years. Afterwards the monetary policy rule kicks in. However, directly afterwards very large changes in the interest rate are prevented by the high interest rate smoothing coefficient. The graph on the lower right shows the nominal interest rate. In fact, in both baseline cases a permanent reduction of government consumption leads to a fall of the nominal interest rate of at least four years. Holding the interest rate constant for two or four years leads to a direct reduction of the nominal interest rate once the monetary policy rule kicks in. The implications on output and inflation are small except for the case of holding the interest constant for four years and using transfers for the long-run adjustment. In this case the drop in output and inflation and the implied increase in the real interest rate reinforce each other so much that output decreases by more than 4% after one year. Tax revenues fall substantially and the debt-ratio peaks at an increase of 6.5 percentage points after two and a half years. As

in our setup we simulate a stabilization of the debt ratio at the value that is reached after the end of the *transition phase*, i.e. after 20 quarters, holding the nominal interest constant has also an impact on the new steady-state, where the debt-ratio is higher rather than lower. Of course, a policy maker could still choose a final debt-to-GDP target below the initial steady state and finally reach a lower debt-ratio, but the adjustment would take considerably longer. In case of a shorter constant interest rate period or a long run adjustment of the income tax the differences from the baseline simulation are small. Hence, the long-run expectations matter a lot.

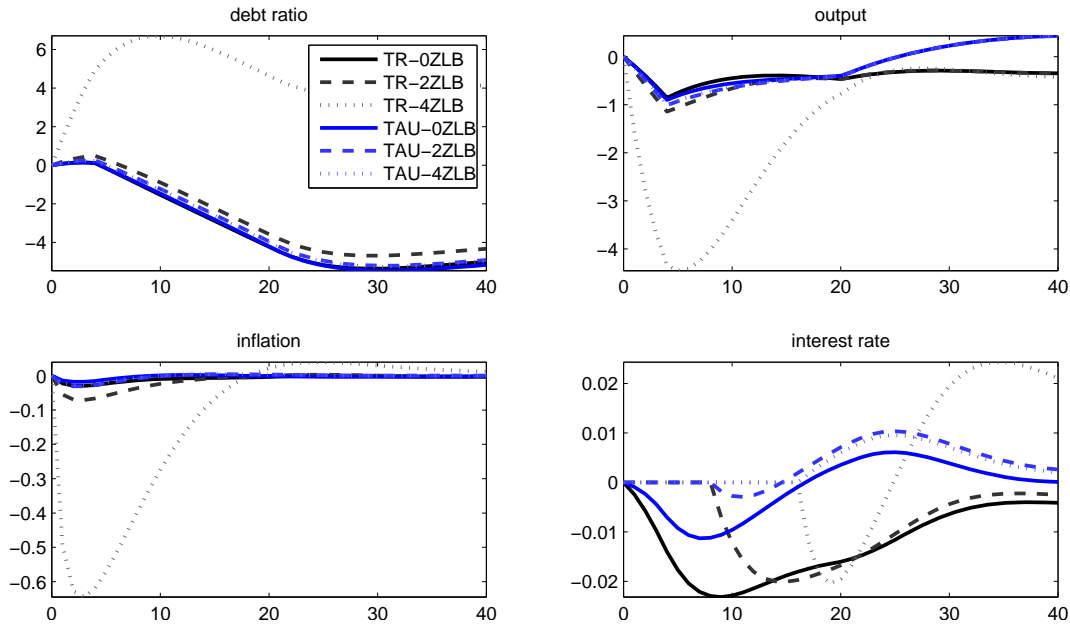


Figure 7: Transmission of a government consumption cut with constant interest rate.

Figure 8 shows the simulation results for the government investment based consolidation scenario. The effects of holding the nominal interest rate constant are qualitatively very similar to the government consumption based consolidation. They are, however, quantitatively much stronger because of the more negative effects of a reduction in government investment on output. Again, the largest difference from the baseline case is visible for holding the nominal interest rate constant for four years and adjusting transfers in the long-run. Output drops by 9% and the debt-ratio increases up to 18 percentage points. But also for the case of adjusting the income tax rate in the long-run or holding the interest rate constant for two years only, the drop in output is about twice as large as in the baseline case and accordingly the debt-ratio reduction is halved.

Figure 9 shows the case of a transfer cut based consolidation. The baseline simulation leads only in case of a long-run transfer adjustment to a temporary drop in the nominal interest rate. In case of a long-run income tax reduction, the nominal interest rate even increases slightly by 0.5 basis points. So, holding the interest rate constant is only for the long-run transfer adjustment scenario contractionary, while there is no zero lower bound problem for the long-run income tax adjustment scenario. If the interest rate is hold nevertheless constant, this corresponds to an expansionary monetary policy. Again, the largest effects are visible for the case of a long-run transfer adjustment and holding the interest rate constant for four years. The effects on output,

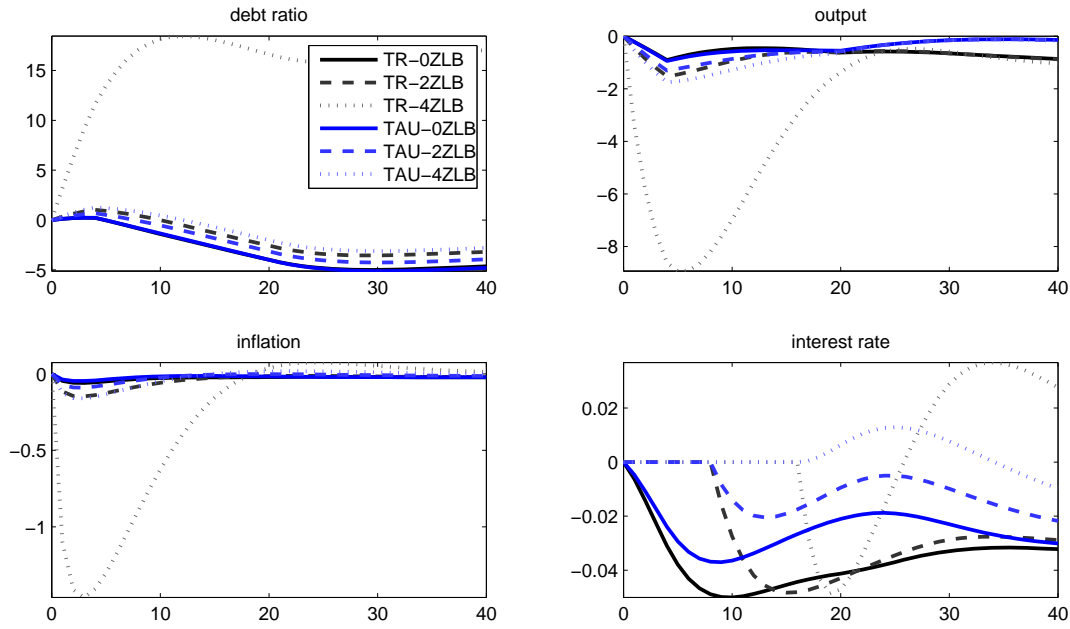


Figure 8: Transmission of a government investment cut with constant interest rate.

inflation and the debt-ratio are, however, smaller than in the previous scenarios because the decrease in transfers is only temporary and reversed in the long-run. For the long-run income tax adjustment the increase in inflation is larger than in the baseline scenario, output increases and accordingly the reduction in the debt-ratio is somewhat higher.

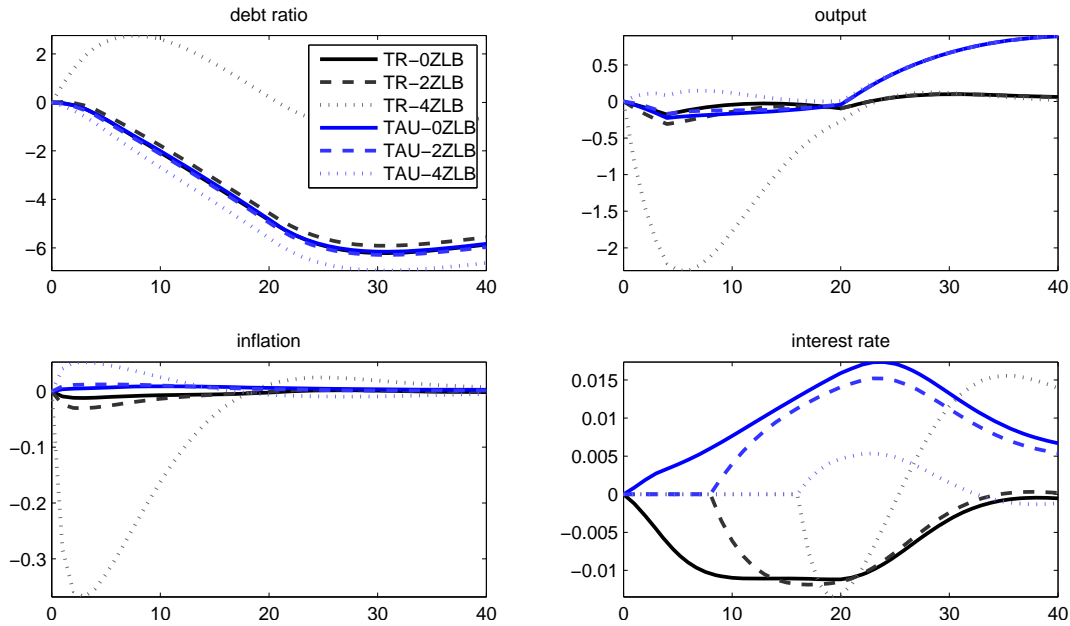


Figure 9: Transmission of a transfer cut with constant interest rate.

Figure 10 shows the case of a fiscal consolidation via raising the consumption tax rate. The effects are qualitatively and quantitatively extremely similar to the just described transfer based consolidation scenario.

Also for the income tax based consolidation scenario shown in figure 11 the effects are similar to the transfer and consumption tax based consolidations, though somewhat larger. Again, only

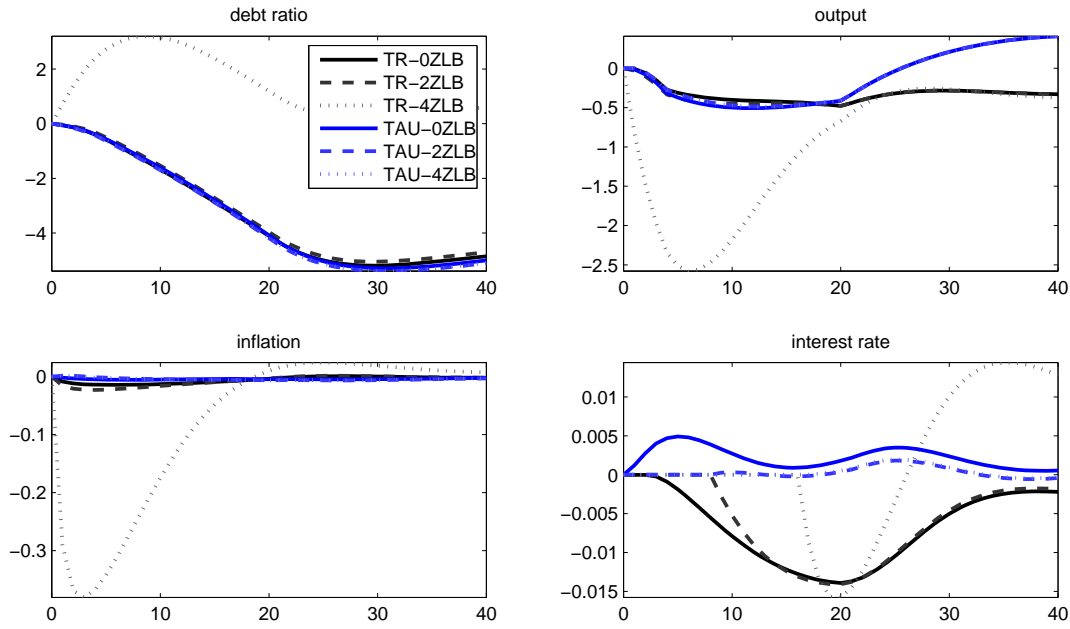


Figure 10: Transmission of a consumption tax increase with constant interest rate.

for the long-run transfer adjustment scenario the interest rate would decrease in the baseline simulation so that by credibly announcing a long-run adjustment of the income tax rate the zero lower bound problematic can be fully circumvented.

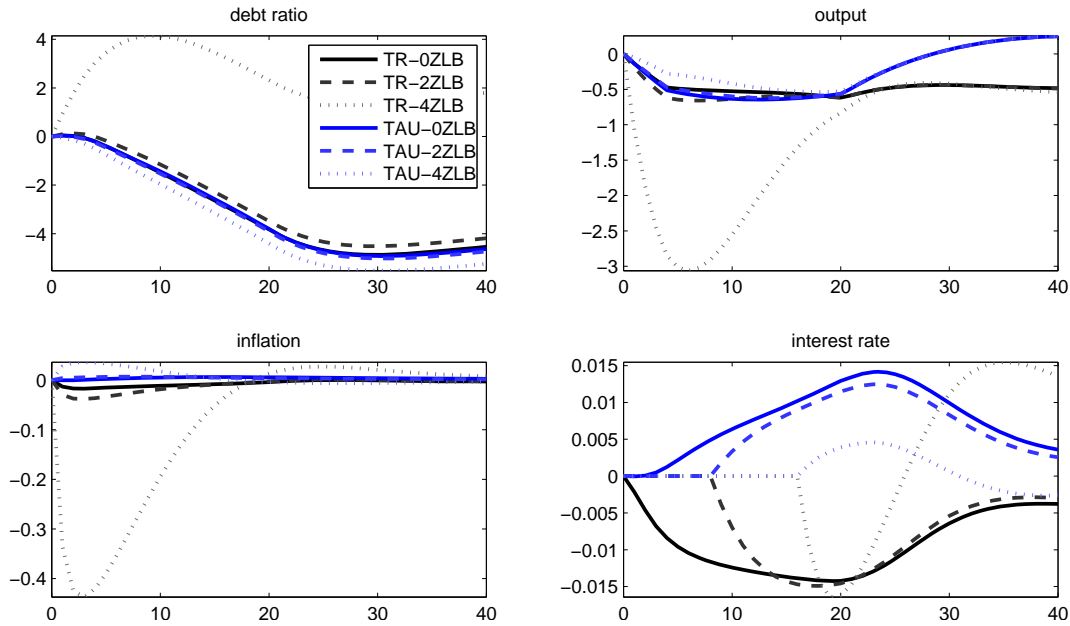


Figure 11: Transmission of an income tax increase with constant interest rate.

Finally, figure 12 shows the simulation results for the capital tax based consolidation. In the baseline simulation the nominal interest rate increases for about one and a half years, but the decrease afterwards is the strongest and longest of all consolidation scenarios as the effects on output and inflation are the largest. Holding the interest rate constant for two years leads to only modest deviations from the baseline scenario where the interest rate would first increase and then start to decrease after six quarters. Holding the interest rate constant for four years

has, however, very large effects. In the case of a long-run income tax reduction output falls by 4% rather than by 2% in the baseline scenario. Accordingly, the debt ratio increases rather than decreases. For the long-run transfer adjustment scenario the effects of holding the interest rate constant for four years are dramatic. Output contracts by 14% after one year, inflation decreases by 2% and the increase in the debt-ratio peaks at above 30 percentage points.

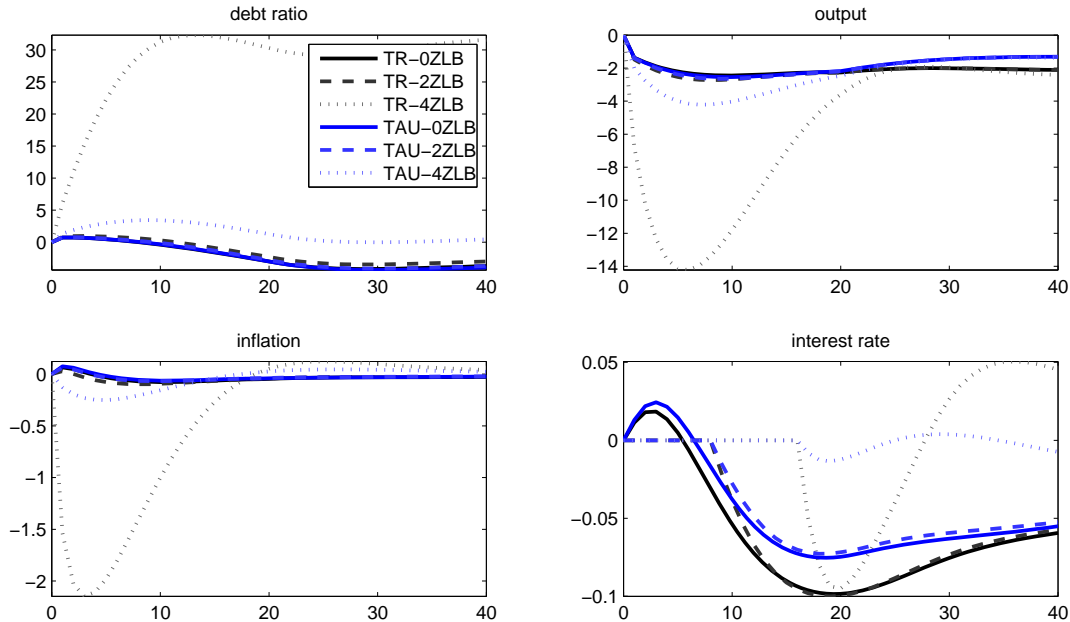


Figure 12: Transmission of a capital tax increase with constant interest rate.

Overall, the results show that the choice of the long-run stabilization has an important impact on the outcomes of a fiscal consolidation that starts when the nominal interest rate cannot decrease further and the expected economic environment is in a state where this situation is expected to hold for four years. A shorter constant interest rate period has a much smaller effect on the consolidation scenarios and the deviations from the baseline results are in many case negligible.

5 Welfare analysis

Previous works on fiscal consolidation focused on the quantitative effects on macroeconomic aggregates like GDP and its components. Consolidation strategies that have a positive effect on output are usually considered to be advantageous over consolidation strategies that have a less positive or a negative effect on output. In addition to this analyses of the previous sections, we consider here the effects on welfare which can be very different. Welfare is measured by the weighted utility of unconstrained and rule-of-thumb consumers. Both consumers' utility increases with consumption and decreases with hours worked so that output increasing policies that lead to a large increase in hours worked, but only a modest increase in consumption might even be welfare reducing.

Welfare for optimizing households V_o and rule-of-thumb households V_r is given by their life-time utility functions and aggregate welfare V is the sum of both weighted with their population

shares:

$$V_{o,t} = \sum_{s=0}^{\infty} \beta^s \left[\ln(\tilde{C}_{o,t+s} - h\tilde{C}_{o,t+s-1}) - \chi \frac{N_{o,t+s}^{1+\eta}}{1+\eta} \right] \quad (37)$$

$$V_{r,t} = \sum_{s=0}^{\infty} \beta^s \left[\ln(\tilde{C}_{r,t+s} - h\tilde{C}_{r,t+s-1}) - \chi \frac{N_{r,t+s}^{1+\eta}}{1+\eta} \right] \quad (38)$$

$$V_t = (1 - \zeta)V_{o,t} + \zeta V_{r,t} \quad (39)$$

By evaluating equations (37) to (39) for different paths of $\tilde{C}_{o,t}$, $\tilde{C}_{r,t}$, $N_{o,t}$ and $N_{r,t}$, we can assess whether certain policies are welfare reducing or welfare enhancing and we can rank different policies from a welfare point of view.

5.1 Steady state welfare analysis

We start by ignoring the short-run transmission effects and compare the steady state effects of fiscal consolidation on welfare. Therefore, we compute welfare for the initial steady state and the final steady-state that is achieved in the long-run after the debt-ratio has been reduced and stabilized by either increasing transfers or decreasing the income tax rate. Welfare for the initial steady state denoted with i is computed as

$$V_o^i = \frac{1}{1 - \beta} \left[\ln((1 - h)\tilde{C}_{o,i}) - \chi \frac{N_{o,i}^{1+\eta}}{1 + \eta} \right] \quad (40)$$

$$V_r^i = \frac{1}{1 - \beta} \left[\ln((1 - h)\tilde{C}_{r,i}) - \chi \frac{N_{r,i}^{1+\eta}}{1 + \eta} \right] \quad (41)$$

$$V^i = (1 - \zeta)V_o^i + \zeta V_r^i. \quad (42)$$

Accordingly, welfare for the final steady state denoted with f is given by:

$$V_o^f = \frac{1}{1 - \beta} \left[\ln((1 - h)\tilde{C}_{o,f}) - \chi \frac{N_{o,f}^{1+\eta}}{1 + \eta} \right] \quad (43)$$

$$V_r^f = \frac{1}{1 - \beta} \left[\ln((1 - h)\tilde{C}_{r,f}) - \chi \frac{N_{r,f}^{1+\eta}}{1 + \eta} \right] \quad (44)$$

$$V^f = (1 - \zeta)V_o^f + \zeta V_r^f. \quad (45)$$

As in Schmitt-Grohé and Uribe (2006) we express changes in welfare in consumption equivalence units λ as otherwise an interpretation of welfare differences is difficult. λ can be interpreted as the permanent change in consumption that would be necessary to achieve the same change in welfare as caused by a fiscal consolidation. We can compute this measures separately for both households types and denote it as λ_o and λ_r . The sum of these two weighted with population shares gives the aggregate change of welfare in consumption equivalence units λ . The three

measures are implicitly defined by:

$$V_o^f = \frac{1}{1-\beta} \left[\ln((1-h)(1+\lambda_o)\tilde{C}_{o,i}) - \chi \frac{N_{o,i}^{1+\eta}}{1+\eta} \right] \quad (46)$$

$$V_r^f = \frac{1}{1-\beta} \left[\ln((1-h)(1+\lambda_r)\tilde{C}_{r,i}) - \chi \frac{N_{r,i}^{1+\eta}}{1+\eta} \right] \quad (47)$$

$$\lambda = (1-\zeta)\lambda_o + \zeta\lambda_r. \quad (48)$$

The analytical solutions for λ_o , λ_r and λ are given by:

$$\lambda_o = \frac{\exp\left(\left[(1-\beta)V_o^f + \chi \frac{N_{o,i}^{1+\eta}}{1+\eta}\right]\right)}{(1-h)C_{o,i}} - 1 \quad (49)$$

$$\lambda_r = \frac{\exp\left(\left[(1-\beta)V_r^f + \chi \frac{N_{r,i}^{1+\eta}}{1+\eta}\right]\right)}{(1-h)C_{r,i}} - 1 \quad (50)$$

$$\lambda = (1-\zeta)\lambda_o + \zeta\lambda_r. \quad (51)$$

Table 4 shows the results for the welfare comparison of both steady states for the different fiscal consolidation scenarios.

Table 4: Steady state welfare effects of fiscal consolidation

	C_G	I_G	TR_G	τ^c	τ^n	τ^k
	long run balancing via transfer adjustment					
λ	2.20	-0.48	-0.03	0.70	0.99	-1.58
λ_o	2.04	-0.60	-0.13	0.55	0.92	-1.95
λ_r	2.69	-0.09	0.27	1.16	1.21	-0.49
	long run balancing via income tax adjustment					
λ	0.86	-1.23	-1.46	-0.55	-0.22	-2.59
λ_o	0.69	-1.36	-1.57	-0.71	-0.30	-2.96
λ_r	1.36	-0.83	-1.13	-0.07	0.02	-1.48

Notes: λ denotes the steady state welfare effects of a fiscal consolidation in consumption equivalence units. λ_o and λ_r refer to the change in steady state welfare for unconstrained and rule-of-thumb households, respectively. Positive numbers refer to an increase in welfare, while negative numbers denote a decrease in welfare.

The welfare change in consumption equivalence units reflects the changes in consumption and hours worked from the long-run analysis of fiscal consolidation in table 3. In particular, the scenarios where in the long-run transfers are adjusted have a more positive impact on welfare than the scenarios where in the long-run the income tax is lowered. While the latter strategy leads to a much more positive effect on output, it increases the opportunity costs of enjoying one more unit of leisure so that hours worked increase which reduces welfare. For the long-run transfer adjustment scenario consolidation via government consumption, the income tax rate and the consumption tax rate lead to an increase in welfare, while the consolidation via the three remaining instruments leads to reductions in welfare. The differences are large: the steady state effect of a consolidation via government consumption leads to the same increase in welfare as a permanent increase of consumption by 2.2%, while a consolidation via increases in the capital

tax rate reduce welfare by 1.6%. For the long-run income tax adjustment scenario the welfare effects are overall less positive so that only a government consumption based consolidation leads to an increase in welfare of 0.83%. The worst effects on welfare has the consolidation scenario, where the capital tax rate increases and the income tax rate decreases; the welfare effect is equivalent to permanent reduction of consumption by 2.6%. The ranking of the six consolidation strategies is similar for both long-run scenarios; only transfers and government investment based consolidation switch their places in the ranking. The ranking via aggregate welfare, welfare of unconstrained households and rule-of-thumb households is the same, but the differences in welfare for the two household types are for some scenarios large.

The welfare effects of a government consumption based consolidation are most positive owing to the increase in consumption and the decrease in hours worked via the *wealth effect*. The income tax based consolidation scenario has the second most positive effects as it leads to a sizeable decrease in hours worked which also reduces potential output. This shows that such a welfare analysis needs to be taken with a grain of salt as developments that seem to be negative from studying output developments turn out to be positive from a welfare perspective. The increase in welfare is, however, only half as big as for the government consumption based consolidation. The consumption tax based consolidation makes consumption more expensive leading to less positive effects on welfare. A transfer cut based consolidation, which leads to the most positive effects on output, is from a welfare perspective less positive. Combined with income tax reductions hours worked increase which reduces welfare. Government investment and capital tax based consolidation have both a very negative effect on potential output and as the effect is so large consumption decreases a lot and hours worked decrease either only slightly or increase, so that also from a welfare perspective these are the least favorable consolidation strategies. The loss in consumption equivalence units is more than 1% larger for a capital tax based consolidation than for a government investment consolidation.

5.2 Welfare analysis of steady state and transition period

So far, only welfare of steady states has been compared. As the new steady state is reached for some scenarios only after several decades this analysis is not sufficient. The simulation results for the short-run transmission of fiscal consolidation in section 4 showed that there are large temporary movements in consumption and hours worked. These might be important for welfare analysis as the final steady state is substantially discounted if it is reached in the far future only.

To compute the welfare impact of the whole fiscal consolidation path from period one until the indefinite future including convergence to the new steady state, we write equations (37) and (38) recursively:

$$V_{o,t} = \ln(\tilde{C}_{o,t} - h\tilde{C}_{o,t-1}) - \chi \frac{N_{o,t}^{1+\eta}}{1+\eta} + \beta [V_{o,t+1}] \quad (52)$$

$$V_{r,t} = \ln(\tilde{C}_{r,t} - h\tilde{C}_{r,t-1}) - \chi \frac{N_{r,t}^{1+\eta}}{1+\eta} + \beta [V_{r,t+1}]. \quad (53)$$

$$(54)$$

Evaluating these expressions in $t = 1$ yields the welfare based on the paths of consumption and hours worked for all periods $t = 1, \dots, \infty$ for the two households types owing to the perfect foresight assumption. We denote this by $V_{o,1}$ and $V_{r,1}$, respectively. Aggregate welfare is thus given by $V_1 = (1 - \zeta)V_{o,1} + \zeta V_{r,1}$. The change in welfare relative to a scenario without fiscal consolidation, i.e. remaining forever in the initial steady state, in consumption equivalence units is denoted by λ_o , λ_r and λ . These measures are implicitly given by:

$$V_{o,1} = \frac{1}{1 - \beta} \left[\ln((1 - h)(1 + \lambda_o)\tilde{C}_{o,i}) - \chi \frac{N_{o,i}^{1+\eta}}{1 + \eta} \right] \quad (55)$$

$$V_{r,1} = \frac{1}{1 - \beta} \left[\ln((1 - h)(1 + \lambda_r)\tilde{C}_{r,i}) - \chi \frac{N_{r,i}^{1+\eta}}{1 + \eta} \right] \quad (56)$$

$$\lambda = (1 - \zeta)\lambda_o + \zeta\lambda_r. \quad (57)$$

Hence, the analytical solutions for λ_o , λ_r and λ are:

$$\lambda_{o,1} = \frac{\exp\left(\left[(1 - \beta)V_{o,1} + \chi \frac{N_{o,i}^{1+\eta}}{1 + \eta}\right]\right)}{(1 - h)C_{o,i}} - 1 \quad (58)$$

$$\lambda_{r,1} = \frac{\exp\left(\left[(1 - \beta)V_{r,1} + \chi \frac{N_{r,i}^{1+\eta}}{1 + \eta}\right]\right)}{(1 - h)C_{r,i}} - 1 \quad (59)$$

$$\lambda_1 = (1 - \zeta)\lambda_{o,1} + \zeta\lambda_{r,1}. \quad (60)$$

Table 5 shows the computed welfare effects of fiscal consolidation in consumption equivalence units including the transition and the steady state analysis. We include also the difference between these values and the values in table 4 ($\lambda_1 - \lambda$, $\lambda_{o,1} - \lambda_o$, $\lambda_{r,1} - \lambda_r$) to isolate the welfare effects of the transition phase.

The results show that the welfare effects of the transition period should not be ignored. While the transition reduces in some cases the welfare of rule-of-thumb households relative to the pure steady state evaluation, aggregate welfare increases in all cases. The size of the effect of the transition on welfare varies strongly for the different instruments. For a government investment and a capital tax based consolidation, which had before highly negative welfare effects, the positive changes are strongest. The welfare effect of a fiscal consolidation via reductions of government investment increases from -0.5% for the steady state analysis to $+1\%$ when including the transition period for the long-run transfer adjustment scenario. For the capital tax based consolidation welfare even increases from -1.6% to about $+0.4\%$ in consumption equivalence units. For government consumption, transfer, consumption tax and income tax based consolidations the changes are much smaller. Overall the changes compared to the pure steady state welfare evaluation are larger for the long-run income tax adjustment scenario than for the long-run transfer adjustment scenario because higher steady state labor in the new steady state is usually not achieved during the *implementation*, *transition* and the beginning of the *debt-stabilization period*, but only afterwards, which is substantially discounted. These temporary reductions in hours worked increase welfare so much, that - when including the transition period

- fiscal consolidation has in general positive effects on welfare or welfare effects that are close to zero. The only exception is the case of a permanent transfer reduction combined with long-run income tax reductions where welfare decreases by 1.25%. Interestingly, this is the scenario with the most positive effect on long-run GDP as shown in table 3.

Table 5: Welfare effects of fiscal consolidation, transition and steady state analysis

	C_G	I_G	TR_G	τ^c	τ^n	τ^k
long run balancing via transfer adjustment						
λ_1	2.38	0.98	0.01	0.75	1.06	0.44
$\lambda_1 - \lambda$	0.18	1.46	0.04	0.04	0.07	2.02
$\lambda_{o,1}$	2.32	0.95	0.01	0.69	1.09	0.37
$\lambda_{o,1} - \lambda_o$	0.27	1.55	0.14	0.14	0.17	2.31
$\lambda_{r,1}$	2.58	1.09	0.02	0.92	0.98	0.67
$\lambda_{r,1} - \lambda_r$	-0.11	1.18	-0.25	-0.24	-0.23	1.16
long run balancing via income tax adjustment						
λ_1	1.19	0.10	-1.24	-0.36	-0.01	-0.58
$\lambda_1 - \lambda$	0.34	1.33	0.22	0.20	0.21	2.01
$\lambda_{o,1}$	1.11	0.05	-1.27	-0.43	0.00	-0.67
$\lambda_{o,1} - \lambda_o$	0.42	1.41	0.30	0.28	0.29	2.29
$\lambda_{r,1}$	1.45	0.26	-1.17	-0.13	-0.03	-0.29
$\lambda_{r,1} - \lambda_r$	0.08	1.09	-0.03	-0.05	-0.05	1.19

Notes: λ_1 denotes the welfare effects of a fiscal consolidation in consumption equivalence units including the transition period and the final steady state. $\lambda_{o,1}$ and $\lambda_{r,1}$ refer to the change in welfare for unconstrained and rule-of-thumb households, respectively. Positive numbers refer to an increase in welfare, while negative numbers denote a decrease in welfare. The rows $\lambda_1 - \lambda$, $\lambda_{o,1} - \lambda_o$, $\lambda_{r,1} - \lambda_r$, measure the welfare effects of the transition by subtracting the steady state effects from table 4 from the overall welfare effects.

The large differences of the steady state welfare analysis and the analysis including the transition for government investment and capital tax based consolidations are caused by the very slow convergence to the new steady state which is, thus, substantially discounted in the welfare evaluation. During the transition in both cases consumption is above the final steady state for a long time, while hours are strongly reduced on impact, which leads together to a strong increase in welfare. For the government investment based consolidation the temporary increase in consumption even above the initial steady state level is caused by the very gradual decline of public capital towards the new steady state which reduces the productivity of private capital and hours worked also very gradually. For the capital tax based consolidation scenario there is a large initial drop in GDP caused by high capital utilization adjustment costs. This reduces hours worked without reducing consumption and investment strongly on impact leading overall to positive welfare effects of the transition period. For the other consolidation scenarios the impact of the transition period on welfare is positive, but small. There is a continuous convergence towards the new steady state of consumption of unconstrained households often combined with an initial drop in hours worked as output is reduced because either government demand drops during the *implementation phase* or disposable income of rule-of-thumb consumers decreases. This drop in hours leads to an increase in welfare for unconstrained households. For rule-of-thumb households there is the same positive effect of reductions in hours worked on welfare, but their disposable income decreases temporarily leading to a temporary decrease in consumption, so that the transition in many cases has a negative effect on welfare of rule-of-thumb consumers.

We have done here a welfare evaluation based on a similar model and utility function as used in previous literature which was restricted to the quantitative evaluation of fiscal consolidation effects on macroeconomic aggregates without considering welfare implications. One main results is that from a welfare perspective consolidation scenarios that lead to a decrease in potential output and thus a decrease in hours worked are favourable. While a useful welfare analysis must be consistent with the derivation of the first order conditions of households and therefore must use the same utility function, the results should not be wrongly understood as a policy recommendation. It might be the case that the welfare function overemphasises the positive effects of reductions in hours worked. The current model ignores that a reduction in potential output might lead to an increase in the unemployment rate. There is no unemployment in the model so that all reductions in hours worked are interpreted as increases in leisure which are welfare enhancing. A potential quick fix would be to just evaluate the consumption term in the utility function. We think, however, that it does not make sense to use such a different utility function for the welfare evaluation as it would not be consistent with the derivation of the behavioral equations of the households. So, for future research we propose to check the results for either different utility functions - which are then used for both the derivation of the model equations and the welfare evaluation - and/or a more rigorous model of the labor market.

6 Conclusion

We provide a systematic analysis of several fiscal consolidation measures using a dynamic general equilibrium model. We find that ranking consolidation instruments based on a welfare criterion can lead to very different results than ranking based on the size of output multipliers. For the latter, a consolidation strategy which relies on transfer cuts has the most favorable effects, while a consolidation via an increase in the consumption tax rate ranks secondly. A consolidation strategy based on a reduction of public investment or on increases in taxes on capital has detrimental effects on output and therefore ranks lowest. If instead, the ranking is obtained considering steady state welfare, we find that a government consumption based strategy has the most positive effects, while the transfer scenario ranks somewhere in the middle. Since we employ a dynamic model we are able to compute welfare consequences of fiscal consolidation, taking into account the transition dynamics from the initial to the final steady state. We show that incorporating the transition has important welfare implications. A transfer based scenario now ranks lowest, whereas the public investment and the capital tax scenario rank in the middle.

Furthermore, we assess the effectiveness of various fiscal instruments in terms of a reduction of the debt-to-GDP ratio. In general, we find that consolidation scenarios which lead to favorable output multipliers are also superior with respect to the reduction of the debt-to-GDP ratio. The choice of the long-run debt stabilization instrument only plays a minor role for the overall reduction of the debt-to-GDP ratio.

In addition, we provide a detailed analysis of the short and long-run transmission of fiscal consolidation. For the long-run, we are able to explain the behavior of key macroeconomic variables, such factor prices and factor inputs using some key steady state relations. Our modeling strategy therefore improves economic intuition for macroeconomic outcomes of fiscal consolida-

tion, which so far is underdeveloped in the existing literature.

Finally, we check the robustness of our results when the zero lower bound on nominal interest rates is binding. We find that the length of the period of a binding zero lower bound is crucial for the respective economic outcomes. If the interest rate remains constant for two years the adjustment path to the new equilibrium is nearly the same as in the benchmark scenario. On the contrary, we observe a large negative impact for the case where the zero lower bound is binding for four years. Interestingly, in this scenario the choice of the long-run stabilization instrument has considerable effects on fiscal policy transmission.

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