Abstract

This paper investigates the effectiveness of fiscal consolidations via spending cuts or increases in labor income taxes within a currency union in a New Keynesian general equilibrium framework which takes explicit account of the zero bound constraint on policy rates. In this environment, we document that fiscal consolidations via government spending cuts tend to have less adverse impact on output in the medium term in comparison to labor-income tax hikes when monetary policy can be used to offset the drag on demand. Accordingly, government spending cuts are more effective than labor tax hikes to reduce government debt in the medium term, consistent with empirical studies on fiscal consolidations. However, for a small member of a currency union, we find that consolidation via labor-tax hikes can be more effective in the near term as they depend less on monetary accommodation. Finally, we study the impact of fiscal retrenchment in a liquidity trap when a larger subset of the currency union members consolidate simultaneously. In this case, our results mimics the small open economy case by suggesting that labor tax hikes are more effective than front-loaded spending cuts to reduce government debt quickly if the liquidity trap is expected to be sufficiently long-lived absent any fiscal actions.

JEL Classification: E32, F41

Keywords: Monetary Policy, Fiscal Policy, Liquidity Trap, Zero Bound Constraint, Open Economy Macroeconomics, DSGE Model.

*This paper was originally prepared for the Sveriges Riksbank conference “Monetary Policy in an Era of Fiscal Stress” which was held in Stockholm June 16-17, 2011. We thank our discussant Martin Floden and other conference participants for their useful comments. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System. ** Corresponding Author: Telephone: 202-452-3055. Fax: 202-263-4850 E-mail addresses: christopher.erceg@frb.gov and jesper.l.linde@frb.gov
1. Introduction

Following the intensification of the financial crisis in the fall of 2008, many countries implemented large fiscal stimulus packages to mitigate the effects of the recession. A number of influential papers supported these policy actions on the premise that fiscal multipliers were likely to be especially large in an environment in which monetary policy was unlikely to respond by raising interest rates. However, the rise in sovereign spreads in a number of European countries since late 2009, especially those with high government debt or deficit levels, has spurred plans for substantial and accelerated fiscal consolidation in those countries. And a number of countries in the euro area, like Italy, Spain, Ireland and Portugal are currently implementing very sizeable fiscal consolidation packages. In addition, larger countries within the euro area like Germany and France have also announced sizeable fiscal consolidation packages, and outside the euro area the United Kingdom has announced and is currently undertaking substantial consolidative actions. Against this background, a key question is the effectiveness of various fiscal instruments to reduce debt in the short- and medium-term, and closely linked to this question is to what extent the austerity measures will reduce economic activity and hence tax revenues.

Although there is general agreement that reducing debt via persistent spending cuts may have important long-term output benefits though lower tax rates, the short-term effects of various fiscal instruments are still an active research agenda. An extensive empirical literature on large fiscal consolidations originating with Giavazzi and Pagano (1990) and Alesina and Perotti (1995, 1997), and more recently Alesina and Ardagna (2009), argues that large and durable cuts in government expenditures have appeared to boost output even in the near term under certain conditions, and that fiscal consolidations through spending cuts have tended to be successful in reducing government debt quickly than consolidations via tax hikes.

Following the prescriptions of this literature, fiscal austerity measures in the peripheral

---


2 IMF (2010) argues against the notion that fiscal consolidations can have expansionary effects by using Romer and Romer (2010) dating of fiscal retrenchments.
countries in the euro area rely to a large extent on spending cuts, as opposed to attempting
to raise tax revenues by increasing various tax rates. As these countries lack credibility from
financial markets to undertake their consolidations gradually, the announced consolidation
packages are quite front-loaded.

While the literature on large fiscal consolidations discussed above suggest that spending
cuts are preferable to tax hikes in order to mitigate the impact on economic activity and
to reduce debt quickly, it is not clear how the prescriptions from this literature carries
over to current circumstances, where many of the consolidating countries cannot pursue an
independent monetary policy due to membership in a currency union, or because policy rates
are expected to be bounded by zero for a protracted period. We attempt to fill this gap by
using an open economy DSGE model to analyze how fiscal consolidations via either spending
cuts or tax hikes that are concentrated in a subset of member countries of a currency union
affect the union both at an aggregate level, and differentially across member states. Our
framework takes explicit account of possible constraints on both monetary and fiscal policy
by assuming that monetary policy is constrained by the zero lower bound (ZLB) on policy
rates, and also consider the possibility that fiscal policy in many of the member countries
may be constrained to react aggressively to debt or deficits.

We start out by building intuition for our results in a simple transparent open economy
model with only nominal wage and price frictions, which consists of two country blocks that
are integrated into a currency union, and hence share a single currency. We then move
on to an analysis in a workhorse model, which inherits many of the features of a broad
class of new open economy macro models. These include the various nominal and real
frictions that have been identified as empirically important in the closed economy models
of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2003), as well as
analogous frictions relevant in an open economy framework, such as costs of adjusting trade
flows. The model also incorporates “rule of thumb” households which consume all of their
after-tax income as in Erceg, Guerrieri, and Gust (2006), and both microeconomic and
macroeconomic evidence exists to suggest the relevance of households with such behavior.\footnote{Johnson et al. (2006) and Parker et al. (2011) find evidence of a substantial response of household spending, particularly for liquidity-constrained households, to the temporary tax rebates of 2001 and 2008 in the United States, using micro data from the Consumer Expenditure Survey. On the macro side, Gali,
In addition, we embed a financial accelerator channel into the model following the approach of Bernanke, Gertler, and Gilchrist (1999). The recent recession and the work by Christiano, Motto and Rostagno (2010) have highlighted the importance of financial frictions both as an amplification mechanism and as a source of business cycles fluctuations. Fiscal policy is determined separately by each country block, and includes rules for adjusting an endogenous component of government spending or taxes in response to government debt.

We calibrate the model to the euro area, identifying one country block as the “South”, and the other the “North.” Our analysis focuses on a “Small South” calibration in which the GDP of the South is a tiny fraction of the North’s GDP, a calibration which approximates the case of a small open economy. In addition, we also consider the effects of perfectly coordinated fiscal consolidations in both the South and the North, in which case the effects in South and North mimics those in a closed economy.

In line with conventional wisdom, we find that fiscal consolidations via government spending cuts tend to have less adverse impact on output in the medium term in comparison to labor-income tax hikes when monetary policy can be used to offset the drag on demand. Accordingly, government spending cuts are more effective than labor tax hikes to reduce government debt in the medium term, consistent with the literature on large fiscal consolidations. However, in cases when monetary policy cannot be used to offset the drag on demand, i.e. for a consolidating small member which carries little weight on the interest setting of the currency union central bank, we find that consolidation via increases in labor-income taxes are more effective to reduce debt quickly than spending cuts as tax hikes depend less on monetary accommodation.

When a larger subset of currency union members consolidate at the same time and the currency union is in a liquidity trap, we find that labor tax hikes is a more effective tool to reduce government debt than front-loaded spending cuts if the expected duration of the liquidity trap is sufficiently long absent any fiscal austerity measures, or the size of the

López-Salio and Vallés (2007) present evidence from structural VARs that government spending shocks tend to boost private consumption, and show how the inclusion of rule-of-thumb agents in their DSGE model helps it account for this behavior. Blanchard and Perotti (2002) and Monacelli and Perotti (2008) obtain similar empirical findings.

It is important to notice that absent any nominal rigidities, our model implies that spending cuts are more effective than equally sized labor-tax hikes to reduce government debt in both the short- and long-term. In this case, whether South is a small member in a currency union or has monetary independence is irrelevant for the effectiveness of the fiscal austerity measures.
consolidation package is large enough to extend the duration by sufficiently many quarters. Only if the fiscal austerity measures can be implemented very gradually, spending cuts are preferable to tax hikes in a protracted liquidity trap. However, it should be emphasized that gradual spending cuts are still contractionary even in a long-lived liquidity trap in our framework with sticky wages and hand-to-mouth consumers, unlike the findings in Corsetti et al. (2010) who argue that spending reversals can be expansionary in a pure sticky price framework. Sticky wages makes inflation respond less to the fiscal actions, and a larger share of hand-to-mouth share implies that the commitment to future spending cuts causes less crowding in effects on private absorption today. [Remains to be done: Tie and explain our results more closely to the recent work by e.g. Corsetti et al, Eggertsson, Drautzburg and Uhlig, Davig and Leeper.]

The reminder of the paper is organized as follows. In the next section, we lay out and build intuition behind our results in a simple open economy model with nominal price and stickiness (but no real rigidities). Next, we present the workhorse two-country open economy model. In Section 4, we discuss how we calibrate and compute the solution of the model under the zero lower bound for nominal interest rates. The results for the benchmark parameterization of the model are reported in Section 5. In Section 6, we assess the sensitivity of the results for alternative parameterizations of the model. Finally, we provide some conclusions in Section 7.

2. The Model

Our model consists of two country blocks that differ in size, but are otherwise isomorphic. The first country block is called the “South”, and the second country block the “North.” The country blocks share a common currency, and monetary policy is conducted by a single central bank. During “normal” times when the zero bound constraint on policy rates is not binding, the central bank adjusts policy rates in response to the aggregate inflation rate and output gap of the currency union. By contrast, fiscal policy may differ across the two blocks.

Given the isomorphic structure, our exposition below largely focuses on the structure of the South. It is important to recall, however, that differences in country size translate into
difference in steady state trade shares. Thus, the standard small open economy paradigm emerges as a special case in which the population size of the South is calibrated to be an arbitrarily small fraction of the population of the currency union.

Our specification of the financial accelerator channel closely parallels earlier work by Bernanke, Gertler, and Gilchrist (1999) and Christiano, Motto, and Rostagno (2008). Given that the mechanics underlying the financial accelerator are well-understood, we simplify our exposition by focusing on a special case of our model which abstracts from a financial accelerator. We conclude our model description with a brief description of how the model is modified to include the financial accelerator (Section 2.6).

2.1. Firms and Price Setting

2.1.1. Production of Domestic Intermediate Goods

There is a continuum of differentiated intermediate goods (indexed by \( i \in [0, 1] \)) in the South block, each of which is produced by a single monopolistically competitive firm. In the domestic market, firm \( i \) faces a demand function that varies inversely with its output price \( P_{Di}(i) \) and directly with aggregate demand at home \( Y_{Dt} \):

\[
Y_{Dt}(i) = \left[ \frac{P_{Di}(i)}{P_{Dt}} \right]^{-\frac{(1+\theta_p)}{\theta_p}} Y_{Dt}, \tag{1}
\]

where \( \theta_p > 0 \), and \( P_{Dt} \) is an aggregate price index defined below. Similarly, firm \( i \) faces the following export demand function:

\[
X_t(i) = \left[ \frac{P_{Mti}(i)}{P_{Mt}} \right]^{-\frac{(1+\theta_p)}{\theta_p}} M_t^*, \tag{2}
\]

where \( X_t(i) \) denotes the quantity demanded of domestic good \( i \) in the North block, \( P_{Mti}(i) \) denotes the price that firm \( i \) sets in the North market, \( P_{Mt} \) is the import price index in the North, and \( M_t^* \) is an aggregate of the North’s imports (we use an asterisk to denote the North block’s variables).

Each producer utilizes capital services \( K_t(i) \) and a labor index \( L_t(i) \) (defined below) to produce its respective output good. The production function is assumed to have a constant-elasticity of substitution (CES) form:

\[
Y_t(i) = \left( \omega_K^{\frac{1}{\theta_p}} K_t(i)^{\frac{1}{\theta_p}} + \omega_L^{\frac{1}{\theta_p}} (Z_t L_t(i))^{\frac{1}{\theta_p}} \right)^{1+\rho}. \tag{3}
\]
The production function exhibits constant-returns-to-scale in both inputs, and \( Z_t \) is a country-specific shock to the level of technology. Firms face perfectly competitive factor markets for hiring capital and labor. Thus, each firm chooses \( K_t (i) \) and \( L_t (i) \), taking as given both the rental price of capital \( R_{Kt} \) and the aggregate wage index \( W_t \) (defined below). Firms can costlessly adjust either factor of production, which implies that each firm has an identical marginal cost per unit of output, \( MC_t \). The (log-linearized) technology shock is assumed to follow an AR(1) process:

\[
\z_t = \rho_z \z_{t-1} + \z_{z,t} 
\]  

(4)

We assume that each intermediate goods producer sets the same price \( P_{Dt} (i) \) in both blocks of the currency union, implying that \( P_{Mt}^* (i) = P_{Dt} (i) \) and that \( P_{Mt}^* = P_{Dt} \). The prices of the intermediate goods are determined by Calvo-style staggered contracts (see Calvo, 1983). In each period, a firm faces a constant probability, \( 1-\xi_p \), of being able to reoptimize its price \( (P_{Dt} (i)) \). This probability of receiving a signal to reoptimize is independent across firms and time. If a firm is not allowed to optimize its prices, we follow Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003), and assume that the firm must reset its home price as a weighted combination of the lagged and steady state rate of inflation

\[
P_{Dt} (i) = \pi_{t-1}^p \pi^{1-\tau} P_{Dt-1} (i) \]  

for the non-optimizing firms. When \( \tau_p \) is set close to unity, this formulation introduces structural inertia into the price-setting equation.

When a firm \( i \) is allowed to reoptimize its price in the domestic market in period \( t \), the firm maximizes

\[
\mathbb{E}_t \sum_{j=0}^{\infty} \xi_p^j \psi_{t,t+j} \left[ \prod_{h=1}^{j} \pi_{t+h-1} P_{Dt} (i) Y_{Dt+j} (i) - MC_{t+j} Y_{Dt+j} (i) \right]. 
\]  

(5)

The operator \( \mathbb{E}_t \) represents the conditional expectation based on the information available to agents at period \( t \). The firm discounts profits received at date \( t + j \) by the state-contingent discount factor \( \psi_{t,t+j} \); for notational simplicity, we have suppressed all of the state indices.\(^5\)

The first-order condition for setting the contract price of good \( i \) in the home market is

\[
\mathbb{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left[ \prod_{h=1}^{j} \pi_{t+h-1} (i) \left( \frac{\pi_{t+h-1} (i)}{1 + \theta_p} \right) - MC_{t+j} \right] Y_{Dt+j} (i) = 0. 
\]  

(6)

\(^5\) We define \( \xi_{t,t+j} \) to be the price in period \( t \) of a claim that pays one dollar if the specified state occurs in period \( t + j \) (see the household problem below); then the corresponding element of \( \psi_{t,t+j} \) equals \( \xi_{t,t+j} \) divided by the probability that the specified state will occur.
The problem for firm $i$ of reoptimizing its price for the export market in period $t$ is identical to that in (5), with the exception that $X_{t+j}(i)$ enters instead of $Y_{Dt+j}$.

2.1.2. Production of the Domestic Output Index

Because households have identical Dixit-Stiglitz preferences, it is convenient to assume that a representative aggregator combines the differentiated intermediate products into a composite home-produced good $Y_{Dt}$:

$$Y_{Dt} = \left[ \int_0^1 Y_{Dt} (i)^{1+\theta_p} \, di \right]^{1+\theta_p}. \quad (7)$$

The aggregator chooses the bundle of goods that minimizes the cost of producing $Y_{Dt}$, taking the price $P_{Dt}(i)$ of each intermediate good $Y_{Dt}(i)$ as given. The aggregator sells units of each sectoral output index at its unit cost $P_{Dt}$:

$$P_{Dt} = \left[ \int_0^1 P_{Dt} (i)^{1+\theta_p} \, di \right]^{-\theta_p}. \quad (8)$$

We also assume a representative aggregator in the foreign economy who combines the differentiated home products $X_t(i)$ into a single index for foreign imports:

$$M_t^* = \left[ \int_0^1 X_t (i)^{1+\theta_p} \, di \right]^{1+\theta_p}, \quad (9)$$

and sells $M_t^*$ at price $P_{Mt}^*$:

$$P_{Mt}^* = \left[ \int_0^1 P_{Mt}^* (i)^{1+\theta_p} \, di \right]^{-\theta_p}. \quad (10)$$

2.1.3. Production of Consumption and Investment Goods

Final consumption goods are produced by a representative consumption goods distributor. This firm combines purchases of domestically-produced goods with imported goods to produce a final consumption good ($C_{At}$) according to a constant-returns-to-scale CES production function:

$$C_{At} = \left( \frac{\omega_C}{\omega_C + \omega_{PC}} C_{Dt}^{\frac{\omega_C}{\omega_C + \omega_{PC}}} + \frac{\omega_C}{\omega_C + \omega_{PC}} (\varphi_C M_{Ct})^{1+\theta_p} \right)^{1+\theta_p}, \quad (11)$$

where $C_{Dt}$ denotes the consumption good distributor’s demand for the index of domestically-produced goods, $M_{Ct}$ denotes the distributor’s demand for the index of foreign-produced
goods, and $\varphi_{C_t}$ reflects costs of adjusting consumption imports. The final consumption good is used by both households and by the government. The form of the production function mirrors the preferences of households and the government sector over consumption of domestically-produced goods and imports. Accordingly, the quasi-share parameter $\omega_C$ may be interpreted as determining the preferences of both the private and public sector for domestic relative to foreign consumption goods, or equivalently, the degree of home bias in consumption expenditure. Finally, the adjustment cost term $\varphi_{C_t}$ is assumed to take the quadratic form:

$$\varphi_{C_t} = \left[1 - \frac{\varphi_{MC}}{2} \left(\frac{MC_{C_t}}{MC_{C_t-1}} - 1\right)\right]^2.$$  

This specification implies that it is costly to change the proportion of domestic and foreign goods in the aggregate consumption bundle, even though the level of imports may jump costlessly in response to changes in overall consumption demand.

Given the presence of adjustment costs, the representative consumption goods distributor chooses (a contingency plan for) $C_{Dt}$ and $M_{Ct}$ to minimize its discounted expected costs of producing the aggregate consumption good:

$$\min_{C_{Dt+k},M_{Ct+k}} \mathbb{E}_t \sum_{k=0}^{\infty} \psi_{t,t+k} \left\{ (P_{Dt+k}C_{Dt+k} + P_{Mt+k}M_{Ct+k}) + P_{Ct+k} \left[ C_{A,t+k} - \left( \frac{\rho_C}{\omega_C} \right)^{1+\rho_C} C_{Dt+k} \left( \frac{1}{1+\rho_C} \right)^{1+\rho_C} \right) \right\}.$$  

The distributor sells the final consumption good to households and the government at a price $P_{C_t}$, which may be interpreted as the consumption price index (or equivalently, as the shadow cost of producing an additional unit of the consumption good).

We model the production of final investment goods in an analogous manner, although we allow the weight $\omega_I$ in the investment index to differ from that of the weight $\omega_C$ in the consumption goods index.\(^6\)

\(^6\) Notice that the final investment good is not used by the government.
2.2. Households and Wage Setting

We assume a continuum of monopolistically competitive households (indexed on the unit interval), each of which supplies a differentiated labor service to the intermediate goods-producing sector (the only producers demanding labor services in our framework) following Erceg, Henderson and Levin (2000). A representative labor aggregator (or “employment agency”) combines households’ labor hours in the same proportions as firms would choose. Thus, the aggregator’s demand for each household’s labor is equal to the sum of firms’ demands. The aggregate labor index $L_t$ has the Dixit-Stiglitz form:

$$L_t = \left[ \int_0^1 (\zeta N_t(h))^{1+\theta_w} dh \right]^{1+\theta_w},$$

(14)

where $\theta_w > 0$ and $N_t(h)$ is hours worked by a typical member of household $h$. The parameter $\zeta$ is the size of a household of type $h$, and effectively determines the size of the population in the South. The aggregator minimizes the cost of producing a given amount of the aggregate labor index, taking each household’s wage rate $W_t(h)$ as given, and then sells units of the labor index to the production sector at their unit cost $W_t$:

$$W_t = \left[ \int_0^1 W_t(h) \frac{1}{\theta_w} dh \right]^{-\theta_w}.$$

(15)

The aggregator’s demand for the labor services of a typical member of household $h$ is given by

$$N_t(h) = \left[ \frac{W_t(h)}{W_t} \right]^{-\frac{1+\theta_w}{\theta_w}} L_t / \zeta.$$

(16)

We assume that there are two types of households: households that make intertemporal consumption, labor supply, and capital accumulation decisions in a forward-looking manner by maximizing utility subject to an intertemporal budget constraint (FL households, for “forward-looking”); and the remainder that simply consume their after-tax disposable income (HM households, for “hand-to-mouth” households). The latter type receive no capital rental income or profits, and choose to set their wage to be the average wage of optimizing households. We denote the share of FL households by $\zeta$ and the share of HM households by $1 - \zeta$. 

9
We consider first the problem faced by FL households. The utility functional for an optimizing representative member of household $h$ is

$$
E_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1 - \sigma} \left( C_t^{O}(h) - \kappa C_{t+j}^{O} - \nu_{ct} \right)^{1 - \sigma} + \right. \\
\left. \frac{\kappa_0}{1 - \chi} (1 - N_{t+j}(h))^{1 - \chi} + \mu_0 F \left( \frac{MB_{t+j+1}(h)}{P_{C_{t+j}}} \right) \right\},
$$

where the discount factor $\beta$ satisfies $0 < \beta < 1$. As in Smets and Wouters (2003, 2007), we allow for the possibility of external habit formation in preferences, so that each household member cares about its consumption relative to lagged aggregate consumption per capita of optimizing agents, $C_{t-1}^{O}$. Consumption is subject to sales tax (VAT) $\tau_{Ct}$. The period utility function depends on an each member’s current leisure $1 - N_t(h)$, his end-of-period real money balances, $\frac{MB_{t+1}(h)}{P_{Ct}}$, and a preference shock, $\nu_{ct}$. The subutility function $F(.)$ over real balances is assumed to have a satiation point, in order to rationalize the possibility of a zero nominal interest rate; see Eggertsson and Woodford (2003) for further discussion. The (log-linearized) consumption demand shock $\nu_{ct}$ is assumed to follow an AR(1) process:

$$
\nu_{ct} = \rho_{\nu} \nu_{ct-1} + \xi_{\nu,t}
$$

Household $h$ faces a flow budget constraint in period $t$ which states that its combined expenditure on goods and on the net accumulation of financial assets must equal its disposable income:

$$
P_{Ct} (1 + \tau_{Ct}) C_t^{O}(h) + P_{Ht} I_t(h) + MB_{t+1}(h) - MB_t(h) + \int_{s}^{t} \xi_{s,t+1} B_{Dt+1}(h) - B_{Dt}(h) + P_{Dt} B_{Gt+1} - B_{Gt} + \frac{P_{Dt} B_{Ft+1}(h)}{\phi_{Dt}} - B_{Ft}(h) \nonumber \\
= (1 - \tau_{Nt}) W_t(h) N_t(h) + \Gamma_t(h) + TR_t(h) - T_t(h) + (1 - \tau_{Kt}) R_{Kt} K_t(h) + P_{Ht} \tau K_t \delta K_t(h) - P_{Dt} \phi_{Ht}(h).
$$

Investment in physical capital augments the per capita capital stock $K_{t+1}(h)$ according to a linear transition law of the form:

$$
K_{t+1}(h) = (1 - \delta) K_t(h) + I_t(h),
$$

where $\delta$ is the depreciation rate of capital.

---

7 We also maintain the assumption that $\mu_0$ is sufficiently small that changes in the monetary base to a first-order approximation have negligible effects on the evolution of public debt.
Financial asset accumulation of a typical member of FL household $h$ consists of increases in nominal money holdings $(MB_{t+1}(h) - MB_t(h))$ and the net acquisition of bonds. While the domestic financial market is complete, cross-border asset trade is restricted to a single non-state contingent bond issued by the government of the North economy.

The terms $B_{Gt+1}$ and $B_{Ft+1}$ represents each household member’s net purchases of the government bonds issued by the South and North governments, respectively. Each type of bond pays one currency unit (e.g., euro) in the subsequent period, and is sold at price (discount) of $P_{Bt}$ and $P^*_{Bt}$, respectively. To ensure the stationarity of foreign asset positions, we follow Turnovsky (1985) by assuming that domestic households must pay a transaction cost when trading in the foreign bond. The intermediation cost depends on the ratio of economy-wide holdings of net foreign assets to nominal GDP, $\Phi_Y$, and is given by:

$$\phi_{bt} = \exp\left(-\phi_b \left( \frac{B_{Ft+1}}{P_t Y_t} \right) \right).$$

If the South is an overall net lender position internationally, then a household will earn a lower return on any holdings of foreign (i.e., North) bonds. By contrast, if the South has a net debtor position, a household will pay a higher return on its foreign liabilities. Given that the domestic government bond and foreign bond have the same payoff, the price faced by domestic residents net of the transaction cost is identical, so that $P_{Bt} = \frac{P_{Bt}}{\phi_{bt}}$. The effective nominal interest rate on domestic bonds (and similarly for foreign bonds) hence equals $i_t = 1/P_{Bt} - 1$.

Each member of FL household $h$ earns after-tax labor income, $(1 - \tau_{Nt})W_t(h) N_t(h)$, where $\tau_{Nt}$ is a stochastic tax on labor income. The household leases capital at the after-tax rental rate $(1 - \tau_{Kt})R_{Kt}$, where $\tau_{Kt}$ is a stochastic tax on capital income. The household receives a depreciation write-off of $P_t \tau_{Kt} \delta$ per unit of capital. Each member also receives an aliquot share $\Gamma_t(h)$ of the profits of all firms and a lump-sum government transfer, $TR_t(h)$ and pays a lump-sum tax $T_t(h)$. Following Christiano, Eichenbaum and Evans (2005), we assume that it is costly to change the level of gross investment from the previous period, so that the acceleration in the capital stock is penalized:

$$\phi_{it}(h) = \frac{1}{2} \phi_i \frac{(I_t(h) - I_{t-1})^2}{I_{t-1}}.$$  

---

8 These contingent claims are in zero net supply from the standpoint of the South as a whole; hence, we omit them from the budget constraint for expositional simplicity.
In every period \( t \), each member of FL household \( h \) maximizes the utility functional (17) with respect to its consumption, investment, (end-of-period) capital stock, money balances, holdings of contingent claims, and holdings of domestic and foreign bonds, subject to its labor demand function (16), budget constraint (19), and transition equation for capital (20). In doing so, a household takes as given prices, taxes and transfers, and aggregate quantities such as lagged aggregate consumption and the aggregate net foreign asset position.

Forward-looking (FL) households set nominal wages in staggered contracts that are analogous to the price contracts described above. In particular, with probability \( 1 - \xi_w \), each member of a household is allowed to reoptimize its wage contract. If a household is not allowed to optimize its wage rate, we assume each household member resets its wage according to:

\[
W_t(h) = \omega_{t-1}^\xi \omega^{1-\xi} W_{t-1}(h),
\]

where \( \omega_{t-1} \) is the gross nominal wage inflation in period \( t - 1 \), i.e. \( W_t/W_{t-1} \), and \( \omega = \pi \) is the steady state rate of change in the nominal wage (equal to gross price inflation since steady state gross productivity growth is assumed to be unity). Dynamic indexation of this form introduces some element of structural persistence into the wage-setting process. Each member of household \( h \) chooses the value of \( W_t(h) \) to maximize its utility functional (17) subject to these constraints.

Finally, we consider the determination of consumption and labor supply of the hand-to-mouth (HM) households. A typical member of a HM household simply equates his nominal consumption spending, \( P_{Cl} (1 + \tau_{Cl}) C_t^{HM} (h) \), to his current after-tax disposable income, which consists of labor income plus net lump-sum transfers from the government:

\[
P_{Cl} (1 + \tau_{Cl}) C_t^{HM} (h) = (1 - \tau_{NI}) W_t (h) N_t (h) + TR_t(h) - T_t (h).
\]

The HM households set their wage to be the average wage of the forward-looking households. Since HM households face the same labor demand schedule as the forward-looking households, each HM household works the same number of hours as the average for forward-looking households.
2.3. Monetary Policy

We assume that the central bank follows a Taylor rule for setting the policy rate of the currency union, subject to the zero bound constraint on nominal interest rates. Thus:

\[ i_t = \max \{ -i, (1 - \gamma_i) (\pi_t + \gamma_\pi (\bar{\pi}_t - \pi) + \gamma_\pi x_{t}) + \gamma_i i_{t-1} \} \]  

In this equation, \( i_t \) is the quarterly nominal interest rate expressed in deviation from its steady state value of \( i \). Hence, imposing the zero lower bound then implies that \( i_t \) cannot fall below \(-i\) and that the systematic part of the policy rule is below \(-i\) when \( i_t = -i \). \( \bar{\pi}_t \) is price inflation rate of the currency union, \( \pi \) the inflation target, and \( x_t \) is the output gap of the currency union. The aggregate inflation and output gap measures are defined as a GDP-weighted average of the inflation rates and output gaps of the South and North. Finally, the output gap in each member is here defined as the deviation of actual output from its potential level, where potential is the level of output that would prevail if wages and prices were completely flexible.

2.4. Fiscal Policy

The government does not need to balance its budget each period, and issues nominal debt \( B_{Gt+1} \) at the end of period \( t \) to finance its deficits according to:

\[ P_{Bt} B_{Gt+1} - B_{Gt} = P C_t G_t + T R_t - T_t - \tau_N W_t L_t - \tau_C P C_t C_t - (\tau_{Kt} R_{Kt} - \delta P_t) K_t \]

\[-(M B_{t+1} - M B_t), \]  

where \( C_t \) is total private consumption. Equation (26) aggregates the capital stock, money and bond holdings, and transfers and taxes over all households so that, for example, \( T_t = \zeta_t \int_0^1 T_t(h)dh \). The taxes on capital \( \tau_{Kt} \) and consumption \( \tau_{Ct} \) are assumed to be fixed, and the ratio of real transfers to (trend) GDP, \( tr_t = \frac{T_{Rt}}{G_{t+1}} \), is also fixed. Given that the central bank uses the nominal interest rate as its policy instrument, the level of seigniorage revenues are determined by nominal money demand.

The distortionary tax on labor income \( \tau_{Nt} \) adjusts in response to both the lagged debt/trend GDP ratio, \( b_{Gt} \), and to the current deficit, \( \Delta b_{Gt+1} \), subject to some smoothing:

\[ \tau_{Nt} - \tau_N = \nu_{\tau_0} (\tau_{Nt-1} - \tau_N) + (1 - \nu_{\tau_0}) [\nu_{\tau_1} (b_{Gt} - b_{G}) + \nu_{\tau_2} (\Delta b_{Gt+1})], \]
where \( b_{Gt+1} = \frac{B_{Gt+1}}{\Pi_{t+1}} \) and \( b_G \) is the steady state ratio of government debt to nominal (trend) output. Hence, \( r_{Nt}^{endo} \) works as an automatic stabilizer to ensure that debt as share of output is stationary.

Government purchases have no direct effect on the utility of households, nor do they affect the production function of the private sector. To begin with, we assume that \( G_t \) is exogenously given, and does not respond to the state of the economy. This assumption is changed in Section 4.

### 2.5. Resource Constraint and Net Foreign Assets

The domestic economy’s aggregate resource constraint can be written as:

\[
Y_{Dt} = C_{Dt} + I_{Dt} + \phi_{It},
\]

where \( \phi_{It} \) is the adjustment cost on investment aggregated across all households. The final consumption good is allocated between households and the government:

\[
C_{At} = C_t + G_t,
\]

where \( C_t \) is total private consumption of FL (optimizing) and HM households:

\[
C_t = C_t^O + C_t^{HM}.
\]

Total exports may be allocated to either the consumption or the investment sector abroad:

\[
M_t^* = M_{Ct}^* + M_{It}^*.
\]

Finally, at the level of the individual firm:

\[
Y_t(i) = Y_{Dt}(i) + X_t(i) \quad \forall i.
\]

The evolution of net foreign assets can be expressed as:

\[
\frac{P^*_{B,t} B_{F,t+1}}{\phi_{bt}} = B_{F,t} + P^*_t M_t^* - P_{Mt} M_t.
\]

This expression can be derived from the budget constraint of the FL households after imposing the government budget constraint, the consumption rule of the HM households, the
definition of firm profits, and the condition that domestic bonds \((B_{Dt+1})\) are in zero net supply.

Finally, we assume that the structure of the foreign country (the North) is isomorphic to that of the home country (the South).

2.6. Production of capital services

We incorporate a financial accelerator mechanism into both country blocks of our benchmark model following the basic approach of Bernanke, Gertler and Gilchrist (1999). Thus, the intermediate goods producers rent capital services from entrepreneurs (at the price \(R_{Kt}\)) rather than directly from households. Entrepreneurs purchase physical capital from competitive capital goods producers (and resell it back at the end of each period), with the latter employing the same technology to transform investment goods into finished capital goods as described by equations 20) and 22). To finance the acquisition of physical capital, each entrepreneur combines his net worth with a loan from a bank, for which the entrepreneur must pay an external finance premium (over the risk-free interest rate set by the central bank) due to an agency problem. We follow Christiano, Motto and Rostagno (2008) by assuming that the debt contract between entrepreneurs and banks is written in nominal terms (rather than real terms as in Bernanke, Gertler and Gilchrist, 1999). Banks obtain funds to lend to the entrepreneurs by issuing deposits to households at the interest rate set by the central bank. By assuming perfect competition and free entry among banks and that all bank portfolios are well diversified (i.e., that each bank lends out to a continuum of entrepreneurs, whose default risk is independently distributed), it follows that banks make zero profits in each state of the economy and that there is no credit risk to households associated with bank deposits.\(^9\)

3. Solution Method and Calibration

To analyze the behavior of the model, we log-linearize the model's equations around the non-stochastic steady state. Nominal variables are rendered stationary by suitable transfor-

\(^9\) We refer to Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2008) for further details. An excellent exposition is also provided in Christiano, Trabandt and Walentin (2007).
mations. To solve the unconstrained version of the model, we compute the reduced-form solution of the model for a given set of parameters using the numerical algorithm of Anderson and Moore (1985), which provides an efficient implementation of the solution method proposed by Blanchard and Kahn (1980). When we solve the model subject to the non-linear monetary policy rule (25), we use the techniques described in Hebden, Lindé and Svensson (2009). An important feature of the Hebden, Lindé and Svensson algorithm is that the duration of the liquidity trap is endogenous, and is affected by shocks hitting the model economy.

The model is calibrated at a quarterly frequency. Structural parameters are set at identical values for each of the two country blocks, except for the parameter $\zeta$ determining population size (as discussed below), and the parameters determining trade shares. We assume that the discount factor $\beta = 0.995$, consistent with a steady-state annualized real interest rate $\tau$ of 2 percent. By assuming that gross inflation $\pi = 1.005$ (i.e. a net inflation of 2 percent in annualized terms), the implied steady state nominal interest rate $i = \tau$ equals 0.01 at a quarterly rate, and 4 percent at an annualized rate.

The utility functional parameter $\sigma$ is set equal to 1 to ensure that the model exhibit balanced growth, while the parameter determining the degree of habit persistence in consumption $\kappa = 0.8$. We set $\chi = 4$, implying a Frisch elasticity of labor supply of $1/2$, which is roughly consistent with the evidence reported by Domeij and Flodén (2006). The utility parameter $\chi_0$ is set so that employment comprises one-third of the household’s time endowment, while the parameter $\mu_0$ on the subutility function for real balances is set at an arbitrarily low value (given the separable specification, variation in real balances has no impact on other variables). We choose $\varsigma = 0.47$ so that about 50 percent of households are Ricardian FL agents. This share implies that consumption of HM households equals about 25 percent of total consumption in steady state. The lower share of total consumption reflects that HM households consume less on average than FL households as they are assumed not to save and accumulate any capital.

The depreciation rate of capital $\delta$ is set at 0.03 (consistent with an annual depreciation rate of 12 percent). The parameter $\rho$ in the CES production function of the intermediate goods producers is set to $-2$. This implies an elasticity of substitution between capital and
labor, \((1 + \rho)/\rho\), of \(1/2\), somewhat below the unity elasticity implied by the Cobb-Douglas specification. The quasi-capital share parameter \(\omega_K\) – together with the price markup parameter of \(\theta_P = 0.20\) is chosen to imply a steady state investment to output ratio of 15 percent. We set the cost of adjusting investment parameter \(\phi_I = 3\), slightly below the value estimated by Christiano, Eichenbaum and Evans (2005).

The calibration of the parameters determining the financial accelerator follows Bernanke, Gertler and Gilchrist (1999), and is identical across country blocks. In particular, the monitoring cost, \(\mu\), expressed as a proportion of entrepreneurs’ total gross revenue, is set to 0.12. The default rate of entrepreneurs is 3 percent per year, and the variance of the idiosyncratic productivity shocks to entrepreneurs is 0.28.

We maintain the assumption of a flat Phillips curve by setting the price contract duration parameter \(\xi_p = 0.9\). We allow for some intrinsic persistence by setting the price indexation parameter \(\iota_p = 0.65\). It bears emphasizing that our choice of \(\xi_p\) does not necessarily imply an average price contract duration of 10 quarters. Altig et al. (2010) show that even a model with a low slope of the Phillips curve can be consistent with frequent price reoptimization. Our choice of \(\xi_p\) implies a Phillips curve slope of about 0.007. This is somewhat lower than the median estimates of literature, which cluster in the range of about 0.009 – .014, but well within standard confidence intervals provided by empirical studies (see e.g. Adolfson et al (2005), Altig et al. (2010), Galí and Gertler (1999), Galí, Gertler, and López-Salido, Lindé (2005), and Smets and Wouters (2003, 2007). As argued in Erceg and Lindé (2010a), a low slope of the Phillips curve is consistent with the development during the recent crisis where inflation and inflation expectations have fallen very moderately despite large contractions in output.

Given strategic complementarities in wage-setting across households, the wage markup influences the slope of the wage Phillips curve. Our choices of a wage markup of \(\theta_W = 1/3\) and a wage contract duration parameter of \(\xi_w = 0.85\) – along with a wage indexation parameter of \(\iota_w = 0.65\) - imply that wage inflation is about as responsive to the wage markup as price inflation is to the price markup.

The parameters pertaining to fiscal policy are intended to roughly mimic the revenue and spending sides of euro area government budgets, and are set as follows. The share of
government spending on goods and services is set equal to 23 percent of steady state output. The government debt to GDP ratio, $b_G$, is set to 0.75, roughly equal to the average level of debt in euro area countries at end-2008. The net transfers (i.e. lump-sum transfers minus lump-sum taxes $TR_t - T_l$) to GDP ratio is set to 20 percent. The steady state VAT tax rate $\tau_C$ is set to 0.2, while the capital tax $\tau_K$ is set to 0.30. Given the annualized steady state real interest rate (2 percent), the government’s intertemporal budget constraint then implies that the labor income tax rate $\tau_N$ equals 0.42 in steady state (a quite reasonable average labor tax rate for European economies). For the tax rate reaction function, we choose $\nu_{\tau_0} = 0.985$, $\nu_{\tau_1} = 0.1$, $\nu_{\tau_2} = 0.1$, implying that an increase in annualized debt with 10 percent of trend GDP triggers a 1 percent labor tax hike in the long-run. However, because of the high value for the smoothing coefficient, this benchmark tax rule is largely unresponsive to debt and deficits in the short-run, and therefore has similar implications to adjustment via lump-sum taxes in the short to medium-run.

Using Eurostat data for 2008, the average share of imports of the South countries (of Greece, Ireland, Portugal, Italy, and Spain) from the remaining countries of the euro area accounted for about 14 percent of GDP in 2008. This pins down the trade share parameters $\omega_C$ and $\omega_I$ for our large South calibration under the additional assumption that the import intensity of consumption is equal to 3/4 that of investment. These South countries comprise about 1/3 of euro area GDP, or are half as large as the North countries, so that $\zeta = 0.5$. Given that trade is balanced in steady state, this parameterization implies an export and import share of the North countries of 7 percent of GDP.

Our small South calibration is based on data for the Greek economy. The import share of the Greek economy from the rest of the euro area is also around 14 percent, so that the trade parameters $\omega_C$ and $\omega_I$ remain unchanged across these calibrations; however, since Greece only comprises about 2 percent of euro area GDP, we adjust $\zeta$ so that its trade share of the North block is only about 0.3 percent.

We assume that $\rho_C = \rho_I = 2$, consistent with a long-run price elasticity of demand for imported consumption and investment goods of 1.5. While this is higher than most empirical estimates using macro data, the presence of adjustment costs reduces the near-term relative price sensitivity. In particular, we set the adjustment cost parameters $\varphi_{MC} = \varphi_{MI} = 3$, "$\varphi_{MC} = \varphi_{MI} = 3$.
implying a half-life of adjustment of about half a year. We choose a small value (0.00001) for the financial intermediation cost \( \phi_b \), which is sufficient to ensure the model has a unique steady state.

We set the parameters of the monetary rule so that \( \gamma_\pi = 1.5 \), \( \gamma_x = 0.125 \), and \( \gamma_i = 0.7 \). Relative to the standard Taylor rule, this rule is more aggressive in responding to inflation, and incorporates considerable interest rate inertia; these features seem a relevant characterization of ECB monetary policy.

Finally, the persistence coefficient \( \rho_{\nu_c} \) for the consumption demand shock \( \nu_{c,t} \) (see eq. 18) is set to 0.9, while the persistence coefficient \( \rho_z \) for the technology shock (see eq. 4) assumes the value 0.975.

4. Results

We now proceed to report the results. As the analysis imposes the zero lower bound constraint on policy rates, we start by generating a baseline scenario which causes the economy to enter into an 8-quarter liquidity trap absent any fiscal actions. From this baseline, we then consider the effects of fiscal retrenchment in, first, the small South calibration of the model. Second, we proceed with an analysis of more coordinated actions, i.e. when the fiscal consolidation is assumed to be undertaken by a larger subset of currency union members - i.e. the large South calibration.

4.1. Initial Economic Conditions

Given that the effects of fiscal policy depend on the perceived depth and duration of the underlying liquidity trap, we proceed by first specifying initial conditions that are consistent with a deep recession. In particular, we assume that negative taste and technology shocks in South and North generate a sharp fall in output and inflation as shown by the solid lines in Figure 1, and cause the policy rate to decline to its lower bound of zero for eight quarters. The taste shocks are scaled to induce a maximum output contraction of 10 percent relative to baseline, which is similar to the fall in peripheral European output relative to a pre-2007
trend during the current recession.\textsuperscript{10} The negative technology shock also implies that the fall in output relative to its pre-crisis trend is highly persistent, a fact consistent with historical evidence for banking and financial crises (e.g. Reinhart and Rogoff).

The large and persistent fall in output implies that government tax revenues fall and spending increases (as share of GDP), triggering a persistent primary deficit and higher debt service costs. This puts substantial upward pressure on government debt, which is projected to rise on a seemingly unsustainable path above 100 percent of GDP after 10 years absent any fiscal actions. Against this backdrop, we assume that fiscal policy makers in South decide to undertake fiscal austerity measures in the first period when the policy rate is bounded by nil in Figure 1.\textsuperscript{11}

4.2. Fiscal Consolidation in Small South Only

We now turn to the consolidation in the small South calibration of the model, which closely mimics a small open economy as South in this case only constitutes a very small share of the currency union. First, we describe the nature of the consolidation experiment, and then turn to discuss the results.

We assume that South policy makers announce a lower target for the government debt to trend output. As policy makers realize that reaching this new target level directly could have undesirable consequences, we assume that policy maker’s target path is gradually lowered towards the new target level. A simple way to model this is to assume that the (end of period $t$) debt target $b_{Gt}^*$ follows an AR(2) process

$$b_{Gt+1}^* = \rho_{d_1} (b_{Gt}^* - b_{Gt-1}^*) - \rho_{d_2} b_{Gt}^* + \varepsilon_{d^*t},$$  \hspace{1cm} (34)

where $0 \leq \rho_{d_1} < 1$ and $\rho_{d_2} > 0$. By setting $\rho_{d_1} = 0.935$ and $\rho_{d_2} = 0.0001$, the distance to the new debt target level is reduced by half after 3 years, and fully reached after 10 years.\textsuperscript{12}

\textsuperscript{10} An implication of our symmetric calibration of the model is that we overexaggerate the fall in non-peripheral euro area economies (for which output has only fallen about 6-7 percent on average from its pre-crisis trend).

\textsuperscript{11} Note that because the shocks are assumed to be equally sized for South and North and the model calibration is symmetric apart from the relative size of the small and large South, the baseline scenario is identical for the small/large South calibrations of the model.

\textsuperscript{12} As we are considering a stationary model, the debt target is eventually assumed to converge back to the steady state level $b_G^*$, but by setting $\rho_{d_2} = 0.0001$, the convergence is very slow and irrelevant for the impact in the near- and medium term.
Moreover, the government is assumed to attempt to keep actual debt close to the target path by either lowering government spending or raising labor income taxes. When government spending is used, the policy rule (27) is replaced by

\[ g_t = \nu_{g_0} g_{t-1} + (1 - \nu_{g_0}) \left[ \nu_{g_1} (b^*_{G_t} - b^*_{G_t}) + \nu_{g_2} (\Delta b_{Gt+1} - \Delta b^*_{Gt+1}) \right]. \] (35)

The idea behind the specification in (35) is that the government, subject to some smoothing \( \nu_{g_0} > 0 \), is trying to make the actual change in debt to trend GDP \( (\Delta b_{Gt+1}) \) close to its objective \( (\Delta b^*_{Gt+1}) \), and make up for past shortcomings by the “error-correction” term \( b^*_{Gt} - b^*_{Gt} \). By replacing the labor income tax rule (27) with this rule, the labor income tax rate is kept constant at its steady state value \( \tau_N \) during the spending based consolidation. In contrast, when the government pursues a tax-based consolidation strategy, the labor tax rule (27) is simply augmented with the time-varying debt target:

\[ \tau_{Nt} - \tau_N = \nu_{\tau_0} (\tau_{Nt-1} - \tau_N) + (1 - \nu_{\tau_0}) \left[ \nu_{\tau_1} (b^*_{Gt} - b^*_{Gt}) + \nu_{\tau_2} (\Delta b_{Gt+1} - \Delta b^*_{Gt+1}) \right]. \] (36)

When the government adopts the labor income tax based consolidation strategy, real government spending \( g_t \) and net transfers \( tr_t - \tau_t \) (as percent deviation from their respective steady state levels) are kept constant (implying that their shares of actual output will change proportionally with the response of real output decline).

We set the coefficients \( \nu_{g_0} = \nu_{\tau_0} = 0.5 \), and assume that \( \{\nu_{g_1}, \nu_{\tau_1}\} \) and \( \{\nu_{g_2}, \nu_{\tau_2}\} \) are such that \( g_t/\tau_{Nt} \) in the long-run are decreased/increased with 0.5 and 0.25 percent of trend GDP, respectively, in response to target deviations from debt \( (b^*_{Gt} - b^*_{Gt}) \) and deficit \( (\Delta b_{Gt+1} - \Delta b^*_{Gt+1}) \).

\[ \text{13} \] Apart from implying similar impact on potential output (i.e. the flex price-wage level of output) during the first year, the coefficients in the consolidation rules (35) and (36), imply that the deviation between actual and target debt levels are very small in the flex price-wage equilibrium from year 3 and onwards in both specifications.

Finally, it is important to point out that North debt rule is assumed to be unchanged and given by the benchmark (unresponsive) calibration of the labor income tax rule in (27) as described in Section 3.

Motivated by the results in Figure 1 - which shows debt projected to increase with somewhat more that 25 percent above the steady state level absent any fiscal austerity measures, we consider a reduction in the South debt target with 25 percent of baseline GDP.

\[ \text{21} \]
The calibration of the debt target process (34) then implies a reduction in the debt target with 12.5 percent after 3 years, and the full 25 percent after about 10 years.

In Figure 2, we compare the impact of implementing this consolidation with spending cuts and labor-income tax hikes. For comparison purposes, we also include responses for the case in which the South has a floating exchange rate with the North, and has the means to independently adjust its policy rate following the specification in the rule (25), but adapted to domestic conditions only. Hence, the impulse response functions shown in Figure 2 depicts the effects when South is a small currency union member (denoted “CU”), and when it has monetary independence (denoted “Ind Pol”) and latitude to adjust policy rates. As South here is assumed to be small and the spillover effects to the North negligible, we only report results for the South bloc. For the same reason, whether the currency union is in a liquidity trap or not has a negligible impact on the results.

We start by discussing the effects under independent monetary policy, i.e. the dotted lines in Figure 2. Consistent with conventional wisdom about the effects of fiscal austerity measures, fiscal retrenchment via spending cuts (thick black lines) are associated with considerably less adverse output effects than when implemented labor income tax hikes (thin red lines), largely reflecting that potential output falls much less for the spending based consolidation. However, in contrast to Uhlig (2010), we find that the effects on potential output are negative for almost as long as 10 years, reflecting that the lower spending does not allow the distortionary labor income tax to fall. For the labor-tax hike, potential output drops more precipitously and persistently as expected, implying that spending based consolidations are more effective than labor-tax based consolidations to reduce government debt to actual output in the longer term in the absence of sticky prices and wages (in which case whether small South is in a currency union or has monetary independence is irrelevant). Despite the large fall in actual and potential output following the tax hikes, the spending cuts induces a more negative output gap and downward pressure on inflation in the near term.

Accordingly, a small open economy with an independent monetary policy will accommodate spending cuts substantially more than labor tax hikes, although a central bank would cut interest rates to both type of actions as shown in the upper left panel in the figure. The different effects on the potential real interest rate and the differing monetary and private
absorption responses trigger a depreciation of the exchange rate in the spending cut case, but an appreciation of the exchange rate following the labor tax hike (recalling that a labor income tax hike is a negative supply side type of shock and is hence associated with an appreciation of the real exchange rate). Moreover, and consistent with the empirical evidence on successful fiscal consolidations cited in the introduction, spending cuts are more effective than labor-tax hikes to reduce government debt even in the near term due to their smaller crowding out effects on output after a year.

We now turn to comparing the results with an independent monetary policy with the corresponding effects if South had been in a currency union with the North and hence is subject to a fixed nominal exchange rate and affects policy rates in the currency union only insofar its consolidation affects currency union wide inflation and output gaps. This case is depicted by solid lines in Figure 2. As is clear from Figure 2, the effects are very different when South is a small member of a currency union. In this case, the effects on output are much more adverse in the spending cut case. There are two drivers behind this result, first, the no-monetary accommodation following the spending cut, which tends to drive down private absorption to a greater extent relative to the independent monetary policy case. Second, and related to the first, the nominal exchange rate is kept fixed instead of depreciating considerably in the floating exchange rate case. In effect, these monetary constraints make the spending shock substantially more contractionary than the labor income tax hike in the short- and medium-term. Consequently, spending cuts are less effective in reducing government debt in the near term in a currency union relative to the case with monetary independence. In fact, government debt as share of actual output rises for almost three years before starting to decline relative to its initial level. However, as can be seen from Figure 2, a hike in labor taxes is an even more effective instrument to reduce government debt in the currency union case. This latter results reflects that the adverse output effects of a labor tax hike are in fact mitigated in a currency union, and that real rates falls instead of rising. Although the central bank would cut the nominal interest rate if it had monetary independence, a labor tax hike would also be associated with a relatively quick nominal and real exchange rate appreciation. For our small South currency union member, neither of these things will happen, and in our sticky price framework this implies that the real
exchange rate will appreciate more slowly and output therefore contracts less in a currency union following a labor income tax hike. By implication, a spending based consolidation approach is not as effective as labor-taxes to reduce debt quickly when South is a small member of a currency union.

4.3. Fiscal Consolidation in Large South

So far, we have assumed that the small South member is the only consolidating member in the currency union. However, as can be understood the results in from Figure 2 the effects of the fiscal consolidative actions in South will importantly depend on the actions of the North members. If a substantial share of North member states are taking similar actions, then the effects in the South may be very different, due to trade-linkages and the internalization of the consolidative actions by the central bank.

In Figure 3 we therefore redo the basic experiment in Figure 2 for the “Large South” calibration of the model (i.e. the case when South constitutes a third of the currency union). However, instead of contrasting the monetary independence case with unconstrained currency union case, we compare unconstrained responses in a currency union (“Normal”) with a situation where the currency union is in an 8-quarter liquidity trap (as in the baseline scenario in Figure 1) absent any fiscal actions.\(^ {14} \)

By comparing the unconstrained responses (dotted lines) in Figure 3 to the currency union responses (solid lines) in Figure 2, we see that the standard currency area argument holds up in our model: when monetary policy is reacting to currency area wide variables only, then a small member of a currency union is better off (in terms of output contraction) when its consolidations are synchronized with other member states. Especially this is so for spending based austerity programs, as they require more accommodative monetary policy actions, which they will get by the currency union central bank when the share of consolidating members increase. Hence, considering the small differences in debt paths for spending and tax based consolidations when currency union interest rate setting is unconstrained, spending based consolidation again looks like desirable given the noticeably more modest

\(^ {14} \) The impulse response functions shown in Figure 3 are computed as the difference between the scenario which includes both the baseline shocks and fiscal austerity measures, and the scenario with only the baseline shocks (i.e., the baseline in Figure 1).
output decline in the medium- and longer-term. Only for the first year, there is slightly less improvement with spending cuts due to the sharper initial decline in output which causes tax revenues to fall and debt service costs to rise by more than the spending cut itself according to our model.

However, the effectiveness of austerity measures changes dramatically in a situation when monetary policy is precluded to cut interest rates for a protracted period due to the zero lower bound constraint on policy rates absent any fiscal retrenchment. The solid lines in Figure 3 report the effects in an 8-quarter liquidity trap (absent any fiscal actions, denoted “ZLB”). As can be seen in the figure, the effectiveness of a spending based approach are dramatically worsened when the economy is in a liquidity trap, in which case government debt to GDP rise with as much as 7 percent after two years in the large South and do not display any noticeable fall until about 4 years after the initialization of the consolidation. Because of the substantial drag on demand and inflation, the spending based strategy extends the duration of the liquidity trap from 8 to 12 quarters. Interestingly, the effectiveness of labor tax hikes are only moderately affected, and are hence more effective in reducing debt in the near term. Moreover, the output contraction is only about a third as large the first two years when taxes are increased, and consequently the liquidity trap duration is only extended by 1 quarter.

As can be seen from the figure, an important factor behind the much more contractionary effects under spending cuts is that the spillover effects to the North output becomes substantially more negative in a liquidity trap, in contrast to a situation where policy is unconstrained by the zero lower bound and where the resulting cut in policy rates will provide more stimulus to private absorption in the North relative to the decline in net exports to the South. An implication of this finding is that we, in contrast to Cook and Devereaux (2011), do not find that fiscal policy is not associated with “beggar-thy-neighbor” effects in a liquidity trap. Only in normal times, we find evidence of such effects.

The results in Figure 3 make clear that the near-term impact of the different fiscal instruments importantly depend on different degrees of monetary accommodation. Therefore, it is of interest to examine the effects of consolidation in large South for alternative assumptions about the degree of monetary accommodation, i.e. the expected duration of the liquidity trap absent any fiscal retrenchment. This issue is of particular interest in the current situ-
ation, as there is limited room for many central banks to move interest rates by much in response to sizeable consolidative fiscal actions by the government. To do this, we follow Erceg and Lindé (2010a) and compute “marginal” multipliers as function of the expected liquidity trap. With marginal multipliers we mean the impact of a small decline in debt target implemented by spending cuts (tax hikes) for alternative durations of the liquidity trap absent any fiscal actions. If policy is unconstrained, there is no distinction between the marginal and “average” multipliers plotted in Figure 3. But in a liquidity trap, there is an important distinction between the two concepts when the duration of the liquidity trap is endogenous; for instance, the more severe impact of the spending based consolidation in Figure 3 is due to the fact that consolidation size was large enough to extend the liquidity trap duration by 4 quarters, while the tax based consolidation only extended the duration by 1 quarter. As discussed in more detail in Erceg and Lindé (2010a), the marginal multiplier follows a step function. The multiplier is constant until government spending cuts (labor tax hikes) reaches a threshold value that is large enough to extend the duration of the liquidity trap by one period. Following Uhlig (2010), we compute the present value output multiplier at horizon $K$ as

$$m^y_K = \frac{1}{f_i^y} \sum_{t=0}^{K} \beta^K \Delta y_{t+K}$$

(37)

i.e. as the discounted average of output divided by the discounted average of the relevant fiscal instrument $f_i$ (both expressed as share of trend output, $f_i^y$). $\Delta$ indicates that all variables are computed as deviations from their baseline paths (i.e. if no discretionary fiscal actions had been undertaken). For government debt, we compute

$$m^{debt}_K = \frac{1}{f_i^y} \sum_{t=0}^{K} \Delta b_{Gt+K}$$

(38)

i.e. the level of government to output at horizon $K$ divided by the average change in the relevant fiscal instrument $f_i$ (as share of trend output, $f_i^y$) during periods 0, ..., $K$. Again, $\Delta$ indicates that all variables are computed as deviations from their baseline paths (i.e. if no discretionary fiscal actions had been undertaken).15

---

15 For the spending consolidation based debt multiplier, we switch the sign of $m^{debt}_K$ in (38) as the denominator is negative in this case, in order to get an intuitive interpretation of the debt multiplier. By applying the formula above, we obtain that the debt multiplier is negative in a long-lived liquidity trap, as the numerator (debt) rises at the three year horizon although the denominator (spending) is negative.
We compute the marginal multipliers for different liquidity trap durations $0, \ldots, 11$, and study the impact on output and debt at the three year horizon (following Alesina and Perotti, 1997) by setting $K = 11$ in the formulas 37 and 38. We also include the effects of actions in the small South, in which case the marginal (and average) multipliers coincide and are constant for the relevant changes in the fiscal instruments we consider (as the small South has negligible effects on the interest rate decision of the currency union central bank).

In Figure 4, we show the results of this exercise. Consider first the upper left panel in the Figure. When policy is unconstrained, the marginal output and debt multipliers $m_{11}^y$ and $m_{11}^{\text{debt}}$ can simply be computed from the dotted lines in Figure 3. For the small South calibration, the corresponding multipliers can be simply computed from the solid lines in Figure 2. As expected, we see that the output multiplier is considerably smaller for the coordinated spending cut (large South), and that it is therefore possible to reduce debt quicker relative to the non-coordinated case (i.e. small South calibration) as shown in the upper right panel (see solid line for the zero lower bound duration $= 0$). However, if the spending based consolidation is undertaken jointly with a subset of members in the currency union and is so large that it drives the economy into a liquidity trap - or extends the duration of the liquidity trap - the output multiplier will be increasingly higher following the convex step function in the upper right panel. The main mechanism behind the convex multiplier schedule is that spending shocks have an increasingly larger impact on expected inflation in a prolonged liquidity trap, as discussed in further detail by Erceg and Lindé (2010a). Accordingly, both the average and marginal multipliers will increase as the duration of the liquidity trap is extended. The results in Figure 4 implies the marginal multiplier is constant and equals the average multiplier for small fiscal actions, but if the coordinated impetus is sufficiently large, then it will change the duration of the liquidity trap, and a wedge will arise between the marginal and average multipliers.

An implication of this is that marginal multipliers in the large and small South can cross. The results in Figure 4 indeed shows that a such a crossing occurs for the spending cut if the policy rate is expected to be bounded by zero for 9 quarters absent any fiscal retrenchment.$^{16}$

$^{16}$ Our analysis of the coordinated actions implies an important distinction of the effects of austerity measures for a small member of a currency union and an economy (with same trade-linkages) with independent monetaray policy which is in a liquidity trap. Consolidative actions in an open economy with an independent
The large increasing output multiplier has important implications for the government debt multiplier, which switches sign depending on the expected duration of the liquidity trap. For a long lived liquidity trap of 11 quarter, $m_{11}^{debt} = 3$ implies government debt will increase with 3 percent at the 3-year horizon for a one percent average decline in spending relative to baseline output. Studying the evolution of government spending and debt in Figure 3, we see an average spending drop about 4 percent, and a debt increase about 7 percent. By implication, the average multiplier is only 1.75, and hence masks the important distinction between the average and marginal multiplier in long-lived liquidity trap. Our finding that fiscal spending multipliers are enhanced in a liquidity trap is consistent with the empirical VAR panel evidence provided by Corsetti, Meier and Müller (2010), who argues that fiscal contractions have more negative effects on output in crisis periods.

The bottom two panels show corresponding results for a changes in the labor tax. As expected, the output multiplier schedule has the opposite sign. Interestingly, and as expected from Figure 3, there is never a crossing of the non-coordinated action in small South only and in the case where the actions are coordinated among a subset of currency union members. An implication is that labor tax based consolidations are always more contractionary when they are undertaken by a larger subset of currency union members, regardless of the degree of monetary accommodation. Another interesting finding is labor tax based consolidations are increasingly more contractionary with the duration of the zero lower bound, albeit not to the same extent as government spending cuts. This finding is contrary to the results in Eggertsson (2010), who argues that a tax hike could have large positive multiplier in a prolonged liquidity trap. There are four key differences his and our approach which accounts for the different results; first, the existence of hand-to-mouth households in our model, and second, that Eggertsson considers an environment without wage stickiness while we assume a more plausible degree of wage stickiness in our analysis. Third, he considers front-loaded temporary hikes (for which the potential real interest rate will rise instead of fall as with our gradual tax profile), and the fourth and final reason is that we consider a rule based hike (which introduces a wedge between the actual and potential labor tax rate) as opposed to monetary policy will be less contractionary relative to a consolidating member of a currency union in normal times when policy can respond (as shown in Figure 2, but in a prolonged liquidity trap the effects can be more severe depending on the degree of price stickiness. That is, a crossing of marginal multipliers obtains in this setting as well. See Erceg and Linde (2012) for further details.
an exogenous hike (for which this wedge is non-existant). [Provide more intuition here.] In addition, we entertain a higher degree of sticky prices than Eggertsson does.

Our findings in 4 suggest that tax hikes are more effective than spending cuts in bringing down debt quickly for small South member, and that tax hikes at the margin is a more effective tool to reduce government debt in the near term in a deep liquidity trap for the large South calibration. Hence, our analysis suggest that there is a strong argument to be made under the current circumstances in favor of a mix of gradual spending cuts and temporary labor tax hikes as opposed to relying solely on front-loaded spending cuts in consolidating euro area countries.

Finally, it is important to notice that the results in Figures 4 implies that the size of the fiscal consolidation is crucial for its effectiveness in a liquidity trap. A smaller reduction in the debt target would not necessarily be associated with large multipliers even in an 8-quarter liquidity trap. To see this, Figure 5 plots the effects of different sized spending based consolidations; our benchmark case of a 25 percentage points reduction in the debt target, but also the solutions for debt target reductions limited to 15 and 5 percentage points. For the smallest reduction, it also reports the response when monetary policy unconstrained (dotted lines).

As can be seen in the figure, the effectiveness of the spending based consolidation strategy depends importantly on the size of the reduction in the debt target; if the reduction in the debt target is not too large, a spending based strategy will still reduce debt in the near term as it does not extend the duration of the liquidity trap (it is unchanged at 8 quarters). This highlights the importance of distinguishing between the average and marginal multiplier schedules when constructing austerity measures by properly accounting for the endogeneity of the liquidity trap duration for alternative consolidation strategies.

5. Sensitivity Analysis

In this section, we examine the robustness of the results for alternative parameterizations of the model. First, given that previous work by e.g. Corsetti et al. (2010) have emphasized that the effects might be quite different if the fiscal austerity measures are implemented
more gradually, we consider the effects of a more gradual consolidation profile. Second, we explore conditions suggested by the literature on "expansionary fiscal consolidations" following Giavazzi and Pagano (1990) and Alesina and Perotti (1995, 1997). In particular, we examine if fiscal retrenchment can expand output even in the near-term for a country facing unfavorable initial borrowing conditions when interest rate spreads are responsive to lower current and future expected debt and deficits levels. Third, we examine the robustness of the results when omitting HM households in the model. This offers a useful comparison to more standard models used in the literature, e.g. Christiano, Eichenbaum and Rebelo (2011), and the simulations document that HM households indeed plays an amplifying role in our model. Fourth and finally, we study a case where we instead assume that government spending and labor taxes follow exogenous AR(1) processes instead of being endogenously determined by the assumed profile for the debt target. This is arguably a more conventional modeling of fiscal policy, and it is therefore of interest to examine to what extent our results hold up for this alternative assumption. [Remarks: 1. We should make a sensitivity experiment where the North pursues more aggressive debt stabilizing rules in response to large South austerity actions. 2. We should make a sensitivity experiment where $\tau_{\text{CT}}$ is used instead of $\tau_{\text{NT}}$.]

5.1. Gradual Fiscal Austerity Measures

To implement a more gradual profile of the consolidation, we change the parameter $\rho_{d_1}$ in (34) to imply a full reduction after in the debt target after a little more than 20 years (compared to 10 years in the benchmark calibration) and a half-life reduction after 5 years (compared to 3 years in our baseline calibration). Our interpretation of the more gradual implementation is that it corresponds to a situation where South enjoys a higher degree of credibility for long-term fiscal sustainability, and is not forced by financial markets to pursue as front-loaded cuts or tax hikes.

We start by studying the effects in the small South calibration in Figure 6. As before, we also include results when South is assumed to have access to independent monetary policy and latitude to cut rates. And since the actions of the small South have negligible effects on the North, we only report results for South variables in the figure.

---

17 We implement this alternative debt target path by increasing $\rho_{d_1}$ from 0.935 to 0.98.
As can be seen by comparing the results in Figure 6 with the benchmark results in Figure 2, the results are qualitatively similar, although - and consistent with the findings in Corsetti et al. (2010) - there is a tendency that spending-based consolidation are less contractionary and more efficient when the consolidation is more gradual. But for this particular profile, spending based consolidations are still less effective than tax hikes to quickly reduce the government debt to output ratio in the CU case. However, the unconstrained paths for the policy rate reveals that spending cuts are associated with less monetary accommodation relative to tax hikes, in contrast to the benchmark results in Figure 2. This will have important implications for the effectiveness of more coordinated cuts when the currency union has limited ability to respond to the fiscal austerity measures.

To examine the effectiveness of gradual spending cuts vs tax hikes in this latter case, we repeat the analysis in Figure 4 and compute marginal multipliers for non-coordinated (small South) and more coordinated (large South) changes as functions of the duration of the liquidity trap absent any fiscal austerity measures. As can be seen by comparing the results in Figure 7 with the benchmark results in Figure 4, we find that they are very similar for non-coordinated actions in the small South. Consistent with the benchmark model, fiscal austerity measures are more (less) effective in reducing debt in the coordinated case relative to the non-coordinated for spending cuts (tax hikes) when monetary policy can accommodate. Also, because more gradual tax hikes require more monetary accommodation (as indicated by 6), the output and debt multipliers are higher relative to the benchmark case with more front-loaded hikes (Figure 4) if a sufficiently large consolidation is implemented, or the expected duration of the liquidity trap is sufficiently long-lived absent any fiscal actions (e.g. compare $m_{11}^{q}$ in the tax case in Figures 4 and 6 for an 11 quarter trap).

Turning to spending based consolidations, we find, as expected from previous results in the literature (Christiano, Eichenbaum and Rebelo, 2011, Corsetti et al. 2010, Erceg and Linde, 2010a), that the the convexity of the step function for government spending cuts in Figure 7 is less step than the one in 4. This is so because less of the austerity measures comes on line when the zero lower bound is binding, and consequently less monetary accommodation is warranted in the short run (as indicated by Figures 2 and 6).

So, while the result that non-coordinated fiscal consolidations via tax hikes are more
effective than spending cuts to reduce government debt in the near-term in small currency union member is invariant to whether the austerity measures are front-loaded or gradual, our analysis suggest that the desired mix of spending cuts vs. taxes hikes when the consolidations are synchronized between a large subset of member states should be tilted towards gradual spending cuts and front-loaded but more temporary labor-tax hikes in order to reduce debt quickly.

5.2. Endogenous Risk Premium

In the benchmark calibration of the model, we assumed that interest rates faced by the government and banks in South and North were equal to the currency area interest rate set by the central bank (notwithstanding a tiny difference to imply stationary dynamics). To examine conditions under which fiscal consolidation may be expansionary, we amend our model and instead assume that the interest rate faced by the government and banks in the South equals the interest rate set by the central bank plus a risk-spread that depends positively on the government deficit and debt level. If we let \( i_t^S \) denote the interest rate in South, we thus have

\[
i_t^S - i_t = \psi_b (b_{Gt+1} - b_G) + \psi_d (b_{Gt+1} - b_G),
\]

(39)

where we recall that \( b_{Gt+1} \) is the end-of-period \( t \) government debt level (relative to trend GDP) and \( i_t \) the interest rate set by the central bank. The specification in (39) is motivated by the spread regressions by Laubach (2010) for the Euro area, and captures the idea that countries with high government deficits and debt levels face higher spreads due to a higher risk of default. There is a substantial empirical literature that has examined the question of whether higher deficits and debt lead to increasing interest rates, but it has provided at best mixed evidence in favor of positive values of \( \psi_b \) and \( \psi_d \), see e.g. Evans (1985, 1987, and more recent contributions by ). However, the papers in this literature have typically used data from both crisis periods and non-crisis periods, and as argued by Laubach (2010) based on cross-country evidence, this is likely to bias downward the estimates, as the parameters tend to be close to zero in non-crisis periods and positive in crisis periods only. As we are examining the effects of fiscal consolidations in crisis periods, we entertain the assumption
that $\psi_b$ and $\psi_d$ are both positive.

As a tentative calibration, we set $\psi_b = 0.025$ and $\psi_d = 0.05$, implying that a 1 percent decline in government debt decreases the spread by 10 basis points (at an annualized rate), and that a one percent decline in the budget deficit decreases the spread with an additional 20 basis points. At a longer horizon, the calibration implies that a 25 percent reduction in government debt reduces the long-term interest rate spread by 2.5 percent. While these elasticities maybe somewhat on the upper side relative to the evidence reported by Laubach (2010), they are nevertheless useful to help gauge the potential implications of this channel.

In Figure 8, we report the results of this experiment for the small South member calibration of the model. For comparison purposes, we include the benchmark results when spreads are exogenous and hence not assumed to change. The model where the interest rates spreads for South is given by (39) is referred to as “Endo Spread”, and the benchmark model is referred to as the “No Endo Spread”.

From the figure, we see that fiscal austerity actions that restores credibility for fiscal sustainability and reduces long term spreads has the potential of generating much more favorable effects on output and government debt, even when the South is a small member of a currency union. Under our calibration for the endogenous risk spread, we find that output in South expands after five years following a spending cut, which stands in sharp contrast to the model without the endogenous risk premium in (39) which output in the South contracts for more than 10 years in response to the same spending cut. For a tax hike, output even expands from the outset. The stark difference in results is driven by the large and persistent decline in the 5-year spread on government bonds in South, in each period $t$ computed as $\frac{1}{20} \sum_{j=0}^{19} (i_{t+j}^s - i_{t+j})$, which is visualized in the upper right panel in Figure 8. The spreads eventually declines by almost 300 basis points, and the key parameter behind the persistent decline is $\psi_b$, as this parameter implies that the government spread will be closely tied to the persistent decline in the government debt level. Interestingly, if the spreads are sufficiently sensitive to debt, our simulations actually qualifies to be classified as a “successful” according to the literature on “expansionary fiscal consolidations literature” (Giavazzi and Pagano, 1990, Alesina and Perotti, 1995) since output growth can be higher during a substantial fiscal consolidation which persistently reduces government debt by a
substantial amount. Also, and consistent with the consolidation literature, spending cuts are more likely to be associated higher growth during when debt is shrinking (i.e. from period 8 and onwards) compared to tax-based consolidations in which case growth dynamics is not as pronounced.

An important insight from our framework is that if the commitment to pursue labor tax hikes and spending cuts are assumed to be equally credible, then the same favorable effects should arise for labor tax hikes, which now is associated with crowding in of private absorption (not shown) due to the falling risk spreads. In fact, our results suggest that tax-based consolidations should lead to stronger decline in long-term spreads in the near term, as tax-based consolidations induce a stronger fall in debt in the near term. Therefore, unless spending-based austerity measures are perceived to be more credible relative to tax hikes because cuts are more difficult to implement from a political perspective, tax hikes is even more so an effective strategy to reduce debt quickly in the near term relative to spending cuts under endogenous spreads.

5.3. No HM households

In Figure 9, we examine the sensitivity of our main results to the share of hand-to-mouth (HM) agents, considering both non-coordinated fiscal austerity measures in the small South and coordinated among a subset of the member states (large South) when the currency union is in a liquidity trap. In our model, a higher value of $\zeta$ is crucial for generating a initial decline in private consumption after a contraction in government spending in normal times. Under the benchmark calibration of the model, we used $\zeta = 0.47$ so that 53 percent of households are Ricardian agents. Although not shown, our benchmark calibration of $\zeta$ implies that the model generates an initial decline in private consumption following a contraction in government spending, consistent with the VAR evidence by e.g. Gali, López-Salido and Vallés (2007). In Figure 9, we report results when setting $\zeta = 0$. Comparing the results to Figure 4, we notice from the figure that the results for a non-coordinated spending cut are not very sensitive to the share of HM households, but the results for a coordinated cut in government expenditures are rather sensitive to the share of HM households, which are substantially muted without HM households in the model. In particular, the slope of the
step function is noticeably flatter in a prolonged liquidity trap, and the marginal impact of an extra coordinated spending cut in the currency union is hence smaller (relative to Figure 4) without HM households in the model.

Turning to the results for the labor income tax rate in the lower panels in Figure 9, we notice that the output multiplier is also smaller for a non-coordinated hike in the South only. Accordingly, labor tax hikes are still more effective than spending cuts to reduce government debt for non-coordinated consolidations without HM households, consistent with our findings in the benchmark model (with HM households). In addition, for coordinated actions, we see that the marginal tax output multipliers are substantially lower than their spending counterparts, and much larger hikes in labor taxes are hence needed in this specification to drive the economy into a long-lived liquidity trap according to our model. Consistent with this finding, we see that the government debt multipliers implies that coordinated tax hikes always reduces debt after three years, even in the case of an 11 quarter long-lived liquidity trap.

These findings imply that labor tax hikes are preferable to spending cuts for coordinated actions that needs to be implemented quickly in a long-lived liquidity trap when the main objective is to reduce debt quickly in the near term, consistent with our findings in the benchmark model. For non-coordinated austerity measures in the South only, tax hikes are still preferable to spending cuts, verifying the findings in the benchmark model.

5.4. Exogenous Modeling of Government Spending and Labor Taxes

Finally, we study the case where we instead assume that government spending and labor taxes follow exogenous AR(1) processes instead of being endogenously determined by an assumed profile for the debt target.

In this case, $\tau_{Nt}$ is determined by two components,

$$\tau_{Nt} = \tau_{Nt}^{endo} + \tau_{Nt}^{exo},$$

(40)

where the first component $\tau_{Nt}^{endo}$ is given by eq. (27) with the coefficients as specified in Section 3. The second component of the labor-income tax rate $\tau_{Nt}^{exo}$, is a discretionary part
which is assumed to follow an highly persistent AR(1) process

\[
(\tau_{Nt}^{exo} - \tau_N) = 0.99 (\tau_{Nt-1}^{exo} - \tau_N) + \varepsilon_{\tau,t}.
\]  (41)

Government spending is assumed to follow a process with identical persistence

\[
g_t - g = 0.99(g_{t-1} - g_{t-2}) + \varepsilon_{g,t}.
\]  (42)

Notice that even when the instrument under consideration is a spending is cut, \(\tau_{Nt}^{endo}\) will ultimately respond to stabilize the debt level around its steady state level. But given that the coefficients in the reaction function (27) are calibrated to imply that \(\tau_{Nt}^{endo}\) is very unresponsive to debt, the movements in \(\tau_{Nt}^{endo}\) are very small even after 10 years (less than 0.5 percentage points).

In Figure 10, we show the effects of a exogenous decreases (increases) in spending (taxes) with 1 percent of baseline GDP for the small South calibration. As in Figure 2, we contrast the case when South is a small member in a currency union with a hypothetical case of monetary independence and latitude to cut policy rates.

By comparing the results in Figure 10 with the benchmark results in Figure 2, we see that they are qualitatively similar, but there are some noticeable differences. First of all, under the assumption of exogenous movements in taxes and spending, the potential real rate moves in opposite directions, as the change in the fiscal instruments are front-loaded. For the spending cut, this warrants a more front-loaded and aggressive policy response in order to reduce the actual real rate. As this is not achieved even under an independent monetary policy rule, output declines more than under a tax hike during the first year (in a currency union, output declines more under the spending cut for almost 3 years).

The implications for government debt are similar to those in the benchmark calibration of the model; under an independent monetary policy, debt declines substantially faster under a persistent spending cut relative to the labor tax hike case. But just as in the benchmark model, debt actually rises initially when South is a small member of a currency union and cuts spending, albeit for a shorter period (about 1 year). Under a labor tax hike, debt declines even in the near term, and a (possibly short-lived) tax hike is therefore still the preferred action for a small currency union member if there is a need to reduce debt quickly in the near term.
Finally, we compute the marginal multiplier schedules for output and debt in the case of coordinated actions (i.e. the large South calibration), and compare them to the multipliers under the small South calibration, assuming that $g_t$ and $\tau^{exp}_{Nt}$ follows the processes in (41) and (42). The results of this exercise is reported in Figure 11. As in the benchmark modeling of the spending and tax cuts, the marginal multiplier schedules are a convex function of the expected liquidity trap duration. As regards to the benchmark results in Figure 4, there are three noticeable differences. First, in contrast to the findings in the benchmark experiment for the large South, the 3-year output and debt spending multipliers when policy is unconstrained are actually lower than in corresponding tax multipliers, implying that a spending based consolidation is more effective even in the near term. Second, the “steps” in the multiplier function are somewhat larger, and increase more noticeably even in shorter-lived liquidity traps. The intuition behind this finding is that the spending and tax hikes are more front-loaded and comes on line when the ZLB is binding, and so they warrant more monetary accommodation of the central bank. Third and finally, in contrast to the benchmark calibration, an exogenous tax hike triggers an increase in the debt at the margin when the liquidity trap duration is 10 quarters or longer, in contrast to the benchmark case in which the marginal impact on debt is always negative at the 3-year horizon.

6. Conclusions

The framework adopted in this paper has the limitation that the currency union as a whole is modeled as a closed economy. Thus, it does not allow for the possibility that the effects of fiscal consolidation could be assuaged by currency depreciation. Clearly, it would be of interest to extend our analysis to a three country framework. In addition, we solve our model under the assumption of perfect foresight, and thus abstract from the effects of future shock uncertainty on private sector behavior. A useful extension would involve incorporating the effects of shock uncertainty into the analysis along the lines suggested by Adam and Billi (2008). Finally, it would be of interest to compare the solution that obtains when the model is solved in non-linear form as opposed to our adopted approach of log-linearizing all equations (apart from the policy rule which is subject to the ZLB).
References


Figure 1: Baseline Scenario When Monetary Policy is Unconstrained and Subject to the Zero Lower Bound
Figure 2: Responses to Debt Consolidations via Spending Cuts and Labor–Income Tax Hikes in Small South in a Currency Union (solid) and with Independent Monetary Policy (dotted).
Figure 3: Responses to Debt Consolidations Via Spending Cuts and Labor–Income Tax Hikes in Large South in an 8–quarter Liquidity Trap (solid) and in Normal Times (dotted).
Figure 4: Marginal Output and Government Debt Multipliers in Small and Large South to Spending Cuts and Labor Tax Hikes as Function of Liquidity Trap Duration.

Spending-Based Consolidation

Output

Government Debt to Actual GDP

Tax-Based Consolidation

Output

Government Debt to Actual GDP
Figure 5: Responses to Different Sized Debt Target Reductions in Large South via Spending Cuts in an 8-quarter Liquidity Trap.
Figure 6: Responses to More Gradual Debt Target Reductions in Small South in a Currency Union (CU) with Independent Unconstrained Monetary Policy.

- **South Nominal Interest Rate (APR)**
- **South CPI Inflation (APR)**
- **South Real Interest Rate (APR)**
- **South Potential Real Rate (APR)**
- **South Output**
- **South Potential Output**
- **South/North Nominal Exchange Rate**
- **South Govt Debt as Share of GDP**
- **South Govt Spend (trend GDP share)**
- **South Labor-income Tax Rate**

Legend:
- **Spending Cut**
- **Spending Cut, CU**
- **Labor Tax Hike**
- **Labor Tax Hike, CU**
Figure 7: Marginal Output and Government Debt Multipliers in Small and Large South to a More Gradual Reduction in the Government Debt Target as Function of Liquidity Trap Duration.
Figure 8: Responses in Small South to a Fiscal Consolidation in South Only in a Currency Union With and Without an Endogenous Response of Interest Rate Spreads.
Figure 9: Marginal Output and Government Debt Multipliers in Small and Large South to Benchmark Reduction in Govt Debt Target as Function of Liquidity Trap Duration: No Keynesian Households.

Spending-Based Consolidation

Output

Government Debt to Actual GDP

Zero Lower Bound Duration

Multiplier (3-year)

Small South

Large South, marginal

Tax-Based Consolidation

Output

Government Debt to Actual GDP

Zero Lower Bound Duration

Multiplier (3-year)

Small South

Large South, marginal
Figure 10: Responses to Exogenous AR(1) Spending Cuts and Labor–Income Tax Hikes in Small South in a Currency Union (solid) and with Independent Monetary Policy (dotted).
Figure 11: Marginal Output and Government Debt Multipliers in Small and Large South as Function of Expected Liquidity Trap Duration: Exogenous AR(1)–Processes for Spending and Labor Taxes.

Spending–Based Consolidation

Output

Government Debt to Actual GDP

Tax–Based Consolidation

Output

Government Debt to Actual GDP