Fiscal Consolidations in Currency Unions: Spending Cuts Vs. Tax Hikes*

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Abstract

This paper investigates the impact 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 coordinated 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 the effects of fiscal policy. 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 labor-tax hikes are more effective as they depend less on monetary accommodation. Furthermore, we examine the effects of coordinated fiscal consolidations in a currency union in a liquidity trap when monetary policy is constrained to lower policy rates for a protracted period. In this case, the effects of coordinated consolidations mimics the results for a small open economy in currency union in that labor tax hikes is a more effective tool to reduce government debt than front-loaded spending cuts if the liquidity trap is expected to be sufficiently long-lived.

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1. Introduction

Following the intensification of the financial crisis in the fall of 2008, many countries implemented large fiscal stimulus packages aimed at mitigating the effects of the recession. A number of influential papers were supportive of 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.[1] 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 peripheral countries in the euro area, most notably Greece, 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. Moreover, even a country like the United States, which have access to capital markets on very favorable terms, appear committed to fiscal retrenchment.

An extensive empirical literature on expansionary fiscal consolidation originating with Giavazzi and Pagano (1990) and Alesina and Perotti (1995, 1997) and more recently by Alesina and Ardagna (2009) has shown that sharp and durable cuts in government expenditure 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 than consolidations

[1] Davig and Leeper (2011), Eggertsson (2008), Eggertsson (2010), Christiano, Eichenbaum, and Rebelo (2011) and Woodford (2011) argue that the fiscal spending multiplier is likely to be very large in a prolonged liquidity trap; Cogan et al (2010) and Mertens and Ravn (2010) offer a contrasting view.

via tax hikes.[2] Following the prescriptions of this literature, the fiscal austerity measures in the peripheral countries in the euro area relies largely on cutting spending, as opposed to attempting to raising revenues by tax hikes. As these countries lack credibility from financial markets to undertake their consolidations gradually, the announced consolidation packages are quite front-loaded.

Although there is general agreement that reducing debt via persistent spending cuts may have important long-term output benefits though lower tax rates, there is less empirical evidence regarding the short-term effects of fiscal austerity. Especially for countries which 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. This paper uses 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.

Our model consists of two country blocks that are integrated into a currency union, and hence share a single currency. The model structure 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

[2] IMF (2010) argues against the notion that fiscal consolidations can have expansionary effects by using Romer and Romer (2010) dating of fiscal retrenchments.

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 there exists both microeconomic and macroeconomic evidence in favor of the existence of households with such behavior.[3] 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) has 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.

Our key findings can be summarized as follows. First, 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

[3] 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, Galí, 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.

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 cited earlier.[4] 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 than spending cuts as the former strategy depends less on monetary accommodation. Finally, we examine the effects of coordinated fiscal consolidations in a currency union in a liquidity trap when monetary policy is constrained to lower the policy interest for a protracted period, in which case our model framework nests a closed economy. In this case, we find that if the expected duration of the liquidity trap is sufficiently long absent any fiscal austerity measures, or the size of the consolidation package is large enough to extend the duration by sufficiently many quarters, then the effects of coordinated consolidations in a liquidity trap mimics the results for a small open economy in currency union, in that labor tax hikes is a more effective tool to reduce government debt than front-loaded spending cuts. Only if the fiscal austerity measures are implemented very gradually, we find that spending cuts are preferable to tax hikes even 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

[4] It is important to notice that absent any nominal rigidities, our model has the implication 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.

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, Uhlig, Davig and Leeper.]

The reminder of the paper is organized as follows. In the next Section, we present the two country open economy model. In Section 3, 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 4. In Section 5, we assess the sensitivity of the results for alternative parameterizations of the model. Finally, we provide some conclusions in Section 6.

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 $P_{Dt}(i)$ and directly with aggregate demand at home Y_{Dt}:

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

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

$$X_t(i) = \left[\frac{P^*_{Mt}(i)}{P^*_{Mt}}\right]^{\frac{-(1+\theta_p)}{\theta_p}} M^*_t, \tag{2}$$

where $X_t(i)$ denotes the quantity demanded of domestic good i in the North block, $P^*_{Mt}(i)$ 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:

$$Y_t(i) = \left(\omega_K^{\frac{\rho}{1+\rho}} K_t(i)^{\frac{1}{1+\rho}} + \omega_L{}^{\frac{\rho}{1+\rho}} (Z_t L_t(i))^{\frac{1}{1+\rho}}\right)^{1+\rho}. \tag{3}$$

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.

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 $P_{Dt}(i) = \pi_{t-1}^{\iota_p} \pi^{1-\iota_p} P_{Dt-1}(i)$ for the non-optimizing firms. When ι_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

$$\mathbb{E}_t \sum_{j=0}^{\infty} \xi_p^j \psi_{t,t+j} \left[\prod_{h=1}^{j} \pi_{t+h-1} P_{Dt}(i) Y_{Dt+j}(i) - MC_{t+j} Y_{Dt+j}(i) \right]. \tag{4}$$

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

$$\mathbb{E}_t \sum_{j=0}^{\infty} \psi_{t,t+j} \xi_p^j \left(\frac{\prod_{h=1}^{j} \pi_{t+h-1}(i)}{(1+\theta_p)} - MC_{t+j} \right) Y_{Dt+j}(i) = 0. \tag{5}$$

The problem for firm i of reoptimizing its price for the export market in period t is identical to that in (4), 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}:

$$Y_{Dt} = \left[\int_0^1 Y_{Dt}(i)^{\frac{1}{1+\theta_p}} \, di \right]^{1+\theta_p}. \tag{6}$$

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}:

$$P_{Dt} = \left[\int_0^1 P_{Dt}(i)^{\frac{-1}{\theta_p}} \, di \right]^{-\theta_p}. \tag{7}$$

[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.

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:

$$M_t^* = \left[\int_0^1 X_t\left(i\right)^{\frac{1}{1+\theta_p}} di\right]^{1+\theta_p}, \tag{8}$$

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

$$P_{Mt}^* = \left[\int_0^1 P_{Mt}^*\left(i\right)^{\frac{-1}{\theta_p}} di\right]^{-\theta_p}. \tag{9}$$

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:

$$C_{At} = \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\varphi_{Ct} M_{Ct})^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}, \tag{10}$$

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 φ_{Ct} 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 ω_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 φ_{Ct} is assumed to take the

quadratic form:

$$\varphi_{Ct} = \left[1 - \frac{\varphi_{M_C}}{2}\left(\frac{\frac{M_{Ct}}{C_{Dt}}}{\frac{M_{Ct-1}}{C_{Dt-1}}} - 1\right)^2\right]. \tag{11}$$

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:

$$\min_{C_{Dt+k}, M_{Ct+k}} \mathbb{E}_t \sum_{k=0}^{\infty} \psi_{t,t+k} \Bigg\{ (P_{Dt+k} C_{Dt+k} + P_{Mt+k} M_{Ct+k}) \tag{12}$$
$$+ P_{Ct+k}\left[C_{A,t+k} - \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt+k}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\varphi_{Ct+k} M_{Ct+k})^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}\right]\Bigg\}.$$

The distributor sells the final consumption good to households and the government at a price P_{Ct}, 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 ω_I in the investment index to differ from that of the weight ω_C in the consumption goods index.[6]

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

[6] Notice that the final investment good is not used by the government.

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:

$$L_t = \left[\int_0^1 \left(\zeta N_t\left(h\right)\right)^{\frac{1}{1+\theta_w}} dh\right]^{1+\theta_w}, \tag{13}$$

where $\theta_w > 0$ and $N_t(h)$ is hours worked by a typical member of household h. The parameter ζ 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 $W_t\left(h\right)$ as given, and then sells units of the labor index to the production sector at their unit cost W_t:

$$W_t = \left[\int_0^1 W_t\left(h\right)^{\frac{-1}{\theta_w}} dh\right]^{-\theta_w}. \tag{14}$$

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

$$N_t\left(h\right) = \left[\frac{W_t\left(h\right)}{W_t}\right]^{-\frac{1+\theta_w}{\theta_w}} L_t/\zeta. \tag{15}$$

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 ς and the share of HM households by $1-\varsigma$.

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

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} \left(C^O_{t+j}(h) - \varkappa C^O_{t+j-1} - \nu_{ct} \right)^{1-\sigma} + \right. \tag{16}$$
$$\left. \frac{\chi_0 Z_{t+j}^{1-\sigma}}{1-\chi} (1 - N_{t+j}(h))^{1-\chi} + \mu_0 F\left(\frac{MB_{t+j+1}(h)}{P_{Ct+j}} \right) \right\},$$

where the discount factor β 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^O_{t-1}. 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, ν_{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.

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:

$$\begin{gathered} P_{Ct} C^O_t(h) + P_{It} I_t(h) + MB_{t+1}(h) - MB_t(h) + \textstyle\int_s \xi_{t,t+1} B_{Dt+1}(h) \\ -B_{Dt}(h) + P_{Bt} B_{Gt+1} - B_{Gt} + \frac{P^*_{Bt} B_{Ft+1}(h)}{\phi_{bt}} - B_{Ft}(h) \\ = (1 - \tau_{Nt}) W_t(h) N_t(h) + \Gamma_t(h) + TR_t(h) - T_t(h) + (1 - \tau_{Kt}) R_{Kt} K_t(h) + \\ P_{It} \tau_{Kt} \delta K_t(h) - P_{Dt} \phi_{It}(h). \end{gathered} \tag{17}$$

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

$$K_{t+1}(h) = (1 - \delta) K_t(h) + I_t(h), \tag{18}$$

where δ is the depreciation rate of capital.

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,[7] 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, P_tY_t, and are given by:

$$\phi_{bt} = \exp\left(-\phi_b\left(\frac{B_{Ft+1}}{P_tY_t}\right)\right). \tag{19}$$

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 τ_{Nt} is a stochastic tax on labor income. The household leases capital at the after-tax

[7] 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.

rental rate $(1-\tau_{Kt})R_{Kt}$, where τ_{Kt} is a stochastic tax on capital income. The household receives a depreciation write-off of $P_{It}\tau_{Kt}\delta$ 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:

$$\phi_{It}(h) = \frac{1}{2}\phi_I \frac{(I_t(h) - I_{t-1})^2}{I_{t-1}}. \tag{20}$$

In every period t, each member of FL household h maximizes the utility functional (16) 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 (15), budget constraint (17), and transition equation for capital (18). 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:

$$W_t(h) = \omega_{t-1}^{\iota_w}\omega^{1-\iota_w}W_{t-1}(h), \tag{21}$$

where ω_{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 (16) 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, $P_{Ct}C_t^{HM}(h)$, to his current after-tax disposable income, which consists of labor income plus net lump-sum transfers from the government:

$$P_{Ct}C_t^{HM}(h) = (1-\tau_{Nt})W_t(h)\,N_t(h) + TR_t(h) - T_t(h)\,. \tag{22}$$

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:

$$i_t = \max\left\{-i, (1-\gamma_i)\left(\tilde{\pi}_t + \gamma_\pi(\tilde{\pi}_t - \pi) + \gamma_x\tilde{x}_t\right) + \gamma_i i_{t-1}\right\} \tag{23}$$

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 $i_t = -i$.

$\tilde{\pi}_t$ is price inflation rate of the currency union, π the inflation target, and $\tilde{x}_t$ 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

Government purchases have no direct effect on the utility of households, nor do they affect the production function of the private sector. To capture the possibility of implementation lags in spending, we assume that government spending follows an AR(2) process as in Uhlig (2010):

$$g_t - g_{t-1} = \rho_{g_1}(g_{t-1} - g_{t-2}) - \rho_{g_2} g_{t-1} + \varepsilon_{g,t}. \tag{24}$$

The government does not need to balance its budget each period, and issues nominal debt to finance its deficits according to:

$$\begin{aligned} P_{Bt}B_{Gt+1} - B_{Gt} = P_{Ct}G_t + TR_t - T_t - \tau_{Nt}W_tL_t - (\tau_{Kt}R_{Kt} - \delta P_{It})K_t \\ -(MB_{t+1} - MB_t). \end{aligned} \tag{25}$$

Equation (25) 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 capital tax τ_{Kt} is assumed to be fixed, and the ratio of real transfers to (trend) GDP, $tr_t = \frac{TR_t}{P_t Y}$, 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 τ_{Nt} is determined by two components,

$$\tau_{Nt} = \tau_{Nt}^{endo} + \tau_{Nt}^{exo}, \tag{26}$$

where τ_{Nt}^{endo} adjusts in response to both the debt/GDP ratio, b_{Gt+1}, and to the total government deficit, $b_{Gt+1} - b_{Gt}$:

$$\tau_{Nt}^{endo} = \nu_0 \tau_{N,t-1}^{endo} + \nu_1 (b_{Gt+1} - b_G) + \nu_2 (b_{Gt+1} - b_{Gt}), \tag{27}$$

where $b_{Gt+1} = \frac{B_{Gt+1}}{P_t Y}$ and b_G is the government's target value for the ratio of government debt to nominal (trend) output. Hence, τ_{Nt}^{endo} works as an automatic stabilizer and ensures that the level of debt to trend output is stationary. The second component of the labor-income tax rate τ_{Nt}^{exo}, is a discretionary part which is assumed to follow an AR(2) process:

$$\tau_{Nt}^{exo} - \tau_{Nt-1}^{exo} = \rho_{\tau_1} (\tau_{Nt-1}^{exo} - \tau_{Nt-2}^{exo}) - \rho_{\tau_2} \tau_{Nt-1}^{exo} + \varepsilon_{\tau,t}, \tag{28}$$

where $0 \leq \rho_{\tau_1} < 1$ and $\rho_{\tau_2} > 0$. Notice that if $\rho_{\tau_1} = 0$, then τ_{Nt}^{exo} follows an AR(1) with persistence $1 - \rho_{\tau_2}$.

2.5. Resource Constraint and Net Foreign Assets

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

$$Y_{Dt} = C_{Dt} + I_{Dt} + \phi_{It}, \tag{29}$$

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

$$C_{At} = C_t + G_t, \tag{30}$$

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

$$C_t = C_t^O + C_t^{HM}. \tag{31}$$

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

$$M_t^* = M_{Ct}^* + M_{It}^*. \tag{32}$$

Finally, at the level of the individual firm:

$$Y_t(i) = Y_{Dt}(i) + X_t(i) \quad \forall i. \tag{33}$$

The evolution of net foreign assets can be expressed as:

$$\frac{P_{B,t}^* B_{F,t+1}}{\phi_{bt}} = B_{F,t} + P_{Mt}^* M_t^* - P_{Mt} M_t. \tag{34}$$

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 entrepeneurs (at the price R_{Kt}) rather than directly from households. Entrepeneurs 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 18) and 20). 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.[8]

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 transformations. 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

[8] 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).

monetary policy rule (23), 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 ζ 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 $\overline{r}$ 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 $i =$ equals 0.01 at a quarterly rate, and 4 percent at an annualized rate.

The utility functional parameter σ is set equal to 1 to ensure that the model exhibit balanced growth, while the parameter determining the degree of habit persistence in consumption $\varkappa = 0.8$. 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 χ_0 is set so that employment comprises one-third of the household's time endowment, while the parameter μ_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 21 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 δ is set at 0.025. (consistent with an annual depreciation rate of 10 percent). The parameter ρ 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 ω_K – together with the price markup parameter of $\theta_P = 0.10$ is chosen to imply a steady state investment to output ratio of 20 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, μ, expressed as a proportion of entrepreneurs' total gross revenue, is set to 0.12. The default rate of entrepeneurs is 3 percent per year, and the variance of the idiosyncratic productivity shocks to entrepreneurs is 0.28.

We maintain the assumption of a relatively 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 ξ_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 ξ_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 (2010), 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 set as follows. The share of government spending of total expenditure is set equal to 20 percent. The government debt to GDP ratio, b_G, is set to 0.75, about equal to the average level of debt in euro area countries at end-2008. The lump-sum tax revenue to GDP ratio is set to a small value of 0.02. Given that the capital tax τ_K is set to zero, the government's intertemporal budget constraint implies that the labor income tax rate τ_N equals 0.35 in steady state.

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 comprised about 14 percent of GDP in 2008. This pins down the trade share parameters ω_C and ω_I for the South under the additional assumption that the import intensity of consumption is equal to 3/4 that of investment. The size of the South relative to the North is based on data for the Greek, Portugal and the Ireland economies. Each of these economies accounts for about 2 percent of euro area GDP, so that $\zeta = 0.02$. This case approximates a small open economy. Given that trade is balanced in steady state, this parameterization implies an export and import share of the North countries of 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 $\varphi_{M_C} = \varphi_{M_I} = 3$, implying a half-life of adjustment of about half a year. We choose a small value (0.00001) for the financial intermediation cost ϕ_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. For the tax rate reaction function, we choose $\nu_0 = 0.9$, $\nu_1 = 0.02$, $\nu_2 = 0.05$. This benchmark tax rule is not very aggressive, and has similar implications to adjustment via lump-sum taxes in the short to medium-run.

4. Results

We now proceed to report the results. We start with a discussion of the effects of spending cuts and tax hikes in the South block only, and then proceed to an analysis of the effects of the fully coordinated actions, i.e. fiscal consolidations that are assumed to take place both in the South and the North. Due to our symmetric calibration of the model, the effects of coordinated actions mimics the effects in a closed economy framework.

4.1. Non-Coordinated Fiscal Consolidation in South Only

We begin by comparing the impact of a front-loaded spending cuts and labor-income tax hikes with 1 percent of trend GDP in the South only, which accordingly approximates the effects in a small open economy. In both cases, we set the parameters in (24) and (28) so that they follow AR(1) processes with a persistence of 0.99. 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 (23), but adapted to domestic conditions only. Hence, the impulse response functions shown in Figure 1 depicts the effects when South is a small currency union member (denoted "CU"), and when it has monetary independence (denoted "Ind Pol").

We start by discussing the effects under independent monetary policy, i.e. the dotted lines in Figure 1. As can be seen from the figure, fiscal retrenchment via spending cuts (thick black lines) are associated with more adverse output effects in the short-run than labor income tax hikes (thin red lines), whereas labor-income tax hikes cause output to contract more in the medium and long run. However, in contrast to Uhlig (2010), we find that the effects on output are negative for almost as long as 10 years. To a large extent, this reflects our assumption of an unresponsive parameterization of the labor-income tax rule (27). Had we assumed larger values of ν_1 and ν_2, output would have expanded well before 10 years in the spending cut case. Also, more weight on the output gap in the policy rule would be more stimulative for output in the longer-term, as potential output expands after 5 years following a spending cut. For the labor-tax hike, potential output falls more persistently as expected. It is important to notice that this feature implies that spending

cuts are more effective than equally sized labor-tax hikes to quickly reduce government debt in the absense of sticky prices and wages, in which 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. The effects on the potential real interest rate are opposite; whereas the potential real interest rate increases to a labor tax hike with about 1 percentage points, it decreases by almost 2 percentage points following a spending cut. 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 actions as shown in the upper left panel in the figure. Due to the assumption of hand-to-mouth consumers, the spending cut has a slight crowding out effect on private absorption initially, but the strong monetary accommodation quickly make FL households to offset this effect and private absorption expands. 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. Following the persistent spending cuts and labor income tax hikes, government debt (as share of GDP) falls persistently with over 2 percent after 3 years, and almost 6 percent of actual GDP after 10 years. 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 due to their smaller crowding out effects on output after a year. Finally, notice that the labor income tax plotted in the lower right panel in Figure 1 - τ_{Nt} in (26) - responds also to the spending cut. In this case, fluctuations in τ_{Nt} are explained by movements in τ_{Nt}^{endo} in (27), which are required to stabilize the level of debt in the long-run. The decline in τ_{Nt}^{endo} following the hike in τ_{Nt}^{exo} in (28) also explains

why τ_{Nt} declines at a somewhat faster pace relative to the persistence of the g_t shock.

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 1. As is clear from Figure 1, 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, and only somewhat less contractionary in the longer term. Consequently, spending cuts are less effective in reducing government debt in a currency union relative to the case with monetary independence. Moreover, as can be seen from Figure 1, a front-loaded hike in labor tax rate is a more effective instrument to reduce government debt in the currency union case. Apart from the fact that spending cuts are more contractionary for a small member of a currency union, this latter results also reflects that the adverse output effects of a labor tax hike are in fact mitigated in a currency union. 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 nominal exchange rate appreciation. For our small South currency union member, neither of these things will happen, and in our calibration

of the model the exchange rate effect dominates and output therefore contracts less in a currency union following a labor income tax hike.

4.2. Coordinated Fiscal Consolidations in the Currency Union

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 1 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 2 we compare the effects of non-coordinated (South only, solid lines) and where a 1/3 of the North members undertake identical actions as those in the South (labeled "Partly Coord", dotted lines). By comparing the non-coordinated to the partly coordinated results in the figure, 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 when its consolidations are synchronized with other member states. In particular, as cuts in government spending require more accommodate monetary policy actions, we find that differences between the solid and dashed lines for spending cuts in Figures 1 and 2 are especially noticeable. As taxes requires less monetary accommodation (see Figure 1), the differences between the coordinated and partly coordinated case are less pronounced. And the basic result from Figure 1 still holds in Figure 2: even if the fiscal consolidative actions are partly coordinated with the North, spending cuts are less effective than tax hikes to reduce government debt quickly for a small member of a currency union.

However, consistent with the findings in Figure 1, the results do indicate that government spending cuts are more effective relative to labor tax hikes in reducing debt when there the actions are more coordinated, as there will be more monetary accommodation by the currency union central bank.

In Figure 3 we therefore go one step further and compare the effects of non-coordinated (South only) and perfectly coordinated (all North members) fiscal actions in the currency union. Due to the symmetric calibration, our model collapses to a closed economy model in the perfectly coordinated case. Hence, although we only report results for the South in Figure 3, the effects on the union are identical in the fully coordinated case. In the non-coordinated case, the effects on the North are arbitrarily small since the spillover effects from the South to the North are tiny for the size of the fiscal impetus we consider (recall that South only accounts for 2 percent of currency union). As can be seen the results in Figure 3, full coordination has an important impact on the effects. For the spending cut, there is a even large degree of monetary policy accommodation by the currency union central bank, which reduces the adverse effects on output through less crowding out effects on private absorption. For the labor tax hike, the opposite effects emerges, and a labor tax hike actually associated with a larger decline in South output when it is coordinated, mainly driven by the larger fall in potential output. [**Provide more intuition here.**] By implication, the impact on government debt thus importantly hinges on the degree of coordination. A high degree of coordination makes spending cuts attractive relative to tax hikes as it enables the South to make more progress on reducing the debt level in the medium term (three years). Only for the first year, there is a slightly less improvement with spending cuts due to the sharper initial decline in output which causes tax revenues to fall by more than the spending cut

itself according to our model.

It is also instructive to compare the coordinated results in Figure 3 with the results for South only with independent monetary policy in Figure 1. Due to the nature of our model, these two cases mimics the effects of fiscal consolidation in a small open economy with independent monetary policy and the effects in a closed economy when monetary policy is able to respond. As can be seen by comparing the results, it the case that fiscal retrenchment via spending cuts have slightly less adverse output effects in an open economy framework, mainly due to the currency depreciation and the associated improvement in net exports (leakage). For the labor income tax hike, the effects on output are very similar in the short run, but somewhat more contractionary in the medium and long-term in the open economy due to the appreciation of the real exchange rate which is driven by the rise in the potential real interest rate.

As mentioned earlier, the paths for the policy rate in Figure 3 make clear that the different fiscal instruments rely on different degrees of monetary accommodation. Therefore, it is of interest to examine the effects of coordinated actions for alternative assumptions about the degree of monetary accommodation. This is of particular interest in the current situation, as there is little 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 the marginal multipliers from coordinated fiscal actions assuming that policy rate in the currency union initially is arbitrarily close to the zero lower bound absent any fiscal actions by the government.[9] As discussed in more detail in Erceg and Lindé

[9] Following Erceg and Linde (2010b), we assume that the policy rate in the currency union is driven close to zero by being exposed to a persistent negative ν_{ct} shock in consumption preferences in the utility function (16).

(2010a), the marginal multiplier follows a step function when the duration of the liquidity trap is endogenous, which is a feature of the policy rule in eq. (23). 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. We compute average multipliers for output and government debt for a three year window using the formula

$$y_{mult} = \sum_{t=0}^{11} \Delta y_t / \sum_{t=0}^{11} \Delta fi_t, debt_{mult} = \sum_{t=0}^{11} \Delta b_{Gt+1} / \sum_{t=0}^{11} \Delta fi_t, \tag{35}$$

i.e. as the cumulated sum of output and government debt (as share of actual output) divided by the cumulated sum of the relevant fiscal instrument fi_t (as share of trend output). Δ indicates that all variables are computed as deviations from their baseline paths (i.e. if no discretionary fiscal actions had been undertaken). Uhlig (2010) applies a similar formula to compute the multiplier, but discount the forward values with the steady state real interest rate. As the discount factor is very close to unity in our model, this has very little impact on the obtained results. From the average multipliers, we can back out the marginal multipliers as described in the appendix.[10] [**To be added.**] We also include the effects of non-coordinated actions in the South only, 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 the interest rate decision of the central bank which is assumed to be dictated by the currency union wide averages of inflation and output gaps.

In Figure 4, we show the results of this exercise. Consider first the upper left panel in the Figure. Absent any discretionary changes, the currency union and the South is near

[10] For the spending *cut* debt multiplier, we switch the sign of $debt_{mult}$ in (35) as the denominator is negative in this case, in order to get an intuitive interpretation of the debt multiplier. By just applying the formula, we obtain that the debt multiplier is negative in a long-lived liquidity trap, as the numerator (debt) rises but the denominator (spending) is negative.

the zero lower bound, and at the margin subject to the spending multipliers implied by the unconstrained paths in Figure 3. If the South only cuts or increases government spending, it will be subject to a output multiplier slightly less than unity, which is the cumulated sum of the dotted line for output up to quarter 11 in Figure 3 divided by the cumulated sum of the government spending path up to quarter 11 in the same figure. However, if the fiscal cut are undertaken jointly within the currency union and is so large that it extends the duration of the liquidity trap, the multiplier will be increasingly higher following the step function in the panel, because larger cuts will require a higher degree of monetary accommodation which is not available. Accordingly, both the average and marginal multipliers will increase as the duration of the liquidity trap is extended. The fact that coordinated spending actions calls for strong monetary accommodation was discussed above and shown in Figure 3. For any given duration of the liquidity trap absent fiscal austerity measures, the results in Figure 4 implies the marginal multiplier is constant and equals the average multiplier for small changes in government spending, 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. Because the multiplier is a convex increasing function of the duration of the liquidity trap, fiscal consolidations via spending cuts will be most contractionary in a situation when little monetary accommodation can materialize for a considerable period absent any fiscal actions. The main mechanism behind the larger multipliers 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), and this explains why there is a crossing between the South only multiplier and the coordinated marginal multiplier: Only if the currency union is unconstrained, the adverse effects on South output will be

smaller if it pursues a fiscal consolidation that is coordinated with the North, but if North monetary policy is constrained, then the adverse effects on South output can be larger with a coordinated cut relative to the situation where only the South consolidates. The results in Figure 4 suggests that the crossing for the spending cut occurs if the policy rate is expected to be bounded by zero for 6 quarters absent any fiscal retrenchment, or at the margin for a spending cut around 3 percent if the currency union initially is arbitrary close the zero bound. 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. Starting from an 8 quarter liquidity trap, even a moderately sized fiscal spending cut of -1 percent of baseline GDP will extend the duration of the liquidity trap from 8 to 10 quarters and cause the government debt multiplier to be above 3, implying that government debt to actual output *rises* substantially after three years. Our findings 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. Finally, notice that the output and debt multipliers to the right of the 1 period zero lower bound duration tick shows the effects when monetary policy is unconstrained by the zero lower bound, and these marginal multipliers are readily computed from the coordinated results in Figure 3.

The bottom two panels show corresponding results for a changes in the labor tax. As expected, the output multipliers have the opposite signs. Interestingly, and as expected from Figure 3, there is never a crossing of the non-coordinated action in South only and in the case where the actions are coordinated with North. An implication is that labor tax hikes are always more contractionary in a closed economy setting, regardless of the degree

of monetary accommodation. Another interesting finding is labor tax hikes 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. Two key differences which accounts for the differences in the results; first, the existence of hand-to-mouth households in our model, and second, that he considers an environment without wage stickiness while we assume a more plausible degree of wage stickiness in our analysis.[**Provide more intuition here.**] In addition, we entertain a higher degree of sticky prices than Eggertsson does. Finally, and importantly, we see from Figure 4 that tax hikes at the margin is a more effective tool to reduce government debt in a liquidity trap that is expected to last 8 quarters absent any fiscal actions. Only when monetary policy is unconstrained by the zero lower bound, tax hikes will have less favorable effects on government debt at the three year horizon relative to spending by a small margin. For these reasons, and since tax hikes are more effective than spending cuts in bringing down debt for small South member which undertakes non-coordinated fiscal retrechment, our analysis suggest that there is a strong argument to be made in favor of labor tax hikes as opposed to front-loaded spending cuts in consolidating euro area countries in the current situation.

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) and Erceg and Linde (2010a) have emphasized that the effects might be quite different if the fiscal austerity

measures are implemented gradually, we consider the effects of more gradual consolidation packages. Second, we consider the effects of fiscal actions that are front-loaded but perceived to be less persistent than the measures in our baseline calibration, which might be an important feature currently for some of the consolidating Peripheral countries in the euro area. Next, 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 important role in our model. Finally, 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 show that even a front-loaded fiscal retrenchment can expand output even in the near-term for a country facing unfavorable initial borrowing conditions provided that interest rate spreads are sufficiently responsive to lower future expected debt and deficits levels.

5.1. Gradual Fiscal Austerity Measures

To implement a more gradual profile of the consolidative actions, we relax the assumption that ρ_{g_1} and ρ_{τ_1} in eqs. (24) and (28) are zero, and instead assume that they equal 0.90. Furthermore, we adjust ρ_{g_2} and ρ_{τ_2} and the initial shocks we add so that the discretionary components of the spending cut and labor tax hike equals one percent of baseline GDP first after 20 quarters. Importantly, these values also imply that the undiscounted present value of the fiscal instruments, i.e. $\sum_t^{1000} \Delta fi_t$ are identical to the ones implied by the front-loaded AR(1) processes used in the benchmark model. We interpret this situation with more gradual implementation of fiscal austerity measures corresponding to a situation where the member

enjoys a high degree of credibility for long-term fiscal sustainability, and is not forced by financial markets to pursue front-loaded cuts or tax hikes.

We start by comparing the effects of non-coordinated and coordinated cuts and tax hikes of South and North, assuming that the currency union is unconstrained by the zero lower bound on interest rates. Figure 5 report the effects of this case. As North is approximately unaffected by the actions of the South and the effects for the South and North are identical in the perfectly synchronized case, we only report results for South variables. As can be seen from Figure 5, spending cuts are now slightly more contractionary in the near term than tax hikes in the short and medium term for the South only case, and substantially less contractionary in the long-term. For the coordinated case, spending cuts are less contractionary than tax hikes for both the short- and long-term. Accordingly, spending cuts are still less effective than tax hikes to quickly reduce the government debt to output ratio in the case of non-coordinated cuts in the Periphery, but about equally effective when monetary policy can accommodate. One additional important difference concerns the effects on the potential real interest rate, which now have opposite signs relative to those obtained in the benchmark simulations (see Figure 3). Therefore, a more gradual spending cut and tax hike has different implications for the degree of monetary accommodation in the short term in the coordinated case. In contrast to the corresponding results in Figure 3, we see from Figure 5 that more monetary accommodation is now pursued in response to the tax hike instead of the spending cut in the near term. This will have important implication for the effects of 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

and coordinated changes as functions of the duration of the liquidity trap absent any fiscal austerity measures. As can be seen by comparing the obtained result in Figure 6 with the benchmark results in Figure 4, the results are very similar for non-coordinated actions in the 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. For coordinated actions via tax hikes, the impact on government debt can be negative due to outsized output multipliers if sufficiently large consolidative actions are undertaken via tax hikes, or the expected duration of the liquidity trap is sufficiently long-lived absent any fiscal actions. However, as expected from previous results in the literature (Christiano, Eichenbaum and Rebelo, 2011, Corsetti et al. 2010, Erceg and Linde, 2010a), the convexity of the step function for government spending cuts in Figure 6 is considerably less step than the one in 4 because less of the austerity measures comes on line when the zero lower bound is binding and less monetary accommodation is warranted in the short run (see Figure 5). As a result, a key difference between the results in Figures 4 and 6 is that the results in the latter imply that coordinated gradual spending cuts are more effective than tax hikes to reduce government debt within a currency union in a situation where monetary policy cannot provide monetary accommodation for a 1-2 years.

So, while the result that non-coordinated fiscal consolidations via tax hikes are more effective than spending cuts to reduce government debt in small currency union member is invariant to whether the austerity measures are front-loaded or gradual, our results do suggest that the desired mix of *very gradual* spending cuts vs. taxes hikes that are synchronized between a large subset of member states should be tilted toward spending cuts to reduce

debt quickly.

5.2. Less Persistent Fiscal Austerity Measures

We now redo the analysis under the assumption that the consolidative actions are perceived to be less persistent than in our benchmark simulation. More specifically, we assume that the fiscal instruments in eqs. (24) and (28) follow AR(1) processes with persistence coefficients of 0.85 instead of 0.99 in our benchmark calibration.

In Figure 7, we report the results of consolidative spending cuts and tax hikes equal to 1 percent of baseline GDP. By comparing the results in Figure 7 with the benchmark results in Figure 3, we see that the qualitative aspects of the results are unchanged: tax hikes are more effective than spending cuts to reduce debt if only the South consolidates, but if the fiscal measures are undertaken simultaneously in the South and North, then spending cuts are more effective after a year when monetary policy can accommodate the resulting drag on demand and boost private absorption.

To examine the robustness of the results in a liquidity trap, we redo the benchmark experiments in Figure 4, and Figure 8 reports the corresponding results when the fiscal measures are perceived to be less persistent. As can be seen from the figure, and by comparison with the results in Figure 4, the benchmark conclusions are unaffected. Interestingly, even front-loaded and short lived labor-tax hikes have a sizeable negative impact on GDP in our model in a prolonged liquidity trap, contrary to the findings in Eggertsson (2010). Sticky wages and our assumption of HM households, along with more sticky prices are the key explanations behind the different results.

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 South and coordinated measures in both the South and the North when the currency union is in a liquidity trap. In our model, a higher value of ς 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 $\varsigma = 0.47$ so that 53 percent of households are Ricardian agents. Although not shown, our benchmark calibration of ς 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 $\varsigma = 0$. 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. This is due to the fact that a larger share of HM households in the model implies a larger decline in the potential real interest rate in response to a coordinated spending cut. 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. Erceg and Lindé (2010a) provide a more detailed discussion of how the presence of HM agents affects the fiscal spending multiplier through this channel.

Turning to the results for the labor income tax rate in the lower panels in Figure 9, we notice that the output multiplier is considerably smaller for a non-coordinated hike in the South only. Accordingly, labor tax hikes are 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 (starting from a situation where the initial policy rate is close to the zero lower bound). Consistent with this finding, we see that the government debt multipliers implies that coordinated tax hikes always reduces debt, expect in the case of an 11 quarter long-lived liquidity trap in which the debt would rise marginally. These findings imply that also 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. 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

$$i_t^S - i_t = \psi_b(b_{Gt+1} - b_G) + \psi_d(b_{Gt+1} - b_{Gt}), \tag{36}$$

where we recall that b_{Gt+1} is the end-of-period t government debt level and i_t the interest rate set by the central bank. The specification in (36) is motivated by the spread equation estimated 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 ψ_b and ψ_d, see e.g. Evans (1985, 1987). 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 ψ_b and ψ_d are both positive.

As a tentative calibration, we set $\psi_b = 0.04$ and $\psi_d = 0.10$, implying that a one percent decline in government debt decreases the spread by 4 basis points, and that a one percent decline in the budget deficit decreases the spread with an additional 10 basis points. While these elasticities are 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 10, we report the results of this experiment for a non-coordinated South only discretionary cut in government spending (24) and hike in the labor-tax rate (28) with 1 percent of baseline GDP. As in the benchmark simulation, the discretionary components are assumed to follow AR(1) processes with persistence coefficient 0.99. The model where the interest rates spreads for South is given by (36) 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 only two years following a spending cut, which stands in sharp contrast to the model without the endogenous risk premium in (36) which output in the South contracts for almost 10 years in response to the same spending cut. For a tax hike, output even expands with a year. The stark difference in results is driven by the large and persistent decline in the 10-year spread on government bonds in South, in each period t computed as $\frac{1}{40}\sum_{j=0}^{39}\left(i_{t+j}^{S}-i_{t+j}\right)$, which is visualized in the upper right panel in Figure 10. The spread eventually declines by almost 150 basis points, and the key parameter behind the persistent decline is ψ_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 spread falls sufficiently, 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. However, an important difference in our frame-

work is that if the commitment to pursue labor tax hikes and spending cuts are assumed to be equally credible, then the same favorable effects arise for labor tax hikes, which now is associated with crowding in of private absorption due to the falling risk spreads. Therefore, unless spending cuts are perceived to be more persistent relative to tax hikes because cuts are more difficult to implement from a political perspective, both tax hikes and spending cuts that are viewed as equally persistent should both have the potential to boost output growth and reduce debt if this channel is active. In this sense, our results goes against the empirical findings in the "expansionary fiscal consolidations literature".

Finally, we compare the results of non-coordinated (South only) and coordinated (South and North) fiscal austerity measures, again assuming that interest rate spreads in the South are debt deficit sensitive as postulated by (36) above. A key assumption in this experiment is that the currency union is assumed to be in a liquidity trap expected to last 8 quarters absent any fiscal austerity measures. Following Erceg and Lindé (2010a, 2010b), we assume that a persistent negative shock ν_{ct} to consumption preferences in the utility function (16) is the underlying force driving the economy into a prolonged liquidity trap. As in the previous and benchmark simulations, the discretionary components are assumed to follow AR(1) processes with persistence coefficient 0.99 for both South and North and size of the fiscal impetus is kept unchanged.

In Figure 11, we report the results of this final experiment. As can be seen from the figure, the effects on the South are not nearly as benign in this case as when only South consolidates.[11] The explanation behind this finding is that the consolidation in the North puts

[11] Notice that although the spending cuts are coordinated, the South/North real exchange changes because the time varying spreads for South introduce an asymmetry in the model.

considerable drag on external demand for the South, which is not offsetted by accommodative monetary policy as the currency union as a whole is assumed to be in a liquidity trap lasting 8 quarters absent any austerity measures. In addition, the duration of the liquidity trap is extended by 1 quarter in response to the North spending cuts and tax hikes, respectively, and for the reasons discussed in connection with Figure 4, this puts additional pressure on South output. Therefore, South output declines for a considerable period, and government debt actually rises for two years following coordinated spending cuts, and accordingly the South spreads does not decline to the same extent in the short term. However, as progress on reducing the debt will eventually be made, and South in the experiment is assumed to have full credibility for the persistent consolidation plan, long-term spreads nevertheless decrease and eventually induces crowding in of private demand which offsets the drag on external demand for the South. An implication of these latter findings, however, is that if South does not have credibility for persistent austerity measures, then endogenous spreads can work against the South if North simultaneously undertakes consolidative actions in a liquidity trap. In fact, it can be shown that coordinated fiscal consolidations that are perceived to be short-lived in the South, but persistent in the North, will worsen government debt in the South very persistently and induce spreads in the South to rise instead of shrinking in Figures 10 and 11.

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).[**To be completed.**]

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Figure 1: Responses to Front−Loaded Government Spending Cuts and Labor−Income Tax Hikes in Small South in a Currency Union (solid) and with Independent Monetary Policy (dotted).

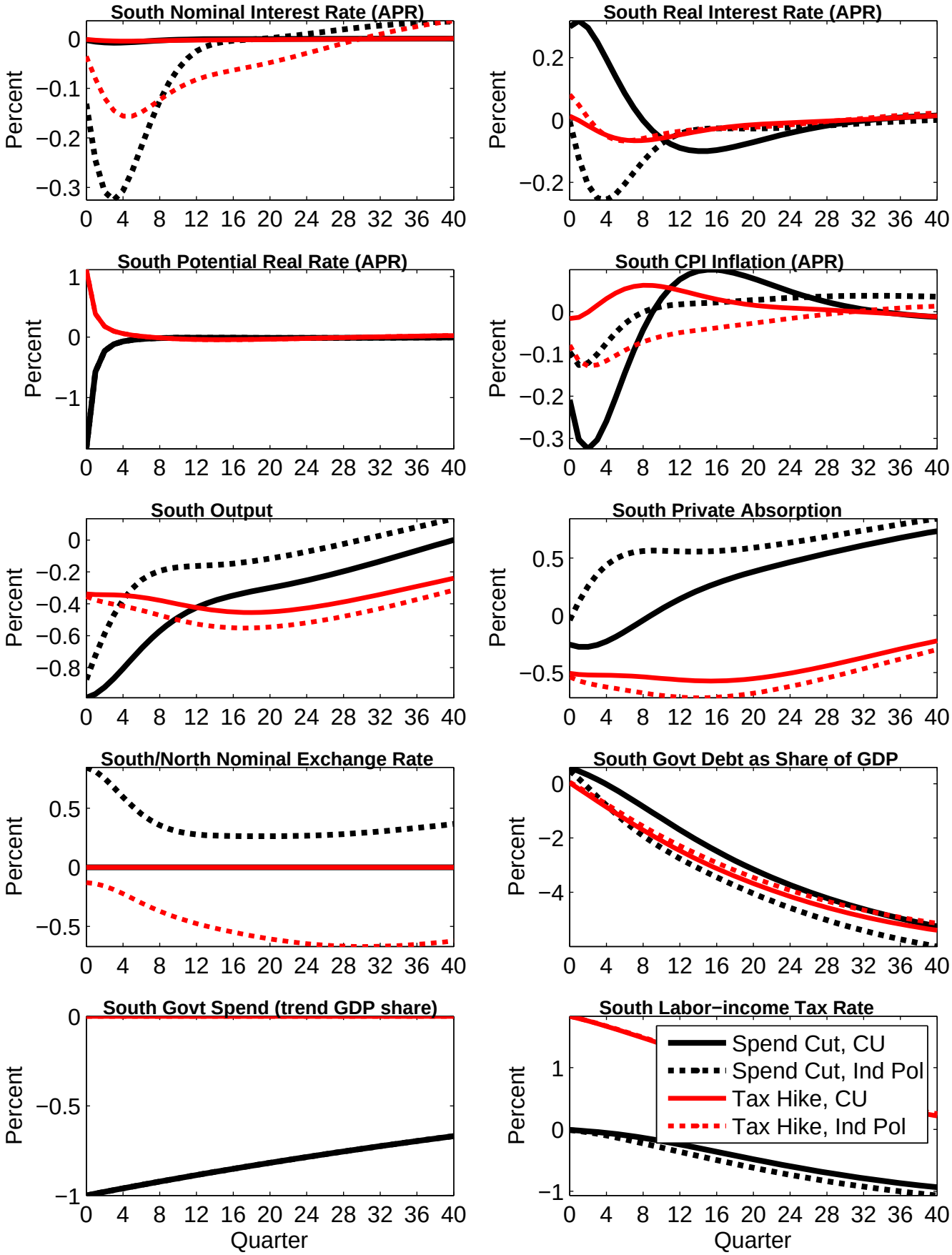

Figure 2: Responses in South to Non−Coordinated (solid) and Partly Coordinated (dotted) Front−Loaded Government Spending Cuts and Labor−Income Tax Hikes in a Currency Union.

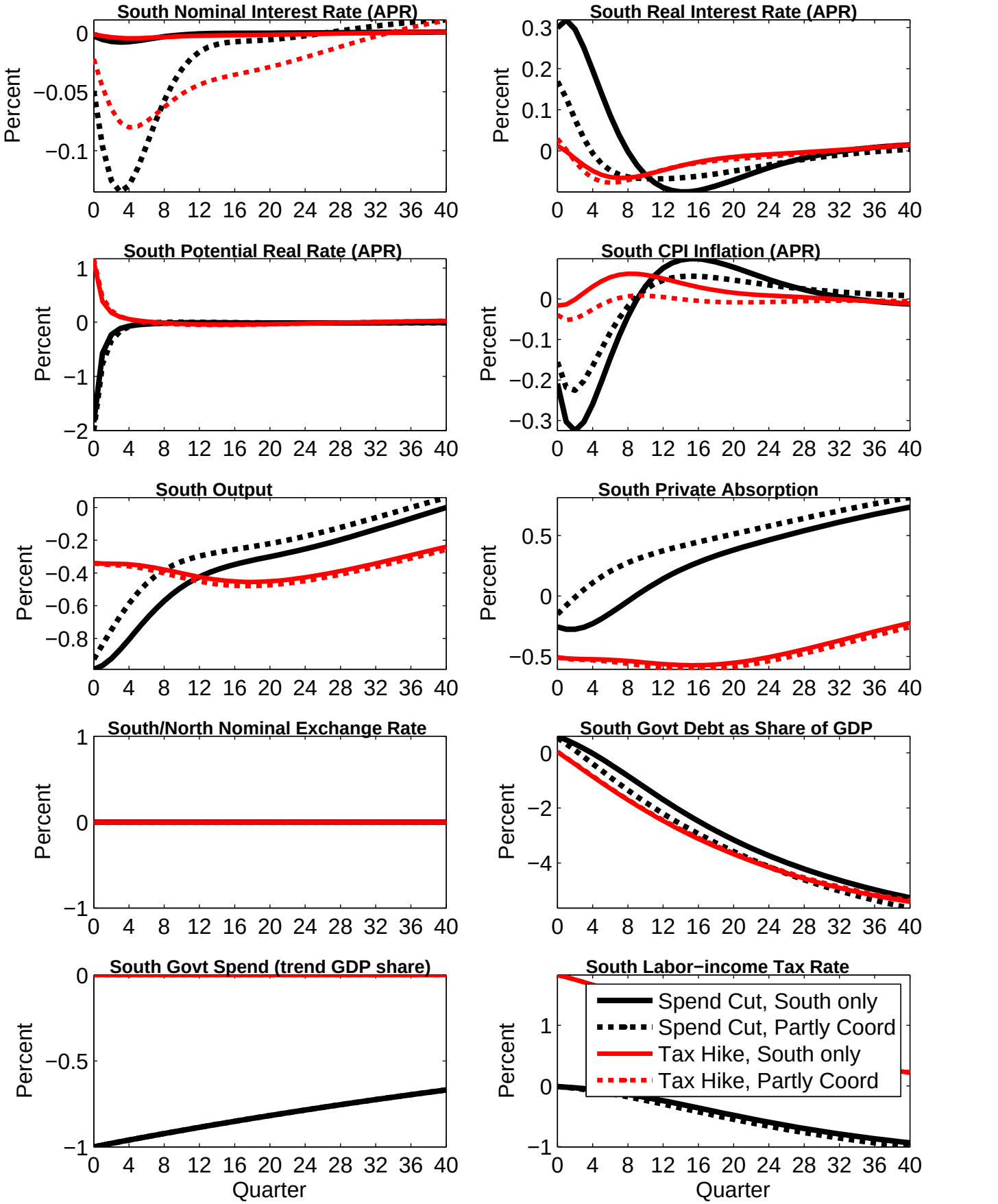

Figure 3: Responses in South to Non−Coordinated (South only) and Fully Coordinated (North and South) Front−Loaded Spending Cuts and Tax Hikes in a Currency Union.

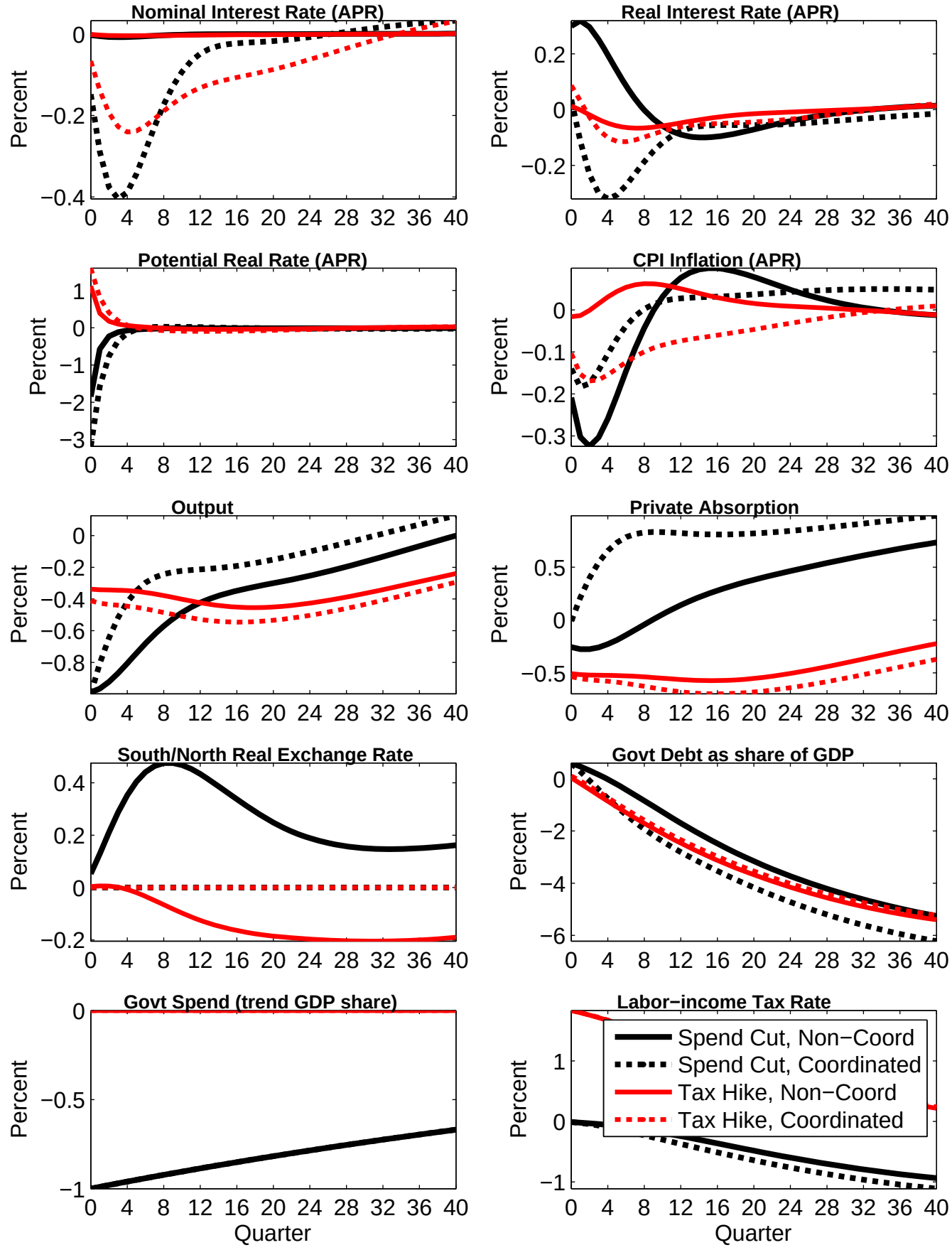

Figure 4: Marginal Output and Government Debt Multipliers in South to Coordinated and Non−Coordinated Spending Cuts and Labor Tax Hikes in a Currency Union.

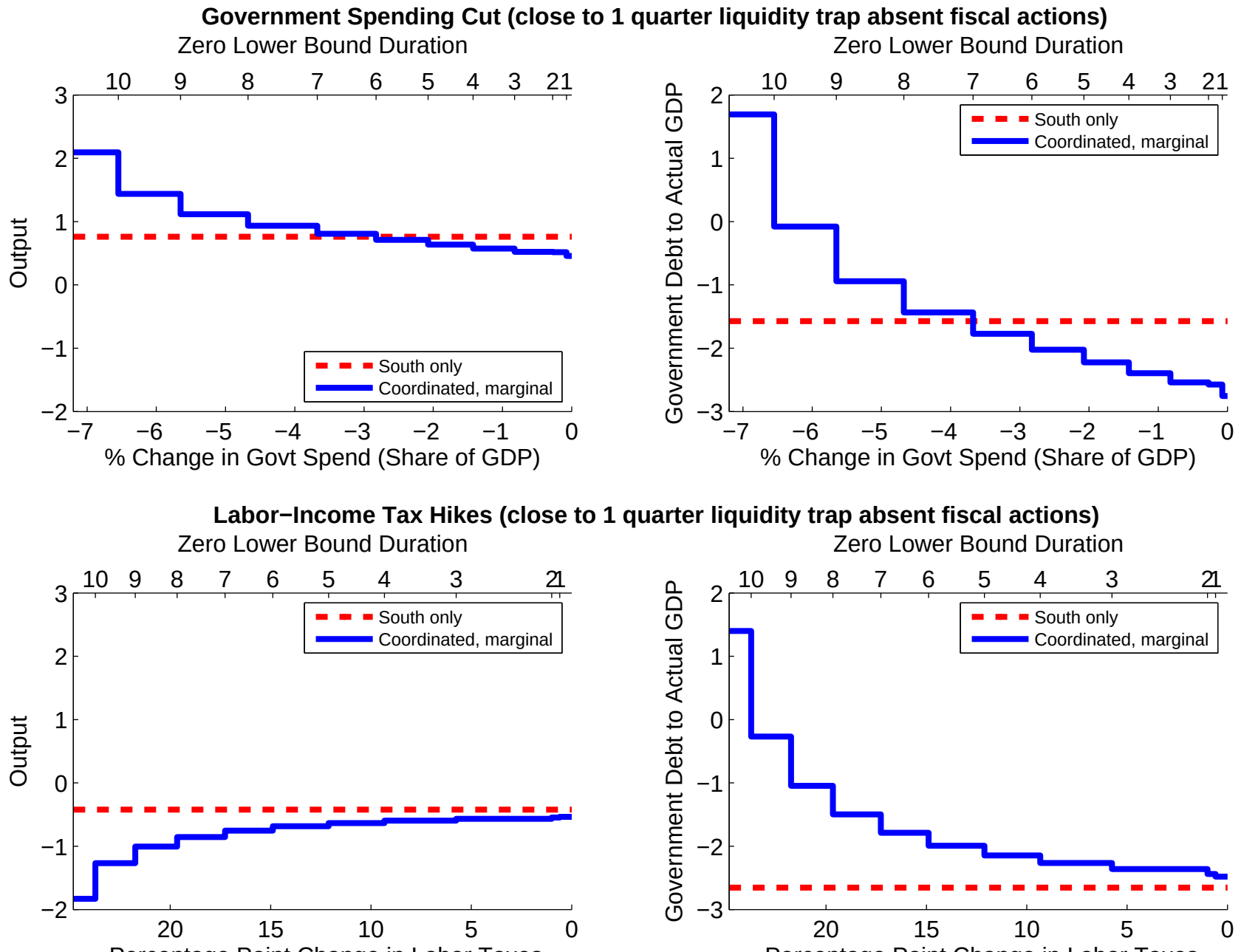

Figure 5: Responses in South to Gradual Non−Coordinated (South only) and Coordinated (North and South) Spending Cuts and Tax Hikes in a Currency Union.

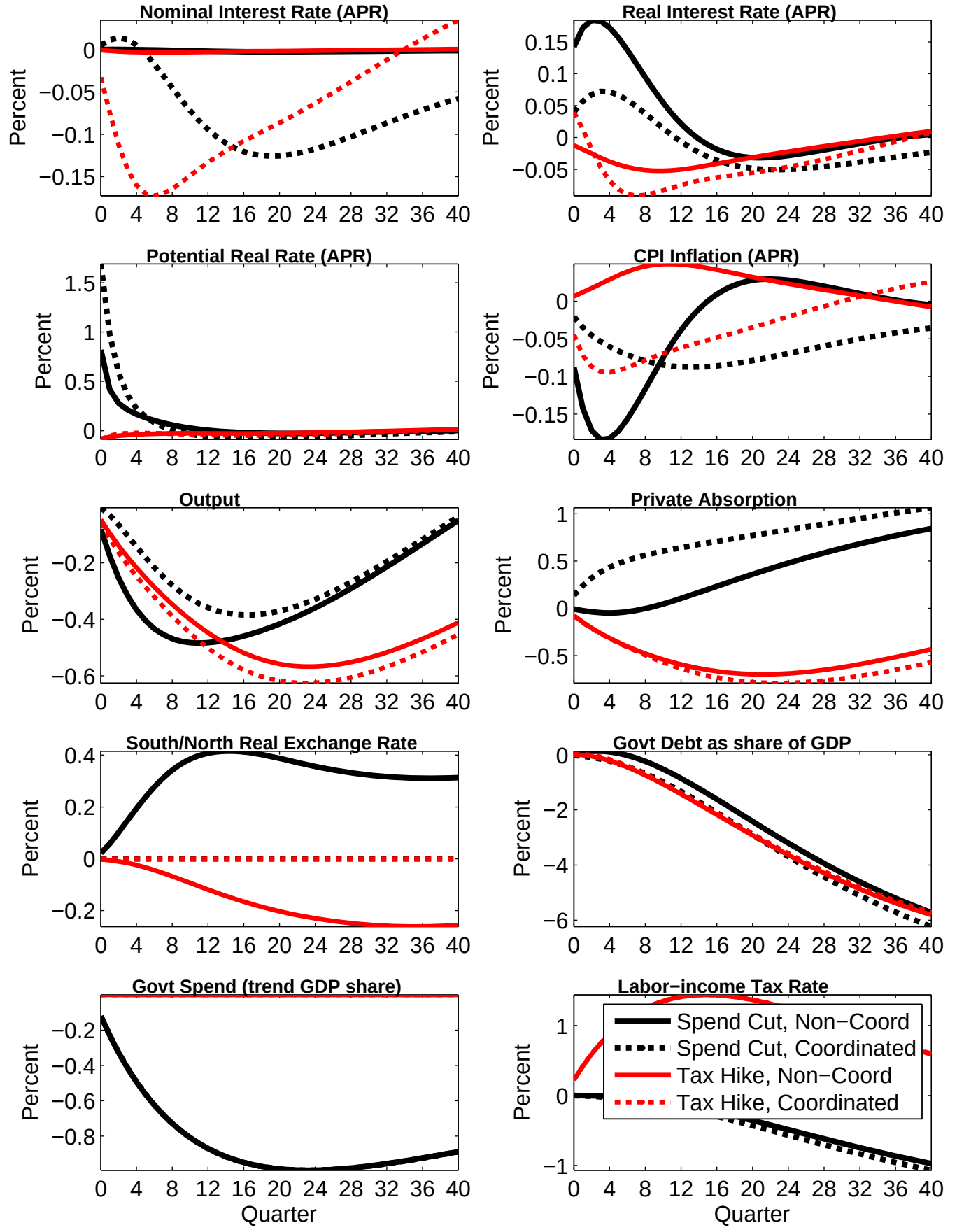

Figure 6: Marginal Output and Government Debt Multipliers in South to Gradual Coordinated and Non−Coordinated Spending Cuts and Labor Tax Hikes in a Currency Union as Function of the Expected Liquidity Trap Duration Absent Any Fiscal Actions.

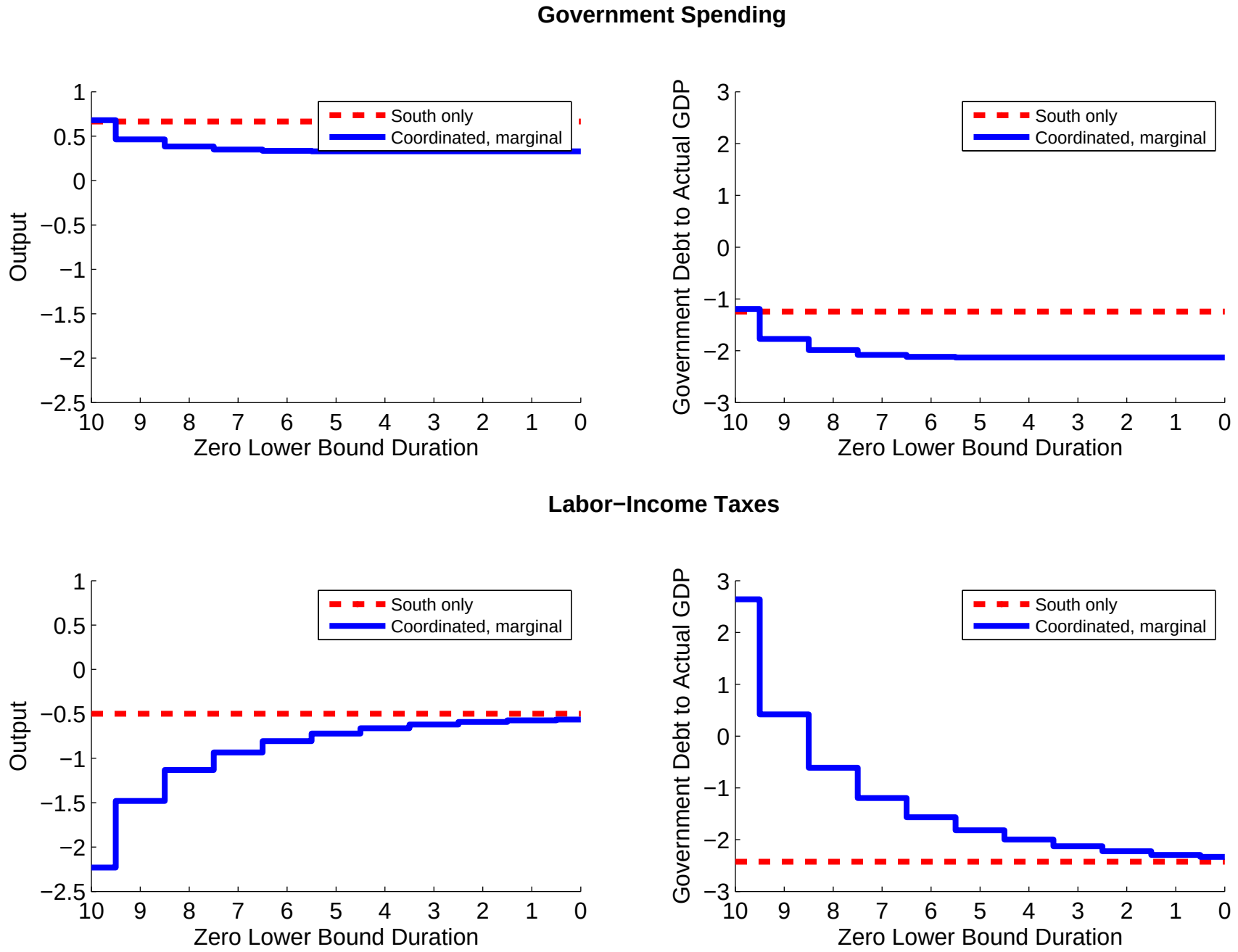

Figure 7: Responses in South to Front Loaded and Less Persistent Non−Coordinated (South only) and Coordinated (North and South) Spending Cuts and Tax Hikes in a Currency Union.

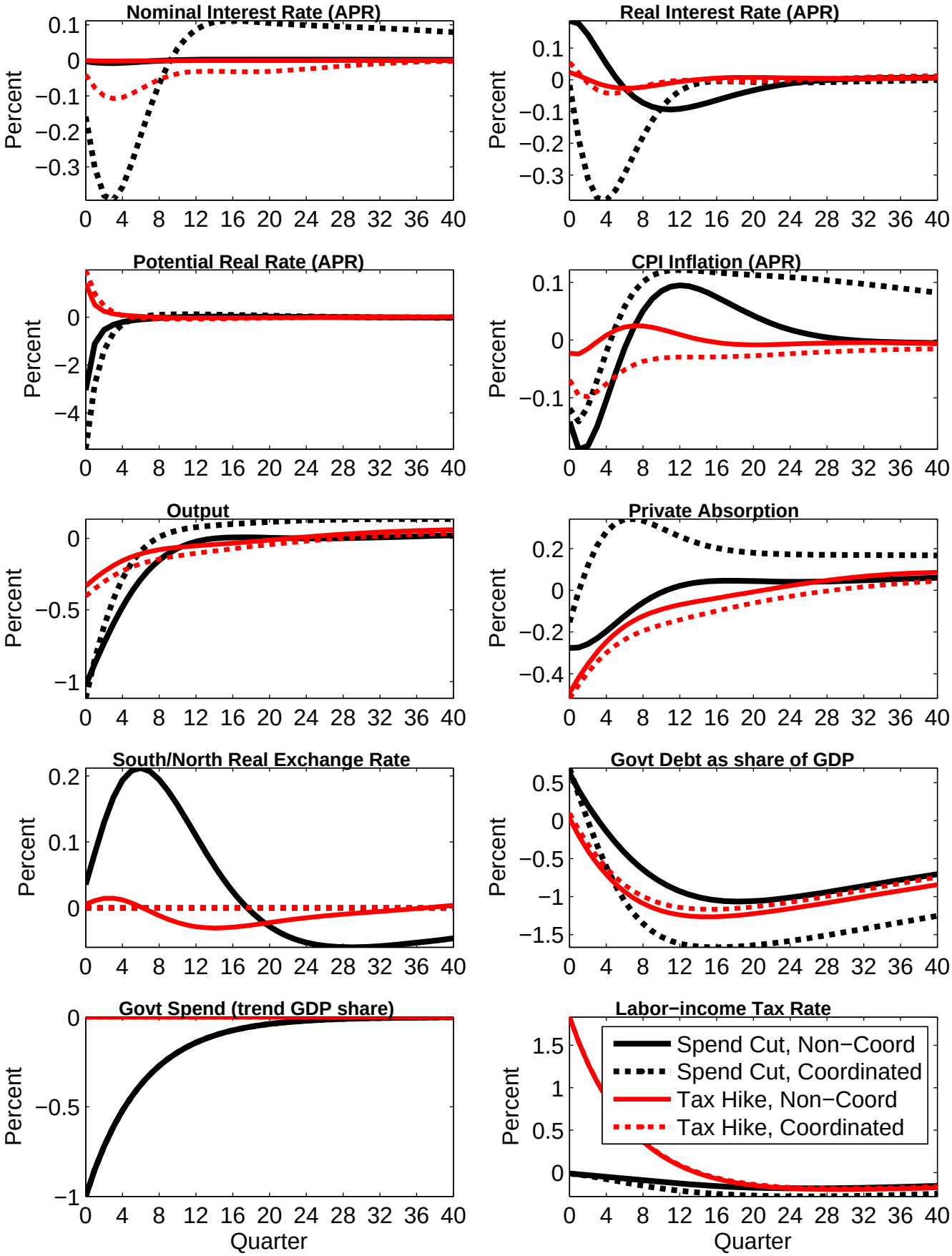

Figure 8: Marginal Output and Government Debt Multipliers in South to Less Persistent Coordinated and Non−Coordinated Spending Cuts and Labor Tax Hikes in a Currency Union as Function of the Expected Liquidity Trap Duration Absent Any Fiscal Actions.

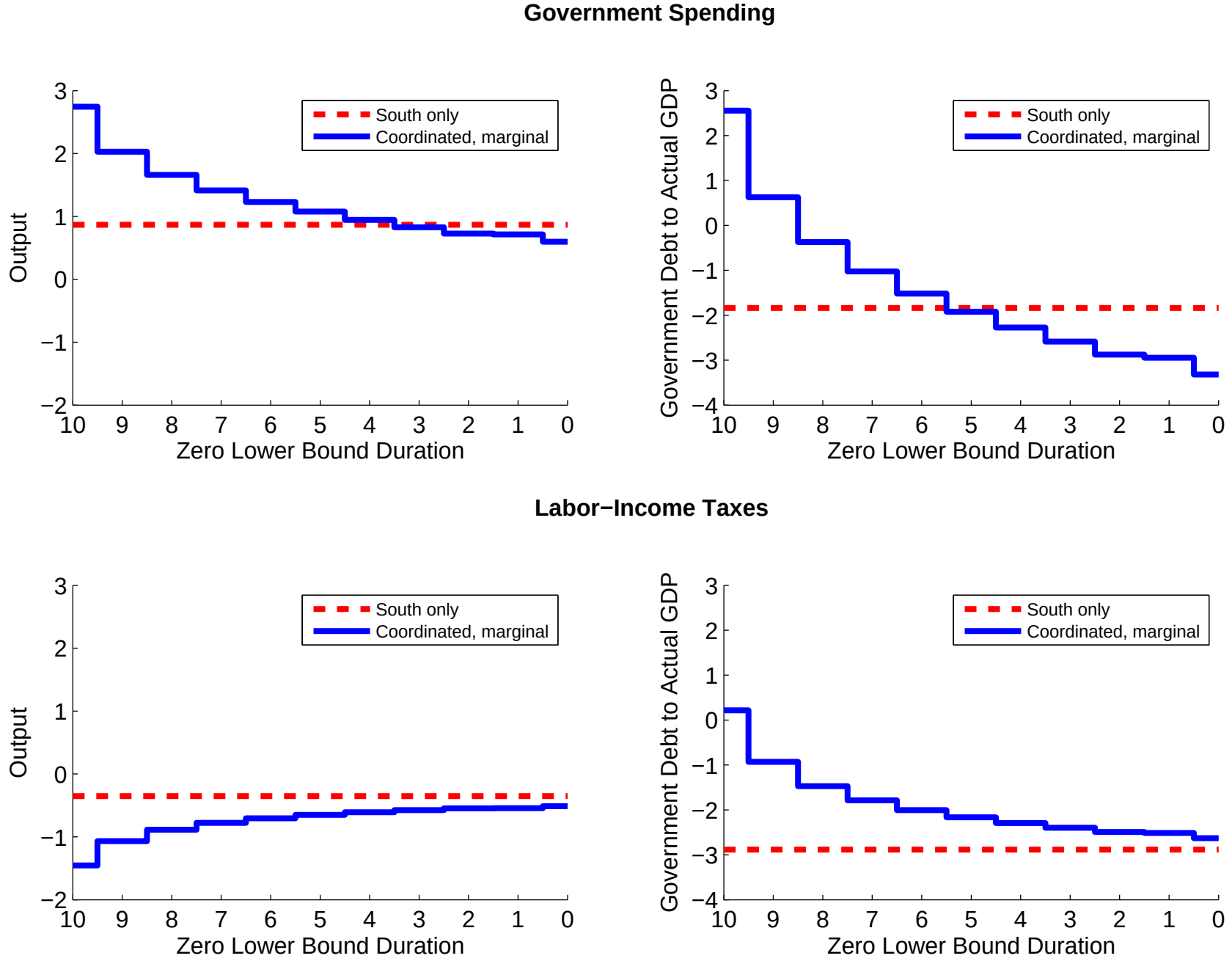

Figure 9: Marginal Output and Government Debt Multipliers in South to Coordinated and Non−Coordinated Spending Cuts and Labor Tax Hikes in a Currency Union as Function of the Expected Liquidity Trap Duration Absent Any Fiscal Actions: No Hand−to−Mouth Households in the Model.

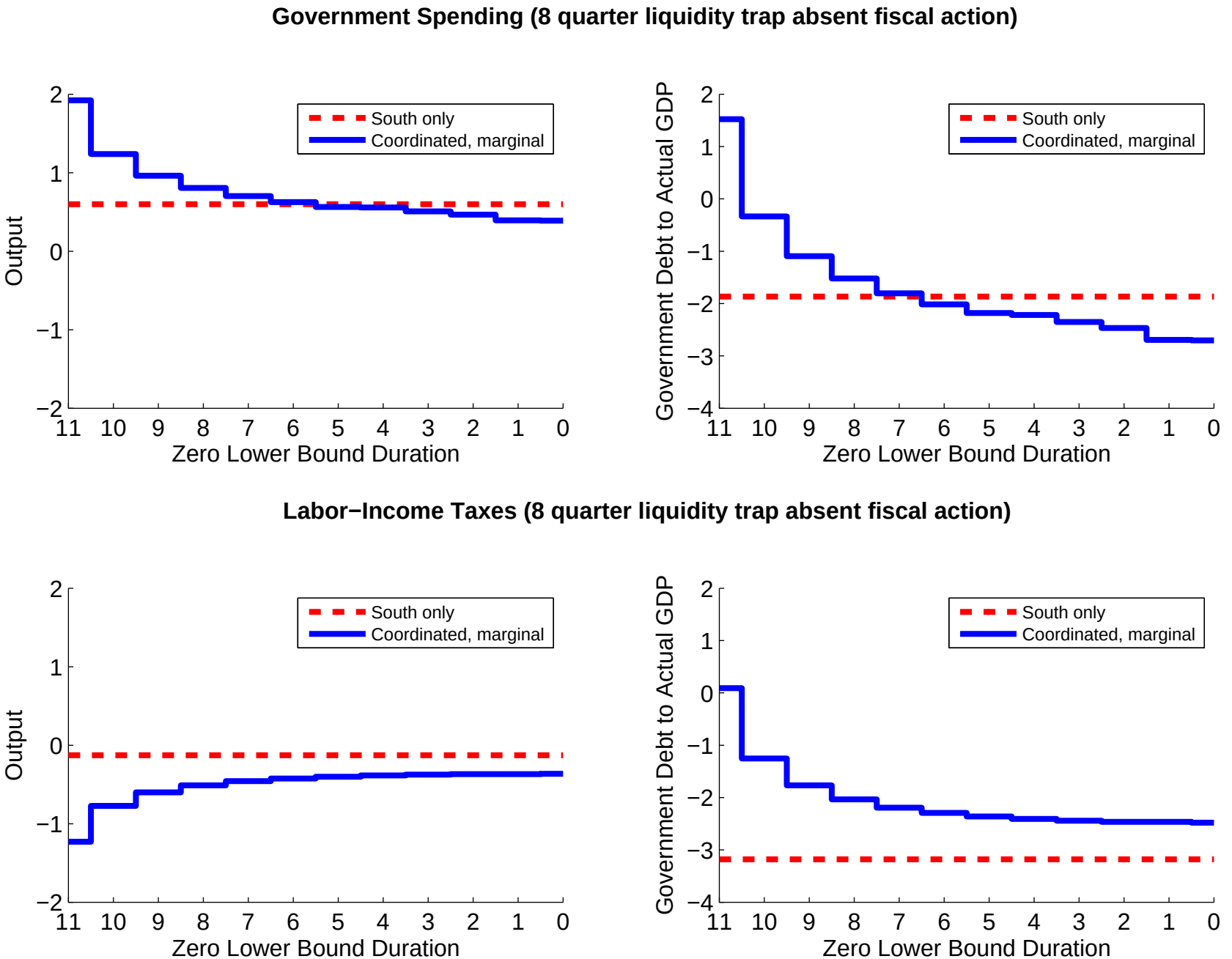

Figure 10: Responses in South to Non−Coordinated (South only) Spending Cuts and Labor−Tax Hikes in a Currency Union With and Without an Endogenous Response of Interest Rate Spreads.

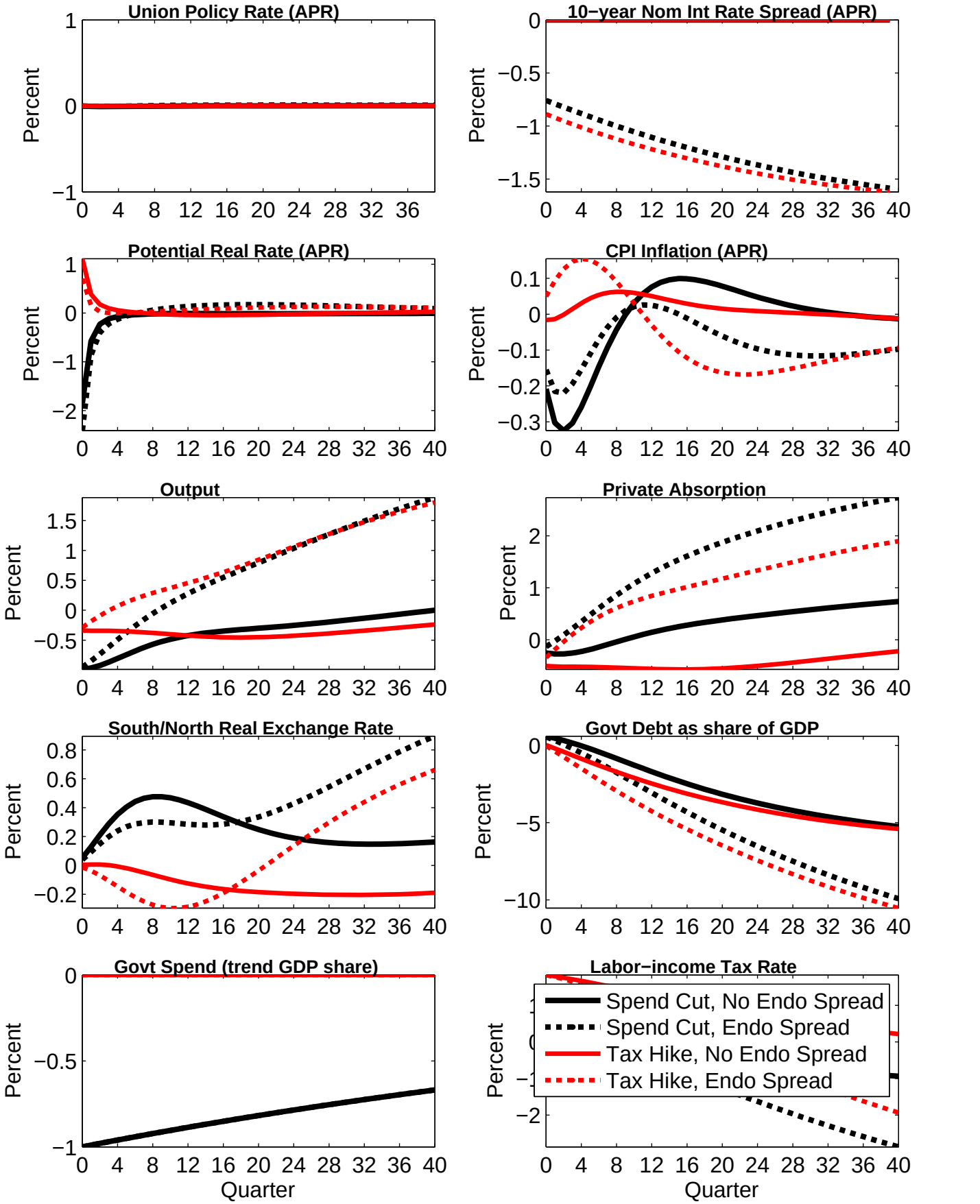

Figure 11: Responses in South to Non−Coordinated (South only) and Coordinated Spending Cuts and Labor−Tax Hikes in a Currency Union Where South Spreads are Endogenous: Liquidity Trap Expected to Last 8 Quarters Absent Any Fiscal Actions.