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MACROECONOMIC EFFECTS OF SIMULTANEOUS IMPLEMENTATION OF REFORMS AFTER THE CRISIS

by Andrea Gerali *, Alessandro Notarpietro* and Massimiliano Pisani*

Abstract

This paper evaluates the macroeconomic effects of simultaneously implementing fiscal consolidation and competition-friendly reforms in a country of the euro area by simulating a large-scale dynamic general equilibrium model. We find, first, that the joint implementation of reforms has additional expansionary effects on long-run economic activity. Increasing competition in the service sector favors a higher income tax base. Given the targeted public debt-to-GDP ratio, labor and capital income tax rates can be reduced more than with fiscal consolidation alone. Second, fiscal consolidation has non-negligible medium-run costs; however, they are reduced by joint implementation with the services reform. The results are robust to alternative assumptions that capture the impact of financial crisis on the financing conditions of households.

JEL Classification: C51, E30, E63.
Keywords: competition, fiscal policy, markups, monetary policy, public debt, spread.

Contents

* Bank of Italy, Economic Outlook and Monetary Policy Department.

Fiscal consolidation should be designed in a growth friendly manner while structural reforms will boost potential growth.

European Central Bank President Mario Draghi, Hearing at the Committee on Economic and Monetary Affairs of the European Parliament, Brussels, 3 March 2014.

1 Introduction

Two legacies of the recent European sovereign crisis are the high level of public debt and the persistently weak economic performance.[1] They will probably condition the European economic outlook for several years to come and are closely related. Public debt consolidation should be achieved by limiting the increase in tax rates, which could further jeopardize European economic performance.[2] At the same time, restoring high economic growth helps to increase the tax base and, hence, to contain the increase in tax rates needed to improve public finances.

The close connection between public debt sustainability and growth performance calls for the appropriate set of policies to be found, in particular, and crucially, for possible synergies across policies to foster a structural (supply-side) improvement of the European economy.

This paper evaluates the macroeconomic effects of simultaneously implementing growth-friendly fiscal consolidation and competition-friendly reforms in one European country by simulating a large-scale dynamic general equilibrium model.

The assessment is based on simulating a three-country large-scale new-Keynesian dynamic general equilibrium model of one country in the euro area (labelled "Home"), the rest of the euro area (REA) and the rest of the world (RW) economy, akin to the Eurosystem EAGLE (Euro Area and Global Economy model, see Gomes et al., 2010).[3] The euro area (EA) is a two-region monetary union and therefore has a common monetary policy and nominal exchange rate against

[1]The views expressed in this paper are those of the authors alone and should not be attributed to the Bank of Italy. We thank Alberto Locarno, Giuseppe Ferrero, Henrik Kucsera, Eva Ortega, Máté Tóth, two anonymous referees and participants at 2014 Royal Economic Society Conference; Magyar Nemzeti Bank 12th Macroeconomic Policy Research Workshop on Growth, Rebalancing and Macroeconomic Adjustment after Large Shocks, Bank of Italy seminar, Working Group on Econometric Modelling of the European System of Central Bank (2014), 2014 Central Bank Macroeconomic Modelling Workshop.

[2]According to the Europe 2020 Strategy "raising taxes on labour, as has occurred in the past at great costs to jobs, should be avoided". See European Commission (2010).

[3]See also the Global Economic Model developed at the International Monetary Fund (see Laxton and Pesenti 2003 and Pesenti 2008) and the New Area Wide Model developed at the European Central Bank (see Christoffel et al., 2008 and Coenen et al., 2008).

the RW block (the latter has its own monetary policy and currency). The model features country-specific public sectors and monopolistic competition in product and labor markets. The public sector has lump-sum transfers and public consumption on the expenditure side and, crucially, (distortionary) taxes on labor income, capital income and consumption on the revenue side. Public debt is stabilized through a fiscal rule, that accordingly sets one of the available fiscal items to hit the public debt target and stabilize the public deficit. Monopolistic competition in the product (labor) market is formalized by a mark-up between the marginal cost (marginal rate of substitution between consumption and leisure) and prices (wages). In this framework, mark-ups are inversely related to the degree of substitutability across product and labor varieties, and hence the underlying level of competition. Given the presence of nontradables, we can analyze the effects of increasing the degree of competition in the service sector, traditionally considered mainly nontradable. Finally, the inclusion of the RW allows for a full characterization of trade flows. All simulations are run under the assumption of perfect foresight. As such, fiscal and competition-friendly reforms are fully credible, there is no uncertainty and households and firms anticipate the transition paths and the final equilibria.

We initially simulate fiscal consolidation strategies based on labor or, alternatively, capital income taxes to permanently reduce the public debt-to-(annualized) GDP ratio by 10 percentage points over a ten-year period. This means that, in the case of labor (capital) income tax-based consolidation, the adjusted instrument in the fiscal rule is the labor (capital) tax rate. Initially the rule commands an increase in labor (capital) tax rate. As the reduction in the debt-to-GDP ratio and in the implied interest payment progress, new fiscal room is created to actually reduce tax rates. The resulting path of tax rates is typically hump-shaped and the consolidation ends up by reducing the labor (capital) tax rate on a permanent basis.

Next, we evaluate the macroeconomic impact of competition friendly-reforms in the service sector. The sector-specific (gross) mark-up is gradually reduced by 5 percentage points over a ten-year-period. The effects of the reform are evaluated first in isolation and then, crucially for the goal of this paper, combined with the consolidation of public debt.

A final set of simulations evaluates the robustness of short-to-medium term results to alternative assumptions that capture the impact of the financial crisis on the financing conditions of

households. First, in the spirit of Corsetti et al. (2012) and following Locarno et al. (2013), it is assumed that the "sovereign risk channel" of public debt holds in the Home country (but neither in the REA nor in the RW), i.e. the domestic government and households pay a premium, on top of the risk-free rate, that reflects the risk of sovereign default and is linked to the expected fiscal deficit. When the channel is active, the consolidation of public debt, by reducing expected future deficits, favors the reduction in the spread and, hence, in the rate paid by the government and households' sector when borrowing. The economy would therefore benefit from the reduction in the spread associated with the consolidation. The second assumption is that the (EA-wide) monetary policy rate does not follow the standard Taylor rule but is held constant at its baseline level, in the spirit of the ongoing debate on the effects of zero lower bound (ZLB). Similarly to the spread, the ZLB affects the financing conditions of households and hence the response of the main macroeconomic variables to the consolidation and the competition reform.

Our results are as follows.

First, in the long run GDP increases by 2.3 and 4.9 percent in the case of the services reform jointly implemented with the labor income tax based and capital income tax based consolidation, respectively. GDP increases by 0.3 and 1.2 percent respectively of the initial level in the case of labor income and capital income tax based consolidations implemented in isolation. Similarly, the increase in the service sector competition favors the increase in GDP by 1.3 percent. The joint implementation of public debt consolidation and competition reform has further, additional expansionary effects. Indeed, increasing competition in the service sector has not only a positive direct effect on output but also an indirect one. The higher output implies a higher labor income and capital income tax base. For a given target of the public debt-to-GDP ratio, in the long run it is possible to reduce the tax rates by more than with isolated fiscal consolidation. The additional reduction in taxation further stimulates economic activity.

Second, in the medium run the output loss, associated with the temporary increase in taxes during the consolidation, is partly mitigated by the joint implementation with the services reform. Competition-friendly reforms partially counterbalance the recessionary effects of the increase in tax rates, limiting the decrease in the income tax base. This makes it possible to limit the increase in tax rates needed to reduce public debt.

Third, short- and medium-term macroeconomic effects are robust to the introduction of the sovereign risk channel and the ZLB.

Our paper is related to several contributions in the literature. Forni et al. (2010a, b) and Lusinyan and Muir (2013) evaluate the macroeconomic impact of structural reforms and fiscal consolidation in Italy. Gomes et al. (2013) evaluate the macroeconomic impact of enhancing competition in the German labor market and service sector. Unlike these papers, we analyze the interaction between structural reform in the service sector and fiscal consolidation. Synergies across policies are also analyzed by Fiori et al. (2012). They investigate the effect of product market liberalisation on employment and consider possible interactions between policies and institutional changes in product and labour markets. Our contribution focuses on the interaction between fiscal consolidation and liberalisation. Moreover, we assess the extent to which the households' financing conditions affect the short- and medium-run macroeconomic effects of simultaneously implementing the reforms. From this perspective, our paper is related to Corsetti et al. (2012), who evaluate the impact of strained government finances on macroeconomic stability and the transmission of fiscal policy, by studying the "sovereign risk channel" through which sovereign default risk raises funding costs in the private sector. We build on their contribution by introducing in our model the "sovereign risk channel". Unlike them, our contribution is quantitative. Fernández-Villaverde et al. (2012) and Eggertson et al. (2014) assess the short-run impact of structural reforms in a large part of the EA when monetary policy is constrained by the ZLB. Unlike them, we focus on a single, relatively small, member country.

The paper is organized as follows. Section 2 reports the main theoretical features of the model setup and the calibration. In particular, it shows equations of the fiscal sector, the imperfect competition regime in the service sector, the formalization of sovereign spread and ZLB. Section 3 reports the main results of implementing the reforms. Section 4 contains a robustness analysis to assess the role of the "sovereign risk channel" and the ZLB. Section 5 concludes. Finally, the Appendix reports other equations of the model.

2 The model

An overview of the model is initially reported. Subsequently, the crucial features for the simulations are illustrated, i.e. how taxes, monopolistic competition, sovereign spread and monetary policy rate affect choices of households. Finally, the calibration is reported.

2.1 Overview

The model represents a world economy composed by three regions: Home, REA and RW. In each region there is a continuum of symmetric households and symmetric firms. Home households are indexed by $j \in [0; s]$, households in the REA by $j^* \in (s; S]$, households in the RW by $j^{**} \in (S; 1]$.[4]

Home and the REA share the currency and the monetary authority. The latter sets the nominal interest rate according to EA-wide variables. The presence of the RW outside the EA allows to assess the role of the nominal exchange rate and extra-EA trade. In each region there are households and firms. Households consume a final good, which is a composite of intermediate nontradable and tradable goods. The latter are domestically produced or imported. Households trade a one-period nominal bond, denominated in euro. They also own domestic firms and use another final good (different from the final consumption good) to invest in physical capital. The latter is rented to domestic firms in a perfectly competitive market. All households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive labor markets by charging a mark-up over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce two final goods (consumption and investment goods) and monopolistic firms that produce intermediate goods. The two final goods are sold domestically and are produced combining all available intermediate goods using a constant-elasticity-of-substitution (CES) production function. The two resulting bundles can have different composition. Intermediate tradable and nontradable goods are pro-

[4]The parameter s is the size of the Home population, which is also equal to the number of firms in each Home sector (final nontradable, intermediate tradable and intermediate nontradable). Similar assumptions holds for the REA and the RW.

duced combining domestic capital and labor, that are assumed to be mobile across sectors. Intermediate tradable goods can be sold domestically and abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We also assume that markets for tradable goods are segmented, so that firms can set three different prices, one for each market. In line with other dynamic general equilibrium models of the EA (see, among the others, Christoffel et al. 2008 and Gomes et al. 2010), we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption, production and prices react in a gradual way. On the real side, habit preferences and quadratic costs prolong the adjustment of households consumption and investment, respectively. On the nominal side, quadratic costs make wages and prices sticky.[5]

2.2 Public debt consolidation and tax rates

Public debt consolidation affects households' choices through the implied change in the tax rates. Fiscal policy is set at the regional level. The government budget constraint is:

$$\frac{B_{t+1}^g}{R_t^H} - B_t^g \leq (1+\tau_t^c) P_{N,t} C_t^g + Tr_t - T_t \tag{1}$$

where $B_t^g \geq 0$ is nominal public debt. It is a one-period nominal bond issued in the EA-wide market that pays the gross nominal interest rate R_t^H. The variable C_t^g represents government purchases of goods and services, $Tr_t > 0$ (< 0) are lump-sum transfers (lump-sum taxes) to households. Consistent with the empirical evidence, C_t^g is fully biased towards the intermediate nontradable good. Hence it is multiplied by the corresponding price index $P_{N,t}$.[6]

We assume that the same tax rates apply to every household. Total government revenues T_t from distortionary taxation are given by the following identity for the case of Home (similar expressions hold for REA and RW):

$$T_t \equiv \int_0^s \left(\tau_t^\ell W_t(j) L_t(j) + \tau_t^k \left(R_t^k K_{t-1}(j) + \Pi_t^P(j)\right) + \tau_t^c P_t C_t(j)\right) dj - \tau_t^c P_{N,t} C_t^g \tag{2}$$

where τ_t^ℓ is the tax rate on individual labor income $W_t(j) L_t(j)$, τ_t^k on capital income $R_t^k K_{t-1}(j)+$

[5] See Rotemberg (1982).
[6] See Corsetti and Mueller (2006).

$\Pi_t^P(j)$ and τ_t^c on consumption $C_t(j)$. The variable $W_t(j)$ represents the individual nominal wage, $L_t(j)$ is individual amount of hours worked, R_t^k is the rental rate of existing physical capital stock $K_{t-1}(j)$, $\Pi_t^P(j)$ stands for dividends from ownership of domestic monopolistic firms (they are equally shared across households) and P_t is the price of the consumption bundle.

The government follows a fiscal rule defined on a single fiscal instrument to bring the public debt as a percent of domestic GDP, $b^g > 0$, in line with its target $\bar{b}^g$ and to limit the increase in public deficit as ratio to GDP (b_t^g/b_{t-1}^g):[7]

$$\frac{i_t}{i_{t-1}} = \left(\frac{b_t^g}{\bar{b}^g}\right)^{\phi_1} \left(\frac{b_t^g}{b_{t-1}^g}\right)^{\phi_2} \tag{4}$$

where i_t is one of the five fiscal instruments among three tax rates ($\tau_t^\ell, \tau_t^k, \tau_t^c$) and the two expenditure items (C_t^g, Tr_t). Parameters ϕ_1, ϕ_2 are lower than zero when the rule is defined on an expenditure item, calling for a reduction in expenditures whenever the debt level is above target and for a larger reduction whenever the dynamics of the debt is not converging. To the contrary, they are greater than zero when the rule is on tax rates.

The simulation of Home fiscal consolidations implies that the target on government debt, $\bar{b}^g$, is gradually and permanently reduced. The adjusted instrument is the labor income tax or, alternatively, the capital income tax rate. Initially, tax rates are raised to favour the decrease in public debt. The achievement of the new lower target implies lower interest payment, which allows for an endogenous permanent reduction in the fiscal instrument. Fiscal instruments other than the one in the rule are kept constant at their corresponding initial steady-state (baseline) level. For REA and RW, it is always lump-sum transfers to adjust.

2.3 Competition-friendly reform in the service sector

The other building block of the simulations is the reform in the Home service sector. There is a large number of firms offering a continuum of different services that are imperfect substitutes. Each product is made by one monopolistic firm, which sets prices to maximize profits. The

[7] The definition of nominal GDP is:

$$GDP_t = P_t C_t + P_t^I I_t + P_{N,t} C_t^g + P_t^{EXP} EXP_t - P_t^{IMP} IMP_t \tag{3}$$

where P_t, P_t^I, P_t^{EXP}, P_t^{IMP} are prices of consumption, investment, exports and imports, respectively.

elasticity of substitution between services of different firms determines the market power of each firm. In the long-run flexible-price steady state, the following first order condition for price setting holds for firms producing services:

$$\frac{P_N}{P} = \frac{\theta_N}{\theta_N - 1} \frac{MC_N}{P}, \theta_N > 1 \tag{5}$$

where P_N/P is the relative price of the generic service and MC_N/P is the real marginal cost. The mark-up is $\theta_N/(\theta_N - 1)$ and depends negatively on the elasticity of substitution between different services, θ_N. The higher the degree of substitutability, the lower the implied mark-up and the higher the production level, for a given price. As such, the long-run mark-up reflects imperfect competition. The short-run mark-up does reflect not only the elasticity of substitution between goods produced in the same sector, but also the (sector-specific) nominal rigidities (adjustment costs on nominal prices). In the simulations we gradually and permanently increase the elasticity of substitution among Home intermediate nontradable goods (our proxy for services) to augment the degree of competition in that sector.[8]

2.4 Further characterization of the crisis: "sovereign risk channel" and EA-wide ZLB

2.4.1 "Sovereign risk channel"

To further characterize the macroeconomic effects of the policy measures during the crisis periods, in the Section "Robustness" we consider the so-called "sovereign risk channel". In the spirit of Corsetti et al. (2012), the interest rate paid by the domestic government and households when borrowing is determined as a spread over the EA risk-free nominal interest rate. The (gross) spread reflects the risk of sovereign default and is linked to (expected) variations in the fiscal deficit:

$$spread_t^H = f\left(E_t\left\{\frac{b_{t+1}^g}{b_t^g}\right\}\right) \tag{6}$$

The term on the right-hand side includes (expected) changes in the public debt-to-GDP ratio, where $b_{t+1}^g > 0$ is the public debt-to-GDP ratio at the beginning of period $t+1$. As such, the

[8] An equation similar to (5) holds for intermediate tradable goods.

(gross) interest rate R^H is:

$$R_t^H \equiv R_t * spread_t^H \tag{7}$$

where R_t is the (gross) risk-free nominal interest rate, which is the policy rate set by the EA monetary authority. When the channel is active, the interest rate R_t^H is paid not only by the Home government, but also by Home households. It is assumed that changes in government spread are immediately and fully passed-through into interest rates paid by households. Such assumption simplifies the formalization of the impact of sovereign spreads on private sector funding costs and is in line with the empirical evidence. The discretionary consolidation of public debt, by reducing expected future deficits, favours the reduction in the spread and, hence, in the rate R_t^H paid by the Home government and households.

2.4.2 The ZLB

Similarly, in the robustness analysis we evaluate the macroeconomic effects of the reforms when the ZLB on monetary policy holds. The monetary policy rate is stuck at the ZLB or is controlled by the monetary authority according to a standard Taylor rule:

$$\left(\frac{R_t}{\bar{R}}\right) = \max\left(1, \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \left(\frac{\Pi_{EA,t}}{\bar{\Pi}_{EA}}\right)^{(1-\rho_R)\rho_\pi} \left(\frac{GDP_{EA,t}}{GDP_{EA,t-1}}\right)^{(1-\rho_R)\rho_{GDP}}\right) \tag{8}$$

where R_t is the gross monetary policy rate. The parameter ρ_R $(0 < \rho_R < 1)$ captures inertia in interest rate setting, while the term $\bar{R}$ represents the steady state gross nominal policy rate. The parameters ρ_π and ρ_{GDP} are respectively the weights of EA consumer price index (CPI) inflation rate $(\Pi_{EA,t})$ (taken as a deviation from its long-run constant target $\bar{\Pi}_{EA}$) and GDP $(GDP_{EA,t})$. The CPI inflation rate is a geometric average of Home and REA CPI inflation rates (respectively Π_t and Π_t^*) with weights equal to the correspondent country size (as a share of the EA GDP):

$$\Pi_{EA,t} \equiv (\Pi_t)^{\frac{s}{s+S}} (\Pi_t^*)^{\frac{S}{s+S}} \tag{9}$$

The EA GDP, $GDP_{EA,t}$, is the sum of Home and REA GDPs (respectively GDP_t and GDP_t^*):

$$GDP_{EA,t} \equiv GDP_t + GDP_t^* \tag{10}$$

When the policy rate exits from the ZLB, it reverts to the Taylor rule.

2.5 The impact on households' decisions

Households' preferences are additively separable in consumption and labor effort. The generic household j receives utility from consumption C and disutility from labor L. The expected lifetime utility is:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t\left(j\right) - hC_{t-1}\right)^{1-\sigma}}{\left(1-\sigma\right)} - \frac{L_t\left(j\right)^{1+\tau}}{1+\tau} \right] \right\} \tag{11}$$

where E_0 denotes the expectation conditional on information set at date 0, β is the discount factor ($0 < \beta < 1$), $1/\sigma$ is the elasticity of intertemporal substitution ($\sigma > 0$) and $1/\tau$ is the labor Frisch elasticity ($\tau > 0$). The parameter h ($0 < h < 1$) represents external habit formation in consumption.

The budget constraint is:

$$\begin{aligned} \frac{B_t\left(j\right)}{\left(1+R_t^H\right)} - B_{t-1}\left(j\right) \quad \leq \quad & \left(1-\tau_t^k\right)\left(\Pi_t^P\left(j\right) + R_t^K K_{t-1}\left(j\right)\right) + \\ & + (1-\tau_t^\ell) W_t\left(j\right) L_t\left(j\right) - (1+\tau_t^c) P_t C_t\left(j\right) - P_t^I I_t\left(j\right) \\ & + Tr_t\left(j\right) - AC_t^W\left(j\right) \end{aligned}$$

Home households hold a one-period bond, B_t, denominated in euro ($B_t > 0$ is a lending position).[9] The related short-term nominal rate is R_t^H. It depends not only on the monetary policy rate, set by the EA monetary authority, but also, in the case of Home households, on the spread. Households own all domestic firms and there is no international trade in claims on firms' profits. The variable Π_t^P includes profits accruing to the households. The variable I_t is the investment bundle in physical capital. The variable P_I is the price of the investment bundle.[10] Households

[9] We assume that government and private bonds are traded in the same international market. The bond traded by households and governments is in worldwide zero net supply. The implied market clearing condition is:

$$-B_t^g + \int_0^s B_t\left(j\right) dj - B_t^{g*} + \int_s^S B_t\left(j^*\right) dj^* - B_t^{g**} + \int_S^1 B_t\left(j^{**}\right) dj^{**} = 0 \tag{12}$$

where $B_t^{g*}, B_t^{g**} > 0$ are respectively the amounts of borrowing of the REA and RW public sectors, while $B_t\left(j^*\right)$ and $B_t^{**}\left(j^{**}\right)$ are respectively the per-capita bond positions of households in the REA and in the RW. A financial friction μ_t is introduced to guarantee that net asset positions follow a stationary process and the economy converges to a steady state. Revenues from financial intermediation are rebated in a lump-sum way to households in the REA. See Benigno (2009).

[10] As for the consumption basket, the investment bundle is a composite of tradable and nontradable goods. The

accumulate physical capital K_t and rent it to domestic firms at the nominal rate R_t^k.

The law of motion of capital accumulation is:

$$K_t(j) \leq (1-\delta) K_{t-1}(j) + \left(1 - AC_t^I(j)\right) I_t(j) \tag{13}$$

where $0 < \delta < 1$ is the depreciation rate. Adjustment cost on investment AC_t^I is:

$$AC_t^I(j) \equiv \frac{\phi_I}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)^2,\ \phi_I > 0 \tag{14}$$

Finally, households act as wage setters in a monopolistic competitive labor market. Each household j supplies one particular type of labor services that are imperfect substitutes to services supplied by other households. She sets her nominal wage taking into account labor demand and adjustment costs AC_t^W on the nominal wage $W_t(j)$:

$$AC_t^W(j) \equiv \frac{\kappa_W}{2}\left(\frac{W_t(j)/W_{t-1}(j)}{\Pi_{W,t-1}^{\alpha_W}\bar{\Pi}_{EA}^{1-\alpha_W}} - 1\right)^2 W_t L_t,\ \kappa_W > 0 \tag{15}$$

where $0 \leq \alpha_W \leq 1$ is a parameter, the variable $\Pi_{W,t}^{\alpha_W} \equiv W_t/W_{t-1}$ is the wage inflation rate. The adjustment costs are proportional to the per-capita wage bill of the overall economy, $W_t L_t$.

2.5.1 Consolidation, tax rates and synergy with the competition reform

Fiscal consolidation, by changing tax rates, affects households' optimal choices. Let us consider taxes on labor. Each household offers a specific kind of labor services that is an imperfect substitute for services offered by other households and set its wage to maximize utility. The elasticity of substitution between labor varieties determines the related market power. The first order condition for labor supply, L, in the (flexible-price symmetric) steady-state equilibrium is:

$$\frac{W}{P}\left(1 - \tau^{\ell}\right) = \frac{\theta_L}{\theta_L - 1} C^{\sigma} L^{\tau}, \theta_L > 1 \tag{16}$$

where W/P is the real wage (expressed in units of domestic consumption). Fiscal consolidation, by reducing the public debt and the related interest payment, creates room to reduce τ_t^{ℓ} in the

composition of consumption and investment goods can be different.

long run. Ceteris paribus, the after-tax real wage $W\left(1-\tau^{\ell}\right)/P$ would increase and, hence, labor supply would increase as well. A similar short-run condition holds, that differs from its long-run counterpart only because adjustment costs on nominal wages affect the (short-run) mark-up jointly with the elasticity of substitution. In the short run the labor income tax rate has to be increased to reduce public debt, as commanded by equation (4). This has recessionary effects on the economy, as it induces households to temporarily reduce labor supply.

Similarly, the tax rate on capital income, τ^K, affects the long-run (steady-state) value of the implied after-tax income through the following first order condition for capital:

$$r^K\left(1-\tau^K\right)=\frac{1-\beta\left(1-\delta\right)}{\beta}P_I$$

As for labor income tax, the reduction in public debt and in the related interest payment allow to reduce the tax rate on physical capital in the long run. This would increase, ceteris paribus, the after-tax rental rate $r^K\left(1-\tau^K\right)$ and hence would favour investment. A similar condition holds in the short run, that differs from its long-run counterpart because of adjustment costs on investment, that introduce a "wedge" (proportional to the "Tobin's Q") between the real interest rate on bonds and real rental rate of capital. In the short run the capital income tax rate has to be increased to reduce public debt, as commanded by equation (4). This has recessionary effects on the economy, as it induces households to reduce investment.

The reform in the service sector does affect the economy not only directly, but also through its synergies with the fiscal consolidation. The reform reduces the mark-up and hence the price of intermediate nontradable goods (see equation 5). Intermediate nontradable goods enter the final consumption and investment basket and reduce their prices.[11] Households have an incentive to increase consumption and investment, stimulating the economy. The implied increase in GDP is the source of synergy with the fiscal consolidation. The higher GDP implies a larger income tax base. Given the target for public debt-to-GDP ratio, labor or capital income tax rates can be further reduced in the long run and, hence, provide an additional stimulus to the economy.

The additional benefit of the synergy shows up not only in the long run but also in the medium run. The fiscal rule (4) calls for an initial increase in tax rates to reduce public debt as a

[11] See the Appendix for details on the final consumption and investment basket composition.

ratio to GDP. The reform partially counterbalances the recessionary effects of the consolidation, limiting the reduction in the income tax base. As such, the initial increase in tax rates is lower when the competition-friendly reform is implemented.

2.5.2 Spread and monetary policy rate

Spread and ZLB affect domestic households decisions through the cost of borrowing. Home households face the interest rate R_t^H (see equation 7), which is equal to the product of the monetary policy rate and the spread. The implied Euler equation (obtained by maximizing utility subject to the budget constraint with respect to the bond holdings B_t) is:

$$\lambda_t = \beta E_t \left(R_t^H \frac{(1+\tau_t^c)P_t}{(1+\tau_{t+1}^c)P_{t+1}} \lambda_{t+1} \right) \tag{17}$$

where λ is the marginal utility of household's consumption.[12] The higher the spread, the higher the interest rate R^H and hence the larger the incentive for households to postpone consumption. Similarly, when the EA-wide policy rate is stuck at the ZLB, a country-specific shock that lowers (increases) the expected country-specific inflation would increase the (country-specific) real interest rate and, hence, induce households to postpone consumption.

Similar relations hold in the REA and in the RW with two exceptions, both related to the sovereign spreads. First, neither the public nor the private sectors in the REA and RW pay the spread when borrowing. So it is the riskless interest rate that appears in the corresponding Euler equations. Second, the spread paid by Home households and government are rebated in a lump-sum way to households in the REA.

2.6 Calibration

The model is calibrated at quarterly frequency. We assume that the "representative" Home country is characterized by a high level of public debt and low competition in several economic sectors. We set some parameter values so that steady-state ratios are consistent with average euro-area 2012 national account data, which are the most recent and complete available data. For

[12] The consumption tax rate, τ^c, is held constant at its (initial) steady state level in all scenarios.

remaining parameters we resort to previous studies and estimates available in the literature.[13]

Table 1 contains parameters that regulate preferences and technology. Parameters with "$*$" and "$**$" are related to the REA and the RW, respectively. Throughout we assume perfect symmetry between the REA and the RW, unless differently specified. We assume that discount rates and elasticities of substitution have the same value across the three regions. The discount factor β is set to 0.9927, so that the steady state real interest rate is equal to 3.0 per cent on an annual basis. The value for the intertemporal elasticity of substitution, $1/\sigma$, is 1. The Frisch labor elasticity is set to 0.5. The depreciation rate of capital δ is set to 0.025. Habit is set to 0.6.

In the production functions of tradables and nontradables, the elasticity of substitution between labor and capital is set to 0.93. To match investment-to-GDP ratios, the bias towards capital in the production function of tradables is set to 0.56 in Home and, in the REA and in the RW, to 0.46. The corresponding value in the production function of nontradables is set to 0.53 in Home and 0.43 in the REA and RW. In the final consumption and investment goods the elasticity of substitution between domestic and imported tradable is set to 1.5, while the elasticity of substitution between tradables and nontradables to 0.5, as empirical evidence suggests that it is harder to substitute tradables for nontradables than to substitute across tradables. The biases towards the domestically produced good and composite tradable good are chosen to match the Home and REA import-to-GDP ratios. In the consumption bundle the bias towards the domestic tradeable is 0.68 in Home, 0.59 in the REA and 0.90 in the RW. The bias towards the composite tradeable is set to 0.68 in Home, to 0.50 in the REA and the RW. For the investment basket, the bias towards the domestic tradeable is 0.50 in Home, 0.49 in the REA and 0.90 in the RW. The bias towards the composite tradable is 0.78 in Home, 0.70 in the REA and in the RW.

Table 2 reports gross mark-up values. In the Home tradable and nontradable sectors and in the Home labor market the mark-up is set to 1.08, 1.29 and 1.60, respectively (the corresponding elasticities of substitution across varieties are set to 13.32, 4.44 and 2.65). In the REA tradable and nontradable sectors and in the REA labor market the gross mark-ups are respectively set to 1.11, 1.24 and 1.33 (the corresponding elasticities are set to 10.15, 5.19 and 4.00). Similar values are chosen for the corresponding parameters in the RW.

[13] See the New Area Wide Model (NAWM, Christoffel et al. 2008) and Euro Area and Global Economy Model (EAGLE, Gomes et al. 2010)

Table 3 contains parameters that regulate the dynamics. Adjustment costs on investment change are set to 6. Nominal wage quadratic adjustment costs are set to 200. In the tradable sector, we set the nominal adjustment cost parameter to 300 for Home tradable goods sold domestically and in the REA; for Home goods sold in the RW, the corresponding parameter is set to 50. The same parameterization is adopted for the REA, while for the RW we set the adjustment cost on goods exported to Home and the REA to 50. Nominal price adjustment costs are set to 500 in the nontradable sector. The two parameters regulating the adjustment cost paid by the private agents on their net financial position are set to 0.00055 so that they do not greatly affect the model dynamics.

Table 4 reports parametrization of the systematic feedback rules followed by the fiscal and monetary authorities. In the fiscal policy rule (4) we set $\phi_1 = 0.05$, $\phi_2 = 1.01$ for Home and $\phi_1 = \phi_2 = -1.01$ for the REA and the RW. The instrument in the Home fiscal rule depends on the simulated consolidation. In the case of labor (capital) income tax-based consolidation, the adjusted instrument is the labor (capital) tax rate. When the services reform is implemented in isolation, the adjusted instruments are lump-sum transfers, so that the effects of the structural reform are not affected by fiscal policy (the Ricardian equivalence holds). For REA and RW, it is always lump-sum transfers to adjust. The central bank of the EA targets the contemporaneous EA-wide consumer price inflation (the corresponding parameter is set to 1.7) and the output growth (the parameter is set to 0.1). Interest rate is set in an inertial way and hence its previous-period value enters the rule with a weight equal to 0.87. Same values hold for the corresponding parameters of the Taylor rule in the RW.

Table 5 reports the actual great ratios and tax rates, which are matched in the model steady state under our baseline calibration. We assume a zero steady state net foreign asset position of each region. This implies that for each region - in steady state - the net financial position of the private sector is equal to the public debt. The size of Home and REA GDPs, as a share of world GDP, are set to 3 percent and to 17 percent, respectively.

As for fiscal policy variables, the public consumption-to-GDP ratio is set to 0.20. The tax rate on wage income τ^{ℓ} is set to 42.6 per cent in Home and to 34.6 in the REA. The tax rate on physical capital income τ^{k} is set to 34.9 in Home and 25.9 in the REA, while the tax rate

on consumption τ^c is equal to 16.8 in Home and to 20.3 in the REA. The public debt-to-yearly GDP ratio is calibrated to 130 percent for Home and to 0.79 for the REA. Variables of the RW are set to values equal to those of corresponding REA variables.

We can gauge in some 75bp the cost (gain) of permanently increasing (reducing) the public-sector deficit by 1 percentage point of GDP. The "estimate" is admittedly rough, highly tentative and does not distinguish sovereign risk from redenomination risk. If taken at face value and exploited to feed consolidation scenarios in our setup, it would imply a permanent and large reduction in the spread and, hence, large and most likely implausible expansionary effects. Moreover, announced consolidation plans are seldom fully credible and as such are only partially reflected in forward-looking agents's decisions. Therefore, we take a conservative approach and emend the "estimate" by making the following two assumptions. First, the initial reduction in the spread is equal to 75bp even if the reduction in public sector deficit is overall larger than 1 percentage point of GDP. Second, the spread reduction is temporary (instead of permanent): after the initial decrease the spread gradually returns to zero in two years. Our calibration is conservative also if compared to other contributions. Among the others, Corsetti et al. (2012) report that a 10 p.p. reduction in the public debt-to-GDP ratio brings about a 200 basis-points reduction in the sovereign spread.

3 Results

In this section we initially describe the simulated scenarios. Subsequently, the long-run (steady-state) and short-run (transition) results are reported. Finally, we conduct some robustness analysis and report the short and medium-run effects of fiscal and competition reforms under alternative assumptions about the financing condition of Home households, i.e. when the sovereign spread is temporarily reduced and when the monetary policy rate is held constant.

3.1 Simulated scenarios

The fiscal consolidation scenarios are simulated as follows: we modify the fiscal rule (4) defined on labor (capital) income taxes by assuming that the target value of debt $\bar{b}^g$ becomes a time-

dependent variable. We exogenously specify a path for $\bar{b}^g$ that implies that the Home public debt-to-(annualized) GDP ratio is decreased by 10 percentage points, from 130 to 120 percent, over a 10-year period.

The competition friendly-reforms in the Home service sector are simulated by gradually reducing the sector-specific (gross) mark-up by 5 percentage points, from 1.29 to 1.24 percent over a 10 year-period. When the services reform is implemented in isolation, lump-sum transfers endogenously adjust according to the fiscal rule. As such, the effects of the structural reform are not affected by fiscal policy.

When the "sovereign risk channel" is not active, the variable $spread_t^H$ (see equation (6)) is kept at the baseline level throughout the simulation. When including the "sovereign risk channel", we simulate fiscal consolidation scenarios in which $spread_t^H$ decreases.

Finally, when running constant monetary policy scenarios, we assume that the monetary policy rate is constant in the first two years after which it reverts to being set according to the Taylor rule (see equation (8)).

3.2 Long-run effects

We start by illustrating the steady-state effects of labor income tax-based, capital income tax-based consolidation and services reform, implemented in isolation and simultaneously.

3.2.1 Public debt consolidation and tax reduction

Table 6 reports long-run (steady-state) results of permanently reducing the public debt-to-GDP ratio. As interest payments are lower in the final steady-state equilibrium than in the initial one, taxes can be permanently reduced. Column (a) reports the case of reducing the labor income tax rate (other exogenous fiscal items are held at their corresponding initial steady state levels). In correspondence of the new level of debt, the tax rate (not reported) is equal to 42 percentage points, 0.7 percentage points less than its initial value. The increase in labor favours capital productivity. Home (real) output, consumption, investment and employment increase by 0.3, 0.4, 0.2 and 0.4 percent of their corresponding initial steady state levels, respectively.

Column (b) shows the effects of exploiting the reduction in interest payments to decrease the capital income tax rate (from 34.9 to 33.6 percent). GDP, consumption, investment and employment increase by 1.2, 0.6, 2.6 and 0.1 percent, respectively. Investment increases more than in the previous simulation while employment increases less, as the reduction in capital income taxes makes investment cheaper than labor.

In both simulations the excess supply of goods and services induces a depreciation of the Home real exchange rate. The implied effects are two. Domestic tradables become cheaper and the purchasing power of foreign households increases. Both effects favor an increase in Home exports. Home imports increase because of higher domestic demand, notwithstanding the worsening of the Home terms of trade. The effects on the trade variables are larger in the case of capital income tax-based than in that of labor income tax-based consolidation, because the former consolidation strategy has a larger supply-side effect than the latter. The terms of trade deteriorate to absorb the excess supply of Home tradables.

Finally, spillovers to the REA are small, given the relatively small share of Home tradables in foreign aggregate demand.

3.2.2 Increasing competition in the service sector

Column (c) of Table 6 reports the long-run (steady-state) effects of increasing competition in the Home service sector. Firms increase production of services and reduce their prices. This favours the increase in demand of capital and labor for production purposes. The reduction in the price of services is an incentive for households to increase consumption, given its high services' content. The increases in GDP, consumption and investment are respectively equal to 1.3, 0.7 and 2.0 percent. Employment also increases, by 0.6 percent. Home exports and imports increase, by 0.6 and 0.2 percent, respectively.

The terms of trade deterioration is lower than the real exchange rate depreciation. The reason is that the increase in the price of domestic tradables partially counterbalances the real exchange rate depreciation. The increase in the price of domestic tradables (expressed in Home consumption units) has two sources. First, tradables and services are complement, hence a higher demand of the latter drives up the demand of the former. Second, higher demand of domestic

inputs (labor and capital) drives up marginal costs also in the manufacturing sector, that is not subject to any mark-up-reducing reform.

As in the previous simulation, spillovers to the REA are small (the increase in REA GDP is muted).

3.2.3 Joint implementation of fiscal consolidation and competition reform

Column (d) reports results of implementing (simultaneously) both labor income tax-based consolidation and the services competition reform. The increase in GDP is larger than in the case of implementing reforms separately, as reported in columns (a) and (c). The reason is that the increase in competition raises Home output and, hence, the labor income tax base. Given the 10 percentage point reduction in public debt-to-GDP ratio, the higher tax base allows to decrease the labor income tax rate by 2.4 percentage points, an amount larger than the one obtained when implementing the fiscal consolidation only, equal to 0.7 percentage points. The additional tax rate reduction further stimulates the economy. Overall, GDP increases by 2.3 percent, consumption by 1.8, investment by 2.7, employment by 1.9.

A similar picture emerges when the competition reform is implemented jointly with the capital income tax-based consolidation (column e). Investment, which is rather elastic in the long run, benefits from the additional reduction in the tax rate, from 34.9 to 31.0 percentage points (to 33.6 percentage points when the fiscal consolidation is implemented in isolation). GDP, consumption, investment and employment increase by 4.9, 2.6, 10.4 and 1.0 percent, respectively.

Overall, results suggest not only that reforms are beneficial, but also that the simultaneous implementation magnifies the macroeconomic impact of the individual reforms. As such, coordinating the implementation of fiscal and competition reforms could be a crucial policy measure for maximizing their long-run effectiveness.

3.3 Transition dynamics

In what follows we report the transition dynamics in correspondence of the considered policy measures. The effects of the fiscal consolidation are initially shown. Thereafter, we report those of the competition-enhancing reform in the service sector implemented apart and simultaneously

with the fiscal consolidation.

3.3.1 Fiscal consolidation

The top two panels of Figure 1 report the paths of Home labor income tax rate and public debt-to-GDP ratio in the case of labor tax-based consolidation. The fiscal rule (4) commands a gradual increase in the labor tax rate by 2 percentage points in the first six years. As the reduction in the debt-to-GDP ratio progresses, new fiscal room is created to actually reduce the tax rate, because of the lower interest payment. The resulting path of the tax rate is hump-shaped and the consolidation ends up reducing the labor tax rate on a permanent basis below its initial value after 14 years. A similar path characterizes the capital income tax-based consolidation, as reported in the bottom two panels of Figure 1. The tax rate is increased from 34.9 to 37.8 percentage points during the first three years. Thereafter, it gradually decreases and permanently falls below its initial value after 14 years.

Figure 2 shows the path of the main macroeconomic variables under the assumption of labor tax-based consolidation. The increase in the labor tax has a negative effect on the Home economy. GDP decreases by around 0.7 percent after 10 years (trough level). It persistently stays below the baseline value. Consumption, investment and employment decrease by 0.4, 1.1 and 1.0 percent, respectively. As firms reduce employment, physical capital becomes less productive. Investment becomes less convenient and, hence, decreases. Home exports decrease by 1 percent, because of the loss in price competitiveness. From the 15th year, once the debt-to-GDP ratio has achieved its new (lower) level, the labor income tax rate starts to be reduced and the main domestic macroeconomic variables increase towards and above their baseline level.

Similar paths characterize the capital income tax-based consolidation scenario, as reported in Figure 3. The short and medium-run effects of the temporary increase in the tax rate on the Home economy are negative. GDP decreases by about 1.5 percent after 8 years. The decrease in investment is large. As for the increase in labor income taxation, there is a temporary negative supply-side effect, that causes a slight increase in inflation and the appreciation of the Home real exchange rate. The implied loss of international price competitiveness reduces Home exports. Imports decrease, mimicking the path of investment. GDP increases above its baseline level after

16 years, in correspondence of the reduction in taxes on capital income.

Overall, tax-based fiscal consolidations inevitably imply short- and medium-run macroeconomic costs. The latter have to be compared with the long-run benefits, that are large and permanent. Moreover, short-run costs can be alleviated by other factors, such as the simultaneous implementation of the reforms in the service sector, as shown in the section after the next one.

3.3.2 Competition reform

Figure 4 shows the macroeconomic effects of the competition reform in the Home service sector. Real GDP slightly decreases in the first year. Two years after the beginning of the reform, GDP is slightly above its baseline level and monotonically increases toward its new long-run level, mainly driven by the increase in the production of services. The initial decrease is associated with households anticipating that services will be cheaper in future than in current periods, when their supply will be large. Given its high services content, households postpone consumption to future periods. Consumption drops in the first two years and then starts to increase but stays below the initial baseline level for around eight years, roughly the amount of time needed to fully implement the reform. Immediately after the beginning of the reform, investment increases, to build a higher stock of capital when production has to be increased (in correspondence of higher competition). The increase in investment drives up demand for domestic tradables. In the medium term exports increase because of the real exchange rate depreciation, associated with the excess supply of services. Imports initially decrease and thereafter increase mimicking domestic aggregate demand.[14]

Overall, the service sector reform has medium-run expansionary effects on the Home economy, while their short-run (first-year) effects are slightly negative.

[14] Spillover effects to the rest of the EA, not reported to save on space, are small.

3.3.3 Simultaneous implementation of the fiscal consolidation and competition reform

The top two panels of Figure 5 report the paths of tax rate and public debt-to-GDP ratio when the labor income tax-based consolidation is jointly implemented with the competition reform. The bottom two panels report the path of tax rate and public debt-to-GDP ratio in the case of joint implementation of capital income tax-based consolidation and competition reform. As in the case of isolated implementations, the public debt is gradually reduced over ten years by alternatively increasing labor income and capital income tax, while the reform in the service sector is implemented over ten years.

Now the tax rates have a less pronounced hump-shaped path than in Figure 1. The relatively quick increase in Home GDP, due to the competition-friendly reform, favours the increase in the labor tax base. Hence, a lower increase in the tax rate is now needed to reduce public debt. The labor and capital income tax rates fall below their corresponding baseline level in a relatively quick way.

Figure 6 reports results when the labor income tax-based consolidation and competition reform are jointly implemented. For comparison, it also contains results of implementing the consolidation in isolation (label "benchmark", results are the same as in Figure 2). Benefits from the services reform are clear. The increase in competition has a stimulating effect on economic activity. The GDP loss entailed by the fiscal consolidation is mitigated. GDP returns above its baseline level six years after the beginning of the reforms. Thereafter, it monotonically increases, favoured by consumption, investment and gross exports. Labor augments to increase production. Imports increase because of the increase in Home aggregate demand, favoured by the increase in permanent income. All mentioned variables decrease when the fiscal consolidation is implemented in a stand-alone way. Interestingly, expansionary effects are larger than in the case of services reform implemented in isolation (see Figure 4). The additional effect is due to the labor tax rate, that can be reduced below its baseline level after ten years because the services reform favours employment, labor income and, hence, expands the related tax base.

Figure 7 shows results obtained when simultaneously implementing the capital income tax-based consolidation and the reform in the service sector. The message is similar to the one of

the previous simulation. There are smaller short-run costs in terms of GDP than in the case of fiscal consolidation. After seven years, GDP is above the baseline and monotonically increases, driven by consumption and investment. This is not the case when it is only the consolidation to be implemented, because the increase in taxes has a negative effect on economic activity. As for labor tax-based consolidation, there is an additional expansionary effect from the simultaneous implementation. The increase in competition allows to reduce the capital income tax rate below its baseline level after ten years, thus benefiting capital accumulation and economic activity (compare Figure 7 with Figure 4).

Overall, we do find that the joint implementation of fiscal consolidation and competition-friendly reforms can benefit the Home economy not only in the long run but also in the short and medium term, by limiting the initial increase in tax rates and hence the implied distortionary effects on economic activity.

4 Robustness. "Sovereign risk channel" and constant monetary policy rate

In what follows we assess the robustness of the short and medium-term results by making two changes with respect to the baseline scenarios presented above.

First, we introduce the "sovereign risk channel" (see equation (6)). It is assumed that the public debt consolidation implies an initial reduction in the spread by 75 annualized basis points. Moreover, as described at the end of the calibration section, announced consolidation plans are seldom fully credible and as such are only partially reflected in forward-looking agents's decisions. Therefore, we assume that the spread reduction is temporary (instead of permanent): after the initial decrease the spread gradually returns to zero in two years.

Second, the EA-wide monetary policy rate is held constant at its baseline level for the initial 8 quarters and thereafter the Taylor rule kicks in (see equation (8)).[15]

[15]Results do not greatly change when the length is increased. We have also run sensitivity analysis on the spread reduction and calibrate it following Laubach (2010). Results do not greatly change. To save on space we do not report them. They are availble upon request.

4.1 Fiscal consolidation

Figure 8 reports the results of the labor income tax-based consolidation. In the "benchmark" scenario the "sovereign risk channel" is not active and the Taylor rule holds. In the "spread" scenario the spread decreases. In the "constant mp" scenario the monetary policy rate is held constant at its baseline level.

Introducing the "sovereign risk channel" does not greatly change the main results. The public debt reduction lowers the spread and, hence, the interest rate paid not only by the government but also, and more importantly, by the private sector. However, the implied macroeconomic gains have a modest size. Consumption and investment decrease to a lower extent, implying a slightly lower GDP loss in correspondence of a given fiscal consolidation. Note also that if the reduction in the spread is assumed to be smaller and/or to last for a shorter period, then the gains would be even smaller.

Holding the monetary policy rate constant does not have significant effects on the main Home macroeconomic variables. The reason is that the monetary policy rate barely decreases when it follows the Taylor rule, for two reasons. First, the impact of changes in the Home economy on the EA inflation rate and activity is rather muted. Second, the negative effect of the consolidation on the Home economic activity and inflation is gradual. As a consequence, there are no large differences in the paths of the EA monetary policy rate (which essentially is always at its baseline) and inflation rates across the two scenarios. The paths of the Home real interest rate (not reported) are rather similar and close to zero.

Figure 9 shows the effects of capital income tax based consolidation. The increase in capital taxation has slightly larger negative effect on short-run aggregate demand and inflation than the increase in labor income tax, because of the drop in investment. As such, the constant monetary policy rate magnifies the increase in the real interest rate more in the case of higher capital income tax than in the case of higher labor income tax. Finally, the fall in the spread slightly reduces the short-run costs of the consolidation.

4.2 Competition reform

Figure 10 shows the short-run effects of increasing competition in the Home service sector when the monetary policy rate is held constant in the first eight quarters and in the benchmark case, where the Taylor holds. Qualitative and quantitative differences across the two scenarios are negligible. Under the Taylor rule, neither the inflation nor the policy rate increase. So the Home real interest rate, that determines the households' intertemporal choices, is rather similar in both scenarios.

4.3 Simultaneous implementation of fiscal consolidation and competition reform

Figures 11 shows results for the case of simultaneously implementing the labor income tax based fiscal consolidation and the services reform when the spread decreases and the monetary policy is constant. Differences are small with respect to the benchmark scenario, where there is no spread reduction and the Taylor rule holds. There are big differences only with respect to the fiscal consolidation scenario, suggesting that it is the implementation of services reform to generate relatively large macroeconomic gains in the short run.

Figure 12 shows results when the fiscal consolidation is based on capital income taxation. Results are similar to those just illustrated.

5 Conclusions

In the aftermath of the sovereign crisis many European countries have been advised to implement reforms to reduce public debt and structurally improve their economy. In this paper we have evaluated the macroeconomic effects of simultaneously implementing two reforms. One is based on consolidating the public debt. It allows taxes to be reduced in the new long-run equilibrium, once a lower level of public debt has been achieved. The other enhances the degree of competition in the service sector. To take into account that the reforms are implemented during the European sovereign debt crisis, we have assumed that financing costs of households are conditioned by the

sovereign spread and by the low and constant (risk-free) monetary policy rate.

According to our results, the simultaneous implementation of both (fiscal and competition) reforms greatly favors the increase of output in the long run. The transition costs of the fiscal consolidation are substantial; they are reduced if it is implemented jointly with the competition-friendly reform. The reason is the increase in the income tax base, associated with the competition-friendly reform, which allows tax rates to be further reduced in the long run and their increase to be limited in the short run.

This paper does not consider reforms in the labor market and their simultaneous implementation with the policy measures considered in this paper. Moreover, the paper does not consider the possibility that fiscal and service reforms could be simultaneously implemented at EA level when the ZLB is binding. We leave these interesting issues for future research.

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Table 1. Parametrization of Home, REA and RW

Parameter	H	REA	RW
Discount rate β	$1.03^{-0.25}$	$1.03^{-0.25}$	$1.03^{-0.25}$
Intertemporal elasticity of substitution $1/\sigma$	1.0	1.0	1.0
Inverse of Frisch Elasticity of Labor Supply τ	2.0	2.0	2.0
Habit h	0.6	0.6	0.6
Depreciation rate of capital δ	0.025	0.025	0.025
Tradable Intermediate Goods			
Substitution between factors of production $\xi_T, \xi_T^*, \xi_T^{**}$	0.93	0.93	0.93
Bias towards capital $\alpha_T, \alpha_T^*, \alpha_T^{**}$	0.56	0.46	0.46
Non tradable Intermediate Goods			
Substitution between factors of production $\xi_N, \xi_N^*, \xi_N^{**}$	0.93	0.93	0.93
Bias towards capital $\alpha_N, \alpha_N^*, \alpha_N^{**}$	0.53	0.43	0.43
Final consumption goods			
Substitution between domestic and imported goods $\phi_A, \phi_A^*, \phi_A^{**}$	1.50	1.50	1.50
Bias towards domestic tradable goods a_H, a_F^*, a_G^*	0.68	0.59	0.90
Substitution between domestic tradables and non tradables $\rho_A, \rho_A^*, \rho_A^{**}$	0.50	0.50	0.50
Bias towards tradable goods a_T, a_T^*, a_T^{**}	0.68	0.50	0.50
Final investment goods			
Substitution between domestic and imported goods $\phi_E, \phi_E^*, \phi_E^{**}$	1.50	1.50	1.50
Bias towards domestic tradable goods υ_H, υ_F^*	0.50	0.49	0.90
Substitution between domestic tradables and non tradables ρ_E, ρ_E^*	0.50	0.50	0.50
Bias towards tradable goods υ_T, υ_T^*	0.78	0.70	0.70

Note: H=Home; REA=rest of the euro area; RW= rest of the world.

Table 2. Gross Mark-ups

Mark-ups and Elasticities of Substitution			
	Tradables	Nontradables	Wages
H	1.08 ($\theta_T = 13.32$)	1.29 ($\theta_N = 4.44$)	1.60 ($\psi = 2.65$)
REA	1.11 ($\theta_T^* = 10.15$)	1.24 ($\theta_N^* = 5.19$)	1.33 ($\psi^* = 4$)
RW	1.11 ($\theta_T^{**} = 10.15$)	1.24 ($\theta_N^{**} = 5.19$)	1.33 ($\psi^{**} = 4$)

Note: H=Home; REA=rest of the euro area; RW= rest of the world.

Table 3. Real and Nominal Adjustment Costs

Parameter ("*" refers to rest of the euro area)	H	REA	RW
Real Adjustment Costs			
Investment ϕ_I, ϕ_I^*, ϕ_I^{**}	6.00	6.00	6.00
Households' financial net position ϕ_{b1}, ϕ_{b2}	0.00055, 0.00055	-	0.00055, 0.00055
Nominal Adjustment Costs			
Wages κ_W, κ_W^*, κ_W^{**}	200	200	200
Home produced tradables κ_H, k_H^* k_H^{**}	300	300	50
REA produced tradables κ_H, k_H^* k_H^{**}	300	300	50
RW produced tradables κ_H, k_H^* k_H^{**}	50	50	300
Nontradables κ_N, κ_N^*, κ_N^{**}	500	500	500

Note: H=Home; REA=rest of the euro area; RW= rest of the world.

Table 4. Fiscal and Monetary Policy Rules

Parameter	H	REA	EA	RW
Fiscal policy rule				
$\phi_1, \phi_1^*, \phi_1^{**}$	± 0.05	± 1.01	-	± 1.01
$\phi_2, \phi_2^*, \phi_2^{**}$	± 1.01	± 1.01	-	± 1.01
Common monetary policy rule	-	-		
Lagged interest rate at t-1 ρ_R, ρ_R^{**}	-	-	0.87	0.87
Inflation ρ_Π, ρ_Π^{**}	-	-	1.70	1.70
GDP growth $\rho_{GDP}, \rho_{GDP}^{**}$	-	-	0.10	0.10

Note: H=Home; REA=rest of the euro area; EA= euro area; RW= rest of the world.

Table 5. Main macroeconomic variables (ratio to GDP) and tax rates

	H	REA	RW
Macroeconomic variables			
Private consumption	61.0	57.1	64.0
Private Investment	18.0	16.0	20.0
Imports	29.0	24.3	4.25
Net Foreign Asset Position	0.0	0.0	0.0
GDP (share of world GDP)	0.03	0.17	0.80
Public expenditures			
Public purchases	20.0	20.0	20.0
Interests	4.0	2.0	2.0
Debt (ratio to annual GDP)	130	79	79
Tax Rates			
on wage	42.6	34.6	34.6
on rental rate of capital	34.9	25.9	25.9
on price of consumption	16.8	20.3	20.3

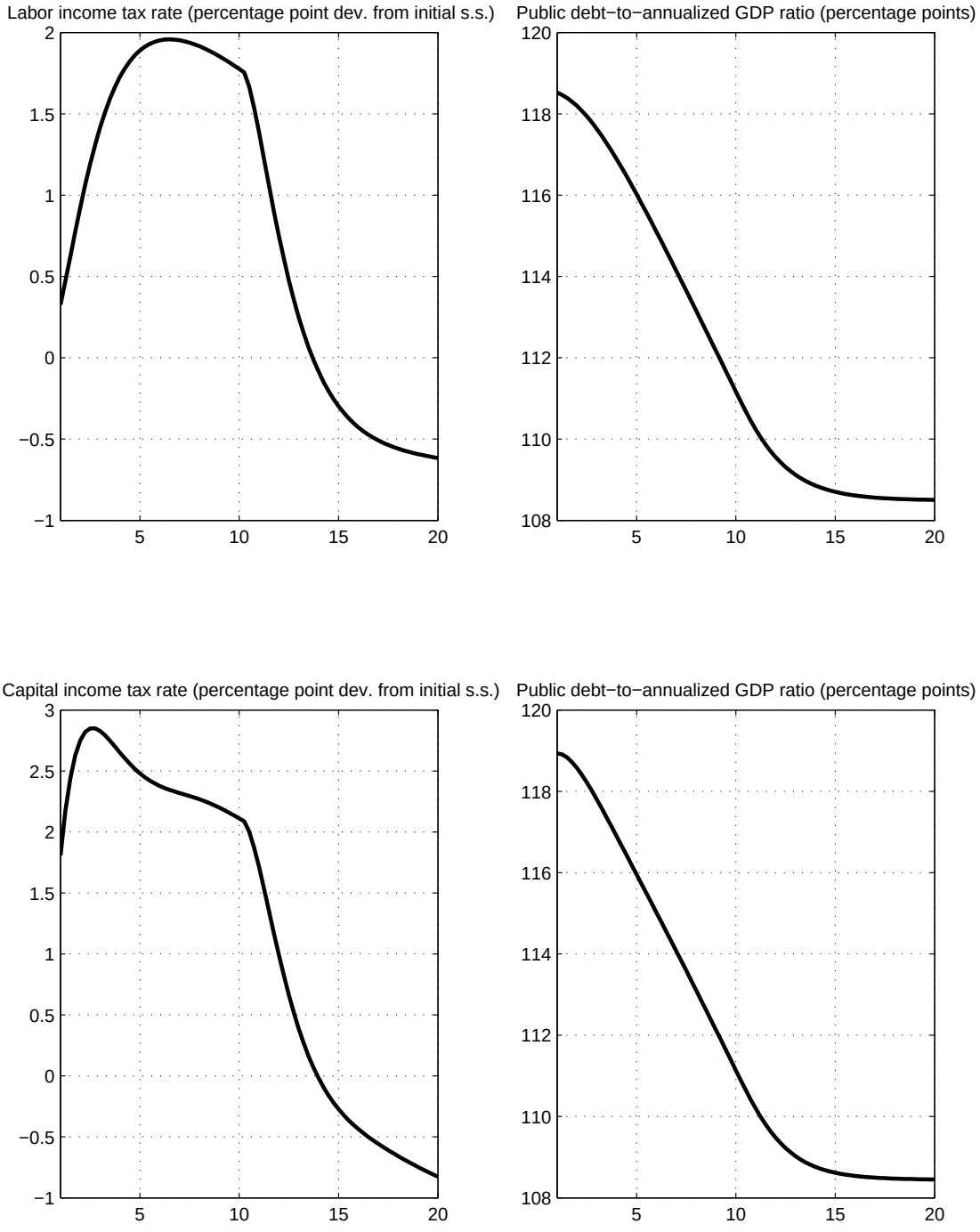
Note: H=Home; REA= Rest of the euro area; RW= Rest of the world. Sources: European Commission (2012); tax rates (in percent) are from Eurostat (2012).

Table 6. Long-run effects of fiscal and competition reforms. Main macroeconomic variables

	(a) τ^w	(b) τ^k	(c) services	(d) services+τ^w	(e) services+τ^k
Home					
GDP	0.32	1.17	1.25	2.29	4.92
Consumption	0.35	0.63	0.66	1.76	2.56
Investment	0.24	2.64	1.97	2.74	10.43
Exports	0.35	1.48	0.55	1.65	5.20
Imports	0.11	0.48	0.18	0.54	1.68
Labor	0.40	0.13	0.60	1.88	1.01
Real exch. rate (vis-à-vis REA)	0.17	0.69	1.57	2.11	3.73
Real exch. rate (vis-à-vis RW)	0.17	0.68	1.56	2.10	3.71
Terms of trade (vis-à-vis REA)	0.23	1.00	0.37	1.11	3.50
Terms of trade (vis-à-vis RW)	0.23	0.98	0.36	1.10	3.43
Rest of euro area					
GDP	0.01	0.03	0.01	0.01	0.04

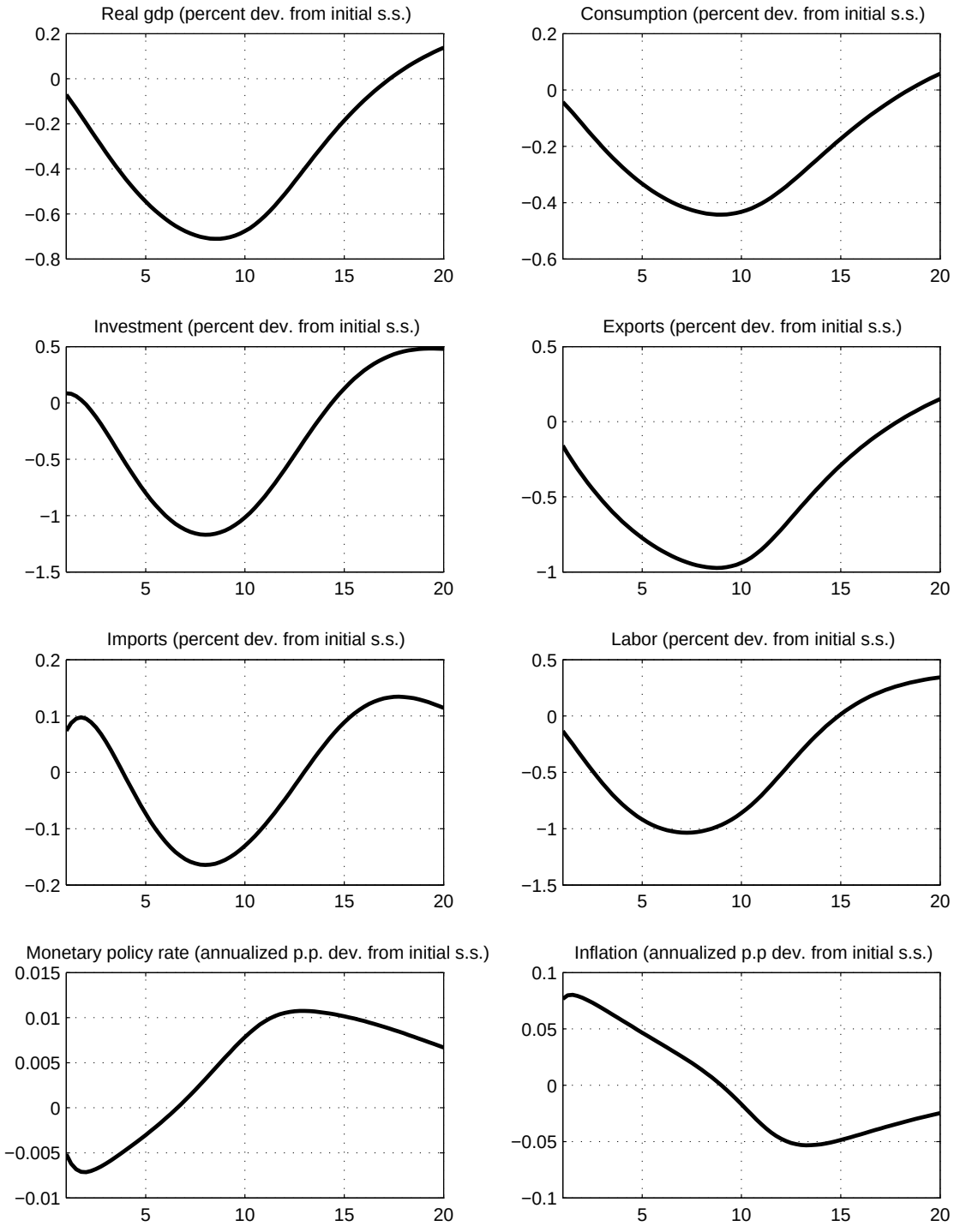
Note: % deviations from initial steady state. For real exchange rate and terms of trade, +=depreciation.

Figure 1. Fiscal consolidation. Tax rates and public debt-to-GDP ratio



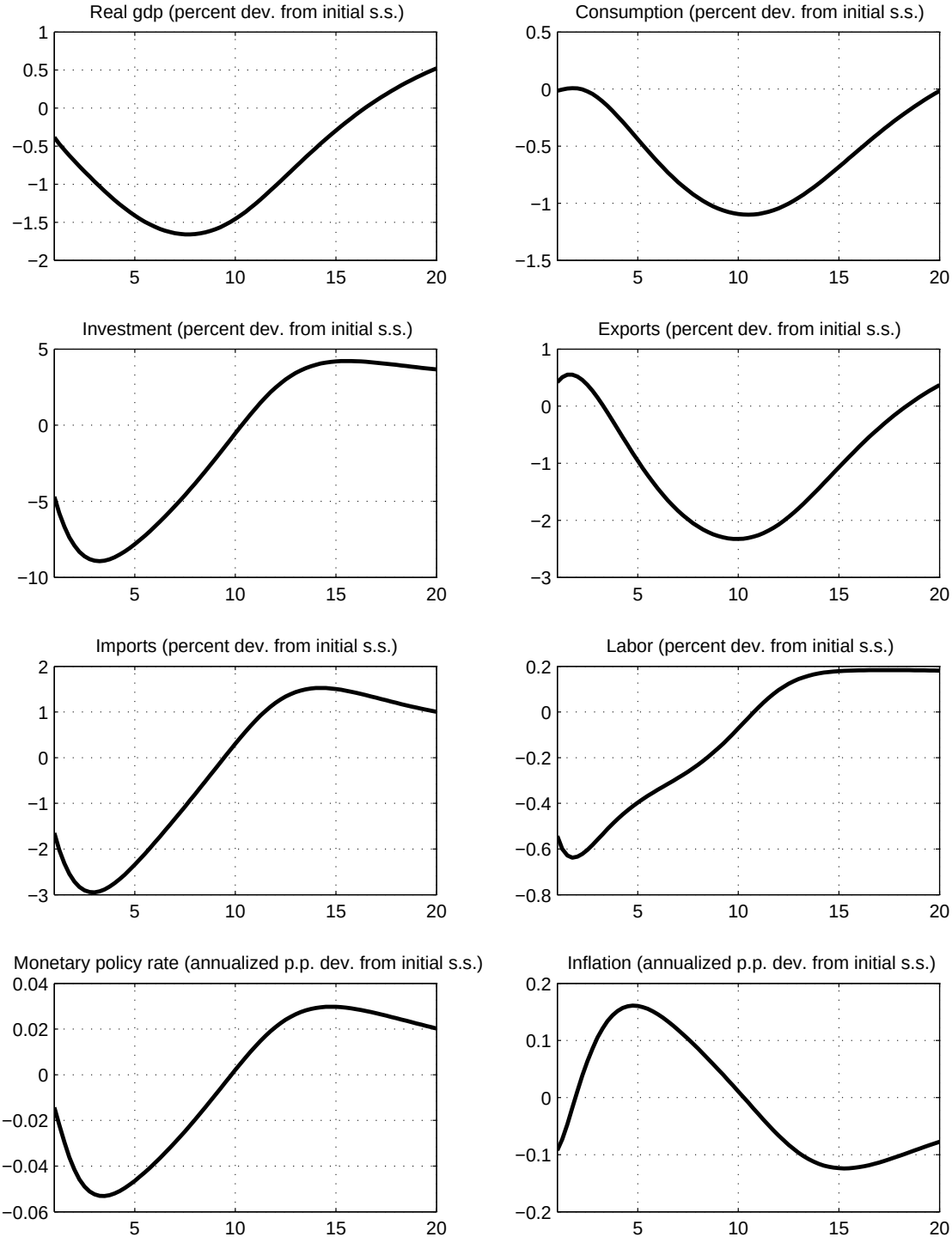
Note. Horizontal axis: years

Figure 2. Labor income tax-based consolidation



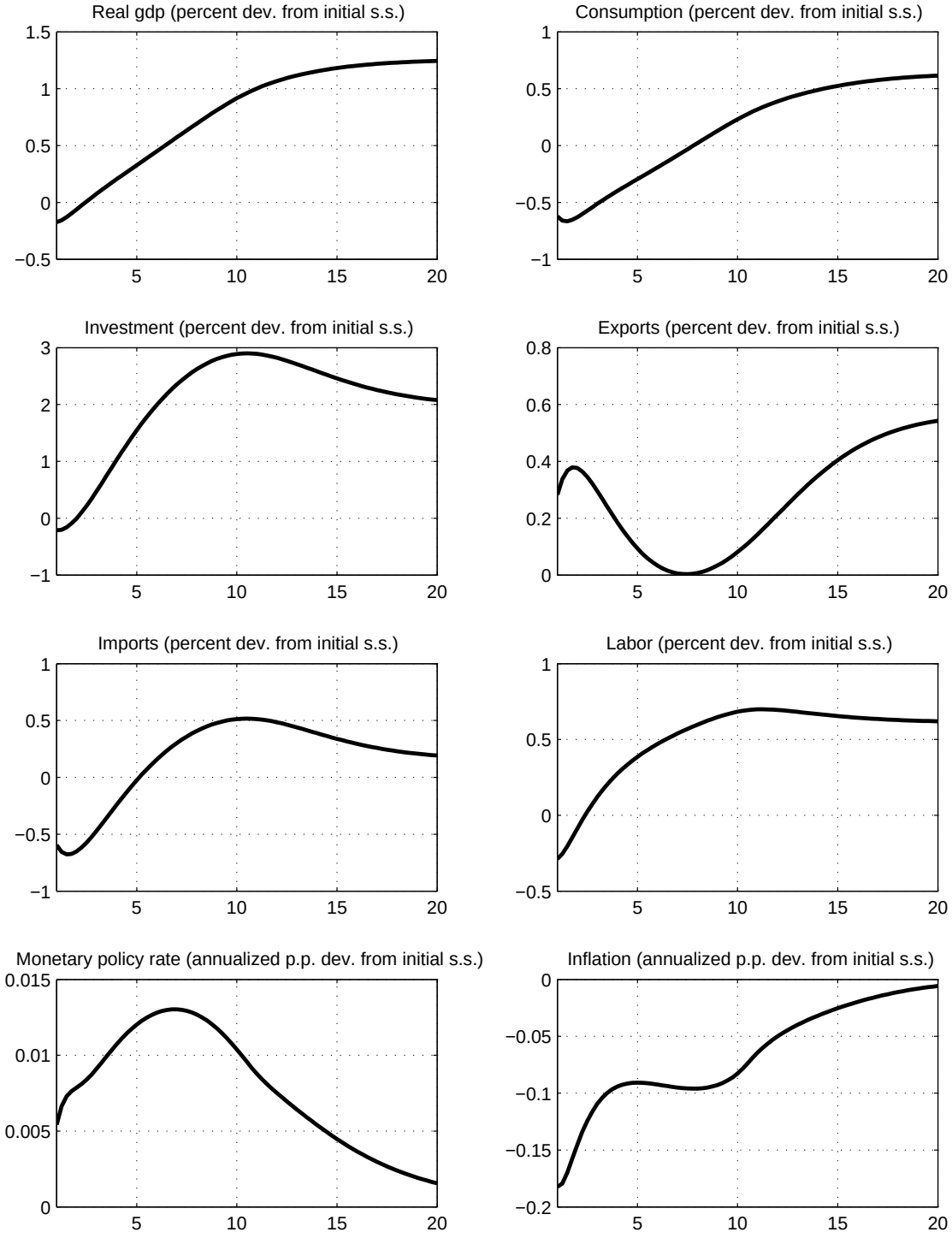
Note. Horizontal axis: years

Figure 3. Capital income tax-based consolidation



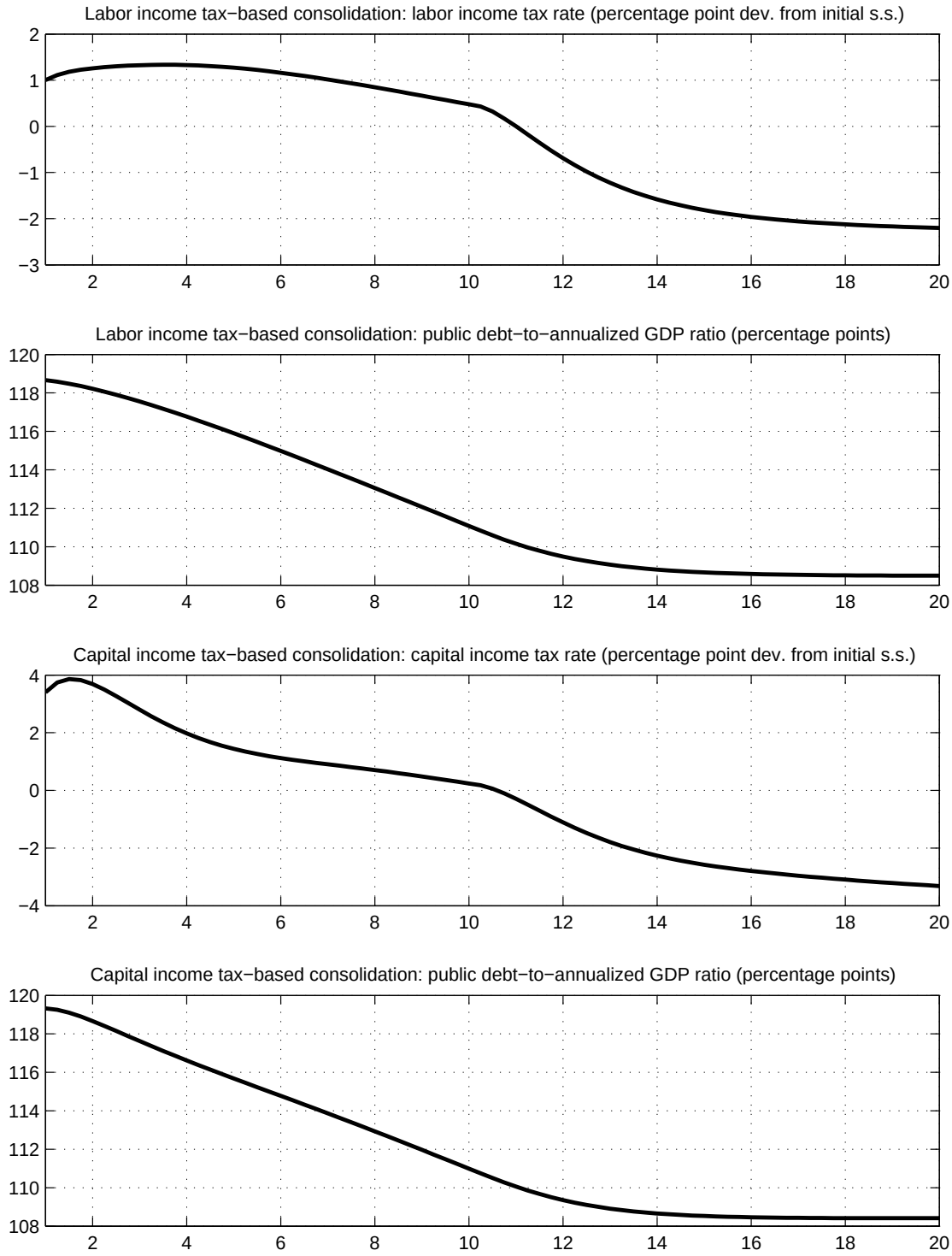
Note. Horizontal axis: years

Figure 4. Services reform



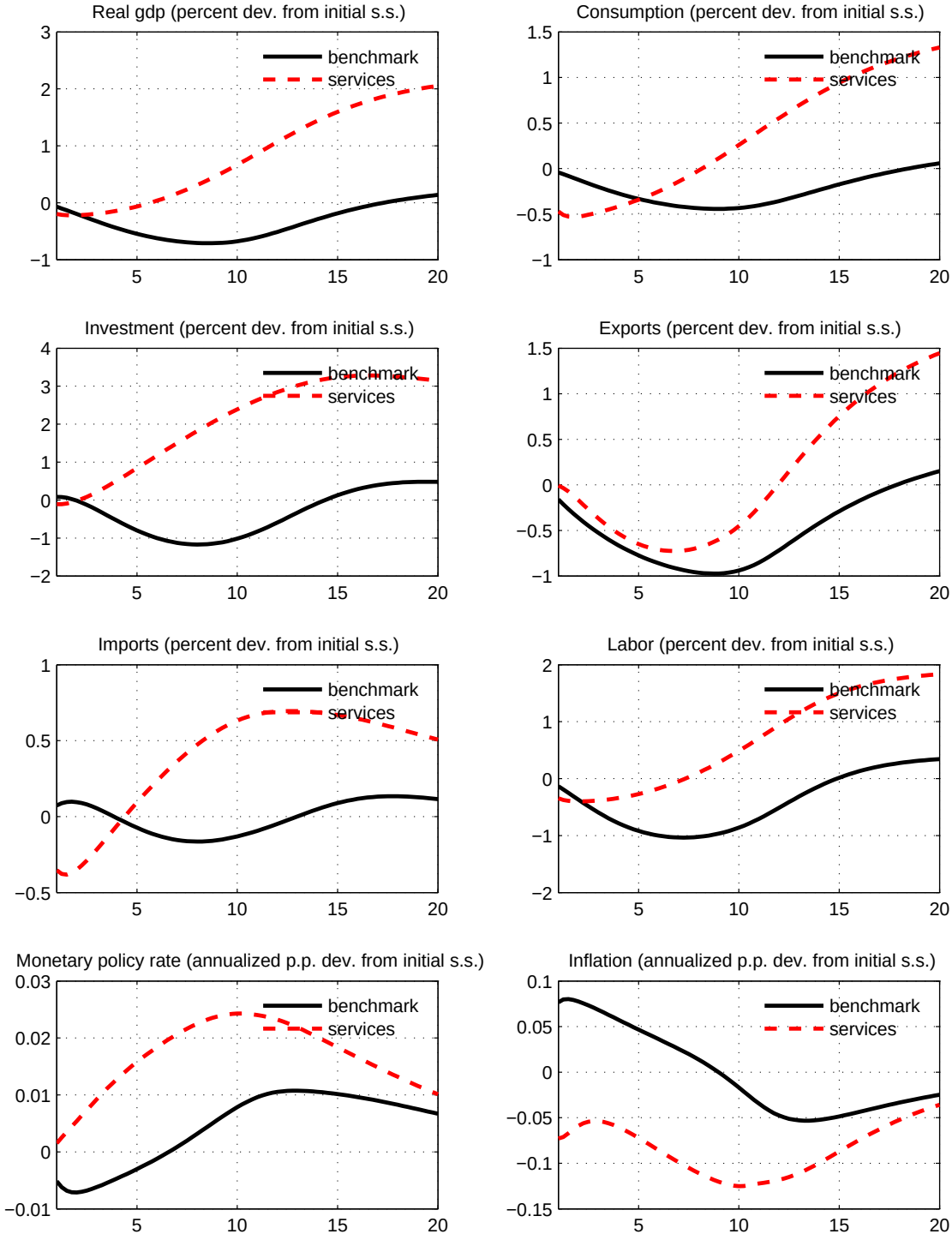
Note. Horizontal axis: years

Figure 5. Fiscal consolidation and services reform. Tax rates and public debt-to-GDP ratio



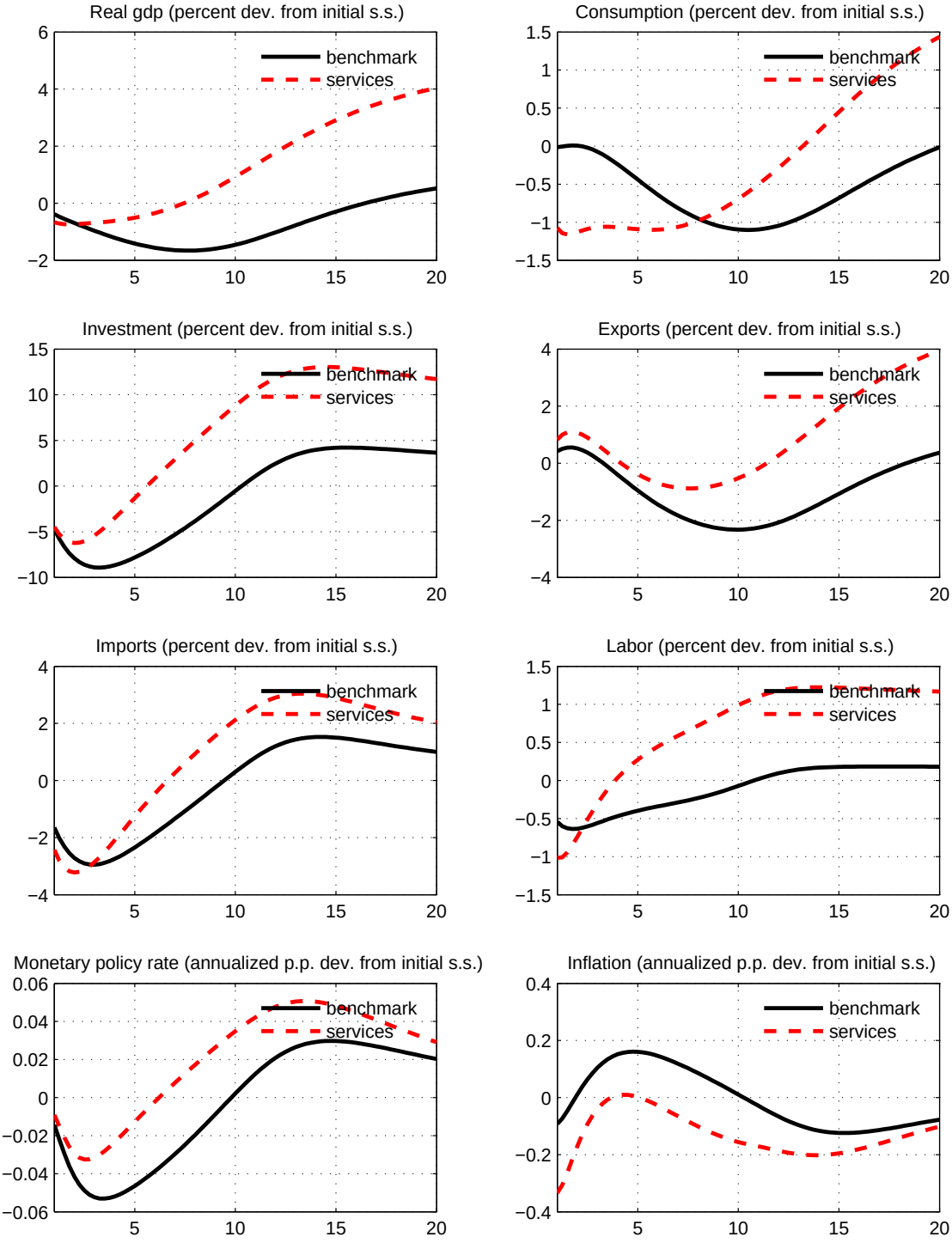
Note. Horizontal axis: years

Figure 6. Labor income tax-based consolidation and services reform



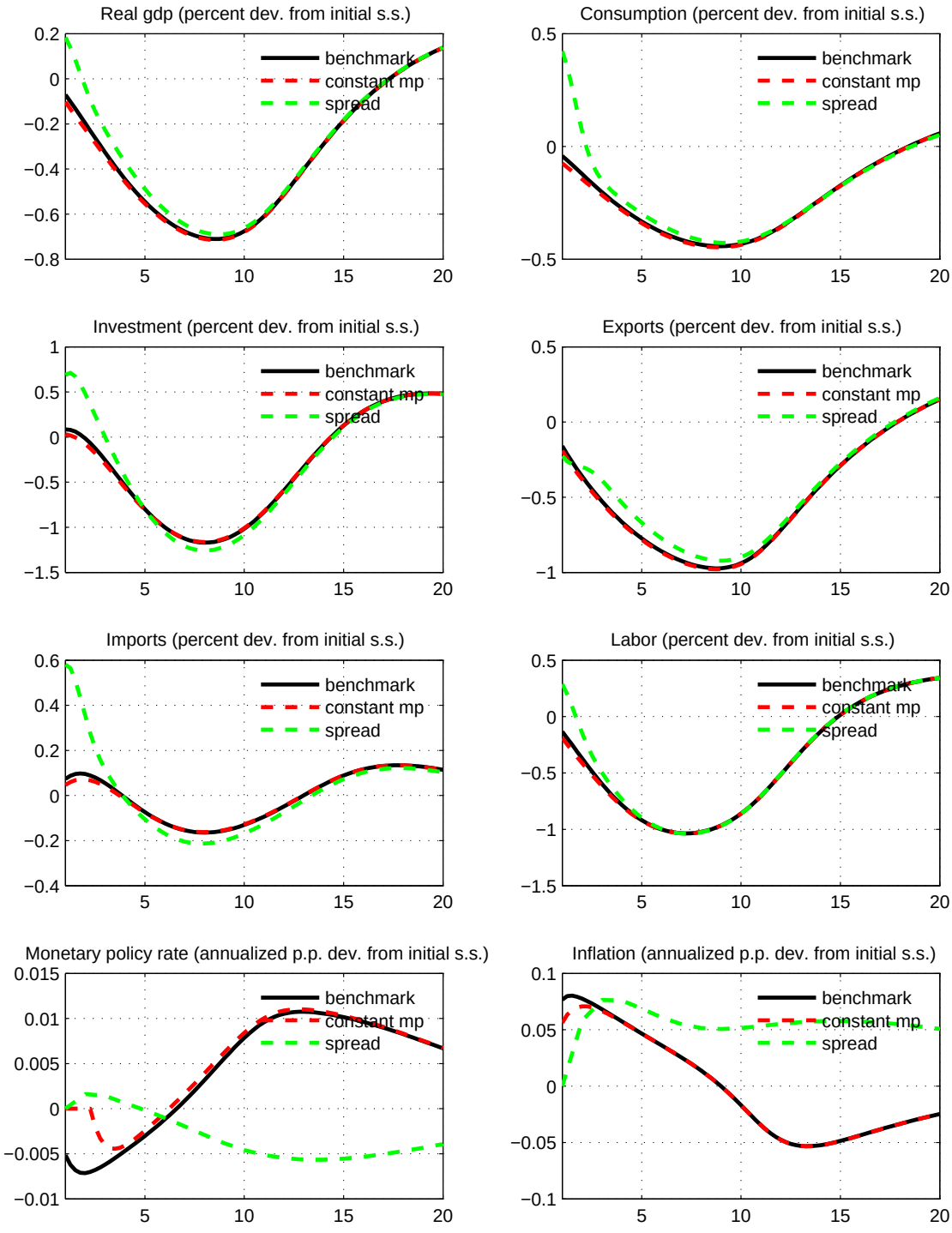
Note. Horizontal axis: years

Figure 7. Capital income tax-based consolidation and services reform



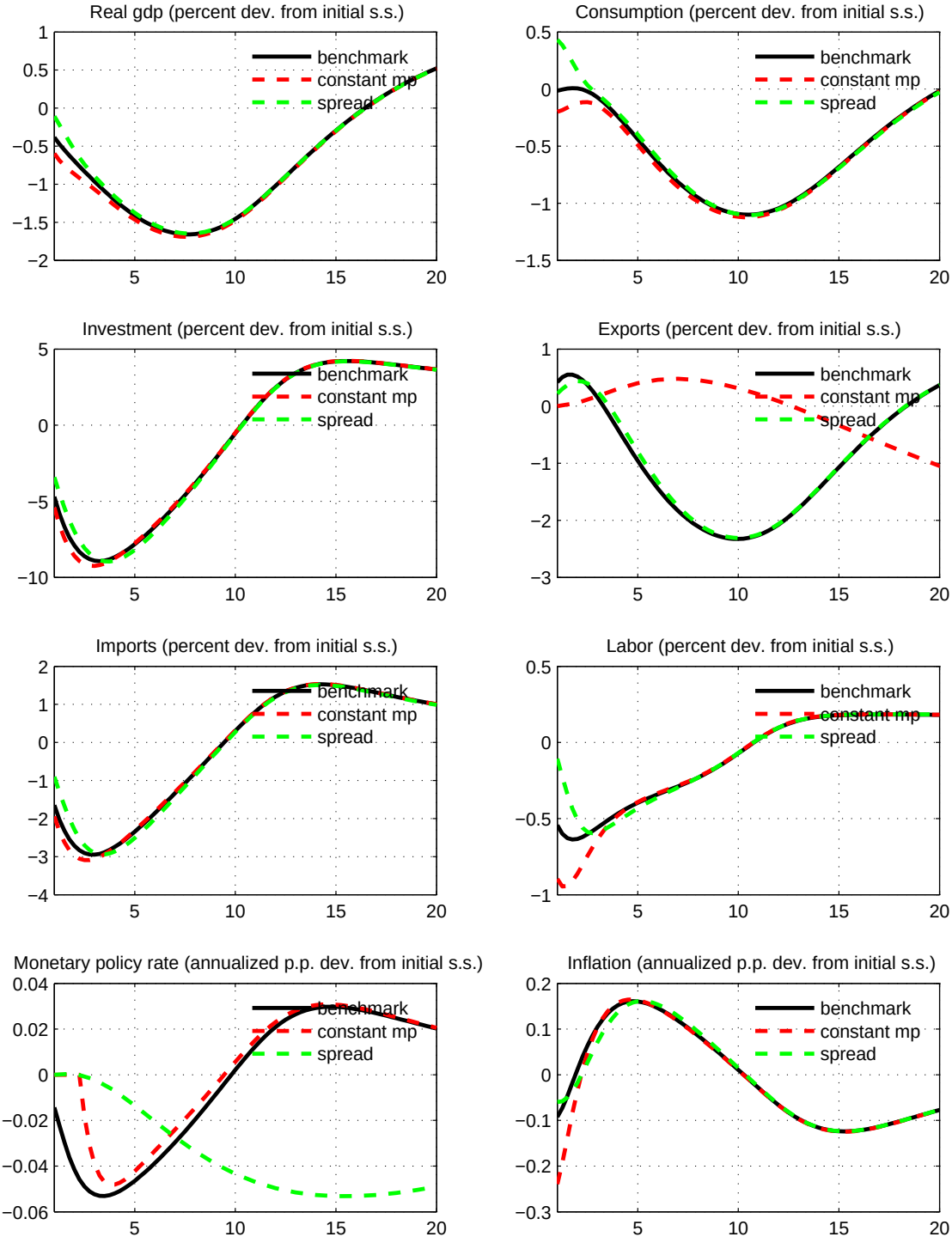
Note. Horizontal axis: years

Figure 8. Labor income tax-based consolidation. Spread and constant monetary policy rate



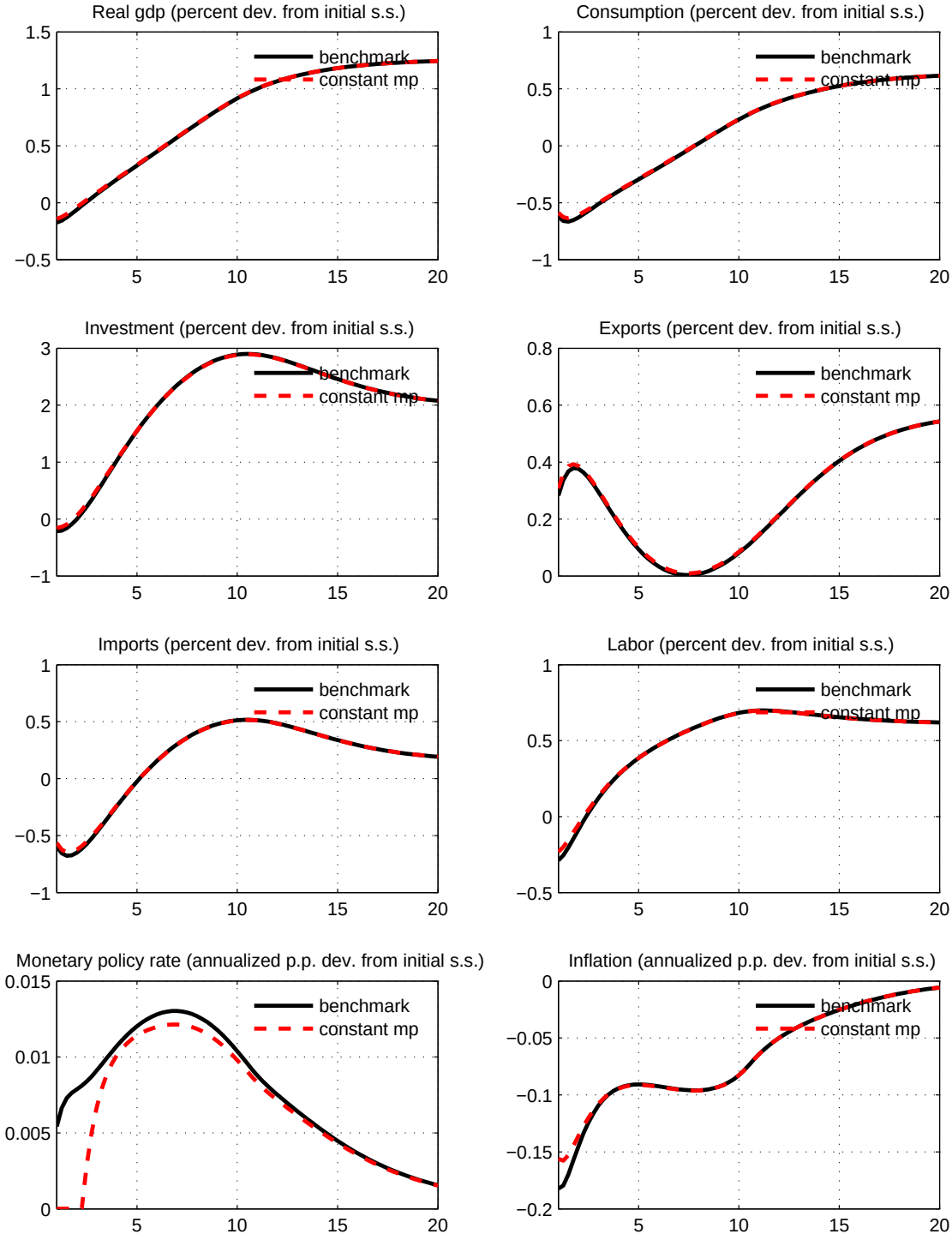
Note. Horizontal axis: years

Figure 9. Capital income tax-based consolidation. Spread and constant monetary policy rate



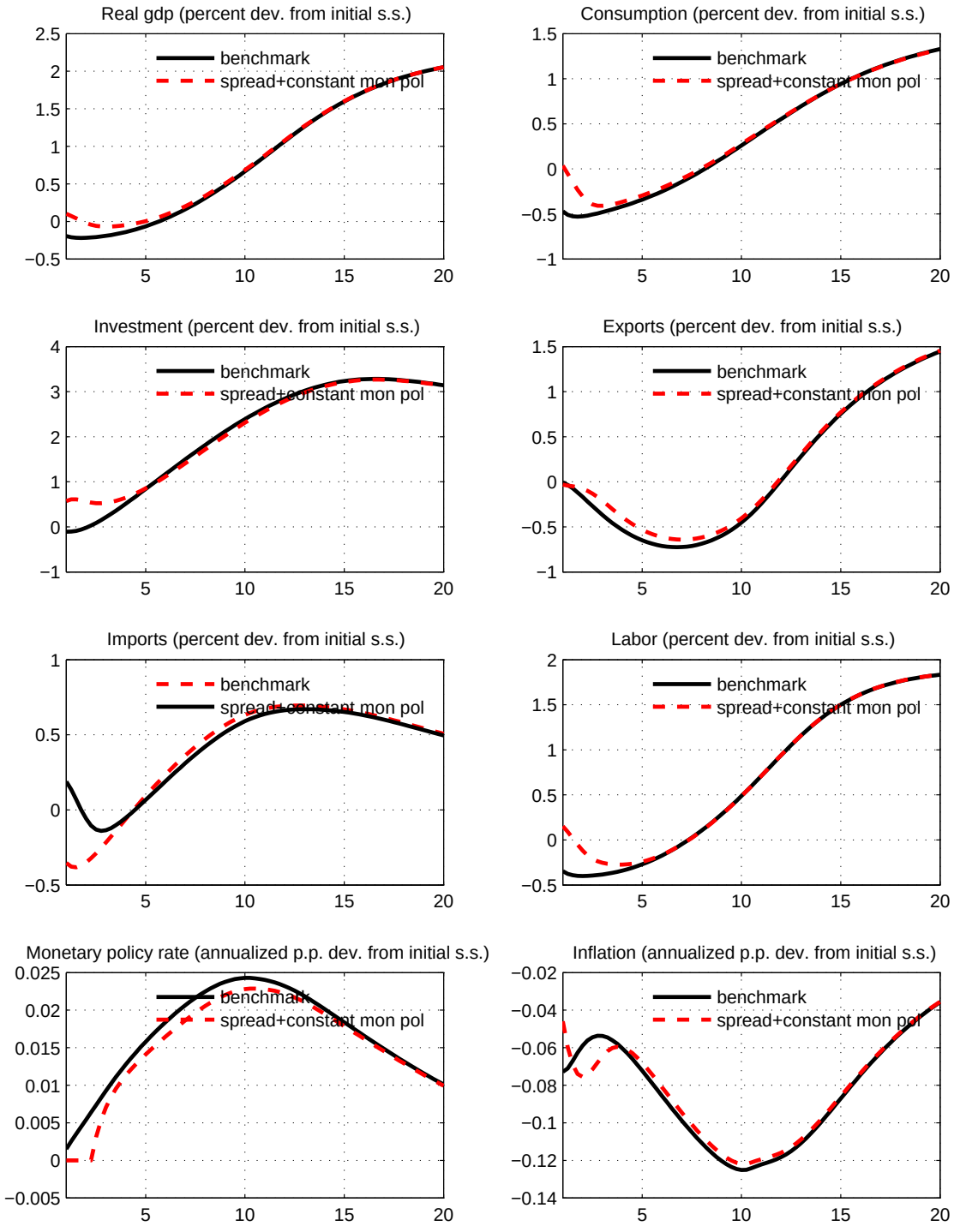
Note. Horizontal axis: years

Figure 10. Services reform and constant monetary policy rate



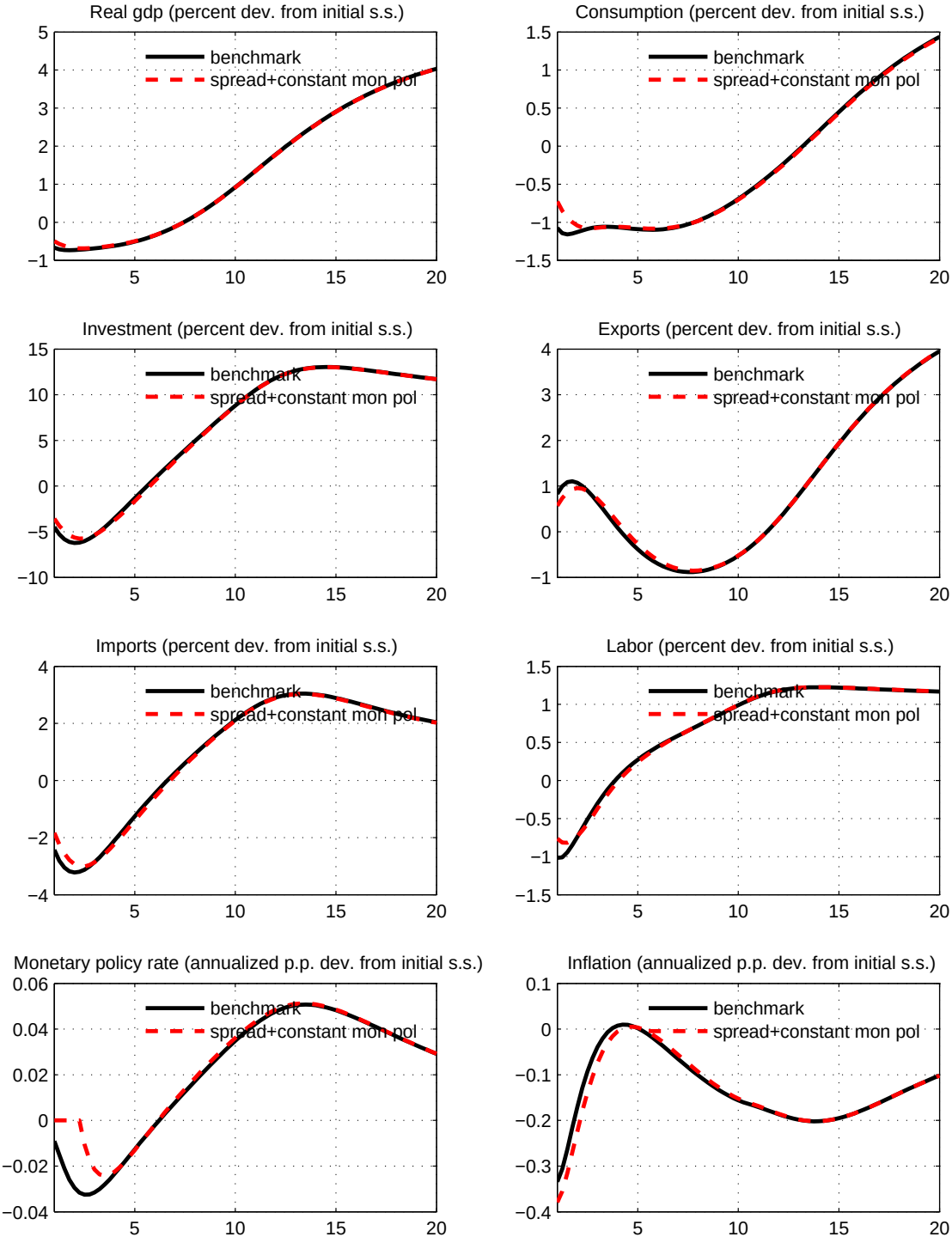
Note. Horizontal axis: years

Figure 11. Services reform and labor tax based consolidation. Spread and constant mon. policy



Note. Horizontal axis: years

Figure 12. Services reform and capital tax based cons. Spread and constant mon. policy



Note. Horizontal axis: years

Appendix

In this Appendix we report a detailed description of the model, excluding the fiscal and monetary policy part and the description of the households optimization problem that are reported in the main text.[16]

There are three countries, Home, the rest of the euro area (REA) and the rest of the world (RW). They have different sizes. Home and the REA share the currency and the monetary authority. In each region there are households and firms. Each household consumes a final composite good made of intermediate goods (nontradable, domestic tradable and imported goods). Households have access to financial markets and smooth consumption by trading a risk-free one-period nominal bond, denominated in euro. They also own domestic firms and capital stock, which is rent to domestic firms in a perfectly competitive market. Households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive markets by charging a mark-up over their marginal rate of substitution.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. Two final goods (private consumption and private investment) are produced combining all available intermediate goods according to constant-elasticity-of-substitution bundle. The public consumption good is a bundle of intermediate nontradable goods.

Intermediate tradable and nontradable goods are produced combining capital and labor in the same way. Tradable intermediate goods can be sold domestically or abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We assume that goods markets are internationally segmented and the law of one price for tradables does not hold. Hence, each firm producing a tradable good sets three prices, one for the domestic market and the other two for the export market (one for each region). Since the firm faces the same marginal costs regardless of the scale of production in each market, the different price-setting problems are independent of each other.

To capture the empirical persistence of the aggregate data and generate realistic dynamics, we include adjustment costs on real and nominal variables, ensuring that, in response to a shock,

[16] For a detailed description of the main features of the model see also Bayoumi (2004) and Pesenti (2008).

consumption and production react in a gradual way. On the real side, quadratic costs and habit prolong the adjustment of the investment and consumption. On the nominal side, quadratic costs make wage and prices sticky.

In what follows we illustrate the Home economy. The structure of each of the other two regions (REA and the RW) is similar and to save on space we do not report it.

A Final consumption and investment goods

There is a continuum of symmetric Home firms producing final nontradable consumption under perfect competition. Each firm producing the consumption good is indexed by $x \in (0, s]$, where the parameter $0 < s < 1$ measures the size of Home. Firms in the REA and in the RW are indexed by $x^* \in (s, S]$ and $x^{**} \in (S, 1]$, respectively (the size of the world economy is normalized to 1). The CES production technology used by the generic firm x is:

$$A_t(x) \equiv \left(\begin{array}{c} a_T^{\frac{1}{\phi_A}} \left(a_H^{\frac{1}{\rho_A}} Q_{HA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} + a_G^{\frac{1}{\rho_A}} Q_{GA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} (1 - a_H - a_G)^{\frac{1}{\rho_A}} Q_{FA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \right)^{\frac{\rho_A}{\rho_A - 1} \frac{\phi_A - 1}{\phi_A}} \\ + (1 - a_T)^{\frac{1}{\phi_A}} Q_{NA,t}(x)^{\frac{\phi_A - 1}{\phi_A}} \end{array} \right)^{\frac{\phi_A}{\phi_A - 1}}$$

where Q_{HA}, Q_{GA}, Q_{FA} and Q_{NA} are bundles of respectively intermediate tradables produced in Home, intermediate tradables produced in the REA, intermediate tradables produced in the RW and intermediate nontradables produced in Home. The parameter $\rho_A > 0$ is the elasticity of substitution between tradables and $\phi_A > 0$ is the elasticity of substitution between tradable and nontradable goods. The parameter a_H $(0 < a_H < 1)$ is the weight of the Home tradable, the parameter a_G $(0 < a_G < 1)$ the weight of tradables imported from the REA, a_T $(0 < a_T < 1)$ the weight of tradable goods.

The production of investment good is similar. There are symmetric Home firms under perfect competition indexed by $y \in (0, s]$. Firms in the REA and in the RW are indexed by $y^* \in (s, S]$ and $y^{**} \in (S, 1]$. Output of the generic Home firm y is:

$$E_t(y) \equiv \left(\begin{array}{c} v_T^{\frac{1}{\phi_E}} \left(v_H^{\frac{1}{\rho_E}} Q_{HE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + v_G^{\frac{1}{\rho_E}} Q_{GE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + (1 - v_H - v_G)^{\frac{1}{\rho_E}} Q_{FE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \right)^{\frac{\rho_E}{\rho_E - 1} \frac{\phi_E - 1}{\phi_E}} \\ + (1 - v_T)^{\frac{1}{\phi_E}} Q_{NE,t}(y)^{\frac{\phi_E - 1}{\phi_E}} \end{array} \right)^{\frac{\phi_E}{\phi_E - 1}}$$

Finally, we assume that public expenditure C^g is composed by intermediate nontradable goods only.

B Intermediate goods

B.1 Demand

Bundles used to produce the final consumption goods are CES indexes of differentiated intermediate goods, each produced by a single firm under conditions of monopolistic competition:

$$Q_{HA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_T}\int_0^s Q(h,x)^{\frac{\theta_T-1}{\theta_T}}\,dh\right]^{\frac{\theta_T}{\theta_T-1}} \tag{18}$$

$$Q_{GA}(x) \equiv \left[\left(\frac{1}{S-s}\right)^{\theta_T}\int_s^S Q(g,x)^{\frac{\theta_T-1}{\theta_T}}\,dg\right]^{\frac{\theta_T}{\theta_T-1}} \tag{19}$$

$$Q_{FA}(x) \equiv \left[\left(\frac{1}{1-S}\right)^{\theta_T}\int_S^1 Q(f,x)^{\frac{\theta_T-1}{\theta_T}}\,df\right]^{\frac{\theta_T}{\theta_T-1}} \tag{20}$$

$$Q_{NA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_N}\int_0^s Q(n,x)^{\frac{\theta_N-1}{\theta_N}}\,dn\right]^{\frac{\theta_N}{\theta_T-1}} \tag{21}$$

where firms in the Home intermediate tradable and nontradable sectors are respectively indexed by $h \in (0,s)$ and $n \in (0,s)$, firms in the REA by $g \in (s,S]$ and firms in the RW by $f \in (S,1]$. Parameters θ_T, $\theta_N > 1$ are respectively the elasticity of substitution across brands in the tradable and nontradable sector. The prices of the intermediate nontradable goods are denoted $p(n)$. Each firm x takes these prices as given when minimizing production costs of the final good. The resulting demand for intermediate nontradable input n is:

$$Q_{A,t}(n,x) = \left(\frac{1}{s}\right)\left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N} Q_{NA,t}(x) \tag{22}$$

where $P_{N,t}$ is the cost-minimizing price of one basket of local intermediates:

$$P_{N,t} = \left[\int_0^s P_t(n)^{1-\theta_N}\,dn\right]^{\frac{1}{1-\theta_N}} \tag{23}$$

We can derive $Q_A(h,x)$, $Q_A(f,x)$, $C_A^g(h,x)$, $C_A^g(f,x)$, P_H and P_F in a similar way. Firms y producing the final investment goods have similar demand curves. Aggregating over x and y, it can be shown that total demand for intermediate nontradable good n is:

$$\begin{aligned} & \int_0^s Q_{A,t}(n,x)\,dx + \int_0^s Q_{E,t}(n,y)\,dy + \int_0^s C_t^g(n,x)\,dx \\ = & \left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N}\left(Q_{NA,t} + Q_{NE,t} + C_{N,t}^g\right) \end{aligned}$$

where C_N^g is public sector consumption. Home demands for (intermediate) domestic and imported tradable goods can be derived in a similar way.

B.2 Supply

The supply of each Home intermediate nontradable good n is denoted by $N^S(n)$:

$$N_t^S(n) = \left((1-\alpha_N)^{\frac{1}{\xi_N}} L_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}} + \alpha^{\frac{1}{\xi_N}} K_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}}\right)^{\frac{\xi_N}{\xi_N-1}} \tag{24}$$

Firm n uses labor $L_{N,t}^p(n)$ and capital $K_{N,t}(n)$ with constant elasticity of input substitution $\xi_N > 0$ and capital weight $0 < \alpha_N < 1$. Firms producing intermediate goods take the prices of labor inputs and capital as given. Denoting W_t the nominal wage index and R_t^K the nominal rental price of capital, cost minimization implies:

$$L_{N,t}(n) = (1-\alpha_N)\left(\frac{W_t}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n) \tag{25}$$

$$K_{N,t}(n) = \alpha\left(\frac{R_t^K}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n)$$

where $MC_{N,t}(n)$ is the nominal marginal cost:

$$MC_{N,t}(n) = \left((1-\alpha)W_t^{1-\xi_N} + \alpha\left(R_t^K\right)^{1-\xi_N}\right)^{\frac{1}{1-\xi_N}} \tag{26}$$

The productions of each Home tradable good, $T^S(h)$, is similarly characterized.

B.3 Price setting in the intermediate sector

Consider now profit maximization in the Home intermediate nontradable sector. Each firm n sets the price $p_t(n)$ by maximizing the present discounted value of profits subject to the demand constraint and the quadratic adjustment costs:

$$AC^p_{N,t}(n) \equiv \frac{\kappa^p_N}{2}\left(\frac{P_t(n)}{P_{t-1}(n)} - 1\right)^2 Q_{N,t} \quad \kappa^p_N \geq 0$$

paid in unit of sectorial product $Q_{N,t}$ and where κ^p_N measures the degree of price stickiness. The resulting first-order condition, expressed in terms of domestic consumption, is:

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_t(n) - \frac{A_t(n)}{\theta_N - 1} \tag{27}$$

where $mc_t(n)$ is the real marginal cost and $A(n)$ contains terms related to the presence of price adjustment costs:

$$\begin{aligned} A_t(n) \quad \approx \quad & \kappa^p_N \frac{P_t(n)}{P_{t-1}(n)}\left(\frac{P_t(n)}{P_{t-1}(n)} - 1\right) \\ & -\beta\kappa^p_N \frac{P_{t+1}(n)}{P_t(n)}\left(\frac{P_{t+1}(n)}{P_t(n)} - 1\right)\frac{Q_{N,t+1}}{Q_{N,t}} \end{aligned}$$

The above equations clarify the link between imperfect competition and nominal rigidities. As emphasized by Bayoumi et al. (2004), when the elasticity of substitution θ_N is very large and hence the competition in the sector is high, prices closely follow marginal costs, even though adjustment costs are large. To the contrary, it may be optimal to maintain stable prices and accommodate changes in demand through supply adjustments when the average mark-up over marginal costs is relatively high. If prices were flexible, optimal pricing would collapse to the standard pricing rule of constant mark-up over marginal costs (expressed in units of domestic consumption):

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_{N,t}(n) \tag{28}$$

Firms operating in the intermediate tradable sector solve a similar problem. We assume that there is market segmentation. Hence the firm producing the brand h chooses $p_t(h)$ in the Home

market,a price $p_t^*(h)$ in the REA and a price $p_t^{**}(h)$ in the RW to maximize the expected flow of profits (in terms of domestic consumption units):

$$E_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left[\begin{array}{c} p_\tau(h) y_\tau(h) + p_\tau^*(h) y_\tau^*(h) + p_\tau^{**}(h) y_\tau^{**}(h) \\ -mc_{H,\tau}(h)\left(y_\tau(h) + y_\tau^*(h) + y_\tau^{**}(h)\right) \end{array} \right]$$

subject to quadratic price adjustment costs similar to those considered for nontradables and standard demand constraints. The term E_t denotes the expectation operator conditional on the information set at time t, $\Lambda_{t,\tau}$ is the appropriate discount rate and $mc_{H,t}(h)$ is the real marginal cost. The first order conditions with respect to $p_t(h)$, $p_t^*(h)$ and $p_t^{**}(h)$ are:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t(h)}{\theta_T - 1} \tag{29}$$

$$p_t^*(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^*(h)}{\theta_T - 1} \tag{30}$$

$$p_t^{**}(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^{**}(h)}{\theta_T - 1} \tag{31}$$

where θ_T is the elasticity of substitution of intermediate tradable goods, while $A(h)$ and $A^*(h)$ involve terms related to the presence of price adjustment costs:

$$\begin{aligned}
A_t(h) &\approx \kappa_H^p \frac{P_t(h)}{P_{t-1}(h)} \left(\frac{P_t(h)}{P_{t-1}(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}(h)}{P_t(h)} \left(\frac{P_{t+1}(h)}{P_t(h)} - 1 \right) \frac{Q_{H,t+1}}{Q_{H,t}} \\
A_t^*(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^*(h)}{P_{t-1}^*(h)} \left(\frac{P_t^*(h)}{P_{t-1}^*(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}^*(h)}{P_t^*(h)} \left(\frac{P_{t+1}^*(h)}{P_t^*(h)} - 1 \right) \frac{Q_{H,t+1}^*}{Q_{H,t}^*} \\
A_t^{**}(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} \left(\frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} \left(\frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} - 1 \right) \frac{Q_{H,t+1}^{**}}{Q_{H,t}^{**}}
\end{aligned}$$

where κ_H^p,$\kappa_H^{p\,*}$,$\kappa_H^{p\,**} > 0$ respectively measure the degree of nominal rigidity in Home, in the REA and in the RW. If nominal rigidities in the (domestic) export market are highly relevant

(that is, if is relatively large), the degree of inertia of Home goods prices in the foreign markets will be high. If prices were flexible ($\kappa_H^p = \kappa_H^{p*} = \kappa_H^{p**} = 0$) then optimal price setting would be consistent with the cross-border law of one price (prices of the same tradable goods would be equal when denominated in the same currency).

C Labor Market

In the case of firms in the intermediate nontradable sector, the labor input $L_N(n)$ is a CES combination of differentiated labor inputs supplied by domestic agents and defined over a continuum of mass equal to the country size ($j \in [0, s]$):

$$L_{N,t}(n) \equiv \left(\frac{1}{s}\right)^{\frac{1}{\psi}} \left[\int_0^s L_t(n,j)^{\frac{\psi-1}{\psi}} dj\right]^{\frac{\psi}{\psi-1}} \tag{32}$$

where $L(n,j)$ is the demand of the labor input of type j by the producer of good n and $\psi > 1$ is the elasticity of substitution among labor inputs. Cost minimization implies:

$$L_t(n,j) = \left(\frac{1}{s}\right) \left(\frac{W_t(j)}{W_t}\right)^{-\psi} L_{N,t}(j), \tag{33}$$

where $W(j)$ is the nominal wage of labor input j and the wage index W is:

$$W_t = \left[\left(\frac{1}{s}\right) \int_0^s W_t(h)^{1-\psi} dj\right]^{\frac{1}{1-\psi}}. \tag{34}$$

Similar equations hold for firms producing intermediate tradable goods. Each household is the monopolistic supplier of a labor input j and sets the nominal wage facing a downward-sloping demand, obtained by aggregating demand across Home firms. The wage adjustment is sluggish because of quadratic costs paid in terms of the total wage bill:

$$AC_t^W = \frac{\kappa_W}{2} \left(\frac{W_t}{W_{t-1}} - 1\right)^2 W_t L_t \tag{35}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity and L is the total amount of labor in the Home economy.

D The equilibrium

We find a symmetric equilibrium of the model. In each country there is a representative agent and four representative sectorial firms (in the intermediate tradable sector, intermediate nontradable sector, consumption production sector and investment production sector). The equilibrium is a sequence of allocations and prices such that, given initial conditions and the sequence of exogenous shocks, each private agent and firm satisfy the correspondent first order conditions, the private and public sector budget constraints and market clearing conditions for goods, labor, capital and bond hold.

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