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## Macroeconomic Effects of Sovereign Restructuring in a Monetary Union: A Model- based Approach

*Lorenzo Forni and Massimiliano Pisani*

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**Macroeconomic Effects of Sovereign Restructuring in a Monetary Union: A Model-based Approach<sup>1</sup>**

**Prepared by Lorenzo Forni and Massimiliano Pisani**

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**Abstract**

We assess the macroeconomic effects of a sovereign restructuring in a small economy belonging to a monetary union by simulating a dynamic general equilibrium model. In line with the empirical evidence, we make the following three key assumptions. First, sovereign debt is held by domestic agents and by agents in the rest of the monetary union. Second, after the restructuring the sovereign borrowing rate increases and its increase is fully transmitted to the borrowing rate paid by the domestic agents. Third, the government cannot discriminate between domestic and foreign agents when restructuring. We show that the macroeconomic effects of the restructuring depend on: (a) the share of sovereign bonds held by residents in the country as compared to that held by foreign residents, (b) the increase in the spread paid by domestic agents and (c) its net foreign asset position at the moment of the restructuring. Our results also suggest that the sovereign restructuring implies persistent reductions of output, consumption and investment, that can be large, in particular if the share of public debt held domestically is large, the private foreign debt is high and the spread paid by the government and the households does increase.

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Author's E-Mail Address: [lforni@imf.org](mailto:lforni@imf.org); [massimiliano.pisani@bancaditalia.it](mailto:massimiliano.pisani@bancaditalia.it)

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## I. Introduction

The recent sovereign debt crisis has raised the question of the economic implications of a possible sovereign restructuring by a member of a monetary union.

While there have been a number of sovereign restructuring episodes in low-income and developing economies in the past, the experience regarding advanced economies is much more limited. Advanced economies differ from low income and developing economies in many ways. They tend to have a larger share of their public debt held domestically, as they tend to have deeper financial systems. Moreover, monetary union member countries display a high degree of financial integration, with significant cross-country holdings of public and private debt. A sovereign restructuring by a monetary union member would therefore happen in a very different context compared to previous instances of sovereign restructuring. This paper provides an assessment of the possible macroeconomic effects of a restructuring in one country of a monetary union.

Three important factors determine the macroeconomic costs and benefits of such a restructuring: first, the share of sovereign bonds held by households resident in the country as compared to the share held by foreign residents; second, the response of international financial investors to the sovereign restructuring; and third, the private sector net foreign asset position at the moment of the restructuring.

Regarding the distribution of government bond holdings between domestic and foreign residents, let's consider, for the sake of argument, two extreme cases. Suppose that the government bonds are held by domestic residents only. Moreover, suppose that they have infinite life-time horizon and taxes are lump-sum. In this case the restructuring would not have any macroeconomic effect, as the public debt is not considered net wealth by its holders. Indeed, its reduction is fully offset by the expectation of lower future taxes, therefore leaving households' permanent income unchanged. Instead, suppose that foreign investors are the only holders of government bonds and, moreover, that they do not 'punish' the government and its citizens by increasing the country's borrowing cost after the restructuring. In this case the country implementing the restructuring would get a positive capital gain associated with the improvement of its net foreign asset position.

However, interest rates tend to increase around restructuring instances and the evidence shows that usually there is a premium that the government has to pay after the fact, as it is perceived as a riskier borrower. This premium or spread can therefore be thought as reflecting the 'loss of reputation as reliable borrower' that the country faces after the restructuring.

Finally, the private sector's net foreign asset position at the time of the sovereign restructuring is relevant

as well. The larger the foreign liabilities, the larger the increase in the interest payments that the higher borrowing costs would imply and, hence, the negative income effect faced by residents.

Overall, the macroeconomic effects of a restructuring depend on the combined effects of, one hand, the capital gain coming from lowering the foreign debt and, on the other, the additional costs of rolling over the (post-haircut) public and private external debt at a higher interest rate. The capital gain induces a positive wealth effect as it corresponds to a lump-sum tax on foreign investors. The higher spread, on the other hand, induces a negative substitution effect (today's consumption is more expensive than future consumption) and a negative income effect (the interest payment on the new after-restructuring foreign asset position of the country as a whole increases).

We try to assess these impacts by developing and simulating a new-Keynesian general equilibrium model of a monetary union. In the model there are two regions, Home and Foreign, each of different size. Home is a relatively small country of the monetary union, while Foreign represents the rest of the union. Home government is assumed to restructure its debt. We consider the case of a relatively small Home country, so that the restructuring does not greatly affect the rest of the monetary union. As such, the restructuring has not systemic implications for the union.<sup>1</sup>

The monetary union setup enables to take into account two specific features. First, monetary policy is conducted at union level. Hence, it does not fully react to the changing macroeconomic conditions in the Home country after the restructuring. Second, fiscal policy is managed at the country level.

On the financial side, the model features two types of bonds, both denominated in the currency of the monetary union. The first one is exchanged between the domestic and foreign private sector only. The second one is issued by the two sovereign states and is bought by both domestic and foreign households. Each bond is in zero net supply at monetary union-wide level. We follow Broner et al. (2010) and assume that the domestic government cannot discriminate between domestic and foreign debt holders.<sup>2</sup>

Regarding the increase in the spread after the restructuring, the existing literature has reached mixed conclusions. Some papers point to relatively short periods of exclusion from the international financial market and moderate increase in spreads (Panizza et al. 2009). Others, such as Cruces and Trebesh (2013), show that spreads are positively correlated with the size of the haircut. We follow the latter and assume that after the sovereign restructuring both the government and the private sector have to pay a spread above the risk-free rate when issuing bonds (the risk-free rate is equal to the interest rate set by the

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<sup>1</sup>Contagion and systemic crises are not the object of the analysis.

<sup>2</sup>As long as there is a functioning secondary market for the debt, foreign holders have always the opportunity to sell their debt on the secondary market. Therefore if the fiscal authority when restructuring its debt tries to discriminate and imposes the haircut only on foreign holders, the latter would sell their bonds on the secondary market to the domestic residents (which should be willing to buy at a price close to the face value).

central bank of the monetary union). The spread is proportional to the size of the haircut and equal for both private and public borrowing. The latter assumption is consistent with evidence that spreads on the sovereigns quickly are passed on to the private sector. In this deliberately parsimonious way we capture the ‘price’ paid by the country for the ‘loss of reputation as reliable borrower’ and the related financial distress that characterize both the private and public sectors after a sovereign restructuring.

Other features are rather standard. Each region is specialized in the production of nontradable final goods, tradable and nontradable intermediate goods. Monetary policy is conducted at union level through a standard Taylor rule.

The Home country is calibrated to broadly resemble a generic small open economy. In the baseline simulation it is assumed that the small economy starts off with a very high level of sovereign debt (equal to 150 percent of yearly GDP) and that Home and Foreign households each hold 50 percent of the Home government debt. Finally, it is assumed that the private sector’s net foreign debt prior to the restructuring is equal to 100 percent of GDP. Given this background, the restructuring is modeled as an unexpected write-off (haircut) of the public debt equal to 40 percent of its nominal value. As a ratio to yearly GDP, it corresponds to a reduction in the public debt from 150 to 90 percent. We also calibrate the post-restructuring spread consistently with the empirical evidence provided by Cruces and Trebesch (2013), where the authors collect information also on the size of haircuts. They show that greater haircuts are associated with larger post-restructuring bond spreads, after controlling for fundamentals as well as country and time fixed effects. The effect on the spread of a 40 percentage point haircut is estimated to be on average about 300 basis points in year one and to decrease over time, being still significant at about 150 basis points in years four and five after the restructuring.<sup>3</sup>

Moreover, we assume that after the restructuring lump-sum transfers are adjusted by the government in order to stabilize the debt at the new (post-haircut) level according to a fiscal rule.<sup>4</sup>

Results are as follows. First, after the haircut GDP shows a decrease which is rather persistent and associated with a reduction in consumption and investment by domestic residents. The recovery is slow, as it takes more than three years for the GDP to return to its baseline level. Second, the GDP loss is relatively large if the share of public debt held domestically is large, the private foreign debt is large and the spread increases. Overall, we do find that the sovereign restructuring induces a rather persistent

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<sup>3</sup>The empirical result of Cruces and Trebesch (2013) is consistent with the classical work of Eaton and Gersovitz (1981), where it is argued that sovereign borrowing can be supported as long as a restructuring is costly. Therefore, non-repayments have to be followed by punishments (in the form of high spreads or exclusion from international borrowing), and larger non-repayments by larger punishments.

<sup>4</sup>We choose a fiscal rule defined in terms of lump-sum taxes for simplicity as it avoids the analysis of the distortions associated with other taxes.

reduction in macroeconomic activity, even under the more favorable initial financial conditions (when the initial share of domestically held sovereign bonds and the level of foreign debt by households are relatively low).

To our knowledge there are not other studies that have assessed the macroeconomic impact of a sovereign distress in a monetary union or advanced economies. A partial exception is Corsetti et al. (2012) that use a closed economy model to stress the role of the ‘sovereign risk’ channel of fiscal policy. In their model a high level of public debt affects the private sector via the effect that the risk of sovereign default has on the spread paid by the private sector. We differ from Corsetti et al. (2012) because we stress the open economy dimension of the problem and specifically the role of the domestic vs. foreign holding of government debt.

Finally, we want to stress that quantifying the likely fall in activity from a sovereign restructuring is a very difficult task. In particular, the way it might play out in reality will depend on a host of characteristics of the sovereign and of the way the restructuring takes place. Therefore it is not our ambition to present predictions of the economic effects of a restructuring. We intend instead to highlight some of the important channels that will shape the outcome and assess their relative importance. As discussed, we will emphasize three such important channels: the reaction of international financial markets (especially regarding the increase in the borrowing costs), the net foreign asset position of the private sector, and the share of government debt held domestically. We do not consider some other important factors that could magnify the negative effects of the restructuring, as the role played by financial frictions, by banks balance sheets and possible contagion effects (especially relevant in a financially integrated monetary union). Moreover, in our baseline simulations we will assume that the budget balance is in equilibrium in the initial steady state and that fiscal policy will aim at stabilizing the debt after the restructuring. This assumption does not match the recent experience of countries that have faced sovereign stress while at the same time undergoing considerable fiscal consolidations. All in all, therefore, our results cannot be easily applied to the experience of any specific country.

The paper is organized as follows. Section 2 describes the main equations of the model (with a focus on those related to the model’s financial and fiscal structure; the remaining ones are reported in the Appendix) and the calibration. Section 3 discusses the results. Section 4 concludes.

## II. The model

### A. Setup

The basic structure of the model is new Keynesian and akin to the International Monetary Fund's Global Economy Model (GEM) and the European Central Bank's New Area Wide Model (NAWM).<sup>5</sup> We divide the monetary union in two regions, the Home country and the rest of the monetary union.

On the production side, we assume that in each country there are firms producing final nontradable goods under perfect competition. The goods are used for private and public consumption as well as for investment. They are produced combining intermediate tradable and nontradable goods. Intermediate goods are produced under monopolistic competition. Firms in the sector are price-setters (each of them is able to set the price of the produced variety, taking into account the demand). In particular, firms producing tradables are able to price-discriminate between domestic and exporting markets (hence they set two country-specific prices). Intermediate goods are produced by combining domestic labor and capital.

We assume households accumulate capital (which they rent to domestic firms) and, more importantly, trade two nominal bonds at the union level. Both bonds are denominated in the currency of the monetary union. One bond is traded among households only. The other is the government bond, traded between households and governments. Households are wage setters (each of them offers differentiated labor services to domestic firms under monopolistic competition).

Monetary and fiscal authorities behave according to feedback rules. A standard Taylor rule holds for monetary policy, which is common to the Home and Foreign regions. The monetary policy rate reacts to monetary union-wide inflation rates and output growth. It is set in an inertial way, to capture gradualism in the conduct of monetary policy. Fiscal policy is conducted at the country level. On the expenditure side, we distinguish between spending on final goods and services produced by the private sector, public wages, and transfers to families. On the revenue side, we distinguish between lump-sum and distortionary taxation of labor income, capital income and consumption.<sup>6</sup> The fiscal sector is closed by a fiscal rule, that stabilizes the public debt using lump-sum transfers.

Finally, the model features the standard real and nominal frictions, such as habit in consumption, adjustment costs related to investment changes, adjustment costs related to nominal prices and wages, and wage and price indexation to a weighted average of previous period inflation and the central bank's inflation target.

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<sup>5</sup>For a description of the GEM and NAWM see Pesenti (2008) and Coenen et al. (2008), respectively. A detailed description of our model is reported in the Appendix.

<sup>6</sup>For a model with similar fiscal features, see Forni et al. (2010).

### Fiscal policy

Fiscal policy is set at the country level. The discussion in this section applies to the Home as well as the Foreign region. The Appendix gives a more detailed description of the model. The government budget constraint is:

$$B_t^{gov} - B_{t-1}^{gov} \left(1 - Loss_t^{B^{gov}}\right) = B_{t-1}^{gov} \left(1 - Loss_t^{B^{gov}}\right) (r_{t-1} + \phi_{t-1}^{gov}) + (1 + \tau_t^c) P_t C_t^{gov} + W_t L_t^{gov} + Tr_t - T_t \quad (1)$$

where  $B_{t-1}^{gov}, B_t^{gov} \geq 0$  are the levels of nominal public debt at the beginning and end of period  $t$ , respectively.<sup>7</sup> The bond is issued in the union-wide market and pays a (net) nominal interest rate  $(r + \phi^{gov})$ . The latter is equal to the sum of the risk-free rate set by the central bank of the monetary union,  $r$ , and the spread  $\phi^{gov}$  that the government has to pay after a restructuring. The (net) nominal rate  $r_t$  is paid at the beginning of period  $t + 1$  and is known at time  $t$ . Similarly, the spread  $\phi_t^{gov}$  is paid at the beginning of period  $t + 1$  and is known at time  $t$  (immediately after the restructuring). The term  $Loss_t^{B^{gov}}$  represents the ‘haircut’ associated with the restructuring, leading to sudden reduction (measured in percent) in the initial value of sovereign debt. In other terms,  $Loss_t^{B^{gov}}$  is greater than zero in  $t = 1$  (the initial period of the simulation) and zero subsequently. The first term on the right-hand side of equation (1) corresponds to the amount of interest expenditure on the new post-restructuring level of public debt. It depends on the new level of debt and the response of the interest rate, in particular the spread component.

Other variables in the equation are standard. The variable  $C^{gov}$  stands for government purchases of goods and services,  $WL^{gov}$  for compensation for public employees,  $Tr > 0$  are lump-sum transfers to households ( $Tr < 0$  are lump-sum taxes). We assume that  $C^{gov}$  has the same composition as private consumption. Hence it is multiplied by the private consumption price index  $P$ . Total government revenues  $T$  are given by the following identity:

$$T_t \equiv \tau_t^\ell W_t L_t + \tau_t^c [P_t C_t + P_t C_t^{gov}] + \tau_t^k [r_t^k K_t + \Pi_t^P] \quad (2)$$

where  $\tau_s$  are tax rates on labor income ( $\tau_t^\ell$ ), capital income ( $\tau_t^k$ ) and consumption ( $\tau_t^c$ ),  $L_t$  is total employment (including public employment  $L_t^{gov}$ , and private employment  $L_t^p$ , with  $L_t = L_t^p + L_t^{gov}$ ),  $r_t^k$  is the rental rate of physical capital  $K_t$  and  $\Pi_t^P$  stands for dividends from ownership of domestic monopolistic

<sup>7</sup>As is standard in this class of models, bonds are one-period securities and each period is equal to one quarter. The actual average maturity of the debt is longer than one quarter. In this case the increase in spreads would bring about a gradual increase in interest costs. Assuming a longer average maturity of the debt in the model would produce similar effects on GDP and on the other variables, although these effects would materialize in a more gradual manner.



firms.

A fiscal rule stabilizes the level of public debt as a percent of GDP,  $b^{gov} > 0$ . We assume a policy rule that uses as instrument the lump-sum transfers as a share of GDP,  $tr_t$ . The instrument responds to: (1) the discrepancy of the current level of  $b^{gov}$  from its long run target  $b^{gov,targ}$ ; (2) the change in  $b^{gov}$  between periods  $t$  and  $t - 1$ ; (3) GDP growth. The implied rule is:

$$\frac{tr_t}{tr_{t-1}} = \left( \frac{b_t^{gov}}{b^{gov,targ}} \right)^{\phi_1} \left( \frac{b_t^{gov}}{b_{t-1}^{gov}} \right)^{\phi_2} \left( \frac{GDP_t}{GDP_{t-1}} \right)^{\phi_3} \quad (3)$$

where  $\phi_1, \phi_2, \phi_3 < 0$ . Parameters  $\phi_1$  and  $\phi_2$  are lower than zero calling for a reduction in transfers whenever the debt level is above target and for a larger reduction whenever the debt growth is high. Parameter  $\phi_3$  is lower than zero as well, as transfer growth is inversely related to GDP growth.<sup>8</sup> In the simulations, the long-run target  $b^{gov,targ}$  is reset in order to stabilize the sovereign debt at the new (after-haircut) level.

### Households

In each region there is a continuum of households having symmetric preferences and budget constraint. They are indexed by  $j \in (0; s)$  (Foreign households by  $j \in [s; 1]$ ), where  $s$  is the size of the Home region and  $1 - s$  the size of the rest of the monetary union. Households' preferences are additively separable in consumption  $C$  and labor effort  $L$ . The expected value of household  $j$  lifetime utility is given by:

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

where  $E_0$  denotes the expectation conditional on information set at date 0,  $\beta$  is the discount factor ( $0 < \beta < 1$ ),  $1/\sigma$  is the elasticity of intertemporal substitution ( $\sigma > 0$ ) and  $1/(\tau - 1)$  is the labor Frisch elasticity ( $\tau > 0$ ).

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<sup>8</sup>The GDP is defined as:

$$GDP = C + P^I I + C^{gov} + P^{EXP} EXP - P^{IMP} IMP + WL^{gov}$$

where  $P^I$ ,  $P^{EXP}$ ,  $P^{IMP}$  are prices of respectively investment  $I$ , export  $EXP$  and import  $IMP$  while  $W$  represents nominal wage.

Given the presence of public employment, and consistently with common practice in the national accounts statistics, we include the public expenditure for wages in GDP.

The budget constraint of household  $j$  is:

$$\begin{aligned}
& B_t(j) - B_{t-1}(j) + B_t^g(j) - B_{t-1}^g(j) \left(1 - Loss_t^{B^{gov}}\right) \\
\leq & B_{t-1}(j) (r_{t-1} + \phi_{t-1}^b) + B_{t-1}^g(j) \left(1 - Loss_t^{B^{gov}}\right) (r_{t-1} + \phi_{t-1}^{gov}) \\
& + (1 - \tau_t^k) [\Pi_t^P(j) + r_t^K K_{t-1}(j)] + \\
& + (1 - \tau_t^\ell) W_t(j) L_t(j) - (1 + \tau_t^c) P_t C_t(j) - P_t^I I_t(j) \\
& + T r_t(j) - AC_t^W(j)
\end{aligned}$$

Home households hold two bonds  $B$  and  $B^g$  denominated in the currency of the monetary union. Both bonds are in zero net supply at the monetary union level (we report the market clearing conditions in the next section). The bond  $B$  is exchanged with Foreign households only. It pays a (net) interest rate  $(r_t + \phi_t^b)$  at the beginning of period  $t + 1$  and known at time  $t$ . The bond  $B^g$  is the government bond, exchanged between households and governments in the monetary union-wide government bond market. As previously mentioned, it pays the interest rate  $r$  set by the central bank of the monetary union and a spread. The term  $Loss_t^{B^{gov}}$  is the same shock as the one in the government budget constraint (1). As said, it measures the (percent) reduction in the value of the government bond at the beginning of period  $t = 1$  (the initial period in the simulation horizon).

After the restructuring, the government pays a higher spread not only to the foreign households but also to the domestic ones. As such, the spread  $\phi^{gov}$  is added on top of the risk-free rate  $r$  also in the households' budget constraint. Moreover, we assume that the spread paid by the government after the haircut is fully transmitted to domestic households. The latter, after the initial sovereign haircut, face an increase in the spread  $\phi^b$  on their foreign debt position,  $B$ , in the households' bond market. In this (deliberately) stylized way we characterize the (ex-post) sovereign haircut channel to the Home economy. Specifically, after the sovereign restructuring credit conditions for the private sector become as stringent as for the government. So the same spread  $\phi^{gov} = \phi^b = \phi$  applies to home households when borrowing from foreign households and to the home government when borrowing from domestic and foreign households. It is defined as follows:

$$\phi_t = \phi_{b1} \left( \exp \left( Loss_t^{B^{gov}} \right) - 1 \right) + \rho_\phi \phi_{t-1} + \phi_{b2} \frac{\exp \left( \phi_{b3} (b - \bar{b}) \right) - 1}{\exp \left( \phi_{b3} (b - \bar{b}) \right) + 1} \quad (4)$$

The first two terms are related to the effects of the sovereign restructuring on Home's borrowing costs in international markets. The larger the restructuring (so the larger  $Loss_t^{B^{gov}}$ ), the higher the spread (first

term on the right-hand side of equation 4), where  $\phi_{b1} > 0$ . In this way financial markets impose a cost to Home households and government for the implied ‘loss of reputation’ as reliable borrowers. Moreover, the increase in the spread is persistent over time (second term on the right-hand side of equation 4, where  $0 \leq \rho_\phi \leq 1$ ). Finally, the third term on the right-hand side of equation (4) guarantees, as in Global Economy Model (see Pesenti 2009), that the foreign asset position of households as a ratio to GDP,  $b$ , converges to its steady state value  $\bar{b}$ . We set  $\phi_{b2}, \phi_{b3} > 0$  to rather low values to limit the impact of the third term on the dynamics and keep the model stationary.<sup>9</sup>

As we will demonstrate later, the combination of the post-haircut spread, the share of public debt held by domestic households and their foreign borrowing position is crucial for assessing the macroeconomic effects of the restructuring on the domestic economy.

We also assume that households own all Home firms and there is no international trade in claims on firms’ profits, represented by  $\Pi^P(j)$ . Each Home agent  $j$  is a wage-setter, being a monopolistic supplier of a single labor variety. The nominal wage  $W_t(j)$  is sticky given the presence of the adjustment cost  $AC_t^W$ :

$$AC_t^W(j) \equiv \frac{\kappa_W}{2} \left( \frac{W_t(j)/W_{t-1}(j)}{\pi_{W,t-1}^{\alpha_W} \bar{\pi}^{1-\alpha_W}} - 1 \right)^2 W_t L_t$$

where  $\kappa_W > 0$  is a parameter and  $W_t L_t$  is the average Home wage income. The term  $\pi_{W,t-1}^{\alpha_W} \bar{\pi}^{1-\alpha_W}$  represents the indexation of wages to the previous period’s gross (average) wage inflation  $\pi_{W,t-1}$  and to the gross consumer price inflation target of the central bank  $\bar{\pi}$ , with weights  $\alpha_W$  and  $1 - \alpha_W$ , respectively ( $0 \leq \alpha_W \leq 1$ ). Finally, each household rents physical capital to domestic firms at the nominal rate  $R^k$ . The law of motion is:

$$K_t(j) = (1 - \delta) K_{t-1}(j) + (1 - AC_t^I(j)) I_t(j) \quad (5)$$

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

$$AC_t^I(j) \equiv \frac{\phi_I}{2} \left( \frac{I_t(j)}{I_{t-1}(j)} - \delta \right)^2 \quad (6)$$

where  $\phi_I > 0$  is a parameter. Similar relations hold in the Foreign country.

<sup>9</sup>There is only one (minor) difference between  $\phi^{gov}$  and  $\phi^b$ . It corresponds to the third term on the right-hand side of equation (4), that in the case of the government spread depends on the current and steady state values of the government bonds held by Home households. As said, the difference is quantitatively small, as we minimize the impact of that term on the dynamics. Finally, all revenues from the imposition of the spread are rebated in a lump-sum way to Foreign households (see Benigno 2009). For the latter, the spread does not enter neither in the government budget constraint nor in the Euler equations.

## B. Bond market clearing conditions

To clarify the financial structure of the model, we report the two bond market clearing conditions. For the bond traded between Home and Foreign households, we have (using the assumption of symmetric households in each country):<sup>10</sup>

$$sB_t + (1 - s)B_t^* = 0 \quad (7)$$

where, as previously said,  $0 < s < 1$  is the size of the Home economy (the size of the union is normalized to 1). For the government bond, the market clearing condition is:

$$sB_t^g - B_t^{gov} + (1 - s)B_t^{g*} - B_t^{gov*} = 0 \quad (8)$$

where  $B_t^{gov} \geq 0$  and  $B_t^{gov*} \geq 0$  represent Home and Foreign government debt, respectively. The net foreign asset position ( $FA_t$ ) of the Home country is given by the sum of Home households and government positions against the rest of the monetary union:

$$FA_t = sB_t + sB_t^g - B_t^{gov} \quad (9)$$

where the sum  $sB_t + sB_t^g$  represents the total asset position of the Home households. The current account  $CA_t$  and the trade balance  $TB_t$  of the Home economy are given respectively by:

$$CA_t = FA_t - FA_{t-1} \quad (10)$$

$$TB_t = CA_t - (sB_{t-1} + sB_{t-1}^g - B_{t-1}^{gov})(r_{t-1} + \phi_{t-1}^{gov}) \quad (11)$$

The current account is the change in the foreign asset position of the Home country. The trade balance is the current account net of the interest payment on the foreign asset position.

Given the above equations and the spread in (4), we are able to assess the impact of the Home sovereign restructuring on the Home foreign asset position and hence on the Home economy.

## C. Calibration

The model is calibrated at quarterly frequency to a generic small peripheral country of a monetary union and the rest of the monetary union. For most parameters we resort to previous studies and estimates available in the literature.<sup>11</sup>

<sup>10</sup>Foreign (rest of the monetary union) variables have a '\*'.

<sup>11</sup>See Forni et al. (2009, 2010) and Gomes et al. (2010).

Table 1 reports the steady-state macroeconomic aggregates and tax rates under our baseline calibration. The tax rate on wage income  $\tau^\ell$  is set to 0.46 in both Home and the rest of the monetary union. Similarly, the tax rate on capital income  $\tau^k$  is set to 0.19, while the tax rate on consumption  $\tau^c$  to 0.18. The public debt-to-yearly GDP ratio is calibrated at 150 percent for Home and at 60 per cent for the rest of the monetary union. Finally, Home households have a foreign debt equal to 100 percent of Home annualized GDP.

Table 2 reports the calibration of the spread paid by the public and private sector (see equation 4). Consistently with evidence provided by Cruces and Trebesch (2013), the effect on the spread of a 40 percentage points haircut is around 300 basis points in year one. Subsequently, it decreases over time in a gradual way. Four years after the restructuring it is around 150 basis points.

Table 3 contains parameters related to preferences and technology. Parameters with a “\*” are related to the rest of the monetary union. We assume that discount rates and elasticities of substitution have the same value across the two regions. The discount factor  $\beta$  is set to 0.992, so that the steady state real interest rate is equal to 3.3 per cent on an annual basis. The intertemporal elasticity of substitution,  $1/\sigma$ , is set to 1, the Frisch labor elasticity to 2, the depreciation rate of capital  $\delta$  to 0.025. For the production of intermediate tradables, the elasticity of substitution between labor and capital is set to 0.9 in both regions. For the production functions of intermediate nontradables, the elasticity is set to 0.9. The bias towards private capital is set close to 0.6 in both regions. 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. In the consumption sector the bias for the composite tradable is set to 0.5 for the Home region as well as for the rest of the monetary union. In the investment sector it is set to 0.75. The population size of Home,  $s$ , is set to 0.05 (the population of the monetary union is normalized to 1).

Table 4 reports gross markups in the intermediate tradable, intermediate nontradable and labor markets. Markups are higher in the nontradable and labor markets. Markups are obtained by calibrating the sector-specific elasticities of substitution between different varieties of goods.<sup>12</sup>

Table 5 contains parameters that regulate the dynamics. Adjustment costs on investment changes are set to 2.8. Nominal wage and price quadratic adjustment costs are set in order to obtain an average frequency of price adjustment in line with the NAWM.

Finally, parametrization of the systematic feedback rules followed by the fiscal and monetary authorities

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<sup>12</sup>For an analysis of the macroeconomic effects of different degree of markups in a model similar to the one used in this paper, see Forni et al. (2010).

are reported in Table 6. For each country-specific fiscal policy rule (3) we set  $\phi_1$ ,  $\phi_2$  and  $\phi_3$  respectively to 0.5, 25 and 25. The central bank of the monetary union targets the contemporaneous monetary union-wide consumer price inflation (the corresponding parameter is set to 1.9) and the output growth (the parameter is set to 0.4).<sup>13</sup> The interest rate is set in an inertial way. Its previous-period value enters the rule with a weight equal to 0.85.

### III. Results

We evaluate next the domestic macroeconomic effects of a sovereign restructuring. We consider perfect foresight scenarios, where there is no uncertainty regarding the future path of policies. We show how the macroeconomic implications change according to (1) different initial (before the restructuring) shares of public debt held by domestic and foreign residents and (2) different initial private sector foreign debt positions. Finally, we compare the effects of restructuring with those of a fiscal adjustment scenario.

#### A. Sovereign restructuring

Our baseline simulation can be described as follows. We assume that the economy starts off from steady state. At the beginning of the first period the haircut is implemented and, hence, the spread increases. In the baseline simulation the public debt of the Home country is reduced from 150 to 90 percent of annualized GDP. This corresponds to a 40 percent reduction in nominal value. After the first period, public transfers adjust according to the fiscal rule (3) to stabilize the debt-to-GDP ratio at the new value (90 percent). Moreover, we assume that 50 percent of the debt is held by domestic agents and that the Home private sector has an initial debt position towards foreign residents equal to 100 percent of annualized GDP.

Figures 1-3 report the results. After the haircut, the public debt is permanently reduced (in Figure 1 the actual value closely follows the target). The interest expenditure paid by the public sector falls, as the reduction in the stock of nominal debt more than compensates for the increase in the spread. Public transfers initially decrease, while they permanently increase above the initial level in the long run as interest payments are now lower, consistently with stabilization of the debt at the new level.<sup>14</sup> The government budget moves to a surplus, that gradually increases during the first two years and then returns to zero when the debt is stabilized. The primary (net of interest expenditure) balance is always in surplus.

<sup>13</sup>The monetary union-wide consumer price inflation rate is weighted (by the country size) geometric average of the corresponding regional variables. The monetary union GDP is the sum of regional GDPs.

<sup>14</sup>Since we assume that fiscal policy is managed by changing lump-sum transfers and that agents are Ricardian, results are not very different if we allow the debt level to increase after the restructuring.

Both the Home government and the private sector face an increase in the spread paid for borrowing in the international financial market. The spread increases by about 3 (annualized) percentage points on impact. Subsequently, it gradually decreases over time. It remains above one percent for about 5 years. As previously said, the increase in the spread captures ‘the loss of reputation’ of the country as a reliable borrower.

GDP decreases by 13 percent of the initial steady state level after one year, by 10 percent after one year and a half. It stays persistently below the baseline and returns close to but still below its initial level after three years (Figure 2). The increase in spread leads to an increase in the real interest rate faced by Home households<sup>15</sup>, inducing a large reduction in consumption and investment, of 20 and 50 percent, respectively. Subsequently, consumption and investment both return to the baseline levels in a very gradual way.

The key trade-off of the restructuring works as follows. After the sovereign restructuring, Home households pay a lower amount of current and expected taxes, as the stock of public debt is reduced. The cut in the nominal value of the sovereign bond they hold is smaller than the reduction in the expected stream of taxes they have to pay, as 50 percent of the sovereign bonds are held by foreign residents. From this perspective, households benefit from the haircut. In other words, the sovereign debt held by foreign households is a foreign liability that Home households have sooner or later to repay (through taxes). As such, the sovereign restructuring implies a reduction in this foreign liability and, hence, a positive wealth effect for the Home households. On the other hand, the spread paid by Home households increases after the restructuring. This induces a negative income effect, due to the higher interest payments, and a negative substitution effect that induces agents to postpone consumption, due to the higher interest rate. Regarding the other macroeconomic variables, gross exports increase and imports decrease.<sup>16</sup> The increase in exports is associated with the reduction in the prices of tradables produced in the Home country, which becomes relatively more competitive. The lower prices are due to the lower Home aggregate demand, which in turn reduces Home imports from the rest of the monetary union as well. Employment decreases by about 20 percent. The decrease is driven by the lower labour demand by firms (the real wage, not reported, also decreases over time). The Home CPI inflation rate falls by five (annualized) percentage points, driven by the reduction in aggregate demand. We do not report spillovers to the rest of the monetary union, as they are relatively small.<sup>17</sup>

<sup>15</sup>The nominal interest rate set by the monetary authority does not greatly change, given the low weight of the Home country in monetary union and hence in the Taylor rule.

<sup>16</sup>Real export and imports are evaluated at the initial steady-state prices.

<sup>17</sup>As said, we assume that the Home country is relatively small compared to the rest of the monetary union and that there is no

As reported in Figure 3 (third panel), the overall foreign asset position of the Home country improves. The reduction in public sector borrowing from abroad is larger than the increase in Home households' private borrowing to smooth consumption. The Home current account (as a ratio to GDP) improves on impact, thanks to the lower amount of interest payment on the reduced foreign asset position of the country, in spite of the increase in the spread.

In Figures 4-6 we report results obtained when the haircut is equal to 20 percent of the initial public debt level, as compared to 40 percent in the baseline simulation. The lower haircut implies a lower overall and primary public sector's surpluses. As in the benchmark case, the budget returns to balance in the long run.

Qualitatively, the transmission mechanism of the sovereign restructuring is similar to the one in the baseline simulation. Spreads increase and their negative effect is larger than the positive wealth effect associated with the lower sovereign debt.

Quantitatively, the lower haircut implies relatively lower macroeconomic costs. The home households face a lower increase in spread, equal to about 1.5 percentage points (3 percentage points in the benchmark case). The GDP decreases by 6 percent after one year (around 13 percent in the benchmark case). As in the benchmark scenario the decrease is rather long-lasting. The current account and the foreign asset position of the Home economy improve to a lower extent than in the baseline simulation. For inflation, it decreases by one percent (two percent in the baseline simulation).

Overall, results suggest that the restructuring can have sizeable negative effects on economic activity. The main reason is the wide and persistent increase in the spreads paid by both the public and private sector. To further investigate this channel, Figure 7 shows results assuming the spread does not increase. In this case the economic activity shows a positive response. GDP, consumption and investment increase on impact, as Home households benefit from the positive wealth effect connected with the haircut on foreign bondholders.<sup>18</sup>

## **B. Alternative initial shares of domestically held public debt**

Figures 8-9 contain results assuming different initial shares of domestically held public debt. In Figures 8 and 9, Home households hold 100 and, alternatively, 0 percent of public debt. As in the baseline case, we consider a cut equal to 40 percent of the initial nominal value of public debt. When the Home government bonds are held only by Home households, the negative macroeconomic effects are larger than

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financial contagion.

<sup>18</sup>In this case the spread on households' financial position is set to a rather low value, to make the model stationary. See Benigno (2009).



in the baseline simulation (Figure 8). The GDP decreases by 17 percent (compared to around 13 percent in the baseline simulation). Now there is no wealth effect in favor of Home households. However, the households still face the increase in spread. Hence, they have a larger incentive to postpone consumption and investment than in the benchmark scenario. In this case the crucial assumption is that the increase in spreads depends upon the decision to restructure the debt and on the amount of the haircut, not on whether and how much foreign investors are hit by the haircut. As before, the spread is associated with the loss of reputation of the Home government as a reliable borrower and investors, foreign and domestic, will therefore ask for a premium when lending to it after a restructuring.

When the Home government bonds are held only by Foreign households (Figure 9), the Home economy has a much milder negative macroeconomic consequences from the sovereign restructuring. The GDP decreases by 3 percent. Now the reduction in the foreign debt position of the country as well as the positive wealth effect for the domestic households are larger. As said before, the Home public sector bonds held by Foreign households are ultimately liabilities of the domestic households (they will pay taxes in the future to reimburse the Foreign households). Still, the increase in the spread induces a negative substitution effect, but overall GDP, consumption, investment and employment decrease much less than in the baseline scenario.

Overall, the macroeconomic effects of the sovereign restructuring depend in a relevant way on the initial share of public debt held by domestic residents. When domestic households hold a relatively low share of government debt (or, conversely, when foreign residents hold a relatively large share of government debt), the macroeconomic costs of a restructuring are lower, and the favorable income and wealth effects larger.

### **C. The role of the households' initial foreign asset position**

To further provide intuition on the effects of a restructuring, we show results obtained for an initial foreign asset position of the domestic private sector equal to zero (Figure 10). The haircut is 40 percent as in the baseline scenario. The decrease in GDP and its main components is somewhat lower as compared to the baseline case.<sup>19</sup> The increase in spread induces households to postpone consumption and investment through the (standard) intertemporal substitution effect. As the initial private sector net foreign asset position is zero, the negative income effect (coming from the cost of rolling over the private debt at a higher interest rate) on Home households is lower than in the baseline case. The reason is that now Home

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<sup>19</sup>As illustrated in the calibration section, in the baseline simulation it is assumed that Home households have an initial financial liability against the Foreign households equal to 100 percent of Home annualized GDP.

households have to pay (indirectly) through taxes only the higher interests on the stock of public debt held by Foreign households after the restructuring. In this case, Home households don't have a direct financial liability towards Foreign households. As such, they don't face over time an increase in the associated financial cost as large as in the baseline case. Quantitatively, the reduction in GDP is equal to 8 percent of the baseline level, compared to 13 percent in the baseline simulation.

#### **D. Comparing debt restructuring and fiscal consolidation**

Finally, in this section we compare the macroeconomic effects of the sovereign default with those of fiscal consolidation. In both cases, the public debt is reduced by 40 percent of its initial value. Under fiscal consolidation, the public debt is reduced in a gradual way, over around 6-7 years by appropriately reducing lump-sum transfers. Differently from the case of restructuring, in the case of consolidation we assume no increase in the spread (the spread is equal to zero). Moreover, for this simulation we introduce rule-of-thumb households into the model in order for lump-sum transfers to have real effects. Our simulations show that a fiscal consolidation that reduces the debt by 40 percent has smaller macroeconomic costs as compared to an haircut scenario, even if the latter is simulated in a model without rule-of-thumb agents.

Following Campbell and Mankiw (1989) and Galì, Lopez-Salido and Vallès (2007), we assume that in each period the liquidity constrained households consume their after-tax disposable income. That is, the budget constraint of the generic liquidity-constrained household  $j$  is:

$$(1 + \tau_t^c)P_t C_t(j) = (1 - \tau_t^l)W_t(j) L_t(j) + TR_t(j) \quad (12)$$

where  $TR$  represent lump-sum transfers. We assume that liquidity-constrained households wage, hours worked and tax rates are the same as those of unconstrained households. The share of rule-of-thumb households is set at 30 percent of the overall population. We model the fiscal consolidation as a reduction in lump-sum transfers for an easier comparison with the restructuring scenario (the haircut is essentially a lump-sum tax).

Figure 11 shows the results obtained under the restructuring and, alternatively, under the consolidation. In the restructuring scenario the GDP fall is much more pronounced than under the case of consolidation, as the increase in spread induces the contraction in economic activity. Compared to the case of no liquidity-constrained households (see Figure 2), the effect of the restructuring is larger as the liquidity-constrained households strongly reduce their consumption due to lower labor income. More importantly, the GDP

reduction is much larger than the one under consolidation. In the former case, the effect of the increase in the spread is sufficiently large to induce a sharp reduction in consumption and investment. Under consolidation, liquidity constrained households reduce their consumption because of lower transfers, but this happens in a gradual way, to stabilize the debt at the new lower final level. Finally, the recessionary effects of the consolidation are also smaller than those obtained when the debt is restructured and there are no rule-of-thumb households (Figure 1). Overall, the results suggest that the deterioration of the economic activity is larger under the restructuring episodes than under the consolidation of public debt.<sup>20</sup>

#### **IV. Conclusions**

This paper has assessed the domestic macroeconomic effects of a sovereign restructuring using a monetary union model. The financial distress associated with the restructuring is captured by the increase in the spread on public debt, which induces a similar increase in the spread on private debt. Overall, simulations suggest negative effects of the sovereign restructuring on domestic economic activity. The negative effects are greatly magnified when the share of the public debt held domestically is large. We have also compared the simulated effects of a restructuring with those of a smooth fiscal consolidation achieved by reducing transfers. In the case of fiscal consolidation the adjustment path does not depend on how much public debt is held abroad as the entire amount of the debt has to be repaid. On the other hand the country avoids an increase in spreads. On balance, based on our calibrations, we have shown that the negative effects on GDP are substantially smaller in the short to medium run, while slightly more persistent.<sup>21</sup>

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<sup>20</sup>We have run similar simulations assuming a restructuring and a consolidation of public debt equal to 20 percent. Results, available upon request, suggest that also in this case the macroeconomic costs of restructuring are larger. GDP through would be equal to 10 percent (consumption and investment throughs would be equal to 10 and 30, percent respectively). Under consolidation, GDP through would be equal to 3 percent (consumption by 3 and 6 percent).

<sup>21</sup>In some cases, the fiscal consolidation could have mild recessionary effects. For example, when it's implemented through public spending cuts that would allow for reduction in both public debt and expected future taxes. See for example Forni et al. (2010).

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## Appendix

In this Appendix we report a detailed description of the model, excluding the fiscal policy part, the description of the households optimization problem that are reported in the main text.<sup>22</sup>

There are two countries, the Home country and rest of the monetary union, having different sizes and sharing the currency and the central bank. In each region there are households and firms. Each household consumes a final composite good made of non-tradable, domestic tradable and imported intermediate goods from the rest of the area. Households have access to financial markets and smooth consumption by trading a risk-free one-period nominal bond. 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 markup over their marginal rate of substitution. A fraction of households, as said in the text, does not optimize over time but simply consume the overall wage income available in each period.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. The three final goods (a private consumption, a private investment and a public consumption good) are produced combining all available intermediate goods in a constant-elasticity-of-substitution matter. Tradable and non-tradable intermediate goods are produced combining capital and labor in the same way. Tradable intermediate goods are split in domestically-consumed and export goods. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We assume that Home and the rest of the monetary union are segmented markets and the law of one price for tradables does not hold. Hence, each firm producing a tradable good sets two prices, one for the domestic market and the other for the export market. 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, consumption and production do not immediately jump to a new long-term equilibrium. On the real side, quadratic costs prolong the adjustment of the capital stock. On the nominal side, quadratic cost make wage and prices sticky.

Imperfect competition in product and labor markets is reflected in markups over marginal costs. The elasticity of substitution between products of different firms determines the market power of each profit-

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<sup>22</sup>For a detailed description of the main features of the model see also Pesenti (2008).

maximizing firm. The setup in the labor market is similar. Each worker offers a differentiated kind of labor services that is an imperfect substitute for services offered by other workers. The lower the degree of substitutability, for example because of skill differences or anti-competitive regulation, the higher is the markup and the lower employment in terms of hours. Hence, markups are modeled by a single parameter. In what follows we illustrate the Home economy. The structure of the Foreign economy (the rest of the monetary union) is similar and to save on space we do not report it.

## A Final consumption and investment goods

There is continuum of symmetric Home firms producing Home final non-tradable consumption under perfect competition. Each firm producing the consumption good is indexed by  $x \in (0, s]$ , where the parameter  $0 < s < 1$  is a measure of country size. Foreign firms producing the Foreign final consumption goods are indexed by  $x^* \in (s, 1]$  (the size of the monetary union is normalized to 1). The CES production technology used by firm  $x$  is:

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

where  $Q_{HA}$ ,  $Q_{FA}$  and  $Q_{NA}$  are bundles of respectively Home tradable, Foreign tradable and Home non-tradable intermediate goods,  $\rho > 0$  is the elasticity of substitution between tradables and  $\phi > 0$  is the elasticity of substitution between tradable and non-tradable goods. The parameter  $a_H$  ( $0 < a_H < 1$ ) is the weight of domestic tradable,  $a_T$  ( $0 < a_T < 1$ ) the weight of tradable goods.

The production of investment good is similar. There are symmetric Home firms under perfect competition indexed by  $y \in (0, s]$ , and symmetric Foreign firms by  $y^* \in (s, 1]$ . Output of Home firm  $y$  is:

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

Finally, we assume that public expenditure  $C^g$  has the same composition as that of private consumption.

## B Intermediate goods

### 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:

$$Q_{HA}(x) \equiv \left[ \left( \frac{1}{s} \right)^{\theta_T} \int_0^s Q(h, x)^{\frac{\theta_T-1}{\theta_T}} dh \right]^{\frac{\theta_T}{\theta_T-1}} \quad (13)$$

$$Q_{FA}(x^*) \equiv \left[ \left( \frac{1}{1-s} \right)^{\theta_T} \int_s^1 Q(f, x)^{\frac{\theta_T-1}{\theta_T}} df \right]^{\frac{\theta_T}{\theta_T-1}} \quad (14)$$

$$Q_{NA}(x) \equiv \left[ \left( \frac{1}{s} \right)^{\theta_N} \int_0^s Q(n, x)^{\frac{\theta_N-1}{\theta_N}} dn \right]^{\frac{\theta_N}{\theta_N-1}} \quad (15)$$

where firms in the Home tradable and non-tradable intermediate sectors and in the Foreign intermediate tradable sector are respectively indexed by  $h \in (0, s)$ ,  $n \in (0, s)$ ,  $f \in (s, 1]$ . Parameters  $\theta_T, \theta_N > 1$  are respectively the elasticity of substitution between brands in the tradable and non-tradable sector. The prices of the non-tradable intermediate 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 non-tradable intermediate input  $n$  is:

$$Q_{A,t}(n, x) = \left( \frac{1}{s} \right) \left( \frac{P_t(n)}{P_{N,t}} \right)^{-\theta_N} Q_{NA,t}(x) \quad (16)$$

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

$$P_{N,t} = \left[ \int_0^s P_t(n)^{1-\theta_N} dn \right]^{\frac{1}{1-\theta_N}} \quad (17)$$

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 non-tradable 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 non-tradable component of the public sector consumption. Home demands for Home and Foreign tradable intermediate goods can be derived in a similar way.



## Supply

The supply of each Home non-tradable intermediate good  $n$  is denoted by  $N_t^S(n)$ :

$$N_t^S(n) = \left( (1 - \alpha_N)^{\frac{1}{\xi_N}} L_{N,t}(n)^{\frac{\xi_N - 1}{\xi_N}} + \alpha^{\frac{1}{\xi_N}} K_{N,t}(n)^{\frac{\xi_N - 1}{\xi_N}} \right)^{\frac{\xi_N}{\xi_N - 1}} \quad (18)$$

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:

$$L_{N,t}^p(n) = (1 - \alpha_N) \left( \frac{W_t}{MC_{N,t}(n)} \right)^{-\xi_N} N_t^S(n) \quad (19)$$

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

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

$$MC_{N,t}(n) = \left( (1 - \alpha) W_t^{1 - \xi_N} + \alpha (R_t^K)^{1 - \xi_N} \right)^{\frac{1}{1 - \xi_N}} \quad (20)$$

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

## Price setting in the intermediate sector

Consider now profit maximization in the Home country's nontradable intermediate sector. Each firm  $n$  sets the price  $p_t(n)$  by maximizing the present discounted value of profits subject to demand constraint (18) and the quadratic adjustment costs:

$$AC_{N,t}^p(n) \equiv \frac{\kappa_N^p}{2} \left( \frac{P_t(n)}{P_{t-1}(n)} - 1 \right)^2 Q_{N,t} \kappa_N^p \geq 0$$

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

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_t(n) - \frac{A_t(n)}{\theta_N - 1} \quad (21)$$

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

$$A_t(n) \approx \kappa_N^p \frac{P_t(n)}{P_{t-1}(n)} \left( \frac{P_t(n)}{P_{t-1}(n)} - 1 \right) - \beta \kappa_N^p \frac{P_{t+1}(n)}{P_t(n)} \left( \frac{P_{t+1}(n)}{P_t(n)} - 1 \right) \frac{Q_{N,t+1}}{Q_{N,t}}$$

The above equations clarify the link between imperfect competition and nominal rigidities. As emphasized by Bayoumi et al.(2004), when the elasticity of substitution  $\theta_N$  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 markup over marginal costs is relatively high. If prices were flexible, optimal pricing would collapse to the standard pricing rule of constant markup over marginal costs (expressed in units of domestic consumption):

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_{N,t}(n) \quad (22)$$

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 and  $p_t^*(h)$  in the Foreign market as to maximize the expected flow of profits (in terms of domestic consumption units):

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

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  $p_t(h)$  and  $p_t^*(h)$  are:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t(h)}{\theta_T - 1} \quad (23)$$

$$p_t^*(h) = \frac{\theta_T^*}{\theta_T^* - 1} mc_t(h) - \frac{A_t^*(h)}{\theta_T^* - 1} \quad (24)$$

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

$$A_t(h) \approx \kappa_H^p \frac{P_t(h)}{P_{t-1}(h)} \left( \frac{P_t(h)}{P_{t-1}(h)} - 1 \right) - \beta \kappa_H^p \frac{P_{t+1}(h)}{P_t(h)} \left( \frac{P_{t+1}(h)}{P_t(h)} - 1 \right) \frac{Q_{H,t+1}}{Q_{H,t}}$$

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

where  $\kappa_H^p > 0$  ( $\kappa_H^{p^*} > 0$ ) measure the degree of nominal rigidity in the Home (Foreign) country. 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 market will be high. If prices were flexible ( $\kappa_H^p = \kappa_H^{p^*}$ ) and  $\theta_T = \theta_T^*$ , then optimal price setting would be consistent with the cross-border law of one price:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) = p_t^*(h) \quad (25)$$

## C Labor Market

In the case of firms in the nontradable intermediate 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 ( $j \in [0, s]$ ):

$$L_{N,t}(n) \equiv \left( \frac{1}{s} \right)^{\frac{1}{\psi}} \left[ \int_0^s L_t(n, j)^{\frac{\psi-1}{\psi}} dj \right]^{\frac{\psi}{\psi-1}} \quad (26)$$

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:

$$L_t^p(n, j) = \left( \frac{1}{s} \right) \left( \frac{W_t(j)}{W_t} \right)^{-\psi} L_{N,t}^p(j), \quad (27)$$

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

$$W_t = \left[ \left( \frac{1}{s} \right) \int_0^s W_t(h)^{1-\psi} dj \right]^{\frac{1}{1-\psi}}. \quad (28)$$

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:

$$AC_t^W = \frac{\kappa_W}{2} \left( \frac{W_t}{W_{t-1}} - 1 \right)^2 W_t L_t \quad (29)$$

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 Monetary Policy

The monetary authority controls the short-term rate according to a Taylor rule of the form:

$$\left( \frac{1+i_t}{1+i} \right) = \left( \frac{1+i_{t-1}}{1+i} \right)^{\rho_i} (\Pi_{MU,t})^{(1-\rho_i)\rho_\pi} \left( \frac{GDP_{MU,t}}{GDP_{MU,t-1}} \right)^{(1-\rho_i)\rho_{GDP}} \quad (30)$$

The parameter  $\rho_i$  ( $0 < \rho_i < 1$ ) captures inertia in interest rate setting, while parameters  $\rho_\pi$  and  $\rho_{GDP}$  are respectively the weights of currency union's CPI inflation rate  $\Pi_{MU,t}$  and GDP  $GDP_{MU,t}$ . The CPI inflation rate is a geometric average of CPI inflation rates in the Home and Foreign country (respectively  $\Pi_t$  and  $\Pi_t^*$ ) with weights equal to the correspondent country size:

$$\Pi_{MU,t} \equiv (\Pi_t)^s (\Pi_t^*)^{1-s} \quad (31)$$

The union-wide GDP is the sum of the Home and Foreign GDPs (respectively  $GDP_t$  and  $GDP_t^*$ ), both evaluated at the steady state prices:

$$GDP_{MU,t} \equiv GDP_t + rer * GDP_t^* \quad (32)$$

where  $rer$  is the Home real exchange rate, defined as the ratio of rest of the monetary union to Home consumer prices.

**Table 1.** Great Ratios and tax rates

	Home	Rest of the monetary union
<i>MACRO VARIABLES</i>		
Private consumption $C$	52.6	56.6
Private Investment $I$	18.2	20.2
Imports	24.4	-
Foreign debt (% annualized GDP)	100.0	-
<i>FISCAL VARIABLES</i>		
Public purchases $C^g$	10.0	10.0
Wage bill $WL^g$	10.9	11.2
Interests	4.9	1.9
Tax Rates		
on wage	46	46
on rental rate of capital	19	19
on price of consumption	18	18
Debt(ratio to annual GDP)	150	60.0

**Table 2.** Home country spread

Parameter	Value
$\phi_{b1}$	0.0162
$\phi_{b2}$	0.002
$\phi_{b3}$	0.002
$\rho_\phi$	0.927

**Table 3.** Parametrization

Parameter	Home	Rest of monetary union
Rate of time preference $(1/\beta^4 - 1) * 100$	3.3	3.3
Intertemporal elasticity of substitution $1/\sigma$	1.0	1.0
Frisch elasticity of labor $1/(\tau - 1)$	0.5	0.5
Depreciation rate of (private and public) capital $\delta, \delta^*$	0.025	0.025
Substitution between private and public goods in cons. bundle $\theta$	1.5	1.5
Bias towards private goods in cons. bundle $\omega$	0.8	0.8
Tradable intermediate goods		
Substitution between factors of production $\xi_T, \xi_T^*$	0.9	0.9
Bias towards capital $\alpha_T, \alpha_T^*$	0.61	0.65
Nontradable intermediate goods		
Substitution between factors of production $\xi_N, \xi_N^*$	0.9	0.9
Bias towards capital $\alpha_N$	0.57	0.6
Final consumption goods		
Substitution between domestic and imported goods $\phi_A, \phi_A^*$	1.5	1.5
Bias towards domestic tradable goods $a_H, a_F^*$	0.5	0.9
Substitution between domestic tradables and non tradables $\rho_A, \rho_A^*$	0.5	0.5
Bias towards tradable goods $a_T, a_T^*$	0.5	0.5
Final investment goods		
Substitution between domestic and imported goods $\phi_E, \phi_E^*$	1.5	1.5
Bias towards domestic tradable goods $v_H, v_F^*$	0.4	0.9
Substitution between domestic tradables and non tradables $\rho_E, \rho_E^*$	0.5	0.5
Bias towards tradable goods $v_T, v_T^*$	0.75	0.75
Size $s$ and $(1 - s)$	0.05	0.95

**Table 4.** Gross Markups

	Markups and Elasticities of Substitution		
	Tradables	Non-tradables	Wages
Home	1.2 ( $\theta_T=6$ )	1.3 ( $\theta_N=4.3$ )	1.3 ( $\psi=4.3$ )
Rest of the monetary union	1.2 ( $\theta_T^*=6$ )	1.3 ( $\theta_N^*=4.3$ )	1.3 ( $\psi^*=4.3$ )

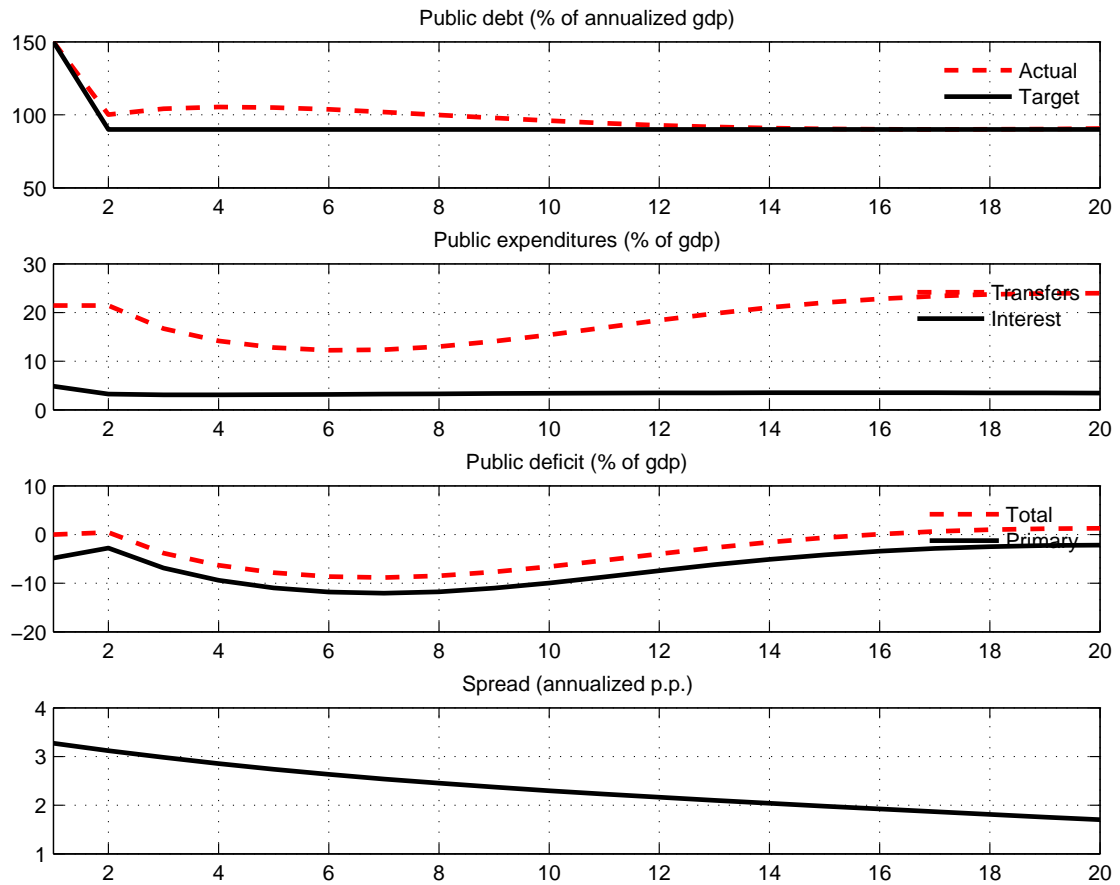
**Table 5.** Real and Nominal Adjustment Costs

Parameter (“*” refers to rest of the monetary union)	Home	Rest of the monetary union
Real Adjustment Costs		
Investment $\phi_I, \phi_I^*$	2.80	2.80
Nominal Adjustment Costs		
Wages $\kappa_W, \kappa_W^*$	400	400
Price of domestically-produced tradables $\kappa_H, \kappa_H^*$	600	600
Price of non tradables $\kappa_N, \kappa_N^*$	600	600
Price of imported intermediate goods $\kappa_F, \kappa_H^*$	600	600
Indexation to past inflation $\alpha, \alpha^*$	0.5	0.5

**Table 6.** Fiscal and Monetary Policy Rules

Parameter	Home	RoMU	MU
Fiscal policy rule			
Public debt deviation from long run level $\phi_1, \phi_1^*$	0.5	0.5	-
Public debt change $\phi_2, \phi_2^*$	25	25	-
GDP growth $\phi_3, \phi_3^*$	25	25	-
Common monetary policy rule			
Lagged interest rate at t-1 $\rho_i$	-	-	0.85
Inflation $\rho_\Pi$	-	-	1.9
GDP growth $\rho_{GDP}$	-	-	0.4

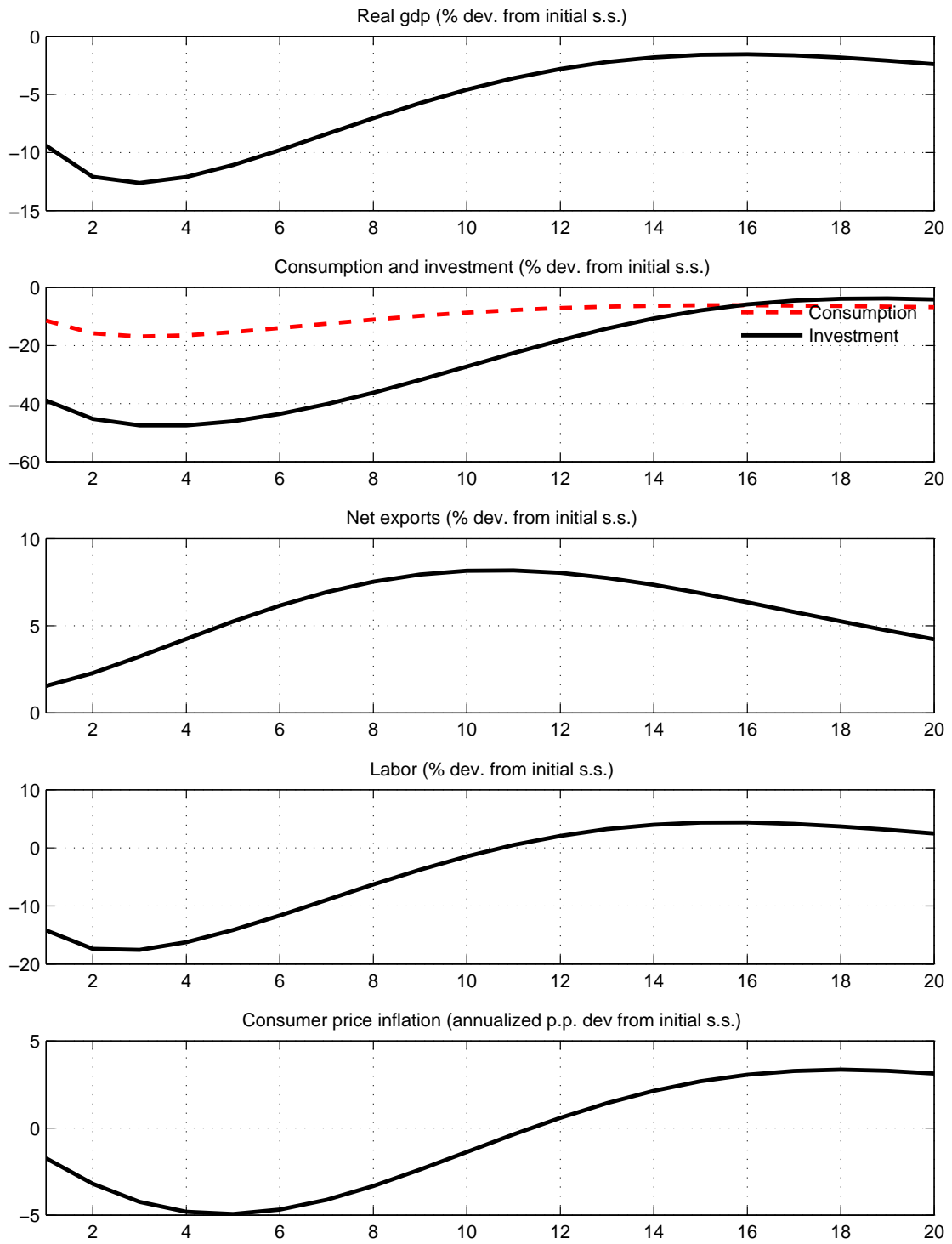
Figure 1. 40 percent restructuring: fiscal variables and spread



Note. Horizontal axis: quarters

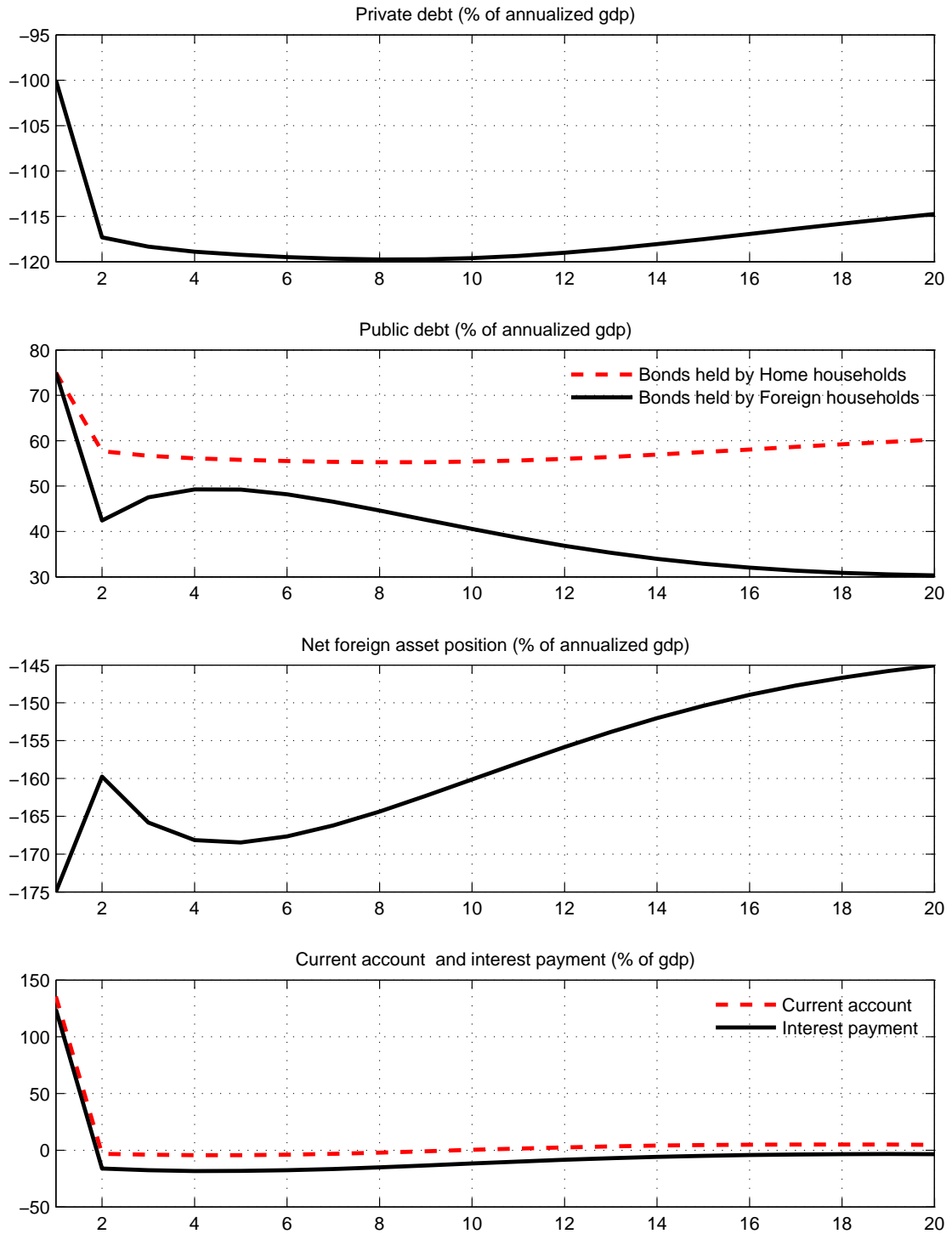


Figure 2. 40 percent restructuring: real variables and inflation



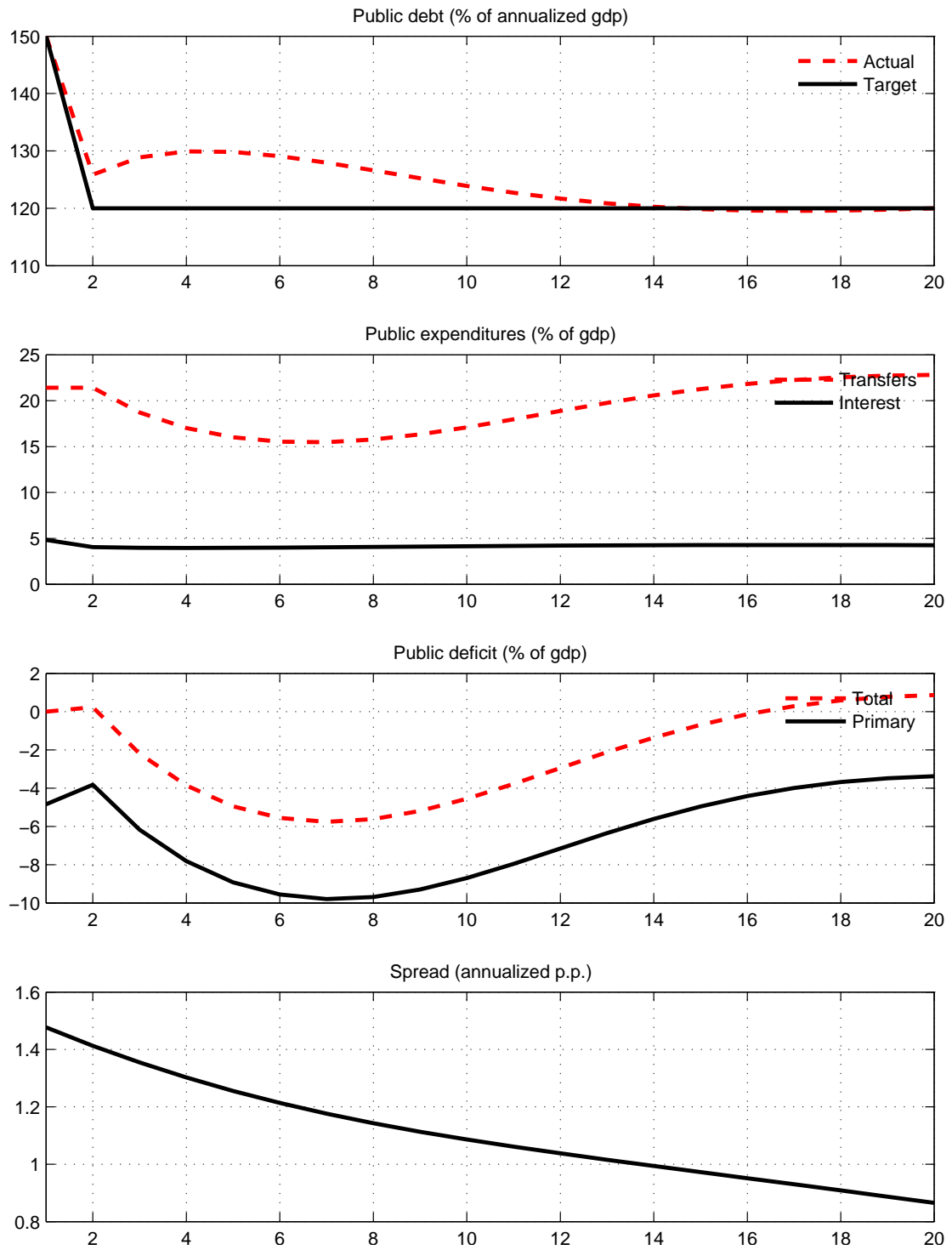
Note. Horizontal axis: quarters

Figure 3. 40 percent restructuring: asset positions



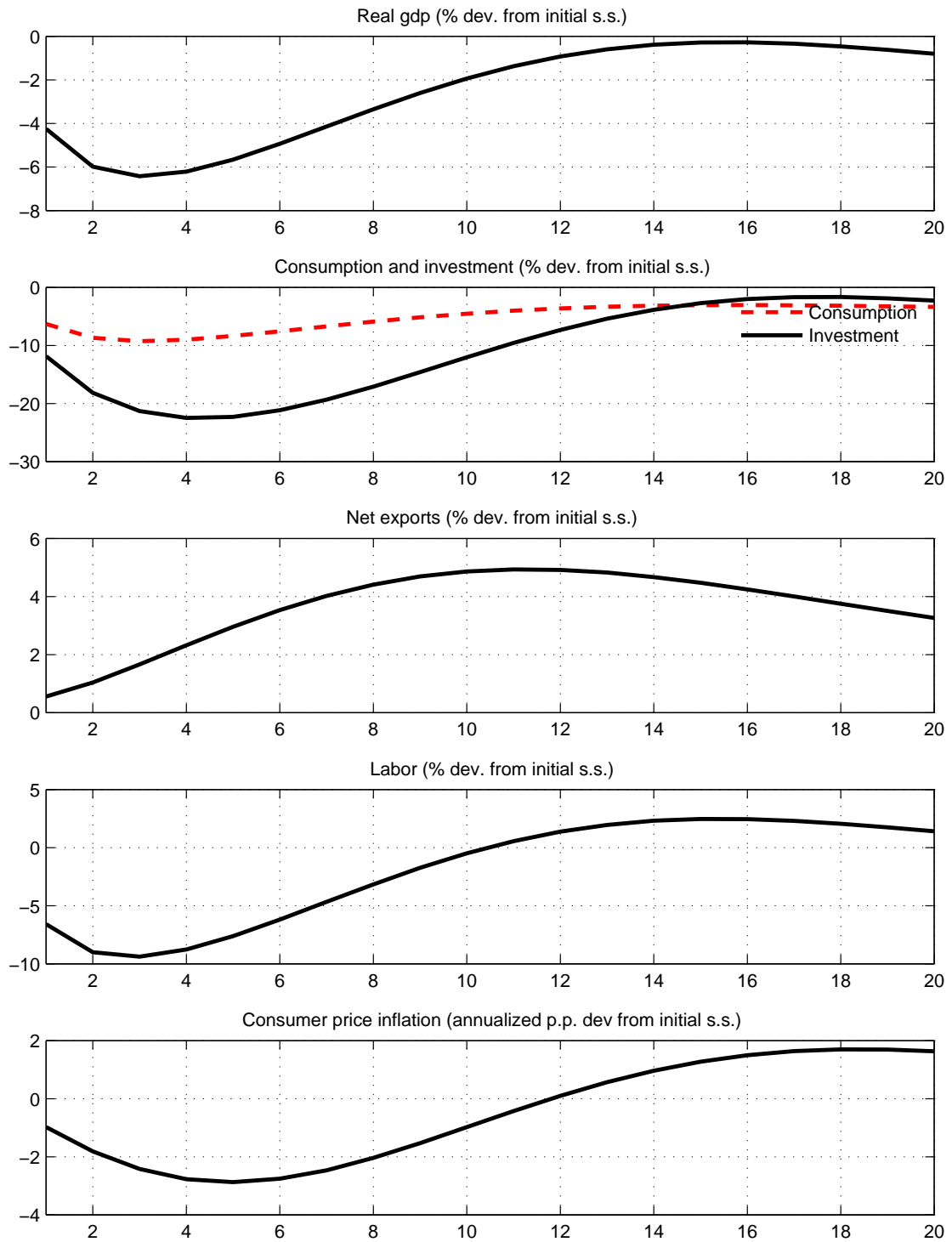
Note. Horizontal axis: quarters

Figure 4. 20 percent restructuring: fiscal variables and spread



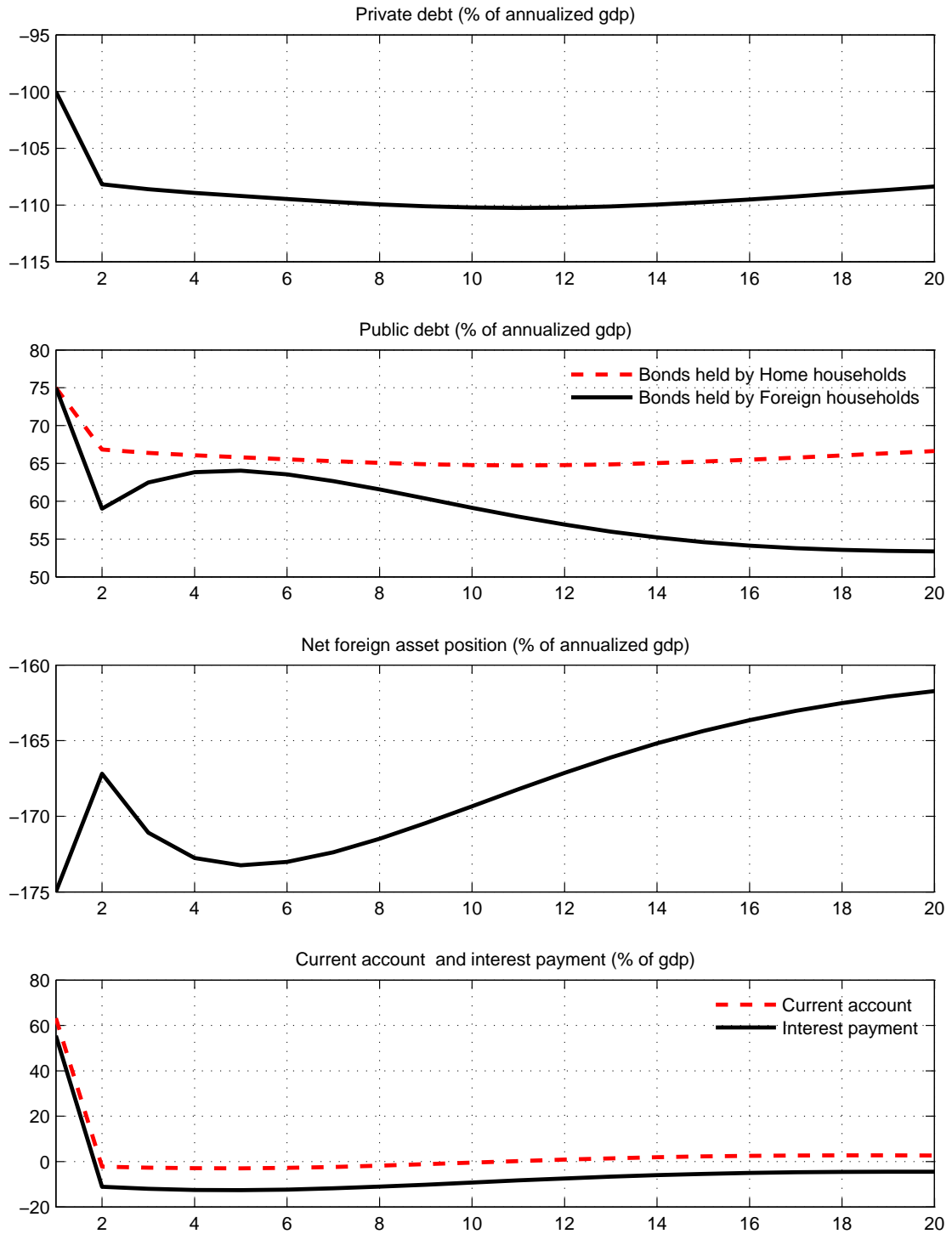
Note. Horizontal axis: quarters

Figure 5. 20 percent restructuring: real variables and inflation



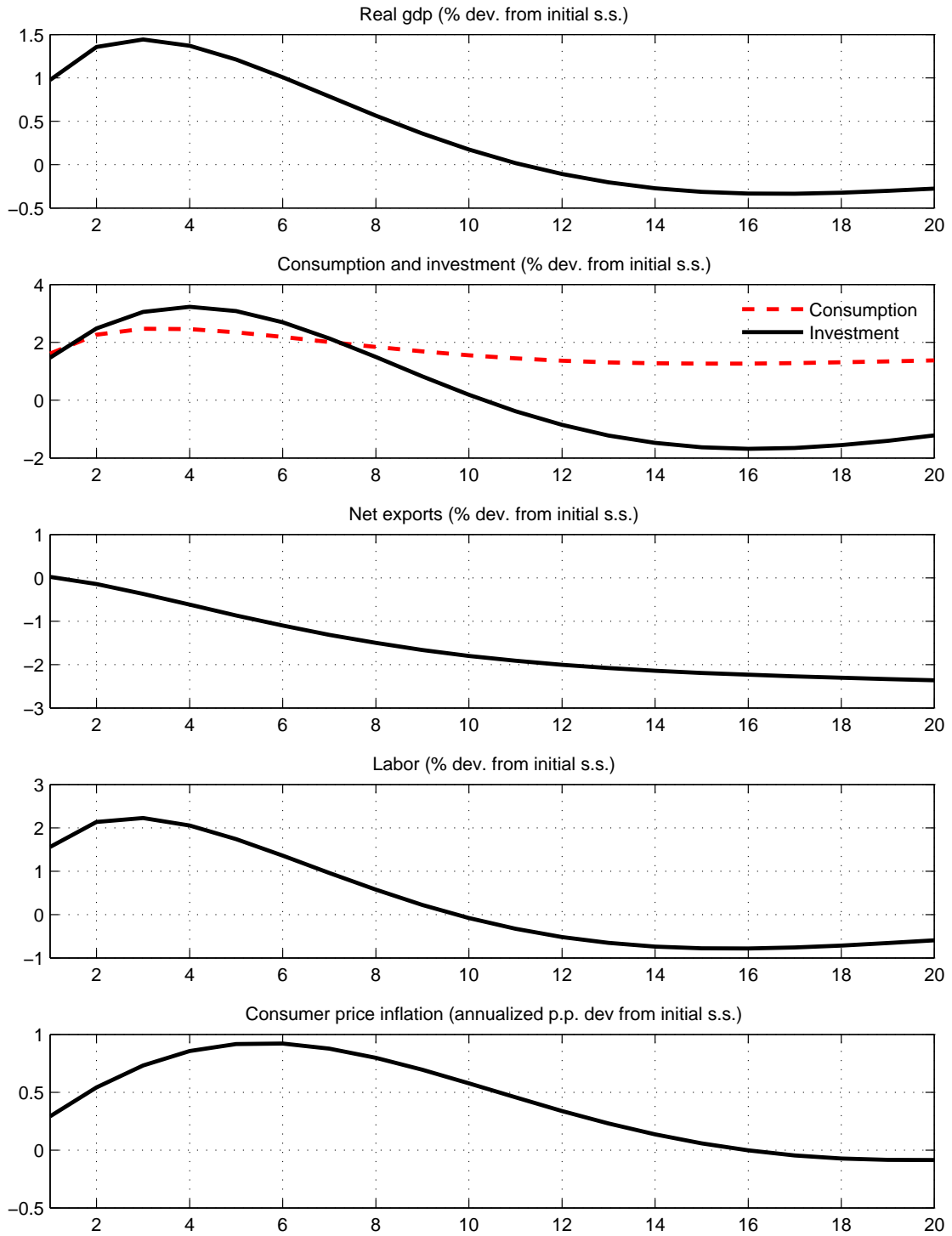
Note. Horizontal axis: quarters

Figure 6. 20 percent restructuring: asset positions



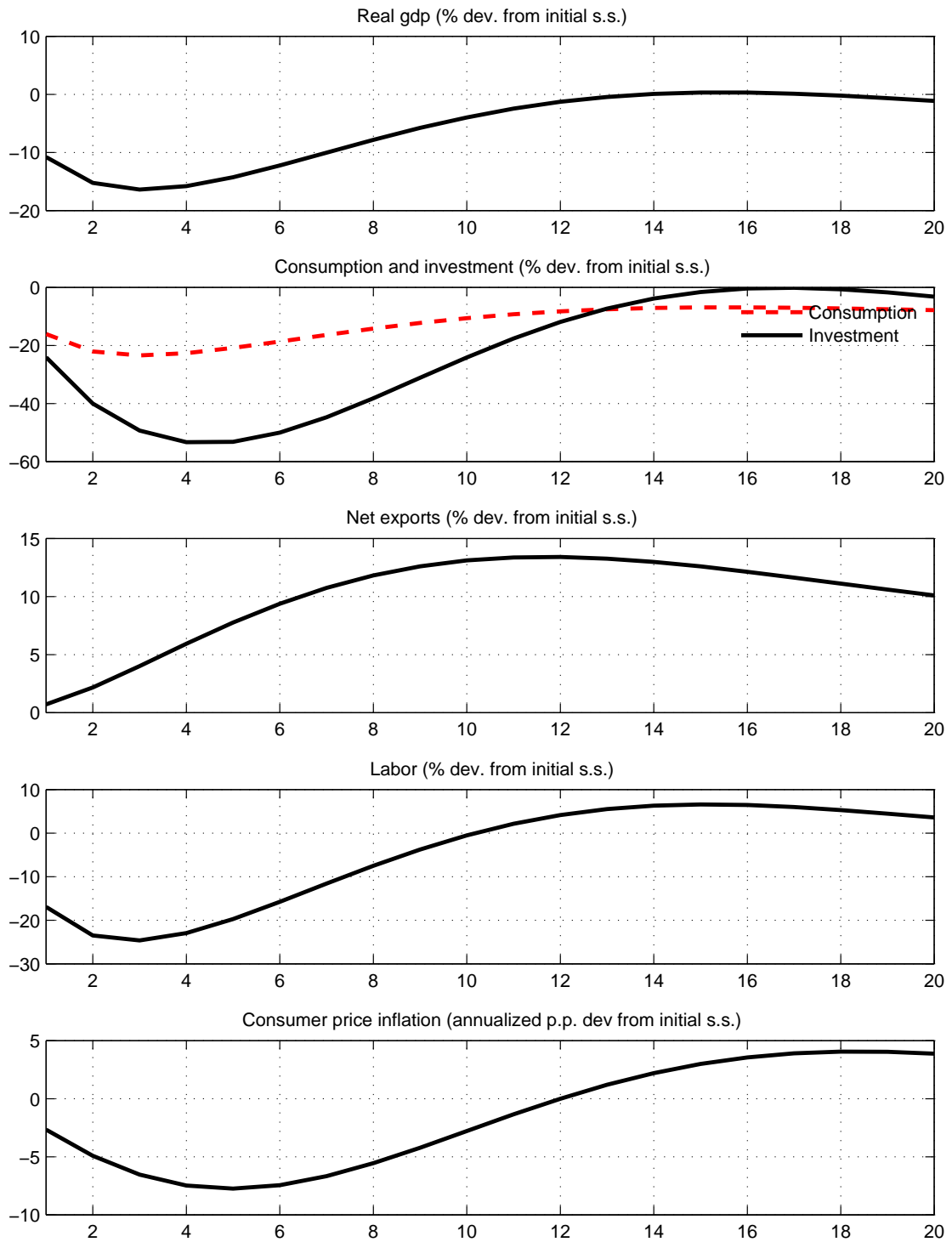
Note. Horizontal axis: quarters

Figure 7. 40 percent restructuring and zero spread



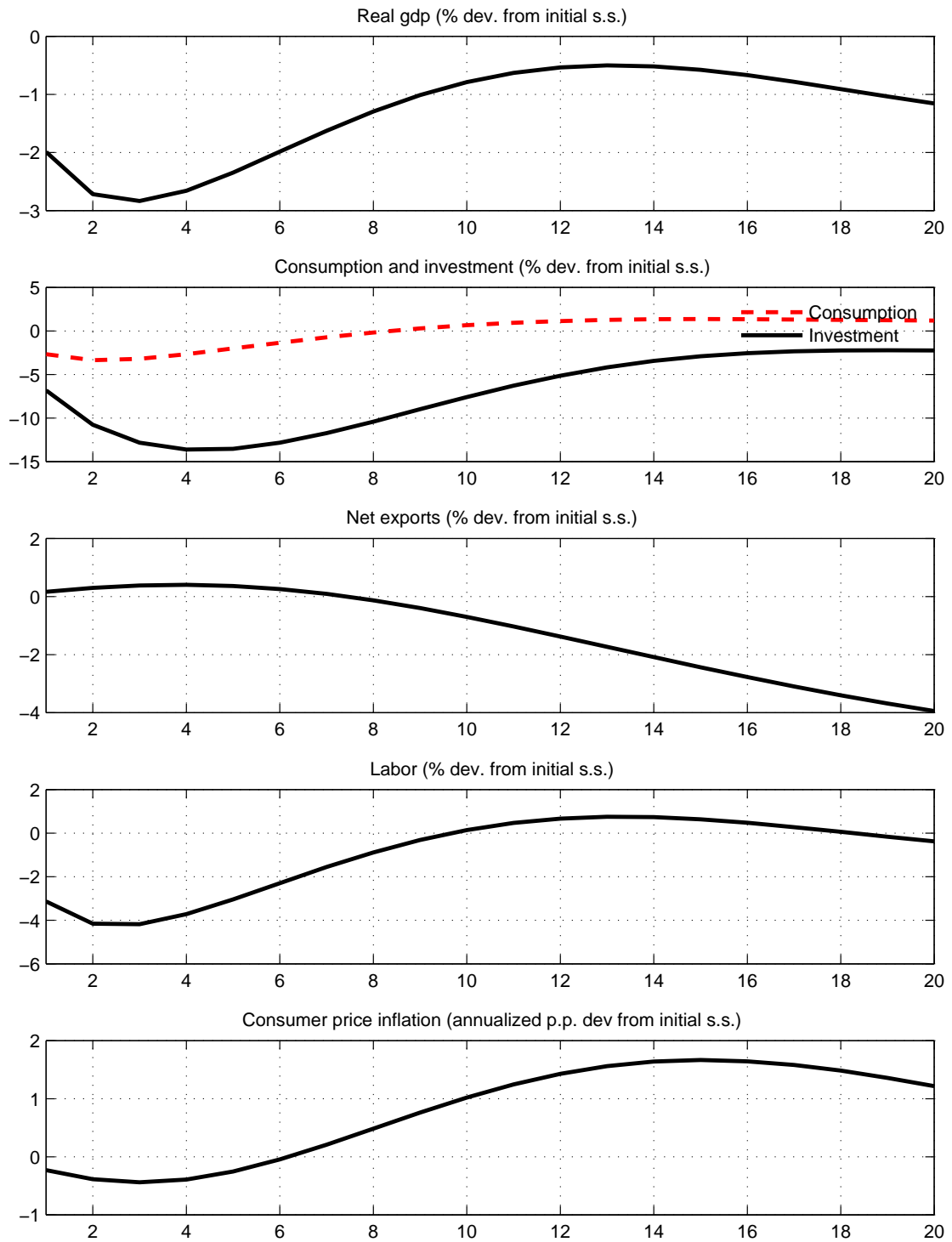
Note. Horizontal axis: quarters

Figure 8. 40 percent restructuring and government bonds held by home households



Note. Horizontal axis: quarters

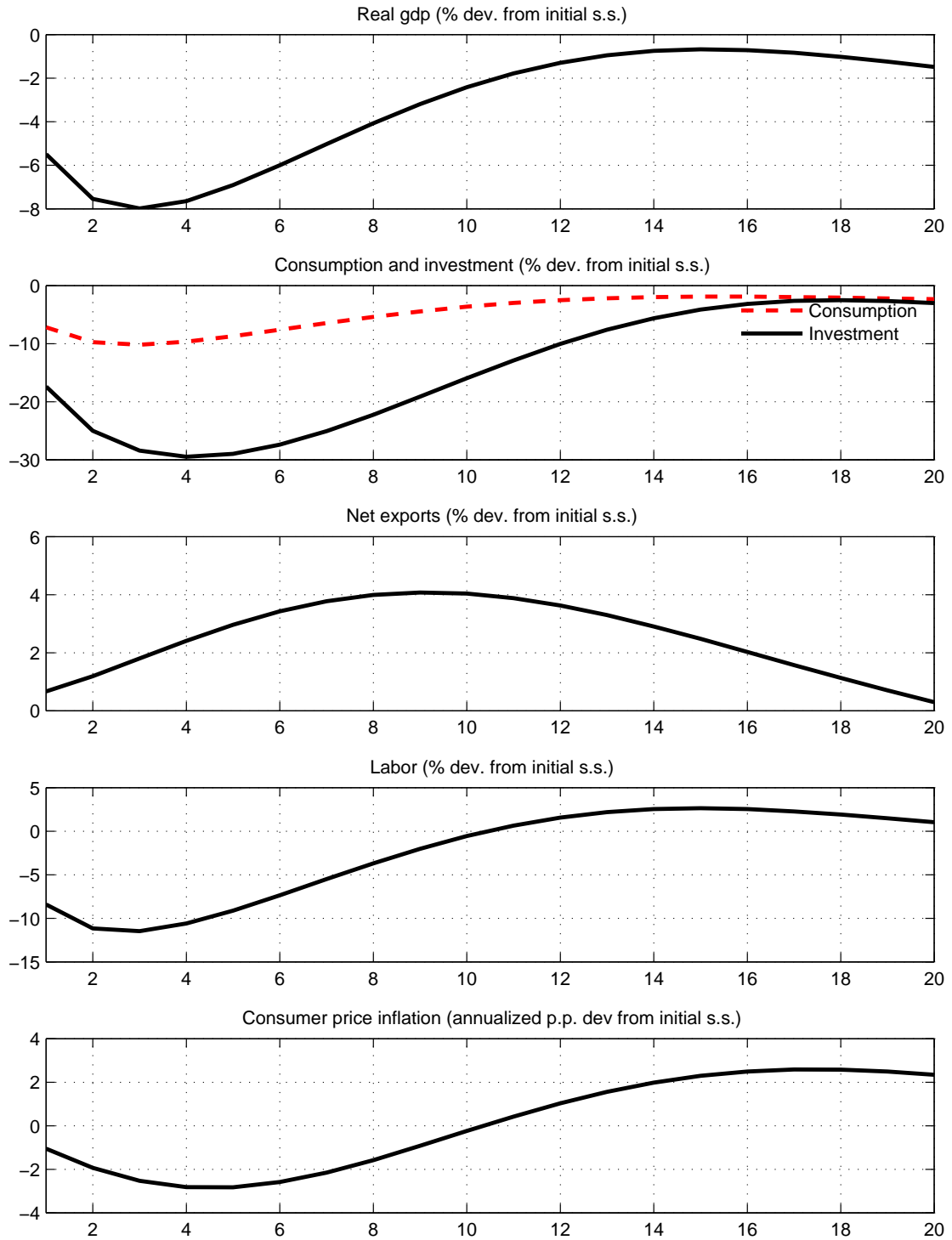
Figure 9. 40 percent restructuring and government bonds held by foreign households



Note. Horizontal axis: quarters

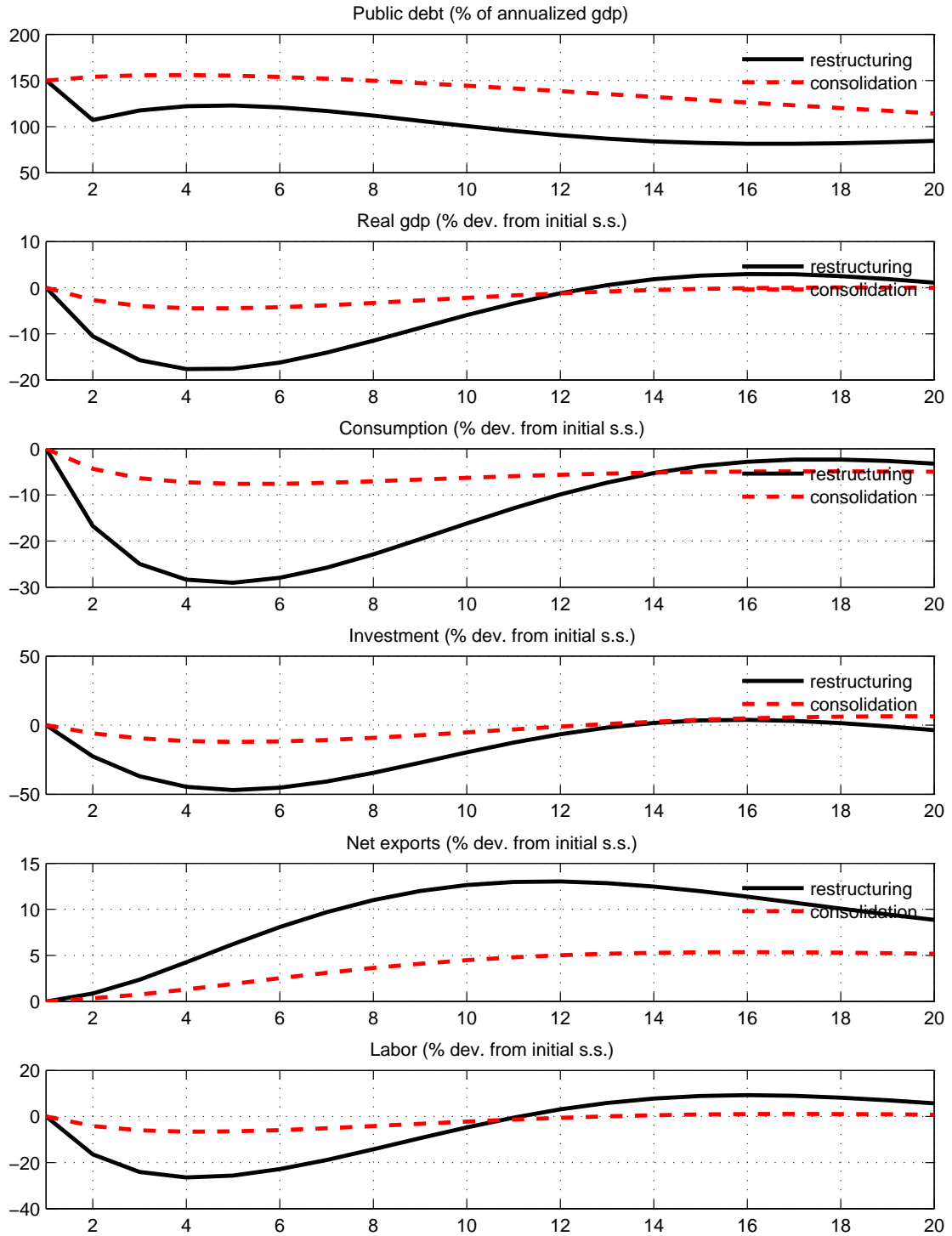


Figure 10. 40 percent restructuring and zero initial households' foreign position



Note. Horizontal axis: quarters

Figure 11. 40 percent restructuring versus consolidation



Note. Horizontal axis: quarters