Fiscal consolidation in an open economy with sovereign premia*

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Abstract

We welfare rank various tax-spending-debt policies. The setup is a New Keynesian model of a semi-small open economy featuring sovereign premia and loss of monetary policy independence. The model is parameterised and solved numerically using fiscal data from the Italian economy over 2001-2011. We compute various optimized state-contingent tax-spending policy rules when the aim is debt consolidation and shock stabilization. Our results indicate: (a) there is no such a thing like "the" debt consolidation - different fiscal policy instruments produce different outcomes; (b) debt consolidation is productive only if we are relatively far-sighted; (c) the best policy mix is to increase consumption taxes, so as to bring public debt down quickly during the early period of fiscal pain, and in turn use the fiscal space created to cut capital taxes. Expectations of cuts in distorting taxes, such as capital and labor taxes, play a key role.

Keywords: Feedback policy, New Keynesian, Sovereign premia, Debt consolidation.

JEL classification: E6, F3, H6

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1 Introduction

Since the global crisis in 2008, and after years of deficits and rising debt levels, public finances have been at the center of attention in most eurozone periphery countries. Although several policy proposals are under discussion, a particularly debated one is public debt consolidation. Proponents claim this is for good reason: as a result of high and rising public debt, borrowing costs have increased, causing crowding out problems and undermining government solvency. Opponents, on the other hand, claim that debt consolidation worsens the economic downturn and leads to a vicious cycle. At the same time, as members of the single currency, these countries cannot use monetary policy to counter the recession and/or monetize public debt. Thus, the only macroeconomic tool available is fiscal policy.

What is the best use of fiscal policy under these circumstances? Is debt consolidation productive? Should the debt ratio be stabilized at its currently historically high level or should it be brought down? If brought down, how quickly? Since it is widely recognized that there is no such a thing like “the” debt consolidation,\(^1\) do the answers to these questions depend on which tax-spending policy instrument is used? Also, since, in practice, policymakers follow simple rules according to which policy instruments react to some economic indicators, the so-called operating targets, which indicators the tax-spending policy instruments should react to, and how strong this reaction should be?

This paper ranks various fiscal policies in light of the above. The setup is a New Keynesian model of a semi-small open economy. By semi-small, we mean that the interest rate, at which the country borrows from the world capital market, increases with the public debt-to-GDP ratio.\(^2\) We focus on a monetary policy regime in which the semi-small open economy fixes the exchange rate and, at the same time, loses monetary policy independence; this mimics membership in a currency union. Hence, the only macroeconomic tool left is fiscal policy. We then allow public spending and the tax rates to respond to, among other things, the gap between actual public debt and target public debt as shares of output, as well as to the gap between actual and target output. We experiment with various target levels depending on whether policymakers aim just to stabilize the economy around its status quo (defined as a

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\(^1\)Likewise, there is no such a thing like "the" fiscal policy multiplier. Different fiscal instruments have different multipliers.

\(^2\)For empirical evidence, see e.g. European Commission (2012).
solution consistent with the current data), or whether they also want to move the economy to a reformed long run (defined as a solution with lower public debt and without sovereign premia).

The model is parameterized and solved numerically using fiscal and public finance data from the Italian economy during 2001-2011. We choose Italy because it exhibits most of the features discussed in the opening paragraph above. It thus looks as a natural choice to quantify our model.

To rank different policies, we compute optimized policy rules when the welfare criterion is household’s expected lifetime utility. Thus, our results are not driven by ad hoc differences in feedback policy coefficients across different policy rules. In particular, adopting the methodology of Schmitt-Grohé and Uribe (2004 and 2007), we compute the welfare-maximizing values of feedback policy coefficients by taking a second-order approximation to both the equilibrium conditions and the welfare criterion.

Before presenting our results, it is worth recalling that the implications of debt consolidation depend both on which policy instrument bears the cost in the early phase of stabilization and on which policy instrument is expected to reap the benefit, once the debt burden has been reduced and fiscal space has been created. The costs in the early phase take the form of spending cuts and/or tax increases, while the opposite holds once fiscal space is created. An optimal policy looks for a balance between these two. Naturally, there is more choice when we also allow for policy mixes (namely, when the policy instrument used in the early costly phase can be different from that used in the long run once debt has been reduced) than when we are restricted to use a single instrument all the time.

The following results stand out. First, as expected, there is no such a thing like "the" debt consolidation. The choice of the fiscal policy instrument matters for both welfare and output. This holds even if we compare optimized policy rules. The choice of the fiscal policy instrument also matters for how quickly debt should be brought down. For instance, in our baseline parameterization, public debt reduction, and so elimination of sovereign premia, should be achieved within a range of five to twenty years (five, when we use consumption taxes, and twenty, when we use labor taxes). The idea is that the more recessionary the instrument, the slower the speed of adjustment should be. Thus, working with optimized policy rules, we find
that the speed of debt consolidation should depend on the fiscal policy mix used. Relatively
to a closed economy, recession is extra costly in a semi-small open economy, because a fall in
output triggers a further rise in the debt ratio that pushes up sovereign premia.

Second, irrespectively of the fiscal policy instruments used, debt consolidation is productive
only if we are relatively far-sighted. For instance, in our baseline computations, when we use
labor taxes, debt consolidation is welfare-improving if we care beyond the first nine years, and
output-improving if we care beyond the first five years. In other words, debt consolidation
always comes at a short term pain. Thus, the argument for, or against, debt consolidation
involves a value judgment. Nevertheless, the gains in output, coming from debt consolidation,
are bigger in magnitude and materialize sooner than the gains in welfare.

Third, when we are far sighted and, in addition, we are allowed to use policy mixes, it is
better to use the consumption tax rate during the early consolidation period and the capital
or labor tax rates (especially, the capital tax rate) in the long run. The idea is to raise
consumption taxes in the very short run so as to bring public debt down (even at a big short-
term cost) and then enjoy the beneficial and long-lasting effects from expected cuts in capital
and labor taxes. Capital and labor taxes are also preferable when we are restricted to use a
single instrument all the time (namely, when we use the same instrument in the transition as
well as in the long run). Thus, expectations of cuts in capital and labor taxes in the future,
once debt has been reduced and fiscal space has been created, dominate any short term effects
and this shapes lifetime utility and output (see also Coenen et al., 2008, for the importance of
expected tax reductions in the future).

Fourth, when we are short sighted, we naturally prefer that policy which implies the mildest
recession in the very short run or, equivalently, that policy that delays the pain of debt reduc-
tion. In our case, where policy is conducted via optimized policy rules, this is achieved when
we use labor taxes. The reason is that, since higher labor taxes are particulalry distorting, it
is better to reduce public debt slowly when we make use of those taxes, and this gradualism is
preferred by short sighted agents. Of course, this comes at the cost of a long-lasting recession
in the medium run.

Fifth, fiscal policy instruments should, in general, react to both public debt imbalances and
the output gap. Nevertheless, if there is need to reduce sovereign premia over time, the net
changes in fiscal instruments should be dominated by reaction to debt rather than to output, and this should be the case even during a recession. Reaction to public debt imbalances is also necessary for dynamic determinacy.

Our paper is related to three strands of the literature. First, it is related to the literature on how monetary and fiscal policy instruments react, or should react, to the business cycle. Second, it is related to the literature on fiscal consolidation that usually compares spending cuts versus tax rises needed for debt reduction. Third, it is related to the literature on sovereign premia.

The papers closer to ours are Coenen et al. (2008), Cantore et al. (2012) and Erceg and Lindé (2013). But, Coenen et al. (2008) and Erceg and Lindé (2013) do not study optimal policy. In particular, they choose a priori the speed/pace of adjustment or, in other words, whether debt consolidation should be frontloaded or not. Cantore et al. (2012) do study optimal policy and, in particular, optimized policy rules like we do, but they impose that all tax rates change by the same proportion; also, in their model for the US, there is monetary policy independence. Therefore, as far as we know, there have not been any previous attempts to welfare rank such a rich menu of tax-spending policy instruments in a New Keynesian open economy with sovereign premia and without monetary policy independence, and study how results depend on whether the government simply stabilizes the economy from shocks, or also reduces public debt and eliminates premia over time.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 presents the data, parameterization and the status quo solution. Section 4 discusses how we work. Results are in Section 5. A sensitivity analysis is in Section 6. Section 7 closes the paper. Technical details are available in Philippopoulos et al. (2013).

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5See e.g. Schmitt-Grohé and Uribe (2003), Bi (2012), Bi et al. (2012), Ghosh et al. (2013) and Corsetti et al. (2013). See below for further details.

6This Appendix is available at http://www.aueb.gr/users/aphil/appendix_Phil_et_al_2013.pdf


2 Model

The setup is a New Keynesian model of a semi-small open economy. As said above, semi-small means that the interest-rate premium is debt-elastic. On other dimensions, our setup is the standard New Keynesian model of an open economy with domestic and imported goods featuring imperfect competition and nominal Calvo-type rigidities.\textsuperscript{7} Fluctuations are driven by shocks to exogenous variables, while intrinsic dynamics are driven by policy reforms.

The domestic economy is composed of \( N \) identical households indexed by \( i = 1, 2, \ldots, N \), of \( N \) firms indexed by \( h = 1, 2, \ldots, N \), each one of them producing a differentiated domestically produced tradable good, as well as of monetary and fiscal authorities. Similarly, for simplicity, there are \( f = 1, 2, \ldots, N \) differentiated imported goods produced abroad. Population, \( N \), is constant over time.

2.1 Aggregation and prices

2.1.1 Consumption bundles

The quantity of variety \( h \) produced at home by domestic firm \( h \) and consumed by domestic household \( i \) is denoted as \( c_{i,t}^H(h) \). Using a Dixit-Stiglitz aggregator, the composite of domestic goods consumed by each household \( i \), \( c_{i,t}^H \), is given by:\textsuperscript{8}

\[
c_{i,t}^H = \left[ \sum_{h=1}^{N} \kappa[c_{i,t}^H(h)]^{\frac{\phi-1}{\sigma}} \right]^{\frac{\phi}{\phi-1}}
\]

where \( \phi > 0 \) is the elasticity of substitution across goods produced in the domestic country and \( \kappa \equiv 1/N \) is a weight chosen to avoid scale effects in equilibrium.

Similarly, the quantity of imported variety \( f \) produced abroad by foreign firm \( f \) and consumed by domestic household \( i \) is denoted as \( c_{i,t}^F(f) \). Using a Dixit-Stiglitz aggregator, the composite of imported goods consumed by each household \( i \), \( c_{i,t}^F \), is given by:

\[
c_{i,t}^F = \left[ \sum_{f=1}^{N} \kappa[c_{i,t}^F(f)]^{\frac{\phi-1}{\sigma}} \right]^{\frac{\phi}{\phi-1}}
\]

\textsuperscript{7}For the New Keynesian model, see e.g. the textbook by Gali (2008). For small open economy New Keynesian models, see e.g. Gali and Monacelli (2005, 2008).

\textsuperscript{8}As in e.g. Blanchard and Giavazzi (2003), we find it more convenient to work with summations rather than with integrals.
In turn, having defined \( c^H_{i,t} \) and \( c^F_{i,t} \), household \( i \)'s consumption bundle, \( c_{i,t} \), is:

\[
    c_{i,t} = \left( \frac{c^H_{i,t}}{P_{t}^H} \right)^\nu \left( \frac{c^F_{i,t}}{P_{t}^F} \right)^{1-\nu} / \nu^{\nu}(1 - \nu)^{1-\nu}
\]  

where \( \nu \) is the degree of preference for domestic goods (if \( \nu > 1/2 \), there is a home bias).

### 2.1.2 Consumption expenditure, prices and terms of trade

Household \( i \)'s total consumption expenditure is:

\[
P_t c_{i,t} = P_t^H c^H_{i,t} + P_t^F c^F_{i,t}
\]  

where \( P_t \) is the consumer price index (CPI), \( P_t^H \) is the price index of home tradables, and \( P_t^F \) is the price index of foreign tradables (expressed in domestic currency).

Each household’s total expenditure on home goods and foreign goods are respectively:

\[
P_t^H c^H_{i,t} = \sum_{h=1}^{N} \kappa P_t^H(h) c^H_{i,t}(h)
\]

\[
P_t^F c^F_{i,t} = \sum_{f=1}^{N} \kappa P_t^F(f) c^F_{i,t}(f)
\]

where \( P_t^H(h) \) is the price of variety \( h \) produced at home and \( P_t^F(f) \) is the price of variety \( f \) produced abroad, both denominated in domestic currency.

We assume that the law of one price holds meaning that each tradable good sells at the same price at home and abroad. Thus, \( P_t^F(f) = S_t P_t^H*(f) \), where \( S_t \) is the nominal exchange rate (where an increase in \( S_t \) implies a depreciation) and \( P_t^H*(f) \) is the price of variety \( f \) produced abroad denominated in foreign currency. A star denotes the counterpart of a variable or a parameter in the rest-of-the-world. Note that the terms of trade are defined as \( P_t^F / P_t^H \) (= \( S_t P_t^H* / P_t^H \)), while the real exchange rate is defined as \( S_t P_t^* / P_t \).

### 2.2 Households

Each household \( i \) acts competitively to maximize expected lifetime utility given by:
\[ E_0 \sum_{t=0}^{\infty} \beta^t U(c_{i,t}, n_{i,t}, m_{i,t}, g_t) \]  

where \( c_{i,t} \) is \( i \)'s consumption bundle as defined above, \( n_{i,t} \) is \( i \)'s hours of work, \( m_{i,t} \) is \( i \)'s real money holdings, \( g_t \) is per capita public spending, \( 0 < \beta < 1 \) is the time discount rate, and \( E_0 \) is the rational expectations operator conditional on the information set.

The period utility function is assumed to be of the form (see e.g. Gali, 2008):

\[
u_{i,t} (c_{i,t}, n_{i,t}, m_{i,t}, g_t) = c_{i,t}^{1-\sigma} n_{i,t}^{-\eta} + m_{i,t}^{1-\mu} + g_t^{1-\zeta} \tag{8}\]

where \( \chi_n, \chi_m, \chi_g, \sigma, \eta, \mu, \zeta \) are preference parameters. Thus, \( \sigma \) is a coefficient of intertemporal substitution and \( \eta \) is the inverse of Frisch labour elasticity.

The period budget constraint of each household \( i \) written in real terms is:

\[
(1 + \tau_{i,t}^k) \left[ \frac{P_{t}}{P_{t-1}} c_{i,t}^{H} + \frac{P_{t}}{P_{t}} c_{i,t}^{F} \right] + \frac{P_{t}}{P_{t-1}} c_{i,t}^{F} + b_{i,t} + m_{i,t} + \frac{S_{t} P_{t}^{*} f_{i,t}^{h}}{P_{t}} + \frac{\phi^h}{2} \left( \frac{S_{t} P_{t}^{*} f_{i,t}^{h}}{P_{t}} - \frac{SP^{*} f_{i,t}^{h}}{P_{t}} \right)^2 = \]

\[
= \left( 1 - \tau_{i,t}^h \right) \left[ \tau_{i,t}^k \frac{P_{t}}{P_{t-1}} k_{i,t-1} + \frac{\omega_{i,t}}{P_{t}} \right] + (1 - \tau_{i,t}^h) w_{t} n_{i,t} + R_{t-1} \frac{P_{t-1}}{P_{t}} b_{i,t-1} + \]

\[
+ \frac{P_{t-1}}{P_{t}} m_{i,t-1} + \frac{Q_{t-1}}{P_{t-1}} f_{i,t-1}^{h} - \tau_{i,t}^l \tag{9}\]

where \( x_{i,t} \) is \( i \)'s domestic investment, \( b_{i,t} \) is the real value of \( i \)'s end-of-period domestic government bonds, \( m_{i,t} \) is \( i \)'s end-of-period real domestic money holdings, \( f_{i,t}^{h} \) is the real value of \( i \)'s end-of-period internationally traded assets denominated in foreign currency, \( r_{i,t}^k \) denotes the real return to the beginning-of-period domestic capital, \( k_{i,t-1}, \omega_{i,t} \) is \( i \)'s real dividends received by domestic firms, \( w_{t} \) is the real wage rate, \( R_{t-1} \geq 1 \) denotes the gross nominal return to domestic government bonds between \( t - 1 \) and \( t \), \( Q_{t-1} \geq 1 \) denotes the gross nominal return to international assets between \( t - 1 \) and \( t \), \( \tau_{i,t}^l \) are real lump-sum taxes/transfers to each household, and \( 0 \leq \tau_{i,t}^k, \tau_{i,t}^h, \tau_{i,t}^l \leq 1 \) are tax rates on consumption, capital income and labour income respectively. Small letters denote real values, namely, \( m_{i,t} \equiv \frac{M_{i,t}}{P_{t}}, b_{i,t} \equiv \frac{B_{i,t}}{P_{t}}, f_{i,t}^{h} \equiv \frac{F_{i,t}^{h}}{P_{t}}, \)

\( w_{t} \equiv \frac{W_{t}}{P_{t}}, \omega_{i,t} \equiv \frac{\Omega_{i,t}}{P_{t}}, \tau_{i,t}^{l} \equiv \frac{\tau_{i,t}^{l}}{P_{t}} \), where capital letters denote nominal values. The parameter \( \phi^h \geq 0 \) measures transaction costs related to foreign assets as a deviation from their long-run
value, \( f_t^h \).\(^9\)

The law of motion of physical capital for each household \( i \) is:

\[
k_{i,t} = (1 - \delta)k_{i,t-1} + x_{i,t} - \xi \left( \frac{k_{i,t}}{k_{i,t-1}} - 1 \right)^2 k_{i,t-1}
\]

(10)

where \( 0 < \delta < 1 \) is the depreciation rate of capital and \( \xi \geq 0 \) is a parameter capturing adjustment costs related to physical capital.

Each household \( i \) acts competitively taking prices and policy as given. Details and the first-order conditions are included in Appendix 1 in Philippopoulos et al. (2013).

2.3 Implications for price bundles

Given the above, the three price indexes are:

\[
P_t = (P_t^H)^\nu (P_t^F)^{1-\nu}
\]

(11)

\[
P_t^H = \left[ \sum_{h=1}^{N} \kappa[P_t^H(h)]^{1-\phi} \right]^{\frac{1}{1-\phi}}
\]

(12)

\[
P_t^F = \left[ \sum_{f=1}^{N} \kappa[P_t^F(f)]^{1-\phi} \right]^{\frac{1}{1-\phi}}
\]

(13)

2.4 Firms

Each domestic firm \( h \) produces a differentiated good of variety \( h \) under monopolistic competition and facing Calvo-type nominal fixities.

Nominal profits of firm \( h \) are defined as:

\[
\bar{\Omega}_t(h) \equiv P_t^H(h)y_t^H(h) - r_t^P P_t^H(h)k_{t-1}(h) - W_t n_t(h)
\]

(14)

All firms use the same technology as represented by the production function:

\[
y_t^H(h) = A_t[k_{t-1}(h)]^\alpha [n_t(h)]^{1-\alpha}
\]

(15)

\(^9\)These costs are not important to the main results but help the model with the data.
where \( A_t \) is an exogenous stochastic TFP process whose motion is defined below.

Profit maximization by firm \( h \) is subject to the demand for its product as given by:

\[
y_t^H(h) = y_t^H(h) = c_t^H(h) + x_t(h) + g_t(h) + c_t^{F*}(h) = \left[ \frac{P_t^H(h)}{P_t^H} \right]^{-\phi} y_t^H
\]

(16)

That is, demand for firm \( h \)'s product, \( y_t^H(h) \), comes from domestic households’ consumption and investment, \( c_t^H(h) \) and \( x_t(h) \), where \( c_t^H(h) = \sum_{i=1}^{N_i} c_{it}^H(h) \) and \( x_t(h) = \sum_{i=1}^{N_i} x_{it}(h) \), from the domestic government, \( g_t(h) \), and from foreign households’ consumption, \( c_t^{F*}(h) = \sum_{i=1}^{N_i} c_{it}^{F*}(h) \).

In addition, following Calvo (1983), firms choose their prices facing a nominal fixity. In particular, in each period, each firm \( h \) faces an exogenous probability \( \theta \) of not being able to reset its price. A firm \( h \), which is able to reset its price at time \( t \), chooses its price \( P_t^#(h) \) to maximize the sum of discounted expected nominal profits for the next \( k \) periods in which it may have to keep its price fixed. This objective is given by:

\[
E_t \sum_{k=0}^{\infty} \theta^k \Xi_{t,t+k} \Omega_{t+k}(h) = E_t \sum_{k=0}^{\infty} \theta^k \Xi_{t,t+k} \left\{ P_t^#(h) y_{t+k}^H(h) - \Psi_{t+k}(y_{t+k}^H(h)) \right\}
\]

where \( \Xi_{t,t+k} \) is a discount factor taken as given by the firm, \( y_{t+k}^H(h) = \left[ \frac{P_{t+k}^H(h)}{P_{t+k}^H} \right]^{-\phi} y_{t+k}^H \) and \( \Psi_t(.) \) is the minimum nominal cost function for producing \( y_t^H(h) \) at \( t \) so that \( \Psi_t(.) \) is the associated nominal marginal cost. Details for the firm’s problem and its first-order conditions are in Appendix 2 in Philippopoulos et al. (2013).

### 2.5 Government budget constraint

The period budget constraint of the government written in real and aggregate terms is (for details, see Appendix 3 in Philippopoulos et al., 2013):

\[
d_t + m_t = R_{t-1} \frac{P_{t-1}}{P_t} \lambda_{t-1} d_{t-1} + Q_{t-1} \frac{S_{t-1} P_t}{P_{t-1}^2} \frac{P_{t-1}}{P_{t-1}^2} \frac{P_{t-1}}{P_{t-1}^2} (1 - \lambda_{t-1}) d_{t-1} + \frac{P_{t-1}}{P_t} m_{t-1} + \frac{P_{t-1}}{P_t} g_t - \tau_t (\frac{P_t^H}{P_t} c_t^H + \frac{P_t^F}{P_t} c_t^F) - \tau_t (\frac{P_t^H}{P_t} P_t^H k_{t-1} + \bar{\omega}_t) - \tau^d_t w_t n_t - \tau^l_t + \frac{\phi}{2} [(1 - \lambda_t) d_t - (1 - \lambda) d_t^2]
\]

(17)

where \( d_t \equiv \frac{D_t}{P_t} \) is the real value of end-of-period total public debt and \( m_t \) is the end-of-period total stock of real money balances. As above, small letters denote real values, e.g. \( d_t \equiv \frac{D_t}{P_t} \).
Total public debt, $D_t$, can be held by domestic private agents, $\lambda_t D_t$, as well as by foreign private agents, $(1 - \lambda_t) D_t$, where the share $0 \leq \lambda_t \leq 1$ is a fiscal policy instrument. Also, recall that the government allocates its total expenditure among product varieties $h$ by solving an identical problem with household $i$, so that $g_t(h) = \left[ \frac{P_t^H(h)}{P_t^H} \right]^{-\phi} g_t$. The parameter $\phi^g \geq 0$ measures transaction costs related to foreign liabilities similar to those of the household.

In each period, one of the fiscal policy instruments $(\tau^c_t, \tau^k_t, \tau^n_t, g_t, \tau^d_t, \lambda_t, d_t)$ needs to follow residually to satisfy the government budget constraint.

### 2.6 Closing the model: the world interest rate

As is known, to avoid nonstationarities, we have to depart from the benchmark small open economy model. Here, following Schmitt-Grohé and Uribe (2003) and many others, we do so by endogenizing the interest rate faced by the domestic country when it borrows from the world capital market, $Q_t$. In particular, we assume that $Q_t$ is an increasing function of total public debt as share of output, $\frac{D_t}{P_t^H Y_t^H}$, when the latter exceeds a certain threshold.

In particular, following Schmitt-Grohé and Uribe (2003) and Christiano et al. (2011), we use the functional form:

$$Q_t = Q_t^* + \psi \left( e^{\left( \frac{D_t}{P_t^H Y_t^H} - \bar{d} \right)} - 1 \right)$$

where $Q_t^*$ is exogenously given, $\bar{d}$ is an exogenous threshold value above which the interest rate on government debt starts rising above $Q_t^*$ and the parameter $\psi$ measures the elasticity of the interest rate with respect to deviations of total public debt from its threshold value.

### 2.7 Monetary and fiscal policy regimes

To solve the model, we need to specify the exchange rate and the fiscal policy regimes. Concerning the exchange rate regime, since the model is applied to Italy over the last decade, we solve it for a case without monetary policy independence. In particular, we assume that the

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10 For details, see Schmitt-Grohé and Uribe (2003). See also Fernández-Villaverde et al. (2011).

11 As said above, this rather common assumption is supported by a number of empirical studies (see e.g. European Commission, 2012). Alternatively, to model sovereign premia, we could appeal to the notion of a fiscal limit or to the notion that default is a strategic choice of the sovereign (see Corsetti et al., 2013).

12 The value of $\bar{d}$ can be thought of as any value of debt above which sustainability concerns start arising (see e.g. European Commission, 2011, for various thresholds for sustainable public debt). In any case, as we report below, our qualitative results are robust to the value of $\bar{d}$. 

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nominal exchange rate, $S_t$, is exogenously set and, at the same time, the domestic nominal interest rate on domestic government bonds, $R_t$, becomes an endogenous variable.\(^{13}\) Concerning fiscal policy, we start by assuming that, along the transition, the residually determined public financing policy instrument is the end-of-period total public debt, $D_t$ (see below for other cases).

### 2.8 Fiscal policy rules

Without room for monetary policy independence, only fiscal policy can be used for policy action. Following Schmitt-Grohé and Uribe (2007) and many others, we focus on simple rules, meaning that the fiscal authorities react to a small number of easily observable macroeconomic indicators (we report that our main results do not change when we add more indicators). In particular, we allow the spending-tax policy instruments,\(^{14}\) namely, government spending as share of output, defined as $s^g_t$, and the tax rates on consumption, capital income and labor income, $\tau^c_t$, $\tau^k_t$ and $\tau^n_t$, to react to the public debt-to-output ratio as deviation from a target, as well as to the output gap, according to the linear rules:\(^{15}\)

\[
\begin{align*}
    s^g_t - s^g &= -\gamma^g_t (l_{t-1} - l) - \gamma^g_y (y^H_t - y^H) \\
    \tau^c_t - \tau^c &= \gamma^c_t (l_{t-1} - l) + \gamma^c_y (y^H_t - y^H) \\
    \tau^k_t - \tau^k &= \gamma^k_t (l_{t-1} - l) + \gamma^k_y (y^H_t - y^H)
\end{align*}
\]

\(^{13}\)This is similar to the modeling of e.g. Erceg and Linde (2012). The fact that $S_t$ is exogenous does not necessarily imply that $R_t$ should become an endogenous variable. Some other policy instrument could play the role of the adjusting policy instrument, so that both $S_t$ and $R_t$ could be treated as policy instruments. We have experimented with several candidates in our numerical solutions below and we can report that, only when we treat $R_t$ as endogenous, the model gives well-defined solutions under fixed exchange rates (for details, see Appendix 4 in Philippopoulos et al., 2013). Recall that in the popular case of flexible, or managed floating, exchange rates, $S_t$ and $R_t$ switch positions, in the sense that $S_t$ becomes an endogenous variable, while $R_t$ is used as a policy instrument usually assumed to follow a Taylor-type rule. For the modeling of different exchange rate regimes in similar models, see e.g. Gali and Monacelli (2005) and Collard and Della (2006). Notice that, under certainty, the household’s optimality conditions imply $R_t = Q_t \frac{S_{t+1}}{S_t}$, which is the uncovered interest parity condition. Under fixed exchange rates, we simply have $R_t = Q_t$, where $Q_t$ consists of the exogenous rest-of-the world interest rate and the endogenous sovereign premium.

\(^{14}\)We focus on distorting policy instruments, because using lump-sum ones would be like a free lunch.

\(^{15}\)For similar rules, see e.g Schmitt-Grohé and Uribe (2007), Bi (2010) and Cantore et al. (2012). See European Commission (2011) for fiscal reaction functions used in practice.
\[ \tau^n_i - \tau^n = \gamma^{n}_{l} (l_{t-1} - l) + \gamma_{y}^{n} (y_{t}^{H} - y^{H}) \]  

(22)

where variables without time subscripts denote target values (defined below), and \(\gamma^{q}_{l} \geq 0\) and \(\gamma_{y}^{q} \geq 0\), where \(q \equiv (g,c,k,n)\), are respectively feedback fiscal policy coefficients on the output share of inherited public liabilities, \(l_{t-1}\), and output, \(y_{t}^{H}\), as deviations from their target values.

From the government budget constraint in subsection 2.5 above, \(l_t\) is defined as:

\[ l_t \equiv \frac{R_t \lambda_t D_t + Q_t \frac{S_{t+1}}{S_t} (1 - \lambda_t) D_t}{P_t^{H} y_{t}^{H}} \]

where \(\frac{S_{t+1}}{S_t}\) is the gross rate of exchange rate depreciation.

2.9 Exogenous variables and shocks

We assume that foreign imports or equivalently domestic exports, \(c_t^{F*}\), are a function of terms of trade, \(TT_t \equiv \frac{P_t^F}{P_t^T}\), where both variables are expressed as deviations from their long-run values:

\[ \frac{c_t^{F*}}{c^{*}_{t}} = \left( \frac{TT_t}{TT} \right)^{\gamma} \]  

(23)

where \(0 < \gamma < 1\) is a parameter. The idea is that foreign imports rise when the domestic economy becomes more competitive.

Regarding the other rest-of-the-world variables, namely, the exogenous part of the foreign interest rate, \(Q_t^{*}\), and the gross rate of domestic inflation in the foreign country, \(\Pi_{t}^{H*} \equiv \frac{P_t^{H*}}{P_{t-1}^{H\tau}}\), we assume that they are constant over time and equal to \(Q_t^{*} = 1.03\) (which is the data average - see below) and for simplicity \(\Pi_{t}^{H*} = 1\) at all \(t\).

We set the exogenous gross rate of exchange rate depreciation, \(\epsilon_t \equiv \frac{S_{t+1}}{S_t}\), at one, while, the output share of lump-sum taxes/transfers, \(s_{t}^{l}\), and the share of domestic public debt in total public debt, \(\lambda_t\), are set respectively at \(s_{t}^{l} = -0.21\) and \(\lambda_t = 0.6\) at all \(t\), which are their data average values (see below).

Finally, stochasticity comes from TFP, which follows:

\[ \log (A_t) = (1 - \rho^a) \log (A) + \rho^a \log (A_{t-1}) + \epsilon_t^a \]  

(24)
where $0 < \rho^a < 1$ is a parameter, $\varepsilon_t^a \sim N\left(0, \sigma_a^2\right)$ and, as said above, variables without time subscript denote long-run values. As we report below, our main results do not change when we add extra shocks.

### 2.10 Decentralized equilibrium (given feedback policy coefficients)

We now combine all the above to present the Decentralized Equilibrium (DE) which is for any feasible policy and, in particular, for any feedback policy coefficients. The DE is defined to be a sequence of allocations, prices and policies such that: (i) households maximize utility; (ii) a fraction $(1 - \theta)$ of firms maximize profits by choosing an identical price $P_t^\#$, while a fraction $\theta$ just set prices at their previous period level; (iii) all constraints, including the government budget constraint and the balance of payments, are satisfied; (iv) markets clear; (v) policy makers follow the feedback rules as specified in subsection 2.8. This DE is given the exogenous variables, $\{c_t^F, Q_t^*, \Pi_t^H, \epsilon_t, s_t^l, \lambda_t, A_t\}_{t=0}^\infty$, which have been defined in subsection 2.9, initial conditions for the state variables and the values of the feedback policy coefficients in the policy rules.

We end up with a first-order dynamic system of 33 equations. Solution details and the final equilibrium system are presented in Appendix 5 in Philippopoulos et al. (2013). To solve this system, we will take a second-order approximation around its steady state. We thus start with the steady state solution in the next section. In turn, we will study transition dynamics and the optimal choice of feedback policy coefficients along the transition.

### 3 Data, parameterization and steady state solution

This section parameterizes the model by using the averages of fiscal and public finance data from Italy over 2001-2011 and then presents the resulting steady state solution. Recall that, since policy instruments react to deviations of macroeconomic indicators from their long-run values, feedback policy coefficients do not play any role in the long-run solution.
3.1 Data and parameter values

The sources of fiscal and public finance data for Italy are OECD and Eurostat. The time unit is meant to be a year. The baseline parameter values, as well as the values of policy variables, are summarized in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>0.42</td>
<td>share of capital</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.9603</td>
<td>rate of time preference</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.5</td>
<td>home goods bias parameter at home</td>
</tr>
<tr>
<td>$\mu$</td>
<td>3.42</td>
<td>parameter related to money demand elasticity</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.04</td>
<td>rate of capital depreciation</td>
</tr>
<tr>
<td>$\phi$</td>
<td>6</td>
<td>price elasticity of demand</td>
</tr>
<tr>
<td>$\eta$</td>
<td>1</td>
<td>inverse of Frisch labour elasticity</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>1</td>
<td>elasticity of intertemporal substitution</td>
</tr>
<tr>
<td>$\nu^*$</td>
<td>0.5</td>
<td>home goods bias parameter abroad</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.5</td>
<td>price rigidity parameter</td>
</tr>
<tr>
<td>$\psi$</td>
<td>0.05</td>
<td>risk premium parameter</td>
</tr>
<tr>
<td>$\chi_m$</td>
<td>0.001</td>
<td>preference parameter related to real money balances</td>
</tr>
<tr>
<td>$\chi_n$</td>
<td>7</td>
<td>preference parameter related to work effort</td>
</tr>
<tr>
<td>$\chi_g$</td>
<td>0.1</td>
<td>preference parameter related to public spending</td>
</tr>
<tr>
<td>$d^*$</td>
<td>0.9</td>
<td>threshold value for public debt as share of output</td>
</tr>
<tr>
<td>$\rho^\sigma$</td>
<td>0.92</td>
<td>persistence of TFP</td>
</tr>
<tr>
<td>$\sigma_a$</td>
<td>0.017</td>
<td>standard deviation of TFP</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.9</td>
<td>terms of trade elasticity of foreign imports</td>
</tr>
<tr>
<td>$\xi$</td>
<td>0.3</td>
<td>adjustment cost parameter on physical capital</td>
</tr>
<tr>
<td>$\phi^p$</td>
<td>0.3</td>
<td>adjustment cost parameter on foreign public debt</td>
</tr>
<tr>
<td>$\phi^b$</td>
<td>0.3</td>
<td>adjustment cost parameter on private foreign assets</td>
</tr>
<tr>
<td>$\tau^c$</td>
<td>0.17</td>
<td>consumption tax rate</td>
</tr>
<tr>
<td>$\tau^k$</td>
<td>0.32</td>
<td>capital tax rate</td>
</tr>
<tr>
<td>$\tau^n$</td>
<td>0.42</td>
<td>labour tax rate</td>
</tr>
<tr>
<td>$s^g$</td>
<td>0.22</td>
<td>government spending as share of GDP</td>
</tr>
<tr>
<td>$s'$</td>
<td>-0.21</td>
<td>lump-sum transfers as a share of GDP</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.6</td>
<td>share of total public debt held by domestic private agents</td>
</tr>
</tbody>
</table>

The value of the rate of time preference, $\beta$, follows from setting the gross nominal interest rate at $R = 1.0413$ (this implies a risk premium of 1.1% over the German 10-year bond rate, which is the average value in the data) and the long-run gross price inflation rate at $\Pi = 1$. The real money balances elasticity, $\mu$, is taken from Pappa and Neiss (2005). We employ conventional values used by the literature for the elasticity of intertemporal substitution, $\sigma$, the inverse of Frisch labour elasticity, $\eta$, and the price elasticity of demand, $\phi$, which are all
taken from Andrès and Doménech (2006) and Gali (2008). Regarding preference parameters in the utility function, $\chi_m$ is chosen so as to obtain a yearly steady-state value for real money balances as ratio of output equal to 0.46, $\chi_n$ is chosen so as to obtain yearly steady-state labour hours equal to 0.27, while $\chi_g$ is set at 0.1. The price rigidity parameter, $\theta$, is set at 0.5 (as we report below, we have experimented with various values of $\theta$ and all key results remain unaffected).

In our baseline parameterization, the critical value of the output share of public debt, above which sovereign risk premia emerge, $\overline{d}$, is set at 0.9. This is consistent with evidence provided by e.g. Reinhart and Rogoff (2010) and Checherita-Westphal and Rother (2012) that, in most advanced economies, the adverse effects of public debt arise when it is around 90-100% of GDP. The associated sovereign premium parameter, $\psi$, is set at 0.05, which, jointly with the value of $\overline{d}$, implies a steady-state premium for Italy over the German rate equal to 1.1. These values are in line with empirical findings for OECD countries (see Ardagna et al., 2004). As we report below, our results are robust to changes in these parameter values.

Concerning exogenous variables, the persistence and standard deviation parameters of the TFP shock are set respectively at $\rho^a = 0.92$ and $\sigma_a = 0.017$ (the value of $\rho^a$ is similar to that in Schmitt-Grohé and Uribe, 2007, while the value of $\sigma_a$ is close to that in Bi, 2010, and Bi and Kumhof, 2009). As reported below, our results are robust to changes in these values. Regarding the rest-of-the-world variables, $\Pi^H_t$, $Q^*_t$ and $c^F_t$, we set their long-run average values equal to $\Pi^H = 1$, $Q^* = 1.03$ and $c^F = 0.9c^F$, where 0.9 is calibrated to replicate the net export position found in the Italian data. In the baseline parameterization, $\gamma$ in equation (23) for foreign imports is set at 0.9.

The long-run values of fiscal and public finance policy instruments, $\tau^c_t$, $\tau^k_t$, $\tau^n_t$, $s^g_t$, $s^l_t$, $\lambda_t$ are set at their data averages. In particular, $\tau^c$, $\tau^k$, $\tau^n$ are the effective tax rates on consumption, capital and labor in the data over 2001-2011. Moreover, $s^g$ and $-s^l$, namely, government spending and lump-sum transfer payments as shares of output, are set at their average values in the data, which are 0.22 and 0.21 respectively. Finally, $\lambda$, the share of total public debt held by domestic private agents is set at 0.6, which is again its average value in the data during the same period.
3.2 Steady state solution or the "status quo"

Table 2 presents the steady state solution of the model economy when we use the parameter values and the policy instruments in Table 1. In this solution, we treat total public debt, \( d \), as the residually determined public finance instrument. In Table 2, we also present some key ratios in the Italian data whenever available. Notice that most of the solved ratios are close to their actual values. In particular, notice the solution for total foreign debt as share of output, which is \( \frac{(1-s)dTT^{1-v} - TT^{*} f^{h}}{y^{T}} = 0.36 \); its value in the data is very close, around 0.35 (see Diz Dias, 2010, for external debt statistics of the euro area).

This solution will serve as a point of departure. That is, in what follows, we depart from this solution to study various policy experiments. This is why we call it the "status quo" solution. In this solution, a lower public debt to output ratio implies a lower sovereign premium and this leads to higher capital, higher output and higher welfare. This can rationalize the debt consolidation policies studied in what follows.

Table 2: Steady state solution (the "status quo")

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Steady-state solution</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n )</td>
<td>hours worked</td>
<td>0.27</td>
<td>-</td>
</tr>
<tr>
<td>( w )</td>
<td>real wage rate</td>
<td>1.13</td>
<td>-</td>
</tr>
<tr>
<td>( r^{k} )</td>
<td>real return to physical capital</td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>( Q - Q^{*} )</td>
<td>interest rate premium</td>
<td>0.013</td>
<td>0.01</td>
</tr>
<tr>
<td>( TT^{1-v} \frac{C^{*}}{y^{T}} )</td>
<td>consumption as share of GDP</td>
<td>0.65</td>
<td>0.73</td>
</tr>
<tr>
<td>( \frac{k}{y^{T}} )</td>
<td>physical capital as share of GDP</td>
<td>2.95</td>
<td>3.48</td>
</tr>
<tr>
<td>( TT^{*} \frac{f^{h}}{y^{T}} )</td>
<td>private foreign assets as share of GDP</td>
<td>0.08</td>
<td>0.1</td>
</tr>
<tr>
<td>( s^{d} \equiv \frac{d^{*}}{P^{u}y^{T}} )</td>
<td>total public debt as share of GDP</td>
<td>1.1</td>
<td>1.09</td>
</tr>
<tr>
<td>( \frac{(1-s)dTT^{1-v} - TT^{*} f^{h}}{y^{T}} )</td>
<td>total foreign debt as share of GDP</td>
<td>0.36</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Note: Variables and shares are denominated in domestic currency.

4 The role of policy and solution strategy

In this section, we explain the policy experiments we focus on, how we model debt consolidation and how we compute optimized policy rules.

Recall that, along the transition path, nominal rigidities imply that money is not neutral so that monetary policy and the exchange rate regime matter to the real economy. As said in subsection 2.7, here we focus on fixed exchange rates and loss of monetary policy independence.
Also, recall that, along the transition path, different counter-cyclical fiscal policy rules can have different implications. That is, we will welfare rank different counter-cyclical fiscal policy rules when there is no room for monetary policy.

4.1 Two policy scenarios

Motivated by the policy questions asked in the opening paragraphs in the Introduction, we study two environments regarding policy action. In the first, used as a benchmark, the role of policy is only to stabilize the economy against shocks. In particular, we assume that the economy is hit by an adverse temporary TFP shock, which, as the impulse response functions below reveal, produces a contraction in output, a rise in the public debt to output ratio and a rise in the sovereign premium. We focus on an adverse shock in order to mimic the recessionary effect of the 2008 world crisis. Then, the policy questions are which policy instrument to use, and how strong the reaction of policy instruments to deviations from targets should be, in order to minimize cyclical volatility along the transition. Note that, in this case, the policy targets are given by the steady state status quo solution. In other words, we depart from, and end up, at the status quo in subsection 3.2 above, while transition dynamics are driven by temporary shocks only.

The second environment is richer. Now the role of policy is twofold: to stabilize the economy against the same shocks as above and, at the same time, to improve resource allocation by gradually reducing the public debt to GDP ratio over time. The policy questions are as above except that, now, the policy targets are given by the steady state solution of the reformed economy. In other words, in this case, we depart from the status quo solution with sovereign premia, but we end up at a reformed steady state with lower public debt and zero premia. Thus, now there are two sources of transition dynamics: temporary shocks and the difference between the initial and the new reformed long run (see also Cantore et al., 2012).

Although our main interest is in the latter reformed economy, the former serves as a natural welfare benchmark. The next subsection provides the definition of debt consolidation adopted here.
4.2 Debt consolidation

In the reformed economy, the government reduces the share of public debt from 110% (which is its average value in the data over the sample period and is also our status quo solution) to the target value of 90%. Since, in our model, sovereign risk premia arise whenever public debt happens to be above the 90% threshold, premia are eliminated once such consolidation is achieved. Debt reductions can be accommodated by adjustments in the tax-spending policy instruments, namely, the output share of public spending, and the tax rates on capital income, labour income and consumption.

It is widely recognized that debt consolidation implies a tradeoff between short-term pain and medium-term gain (see e.g. Coenen et al., 2008). During the early phase of the transition, debt consolidation comes at the cost of higher taxes and/or lower public spending. In the medium- and long-run, a reduction in the debt burden allows, other things equal, a cut in tax rates, and/or a rise in public spending. Thus, one has to value the early costs of stabilization vis-a-vis the medium- and long-term benefits from the fiscal space created.

It is also widely recognized that the implications of fiscal reforms, like debt consolidation, depend heavily on the public financing policy instrument used, namely, which policy instrument adjusts endogenously to accommodate the exogenous changes in fiscal policy (see e.g. Leeper et al., 2009). In the case of debt consolidation, such implications are expected to depend both on which policy instrument bears the cost of adjustment in the early period of adjustment and on which policy instrument is expected to reap the benefit, once consolidation has been achieved. Notice that if lump-sum policy instruments were available, the costs of adjustment would be trivial.

To understand the logic of our results, and following usual practice in related studies, we will start by experimenting with one fiscal instrument at a time. This means that, along the early costly phase, we allow one of the fiscal policy instruments to react to public debt imbalances (so as to stabilize debt around its new target value of 0.9) and, at the same time, it is the same fiscal policy instrument that adjusts residually in the long-run to close the government budget. Thus, we will start by assuming that the same policy instrument bears the cost of, and reaps the benefit from, debt consolidation. In turn, we will experiment with fiscal policy mixes, which means that we can use different fiscal policy instruments in the transition and in
the long run.

The rules for fiscal policy instruments are as in subsection 2.8 above except that, now, the
targetted values are those of the reformed long-run equilibrium. In all experiments, all other
fiscal policy instruments, except the one used for stabilization, remain unchanged and equal
to their pre-reform status quo values.

Specifically, we work as follows. We first compare the steady state equilibria with, and
without, debt consolidation. In turn, setting as initial conditions for the state variables, their
values from the solution of the economy without debt consolidation (in particular, from the
status quo solution in subsection 3.2), we compute the equilibrium transition path as we travel
towards the steady state of the reformed economy. This is for each method of public financing
used. The feedback policy coefficients of the instrument(s) used along the transition path are
chosen optimally. The way we compute optimized feedback policy rules with, or without, debt
consolidation is explained in the next subsection.

4.3 Optimized feedback policy rules

Irrespectively of the policy experiments studied, to make the comparison of different policies
meaningful, we compute optimized policy rules, so that results do not depend on ad hoc
differences in feedback policy coefficients across different policy rules. The welfare criterion is
household’s expected lifetime utility.

To do so, we work in two steps. In the first preliminary step, we search for the ranges of
feedback policy coefficients, as defined in equations (19-22), which allow us to get a locally
determinate equilibrium (this is what Schmitt-Grohé and Uribe, 2007, call implementable
rules). If necessary, these ranges will be further restricted so as to give economically meaningful
solutions for the policy instruments (e.g. tax rates less than one and non-negative nominal
interest rates). In our search for local determinacy, we experiment with one, or more, policy
instruments and one, or more, operating targets at a time.

In the second step, within the determinacy ranges found above, we compute the welfare-
maximizing values of feedback policy coefficients (this is what Schmitt-Grohé and Uribe, 2005
and 2007, call optimized policy rules). The welfare criterion is to maximize the conditional
welfare of the household, as defined in equation (7), where conditionality refers to the initial
conditions chosen; the latter are given by the status quo solution above. To this end, following e.g. Schmitt-Grohé and Uribe (2004), we take a second-order approximation to both the equilibrium conditions and the welfare criterion. As is known, this is consistent with risk-averse behavior on the part of economic agents and can also help us to avoid possible spurious welfare results that may arise when one takes a second-order approximation to the welfare criterion combined with a first-order approximation to the equilibrium conditions (see e.g. Gali, 2008, pp. 110-111, Malley et al., 2009, and Benigno and Woodford, 2012).

In other words, we first compute a second-order accurate approximation of both the conditional welfare and the decentralized equilibrium, as functions of feedback policy coefficients, by using the perturbation method of Schmitt-Grohé and Uribe (2004) and, in turn, we use a matlab function (such as fminsearch.m or fminsearchbnd.m) to compute the values of the feedback policy coefficients that maximize this approximation.\footnote{All matlab programs used are available upon request. We report that when we use Dynare, version 4, we get the same results.} In this exercise, as said above, if necessary, the feedback policy coefficients are restricted to be within some prespecified ranges so as to deliver determinacy and give meaningful values for policy instruments. All this is with, and without, debt consolidation.

5 Results

In this section, we present the main results. The emphasis will be on the case of the reformed economy but, for reasons of comparison, we also present results for the case without debt consolidation. We start by defining the region of feedback policy coefficients that can give local determinacy.

5.1 Determinacy areas

As is known, local determinacy depends crucially on the values of feedback policy coefficients. Our experiments show that economic policy can guarantee determinacy when fiscal policy instruments $(s^g_t, \tau^g_t, \tau^k_t, \tau^p_t)$ react to public liabilities between critical minimum and maximum values, where these values differ across different policy instruments. In particular, the ranges of fiscal reaction to public liabilities are $0.06 < \gamma^g_t < 1.7$, $0.11 < \gamma^c_t < 3.79$, $0.13 < \gamma^k_t < 2.35$. 

\footnote{All matlab programs used are available upon request. We report that when we use Dynare, version 4, we get the same results.}
and $0.14 < \gamma_t^u < 1.58$ for $s_t^q$, $\tau_t^c$, $\tau_t^k$ and $\tau_t^n$ respectively. By contrast, the values of $\gamma_y^q$, where $q \equiv (g, c, k, n)$, measuring the reaction of fiscal policy instruments to the output gap, are not found to be critical to determinacy. Further details are available upon request.

### 5.2 Optimized rules and welfare under debt consolidation

Within the above determinacy ranges, we now compute optimized policy rules. Results, for the case with debt consolidation, are reported in Table 3. The first column lists the fiscal policy instrument used, while the optimal reaction of this instrument to the debt and output gaps are in the second column. Steady state utility, $u$, is reported in the third column, while expected discounted lifetime utility, $E_0 V_0$, is reported in the last column. Recall that, under each policy regime, feedback policy coefficients are chosen to maximize $E_0 V_0$, so welfare differences should not be expected to be large across regimes. We report that the resulting values of all instruments used are well-defined in all solutions and over all periods, meaning that tax rates are between zero and one and that the nominal interest rate is above the zero bound (below we report results in the case in which the policy instruments are further restricted).

The results in Table 3 show that, if we rank instruments according to expected discounted lifetime utility or steady state utility, the capital and the labor tax rates score better than the consumption tax rate or the share of public spending. This is particularly clear when we focus on steady state utility.

<table>
<thead>
<tr>
<th>fiscal instrument</th>
<th>optimal reaction to debt and output</th>
<th>steady state utility $u$</th>
<th>expected discounted lifetime utility $E_0 V_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_t^q$</td>
<td>$\gamma_t^q = 0.1163$</td>
<td>0.732515</td>
<td>23.4068</td>
</tr>
<tr>
<td></td>
<td>$\gamma_y^q = 0.0085$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_t^c$</td>
<td>$\gamma_t^c = 0.4599$</td>
<td>0.733221</td>
<td>23.5520</td>
</tr>
<tr>
<td></td>
<td>$\gamma_y^c = 0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_t^k$</td>
<td>$\gamma_t^k = 0.4182$</td>
<td>0.772301</td>
<td>24.4192</td>
</tr>
<tr>
<td></td>
<td>$\gamma_y^k = 0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_t^n$</td>
<td>$\gamma_t^n = 0.2677$</td>
<td>0.759887</td>
<td>24.3221</td>
</tr>
<tr>
<td></td>
<td>$\gamma_y^n = 0.0692$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: In all solutions, $R_t \geq 1$, $0 < s_t^q$, $\tau_t^c$, $\tau_t^k$, $\tau_t^n < 1$, at all $t$.

To compare welfare across regimes, we could also use a flat consumption subsidy that makes the agent indifferent between two regimes (see e.g. Lucas, 1990). The policy message will be the same.
Although we prefer to postpone a detailed interpretation of our results until below when we study various time horizons, it is worth pointing out, at this early stage, two results that remain unchanged throughout the paper. First, if we focus on steady state results only, capital and, in turn, labor taxes are better. This is to be expected; once public debt has been reduced, the most efficient way of taking advantage of the fiscal space created is to reduce particularly distorting taxes, like capital and labor taxes. This is also consistent with the Chamley-Judd normative result that the long-run capital tax rate should be zero. Second, in our semi-small open economy model, capital and labor taxes remain superior when the criterion is expected discounted lifetime utility. That is, although now there is a genuine intertemporal tradeoff, expectations of cuts in capital and labor taxes in the future dominate over any other short-term effects and this shapes the lifetime welfare ranking in Table 3.\textsuperscript{18}

The fact that it is expectations of cuts in capital and labor taxes in the future, that play the dominant role in lifetime results, is confirmed when we assume instead that the fiscal space created by debt consolidation is used to increase lump-sum transfers, rather than to reduce distorting taxes, at steady state. In this case, with trivial expected benefits from debt consolidation, consumption taxes and government spending score better than capital and labor taxes in terms of lifetime utility. Results for this case are reported in Table 4 (further details for this case are in Appendix 6 in Philippopoulos et al., 2013). Notice that now, since lump-sum transfers do not affect the real allocation, the steady state solution is the same across different fiscal policy instruments.

\textsuperscript{18}By contrast, in a closed economy without sovereign premia, public spending scores the best in terms of expected discounted lifetime utility. That is, transition effects dominate over steady state effects. See Philippopoulos et al. (2012).
Table 4: Optimized policy rules and welfare under debt consolidation when the residual instrument in the long run is lump-sum transfers

<table>
<thead>
<tr>
<th>Fiscal instrument</th>
<th>Optimal reaction to debt and output</th>
<th>Steady state utility</th>
<th>Expected discounted lifetime utility $E_0V_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s^q_t$</td>
<td>$\gamma^q_t = 0.1127$ \ $\gamma^q_y = 0.0091$</td>
<td>0.742729</td>
<td>23.7482</td>
</tr>
<tr>
<td>$\tau^c_t$</td>
<td>$\gamma^c_t = 0.4505$ \ $\gamma^c_y = 0$</td>
<td>0.742729</td>
<td>23.8103</td>
</tr>
<tr>
<td>$\tau^k_t$</td>
<td>$\gamma^k_t = 0.4007$ \ $\gamma^k_y = 0$</td>
<td>0.742729</td>
<td>23.5129</td>
</tr>
<tr>
<td>$\tau^n_t$</td>
<td>$\gamma^n_t = 0.2567$ \ $\gamma^n_y = 0.0608$</td>
<td>0.742729</td>
<td>23.7269</td>
</tr>
</tbody>
</table>

Notes: In all solutions, $R_t \geq 1, 0 < s^q_t, \tau^c_t, \tau^k_t, \tau^n_t < 1$, at all $t$.

5.3 Impulse response functions under debt consolidation

We now present the associated impulse response functions (IRFs) of some key endogenous variables (recall that transition dynamics are driven both by a temporary adverse supply shock and by debt consolidation). Results for the four fiscal policy instruments, $s^q_t, \tau^c_t, \tau^k_t$ and $\tau^n_t$, are shown in Figures 1a-1d respectively. Variables are expressed as log-deviations from their new, reformed long-run values (while the point of departure is the status quo).

Figure 1a depicts the case in which we use the output share of public spending, $s^q_t$, as the state-contingent instrument. That is, $s^q_t$ reacts to public debt and output with feedback coefficients $\gamma^q_t = 0.1163$ and $\gamma^q_y = 0.0085$ respectively (see Table 3, row 1), while all other policy feedback coefficients are set at zero, meaning that the other policy instruments remain constant at their steady-state values (data averages). In a similar manner, results for $\tau^c_t, \tau^k_t$ and $\tau^n_t$ are depicted respectively in Figures 1b, 1c and 1d.
Figure 1a: IRFs when the fiscal instrument is government spending

Figure 1b: IRFs when the fiscal instrument is the consumption tax rate
Figures 1c-d imply that public spending should fall, and tax rates should rise. In other words, the concern for debt consolidation more than offsets the concern for output stabilization,
even when the economy is hit by an adverse supply shock that triggers a recession. Thus, changes in all fiscal instruments are driven by debt imbalances most of the time. This is confirmed by the results in Table 3 where the optimal reaction to the output gap is much smaller in magnitude than the optimal reaction to debt.

To make our results clearer, Figure 2 presents the implied total public debt as share of output (notice that this is the ratio itself, rather than the deviation of this ratio from its long-run value which was the case in the IRFs above). As can be seen, debt starts at 110%, which is its status quo value, and ends up at 90% at the new reformed long run. In the short run, the economy is also hit by a temporary adverse shock that reduces output and further increases the debt-to-output ratio but eventually, thanks to fiscal reaction, debt starts falling towards its 90% threshold.\footnote{As also discussed in European Commission (2012), consolidations can lead to increases in the debt to output ratio in the short run. This is driven by "the denominator effect".}

Inspection of Figures 1 and 2 implies that the duration of the debt consolidation phase, or equivalently the speed of debt reduction, varies depending on which fiscal instrument is used. If we use the consumption tax rate, $\tau^c_t$, it should take around five years only; if we use capital taxes, $\tau^k_t$, around seven years; if we use public spending, $s^g_t$, above 15 years; and, finally, it should take about 20 years, in the case of labor taxes, $\tau^n_t$. In other words, debt reduction should take place at a much lower speed when we use public spending and especially labor taxes. This is because these two instruments, namely cuts in public spending and rises in labor taxes, are more recessionary than rises in consumption and capital taxes during the early phase of debt consolidation. That consumption taxes are less distorting is well known (see e.g. Bi, 2010). On the other hand, the explanation for capital taxes is that, in the very short run, the capital tax base is inelastic. Namely, in the very short run, capital taxes act like a capital levy on predetermined wealth and this is not so distorting.
The effects of the above debt consolidation policies on output are illustrated in Figure 3. This figure presents the dynamics of output (again, as in Figure 2, this is the level of output rather than its deviation from the long run value) for each fiscal policy instrument used. As can be seen, since it is optimal to reduce debt gradually when we use labor taxes, the recession lasts longer; this is the cost of gradualism. On the other hand, the gain of gradualism comes from a smaller recession in the very short run. By contrast, when we use the other fiscal policy instruments, it is optimal to go for a deeper recession at impact, which is at the benefit of a quicker recovery later on. Notice that although the use of public spending, $s^g$, is particularly recessionary in the short run (this is also the case in Erceg and Lindé, 2013), the associated fall in output is not so prolonged as when we use labor taxes.

Therefore, if we use labor taxes, it is optimal to spread the cost of debt consolidation over more periods. To understand this, recall that here we have an open economy distorted by sovereign premia, where the latter further rise when the debt-to-output ratio rises, or

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20Specifically, our results imply that, at impact, the use of government spending causes an output loss of around 7%, while the same loss is around 6.5% if we use capital taxes, 5.3% if we use consumption taxes and only 3.2% if we use labor taxes. We also report that these dynamics are primarily driven by debt consolidation; even if we switch off the adverse TFP shock, the optimized policy rules imply that debt consolidation leads to a short term recession, irrespective of whether there are adverse shocks or not at the same time.
equivalently when output falls. Thus, a big drop in output would be extra costly here.\textsuperscript{21} Since an increase in labor tax rates is particularly recessionary, it is better to go for a relatively mild use of labor taxes at impact which comes at the cost of a prolonged recession.

Figure 3: Path of the level of output

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3}
\caption{Path of the level of output}
\end{figure}

5.4 Welfare over various time horizons with, and without, debt consolidation

We now study what happens to welfare over various time horizons. This is important because, for several (e.g. political-economy) reasons, economic agents can be impatient. It can also help us to understand the possible conflicts between short-, medium- and long-term effects from debt consolidation. Setting the feedback policy coefficients as in Table 3 above, the expected discounted utility over various time horizons is reported in Table 5. Numbers in parentheses report results without debt consolidation, other things equal. As explained above, without debt consolidation, we again compute optimized feedback policy rules but now the economy starts from, and also returns to, its status quo with transition dynamics driven by shocks only.

\textsuperscript{21}By contrast, in a closed economy without sovereign premia, the short-term recession is much sharper when we use labor taxes. See Philippopoulos et al. (2012).
There are, at least, three messages from Table 5. First, other things equal, debt consolidation improves welfare only if we are relatively far-sighted. In particular, our results imply that expected discounted utility is higher with debt consolidation, when we care beyond the first 11, 11, 10 and 9 years (when we use \( s^g, \tau^c, \tau^k \) and \( \tau^n \) respectively). Reversing the argument, debt consolidation comes at a short-term welfare cost.\(^{22}\) Thus, as it happens with most reforms, the argument for, or against, debt consolidation involves a value judgment.

<table>
<thead>
<tr>
<th></th>
<th>4 periods</th>
<th>10 periods</th>
<th>20 periods</th>
<th>lifetime</th>
<th>steady state</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s^g )</td>
<td>2.0651</td>
<td>5.1840</td>
<td>9.6594</td>
<td>23.4068</td>
<td>0.732515</td>
</tr>
<tr>
<td>(2.4355)</td>
<td>(5.4213)</td>
<td>(9.0370)</td>
<td>(16.2793)</td>
<td>(0.646453)</td>
<td></td>
</tr>
<tr>
<td>( \tau^c )</td>
<td>2.0321</td>
<td>5.1923</td>
<td>9.7458</td>
<td>23.5520</td>
<td>0.733221</td>
</tr>
<tr>
<td>(2.4354)</td>
<td>(5.4209)</td>
<td>(9.0371)</td>
<td>(16.2814)</td>
<td>(0.646453)</td>
<td></td>
</tr>
<tr>
<td>( \tau^k )</td>
<td>2.1850</td>
<td>5.4137</td>
<td>10.0435</td>
<td>24.4192</td>
<td>0.772301</td>
</tr>
<tr>
<td>(2.4351)</td>
<td>(5.4206)</td>
<td>(9.0366)</td>
<td>(16.2824)</td>
<td>(0.646453)</td>
<td></td>
</tr>
<tr>
<td>( \tau^n )</td>
<td>2.2249</td>
<td>5.4931</td>
<td>10.1212</td>
<td>24.3221</td>
<td>0.759887</td>
</tr>
<tr>
<td>(2.4348)</td>
<td>(5.4201)</td>
<td>(9.0374)</td>
<td>(16.2807)</td>
<td>(0.646453)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Results without debt consolidation in parentheses.

Second, without debt consolidation, and to the extent that feedback policy coefficients are optimally chosen, the choice of the fiscal policy instrument used for cyclical stabilization is not so important. Welfare differences appear after the second decimal point across all time horizons (these are the numbers in parentheses in Table 5). By contrast, with debt consolidation, the choice of the fiscal policy instrument matters more (these are the numbers without parentheses in Table 5).

Third, if debt consolidation goes ahead despite its short-term welfare costs, labor and capital taxes score better than public spending and consumption taxes and this holds over all time horizons. This should not come as a surprise if we recall Table 3 and Figure 3 above. In particular, Table 3 explained why capital and labor taxes score better when the criteria are steady state or lifetime utility. In other words, when we are far-sighted, results are dominated by expectations. Consequently, once debt consolidation has been implemented, expectations of cuts in capital and labor taxes explain why these taxes score better in terms of steady state

\(^{22}\)It should be pointed out that the rise in welfare is partly driven by the fact that debt consolidation and elimination of sovereign premia in the reformed long-run equilibrium allow a higher value of the time preference rate than in the pre-reformed long-run solution in section 3 (in particular, the calibrated value of \( \beta \) was 0.9603 in the status quo solution in section 3, while it is 0.9709 without premia).
or expected lifetime utility. Figure 3, on the other hand, explained why labor taxes are better when we focus on short-term utility, in which case expectations of tax cuts in the future are practically irrelevant. In other words, labor taxes are superior in the very short-run because it is optimal to do things slowly when we use a particularly distorting instrument such as labor taxes, and this delay is good when we are short-sighted. Therefore, when we are restricted to use the same policy instrument both in the transition and in the long run, the common belief that it is better to use public spending for debt consolidation (see e.g. European Commission, 2011) is not confirmed in a semi-small open economy with sovereign premia. Erceg and Lindé (2013) also find that labor taxes are better in the short run of an open economy.\footnote{In a closed economy, by contrast, although it is again better to allow the labor and capital taxes to take advantage of the fiscal space in the long run, as it happens in the small open economy, it is better to use public consumption spending in the transition. Actually, in a closed economy, the superiority of public consumption spending during the transition dominates its inferiority in the long run, so that public consumption is the best instrument to use when we look at lifetime utility. This happens because, in a closed economy without sovereign premia, the short-term recession is much deeper, and lasts much longer, when we use labor taxes (see Philippopoulos et al., 2012).} We now turn to policy mixes.

5.5 Policy mixes under debt consolidation

So far, we have studied one fiscal instrument at a time. In particular, as explained in subsection 4.2 above, we have restricted ourselves to the case in which the same fiscal instrument is used during the early phase of fiscal pain as well as during the later phase of fiscal gain. We now study policy mixes in the sense that we are now free to use different policy instruments in the transition and in the long run.

The welfare implications of some interesting mixes, all with debt consolidation, are reported in Table 6. Since the extra benefits from using different instruments in the transition and in the long run can arise only if we are far-sighted, let us focus on expected discounted lifetime utility reported in the last column\footnote{If we are short-sighted, the results and the intuition are as in Table 4. That is, we only care about the recessionary effects of debt consolidation in the early phase.}. Then, a comparison of the results in Tables 5 and 6, implies that policy mixes lead to higher welfare. The reason is that mixes give more choice to policymakers. Also, the results in Table 6 imply that, in terms of lifetime utility, it is better to use the consumption tax rate, during the early consolidation phase, and the capital tax rate in the long run (this is the $\tau^c - \tau^k$ combination in the first row of Table 6). The idea is that, when
we are far-sighted, it is better to bring debt down as soon as possible (even at a short term cost), and this can be achieved better by a sudden rise in consumption taxes in the short run, and in turn enjoy the long-lasting beneficial effects coming from expected cuts in distorting taxes and, in particular, cuts in capital taxes. All these results combined confirm again how important expectations are in case we are far-sighted: expectations of cuts in distorting taxes, made affordable by the fiscal space created by a smaller debt burden, play a key role in the choice of the policy mix when we are far-sighted enough.

Table 6: Welfare over different time horizons with debt consolidation when we use different instruments in the transition and the long run

<table>
<thead>
<tr>
<th>policy instrument in the transition</th>
<th>policy instrument in the long run</th>
<th>4 periods</th>
<th>10 periods</th>
<th>20 periods</th>
<th>lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau^t_t$</td>
<td>$\tau^k$</td>
<td>2.1574</td>
<td>5.3991</td>
<td>10.1139</td>
<td>24.6116</td>
</tr>
<tr>
<td>$s^q_t$</td>
<td>$\tau^k$</td>
<td>2.1619</td>
<td>5.4324</td>
<td>10.1253</td>
<td>24.6039</td>
</tr>
<tr>
<td>$\tau^n_t$</td>
<td>$\tau^n$</td>
<td>2.1562</td>
<td>5.4014</td>
<td>10.0828</td>
<td>24.3709</td>
</tr>
<tr>
<td>$s^t_t$</td>
<td>$\tau^n$</td>
<td>2.1740</td>
<td>5.4285</td>
<td>10.0763</td>
<td>24.3395</td>
</tr>
</tbody>
</table>

We report that when we allow all four fiscal policy instruments (public spending, consumption taxes, capital income taxes and labor income taxes) to react to the debt gap during the transition, it is optimal to use consumption taxes, $\tau^t_t$, and public spending, $s^q_t$, only. By contrast, the optimal feedback policy coefficients on debt in the rules for capital and labor taxes, $\tau^k_t$ and $\tau^n_t$, are zero. Namely, optimized feedback policy coefficients are $\gamma^t_t = 0.2703$, $\gamma^q_t = 0.0947$, $\gamma^k_t = 0$ and $\gamma^n_t = 0.0036$, which imply the highest expected discounted lifetime utility among all cases examined in this paper, i.e. $E_0V_0 = 24.6262$. This generalizes the results in Table 6.

We finally report that when we study the implications of policy mixes for expected discounted output, the results do not change qualitatively. Thus, regarding alternative debt consolidation policies, welfare-maximizing policy does not differ from output-maximizing policy. The only difference is that the gains in output coming from debt consolidation are bigger, and materialize sooner, than the gains in welfare. Results for output are available in Appendix 7 in Philippopoulos et al. (2013).
6 Sensitivity analysis

We finally check the sensitivity of our results to a number of changes. First, our results are robust to changes in all key parameter values. Among the latter, we have extensively experimented with changes in the values of the parameter in the sovereign premium equation, $\psi$, the parameter in the exports function, $\gamma$, the Calvo parameter in the firm’s problem, $\theta$, and the adjustment cost parameters on assets and physical capital, $\phi^a, \phi^h$ and $\xi$, whose values are relatively unknown empirically. We report that our main results do not change within $0.002 \leq \psi \leq 0.09, 0.5 \leq \gamma \leq 1, 0.1 \leq \theta \leq 0.5$ and $0.01 \leq \phi^a, \phi^h, \xi \leq 2$. Our results also do not depend on the value of $\chi_g$, namely, how much agents value public consumption spending. For instance, results for the case in which $\chi_g = 0$ in the utility function are reported in Appendix 8 in Philippopoulos et al. (2013).

Second, our main results continue to hold even when there are restrictions on the magnitude of changes in policy instruments used for stabilization. In particular, in the analysis above, all policy instruments were well-defined economically, in the sense that tax rates and output spending shares were between zero and one all the time. Nevertheless, one could argue that, in addition, the values of policy instruments cannot differ substantially from those in the historical data (for various political economy reasons). We have therefore redone all the above computations restricting the feedback coefficients in the policy rules so as the policy instruments cannot change by more than 25% from their averages in the data. The welfare ranking and the main results do not change (see Appendix 9 in Philippopoulos et al., 2013).

Third, following several related papers (see e.g. Coenen et al., 2008, Forni et al., 2010, and Erceg and Lindé, 2013), we have experimented with time-varying and stochastic debt targets. Thus, instead of using a constant over time debt target, $l$, like in equations (19)-(22) above, we assume that the debt target, defined as $l_t^*$, follows a stochastic $AR(1)$ process of the form:

$$l_t^* = \left(1 - \rho^l\right) l + \rho^l l_{t-1}^* + \varepsilon_t^l$$

(25)

where $0 \leq \rho^l \leq 1$ is an autoregressive policy parameter and $\varepsilon_t^l$ a debt target shock. In our experiments, we assume that $\varepsilon_t^l$ follows an $AR(1)$ process with persistence 0.9 and standard deviation equal to 0.01.
We report that our main results remain the same under this new specification. Actually, we have also allowed the autoregressive policy parameter, $\rho^t$, to be determined optimally, along with the other (feedback) policy parameters. It is interesting that, when we use the labor tax rate, the optimal value of $\rho^t$ is found to be rather high during the consolidation phase, confirming the result discussed above, namely, it is optimal to use a smooth path of labor tax rates. Results with the new debt target can be found in Appendix 10 in Philippopoulos et al. (2013).

Finally, our results are robust to adding more indicators in the feedback policy rules (like inflation or terms of trade) as well as to assuming a more volatile economy (for instance, by increasing the standard deviation of the existing TFP shock or by adding new shocks). Specifically, regarding the latter, we have experimented with adding shocks to the fiscal policy rules in subsection 2.8 and/or to the time-varying debt target in equation (25) above, and the main results again do not change (results are reported in Appendix 11 in Philippopoulos et al., 2013).

7 Concluding remarks and extensions

This paper has studied fiscal policy in a New Keynesian model of a semi-small open economy facing debt-elastic interest-rate premia and not being able to use monetary policy. The focus has been on optimized, simple and implementable feedback policy rules for various categories of taxes and public spending.

Since the results have been written in the Introduction, we close with some possible extensions. It would be interesting to add heterogeneity both in terms of economic agents within a country and in terms of countries. In particular, we could distinguish between private and public employees and so study the distributional implications of the stabilization policies studied here. It is also interesting to use a two-country model, where countries can differ in, say, fiscal imbalances and/or time preferences and so study the cross-border effects of national stabilization and debt consolidation policies. We leave these extensions for future work.
References


