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Public debt consolidation: Aggregate and distributional implications in a small open economy of the Euro Area

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Abstract

This paper builds, calibrates and solves numerically a small open economy D(S)GE model for Greece, as a country that belongs to a monetary union and faces sovereign interest rate premia due to high debt problems. In this model the fiscal authorities are engaged in public debt reduction over time. The emphasis is on the aggregate and distributional implications of debt consolidation, where income heterogeneity, and hence distribution, has to do with the distinction between capital owners, private workers and public employees. The paper focuses on how these implications depend on the specific fiscal policy instruments used for debt consolidation. A rather general result is that, irrespectively of the fiscal policy instruments used, debt consolidation promotes equality both in the new reformed steady state and the transition. Specifically, in all cases, and relative to the status quo, capitalists get worse off, while all the rest become better off.

1 Introduction

In several Euro Area (EA) countries, public debt as share of GDP has reached high levels and, at the same time, fiscal balances remain in deficit and the interest rate-growth rate differential is not projected to be favorable in the coming years (see European Commission (2024)). Also, protracted geopolotical tensions create an uncertain environment hurting the economic activity. Thus, the need for public debt consolidation has come again to the center of attention and this is also emphasized by the currently debated revised fiscal rules of the Stability and Growth Pact.

Greece is a typical example of this situation. Although Greece has managed to decrease its public debt to GDP ratio by an impressive 45 percentage points since the eruption of the pandemic crisis in 2020, its public debt remained around 162% of GDP at the end of 2023.

This paper studies how public debt consolidation in a small open economy that is a member of the EA and has high public debt, like Greece, affects aggregate macroeconomic outcomes and income distribution. The study of distributional implications differentiates this paper from most of the existing literature on debt consolidation which has focused on aggregate implications (see e.g. Coenen et al., 2008, Forni et al., 2010, Erceg and Lindé, 2013, Philippopoulos et al., 2017a, etc.). The paper also differs from Sakkas and Varthalitis (2019) who have addressed both aggregate and distributional implications like in this paper but they do so in a closed economy model for the EA (see below for other differences).

In particular, this paper provides a quantitative study of the aggregate and distributional implications of debt consolidation in a D(S)GE model of a small open economy within a monetary union. In addition to a number of frictions commonly used by the quantitative macroeconomic literature, the model incorporates, in an attempt to capture some key features of the Greek economy, a rather detailed public sector, weak institutions and financial aid from the EU. Obviously, to study the distributional implications of debt consolidation on incomes, we need a model with heterogeneous households. There are many types of income heterogeneity in the literature. Here, we focus on the distinction of households between "capitalists", "private workers" and "public employees". As is well known, the standard small open economy model with incomplete asset markets faces problems of stationarity (see e.g. Schmitt-Grohé and Uribe, 2003); to overcome this problem, we assume debt-elastic sovereign interest rate premia.

Regarding macroeconomic policy, the economy, being in a monetary union, lacks monetary policy independence. Nevertheless, it is free to follow independent or national fiscal policies. In particular, national fiscal authorities conduct their policies through simple and implementable feedback policy rules for government transfers and the tax rates on consumption, income and firms' profits. In particular, we assume that these fiscal policy instruments

- one at a time - are allowed to react to the inherited public debt-to-GDP ratio as a deviation from a target value. Assuming that the latter is below the data, we study the aggregate and distributional implications of various policies aiming at gradual public debt-to-GDP ratio reduction. Public debt consolidation implies an intertemporal trade-off: fiscal pain in the short term (i.e. public spending has to fall and/or taxes have to rise) and fiscal gain in the medium and long term once debt has been reduced (i.e. public spending can rise and/or taxes can be cut).

Experimenting with various policy mixes, we study the implications of debt consolidation both in the long-run and during the transition from the status quo steady state to a new reformed steady state. The status quo steady state is defined to be the solution which corresponds to the case in which fiscal policy instruments are set as in their data values in 2023, whereas, the new reformed steady state is defined to be the solution in which, relative to the status quo, government transfers rise or one of the tax rates is cut as a result of the fiscal space created by public debt consolidation. The model is solved numerically employing parameter values for the Greek economy over the period 1995-2023 and fiscal data in 2023.

The main results are as follows. First, if the criterion is aggregate, or per capita, output, the best policy mix is to use the long term fiscal gain (namely, the fiscal space created once debt has been reduced) to cut the income tax rate and, during the early period of fiscal pain, to use government transfer cuts to bring public debt down.

Second, the above policy mix does not produce a win-win outcome since capitalists get worse off both in the new steady state and in the transition. But, if we care about relative gains, there is a "social" benefit: equality (measured by the ratio of the private worker's to capitalist's net income as well as by the ratio of the public employee's to capitalist's net income) rises both in the new steady state and in the transition. All this is relative to status quo.

Third, if the criterion is aggregate, or per capita, output, it is a bad idea to use the long term fiscal gain to increase government transfers since we switch to an economy with lower output relative to the status quo.

Finally, in all cases studied and irrespectively of the fiscal policy instrument used, debt consolidation promotes equality both in the new reformed steady state and during the transition. Specifically, in all cases, and relative to the status quo, capitalists get worse off, while all the rest become better off.

The remainder of the paper is organized as follows. The model is presented in section 2. Calibration, data and solution for the year 2023 are in section 3. Section 4 describes the policy experiments. Section 5 presents results. Section 6 closes with concluding remarks and possible extensions. An appendix contains details.

2 Model

In this section, we construct a D(S)GE model to study the aggregate and distributional implications of debt consolidation on the Greek economy. We start with an informal description of the model.[1]

2.1 Informal description of the model

Our model will try to embed the key features of the Greek economy. To do so, we add a number of frictions to a standard small open economy model. These frictions are of two categories. The first category includes frictions commonly used by the quantitative macroeconomic literature (see e.g. Uribe and Schmitt-Grohe (2017)). The second category includes Greek-specific features. The commonly used frictions are various types of adjustment costs, a debt-elastic interest rate when the country borrows from abroad, imperfect competition, etc. The Greek-specific features include a relatively detailed public sector including public employees as a separate income group, problems of institutional quality and financial aid from the EU. It should be said that the inclusion of these features is guided by the existing literature on the Greek economy (see e.g. Economides et al (2021) who show that these features can help a rather standard small open economy model to mimic relatively well the Greek data over the euro period and in particular the period after the global financial crisis of 2008).

In what follows, we introduce the building blocks of the model.

Households There are three distinct types of households, called capital owners or capitalists, private workers and public employees. Capital owners own the private firms and receive their profits. They can also purchase government bonds and participate in the international financial market. Private workers work in private firms. Public employees work in state enterprises. All types of households consume a domestic and a foreign imported good, receive income from different types of work and are engaged in rent-seeking activities (the latter are discussed below). The three types of households are modeled in subsection 2.2.

Private firms A domestic final good is produced by final good firms that act competitively using differentiated intermediate goods. The latter are produced by intermediate goods firms which act monopolistically à la Dixit-Stiglitz. Intermediate goods firms choose labor, capital and imported capital goods and can also make use of productivity-enhancing public goods/services. There are also capital good firms that produce the capital used by intermediate goods firms. Any profits generated by private firms

[1]The model is similar to that in Economides et al (2021) and Dimakopoulou et al (2022) used for the study of the Greek sovereign debt crisis in the 2010s and especially of the fiscal role played by the ECB. Here, we assume away monetary policies (conventional and unconventional), private banks and nominal fixities.

are distributed to capitalists. Firms are modeled in subsection 2.3.

State firms State firms use public employees, goods purchased from the private sector and public capital (the latter is augmented by public investment spending) to produce a public good that provides utility-enhancing services to households and productivity-enhancing services to firms, where the associated spending inputs as shares of GDP, as well as the fraction of public employees in population, will be set as in the data. State firms are in subsection 2.4.

Fiscal and public finance policy On the revenue side, the government imposes (income, consumption and corporate) taxes and issues bonds. The latter can be purchased by domestic and foreign investors (where foreign investors can be both private and public like the various EU institutions). We also include redistributive transfers from the EU as an extra government revenue. On the expenditure side, the government spends on wages of public employees, government investment, government purchases of goods from the private sector, as well as transfer payments to households. The government budget constraint is presented in subsection 2.5.

Stationarity in a small open economy As is known, one needs an "imperfection" to get a stationary solution in a small-open economy. Popular devices include a debt-elastic interest rate when agents borrow from abroad, a transaction cost again when agents borrow from abroad, or an endogenous time preference rate (see e.g. Schmitt-Grohe and Uribe (2003)). Here, to bring the dynamics of the model closer to the data, we will assume both a debt-elastic country interest rate and transaction costs, although one of them is enough to guarantee stationarity. The country debt-elastic interest rate is in subsection 2.7, while transaction costs associated with borrowing from private foreign markets are in subsections 2.2.1 and 2.5.2.

Institutions In most situations, poor institutions show up in ill-defined property rights[2] and a consequence of the latter is that private and/or communal properties become common pools. Then, access to a common pool distorts individual incentives to work or save and this leads to resource misallocation and poor macroeconomic performance. Here, we will assume that, because of weak property rights, producers can appropriate only a fraction of their output, while the rest can be taken away by rent seekers, where the latter are assumed to be all types of households who compete with each other for a fraction of the contestable prize in a Tullock-type contest. In addition, when we study the effects of the funds received by the Recovery Fund, we will also investigate the possibility that these funds become part of the common pool. Our measure of the degree of property rights will be as in the data (see subsection 3.1), while the rent-seeking technology is

[2]For the key importance of property rights among other measures of institutional quality, see e.g. Hall and Jones (1999), Acemoglu (2009, chapters 4 and 22), Besley and Persson (2009), Besley and Ghatak (2010) and many others.

introduced in subsection 2.2.1.

Details will be provided as we present each building block of the model.[3]

2.2 Households

As said, there are three distinct types of households, called capital owners or capitalists, private workers and public employees. Capital owners are indexed by the subscript $k = 1, 2, ..., N^k$, workers by the subscript $w = 1, 2, ...N^w$ and public employees by the subscript $b = 1, 2, ..., N^b$. That is, the total population is $N = N^k + N^w + N^b$. Equivalently, in terms of population ratios, we have $n^k \equiv \frac{N^k}{N}$, $n^w \equiv \frac{N^w}{N}$ and $n^b \equiv \frac{N^b}{N} = 1 - n^k - n^w$. For simplicity, total population and its decomposition to the three income groups are exogenously kept constant over time assuming away occupational mobility from one group to another.

2.2.1 Households as capital owners or capitalists

Capital owners or capitalists own the firms and so receive their profits, purchase government bonds and participate in the international asset market. Besides, like all other types of households, they receive income from work and are engaged in rent-seeking activities.

Each capital owner, $k = 1, 2, ..., N^k$, maximizes discounted lifetime utility:

$$\sum_{t=0}^{\infty} \beta^t u\left(c_{k,t}, u_{k,t}; \overline{y}_t^g\right) \tag{1}$$

where $c_{k,t}$ and $u_{k,t}$ denote respectively k's consumption and leisure time, $\overline{y}_t^g$ denotes the per capita quantity of public goods/services provided and produced by the government and $0 < \beta < 1$ is the time discount factor.

For our numerical solutions, we will use the period utility function:

$$u\left(c_{k,t}, u_{k,t}; \overline{y}_t^g\right) = \mu_1 \log c_{k,t} + \mu_2 \log u_{k,t} + \mu_3 \log \overline{y}_t^g$$

where $0 < \mu_1,\ \mu_2,\ \mu_3 < 1$ are preference parameters with $\mu_1 + \mu_2 + \mu_3 = 1$.

Since there are two goods, home and foreign, we define the consumption index:

$$c_{k,t} = \frac{(c_{k,t}^h)^{\nu}(c_{k,t}^f)^{1-\nu}}{\nu^{\nu}(1-\nu)^{1-\nu}} \tag{2}$$

where $c_{k,t}^h$ and $c_{k,t}^f$ denote k's domestic and foreign consumption respectively and $0 < \nu < 1$ measures the weight given to the domestic good relative to the foreign good.

[3] Hence the model differs from that in Sakkas and Varthalitis, which is a paper close to ours, in several ways. For example, they assume two income groups only, defined as skilled and unskilled agents with different types of human capital. Also, as said above, they work in a closed economy setup.

The time constraint of each k in each period is:

$$l_{k,t} + s_{k,t} + u_{k,t} = 1 \tag{3a}$$

where $l_{k,t}$ and $s_{k,t}$ are respectively k's effort time allocated to productive work and rent-seeking activities, i.e. non-leisure time.

The within-period budget constraint of each k written in real terms is:

$$(1+\tau_t^c)\left(\frac{p_t^h}{p_t}c_{k,t}^h + \frac{p_t^f}{p_t}c_{k,t}^f\right) + b_{k,t} + (1+i_t^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}f_{k,t-1} + \frac{p_t^h}{p_t}\psi^p(.) \equiv$$

$$\equiv (1-\tau_t^y)w_t^k l_{k,t} + \pi_{k,t} + (1+i_t^b)\frac{p_{t-1}}{p_t}b_{k,t-1} + \frac{e_t p_t^*}{p_t}f_{k,t} + \overline{g}_t^{tr} +$$

$$+\left(\frac{\Gamma^k(s_{k,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma + N^w\Gamma^w(s_{w,t})^\gamma + N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t \tag{3b}$$

where p_t^h is the price of the domestic good, p_t^f is the price of the foreign good expressed in domestic currency, p_t is the country's CPI specified below, p_t^* is the CPI abroad, e_t is the nominal exchange rate (an increase means a depreciation), $b_{k,t}$ is the real value of one-period government bonds purchased by each k at t and earning a nominal interest rate i_{t+1}^b at $t+1$, $f_{k,t}$ is the real value of one-period foreign debt denominated in foreign prices and acquired by each k at t on which k pays the country-specific nominal interest rate i_{t+1}^* at $t+1$ (if $f_{k,t} < 0$, it denotes a foreign asset and i_{t+1}^* is its nominal return at $t+1$),[4] w_t^k is the real wage rate of capital owners, $\pi_{k,t}$ is the dividend paid to each k by private firms net of taxes, $\psi^p(.)$ is a transaction cost function associated with the agent's participation in the foreign capital market (defined below), $\overline{g}^{tr}$ is a uniform transfer from the government and $0 \leq \tau_t^c, \tau_t^y < 1$ are tax rates on consumption and income.

The last term on the RHS of (3b) is the amount extracted by each k from the common pool. Given institutional failures in the form of weak property rights, we assume that total real output, denoted as Y_t, is a common pool or a contestable prize, so that only a fraction of it, PR_tY_t, remains in the hands of producers because the rest, $(1-PR_t)Y_t$, is taken away by rent seekers, where the rents extracted by each person depend on the socially unproductive activities employed by him/her relative to total socially unproductive activities. That is, if $0 < PR_t \leq 1$ is the economy-wide degree of protection of property rights, the term $\left(\frac{\Gamma^k(s_{k,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma + N^w\Gamma^w(s_{w,t})^\gamma + N^b\Gamma^b(s_{b,t})^\gamma}\right)$ is the fraction of the common pool extracted by each k in a Tullock (1980) type rent-seeking competition with $s_{w,t}$ and $s_{b,t}$ to stand for w's and b's effort time allocated to rent-seeking activities respectively. Regarding the

[4]This is denominated in foreign currency. That is, if $F_{k,t}$ is the nominal value for each agent k, the real value is $f_{k,t} \equiv \frac{F_{k,t}}{p_t^*}$.

rent-seeking technology, the power coeffcient, γ, is between 0 and 1 and measures how quickly diminishing returns arise in socially unproductive activities, while the parameters Γ^k, Γ^w and Γ^b measure the efficacy of k's, w's and b's aggression respectively; All are measures of the technology of fighting.[5,6]

Regarding the per agent cost associated with participation in the foreign financial market, it is assumed to take the form:

$$\psi^p(.) \equiv \frac{1}{N^k}\frac{\psi^p}{2}\left[\frac{\frac{e_t p_t^*}{p_t}\left(N^k f_{k,t} + F_t^g\right)}{\frac{p_t^h}{p_t}Y_t} - \overline{f}\right]^2 Y_t \tag{4}$$

where $\psi^p \geq 0$ is a transaction cost parameter associated with participation in foreign capital markets, F_t^g denotes total public foreign debt (i.e. public debt issued by the domestic government and held by foreign private investors) denominated in foreign currency,[7] $N^k f_{k,t}$ denotes total private foreign debt denominated in foreign currency, Y_t is total real output and the parameter $\overline{f}$ is a threshold value of the country's foreign debt as share of GDP above which such costs arise. In other words, the cost is increasing in the country's total real foreign debt to real GDP.

Each k acts competitively choosing $\{c_{k,t}^h,\ c_{k,t}^f,\ c_{k,t},\ l_{k,t},\ s_{k,t},\ b_{k,t},\ f_{k,t}\}_{t=0}^{\infty}$ subject to the above. The first-order conditions include the definition in (2), the budget constraint in (3b) and also the optimality conditions:

$$\frac{\mu_2}{(1 - l_{k,t} - s_{k,t})} = \frac{\mu_1(1-\tau_t^y)w_t^k}{(1+\tau_t^c)c_{k,t}} \tag{5a}$$

$$\frac{\mu_2}{(1 - l_{k,t} - s_{k,t})} = \left(\frac{\mu_1}{(1+\tau_t^c)c_{k,t}}\right)\times$$
$$\times\left(\frac{\gamma\Gamma^k(s_{k,t})^{\gamma-1}(1-PR_t)\frac{p_t^h}{p_t}Y_t}{N^k\Gamma^k(s_{k,t})^{\gamma} + N^w\Gamma^w(s_{w,t})^{\gamma} + N^b\Gamma^b(s_{b,t})^{\gamma}}\right) \tag{5b}$$

$$\frac{(1+\tau_{t+1}^c)c_{k,t+1}}{(1+\tau_t^c)c_{k,t}} = \beta(1+i_{t+1}^b)\frac{p_t}{p_{t+1}} \tag{5c}$$

$$\frac{(1+\tau_{t+1}^c)c_{k,t+1}}{(1+\tau_t^c)c_{k,t}}\frac{e_t p_t^*}{p_t} = \frac{(1+\tau_{t+1}^c)c_{k,t+1}}{(1+\tau_t^c)c_{k,t}}\frac{e_t p_t^*}{p_t}\times$$

[5]For a similar rent-seeking technology, see also e.g. Murphy et al (1991), Dixit (2004, chapter 5), Hillman (2009, chapter 2), Esteban and Ray (2011) and many others. Quantitative DSGE macro models include e.g. Angelopoulos et al (2009), Economides et al (2021), Economides et al (2022) and Christou et al (2021).

[6]Notice that this modelling, specifically, the different values of Γ^k, Γ^w and Γ^b, allows us to have asymmetries in equilibrium; namely, different types of rent seekers can choose different allocations and receive different wages even if they attack the same pie and share the same preferences.

[7]For more details, see the government budget constraint below.

$$\times\psi^p\left[\frac{\frac{e_t p_t^*}{p_t}\left(N^k f_{k,t}+F_t^g\right)}{\frac{p_t^h}{p_t}Y_t}-\overline{f}\right]+\beta\frac{e_{t+1}p_{t+1}^*}{p_{t+1}}(1+i_{t+1}^*)\frac{p_t^*}{p_{t+1}^*} \tag{5d}$$

$$\frac{c_{k,t}^h}{c_{k,t}^f}=\frac{\nu}{(1-\nu)}\frac{p_t^f}{p_t^h} \tag{5e}$$

It also follows from the above equations that the CPI is:

$$p_t=(p_t^h)^\nu(p_t^f)^{1-\nu} \tag{5f}$$

2.2.2 Households as private workers

Private workers are employed by private firms. They consume, work and participate in rent-seeking activities.[8] Variables are defined as above in the capital owners' problem if we replace the subscript k with the subscript w.

Each private worker, $w=1,2,...,N^w$, maximizes:

$$\sum_{t=0}^{\infty}\beta^t u\left(c_{w,t},u_{w,t};\overline{y}_t^g\right) \tag{6}$$

As above, we use the utility function:

$$u\left(c_{w,t},u_{w,t};\overline{y}_t^g\right)=\mu_1\log c_{w,t}+\mu_2\log u_{w,t}+\mu_3\log\overline{y}_t^g$$

and the consumption index:

$$c_{w,t}=\frac{(c_{w,t}^h)^\nu(c_{w,t}^f)^{1-\nu}}{\nu^\nu(1-\nu)^{1-\nu}} \tag{7}$$

Also, as above, the maximization is subject to the time constraint:

$$l_{w,t}+s_{w,t}+u_{w,t}=1 \tag{8a}$$

and the budget constraint:

$$(1+\tau_t^c)\left(\frac{p_t^h}{p_t}c_{w,t}^h+\frac{p_t^f}{p_t}c_{w,t}^f\right)\equiv(1-\tau_t^y)w_t^w l_{w,t}+\overline{g}_t^{tr}+$$

$$+\left(\frac{\Gamma^w(s_{w,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma+N^w\Gamma^w(s_{w,t})^\gamma+N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t \tag{8b}$$

[8] The assumption that private workers and public employees do not participate in asset markets is without loss of generality. We could assume that all households face transaction costs that make costly their participation in asset markets, but private workers and public employees face higher costs.

where w_t^w is the real wage rate of private workers.[9] Notice that, for simplicity, private workers are assumed to have access to the same contestable prize as all other agents and to receive by the government the same transfer as all other households.

Each w acts competitively choosing $\{c_{w,t}^h, c_{w,t}^f, c_{w,t}, l_{w,t}, s_{w,t}\}_{t=0}^{\infty}$ subject to the above. The first-order conditions include the definition in (7), the budget constraint in (8b) and also:

$$\frac{\mu_2}{(1 - l_{w,t} - s_{w,t})} = \frac{\mu_1 (1 - \tau_t^y) w_t^w}{(1 + \tau_t^c) c_{w,t}} \tag{9a}$$

$$\frac{\mu_2}{(1 - l_{w,t} - s_{w,t})} = \left(\frac{\mu_1}{(1 + \tau_t^c) c_{w,t}} \right) \times$$
$$\times \left(\frac{\gamma \Gamma^w (s_{w,t})^{\gamma - 1} (1 - PR_t) \frac{p_t^h}{p_t} Y_t}{N^k \Gamma^k (s_{k,t})^{\gamma} + N^w \Gamma^w (s_{w,t})^{\gamma} + N^b \Gamma^b (s_{b,t})^{\gamma}} \right) \tag{9b}$$

$$\frac{c_{w,t}^h}{c_{w,t}^f} = \frac{\nu}{(1 - \nu)} \frac{p_t^f}{p_t^h} \tag{9c}$$

2.2.3 Households as public employees

Public employees are employed by state firms. Like private workers, they consume, work and are engaged in rent-seeking activities. Variables are defined as above in the private workers' problem if we replace the subscript w with the subscript b.

That is, each public employee, $b = 1, 2, ..., N^b$, maximizes:

$$\sum_{t=0}^{\infty} \beta^t u \left(c_{b,t}, u_{b,t}; \overline{y}_t^g \right) \tag{10}$$

As above, we use the ulility function:

$$u \left(c_{b,t}, u_{b,t}; \overline{y}_t^g \right) = \mu_1 \log c_{b,t} + \mu_2 \log u_{b,t} + \mu_3 \log \overline{y}_t^g$$

and the consumption index:

$$c_{b,t} = \frac{(c_{b,t}^h)^{\nu} (c_{b,t}^f)^{1-\nu}}{\nu^{\nu} (1 - \nu)^{1-\nu}} \tag{11}$$

Also, as above, the maximization is subject to the time constraint:

$$l_{b,t} + s_{b,t} + u_{b,t} = 1 \tag{12a}$$

[9]Notice that w_t^w can differ from w_t^k because private workers and capitalists offer different labour services exhibiting different productivities (see below the firms' problem) and also because there is no mobility across income groups.

and the budget constraint:

$$(1+\tau_t^c)\left(\frac{p_t^h}{p_t}c_{b,t}^h+\frac{p_t^f}{p_t}c_{b,t}^f\right)\equiv(1-\tau_t^y)w_t^b l_{b,t}+\overline{g}_t^{tr}+$$

$$+\left(\frac{\Gamma^b(s_{b,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma+N^w\Gamma^w(s_{w,t})^\gamma+N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t \quad (12b)$$

where w_t^b is the real wage in the public sector.

Each b acts competitively choosing $\{c_{b,t}^h,\, c_{b,t}^f,\, c_{b,t},\, l_{b,t},\, s_{b,t}\}_{t=0}^{\infty}$ subject to the above.[10] The first-order conditions include the definition in (11), the budget constraint in (12b) and also:

$$\frac{\mu_2}{(1-l_{b,t}-s_{b,t})}=\frac{\mu_1(1-\tau_t^y)w_t^b}{(1+\tau_t^c)c_{b,t}} \quad (13a)$$

$$\frac{\mu_2}{(1-l_{b,t}-s_{b,t})}=\left(\frac{\mu_1}{(1+\tau_t^c)c_{b,t}}\right)\times$$
$$\times\left(\frac{\gamma\Gamma^b(s_{b,t})^{\gamma-1}(1-PR_t)\frac{p_t^h}{p_t}Y_t}{N^k\Gamma^k(s_{k,t})^\gamma+N^w\Gamma^w(s_{w,t})^\gamma+N^b\Gamma^b(s_{b,t})^\gamma}\right) \quad (13b)$$

$$\frac{c_{b,t}^h}{c_{b,t}^f}=\frac{\nu}{(1-\nu)}\frac{p_t^f}{p_t^h} \quad (13c)$$

2.3 Private firms and production of private goods

Following most of the related literature, there are three types of private goods produced by three associated types of private firms. There is a single final good produced by competitive final good firms. There are also differentiated intermediate goods used as inputs for the production of the final good, where each differentiated intermediate good is produced by an intermediate good firm that acts as a monopolist in its own product market à la Dixit-Stiglitz. Finally, competitive capital good firms produce capital used as an input in the production of intermediate goods. Since all firms are owned and managed by capital owners, for notational simplicity, we set the number of capitalists, N^k, equal to the number of final good firms, N^h, the number of intermediate goods firms, N^i, and the number of capital good firms, N^c (i.e. $N^k=N^h=N^i=N^c$).

[10] The choice of $l_{b,t}$ can be thought as a choice of work effort. Allowing for a fixed shift, or hours of work, in the public sector would not change our results to the extent that public employees can still choose the effort they make while at work.

2.3.1 Final good firms

There are N^h final good firms indexed by subscript $h = 1, 2, ..., N^h$. Each h produces an amount $y^h_{h,t}$ by using intermediate goods according to a Dixit-Stiglitz technology:

$$y^h_{h,t} = \left[\sum_{i=1}^{N^i} \frac{1}{N^i}(y^h_{i,t})^\theta\right]^{\frac{1}{\theta}} \tag{14}$$

where $y^h_{i,t}$ is the quantity of intermediate good of variety $i = 1, 2, ..., N^i$ used by each final good firm h and the parameter $0 \leq \theta \leq 1$ measures the degree of substitutability (when $\theta = 1$, intermediate goods are perfect substitutes in the production of the final good and the intermediate goods sector is perfectly competitive).

Each h maximizes its profits:

$$y^h_{h,t} - \sum_{i=1}^{N^i} \frac{1}{N^i}\frac{p^i_t}{p^h_t} y^h_{i,t} \tag{15a}$$

where p^h_t is the price of the final good h and p^i_t is the price of the intermediate good i.

The first-order condition for $y^h_{i,t}$ gives the inverse demand function:

$$p^i_t = p^h_t \left(\frac{y^h_{i,t}}{y^h_{h,t}}\right)^{\theta-1} \tag{15b}$$

which in turn implies from the zero-profit condition:

$$p^h_t = \left[\sum_{i=1}^{N^i} \frac{1}{N^i}(p^i_t)^{\frac{\theta}{\theta-1}}\right]^{\frac{\theta-1}{\theta}} \tag{15c}$$

Notice that in a symmetric equilibrium where intermediate goods firms are alike ex post, $y^h_{h,t} = y^h_{i,t}$ so that $Y_t \equiv N^h y^h_{h,t} = N^h y^h_{i,t}$. Also, $p^h_t = p^i_t$.

2.3.2 Intermediate goods firms

There are N^i intermediate goods firms indexed by the subscript i = 1,2,...,N^i.[11] The gross profit of each firm i, denoted as $\pi^{gross}_{i,t}$, is sales minus the wage bill minus the cost of imported capital goods minus adjustment costs associated with changes in capital:

$$\pi^{gross}_{i,t} \equiv PR_t \frac{p^i_t}{p_t} y^h_{i,t} - w^w_t l^w_{i,t} - w^k_t l^k_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t} - \frac{p^h_t}{p_t}\frac{\xi^k}{2}\left(\frac{k_{i,t}}{k_{i,t-1}} - 1\right)^2 k_{i,t-1} \tag{16a}$$

[11] These firms are modelled as in e.g. Miao (2014, chapter 14), Uribe and Schmitt-Grohe (2017, chapter 4) and Economides et al (2021).

where $l^w_{i,t}$ is labor services provided by private workers and used by firm i, $l^k_{i,t}$ is labor services provided by capital owners and used by firm i, $m^f_{i,t}$ is imported capital goods used by each firm i, $k_{i,t}$ is capital goods purchased from capital good producers by each i in the current period and used in the next period (as we shall see below, the relative price of capital is 1) and ξ^k is a parameter measuring standard capital adjustment costs, while, as said above, firms can appropriate only a fraction, $0 < PR_t \leq 1$, of their output because of ill-defined property rights.

Gross profit is used for retained earnings, payment of corporate taxes to the government and dividends to shareholders:

$$\pi^{gross}_{i,t} \equiv RE_{i,t} + \tau^{\pi}_t \left(PR_t \frac{p^i_t}{p_t} y^h_{i,t} - w^w_t l^w_{i,t} - w^k_t l^k_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t} \right) + \pi_{i,t} \quad (16b)$$

where $RE_{i,t}$ is retained earnings, $0 \leq \tau^{\pi}_t < 1$ is the profit tax rate and $\pi_{i,t}$ is net dividends paid to shareholders by firm i at t.

Purchases of new capital, i.e. investment, are financed by retained earnings:

$$\frac{p^h_t}{p_t} \left[k_{i,t} - (1-\delta) k_{i,t-1} \right] \equiv RE_{i,t} \quad (16c)$$

Combining the above constraints, the firm i's net dividend, $\pi_{i,t}$, distributed to capitalists, is:

$$\pi_{i,t} \equiv (1-\tau^{\pi}_t) \left[PR_t \frac{p^i_t}{p_t} y^h_{i,t} - w^w_t l^w_{i,t} - w^k_t l^k_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t} \right] -$$
$$- \frac{p^h_t}{p_t} \left[k_{i,t} - (1-\delta) k_{i,t-1} \right] - \frac{p^h_t}{p_t} \frac{\xi^k}{2} \left(\frac{k_{i,t}}{k_{i,t-1}} - 1 \right)^2 k_{i,t-1} \quad (17)$$

The production function of each firm i is assumed to be:

$$y^h_{i,t} = A^p \left(\frac{N^g y^g_{g,t}}{N^i} \right)^{\sigma} \left[\left(\chi^p (k_{i,t-1})^{op} + (1-\chi^p)(m^f_{i,t})^{op} \right)^{\frac{\alpha}{op}} \left(A^w l^w_{i,t} + A^k l^k_{i,t} \right)^{1-\alpha} \right]^{1-\sigma} \quad (18)$$

where the parameter $0 \leq \chi^p \leq 1$ measures the intensity of capital, $k_{i,t-1}$, relative to imported capital goods from abroad, $m^f_{i,t}$, the parameter $op \geqslant 0$ measures the degree of substitutability between capital and imported capital goods, the coefficient $1-a$ is the share of labor inputs, the parameters A^w and A^k measure the labor productivity of private workers and capitalists respectively, $A^p > 0$ is the TFP in the private sector and $0 \leq \sigma \leq 1$ is the contribution of public goods/services per firm to private production.

Each firm i maximizes the discounted sum of dividends distributed to its owners:

$$\sum_{t=0}^{\infty} (\beta_{i,t})^t \pi_{i,t} \quad (19)$$

where, since firms are owned by capital owners, we will ex post postulate that the firm i's discount factor, $\beta_{i,t}$, equals the capital owners' marginal rate of intertemporal substitution between consumption at t and $t+1$, namely, $\beta_{i,t} \equiv \frac{\beta(1+\tau_t^c)c_{k,t}}{(1+\tau_{t+1}^c)c_{k,t+1}}$.[12]

Each intermediate good firm i chooses $\{l_{i,t}^k,\ l_{i,t}^w,\ m_{i,t}^f,\ k_{i,t}\}_{t=0}^{\infty}$ to maximize its stream of dividends or net profits, as defined in (17), subject to the production function in (18) and the inverse demand function in (15b). The first-order conditions for $l_{i,t}^k$, $l_{i,t}^w$, $m_{i,t}^f$, $k_{i,t}$ (written in a symmetric equilibrium where intermediate goods firms are alike ex post)[13] are respectively:

$$w_t^k = PR_t\theta\frac{p_t^h}{p_t}\frac{(1-\sigma)(1-\alpha)A^k y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{20a}$$

$$w_t^w = PR_t\theta\frac{p_t^h}{p_t}\frac{(1-\sigma)(1-\alpha)A^w y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{20b}$$

$$\frac{p_t^f}{p_t} = PR_t\theta\frac{p_t^h}{p_t}\frac{(1-\sigma)\alpha y_{i,t}^h(1-\chi^p)(m_{i,t}^f)^{op-1}}{\left[\chi^p(k_{i,t-1})^{op}+(1-\chi^p)(m_{i,t}^f)^{op}\right]} \tag{20c}$$

$$\frac{p_t^h}{p_t}\left[1+\xi^k\left(\frac{k_{i,t}}{k_{i,t-1}}-1\right)\right] = \beta_{i,t}\frac{p_{t+1}^h}{p_{t+1}}[1-\delta+(1-\tau_{t+1}^\pi)PR_{t+1}\theta\frac{\partial y_{i,t+1}^h}{\partial k_{i,t}}-$$

$$-\frac{\xi^k}{2}\left(\frac{k_{i,t+1}}{k_{i,t}}-1\right)^2+\xi^k\left(\frac{k_{i,t+1}}{k_{i,t}}-1\right)\frac{k_{i,t+1}}{k_{i,t}}] \tag{20d}$$

where $\frac{\partial y_{i,t+1}^h}{\partial k_{i,t}} = \frac{(1-\sigma)\alpha y_{i,t+1}^h\chi^p(k_{i,t})^{op-1}}{\left[\chi^p(k_{i,t})^{op}+(1-\chi^p)(m_{i,t+1}^f)^{op}\right]}$.

2.3.3 Capital good firms

There are N^c capital good firms indexed by the subscript $c = 1, 2, ..., N^c$. Working similarly to e.g. Guntner (2015), Uribe and Schmitt-Grohe (2017, pp. 79 and 110), and many others, we assume that capital good producers acquire the depreciated capital stock, choose investment activity and sell the capital good to intermediate goods firms. Here, this problem is modeled in the simplest possible way by assuming away adjustment costs, so that, in each period, each firm c maximizes its profit given by:

$$\pi_{c,t} \equiv Q_t x_{c,t} - x_{c,t} \tag{21}$$

where $x_{c,t}$ is the amount of investment produced and Q_t is the relative price of capital also known as Tobin's q. Without capital adjustment costs, the first-order condition is simply $Q_t = 1$ as was assumed above. Also, the profit is zero in equilibrium.

[12] See the discussion in e.g. Uribe and Schmitt-Grohe (2017, pp. 110-111).

[13] Recall that in a symmetric equilibrium where intermediate goods firms are alike ex post, it arises that $p_t^h = p_t^i$.

2.4 State firms and production of public goods/services

There are N^g state firms indexed by the subscript $g = 1, 2, ..., N^g$ producing the single public good/service. For notational simplicity, we will set $N^g = N^b$, that is, the number of state firms equals the number of public employees.

The cost of each state firm g for producing the public good/service is in real terms:

$$w_t^b l_{g,t} + \frac{p_t^h}{p_t}(g_{g,t}^g + g_{g,t}^i) + \frac{p_t^f}{p_t} m_{g,t}^g \tag{22}$$

where $l_{g,t}$ is labor services used by each firm g, $g_{g,t}^g$ is goods purchased from the private sector by each firm g, $g_{g,t}^i$ is investment made by each firm g, and $m_{g,t}^g$ is imported capital goods used by each firm g.

The production function of each state firm g is assumed to be similar to that in the private sector:

$$y_{g,t}^g = A^g \left(\chi^g (k_{g,t-1}^g)^{og} + (1-\chi^g)(m_{g,t}^g)^{og}\right)^{\frac{\theta_1}{og}} (l_{g,t})^{\theta_2} \left(g_{g,t}^g\right)^{1-\theta_1-\theta_2} \tag{23}$$

where $0 \leq \chi^g \leq 1$ measures the intensity of public capital, $k_{g,t-1}^g$, relative to imported capital goods from abroad, $m_{g,t}^g$, the parameter $og \geqslant 0$ measures the degree of substitutability between public capital and imported capital goods, the coefficients $0 < \theta_1,\ \theta_2,\ 1-\theta_1-\theta_2 < 1$ measure the shares of the associated factors in public production and $A^g > 0$ is the TFP in the public sector.

The stock of each state firm g's capital evolves over time as:

$$k_{g,t}^g = (1-\delta^g) k_{g,t-1}^g + g_{g,t}^i \tag{24}$$

where $0 < \delta^g < 1$ is the depreciation rate of public capital.

To specify the level of output produced by each state firm g, $y_{g,t}^g$, and hence the total amount of public goods/services provided to the society, we obviously have to specify the amounts of inputs, $l_{g,t}$, $g_{g,t}^g$, $m_{g,t}^g$ and $k_{g,t}^g$ (or equivalently $g_{g,t}^i$). Except from work hours or effort which is determined by public employees (see their optimization problem above), we will consider the case in which the values of these inputs are as implied by the data, meaning that the total number of public employees as a share of population as well as the associated government expenditures (on public investment, public wages, goods purchased from the private sector and imported capital goods), as shares of GDP, are set as in the data. Specifically, we define $g_{g,t}^i = \frac{s_t^i n^h y_{i,t}^h}{n^g}$, $g_{g,t}^g = \frac{s_t^g n^h y_{i,t}^h}{n^g}$, $m_{g,t}^g = \frac{p_t^h}{p_t^f}\frac{s_t^m n^h y_{i,t}^h}{n^g}$ and $w_t^b = \frac{s_t^w \frac{p_t^h}{p_t} n^h y_{i,t}^h}{n^g l_{g,t}}$, where $n^h \equiv \frac{N^h}{N}$ and $n^g \equiv \frac{N^g}{N}$ are the fractions of private and state firms in population respectively and s_t^i, s_t^g, s_t^m and s_t^w are respectively the GDP shares of government expenditures on investment, goods purchased from the private sector, imported capital goods and public wages; these values will be set according to the data (see subsection 3.1).

2.5 Government budget constraint and the holders of public debt

Before we present the government budget constraint, we define the holders of Greek public debt.

2.5.1 Public debt and its holders

Let us define the real and per capita public debt at the end of period t as d_t. We assume that it can be held by three different types of creditors: domestic private agents, foreign private agents and foreign public institutions, where the latter include various EU institutions (ESM, other euro states, etc.). In the period before 2008, the Greek public debt was mainly held by private (domestic and foreign) agents/banks. By contrast, during the years of the sovereign debt crisis (2009-2022), most of the Greek public debt has changed hands and is now being held by the "EU" as part of Greece's various official and unofficial bailout programs (see subsection 3.1 below for data and Economides et al (2021) for details).

In particular, in each time period, total public debt (real and per capita), d_t, is decomposed to:

$$d_t \equiv b_t^d + \frac{e_t p_t^*}{p_t} f_t^g + \frac{e_t p_t^*}{p_t} f_t^{eu} \tag{25a}$$

where, expressing them as fractions of total debt, we define:[14]

$$b_t^d \equiv \lambda_t^d d_t \tag{25b}$$

$$\frac{e_t p_t^*}{p_t} f_t^g \equiv \lambda_t^g d_t \tag{25c}$$

$$\frac{e_t p_t^*}{p_t} f_t^{eu} \equiv \lambda_t^{eu} d_t \tag{25d}$$

where $0 \leq \lambda_t^d,\ \lambda_t^g,\ \lambda_t^{eu} \leq 1$ are the fractions of Greek public debt held respectively by domestic private agents, foreign private agents and the EU, where $\lambda_t^d + \lambda_t^g + \lambda_t^{eu} = 1$. If the rest-of-the-world policy fractions, λ_t^g and λ_t^{eu}, are exogenously given (they will be set as in the data presented in subsection 3.1 below), then it follows residually $\lambda_t^d = (1 - \lambda_t^g - \lambda_t^{eu})$.

2.5.2 Government budget constraint

Using the above notation, the flow budget constraint of the government written in per capita and real terms is:

$$\overline{g}_t^{tr} + n^g \left[w_t^b l_{g,t}^g + \frac{p_t^h}{p_t} \left(g_{g,t}^g + g_{g,t}^i \right) + \frac{p_t^f}{p_t} m_{g,t}^g \right] + \frac{p_t^h}{p_t} \psi^g(.) +$$

[14] That is, if F_t^g denotes the nominal value of total public debt held by foreign private agents, expressed in foreign currency, then $f_t^g \equiv \frac{F_t^g}{p_t^* N}$ is its per capita and real value.

$$+(1+i_t^b)\frac{p_{t-1}}{p_t}\lambda_{t-1}^d d_{t-1} + (1+i_t^b)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^g d_{t-1} +$$

$$+(1+i^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^{eu} d_{t-1} \equiv d_t + \frac{T_t}{N} + tr_t^{eu} \tag{26}$$

where $\overline{g}_t^{tr}$ is the lump-sum transfer to each household (as defined above in the capitalist's problem), $n^b[w_t^b l_{g,t}^g + \frac{p_t^h}{p_t}(g_{g,t}^g + g_{g,t}^i) + \frac{p_t^f}{p_t}m_{g,t}^g]$ is the cost of state firms (as defined above in state firm's problem), $\psi^g(.)$ is a transaction cost function associated with the government's participation in the foreign capital market (defined right below) and $\frac{T_t}{N}$ denotes per capita tax revenues (defined right below). The rest of the terms capture interest payments on public debt, where notice that the interest rates on public debt can vary depending on the identity of the creditor. For instance, when the government borrows from the EU, it pays the constant policy interest rate, i^*, only, while, when the government borrows from the (domestic and foreign) market, it pays the market interest rate, i_t^b. Finally, the last term on the RHS, tr_t^{eu}, denotes net transfers from the EU. This term is added to capture the various forms of financial aid received from the EC and the ECB on top of the official fiscal bailouts which, in our model, have already been captured by λ_t^{eu}. This aid can include transfers via the various funds under the umbrella of the European Structural and Investment Fund, as well as various dimensions of the ECB's quantitative monetary policy.[15] All these redistributive at EU level policies can effectively alleviate fiscal burdens as shown in the consolidated governemnt budget constraint above. They can also augment national resources like a typical foreign aid (see the balance of payments below). For simple computational reasons, we will express this transfer, tr_t^{eu}, as a share of the country's GDP, namely, $tr_t^{eu} = s_{eu,t}^{tr}\frac{p_t^h}{p_t}n^h y_{i,t}^h$ where $s_{eu,t}^{tr}$ is an EU policy variable.

As in equation (4) above, we assume that the cost associated with participation in the international financial market takes the form:

$$\psi^g(.) \equiv \frac{\psi^g}{2}\frac{1}{N}\left[\frac{\frac{e_t p_t^*}{p_t}\left(N^k f_{k,t} + \lambda_t^g N d_t\right)}{\frac{p_t^h}{p_t}N^h y_{i,t}^h} - \overline{f}\right]^2 N^h y_{i,t}^h \tag{27}$$

where $\psi^g \geq 0$ is a transaction cost parameter associated with public borrowing from the international market.

Total tax revenues in real and per capita terms are:

$$\frac{T_t}{N} \equiv \tau_t^c\left[n^k\left(\frac{p_t^h}{p_t}c_{k,t}^h + \frac{p_t^f}{p_t}c_{k,t}^f\right) + n^w\left(\frac{p_t^h}{p_t}c_{w,t}^h + \frac{p_t^f}{p_t}c_{w,t}^f\right) + n^b\left(\frac{p_t^h}{p_t}c_{b,t}^h + \frac{p_t^f}{p_t}c_{b,t}^f\right)\right] +$$

[15] For the fiscal role of the ECB in the Greek sovereign debt crisis, see e.g. Economides et al (2021) and Dimakopoulou et al (2021).

$$+\tau_t^y[n^k w_t^k l_{k,t} + n^w w_t^w l_{w,t} + n^b w_t^b l_{b,t}]+$$

$$+\tau_t^\pi n^i \left[PR_t \frac{p_t^i}{p_t} y_{i,t}^h - w_t^k l_{i,t}^k - w_t^w l_{i,t}^w - \frac{p_t^f}{p_t} m_{i,t}^f \right] \tag{28}$$

where $n^i \equiv \frac{N^i}{N}$ is the share in total population of intermediate goods firms.

2.6 Balance of payments

If we add up the budget constraints of all agents (private and public), we get the balance of payments (written in real and per capita terms):

$$\frac{p_t^f}{p_t}\left(n^k c_{k,t}^f + n^w c_{w,t}^f + n^b c_{b,t}^f + n^i m_{i,t}^f + n^g m_{g,t}^g\right) -$$

$$-\frac{p_t^h}{p_t} c_t^{f*} + (1+i_t^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t} n^k f_{k,t-1}+$$

$$+(1+i_t^b)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^g d_{t-1} + (1+i^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^{eu} d_{t-1}+$$

$$+\frac{p_t^h}{p_t}\frac{\psi^p}{2}\left[\frac{\frac{e_t p_t^*}{p_t}\left(n^k f_{k,t} + \lambda_t^g d_t\right)}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{f}\right]^2 n^h y_{i,t}^h+$$

$$+\frac{p_t^h}{p_t}\frac{\psi^g}{2}\left[\frac{\frac{e_t p_t^*}{p_t}\left(n^k f_{k,t} + \lambda_t^g d_t\right)}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{f}\right]^2 n^h y_{i,t}^h = \frac{e_t p_t^*}{p_t} n^k f_{k,t} + \lambda_t^g d_t + \lambda_t^{eu} d_t + tr_t^{eu} \tag{29}$$

where, as said above, being a kind of foreign aid, tr_t^{eu} also appears in the country's resource constraint and the same applies to bond purchases by EU institutions captured by λ_t^{eu}.

2.7 Country's interest rate

Following most of the literature on small open economies (e.g. Schmitt-Grohé and Uribe (2003) and Uribe and Schmitt-Grohé (2017)), we assume that the interest rate at which (domestic) private agents can borrow from abroad, i_t^*, is public debt-elastic. In particular, we use the functional form:

$$i_t^* = i^* + \psi^* \left(\exp\left(\frac{d_t}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{d} \right) - 1 \right) \tag{30}$$

where $\psi^* \geq 0$ is an interest-rate premium parameter and the parameter $\overline{d} \geq 0$ is a threshold value for the public debt-to-GDP ratio above which country premia emerge (for details and references, see Philippopoulos et al (2017a)).

2.8 Rules for fiscal policy instruments

Following a rule-like approach, see e.g. Schmitt-Grohé and Uribe (2007), fiscal policy is conducted through simple implementable feedback rules. Namely, the fiscal authorities adjust fiscal policy instruments according to some rules reacting to an easily observable endogenous macroeconomic indicator capturing the current liabilities state of the economy.[16] More specifically, we allow only the main spending-tax policy instruments, namely, the ratio of real government transfers to real GDP, defined as s_t^{tr}, and the tax rates on consumption, income and capital income, τ_t^c, τ_t^y and τ_t^π respectively, to react to the beginning-of-period public liabilities to output ratio, l_{t-1}, as a deviation from a target value, l, according to the following simple linear rules:[17]

$$s_t^{tr} = s^{tr} - \gamma_l^{tr} \left(l_{t-1} - l \right) \tag{31}$$

$$\tau_t^c = \tau^c + \gamma_l^c \left(l_{t-1} - l \right) \tag{32}$$

$$\tau_t^y = \tau^y + \gamma_l^y \left(l_{t-1} - l \right) \tag{33}$$

$$\tau_t^\pi = \tau^\pi + \gamma_l^\pi \left(l_{t-1} - l \right) \tag{34}$$

where l_{t-1} is defined as:

$$l_{t-1} \equiv \frac{(1+i_t^b)\frac{p_{t-1}}{p_t}(1-\lambda_{t-1}^g-\lambda_{t-1}^{eu})d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} + \frac{(1+i_t^b)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^g d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} + $$
$$+ \frac{(1+i^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^{eu} d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} \tag{35}$$

and where, in the above rules, Eqs.(31)-(34), variables without time subscripts denote policy target values and $\gamma_l^q \geq 0$ for $q = tr$, c, y, π are feedback policy coefficients on the public debt / liabilities as a deviation from a target value. The rest of fiscal policy instruments are assumed to remain constant over time and equal to their data averages (see the next subsection).

In the above rules, a policy target value (like $s^{tr}, \tau^c, \tau^y, \tau^\pi$) will be the value of the corresponding variable in the new reformed steady state (see

[16]Here the magnitude of these reaction coefficients is set arbitrarily in a value close to those of Philippopoulos et al., 2017a, who work with optimized rules.

[17]For similar rules, see e.g. Schmitt-Grohé and Uribe, 2007. See also EMU-Public Finances, 2011, by the European Commission for similar fiscal reaction functions used in practice.

section 4), while the debt policy target is set to a value less than in the data (this will be the case of debt consolidation where fiscal policy systematically brings public debt down over time).

Dynamic stability typically requires at least one of the exogenously set fiscal policy instruments to react to the gap between the public debt/liabilities to GDP ratio and a target or long-run value. In our experiments, this role is played partly by the adjusting fiscal policy instrument during the transition (see section 4) and, at the same time, partly by the ratio of redistributive funds coming from the EU, $s^{tr}_{eu,t}$, that is allowed to respond to the gap between the public debt to GDP ratio and a target or long-run value.[18]

In particular, along the transition, we also use the following feedback policy rule:

$$s^{tr}_{eu,t} = s^{tr}_{eu} + \gamma^{tr} \left(\frac{d_{t-1}}{\frac{p^h_t}{p_t} n^h y^h_{i,t}} - d^* \right) \tag{32}$$

where s^{tr}_{eu} is the value in the departure year 2023, γ^{tr} is a feedback policy coefficient and d^* is a target value of the public debt to output ratio. In our solutions, we set γ^{tr} at 0.3 (which is within usual ranges in the literature; see e.g. Philippopoulos et al (2017b)), while d^* is set at its departure 2023 value. We report that our results are not sensitive to these assumptions to the extent that we have a determinate solution.

2.9 Equilibrium, solution steps and methodology

The final macroeconomic system, including market-clearing conditions, is presented in detail in Appendix. The system consists of 49 equations in 49 endogenous variables. This is given the paths of exogenous variables and initial conditions (also specified in the Appendix).

In the next sections, we will parameterize the model, present the data and solve the system numerically. In particular, our analysis will consist of two steps. First, we will calibrate the model to the Greek economy. Then, using the resulting parameterization and setting the policy variables as in the data in 2023, we will solve the model numerically. As we shall see, the model's steady state solution will match reasonably well the main features of the Greek economy in 2023 and can hence serve as a departure point for our policy experiments. This is in section 3. Second, departing from this initial

[18] In case we allow only one of the main spending-tax instruments (see their rules in the Eqs.(31)-(34)) at a time to react to debt during the transition, dynamic stability requires relatively high values of feedback policy coefficients on the public debt target which, in turn, give extreme values of the corresponding fiscal policy instruments. Hence, in all cases studied (see section 4), for achieving dynamic stability and a more normal behavior of the above fiscal policy instruments, we also allow the ratio of redistributive funds coming from the EU, $s^{tr}_{eu,t}$, to respond to the debt gap.

steady state, we will run debt consolidation experiments with several policy mixes as described in section 4. Steady state and transition results are in section 5. In our solutions, we assume that all this is common knowledge so that we solve the model under perfect foresight by using a non-linear Newton-type method implemented in Dynare.

3 Calibration, data and solution for 2023

In subsection 3.1, we describe how the parameter values are calibrated and discuss the data used. Unless otherwise stated, the period over which we use annual Greek macroeconomic data to calibrate the model extends from 1995 to 2023. Then, subsection 3.2 presents the steady state solution when we use these parameter values and set the exogenous policy variables as in their 2023 data values.

3.1 Parameters and exogenous variables

Regarding structural parameters for technology and preferences, most of them will be calibrated on the basis of Greek data, while, for the rest, we will use commonly employed values by the relevant literature. The model's parameter values are listed in Table 1, where in the fourth column we report whether the value for the specific parameter has been chosen on the basis of calibration or has been set.[19]

Table 1
Baseline parameterization

Starting with preference parameters, private agents' time discount factor, β, is calibrated from the steady state version of the Euler equation for bonds (equation (S4) in Appendix) by using the average value of the real interest rate in the data, where the latter is the difference of the nominal interest rate on the 10-year Greek government bond and the inflation rate measured by the percentage change of the Greek GDP deflator (the data are from Eurostat). The resulting value is $\beta = 0.977$.[20]

The weights given to private consumption and leisure, μ_1 and μ_2, in the households' utility function are calibrated, for given μ_3, from the steady state versions of equations (S2), (S9) and (S14) in Appendix using data for the share of private consumption to GDP (0.6747), the share of labour income to GDP (0.583), the percentage of time devoted to leisure (0.59236) and own calculations for the effective income and consumption tax rates

[19]We wish to report at the outset that our main results are robust to changes in these baseline parameter values at least within reasonable ranges.

[20]Note that for the calibration of β, we have excluded the years 2010-2018 because, during that period, the Greek government did not have access to the bond market.

(0.30194 and 0.18537).[21] The obtained values of μ_1 and μ_2, by assuming $\mu_3 = 0.05$, are 0.5436 and 0.4064 respectively. We report that our main results are robust to changes in μ_3, namely, the weight given to utility-enhancing public goods/services, whose value is agnostic and is usually set between 0 and 0.1 (see e.g. Baxter and King (1993) and Baier and Glomm (2001)).

The degree of preference for home over foreign goods in consumption, ν, also known as home bias, is calibrated from the equilibrium expression $\frac{e_t p_t^*}{p_t} = \left(\frac{p_t^f}{p_t^h}\right)^{2\nu-1}$ (see Appendix), where $\frac{e_t p_t^*}{p_t}$ is the real effective exchange rate and $\frac{p_t^f}{p_t^h}$ is the ratio of the price level of the foreign imported good to the price level of the domestically produced good. Using annual data for the average real effective exchange rate (1.07450) and the average ratio of foreign to domestic prices (1.14243), the resulting value is $\nu = 0.77$.[22]

Continuing with technology parameters, in the production function of private goods, the exponent on labor, $1 - \alpha$, is calibrated from the expression $(1 - \alpha)(1 - \sigma) = 0.583$, where 0.583 is the above mentioned average labour income share to GDP in the data and σ measures the contribution of productivity-enhancing public goods/services in private production. Following e.g. the early paper by Baxter and King (1993), the recent work of Ramey (2021) and many others, we set σ equal to 0.05.[23] This value for σ

[21] These are average values. The data regarding the share of total labor compensation to GDP, the percentage of time devoted to leisure and the share of private consumption to GDP are from "The Conference Board Total Economy Database" (https://conference-board.org/data/economydatabase/total-economy-database-productivity), the Eurostat and our own calculations. In what concerns rent seeking, we assume that this takes place during the hours at work, where the latter are as in the data, i.e. non-leisure time includes both productive and unproductive effort. Also, following usual practice, we have defined total hours available on a yearly basis as $52 \times 14 \times 7 = 5096$. Finally, the series of the effective tax rates are based on our own calculations using data from Eurostat (details on the standard formulas used can be found in e.g. Kollintzas et al (2018)).

[22] The data on the real effective exchange rate have been obtained from the Federal Reserve Bank of ST. Louis, while, for the ratio of foreign to domestic prices, as a proxy, we use the ratio of foreign to domestic GDP deflator. Regarding the foreign GDP deflator, we have chosen to use the German one, whereas the data for both deflators. i.e. the Greek and the German one, are obtained from Eurostat.

[23] Alternatively, we can calibrate the value of σ, as many researchers do, by setting its value equal to the sum of the average public investment and average capital goods imported by state firms, both as shares of GDP. The latter share can be proxied as follows. General government fixed gross capital formation represents 25.1% of total fixed gross capital formation. Thereby, and given that the average share of total imported capital goods to GDP over 1995-2015 (data are not available after 2015) is 19.15%, a reasonable value for the average share of capital goods imported by state firms to GDP is $0.251 \times 0.1915 = 0.048$. This implies a value for σ equal to 0.088 and, in turn, from $(1 - \alpha)(1 - \sigma) = 0.583$, $1 - \alpha$ equals 0.639. In this case, α equals 0.361. However, we report that our main results are robust to such a change. The relevant data for the public investment are obtained from Eurostat, whereas the data for imported capital goods are

implies that α, which is the exponent on the composite CES term including capital and imported capital goods, equals 0.387. The parameter measuring the intensity of capital vis-a-vis imported capital goods, χ^p, is calibrated using data for imported capital goods and gross fixed capital formation, both as shares of GDP. We consider the sum of these two components to give total investment in physical capital, domestic and foreign, in the economy. Using as a proxy for χ^p the share of fixed gross capital formation over total investment in physical capital, we end up with a value for χ^p equal to 0.504 (the same value of 0.504 will be used for χ^g in the state firms' production function discussed below).[24] Regarding the substitutability parameter in the private production function, *op*, is set at 0.5, which implies an elasticity of subsititution between capital and imported capital goods in private production of 2 (the same value of 0.5 will be used for *og* in the state firm's production function below); note that this is a commonly used value for CES production functions (see e.g. Stokey (1996)). Finally, the labor productivity parameters of capital owners and private workers in the private production function, A^k and A^w, are set at 2 and 1 respectively; this difference produces a skill wage premium around 2 which is within usual ranges (see e.g. Autor (2014)).

Also, in the state firms' production function, the Cobb-Douglas exponents on public capital and public employment, θ_1 and θ_2, are set respectively at 0.309 and 0.398, which correspond to average payments for public investment and public wages, expressed as shares of total public payments to all inputs used in the production of public goods (the data are from Eurostat). In turn, the Cobb-Douglas exponent on goods purchased from the private sector, $1-\theta_1-\theta_2$, follows residually and is 0.293.

The capital depreciation rate, δ, is set at 0.04. This value results from calibrating the steady state version of equation (S24) in Appendix by using annual data for gross fixed capital formation and net capital stock from AMECO. Both the TFP parameters (in the private and in the public sector production functions) are normalized at 1.[25]

In the rent-seeking technology, the power coefficient, γ, is assumed to be common across all types of agents and is set at 0.5, while the effectiveness parameters of public employees, private workers and capital owners, Γ^b, Γ^w and Γ^k, are set respectively at 1.3, 0.3 and 1 to reflect their relative political power in rent extraction. This parameterization contributes to getting hours at work within data averages and also makes public employees the main winners from rent extraction. As is widely recognized, in the Greek economy, the power of public sector employees is bigger relative to

obtained from OECD.

[24]The data regarding fixed gross capital formation are obtained from AMECO, whereas the data for imported capital goods are obtained from OECD.

[25]Public sector efficiency, and why it may differ from private sector efficiency, is crucial but is not an issue in this paper.

other social groups (see e.g. Kollintzas et al (2018)), and this is captured by the choice of these specific values (see also e.g. Economides et al (2016) for various advantages of public employees in EU countries and the references therein).

Following the study by Kollintzas and Vassilatos (2000) for the Greek economy, we calibrate the transaction cost parameter associated with capital changes in the private firm i's problem so as the investment loss in terms of output to be around 1%. This obtains for $\xi^k = 0.45$. However, we report that our main results are robust to changes in the value of ξ^k. The two transaction cost parameters associated with private and public participation in the foreign capital market, ψ^p and ψ^g, are calibrated from the steady state version of equation (S5) in Appendix, using annual data for the Greek external debt to GDP ratio and the interest rate on loans to Greek non-financial corporations (their average values are 110.6% and 5.39% respectively and the data are from Eurostat and the Bank of Greece). For the external debt to GDP threshold parameter, $\overline{f}$, we follow Reinhart and Rogoff (2009) and set it at 0.9. The resulting value for ψ^p is 0.092; the same value of 0.092 is used for ψ^g.

The risk premium parameter in the debt-elastic interest rate rule, ψ^*, is calibrated from the steady state version of (S39) in Appendix by using annual data for the Greek public debt to GDP ratio and the interest rates on loans to Greek and German non-financial corporations, i_t^* and i^* respectively (the average values are 131.6%, 5.39% and 2.9% respectively and the data are from Eurostat, the Bank of Greece and the Bundensbank). The value of the public debt to GDP threshold parameter, following again Reinhart and Rogoff (2009), is set at 0.9. The resulting value for ψ^* is 0.0512. Following the econometric study by Dinopoulos et al (2020) for the Greek economy, we set the exports elasticity, represented by parameter ϑ in equation (S32) in Appendix, at 3.040; we report however that our main results are robust to changes in the value of ϑ.

To set the Dixit-Stiglitz parameter measuring imperfect competition in the product market, θ, we use information from Eggertsson et al (2014), who report that the gross markup in traded goods (recall that we have traded goods only in our model) is aroud 1.17 in the periphery countries of the EZ (and 1.14 in the core countries). Thus, as in Eggertsson et al (2014, section 3.7), we pin down θ by targeting a steady state gross markup of 1.17 which gives $\theta = 0.85$ (note that this corresponds to 6.88 in the Eggertsson et al functional specification).[26]

Finally, we also need data for the model's exogenous variables. Their values (data averages over 1995-2023 as well as data for the year 2023) are reported in Table 2. Regarding spending-tax policy instruments, using data

[26]This paramerization results in profits as a share of GDP that approximates 18% in the 2023 solution.

from Eurostat and our own calculations, we set s^i_t, s^g_t, s^m_t, s^w_t, s^{tr}_t, τ^c_t, τ^y_t and τ^π_t, which are respectively the GDP shares of government spending on investment, goods purchased from the private sector, imported capital goods, public wages, transfer payments, as well as the effective tax rates on consumption, income and corporate profits, at 0.039, 0.077, 0.045, 0.107, 0.176, 0.225, 0.354 and 0.273 respectively (these are 2023 values). In what concerns the effective corporate tax rate τ^π_t, we use as a proxy the effective tax rate on capital income. The fractions of Greek public debt in the hands of EU institutions and foreign private agents/banks, λ^{eu}_t and λ^g_t, as in subsection 2.5.1 above, are set at 0.7587 and 0.0596 respectively as indicated in the data for 2023.[27] The aid received from the EU expressed as share of the Greek GDP, $s^{tr}_{eu,t}$, as in subsection 2.5.2 above, is 0.0977; this is the value that follows residually from the government budget constraint written at the steady state when we set all the fiscal and public financing variables as above and, at the same time, we target the public debt to GDP ratio as in the data in the year 2023.

We also need a value for the enforcement of property rights, PR_t. We define this index in a comparative sense relative to Germany, which is the key country in the EU. The respective index for each country is defined as the average of three sub-indices: "the rule of law", "regulatory quality" and "political stability and absence of violence/terrorism", which are three indicators commonly used for the construction of a measure of property rights protection (the data are from the World Governance Indicators) rescaled in the 0 to 1 range (the higher the value, the better the quality of institutions).[28] This gives 0.536 for Greece and 0.766 for Germany in 2023. Then, the relative value we use for the year 2023 is 0.70 (0.536 divided by 0.766).

The population fractions of public employees, n^b, and capitalists or self-employed, n^k, are set at 0.2 and 0.2 respectively, similarly to data from OECD,[29] so that the fraction of private workers, n^w, follows residually at 0.6. For our baseline simulations, we assume that the shares in total population of final good firms (n^h), intermediate goods firms (n^i) and capital good firms (n^c) are all equal to the share in total population of their owners, namely, the capitalists (n^k), that is, $n^h = n^i = n^c = n^k = 0.2$. We also set $n^g = n^b = 0.2$, that is, the share in total population of state firms equals the share in total population of public sector employees.

Table 2
Policy and other exogenous variables

[27] For details on Greek public debt data and its holders since the eruption of the global financial crisis in 2008, see Economides et al (2021).

[28] See also Economides et al (2021) and Christou et al (2021).

[29] The data are available at https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE3

3.2 Solution for the year 2023

Table 3 presents the initial steady state solution (we report the key variables only). This is the steady state solution of the model when we use the parameter values in Table 1 and the values of exogenous variables in Table 2. The exogenous policy variables are set as in the data in the year 2023. Note that we set the latter as in their 2023 data values, and focus on how the resulting solution compares to the actual data in the same year, simply because the year 2023 will serve as a point of departure for our debt consolidations experiments.

As can be seen in Table 3, the solution is not far from the actual data. For instance, the solution does a relatively good job at mimicking most of the macroeconomic ratios in the data. The latter include private consumption, private investment and capital, the position of the country in the international capital market, primary fiscal deficit, net exports, and all as shares of GDP. Recall that these valiables, together with the various government spending items which have been set as in the data, constitute the main components of the GDP identity. The same table includes the solution for hours at work which is also close to the value in the data.

Table 3
Main variables in the solution for year 2023

4 Description of policy experiments

In this section, we define the reformed economy, then we discuss about debt consolidation and, finally, we provide our solution strategy.

4.1 Definition of the reformed economy

Our main thought experiment in this paper is the case in which the economy departs from the status quo steady state (see subsection 3.2 above for details), where fiscal policy instruments are as in the data in the year 2023, and travels to a new reformed steady state with lower public debt-to-GDP ratio. The new reformed steady state is defined to be the case in which the public debt-to-GDP ratio is permanently reduced from 1.619 (which is the status quo solution) to 1.4. The fiscal space created by this reduction allows government to raise transfers or to cut one of the tax rates (either on income, or on firms' profits or on consumption).[30]

[30]Notice that here we focus only in these fiscal policy instruments.

4.2 How we model public debt consolidation

It is widely recognized that debt consolidation implies a tradeoff between short-term fiscal pain and medium-term fiscal gain once the debt finally has been reduced. In our model, during the early phase of the transition, debt consolidation comes at the cost of increasing one of the tax rates or reducing government transfers, while in the medium- and long-run, alleviation in the public debt burden allows, other things equal, a cut in one of the tax rates or a rise in government transfers. Thus, one has to value the early costs of stabilization vis-à-vis the medium- and long-term benefits from the fiscal space created by debt consolidation. This intertemporal tradeoff also implies that the implications of 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 also e.g. Leeper et al., 2010, and Davig and Leeper, 2011). Specifically, these implications depend both on which fiscal policy instrument bears the cost of adjustment in the early period of adjustment and on which fiscal policy instrument is anticipated to reap the benefit, once debt consolidation has been achieved. In the policy experiments considered below, we will experiment with fiscal policy mixes, which means that the fiscal authority is allowed to use one fiscal policy instrument in the transition and perhaps a different one in the new reformed steady state. Notice that we use only one policy instrument at a time, both in the transition and in steady state, to understand the logic of our results.

We examine several cases of debt consolidation where the role of policy is to improve either resource allocation or "equality" by gradually reducing the public debt / liabilities as share of output over time as said in subsection 4.1. Once debt has been reduced, in a new reformed steady state there is fiscal space to raise government transfers or to cut one of the tax rates (on income, capital income and consumption). Hence, we study four possible new reformed steady state solutions analogous to which one of the four fiscal policy instruments takes advantage of the fiscal space created by public debt consolidation. Then, for each one of these steady state solutions, we study four transition paths analogous to which fiscal policy instrument will adjust to bring public debt / liabilities down during the transition to the particularly studied new reformed steady state.[31] To compute the path towards a new reformed steady state for a case of adjusting instrument in the transition, we should determine policy targets (that is policy variables without time subscripts) and coefficients in the feedback policy rules, Eqs.(31)-(34). As for the policy targets, we set as values the new reformed steady state values of the corresponding variables. As for the coefficients of policy instruments on public liabilities gap, we set the coefficient of the adjusting

[31] As said above, we experiment with policy mixes.

instrument in the transition at the arbitrary value 0.1,[32] switching off the corresponding coefficient of the other instruments.

Having described how we model debt consolidation, let us proceed with the solution strategy we follow. First, we take a first-order approximation of the equilibrium conditions around a new reformed steady state. Next, we set the initial values of the (endogenous and exogenous) predetermined variables equal to their status quo steady state values. Finally, we compute the equilibrium transition path travelling towards a new reformed steady state with debt consolidation. Notice that, here, it is natural to use the case without debt consolidation (status quo steady state) as a reference regime through which we compare the several policy reforms.

5 Results

5.1 Steady state results

We start with comparison of the steady state solutions. Recall that in the status quo (SQ) steady state, fiscal policy instruments are set as in the data in year 2023 whereas the aid received from the EU expressed as share of the Greek GDP, $s^{tr}_{eu,t}$, follows residually targeting the public debt to GDP ratio to be also as in the data in the year 2023 (SQ). On the contrary, in the new reformed steady state, the public debt-to-GDP ratio is exogenously cut to 140% so that one of the fiscal policy instruments can follow residually, meaning that s^{tr} is allowed to rise or one of τ^{π}, τ^{y}, τ^{c} is allowed to fall.

Table 4
Values of the residual fiscal policy instruments in steady state

Table 4 reports the value of the associated residual fiscal policy instrument in each case of the new reformed steady state studied as well as in the status quo. In the two following subsections we will investigate how the (aggregate and distributional) implications of debt consolidation in steady state depend on the public financing policy instrument used, examining each public financing case mentioned in the previous section. Namely, we will examine which fiscal policy instrument should be used switching either to a more efficient economy with higher output or to a more "equitable" economy.

[32]Notice that saddle path stability is achieved under all cases studied when one of the fiscal policy instrument adjusts in the transition by setting the coefficient of the chosen instrument at 0.1 (switching off the corresponding coefficient of the other instruments). This value is close to those found by optimized policy rules in related studies (see e.g. Schmitt-Grohé and Uribe, 2007, and Philippopoulos et al., 2017a).

Aggregate implications (efficiency)

Results for output in the SQ and the reformed steady state under various public financing scenarios are shown in Table 5.

Table 5
Output (GDP) in steady state

In terms of aggregate economy, our numerical results imply that allowing for taxes to take advantage of the fiscal space created by debt consolidation, we switch to a more efficient economy with higher output relative to the status quo steady state. On the other hand, using the fiscal space created by debt consolidation to increase government transfers would be a bad idea since this leads to lower output relative to the status quo steady state. Yet, the key message of our results is that, in terms of efficiency, the best way of using the fiscal space generated, once the public debt has finally been reduced, is to cut the income tax rate.

Distributional implications (equity)

Since there are three different income groups in the society - capitalists, private workers and public employees - the income gains from each particular structural reform may be distributed unequally. Results for net income of the capitalist, the private worker and the public employee in each new reformed steady state as well as their percentage change from the SQ steady state are reported in Table 6.

Table 6
Net income of the capitalist, the private worker and the public employee in new steady state and their percentage change from the status quo steady state

Our results for net income of each household type in steady state (see Table 6), y^k, y^w and y^b,[33] show that, relative to the status quo, all income groups gain from debt consolidation only if the residual instrument in the

[33] The net income of the capitalist is defined as $y_t^k \equiv (1-\tau_t^y)w_t^k l_{k,t} + \pi_{k,t} - \tau_t^c\left(\frac{p_t^h}{p_t}c_{k,t}^h + \frac{p_t^f}{p_t}c_{k,t}^f\right) + \overline{g}_t^{tr} + \left[i_t^b\frac{p_{t-1}}{p_t}b_{k,t-1}\right] - \left[i_t^*\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}f_{k,t-1}\right] + \left(\frac{\Gamma^k(s_{k,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma + N^w\Gamma^w(s_{w,t})^\gamma + N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t$, the net income of the private worker is defined as $y_t^w \equiv (1-\tau_t^y)w_t^w l_{w,t} - \tau_t^c\left(\frac{p_t^h}{p_t}c_{w,t}^h + \frac{p_t^f}{p_t}c_{w,t}^f\right) + \overline{g}_t^{tr} + \left(\frac{\Gamma^w(s_{w,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma + N^w\Gamma^w(s_{w,t})^\gamma + N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t$, and the net income of the public employee is defined as $y_t^b \equiv (1-\tau_t^y)w_t^b l_{b,t} - \tau_t^c\left(\frac{p_t^h}{p_t}c_{b,t}^h + \frac{p_t^f}{p_t}c_{b,t}^f\right) + \overline{g}_t^{tr} + \left(\frac{\Gamma^b(s_{b,t})^\gamma}{N^k\Gamma^k(s_{k,t})^\gamma + N^w\Gamma^w(s_{w,t})^\gamma + N^b\Gamma^b(s_{b,t})^\gamma}\right)(1-PR_t)\frac{p_t^h}{p_t}Y_t$.

new reformed steady state is the tax rate on profits. In all other cases studied, although private workers and public employees see their income to increase relative to status quo in the new reformed steady state, capitalists undergo a decrease in their income. Hence, the only case of debt consolidation that produces a win-win outcome (Pareto efficient) is to allow for cuts on profit taxes.

But, even if a policy reform produces a win-win outcome (Pareto efficient), here in the sense that all y^k, y^w and y^b rise, relative outcomes can also be important. Actually, the political economy literature has pointed out several reasons for this, including political ideology, envy, habits, etc. In our model, distributional implications can be measured by changes in the ratios of net incomes, y^w/y^k and y^b/y^k. Results for relative net income of the private worker and the public employee to that of the capitalist in each new reformed steady state (analogous to what is the residual instrument), i.e. y^w/y^k and y^b/y^k, and their percentage change from the status quo steady state are reported in Table 7. According to our numerical results, relative to the status quo, the ratios y^w/y^k and y^b/y^k rise, or equivalently inequality decreases, in all cases studied.

Table 7
Relative net income of the private worker and the public employee to that of the capitalist in new steady state and their percentage change from the status quo steady state

In sum, if we focus on efficiency only, the best way of using the fiscal space created by debt consolidation is to cut the tax rate on income. This policy, although it is not Pareto efficient, it improves income equality relative to the status quo. Finally, using the fiscal space created by debt consolidation to increase government transfers is a bad idea in terms of (Pareto) efficiency, although it improves equality. But, in one way or another, an rise in income equality can be achieved in all cases studied.

5.2 Transition results

We next study what happens in the transition as we depart from the status quo steady state and travel towards a new reformed steady state with lower public debt.

Aggregate implications (efficiency)

Here, we focus on the case in which the residually determined fiscal policy instrument in the new reformed steady state is the tax rate on income.[34] In this case of new reformed steady state, results for the present value of output over different time horizons after debt consolidation takes place, under

[34]For saving space, we report only this case, but all results are available upon request.

various adjusting policy instruments in the transition, are shown in Table 8. Every row of the table, that corresponds to a different case analogous to what fiscal policy instrument is used for bringing public debt down during the transition, shows present value of output over different time horizons.

Table 8
Present value of output (GDP) over different time horizons after debt consolidation when the residual instrument in the new reformed steady state is the tax rate on income

Inspection of the results in Table 8 reveals that if the criterion is aggregate, or per capita, output, the best policy mix is to use the long term fiscal gain (namely, the fiscal space created once the debt has been reduced) to cut the tax rate on income and, during the early period of fiscal pain, to use government transfer cuts to bring the public debt down.

Distributional implications (equity)

Again, we focus on the case of the new reformed steady state in which the residually determined fiscal policy instrument is income tax rate, τ^y. In this case of new reformed steady state, results for the ratio of the present value of the net income of private workers to that of capitalists as well as of public employees to that of capitalists over different time horizons after debt consolidation takes place, under various adjusting fiscal policy instruments in the transition, are shown in Tables 9 and 10 respectively.

Table 9
Ratio of the present value of the net income of private workers to that of capitalists over various time horizons after debt consolidation when the residual fiscal policy instrument in the new reformed steady state is the tax rate on income

Table 10
Ratio of the present value of the net income of public employees to that of capitalists over various time horizons after debt consolidation when the residual fiscal policy instrument in the new reformed steady state is the tax rate on income

Every row of these tables, that corresponds to a different case analogous to what fiscal policy instrument is used for bringing public debt down during the transition, shows the ratio of the present value of the net income of private workers and public employees relative to that of capitalists respectively over different time horizons(i.e. different column). Notice that we will check whether the value of each case of adjusting instrument in the transition (row) for a specific time period (column) is higher than the corresponding status quo steady state value of the same time period over different time horizons (if they are higher, then this case of policy reform improves equality relative to status quo).

Our numerical results show that, although the most efficient policy mix (namely, to use government transfers cuts during the transition and to cut the income tax rate in the new reformed steady state) is not Pareto efficient during the transition (see Table 11), it improves income equality in the transition relative to status quo (see Tables 9 and 10).

Table 11
Present values of the net income of the capitalist, of the private worker and of the public employee over various time horizons when the adjusting instrument in the transition is government transfers and the residual instrument in the new reformed steady state is the tax rate on income.

In sum, in all policy mixes studied, debt consolidation, although it can not produce a win-win outcome relative to the status quo, it can promote equality relative to the status quo both in the new reformed steady state and the transition.[35]

6 Concluding remarks and possible extensions

In this paper, using a D(S)GE model including the key features of the Greek economy, we studied the aggregate and distributional implications of debt consolidation, assuming as a starting point the public debt-to-GDP ratio of the year 2023. Since the results have already been written in the introduction, here we just mention a possible extension. In a model augmented with an informal sector (which seems to be non-negligible in the Greek economy), we could study what happens under public debt consolidation as the degree of the informal sector is reduced and the tax base becomes broader.

[35]For saving space, we do not present all results. However, they are available upon request.

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Appendix: Macroeconomic system

Collecting all equations, the system that we solve numerically consists of the following equations:

Households (the three types)

$$c_{k,t} = \frac{(c^h_{k,t})^\nu (c^f_{k,t})^{1-\nu}}{\nu^\nu (1-\nu)^{1-\nu}} \tag{S1}$$

$$\frac{\mu_2}{(1-l_{k,t}-s_{k,t})} = \frac{\mu_1(1-\tau^y_t)w^k_t}{(1+\tau^c_t)c_{k,t}} \tag{S2}$$

$$\frac{\mu_2}{(1-l_{k,t}-s_{k,t})} = \left(\frac{\mu_1}{(1+\tau^c_t)c_{k,t}}\right)\times$$

$$\times\left(\frac{\gamma\Gamma^k(s_{k,t})^{\gamma-1}(1-PR_t)\frac{p^h_t}{p_t}n^h y^h_{i,t}}{n^k\Gamma^k(s_{k,t})^\gamma + n^w\Gamma^w(s_{w,t})^\gamma + n^b\Gamma^b(s_{b,t})^\gamma}\right) \tag{S3}$$

$$\frac{(1+\tau^c_{t+1})c_{k,t+1}}{(1+\tau^c_t)c_{k,t}} = \beta(1+i^b_{t+1})\frac{p_t}{p_{t+1}} \tag{S4}$$

$$\frac{(1+\tau^c_{t+1})c_{k,t+1}}{(1+\tau^c_t)c_{k,t}}\frac{e_t p^*_t}{p_t} = \frac{(1+\tau^c_{t+1})c_{k,t+1}}{(1+\tau^c_t)c_{k,t}}\frac{e_t p^*_t}{p_t}\times$$

$$\times\psi^p\left[\frac{\frac{e_t p^*_t}{p_t}\left(n^k f_{k,t}+\lambda^g_t d_t\right)}{\frac{p^h_t}{p_t}n^h y^h_{i,t}} - \overline{f}\right] + \beta\frac{e_{t+1}p^*_{t+1}}{p_{t+1}}(1+i^*_{t+1})\frac{p^*_t}{p^*_{t+1}} \tag{S5}$$

$$\frac{c^h_{k,t}}{c^f_{k,t}} = \frac{\nu}{(1-\nu)}\frac{p^f_t}{p^h_t} \tag{S6}$$

$$c_{w,t} = \frac{(c^h_{w,t})^\nu (c^f_{w,t})^{1-\nu}}{\nu^\nu (1-\nu)^{1-\nu}} \tag{S7}$$

$$(1+\tau^c_t)\left(\frac{p^h_t}{p_t}c^h_{w,t} + \frac{p^f_t}{p_t}c^f_{w,t}\right) = (1-\tau^y_t)w^w_t l_{w,t} +$$

$$+\overline{g}^{tr}_t + \frac{\Gamma^w(s_{w,t})^\gamma(1-PR_t)\frac{p^h_t}{p_t}n^h y^h_{i,t}}{n^k\Gamma^k(s_{k,t})^\gamma + n^w\Gamma^w(s_{w,t})^\gamma + n^b\Gamma^b(s_{b,t})^\gamma} \tag{S8}$$

$$\frac{\mu_2}{(1-l_{w,t}-s_{w,t})} = \frac{\mu_1(1-\tau^y_t)w^w_t}{(1+\tau^c_t)c_{w,t}} \tag{S9}$$

$$\frac{\mu_2}{(1-l_{w,t}-s_{w,t})} = \left(\frac{\mu_1}{(1+\tau^c_t)c_{w,t}}\right)\times$$

$$\times \left(\frac{\gamma \Gamma^w (s_{w,t})^{\gamma-1} (1 - PR_t) \frac{p_t^h}{p_t} n^h y_{i,t}^h}{n^k \Gamma^k (s_{k,t})^\gamma + n^w \Gamma^w (s_{w,t})^\gamma + n^b \Gamma^b (s_{b,t})^\gamma} \right) \tag{S10}$$

$$\frac{c_{w,t}^h}{c_{w,t}^f} = \frac{\nu}{(1-\nu)} \frac{p_t^f}{p_t^h} \tag{S11}$$

$$c_{b,t} = \frac{(c_{b,t}^h)^\nu (c_{b,t}^f)^{1-\nu}}{\nu^\nu (1-\nu)^{1-\nu}} \tag{S12}$$

$$(1 + \tau_t^c) \left(\frac{p_t^h}{p_t} c_{b,t}^h + \frac{p_t^f}{p_t} c_{b,t}^f \right) = (1 - \tau_t^y) w_t^b l_{b,t} +$$

$$+ \bar{g}_t^{tr} + \frac{\Gamma^b (s_{b,t})^\gamma (1 - PR_t) \frac{p_t^h}{p_t} n^h y_{i,t}^h}{n^k \Gamma^k (s_{k,t})^\gamma + n^w \Gamma^w (s_{w,t})^\gamma + n^b \Gamma^b (s_{b,t})^\gamma} \tag{S13}$$

$$\frac{\mu_2}{(1 - l_{b,t} - s_{b,t})} = \frac{\mu_1 (1 - \tau_t^y) w_t^b}{(1 + \tau_t^c) c_{b,t}} \tag{S14}$$

$$\frac{\mu_2}{(1 - l_{b,t} - s_{b,t})} = \left(\frac{\mu_1}{(1 + \tau_t^c) c_{b,t}} \right) \times$$

$$\times \left(\frac{\gamma \Gamma^b (s_{b,t})^{\gamma-1} (1 - PR_t) \frac{p_t^h}{p_t} n^h y_{i,t}^h}{n^k \Gamma^k (s_{k,t})^\gamma + n^w \Gamma^w (s_{w,t})^\gamma + n^b \Gamma^b (s_{b,t})^\gamma} \right) \tag{S15}$$

$$\frac{c_{b,t}^h}{c_{b,t}^f} = \frac{\nu}{(1-\nu)} \frac{p_t^f}{p_t^h} \tag{S16}$$

Price indexes

$$p_t = (p_t^h)^\nu (p_t^f)^{1-\nu} \tag{S17}$$

$$p_t^f \equiv e_t p_t^{h*} \tag{S18}$$

Private firms in a symmetric equilibrium (with $n^h \equiv n^i$)

$$y_{i,t}^h = A^p \left(\frac{n^g y_{g,t}^g}{n^h}\right)^\sigma \left[\left(\chi^p (k_{i,t-1})^{op} + (1-\chi^p)(m_{i,t}^f)^{op}\right)^{\frac{\alpha}{op}} \left(A^k l_{i,t}^k + A^w l_{i,t}^w\right)^{1-\alpha}\right]^{1-\sigma} \tag{S19}$$

$$w_t^k = PR_t \theta \frac{p_t^h}{p_t} \frac{(1-\sigma)(1-\alpha)A^k y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{S20}$$

$$w_t^w = PR_t \theta \frac{p_t^h}{p_t} \frac{(1-\sigma)(1-\alpha)A^w y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{S21}$$

$$\frac{p_t^h}{p_t}\left[1+\xi^k\left(\frac{k_{i,t}}{k_{i,t-1}}-1\right)\right] = \beta_{i,t}\frac{p_{t+1}^h}{p_{t+1}}[1-\delta+(1-\tau_{t+1}^\pi)PR_{t+1}\theta r_{t+1}^k - $$

$$-\frac{\xi^k}{2}\left(\frac{k_{i,t+1}}{k_{i,t}}-1\right)^2 + \xi^k\left(\frac{k_{i,t+1}}{k_{i,t}}-1\right)\frac{k_{i,t+1}}{k_{i,t}}] \tag{S22}$$

$$\frac{p_t^f}{p_t} = PR_t \theta \frac{p_t^h}{p_t} \frac{(1-\sigma)\alpha y_{i,t}^h (1-\chi^p)(m_{i,t}^f)^{op-1}}{\left[\chi^p (k_{i,t-1})^{op} + (1-\chi^p)(m_{i,t}^f)^{op}\right]} \tag{S23}$$

$$k_{i,t} = (1-\delta)k_{i,t-1} + x_{i,t} \tag{S24}$$

$$\pi_{i,t} \equiv (1-\tau_t^\pi)\left[PR_t \frac{p_t^h}{p_t} y_{i,t}^h - w_t^k l_{i,t}^k - w_t^w l_{i,t}^w - \frac{p_t^f}{p_t} m_{i,t}^f\right] -$$

$$-\frac{p_t^h}{p_t}[k_{i,t}-(1-\delta)k_{i,t-1}] - \frac{p_t^h}{p_t}\frac{\xi^k}{2}\left(\frac{k_{i,t}}{k_{i,t-1}}-1\right)^2 k_{i,t-1} \tag{S25}$$

where $r_{t+1}^k \equiv \frac{\partial y_{i,t+1}^h}{\partial k_{i,t}} = \frac{(1-\sigma)\alpha y_{i,t+1}^h \chi^p (k_{i,t})^{op-1}}{\left[\chi^p (k_{i,t})^{op} + (1-\chi^p)(m_{i,t+1}^f)^{op}\right]}$, $\beta_{i,t} \equiv \frac{\beta(1+\tau_t^c)c_{k,t}}{(1+\tau_{t+1}^c)c_{k,t+1}}$ and $\beta_{i,t+1} \equiv \frac{(\beta)^2(1+\tau_{t+1}^c)c_{k,t+1}}{(1+\tau_{t+2}^c)c_{k,t+2}}$.

State firms

$$y_{g,t}^g = A^g \left(\chi^g (k_{g,t-1}^g)^{og} + (1-\chi^g)(m_{g,t}^g)^{og}\right)^{\frac{\theta_1}{og}} (l_{g,t})^{\theta_2} \left(g_{g,t}^g\right)^{1-\theta_1-\theta_2} \tag{S26}$$

$$k_{g,t}^g = (1-\delta^g)k_{g,t-1}^g + g_{g,t}^i \tag{S27}$$

Government budget constraint

$$\overline{g}_t^{tr} + n^g \left[w_t^b l_{g,t}^g + \frac{p_t^h}{p_t} \left(g_{g,t}^g + g_{g,t}^i \right) + \frac{p_t^f}{p_t} m_{g,t}^g \right] +$$

$$+ \frac{\psi^g}{2} \left[\frac{\frac{e_t p_t^*}{p_t} \left(n^k f_{k,t} + \lambda_t^g d_t \right)}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{f} \right]^2 \frac{p_t^h}{p_t} n^h y_{i,t}^h +$$

$$+ (1 + i_t^b) \frac{p_{t-1}}{p_t} \lambda_{t-1}^d d_{t-1} + (1 + i_t^b) \frac{p_{t-1}^*}{p_t^*} \frac{e_t p_t^*}{p_t} \frac{p_{t-1}}{e_{t-1} p_{t-1}^*} \lambda_{t-1}^g d_{t-1} +$$

$$+ (1 + i^*) \frac{p_{t-1}^*}{p_t^*} \frac{e_t p_t^*}{p_t} \frac{p_{t-1}}{e_{t-1} p_{t-1}^*} \lambda_{t-1}^{eu} d_{t-1} \equiv d_t + \frac{T_t}{N} + tr_t^{eu} \qquad \text{(S28)}$$

where we use $n^k b_{k,t} = b_t^d = \lambda_t^d d_t = (1 - \lambda_t^g - \lambda_t^{eu}) d_t$ at each t.

Gross Domestic Product (GDP) identity

$$n^k c_{k,t}^h + n^w c_{w,t}^h + n^b c_{b,t}^h + n^h x_{k,t} + n^g (g_{g,t}^g + g_{g,t}^i) + c_t^{f*} +$$

$$+ n^h \frac{\xi^k}{2} \left(\frac{k_{i,t}}{k_{i,t-1}} - 1 \right)^2 k_{i,t-1} = n^h y_{i,t}^h \qquad \text{(S29)}$$

where c_t^{f*} is exports to the rest of the world (defined below).

Balance of payments (economy's resource constraint)

$$\frac{p_t^f}{p_t} \left(n^k c_{k,t}^f + n^w c_{w,t}^f + n^b c_{b,t}^f + n^h m_{i,t}^f + n^g m_{g,t}^g \right) -$$

$$- \frac{p_t^h}{p_t} c_t^{f*} + (1 + i_t^*) \frac{p_{t-1}^*}{p_t^*} \frac{e_t p_t^*}{p_t} n^k f_{k,t-1} +$$

$$+ (1 + i_t^b) \frac{p_{t-1}^*}{p_t^*} \frac{e_t p_t^*}{p_t} \frac{p_{t-1}}{e_{t-1} p_{t-1}^*} \lambda_{t-1}^g d_{t-1} + (1 + i^*) \frac{p_{t-1}^*}{p_t^*} \frac{e_t p_t^*}{p_t} \frac{p_{t-1}}{e_{t-1} p_{t-1}^*} \lambda_{t-1}^{eu} d_{t-1} +$$

$$+ \frac{\psi^p}{2} \left[\frac{\frac{e_t p_t^*}{p_t} \left(n^k f_{k,t} + \lambda_t^g d_t \right)}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{f} \right]^2 \frac{p_t^h}{p_t} n^h y_{i,t}^h +$$

$$+ \frac{\psi^g}{2} \left[\frac{\frac{e_t p_t^*}{p_t} \left(n^k f_{k,t} + \lambda_t^g d_t \right)}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{f} \right]^2 \frac{p_t^h}{p_t} n^h y_{i,t}^h = \frac{e_t p_t^*}{p_t} n^k f_{k,t} + \lambda_t^g d_t + \lambda_t^{eu} d_t + tr_t^{eu} \qquad \text{(S30)}$$

Tax revenues

$$\frac{T_t}{N} \equiv \tau_t^c \left[n^k \left(\frac{p_t^h}{p_t} c_{k,t}^h + \frac{p_t^f}{p_t} c_{k,t}^f \right) + n^w \left(\frac{p_t^h}{p_t} c_{w,t}^h + \frac{p_t^f}{p_t} c_{w,t}^f \right) + n^b \left(\frac{p_t^h}{p_t} c_{b,t}^h + \frac{p_t^f}{p_t} c_{b,t}^f \right) \right] +$$

$$+\tau_t^y [n^k w_t^k l_{k,t} + n^w w_t^w l_{w,t} + n^b w_t^b l_{b,t}] +$$

$$+\tau_t^\pi n^h \left[PR_t \frac{p_t^h}{p_t} y_{i,t}^h - w_t^k l_{i,t}^k - w_t^w l_{i,t}^w - \frac{p_t^f}{p_t} m_{i,t}^f \right] \tag{S31}$$

Exports

$$c_t^{f*} = \left(\frac{p_t^f}{p_t^h} \right)^{\vartheta} \tag{S32}$$

Fiscal variables

$$w_t^b = \frac{s_t^w \frac{p_t^h}{p_t} n^h y_{i,t}^h}{n^g l_{g,t}} \tag{S33}$$

$$g_{g,t}^g = \frac{s_t^g n^h y_{i,t}^h}{n^g} \tag{S34}$$

$$g_{g,t}^i = \frac{s_t^i n^h y_{i,t}^h}{n^g} \tag{S35}$$

$$\overline{g}_t^{tr} = s_t^{tr} \frac{p_t^h}{p_t} n^h y_{i,t}^h \tag{S36}$$

$$m_{g,t}^g = \frac{p_t^h}{p_t^f} \frac{s_t^m n^h y_{i,t}^h}{n^g} \tag{S37}$$

$$tr_t^{eu} = s_{eu,t}^{tr} \frac{p_t^h}{p_t} n^h y_{i,t}^h \tag{S38}$$

Country's interest rate

$$i_t^* = i^* + \psi^* \left(\exp\left(\frac{d_t}{\frac{p_t^h}{p_t} n^h y_{i,t}^h} - \overline{d} \right) - 1 \right) \tag{S39}$$

Fiscal policy rules and the public debt target

$$s_t^{tr} = s^{tr} - \gamma_l^{tr} \left(l_{t-1} - l \right) \tag{S40}$$

$$\tau_t^c = \tau^c + \gamma_l^c \left(l_{t-1} - l \right) \tag{S41}$$

$$\tau_t^y = \tau^y + \gamma_l^y \left(l_{t-1} - l\right) \tag{S42}$$

$$\tau_t^\pi = \tau^\pi + \gamma_l^\pi \left(l_{t-1} - l\right) \tag{S43}$$

$$l_{t-1} \equiv \frac{(1+i_t^b)\frac{p_{t-1}}{p_t}(1-\lambda_{t-1}^g-\lambda_{t-1}^{eu})d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} + \frac{(1+i_t^b)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^g d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} +$$
$$+ \frac{(1+i^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^{eu} d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} \tag{S44}$$

$$s_{eu,t}^{tr} = s_{eu}^{tr} + \gamma^{tr}\left(\frac{d_{t-1}}{\frac{p_t^h}{p_t}n^h y_{i,t}^h} - d^*\right) \tag{S45}$$

Market-clearing conditions in labor and dividend markets

$$N^k l_{k,t} = N^h l_{i,t}^k \tag{S46}$$

$$N^w l_{w,t} = N^h l_{i,t}^w \tag{S47}$$

$$N^b l_{b,t} = N^g l_{g,t} \tag{S48}$$

$$N^k \pi_{k,t} = N^h \pi_{i,t} \tag{S49}$$

Endogenous and exogenous variables We therefore have a dynamic system of 49 equations, (S1)-(S49), in 49 variables. The latter are the paths of $\{c_{k,t}, c_{k,t}^h, c_{k,t}^f\}_{t=0}^\infty$, $\{c_{w,t}, c_{w,t}^h, c_{w,t}^f\}_{t=0}^\infty$, $\{c_{b,t}, c_{b,t}^h, c_{b,t}^f\}_{t=0}^\infty$, $\{l_{k,t}, l_{w,t}, l_{b,t}\}_{t=0}^\infty$, $\{s_{k,t}, s_{w,t}, s_{b,t}\}_{t=0}^\infty$, $\{f_{k,t}, \pi_{k,t}\}_{t=0}^\infty$, $\{y_{i,t}^h, l_{i,t}^k, l_{i,t}^w, k_{i,t}, x_{i,t}, m_{i,t}^f, \pi_{i,t}, w_t^k, w_t^w\}_{t=0}^\infty$, $\{y_{g,t}^g, l_{g,t}, k_{g,t}^g\}_{t=0}^\infty$, $\{p_t, p_t^h, p_t^f, i_t^b, i_t^*\}_{t=0}^\infty$, $\{w_t^b, g_{g,t}^g, g_{g,t}^i, \overline{g}_t^{tr}, m_{g,t}^g\}_{t=0}^\infty$, $\{\frac{T_t}{N}\}_{t=0}^\infty$, $\{c_t^{f*}\}_{t=0}^\infty$, $\{s_{eu,t}^{tr}\}_{t=0}^\infty$, $\{d_t\}_{t=0}^\infty$, $\{\tau_t^c, \tau_t^y, \tau_t^\pi, s_t^{tr}\}_{t=0}^\infty$, $\{l_t\}_{t=0}^\infty$ and $\{tr_t^{eu}\}_{t=0}^\infty$. This is given the paths of not responding to debt fiscal policy instruments, $\{s_t^w, s_t^g, s_t^i, s_t^m\}_{t=0}^\infty$, the fractions of public debt held by private agents abroad and EU institutions, $\{\lambda_t^g, \lambda_t^{eu}\}_{t=0}^\infty$, the population shares, $\{n^k, n^w, n^b, n^h, n^g\}_{t=0}^\infty$, the degree of property rights, $\{PR_t\}_{t=0}^\infty$, foreign prices $\{p_t^{h*}, p_t^{f*}, p_t^*\}_{t=0}^\infty$, the nominal exchange rate, $\{e_t\}_{t=0}^\infty$, and the degree of substitutability between intermediate goods, $\{\theta\}_{t=0}^\infty$.

Transformed variables For convenience, we re-express some variables. We define $\frac{p_t^f}{p_t^h} \equiv TT_t$ to be the terms of trade (an increase means an improvement in competitiveness vis-à-vis the rest of the world). Then, we have $\frac{p_t^h}{p_t} = (TT_t)^{\nu-1}$, $\frac{p_t^f}{p_t} = (TT_t)^{\nu}$, $\frac{e_t p_t^*}{p_t} = (TT_t)^{2\nu-1}$, $\Pi_t \equiv \frac{p_t}{p_{t-1}} = \Pi_t^h \left(\frac{TT_t}{TT_{t-1}}\right)^{1-\nu}$ and $\frac{TT_t}{TT_{t-1}} = \frac{e_t}{e_{t-1}} \frac{\Pi_t^{h*}}{\Pi_t^h}$, where $\Pi_t^h \equiv \frac{p_t^h}{p_{t-1}^h}$. Also, $\frac{e_t}{e_{t-1}}$ is the gross rate of exchange rate depreciation which is set at one in a currency union. Hence, in the final system, we have $\Pi_t = \Pi_t^h \left(\frac{TT_t}{TT_{t-1}}\right)^{1-\nu}$ and $\frac{TT_t}{TT_{t-1}} = \frac{e_t}{e_{t-1}} \frac{\Pi_t^{h*}}{\Pi_t^h}$ and, in all other equations, we use the transformations $\frac{p_t^h}{p_t} = (TT_t)^{\nu-1}$, $\frac{p_t^f}{p_t} = (TT_t)^{\nu}$, $\frac{e_t p_t^*}{p_t} = (TT_t)^{2\nu-1}$. In other words, regarding prices, instead of $\{p_t, p_t^h, p_t^f\}_{t=0}^{\infty}$, now the endogenous variables are $\left\{TT_t, \Pi_t^h, \Pi_t\right\}_{t=0}^{\infty}$. Recall that, in a small open economy, $\Pi_t^{h*} \equiv \frac{p_t^{h*}}{p_{t-1}^{h*}}$ is exogenous (we set it at 1 all the time), while $\Pi_t^* \equiv \frac{p_t^*}{p_{t-1}^*}$ can also be treated for simplicity as exogenous (we set it at 1 all the time) or, more generally, if we use $p_t^* = (p_t^{h*})^{\nu}(p_t^{f*})^{1-\nu}$, it can be written as $\Pi_t^* \equiv \frac{p_t^*}{p_{t-1}^*} = (\Pi_t^{h*})^{\nu} \left(\Pi_t^h\right)^{1-\nu}$, (where we have set $\frac{e_t}{e_{t-1}} \equiv 1$); in our solutions, we simply set $\Pi_t^* \equiv \frac{p_t^*}{p_{t-1}^*} = 1$ all the time.

Tables

Table 1: Baseline parameterization

Parameter	**Description**	**Value**	
ν	home goods bias in consumption	0.77	calibrated
μ_1	weight of consumption in utility	0.5415	calibrated
μ_2	weight of leisure in utility	0.4085	calibrated
β	time discount factor	0.977	calibrated
δ and δ^g	depreciation rates of priv and pub capital	0.04	calibrated
ψ^p	transaction cost in foreign capital market (priv)	0.092	calibrated
ψ^g	transaction cost in foreign capital market (pub)	0.092	calibrated
A^p	TFP in private sector's production function	1	set
A^g	TFP in public sector's production function	1	set
A^k	capital owners' labour productivity	2	calibrated
A^w	private workers' labour productivity	1	calibrated
$1-\alpha$	share of labor in private production	0.613	calibrated
σ	contribution of public output to private production	0.05	set
θ_1	share of capital and imported cap goods in public production	0.309	calibrated
θ_2	share of labor in public production	0.398	calibrated
χ^p	intensity of priv capital relative to imported cap goods (priv)	0.504	calibrated
op	substitutability between capital and imported cap goods (priv)	0.5	set
χ^g	intensity of pub capital relative to imported cap goods (pub)	0.504	calibrated
og	substitutability between capital and imported cap goods (pub)	0.5	set
ξ^k	capital adjustment cost parameter	0.45	set
γ	measure of returns in unproductive activities	0.5	set
ψ^*	country's interest-rate premium parameter	0.051	calibrated
Γ^k	efficiency of cap owners' unproductive activity	1	calibrated
Γ^w	efficiency of priv workers' unproductive activity	0.3	calibrated
Γ^b	efficiency of publ employees' unproductive activity	1.3	calibrated
ϑ	exponent in the function of exports	3.04	set
$\overline{f}$	threshold value of external debt to output	0.9	set
$\overline{d}$	threshold value of public debt to output	0.9	set
θ	substitutability between intermediate goods	0.85	set

Note:A detailed description of the calibration is in subsection 3.1 in the main text. Notice that the term "set" implies that the relevant parameter is set at a value commonly used in the literature.

Table 2: Policy and other exogenous variables

Variable	**Description**	**Data averages (1995-2023)**	**Value in 2023**	
s_t^i	public investment to output (%)	0.043	0.039	data
s_t^g	gov purchases from the priv sector to ouput (%)	0.084	0.077	data
s_t^m	gov spending on imported capital goods to ouput (%)	0.045	0.045	data
s_t^w	public wage bill to output (%)	0.115	0.107	data
s_t^{tr}	gov transfers to output (%)	0.179	0.176	data
τ_t^c	effective consumption tax rate	0.185	0.225	data
τ_t^y	effective income tax rate	0.302	0.354	data
τ_t^π	effective tax rate on capital income	0.220	0.273	data
$s_{eu,t}^{tr}$	transfer from EU to output (%)	-	0.0977	calibrated
λ_t^{eu}	share of total public debt held by EU	-	0.7587	data
λ_t^g	share of total public debt held by foreign private agents	-	0.0596	data
i^*	constant term of world interest rate		0.013	data
n^k	share of cap owners in population	0.2	0.2	data
n^w	share of priv workers in population	0.6	0.6	data
n^b	share of pub employees in population	0.2	0.2	data
n^g	share of state firms in population	0.2	0.2	set
n^h	share of private firms in population	0.2	0.2	set
PR_t	index of property rights	0.77	0.70	data

Table 3: Main variables in the solution for year 2023

Variable	**Description**	**Solution**	**Data (2023)**
c/y	consumption/ouput (%)	76.3	68.4
inv/y	investment/output (%)	11.9	13.9
k/y	capital/output (%)	2.9	3.6
f/y	foreign debt/output (%)	126.3	126.3
b/y	public debt/output (%)	161.9	161.9
$1-u$	hours at work (%)	40.0	40.8
$prdef$	primary deficit/output (%)	-3.14	-1.9
nx/y	net exports/ouput (%)	-4.7	-6.3
c_k	consumption of capital owner	0.333	–
c_w	consumption of private worker	0.128	–
c_b	consumption of public employee	0.280	–
l_k	prd hours at work (capital owner)	0.119	–
l_w	prd hours at work (private worker)	0.383	–
l_b	prd hours at work (public employee)	0.201	–
s_k	unprd hours at work (capital owner)	0.148	–
s_w	unprd hours at work (private worker)	0.053	–
s_b	unprd hours at work (public employee)	0.221	–

Table 4: Values of the residual fiscal policy instruments in steady state

Residual Instrument	Status quo	New steady state
τ^{π}	0.2736	0.2155
τ^{y}	0.3544	0.3137
τ^{c}	0.2248	0.2006
s^{tr}	0.2070	0.2257

Table 5: Output(GDP) in steady state

Residual Instrument	New steady state	% Change relative to the SQ
τ^{π}	0.2680	3.4888 %
τ^{y}	0.2683	3.6060 %
τ^{c}	0.2609	0.7547 %
s^{tr}	0.2578	-0.4382 %

Note: Steady state value of the output in the status quo (SQ) is 0.2590.

Table 6: Net income of the capitalist, the private worker and the public employee in new steady state and their percentage change from the status quo steady state

Residual Instrument	New steady state			% Changes from status quo steady state		
	y^k	y^w	y^b	y^k	y^w	y^b
τ^π	0.3525	0.1318	0.2923	0.4015%	4.0344%	3.6506%
τ^y	0.3492	0.1339	0.2976	-0.5354%	5.7141%	5.5239%
τ^c	0.3402	0.1299	0.2897	-3.1055%	2.5105%	2.7064%
s^{tr}	0.3345	0.1293	0.2849	-4.7340%	2.0760%	0.9966%

Note: y^k, y^w and y^b stand for the net income of the capitalist, the private worker and the public employee respectively in steady state. The values of y^k, y^w and y^w in status quo steady state are 0.3511, 0.1267 and 0.2820 respectively.

Table 7: Relative net income of the private worker and the public employee to that of the capitalist in new steady state and their percentage change from the status quo steady state

Residual Instrument	New steady state		% Changes from staus quo steady state	
	y^w/y^k	y^b/y^k	y^w/y^k	y^b/y^k
τ^π	0.3739	0.8293	3.6184%	3.2362%
τ^y	0.3835	0.8522	6.2831%	6.0919%
τ^c	0.3818	0.8515	5.7959%	5.9982%
s^{tr}	0.3866	0.8516	7.1484%	6.0154%

Note: y^k, y^w and y^b stand for the net income of the capitalist, the private worker and the public employee respectively in steady state. The values of y^w/y^k and y^b/y^k in status quo steady state are 0.3608 and 0.8033 respectively.

Table 8: Present value of output (GDP) over different time horizons after debt consolidation when the residual instrument in the new reformed steady state is the tax rate on income(τ^y).

Adj.Instr.	$\widetilde{y}_5$	$\widetilde{y}_{10}$	$\widetilde{y}_{20}$	$\widetilde{y}_{40}$	$\widetilde{y}_{60}$	$\widetilde{y}_{80}$	$\widetilde{y}_\infty$
τ^π	1.2902	2.4385	4.3662	7.0965	8.8085	9.8832	11.5853
τ^y	1.2862	2.4339	4.3613	7.0915	8.8035	9.8781	11.5803
τ^c	1.2903	2.4390	4.3673	7.0978	8.8099	9.8846	11.5868
s^{tr}	1.2921	2.4410	4.3692	7.0997	8.8117	9.8864	11.5886
Status quo	1.2366	2.3375	4.1897	6.8204	8.4722	9.5094	11.1523

Note: $\widetilde{y}_t$ stands for the present value of output (GDP) for the next t periods after debt consolidation takes place.

Table 9: Ratio of the present value of the net income of private workers to that of capitalists over various time horizons after debt consolidation when the residual fiscal policy instrument in the new reformed steady state is the tax rate on income(τ^y).

Adj. Instr.	$\frac{\widetilde{y}^w_5}{\widetilde{y}^k_5}$	$\frac{\widetilde{y}^w_{10}}{\widetilde{y}^k_{10}}$	$\frac{\widetilde{y}^w_{20}}{\widetilde{y}^k_{20}}$	$\frac{\widetilde{y}^w_{40}}{\widetilde{y}^k_{40}}$	$\frac{\widetilde{y}^w_{60}}{\widetilde{y}^k_{60}}$	$\frac{\widetilde{y}^w_{80}}{\widetilde{y}^k_{80}}$	$\frac{\widetilde{y}^w_{\infty}}{\widetilde{y}^k_{\infty}}$
τ^π	0.4208	0.4078	0.3971	0.3916	0.3900	0.3893	0.3884
τ^y	0.4201	0.4073	0.3968	0.3914	0.3898	0.3891	0.3883
τ^c	0.4216	0.4079	0.3971	0.3915	0.3899	0.3892	0.3884
s^{tr}	0.4208	0.4073	0.3967	0.3913	0.3898	0.3891	0.3882
Status quo	0.3608	0.3608	0.3608	0.3608	0.3608	0.3608	0.3608

Note: $\widetilde{y}^k_t$ and $\widetilde{y}^w_t$ stand for the present value of the net income of capitalists and that of private workers respectively for the next t periods after debt consolidation takes place.

Table 10: Ratio of the present value of the net income of public employees to that of capitalists over various time horizons after debt consolidation when the residual fiscal policy instrument in the new reformed steady state is the tax rate on income (τ^y).

Adj. Instr.	$\frac{\widetilde{y}^b_5}{\widetilde{k}^u_5}$	$\frac{\widetilde{y}^b_{10}}{\widetilde{y}^k_{10}}$	$\frac{\widetilde{y}^b_{20}}{\widetilde{y}^k_{20}}$	$\frac{\widetilde{y}^b_{40}}{\widetilde{y}^k_{40}}$	$\frac{\widetilde{y}^b_{60}}{\widetilde{y}^k_{60}}$	$\frac{\widetilde{y}^b_{80}}{\widetilde{y}^k_{80}}$	$\frac{\widetilde{y}^b_{\infty}}{\widetilde{y}^k_{\infty}}$
τ^π	0.9285	0.9014	0.8792	0.8680	0.8648	0.8634	0.8618
τ^y	0.9267	0.9002	0.8785	0.8676	0.8645	0.8631	0.8615
τ^c	0.9301	0.9015	0.8790	0.8678	0.8647	0.8633	0.8616
s^{tr}	0.9308	0.9017	0.8790	0.8679	0.8647	0.8633	0.8617
Status quo	0.8033	0.8033	0.8033	0.8033	0.8033	0.8033	0.8033

Note: $\widetilde{y}^b_t$ and $\widetilde{y}^w_t$ stand for the present value of the net income of capitalists and that of private workers respectively for the next t periods after debt consolidation takes place.

Table 11: Present values of the net income of the capitalist ($\widetilde{y}^k_t$), of the private worker ($\widetilde{y}^w_t$) and of the public employee ($\widetilde{y}^b_t$) over various time horizons (t) when the adjusting instrument in the transition is government transfers (s^{tr}) and the residual instrument in the new reformed steady state is the tax rate on income(τ^y).

	$t = 10$	$t = 20$	$t = 40$	$t = 80$	$t \to \infty$
$\widetilde{y}^k_t$	3.0041 (3.1691)	5.5163 (5.6803)	9.0780 (9.2470)	12.7066 (12.8928)	14.9222 (15.1203)
$\widetilde{y}^w_t$	1.2237 (1.1435)	2.1884 (2.0497)	3.5525 (3.3367)	4.9438 (4.6522)	5.7935 (5.4560)
$\widetilde{y}^b_t$	2.7086 (2.5457)	4.8488 (4.5630)	7.8784 (7.4281)	10.9697 (10.3566)	12.8578 (12.1460)

Note: The values of the corresponding variables in the status quo are in parentheses.

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