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by

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The impact of the lockdown on the Greek economy and the role of the Recovery Fund[1]

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Abstract

This paper, using a microfounded macroeconomic model that embeds the key features of the Greek economy, tries to quantify the impact of lockdown measures taken to control the spread of the pandemic and various fiscal rescue packages provided to cushion the impact of the economic hit. The paper attempts to give quantitative answers to questions like: What will be the size and duration of the economic downturn? What are implications of national fiscal packages? What will be the role of the resources coming from the European Recovery Fund? Our results imply that the policy rescue packages adopted so far are helpful but, for the Greek economy to enter an era of sustainable growth, a mix of policies is needed that combines: (i) a growth-enhancing tax-spending policy mix (ii) further product market liberalization (iii) a substantial improvement in institutional quality and (iv) associated with (iii), a socially productive use of the resources coming from the Recovery Fund.

JEL classification: O4, H6, E02.

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1 Introduction

In the beginning of 2020, the world was stricken by the covid-19 shock which, due to its high infectivity, forced most governments to take strict containment measures (lockdown) to control the spread of the pandemic. The latter have limited economic activity and have resulted in a severe economic downturn worldwide. To make things worse, a public finance crisis is expected to follow as most governments have stepped in and new unprecedented rescue packages have been adopted in an effort to tackle the health crisis and cushion the impact of the economic downturn. Besides, as is widely recognized (see e.g. European Commission (2020a)), although the shock is symmetric hurting almost all countries, its effects are uneven depending, except from the severity of the pandemic and the stringency of the containment measures in each country, on how the shock propagates in each economy, initial conditions and the way each country responds to the economic downturn.

Greece is not an exception. The Greek government, in an effort to stem the pandemic, has decided an extended lockdown of economic activity which has reversed the growth dynamics of the Greek economy. Actually, the pandemic struck Greece when it was starting to embark on a moderate growth path after many years of depression; as is well known, Greece lost around 25% of its GDP during its sovereign debt crisis in 2009-2016. Moreover, the pandemic found Greece with limited fiscal space; its public debt was already around 180% of GDP in the end of 2019 and most of it is in the hands of EU institutions. However, as a member of the European Union (EU) and the Eurozone (EZ), Greece can benefit from financial support from the European Commission (EC) and the European Central Bank (ECB) and in particular from the redistributive transfers of the newly established Recovery Fund (see European Commission (2020b)). If the plan of the Recovery Fund goes ahead, Greece will benefit up to a net amount of 32 billion euros mainly in the form of grants; this translates to around 17% of the Greek GDP in 2019 and should be used by the end of 2024.

The above facts raise (at least) four interrelated questions: First, what will be the depth and the length (i.e. the size and duration) of the new crisis in Greece? Second, what are the implications of the lockdown measures and the national fiscal rescue packages taken by the Greek government? Can these policies help? Third, what will be the role of the resources coming from the Recovery Fund? How much can they help? Last, what are the distributional implications of all this? In this paper, we will try to provide quantitative answers to these questions.[1]

[1] We will focus on the economic crisis only (namely, the effects of lockdown measures and the associated fiscal responses to get the economy moving again). We leave aside the health crisis that includes how the epidemic affects people's health and the public health system, how the infection spreads, etc. For epidemiology models used in economics, see e.g. Eichenbaum et al. (2020).

The vehicle of analysis will be a medium-scale micro-founded macroeconomic model of a small open economy participating in a currency union. In addition to a number of frictions commonly used by the quantitative macroeconomic literature, the model incorporates, in an attempt to mimic the Greek economy, a rather detailed public sector including public employees as a separate income group, problems of institutional quality that trigger socially unproductive activities, and aid from the EU.[2] Here, we also assume that, during 2020, workers and employees are forced to reduce their work hours and, at the same time, private firms can sell a fraction of their output only; these assumptions are in accordance with most lockdown measures taken in response to rising covid-19 infections (see e.g. European Commision (2020b) and World Economic Outlook (2020a, 2020b)).

Our main results are as follows. Departing from the year 2019, and assuming a rather moderate value for the adverse labor supply shock and the restriction imposed on private firms' sales, our simulations show that in 2020, and in the fictional case of no fiscal policy reaction, the Greek economy could have suffered an output loss of more than 18% relative to 2019 and the public debt to GDP ratio could have jumped to around 212%. This shows the big vulnerability of the Greek economy to supply shocks even of relatively small magnitude. Fiscal rescue packages, on the other hand, can mitigate the economic damage. For example, responding with higher public spending and lower taxes, as the Greek government has already done or has announced to do, can make the recession milder (the output loss is now around 12% in 2020) and the rise in the public debt to GDP ratio smaller (it is now around 205%) thanks to the crowding in effects of fiscal help. The same simulations show that the expected financial assistance from the EU, via the official fiscal aid from the Recovery Fund (as said, the latter is estimated to be around 32 billion euros for Greece), can seriously help the Greek economy, although this depends crucially on the way it is used. If it is used, for example, to finance government purchases from the private sector, it will limit the output loss to around 11.2% in 2020 and will also put the country on a sustainable path with public debt to GDP falling to around 176% in the coming years thanks to enhanced growth dynamics. If, on the other hand, this financial assistance becomes a common pool for rent seeking which in turn distorts individual incentives and misallocates resources,[3] it

[2] The model used here is similar to that in Economides et al. (2020). However, although the model is similar, the focus of that paper was on the Greek sovereign debt crisis in the 2010s and especially on the fiscal role played by the ECB. See below for further details.

[3] A prerequisite of rent seeking is an institutional failure in the form of poorly defined and protected property rights (see e.g. Drazen (2000, chapter 10)). It is this failure that allows private and/or public assets to become common pools or contestable prizes, which, in turn, incentivise self-interested agents (with the right connections) to participate in a Tullock-type rent seeking competition. All this results in a misallocation of resources so that the society incurs productivity and welfare losses. See below for modeling details and the related literature. For the key importance of property rights among other measures

will be completely wasted, the GDP will be as if the country has received zero aid from the EU and the country will be trapped in a bad equilibrium in the coming years. Product market liberalization and improvements in institutional quality (both much below EU averages at the moment) will also be crucial for the quick recovery of the Greek economy. Finally, our simulations show that the big losers from the pandemic crisis are the private workers since their labour earnings are expected to suffer more than that of public employees.

Therefore, similarly to the lessons learnt from the sovereign debt crisis of the previous decade,[4] a different spending-tax policy mix, product market liberalization, an improvement in institutional quality and a socially productive use of the redistributive resources made available by the EU, can help the Greek economy, not only to overcome the pandemic with the minimum possible output losses, but also to achieve higher medium-term economic growth and a lower public debt-to-GDP ratio over time. Reversing the argument, if the same mistakes made during the sovereign debt crisis of the previous decade are repeated (anti-growth policy mix combined with a sharp deterioriation in institutional quality), Greece will enter a new phase of deep economic depression.

Related literature and how we differ The burst of the pandemic has triggered a new and expanding literature that tries to identify the economic effects of the pandemic shock and the policy measures adopted. For instance, in a volume edited by Baldwin and di Mauro (2020), researchers investigate how different aspects of economic activity are expected to be affected by the pandemic; Mckibbin and Fernando (2020) present possible scenarios regarding the macroeconomic implications of covid-19; Baker et al. (2020a) focus on the uncertainty induced by the pandemic; Pestieau and Ponthiere (2020) and Hellwig et al. (2020) examine the design of optimal policy actions in a pandemic; Coibion et al. (2020) focus on the impact of the lockdown on macroeconomic expectations and consumer spending; Fornaro and Wolf (2020) focus on the possibility of stagnation traps induced by pessimistic animal spirits; Guerrieri et al. (2020) argue that negative supply shocks can cause demand shortages; Auray and Eyquem (2020) examine the effects of lockdown in an average euro-area country; Keogh-Brown et al. (2020) and Birch (2020) investigate the impact on the UK economy; Eichenbaum et al. (2020), Atkeson (2020), Ludvigson et al. (2020), Baek et al. (2020) and Baker et al. (2020b), among many others, investigate the effects of the pandemic on the US economy.

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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. For data on institutional quality in Greece relative to other EU countries, see e.g. Papaioannou (2016), Masuch et al. (2018) and Kollintzas et al. (2018); Greece scores very poorly in almost all indices.

[4] See e.g. Economides et al. (2020) and the references therein.

Our paper is the first attempt, as far as we know, to quantify the impact of lockdown on the Greek economy under various fiscal rescue policy scenaria and does so by using a micro-founded general equilibrium model that embeds the key features of the Greek economy before the pandemic. Perhaps more importanlty, it is also the first attempt to quantify the contribution of the European Recovery Fund to an EU member-country suffering from weak fundamentals in general and poor institutional quality in particular. As is shown here, and as is known from the literature on foreign aid, institutional quality is crucial to the way foreign manna-from-heaven funds are used and whether they are actually beneficial in equilibrium.[5]

The remainder of the paper is organized as follows. The model is presented in section 2. Parameterization, data and solution for the year 2019 are in section 3. Section 4 introduces the polciy scenarios studied. Section 5 presents results. Section 6 closes the paper. An appendix contains details.

2 Model

In this section, we construct a micro-founded macroeconomic model in order to study the impact of the lockdown on the Greek economy. We start with an informal description of the model.[6]

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 real and nominal 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 include 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.

[5]See e.g. Drazen (2000) for a review of the literature. Foreign aid has an obvious beneficial direct effect on the recipient country but, if the latter exhibits poor institutions, the possibility of extraction from foreign transfers may push individuals (with the right connections) away from productive work to rent seeking activities, and this hurts the aggregate economy. There is thus a negative indirect effect so that the net effect from aid becomes an empirical matter (see e.g. Svensson (2000) and Economides et al. (2008)).

[6]As said, the model is similar to that in Economides et al. (2020) 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.

(2020) 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 between the global financial crisis of 2008 and 2019).

In what follows, we briefly 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 so 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 The 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 goods and can also make use of productivity-enhancing public goods/services that enter the private production function as an externality. There are also capital good firms that produce the capital used by intermediate goods firms. Any profits generated by private firms are distributed to private sector employees who, as said, own them. 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 and consumption) 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 and the most common way of modeling the latter has been to assume that private and/or communal properties become "common pools".[7] 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 redistributive contest. In addition, when we study the possible effects of funds received by the Recovery Fund, we also investigate the case in which these funds become part of the common pool. Our measure of the degree of property rights will be set as in the data, while the rent-seeking technology is introduced in subsection 2.2.1.

Modelling the lockdown Although there are many ways in which the pandemic can trigger an economy downturn, here we assume that the drop of economic activity is triggered by an adverse labor supply shock as well as by a restriction imposed on private firms' sales. The former captures the effect of the covid-19 shock on employment; this has happened through compulsory lockdown but also through absenteeism, sickness and precautionary behavior as people have reacted to the health risk by reducing their work hours. The latter can be justified on the grounds that most of government measures included a compulsory, full or partial, shut down of private firms. Therefore, we assume, first, that households' labor supply is restricted in the sense that they can supply only a fraction $0 < \Phi_{1,t} \leq 1$ of the labor supply that they would have supplied in the absence of the pandemic other things equal (see also e.g. Eichenbaum et al. (2020)) and, second, that private firm's sales are restricted in the sense that they can sell only a fraction $0 < \Phi_{2,t} \leq 1$ of the product that they would have sold in the absence of the lockdown other things equal.[8] The restriction on the labor

[7] See e.g. Persson and Tabellini (2000, chapter 14), Drazen (2000, chapters 8 and 10), Hillman (2009, chapter 2), Besley and Ghatak (2010), Grossman (2001) and Acemoglu and Robinson (2019) for common-pool problems, weak property rights and extraction.

[8] We report that we have experimented with additional shocks and distortive effects from covid-19, like ad hoc cuts in consumption, etc. The economic damage becomes worse. We use the two specific shocks only because, first, we believe that they can mimic rather realistically the main economic aspects of the lockdown and, second, because, as we shall see, they are enough, on their own, to generate a recession of a similar magnitude to that predicted by most international institutions like the European Commission (2020a, 2020b).

supply causes (among other things) a cut in labor incomes. The restriction on private firms' sales causes (among other things) a fall in the demand for labour and capital as well as in profits/dividends distributed. As we shall see, these shocks, propagated via the various channels of our model, can lead to a severe economy-wide downturn accompanied by a sharp deterioration in public finances. Details are in subsections 2.2, 2.3 and 4.1.

Details will be provided as we present each building block of the above described model. Before we proceed, we wish to make a remark about unemployment. By assuming market-clearing in the labor market(s), any fall in the real economic activity is obviously reflected in a fall in hours of work rather than in unemployed people. We report that this is just for simplicity and our main results do not change by the inclusion of unemployed people (see the discussion in Economides et al. (2020) for modeling details).

2.2 Households

As said, there are three distinct types of households, 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 define $n^k \equiv \frac{N^k}{N}$, $n^w \equiv \frac{N^w}{N}$ and $n^b \equiv \frac{N^b}{N} = 1 - n^k - n^w$. For simplicity, total population and its decomposition to the three groups is exogenous and kept constant over time; we also assume 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 receive their profits, purchase government bonds and can 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 utility function:

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

where $0 < \mu_1$, μ_2, μ_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.

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 anti-social or rent seeking activities.

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

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

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

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

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 $t+1$),[9] w_t^k is the real wage rate paid to capital owners, $\pi_{k,t}^i$ 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 the tax rates on consumption and income. Also, as said above, $0 < \Phi_{1,t} < 1$ measures the degree of restriction imposed by the lockdown on work hours.

The last term on the RHS of (3b) is the amount extracted by each k from the common pool. Given 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

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

fraction of it, PR_tY_t, remains in the hands of its 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 anti-social activities employed by him/her relative to total anti-social activities. That is, $0 < PR_t \leq 1$ is the degree of protection of property rights and 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. Regarding the rent-seeking technology, as in e.g. Dixit (2004, chapter 5) and Hillman (2009, chapter 2), the power coeffcient, γ, is between 0 and 1 and measures how quickly diminishing returns arise in anti-social activities, while the parameter Γ^k measures the efficacy of k's aggresion. Both are measures of the technology of fighting. If Γ^k increases and/or γ decreases, agent k has a stronger incentive to devote effort time to rent seeking. Note that this specification, 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.[10]

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

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

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,[11] $N_t^k f_{k,t}$ 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 total 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 constraints in (3a-3b) and also the optimality conditions:

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

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

[10] See also e.g. Murphy et al. (1991), Hillman (2009, chapter 2), Esteban and Ray (2011), etc, while, quantitative DSGE models include Angelopoulos et al. (2009), Economides et al. (2020) and Christou et al. (2020).

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

$$\frac{(1+\tau^c_{t+1})c_{k,t+1}}{(1+\tau^c_t)c_{k,t}} = \beta(1+i^b_{t+1})\frac{p_t}{p_{t+1}} \tag{5c}$$

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

$$\times\psi^p\left[\frac{\frac{e_t p^*_t}{p_t}\left(N^k_t f_{k,t}+F^g_t\right)}{\frac{p^h_t}{p_t}Y_t}-\overline{f}\right]+\beta\frac{e_{t+1}p^*_{t+1}}{p_{t+1}}(1+i^*_{t+1})\frac{p^*_t}{p^*_{t+1}} \tag{5d}$$

$$\frac{c^h_{k,t}}{c^f_{k,t}} = \frac{\nu}{(1-\nu)}\frac{p^f_t}{p^h_t} \tag{5e}$$

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

$$p_t = (p^h_t)^\nu (p^f_t)^{1-\nu} \tag{5f}$$

2.2.2 Households as private workers

Private workers are employed by private firms. They consume, work and participate in rent-seeking activities.[12]

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

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

where variables are defined as above in the capital owners' problem if we replace the subscript k with the subscript w.

As above, we use the utility function:

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

and the consumption index:

$$c_{w,t} = \frac{(c^h_{w,t})^\nu (c^f_{w,t})^{1-\nu}}{\nu^\nu (1-\nu)^{1-\nu}} \tag{7}$$

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

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

[12] The assumption that 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 workers and public employees face higher costs.

and the budget constraint:

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

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

where w_t^w is the real wage rate of workers. Notice that, for simplicity, workers are assumed to have access to the same contestable prize as all other agents and to receive the same transfer paid by the government to 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 constraints in (8a-8b) and also:

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

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

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

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 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, the ulility function and the consumption index are:

$$u\left(c_{b,t},1-l_{b,t},h_{b,t};\overline{y}_t^g\right)=\mu_1\log c_{b,t}+\mu_2\log u_{b,t}+\mu_3\log\overline{y}_t^g$$

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

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

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

and the budget constraint:

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

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

where w_t^g is the real wage in the public sector while the rest of the variables are defined as in the worker's problem.

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.[13] The first-order conditions include the definition in (11), the constraints in (12a-12b) and also:

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

$$\frac{\mu_2}{(1-l_{b,t}-s_{b,t})}=\left(\frac{\mu_1}{(1+\tau_t^c)c_{b,t}}\right)\left(\frac{\gamma\Gamma^b(s_{b,t})^{\gamma-1}(1-PR_t)Y_t}{n^p\Gamma^p(s_{p,t})^\gamma+n^b\Gamma^b(s_{b,t})^\gamma}\right) \qquad (13b)$$

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

2.3 Private firms and production of private goods

Private firms are owned by capital owners. Following most of the related literature, there are three types of goods produced by three associated types of firms. There is a single domestic final good produced by competitive final good firms. There are also differentiated intermediate goods used as inputs for the production of the final good. Each differentiated intermediate good is produced by an intermediate goods 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. The essential role is played by intermediate goods firms.

2.3.1 Final good firms

There are N^h final good firms indexed by subscript $h=1,2,...,N^h$. For notational simplicity, we will set $N^h=N^k$, that is, the number of final good firms equals the number of their owners.

[13] 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.

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 $i = 1, 2, ..., N^i_t$ 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 profits:

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

where p^h_t is the price of the final good and $p^h_{i,t}$ is the price of intermediate good i.

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

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

which in turn implies from the zero-profit condition:

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

2.3.2 Intermediate goods firms

There are N^i intermediate goods firms indexed by the subscript $i = 1, 2, ..., N^i$. Since they are owned and managed by capital owners, we again set $N^i = N^k$ for notational simplicity.[14]

The gross profit of each i, denoted as $\pi^{gross}_{i,t}$, is sales minus the wage bill minus the cost of imported goods minus adjustment costs associated with changes in capital:

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

[14] These firms are modelled as in e.g. Miao (2014, chapter 14) and Uribe and Schmitt-Grohe (2017, chapter 4). On the other hand, see Economides et al. (2020) for a richer (corporate finance) problem of these firms.

where $l^{w}_{i,t}$ is labor services provided by workers and used by firm i, $l^{k}_{i,t}$ is labor services provided by capital owners and used by i, $m^{f}_{i,t}$ is imported goods used by each 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. Finally, as said above, firms can appropriate only a fraction, $0 < PR_t \leq 1$, of their output because of insecure property rights.

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

$$\pi^{gross}_{i,t} \equiv RE_{i,t} + \tau^{\pi}_{t} \left(\Phi_{2,t} PR_t \frac{p^h_{i,t}}{p_t} y^h_{i,t} - w^w_t l^w_{i,t} - w^k_t l^k_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t} \right) + \pi_{i,t} \tag{16b}$$

where $RE_{i,t}$ is retained earnings, $0 \leq \tau^{\pi}_{t} < 1$ a 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:

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

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

$$\pi_{i,t} \equiv (1-\tau^{\pi}_{t}) \left[\Phi_{2,t} PR_t \frac{p^h_{i,t}}{p_t} y^h_{i,t} - w^w_t l^w_{i,t} - w^k_t l^k_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t} \right] -$$

$$- \frac{p^h_t}{p_t} \left[k_{i,t} - (1-\delta) k_{i,t-1} \right] - \frac{p^h_t}{p_t} \frac{\xi^k}{2} \left(\frac{k_{i,t}}{k_{i,t-1}} - 1 \right)^2 k_{k,t-1} \tag{17}$$

For the firm's production function, we adopt the form:

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

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

Therefore, each firm i maximizes the discounted sum of dividends distributed to its owners:

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

where, since firms are owned by capital owners, we will ex post postulate that the firm's discount factor, $\beta_{i,t}$, equals the capitall owners' marginal rate of substitution between consumption at t and $t+1$, $\beta_{i,t} \equiv \frac{\beta(1+\tau_t^c)c_{k,t}}{(1+\tau_{t+1}^c)c_{k,t+1}}$.[15]

The firm chooses $\{l_{i,t}^w,\, l_{i,t}^k,\, m_{i,t}^f,\, k_{i,t}\}_{t=0}^{\infty}$ to maximize its stream of dividends or net profits, as defined in (16) and (17), subject to the production function in (18) and the inverse demand function for its product coming from the final good firm's problem. The first-order conditions for $l_{i,t}^k$, $l_{i,t}^w$, $m_{i,t}^f$, $k_{i,t}$ are respectively:

$$w_t^k = \Phi_{2,t} PR_t \theta_t \frac{p_t^h}{p_t} \frac{(1-\sigma)(1-\alpha)A^k y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{20a}$$

$$w_t^w = \Phi_{2,t} PR_t \theta_t \frac{p_t^h}{p_t} \frac{(1-\sigma)(1-\alpha)A^w y_{i,t}^h}{(A^k l_{i,t}^k + A^w l_{i,t}^w)} \tag{20b}$$

$$\frac{p_t^f}{p_t} = \Phi_{2,t} PR_t \theta_t \frac{p_t^h}{p_t} \frac{(1-\sigma)\alpha y_{i,t}^h (1-\chi^p)(m_{i,t}^f)^{op-1}}{\left[\chi^p (k_{i,t-1})^{op} + (1-\chi^p)(m_{i,t}^f)^{op}\right]} \tag{20c}$$

$$\frac{p_t^h}{p_t}\left[1 + \xi^k \left(\frac{k_{i,t}}{k_{i,t-1}} - 1\right)\right] = \beta_{i,t} \frac{p_{t+1}^h}{p_{t+1}} [1 - \delta + (1-\tau_{t+1}^\pi)\Phi_{2,t+1} PR_{t+1}\theta_{t+1} r_{t+1}^k - \\ - \frac{\xi^k}{2}\left(\frac{k_{i,t+1}}{k_{i,t}} - 1\right)^2 + \xi^k \left(\frac{k_{i,t+1}}{k_{i,t}} - 1\right)\frac{k_{i,t+1}}{k_{i,t}}] \tag{20d}$$

2.3.3 Capital good firms

There are N^c capital good firms indexed by the subscript $c = 1, 2, ..., N^c$. Since they are owned by capital owners, we again set $N^c = N^k$ for notational simplicity. 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 aquire the depreciated capital stock, choose investment activity and sell the latter 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. Here, without capital adjustment costs, the first-order condition is simply $Q_t = 1$ as was assumed above. Also, the profit is zero in equilibrium.

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

2.4 State firms and production of public goods/services

We now model the way in which state enterprises produce the publicly provided good/service. There are N^g state firms indexed by the subscript $g = 1, 2, ..., N^g$ producing a 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 is in real terms:

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

where $l_{g,t}$ is labor services used by each state firm g, $g_{g,t}^g$ is goods purchased from the private sector by each g, $g_{g,t}^i$ is investment made by each g, and $m_{g,t}^g$ is imported goods used by each 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 goods imported from abroad, $m_{g,t}^g$, the parameter $og \geqslant 0$ measures the degree of substitutability between public capital and imported goods, the coefficients $0 < \theta_1$, θ_2, $1 - \theta_1 - \theta_2 < 1$ measure the shares of the associated factors in production and $A^g > 0$ is TFP in the public sector.

The stock of each state firm'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, $y_{g,t}^g$, 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 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 goods), as shares of GDP, are set as in the data. Specifically, we define $g_{g,t}^i = \frac{s_t^i n^k y_{i,t}^h}{n^b}$, $g_{g,t}^g = \frac{s_t^g n^k y_{i,t}^h}{n^b}$, $m_{g,t}^g = \frac{p_t^h}{p_t^f} \frac{s_t^m n^k y_{i,t}^h}{n^b}$ and $w_t^g = \frac{s_t^w \frac{p_t^h}{p_t} n^k y_{i,t}^h}{n^b l_{b,t}}$, where $n^b \equiv \frac{N^b}{N}$ is the fraction of public employees in population 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 goods and public wages; these values will be set according to the data (see subsection 3.1).

2.5 Fiscal and public financing policy

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 EU institutions like the ESM, other euro states and the ECB. 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 (2009-2018), most of the Greek public debt has changed hands and is now being held by the "EU" as part of Greece's various bailout programs (see subsection 3.1 below for data and Economides et al. (2020) for details).

In particular, in each time period, total public debt, 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:[16]

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

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

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

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 and 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 residually $\lambda_t^d = (1 - \lambda_t^g - \lambda_t^{eu})$.

2.5.2 Government budget constraint

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

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

[16] That is, if F_t^g denotes the nominal value of total public foreign debt expressed in foreign currency, $f_t^g \equiv \frac{F_t^g}{p_t^* N}$ 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, $n^b[w_t^g l_{g,t}^g+\frac{p_t^h}{p_t}(g_{g,t}^g+g_{g,t}^i)+\frac{p_t^f}{p_t}m_{g,t}^g]$ is the cost of state firms, $\psi^g(.)$ 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 tax revenues (defined right below). The rest of the terms capture interest payments on public debt where notice that the interest rates vary depending on the identity of the creditor. For instance, we assume that when the government borrows from the EU, it pays the constant world interest rate, i^*, only, while, when the government borrows from the (domestic and foreign) market, is 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 includes 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 (like the inclusion of Greek government bonds in the ECB's official Asset Purchasing Program which started after the termination of the Greek Economic Adjustment Program in 2018, the various types of support to Greek private banks, and, perhaps more importantly, the continuous issuance of TARGET2 liabilites vis-a-vis the Eurosysterm by the Greek National Central Bank).[17] 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 the transfer from the EU, tr_t^{eu}, as a share of the country's GDP, namely, $tr_t^{eu}=s_{eu,t}^{tr}\frac{p_t^h}{p_t}n^p y_{i,t}^h$ where $s_{eu,t}^{tr}$ is a policy variable.

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

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

where $\psi^g\geq 0$ is a transaction cost parameter associated with public borrowing from foreign markets.

Total tax revenues in real and per capita terms are:

[17] For details and data, see e.g. Economides et al. (2020).

$$\frac{T_t}{N} \equiv \tau_t^c[n^k(\frac{p_t^h}{p_t}c_{k,t}^h + \frac{p_t^f}{p_t}c_{k,t}^f) + n^w(\frac{p_t^h}{p_t}c_{w,t}^h + \frac{p_t^f}{p_t}c_{w,t}^f) + n^b(\frac{p_t^h}{p_t}c_{b,t}^h + \frac{p_t^f}{p_t}c_{b,t}^f)]$$
$$+\tau_t^y[n^k w_t^k \Phi_{1,t} l_{k,t} + n^w w_t^w \Phi_{1,t} l_{w,t} + n^b w_t^g \Phi_{1,t} l_{b,t}] +$$
$$\tau_t^\pi n^k \left[\Phi_{2,t} PR_t \frac{p_t^h}{p_t} y_{i,t}^h - w_t^k l_{i,t}^k - w_t^w l_{i,t}^w - \frac{p_t^f}{p_t} m_{i,t}^f\right] \tag{28}$$

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):

$$\frac{p_t^f}{p_t}\left(n^k c_{k,t}^f + n^w c_{w,t}^f + n^b c_{b,t}^f + n^k m_{i,t}^f + n^b m_{g,t}^g\right) - \frac{p_t^h}{p_t} c_t^{f*} + (1+i_t^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t} n^k f_{k,t-1} +$$
$$+(1+i_t^b)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^g d_{t-1} + (1+i^*)\frac{p_{t-1}^*}{p_t^*}\frac{e_t p_t^*}{p_t}\frac{p_{t-1}}{e_{t-1}p_{t-1}^*}\lambda_{t-1}^{eu} d_{t-1} +$$
$$+\frac{p_t^h}{p_t}\frac{\psi^p}{2}\left[\frac{\frac{e_t p_t^*}{p_t}\left(n^k f_{k,t} + \lambda_t^g d_t\right)}{\frac{p_t^h}{p_t} n^k y_{i,t}^h} - \overline{f}\right]^2 n^k y_{i,t}^h +$$
$$+\frac{p_t^h}{p_t}\frac{\psi^g}{2}\left[\frac{\frac{e_t p_t^*}{p_t}\left(n^k f_{k,t} + \lambda_t^g d_t\right)}{\frac{p_t^h}{p_t} n^k y_{i,t}^h} - \overline{f}\right]^2 n^k y_{i,t}^h = \frac{e_t p_t^*}{p_t} n^k f_{k,t} + \lambda_t^g d_t + \lambda_t^{eu} d_t + tr_t^{eu} \tag{29}$$

where, as said above, being a kind of foreign aid, tr_t^{eu} also appears in the country's resource constraint.

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 private agents can borrow from abroad, i_t^*, is public debt-elastic. In particular, we use the functional form:

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

where ψ^* 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 Solution steps and methodology

Market-clearing conditions and the final macroeconomic system are presented in detail in the Appendix. The system consists of 43 equations in 43 endogenous variables. This is given the paths of the exogenously set variables and initial conditions (see the Appendix for a list of endogenous and exogenous variables).

In the next sections, we will parameterize the model, present the data used and in turn solve the system numerically. In particular, our quantitative analysis will consist of the following steps. First, after presenting parameter values and Greek data, we will get a stationary solution using data of the year 2019. As we shall see, this solution can match reasonably well the main features of the data before the eruption of the pandemic crisis in Greece and can thus serve as a departure point in what follows. This will be in section 3. In turn, departing from the the year 2019, we will feed the model with the lockdown shocks, $\Phi_{1,t}$ and $\Phi_{2,t}$, and quantify the implications of various actual and fictional policy scenaria. In our solutions, we assume that all this is common knowledge so that we solve the model under perfect foresight using a Newton-type non-linear method implemented in DYNARE.

3 Parameters, data and solution for the year 2019

In subsection 3.1, we will present parameter values and introduce the data used for the specification of the exogenous variables. Then, subsection 3.2 will present the stationary solution of the model when we use data for the year 2019 (this was the last year before the burst of the pandemic).

3.1 Parameter values and exogenous policy variables

Regarding structural parameters for technology and preferences, for most of them, we will use commonly employed values, while the rest will be calibrated on the basis of Greek data. Parameter values are listed in Table 1. We report at the outset that our main results are robust to changes in these baseline parameter values at least within reasonable ranges.

Starting with preference parameters, the private agents' time discount factor, β, is set at 0.99. The weights given to private consumption and leisure, μ_1 and μ_2 in households' utility function, are set respectively at 0.40 and 0.55, while the remaining, 0.05, goes to utility-enhancing public goods/services; these values produce work hours, etc, within usual ranges. The degree of preference of home goods over foreign goods, ν, is set at the neutral value of 0.5; this value also contributes to delivering reasonable ratios of home to foreign goods in households' consumption spending.

Continuing with technology parameters, in the production function of private goods, the exponent of labor, $1-\alpha$, is set at 0.6, while, the rest,

$a = 0.4$, is the exponent of the CES term that includes capital and imported goods. In the same production function, the contribution of productivity-enhancing public goods/services to private production, σ, is set at 0.1. The work productivity parameters of capital owners and workers in the private good production function, A^k and A^w, are set at 3 and 1 respectively; this difference produces a skilled wage premium within usual ranges. In the private firm's production function, the parameter measuring the intensity of capital vis-a-vis imported goods, χ^p, as well as the parameter measuring the substitutability between capital and imported goods, op, are both set at 0.5; the same value of 0.5 is used for χ^g and og in the state firm's production function. Also in the state firms' production function, the Cobb-Douglas exponents of public capital and public employment, θ_1 and θ_2, are set respectively at 0.3045 and 0.6, which correspond to payments for public investment and public wages, expressed as shares of total public payments to all inputs used in the production of public goods, as they are in the data; in turn, the Cobb-Douglas exponent of goods purchased from the private sector, $1 - \theta_1 - \theta_2$, follows residually. Both private and public capital depreciation rates, δ and δ^g, are set at 0.05. Similarly, both TFP parameters (in the private and in the public sector production functions) are normalized at 1 (note that public sector efficiency, and why it may differ from private sector efficiency, is crucial but is not an issue in this paper). In the baseline simulations, the Dixit-Stiglitz parameter capturing imperfect competition in product markets, θ, is set at 0.775, which produces a profit ratio around 7% in the case without structural reforms. When we study structural reforms, the same parameter will be assumed to increase gradually up to 0.8 (see e.g. Eggertsson et al. (2014) for evidence in the core and periphery of the eurozone). In the rent-seeking technology, the power coefficient is set at 0.5, which is common across all types of agents, 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.

The transaction cost parameters associated with capital changes in the firm's problem, ξ^k, is set at 0.3. The two transaction cost parameters associated with private and public participation in the foreign capital market, ψ^p and ψ^g, are set at 0.5. The risk premium parameter in the debt-elastic interest rate rule, ψ^*, is set at 0.01; this belongs to usual ranges and also produces a foreign debt to GDP ratio as in the data when the crisis erupted. The fixed world interest rate, i^*, is set at 1%. The two parameters in the function of exports, Ω and ϑ, are set at 0.5 and 2 respectively; these values contribute to producing a trade deficit close to the data. The threshold values of public debt and foreign debt as shares of GDP, above which problems start, are set at 1.1 and 0.3 respectively which are values close to those in Reinhart and Rogoff (2009). The population fractions of public employees, n^b, private workers, n^w, and capitalists or self-employed, n^k, are set at 0.2, 0.6 and 0.2 respectively as in the data.

Table 1
Baseline parameterization

Finally, to solve the model, we also need data for the exogenous variables, like policy instruments and institutional quality, for the year 2019. Regarding spending-tax policy instruments, using data from Eurostat and our own calculations, we set s_t^i, s_t^g, s_t^m, s_t^w, s_t^{tr}, τ_t^c, τ_t^y and τ_t^π, which denote respectively the GDP shares of government spending on investment, goods purchased from the private sector, imported goods, public wages, transfers, as well as the tax rates on consumption, income and corporate profits, at 0.022, 0.077, 0.03, 0.117, 0.207, 0.225, 0.354 and 0.29 respectively. The fractions of Greek public debt in the hands of the EU and foreign agents/banks, λ_t^{eu} and λ_t^g, as modeled in subsection 2.5.1 above, are set at 0.7087 and 0.1596 respectively as in the 2019 data.[18] The aid received from the EU expressed as share of the Greek GDP, $s_{eu,t}^{tr}$, as modeled in subsection 2.5.2 above, is 0.083; this is the value that follows from the government budget constraint when we set all the fiscal and public financing variables as above and, at the same time, target the public debt to GDP ratio as in the data in 2019. Regarding the value of the index for the enforcement of property rights in Greece in 2019, PR_t, we set it at 0.536. This index has been constructed as the average of three sub-indices: "the rule of law", "regulatory quality" and "political stability and absence of violence/terrorism", which are three variables commonly used for the construction of a measure of property rights protection (the data, which have been rescaled from 0 to 1, are from the World Governance Indicators).[19] All these values are also included in Table 1.

3.2 Solution for the year 2019

Using the parameter values listed in Table 1 and data of the year 2019, the stationary solution of the model is reported in Table 2 (we include some key variables only). In this solution, variables do not change (so it can be thought as the "trend" of the Greek economy after its sovereign debt crisis and before the burst of the new pandemic crisis) and all exogenous variables have been set as in the data of the year 2019. Note that, in this solution, the policy variable that adjusts residually to close the goverment budget constraint is public debt with all other policy variables set as explained above.

As can be seen, this solution is in line with data in 2019 and can thus provide a reasonable departure for the policy scenaria studied in the next

[18] For detailed data on Greek public debt and its holders since the eruption of the global financial crisis, see Economides et al. (2020).

[19] For details, see Economides et al. (2020) and Christou et al. (2020).

sections. In particular, the solution does a relatively good job at mimicking the position of the country in the international capital market, as well as the consumption-investment behavior of the private sector.

Table 2
Solution for the year 2019

This solution mimics the Greek economy just before 2020. It will serve as a departure in what follows.

4 Modelling the lockdown, feedback reaction to debt and policy scenaria assumed

In this section, we first model the two lockdown shocks, $\Phi_{1,t}$ and $\Phi_{2,t}$, needed to trigger the ongoing economic downturn. In turn, we add a feedback policy rule typically needed for dynamic stability. Finally, we define the policy scenaria (factual and fictional) we will focus on. Results will be presented in the next section.

4.1 Modeling of the lockdown shocks

We assume that $\Phi_{1,t}$ and $\Phi_{2,t}$ take the value of 0.85 during the year 2020 and then evolve according to the AR(1) processes:

$$\Phi_{1,t} = \Phi^{1-\gamma^{\phi_1}} \Phi_{1,t-1}^{\gamma^{\phi_1}} \tag{31a}$$

$$\Phi_{2,t} = \Phi^{1-\gamma^{\phi_2}} \Phi_{2,t-1}^{\gamma^{\phi_2}} \tag{31b}$$

where γ^{ϕ_1} and γ^{ϕ_2} are persistence parameters chosen so as the impact of the lockdown on economic activity to weaken gradually, without any government reaction, within four-five years, whereas the constant parameter Φ takes the value of 1 which is the value that $\Phi_{1,t}$ and $\Phi_{2,t}$ would have had in the absence of lockdown-type policies.

4.2 Feedback policy rule in the transition

Dynamic stability typically requires at least one of the exogenously set fiscal policy instruments to react to the gap between the public debt to GDP ratio and a target value. Here, without loss of generality, we assume that this role is played by the ratio of redistributive funds coming from the EU, $s_{eu,t}^{tr}$. In particular, along the transition, we use the feedback policy rule:

$$s_{eu,t}^{tr} = s_{eu}^{tr} - \gamma^{tr} \left(\frac{d_t}{\frac{p_t^h}{p_t} n^p y_{i,t}^h} - d^* \right) \tag{32}$$

where s_{eu}^{tr} is the value in the departure 2019 year (which is 0.083), γ^{tr} is a feedback policy coefficient and d^* is a target value of the public debt to output ratio. In our numerical solutions, we set γ^{tr} at 0.2 (which is within usual ranges in the literature; see e.g. Philippopoulos et al. (2017)) and d^* at its departure 2019 value. We report that our results are not sensitive to these assumptions.

4.3 Policy scenaria assumed

We distinguish between policy responses (factual and fictional) at national and at EU level

4.3.1 Policy scenaria at national level

Scenario 1 (S1) Under (S1), the government, during 2020, makes a lump-sum transfer to all households. This transfer covers the reduction in all labor incomes caused by the pandemic shock. That is, we allow for lump-sum transfers in the budget constraints of both private and public sector agents, denoted as $g_{k,t}^{cov}$, $g_{w,t}^{cov}$and $g_{p,t}^{cov}$ respectively, that compensate their members for the loss of labor income due to the lockdown. That is, in equilibrium,

$$g_{k,t}^{cov} = (1 - \tau_t^y) w_t^k (1 - \Phi_{1,t}) l_{k,t} \tag{33a}$$

$$g_{w,t}^{cov} = (1 - \tau_t^y) w_t^w (1 - \Phi_{1,t}) l_{w,t} \tag{33b}$$

$$g_{b,t}^{cov} = (1 - \tau_t^y) w_t^g (1 - \Phi_{1,t}) l_{b,t} \tag{33c}$$

Scenario 2 (S2) On top of (S1), during 2020, we assume that the government also provides a subsidy to private firms in an attempt to increase their demand for labor. Specifically, we assume that the government subsidizes the labor cost by 5% (the latter is consistent with announcements made by the Greek government).

Scenario 3 (S3) On top of (S2), during 2020, the government also increases temporarily by 1 percentage point public investment and government purchases from the private sector as shares to GDP.

Scenario 4 (S4) On top of (S3), during 2020, it is assumed that the government also cuts temporarily by 1 percentage point the tax rates on income and consumption and, at the same time, reduces permanently the profit tax rate by 3 percentage points (the latter has already been announced by the Greek government).

Before proceeding, it is worth making two points. First, all the above policy changes will be financed by adjustements in the end-of-period public debt. Second, among all the above mentioned scenaria, we believe that that the one closer to reality is (S4), since the Greek government has already adopted, or has promised to adopt, a set of policy measures which include, among others, transfers to households and firms, increases in public spending in general and tax reductions or discounts. (S1)-(S3) however can help us to understand the effect of one policy measure at a time.

4.3.2 Help from the European Recovery Fund and extra policy scenarios

In addition to the above responses, the Greek government can benefit from resources coming from the newly established European Recovery Fund, whose aim, as said in the Introduction, will be to raise money from private markets and then allocate it to member-countries depending on how much they have been hurt by the covid-19 pandemic. In particular, Greece could benefit up to a net amount of around 32 billion euros mainly in the form of grants. This amount translates into around 17% of the Greek GDP in 2019, and should be used by the end of 2024. In terms of modeling, we simply add this amount as an extra revenue item to the budget constraint of the government and in turn to the country's balance of payments. Therefore, in an attempt to quantify the effects of this new financial assistance from the EU, in addition to scenaria (S1)-(S4), which had to do with policy reactions at national level, we will also investigate the following four scenaria all of which incorporate this EU assistance to our model:

Scenario 5 (S5) In (S5), on top of the policy measures included in (S4), which will serve as the benchmark, we assume that the Greek government uses the 32 extra billion euros from the EU to finance public investment, $g^{i}_{g,t}$, over the years 2021-2024 (we assume that one fourth of the total amount is used for this purpose each year).

Scenarios 6 (S6) Scenario (S6) is a variation of (S5) in the sense that the Greek government uses the 32 extra billion euros from the EU to finance government purchases from the private sector, $g^{g}_{g,t}$, over the years 2021-2024 (again we assume that one fourth of the total amount is used for this purpose each year).

Scenario 7 (S7) In this scenario, on top of (S5)-(S6), we assume that the country also implements stronger - and at a faster pace - reforms in the product market so as the degree of competition in the Greek product market approaches that in the core eurozone countries within three years. In particular, we assume that the Dixit-Stiglitz parameter of product substitutability increases gradually from 0.775 to 0.80. This attempts to capture the contribution of structural reforms, here in the form of stronger product market liberalization, to economic recovery.

(S5)-(S7) can give us an idea of the potential benefits from the the EU support when the country makes a "good" use of the money received.

Scenario 8 (S8) Finally, in scenario (S8), we go to the other extreme from (S5)-(S7). Now, instead of assuming that Greece uses the amount of 32 billion euros productively (namely, to finance public investment or other productive activities as well as to implement structural reforms), we assume that this amount is misused in the sense that it becomes a contestable prize and that atomistic economic agents compete with each other for a share of this contestable prize. We do so because there is a lot of anecdotal, as well as econometric, evidence that, in countries with weak institutions, like Greece, foreign aid transfers increase the size of the prize that interest groups fight over and hence induce rent seeking activities that mitigate the beneficial effects that foreign aid may have in the first place (see also the discussion in the Introductory section above). Our model with Tullock-type rent seeking competition, as developed in section 2 above, can naturally accommodate this possibility. We simply add the amount of 32 billion euros (one fourth of it in each year from 2021 to 2024) to the contestable prize, $(1 - PR_t)Y_t$, that already exists (see equations (3b), (8b) and (12b) and the associated first-order conditions for rent seeking).

5 Results and policy lessons

This section reports the implications of the above shocks and policy scenaria.

5.1 Aggregate effects

Departing from 2019, Graph 1 illustrates the simulated path of GDP when the economy is hit by the covid-19 shocks in 2020 under (S1). In this scenario, Φ_{1t} and $\Phi_{2,t}$ take the value of 0.85 and 0.85 respectively in 2020 and then return to 1 according to (27a)-(27b). As can be seen in Graph 1, in this scenario, the economy loses more than 18% of its output relatively to 2019. To make it worse, the economy does not manage to rebound in the years after, in the sense that GDP remains below its 2019 level. These results show the big vulnerability of the Greek economy to supply shocks even of relatively small magnitude. They also imply that government intervention is more than necessary.

Graph 1
Economic impact of the lockdown under (S1)
(% deviation of output from its 2019 value)

Graph 2 presents the simulated paths of public debt to GDP ratio under (S1). The ratio exceeds 212% in 2020 due mainly to the snowball effect on GDP. However, as said, all this is without any policy reaction, which once implemented, is expected to limit the economic damage of GDP and the rise in the public debt to GDP ratio. We now turn to policy reactions.

Graph 2
Public debt to GDP (%) under (S1)

In Graph 3, we investigate whether the various policy measures and/or reforms, defined as scenaria (S2), (S3) and (S4) above, can mitigate the economic damage from the lockdown. In particular, if, on top of compensating all income groups for their labor income losses, the government also provides a subsidy to private firms in an attempt to encourage an increase in labour demand (this is (S2)) the recession in 2020 gets milder amounting to a drop of about 15.1% instead of about 18% which was the case under (S1). On the other hand, again, although the economy is expected to grow after 2020, its GDP cannot return to its 2019 level in the coming years. If, on top of (S2), the government also increases temporarily (in 2020) all government spending items by 1 percentage point (this is (S3)), the recession in 2020 gets even milder amounting to a drop of about 14.1% instead of 18% which was the case under (S1). On the other hand, again, although the economy is expected to grow from 2021 ownwards, its GDP cannot return to its 2019 level in the coming years. Putting these results together, reacting with public spending instruments only can produce an incomplete and gradual (U-shaped) recovery only. If now increases in government spending are accompanied by temporary cuts of 1 percentage point in the tax rates on income and consumption and a permanent decrease of the profit taxe by 3 percentage points (this is (S4)), then the aggregate situation gets relatively better although the main picture remains as above: the GDP falls by 12% in 2020 and partially rebounds after 2020.

Graph 3
Economic impact of the lockdown under (S1)-(S4)
(% deviation of output from its 2019 value)

Graph 4 presents the simulated paths of public debt to GDP under (S2)-(S4). For example, the adoption of policy measures, such as the ones described in (S4), can limit the increase of the public debt to GDP ratio to about 204.5%, relative to about 212% in (S1), despite the increased fiscal cost implied by the expansionary tax-spending measures included in (S4); this is thanks to the smaller output loss that this scenario produces. In all cases, however, the public debt to output ratio de-escalates after the impact year as the economy rebounds, athough at different paces depending on the specific scenario assumed.

Graph 4
Public debt to GDP (%) under (S1)-(S4)

Next, Graph 5 presents the simulated paths of output under scenaria (S5), (S6), (S7) and (S8) as defined above. In particular, under (S5)-(S6), the output loss in 2020 is limited to about 11.3% and 11.2% respectively; recall that, according to this scenario, the Greek government has at its disposal extra 32 billion euros from the EU all of which is assumed to be used to finance either public investment (in (S5)) or government purchases from the private sector (in (S6)) and are allocated equally over the years 2021-2024. Moreover, in these two scenaria, in the years after 2020, the GDP is well above its pre-crisis 2019 level. In turn, if the spending and tax policy measures, included in (S5)-(S6), are complemented by the implementation of stronger product market reforms so as the associated degree of competition approaches that in the core eurozone countries (this is (S7)), the output loss is limited to 10.5% in 2020, and the economy enjoys even stronger growth in the years after. Finally, the black line in Graph 5, illustrates the path of GDP under (S8) which is the "misuse" scenario. Now, as defined above, the 32 billion package plays the role of a common pool attacked by rent seekers. This scenario, in addition to a huge waste of resources, condemns the country to economic stagnation and, in terms of GDP, it is as if the country has received no international aid (actually the time path of GDP under (S8) is worse than that under (S4)).

Graph 5
Economic impact of the lockdown under (S5)-(S8)
(% deviation of output from its 2019 value)

Finally, Graph 6 presents the simulated paths of public debt to GDP ratio under scenaria (S5)-(S8). In particular, in the period 2022, the public debt to output ratio falls to about 174.6% under the best possible scenario (S7) and reaches 179% under (S8) respectively (despite the misuse of the EU funds under (S8) there is still a relief of public finances since most of these funds are in the form of grants). In other words, economic growth can help the country to grow out its public debt. By contrast, under the misuse scenario (S8), the public debt ratio remains higher (than in 2019) during the coming years.

Graph 6
Public debt to GDP (%) under (S5)-(S8)

5.2 Distributional effects

Our solutions also allow us to quantify the distributional implications of the aggregate output loss during the pandemic. Recall that we have three distinct income groups in the model, called capital owners or capitalists, private workers and public employees, as modeled in subsection 2.2 above. Since capital owners enjoy income from various other sources apart from work, such as income from government bonds, foreign assets and dividends, we focus on the distributional implications of the pandemic for private workers and public sector employees whose only difference is their employment status. Graph 7 depicts the simulated path of the private worker's to public employee's labour earnings ratio over the period 2019-2024 under (S4) which, as said above, is the scenario closer to reality at least at the moment of writing this paper. The path is derived by using the model's solution into the expressions for labour earnings of these two types of households as in subsection 2.2.

Graph 7
Distributional implications under (S4)
(% deviation of worker's to public employee's labour income ratio from its 2019 value)

Inspection of Graph 7 reveals that, after an improvement on impact possibly due to the measures taken, the labour income gap between private workers and public sector employees becomes wider. That is, as is perhaps expected, the relative losers from the pandemic are those working in the private sector.

6 Closing the paper

In this paper, using a DSGE model including the key features of the Greek economy, we tried to quantify the impact of the economic lockdown due to the covid-19 pandemic. We did so under various policy scenaria. Our analysis was not limited only to impact effects in 2020, but we also tried to capture the growth prospects in the years after the pandemic.

Our main message is that for the Greek economy to enter an era of sustainable economic growth capable of not only mitigating but also overcoming the adverse consequences of the covid-19 crisis in the near future, a mix of coherent and consistent policies is needed that combines: (i) a growth-enhancing tax-spending fiscal policy mix (ii) further product market liberalization (iii) an improvement in institutional quality and the protection of property rights in particular and (iv), associated with (iii), a socially productive use of the redistributive resources provided by the EU. Otherwise, with high probability, the Greek economy is in danger of being trapped in a new long-lasting depression similar to that experienced during the sovereign debt crisis of the previous decade.

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Appendix: The macroeconomic system

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

Households (the three types)

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

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

$$\frac{\mu_2}{(1-l_{k,t}-s_{k,t})} = \left(\frac{\mu_1}{(1+\tau^c_t)c_{k,t}}\right)\left(\frac{\gamma\Gamma^k(s_{k,t})^{\gamma-1}(1-PR_t)\Phi_{2,t}\frac{p^h_t}{p_t}n^k y^h_{i,t}}{n^k\Gamma^k(s_{k,t})^{\gamma}+n^w\Gamma^w(s_{w,t})^{\gamma}+n^b\Gamma^b(s_{b,t})^{\gamma}}\right) \tag{S3}$$

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

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

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

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

$$\begin{aligned}(1+\tau^c_t)\left(\frac{p^h_t}{p_t}c^h_{w,t}+\frac{p^f_t}{p_t}c^f_{w,t}\right) &= (1-\tau^y_t)w^w_t\Phi_{1,t}l_{w,t}+ \\ +\overline{g}^{tr}_t &+ \frac{\Gamma^w(s_{w,t})^{\gamma}(1-PR_t)\Phi_{2,t}\frac{p^h_t}{p_t}n^k y^h_{i,t}}{n^k\Gamma^k(s_{k,t})^{\gamma}+n^w\Gamma^w(s_{w,t})^{\gamma}+n^b\Gamma^b(s_{b,t})^{\gamma}}\end{aligned} \tag{S8}$$

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

$$\frac{\mu_2}{(1-l_{w,t}-s_{w,t})} = \left(\frac{\mu_1}{(1+\tau_t^c)c_{w,t}}\right)\left(\frac{\gamma\Gamma^w(s_{w,t})^{\gamma-1}(1-PR_t)\Phi_{2,t}\frac{p_t^h}{p_t}n^k y_{i,t}^h}{n^k\Gamma^k(s_{k,t})^\gamma + n^w\Gamma^w(s_{w,t})^\gamma + n^b\Gamma^b(s_{b,t})^\gamma}\right) \tag{S10}$$

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

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

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

$$+\overline{g}_t^{tr} + \frac{\Gamma^b(s_{b,t})^\gamma(1-PR_t)\Phi_{2,t}\frac{p_t^h}{p_t}n^p y_{i,t}^h}{n^k\Gamma^k(s_{k,t})^\gamma + n^w\Gamma^w(s_{w,t})^\gamma + n^b\Gamma^b(s_{b,t})^\gamma} \tag{S13}$$

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

$$\frac{\mu_2}{(1-l_{b,t}-s_{b,t})} = \left(\frac{\mu_1}{(1+\tau_t^c)c_{b,t}}\right)\left(\frac{\gamma\Gamma^b(s_{b,t})^{\gamma-1}(1-PR_t)\Phi_{2,t}\frac{p_t^h}{p_t}n^p y_{i,t}^h}{n^k\Gamma^k(s_{k,t})^\gamma + n^w\Gamma^w(s_{w,t})^\gamma + n^b\Gamma^b(s_{b,t})^\gamma}\right) \tag{S15}$$

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

Price indexes

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

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

Private firms in a symmetric equilibrium

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

$$w_t^k = \Phi_{2,t}PR_t\theta_t\frac{p_t^h}{p_t}\frac{(1-\sigma)(1-\alpha)A^k y_{i,t}^h}{A^k l_{i,t}^k + A^w l_{i,t}^w} \tag{S20}$$

$$w_t^w = \Phi_{2,t} PR_t \theta_t \frac{p_t^h}{p_t} \frac{(1-\sigma)(1-\alpha) A^w y_{i,t}^h}{l_{i,t}} \tag{S21}$$

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

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

$$\frac{p_t^f}{p_t} = (1 - \tau_t^\pi) \Phi_{2,t} PR_t \theta \frac{p_t^h}{p_t} \frac{(1-\sigma) \alpha y_{i,t}^h (1 - \chi^p)(m_{i,t}^f)^{op-1}}{\left[\chi^p (k_{i,t-1})^{op} + (1 - \chi^p)(m_{i,t}^f)^{op}\right]} \tag{S23}$$

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

$$\pi_{i,t} \equiv (1 - \tau_t^\pi) \left[\Phi_{2,t} PR_t \frac{p_t^h}{p_t} y_{i,t}^h - w_t^k l_{i,t}^k - w_t^w l_{i,t}^w - \frac{p_t^f}{p_t} m_{i,t}^f\right] -$$

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

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

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

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

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

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

$$n^k c^h_{k,t} + n^w c^h_{w,t} + n^b c^h_{b,t} + n^k x_{k,t} + n^b (g^g_{g,t} + g^i_{g,t}) + c^{f*}_t +$$

$$+ n^k \frac{\xi^k}{2}\left(\frac{k_{p,t}}{k_{p,t-1}} - 1\right)^2 k_{k,t-1} = \Phi_{2,t} n^k y^h_{i,t} \tag{S29}$$

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

Balance of payments (economy's resource constraint)

$$\frac{p^f_t}{p_t}\left(n^k c^f_{k,t} + n^w c^f_{w,t} + n^b c^f_{b,t} + n^k m^f_{i,t} + n^b m^g_{g,t}\right) - \frac{p^h_t}{p_t} c^{f*}_t + (1+i^*_t)\frac{p^*_{t-1}}{p^*_t}\frac{e_t p^*_t}{p_t} n^k f_{k,t-1} +$$

$$+(1+i^b_t)\frac{p^*_{t-1}}{p^*_t}\frac{e_t p^*_t}{p_t}\frac{p_{t-1}}{e_{t-1}p^*_{t-1}}\lambda^g_{t-1} d_{t-1} + (1+i^*)\frac{p^*_{t-1}}{p^*_t}\frac{e_t p^*_t}{p_t}\frac{p_{t-1}}{e_{t-1}p^*_{t-1}}\lambda^{eu}_{t-1} d_{t-1} +$$

$$+\frac{p^h_t}{p_t}\frac{\psi^p}{2}\left[\frac{\frac{e_t p^*_t}{p_t}\left(n^k f_{k,t} + \lambda^g_t d_t\right)}{\frac{p^h_t}{p_t} n^k y^h_{i,t}} - \overline{f}\right]^2 n^k y^h_{i,t} +$$

$$+\frac{p^h_t}{p_t}\frac{\psi^g}{2}\left[\frac{\frac{e_t p^*_t}{p_t}\left(n^k f_{k,t} + \lambda^g_t d_t\right)}{\frac{p^h_t}{p_t} n^k y^h_{i,t}} - \overline{f}\right]^2 n^k y^h_{i,t} = \frac{e_t p^*_t}{p_t} n^k f_{k,t} + \lambda^g_t d_t + \lambda^{eu}_t d_t \tag{S30}$$

Tax revenues

$$\frac{T_t}{N} \equiv \tau^c_t[n^k(\frac{p^h_t}{p_t}c^h_{k,t} + \frac{p^f_t}{p_t}c^f_{k,t}) + n^w(\frac{p^h_t}{p_t}c^h_{w,t} + \frac{p^f_t}{p_t}c^f_{w,t}) + n^b(\frac{p^h_t}{p_t}c^h_{b,t} + \frac{p^f_t}{p_t}c^f_{b,t})]$$

$$+\tau^y_t[n^k w^k_t \Phi_{1,t} l_{k,t} + n^w w^w_t \Phi_{1,t} l_{w,t} + n^b w^g_t \Phi_{1,t} l_{b,t}] +$$

$$\tau^\pi_t n^p \left[\Phi_{2,t} PR_t \frac{p^h_t}{p_t} y^h_{i,t} - w^k_t l^k_{i,t} - w^w_t l^w_{i,t} - \frac{p^f_t}{p_t} m^f_{i,t}\right] \tag{S31}$$

Exports

$$c^{f*}_t = \Omega\left(\frac{p^h_t}{p^f_t}\right)^{-\vartheta} \tag{S32}$$

Fiscal variables

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

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

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

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

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

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

Country's interest rate

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

Market-clearing conditions in labor and dividend markets

$$N^k \Phi_{1,t} l_{k,t} = N^i l_{i,t}^k \tag{S40}$$

$$N^w \Phi_{1,t} l_{k,t} = N^i l_{i,t}^w \tag{S41}$$

$$N^b \Phi_{1,t} l_{b,t} = N^g l_{g,t} \tag{S42}$$

$$N^k \pi_{k,t} = N^i \pi_{i,t} \tag{S43}$$

Endogenous and exogenous variables We therefore have a dynamic system of 43 equations, (S1)-(S43), in 43 endogenous variables. The latter are the paths of $\{c_{k,t}, c_{k,t}^h, c_{k,t}^f\}_{t=0}^{\infty}$, $\{c_{w,t}, c_{w,t}^h, c_{w,t}^f\}_{t=0}^{\infty}$, $\{c_{b,t}, c_{b,t}^h, c_{b,t}^f\}_{t=0}^{\infty}$, $\{l_{k,t}, l_{w,t}, l_{b,t}\}_{t=0}^{\infty}$, $\{s_{k,t}, s_{w,t}, s_{bt}\}_{t=0}^{\infty}$, $\{f_{k,t}, \pi_{k,t}\}_{t=0}^{\infty}$, $\{y_{i,t}^h, l_{i,t}^k, l_{i,t}^w, k_{i,t}, x_{i,t}, m_{i,t}^f, \pi_{i,t}, w_t^k, w_t^w\}_{t=0}^{\infty}$, $\{y_{g,t}^g, l_{g,t}, k_{g,t}^g\}_{t=0}^{\infty}$, $\{p_t, p_t^h, p_t^f, i_t^b, i_t^*\}_{t=0}^{\infty}$, $\{w_t^g, g_{g,t}^g, g_{g,t}^i, \bar{g}_t^{tr}, m_{g,t}^g\}_{t=0}^{\infty}$, $\{\frac{T_t}{N}\}_{t=0}^{\infty}$, $\{c_t^{f*}\}_{t=0}^{\infty}$ and $\{d_t\}_{t=0}^{\infty}$ and $\{Tr_t^{eu}\}_{t=0}^{\infty}$. This is given the paths of the fiscal instruments, $\{\tau_t^c, \tau_t^y, \tau_t^{\pi}, s_t^w, s_t^g, s_t^i, s_t^{tr}, s_t^m, s_{eu,t}^{tr}\}_{t=0}^{\infty}$, the fractions of public debt held by private agents abroad and the EU, $\{\lambda_t^g, \lambda_t^{eu}\}_{t=0}^{\infty}$, 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, $\{e_t\}_{t=0}^{\infty}$, the degree of product market competition, $\{\theta_t\}_{t=0}^{\infty}$, and the restrictions imposed on economic activity due to the pandemic $\{\Phi_{1,t},\ \Phi_{2,t}\}$.

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 $\frac{e_t}{e_{t-1}} = 1$); 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	0.5
μ_1	weight of consumption in utility	0.4
μ_2	weight of leisure in utility	0.55
β	time discount factor	0.99
δ	depreciation rate of priv capital	0.05
δ^g	depreciation rate of pub capital	0.05
ψ^p	transaction cost in foreign capital market (priv)	0.5
ψ^g	transaction cost in foreign capital market (pub)	0.5
A^p	TFP in private sector's production function	1
A^g	TFP in public sector's production function	1
A^k	Capital owners' labour productivity	3
A^w	Private workers' labour productivity	1
$1-\alpha$	share of labor in private production	0.6
σ	contribution of public output to private production	0.1
θ_1	share of capital and imports in public production	0.3045
θ_2	share of labor in public production	0.6
χ^p	intensity of priv capital relative to imports (priv)	0.5
op	substitutability between capital and imports (priv)	0.5
χ^g	intensity of pub capital relative to imports (pub)	0.5
og	substitutability between capital and imports (pub)	0.5
ξ^k	capital adjustment cost parameter	0.3
γ	measure of returns in anti-social activities	0.5
ψ^*	country's interest-rate premium parameter	0.01
Γ^k	efficiency of cap owners' anti-social activity	1
Γ^w	efficiency of priv workers' anti-social activity	0.3
Γ^b	efficiency of publ employees' anti-social activity	1.3
Ω	constant in the function of exports	0.5
ϑ	exponent in the function of exports	2
$\overline{f}$	threshold value of external debt to output	0.8

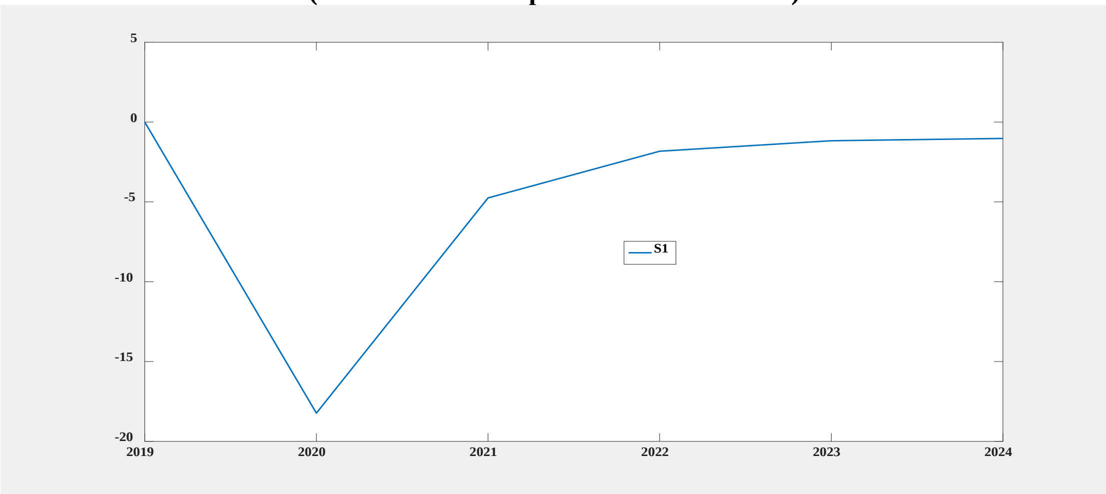
Table 1 cont.
Baseline parameterization

Parameter	Description	Value
i^*	constant term of world interest rate	0.01
θ	substitutability between intermediate goods	0.775
n^k	share of cap owners in population (data)	0.2
n^w	share of priv workers in population (data)	0.6
n^b	share of pub employees in population (data)	0.2
s_t^i	public investment (% GDP)	0.022
s_t^g	government purchases from the private sector (% GDP)	0.077
s_t^m	government spending on imports (% GDP)	0.03
s_t^w	public wage bill (%GDP)	0.117
s_t^{tr}	government transfers (% GDP)	0.207
τ_t^c	consumption tax rate	0.225
τ_t^y	income tax rate	0.354
τ_t^π	tax rate on corporate profits	0.29
$s_{eu,t}^{tr}$	transfer from EU (% GDP)	0.083
λ_t^{eu}	share of total debt held by EU institutions	0.7087
λ_t^g	share of total debt held by foreign investors	0.1596
PR_t	index of property rights	0.536

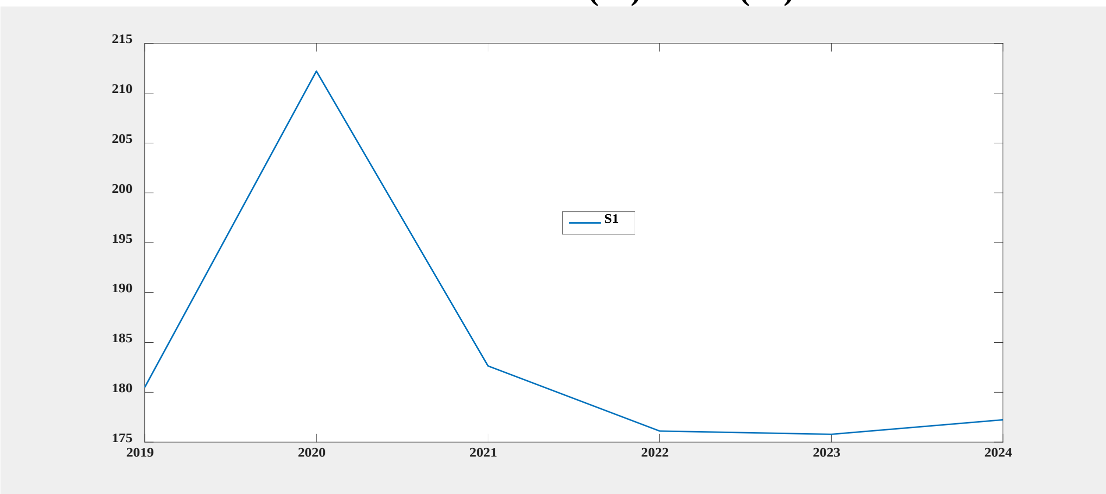
Table 2
Main variables in the solution for year 2019

Variable	Description	Solution	Data
c/y	Consumption/ouput (%)	83.5	76.1
inv/y	Investment/output (%)	13.3	13.1
f/y	Foreign debt/output (%)	155.9	155
b/y	Public debt/output (%)	180.5	180.5
c_k	consumption of capital owner	0.224	–
c_w	consumption of private worker	0.069	–
c_b	consumption of public employee	0.210	–
l_k	work hours of capital owner	0.079	–
l_w	work hours of private worker	0.159	–
l_b	work hours of public employee	0.117	–
s_k	capital owner's effort time allocated to anti-social activities	0.112	–
s_w	private worker's effort time allocated to anti-social activities	0.090	–
s_b	public employee's effort time allocated to antisocial activities	0.169	–
le_w/le_b	priv to pub worker ratio of labour earnings	0.456	–

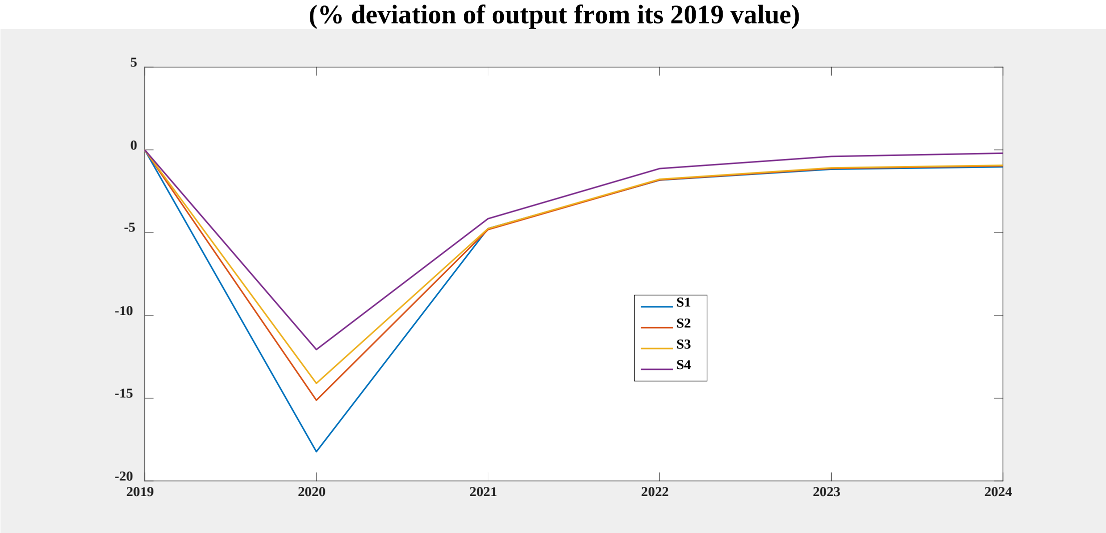
Graph 1
Economic impact of the lockdown under (S1)
(% deviation of output from its 2019 value)



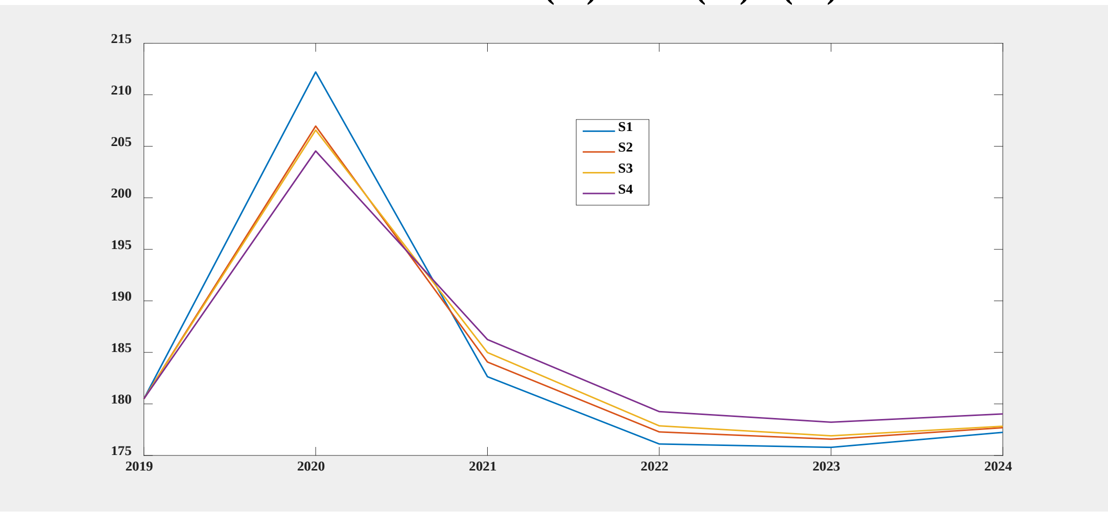
Graph 2
Public debt to GDP (%) under (S1)



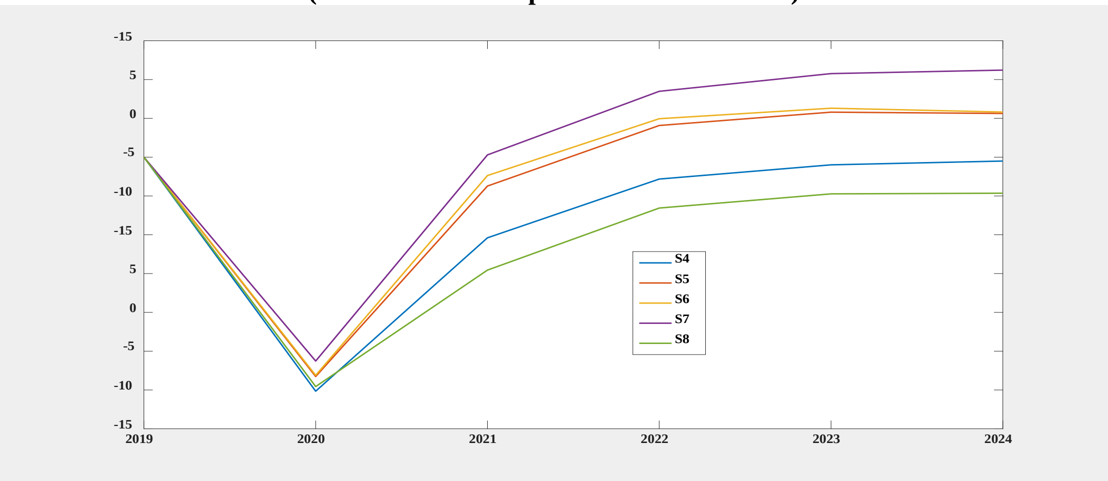
Graph 3
Economic impact of the lockdown under (S1)-(S4)
(% deviation of output from its 2019 value)



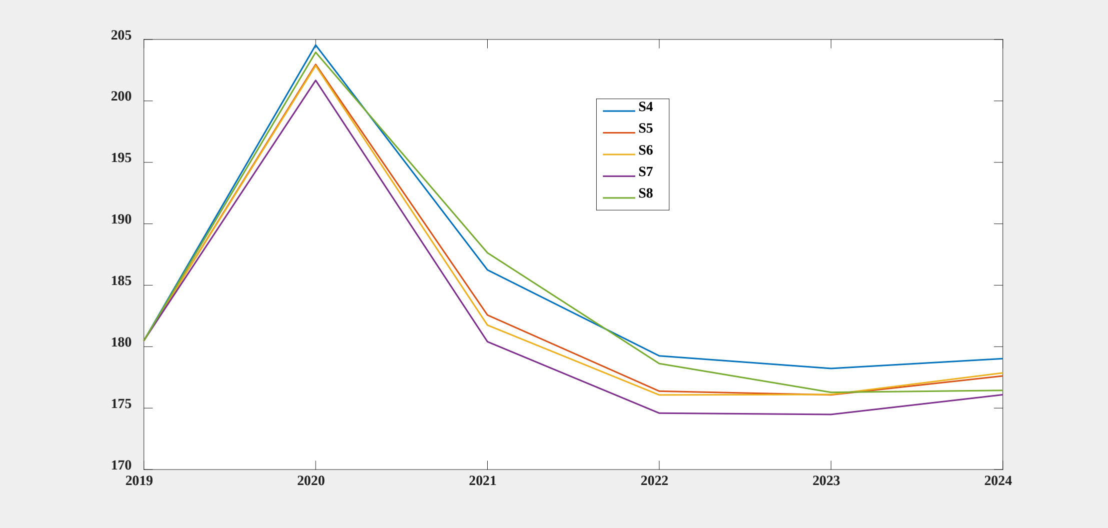
Graph 4
Public debt to GDP (%) under (S1) – (S4)



Graph 5
Economic impact of the lockdown under (S5)-(S8)
(% deviation of output from its 2019 value)



Graph 6
Public debt to GDP (%) under (S5) – (S8)



Graph 7
Distributional implications under (S4)
(% deviation of worker's to public employee's labour income ratio from its 2019 value)