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RENT-SEEKING COMPETITION FROM STATE COFFERS IN GREECE: A CALIBRATED DSGE MODEL

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ABSTRACT

We incorporate an uncoordinated redistributive struggle for extra fiscal privileges and favors into an otherwise standard dynamic stochastic general equilibrium model. Our aim is to quantify the extent of rent seeking and its macroeconomic implications. The model is calibrated to Greek quarterly data over 1961:1-2005:4. Our work is motivated by the rich and distorting tax-spending system in Greece, as well as the common belief that interest groups compete with each other for fiscal privileges at the expense of the general public interest. We find that (i) the introduction of rent seeking moves the model in the right direction vis-à-vis the data (ii) an important fraction of GDP is extracted by rent seekers (iii) there can be substantial welfare gains from reducing rent seeking activities.

Keywords: Fiscal policy, rent seeking, welfare.
JEL classification: E62, E32, O17.

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1. Introduction

Rent seeking is defined as the socially costly pursuit of winning a contestable prize or a monopoly rent. When self-interested individuals are involved in rent seeking activities, their private returns come from redistribution of wealth from others rather than from wealth creation, and so the aggregate economy stagnates. This is a common-pool, prisoners' dilemma situation.[1]

Rent seeking occurs mainly through the public sector. The monopoly rent that the government creates - via coercive taxation, regulation, etc - generates a prize worth pursuing (see e.g. Hillman, 2003, chapter 6). Then, focusing on rent seeking through the public sector, an important form is competition for higher subsidies and transfers, lower taxes and other extra fiscal privileges. This can be called rent-seeking competition from state coffers.

In this paper, we incorporate rent-seeking competition from state coffers into an otherwise standard dynamic stochastic general equilibrium (DSGE) model and calibrate it to the Greek economy over 1961:1-2005:4. Greece is particularly suitable for such an investigation as it has a rich and distorting tax-spending system (see e.g. Angelopoulos and Philippopoulos, 2007). It also scores poorly in international rankings of institutional quality (see e.g. the International Country Risk Guide (ICRG) index). Further, there is a lot of anecdotal evidence that interest groups (e.g. public sector trade unions, industrial associations, professional associations, even individuals with the right connections) compete with each other for privileges at the expense of the general "public interest".[2] We thus expect that rent seeking activities can contribute to explaining the post-war Greek experience in cycles and growth. We also aim to quantify the extent of rent seeking and its macroeconomic implications. A similar theoretical model has been calibrated to a representative Euro country by Angelopoulos et al. (2009).

A key feature of our model is that the state collects tax revenues to finance public goods and services, but each self-interested individual uses a part of his/her private

[1] See e.g. Tullock (1967, 1980), Krueger (1974), Becker (1983), Baumol (1990), Murphy et al. (1991) and Hillman and Ursprung (2000). For surveys of rent seeking, see Drazen (2000, chapter 8), Mueller (2003, chapter 15) and Hillman (2003, chapter 6).

[2] See Hillman (2003, chapter 6) for a discussion of "public" and "special" interests in this context.

resources to extract a fraction of that revenue for his/her own personal benefit.[3] The amount extracted by each individual is proportional to the private resources he/she allocates to rent seeking relative to aggregate resources allocated to rent seeking by all individuals. This redistributive struggle hurts the macro-economy both directly and indirectly: the direct effect arises because there are few resources available to finance public infrastructure and other socially useful services; the indirect effect arises because the possibility of extraction distorts individuals' incentives (before the successful rent seeker receives the prize) by pushing them away from productive work. The latter indirect effect is also known as "misallocation of talent" (see Murphy et al., 1991). Both effects reduce the prize that initiated the struggle in the first place. Nevertheless, although rent seeking is socially costly, it is rational from an individual point of view; this is a coordination problem.

We calibrate the above model to Greek quarterly data over the period 1961:1-2005:4. Our model does well in reproducing the key stylized facts of business cycles in the Greek economy. By stylized facts, we mean the volatility, persistence and co-movement of the main macroeconomic time series. Actually, the introduction of rent seeking activities moves the model in the right direction vis-à-vis the data. Then, there are three main results.

First, in the long run of our model economy, rent seekers grab 42.79% of total transfers which translate to 8.49% of GDP. In other words, privileged spending subsidies and tax treatments amount to 8.49% of output produced. This makes Greece the worst economy in the Euro area in terms of rent seeking magnitude (see Angelopoulos et al., 2009, for other euro countries).

Second, we shed some light on the key determinants of the degree of rent seeking activities. The latter depends of course on almost all exogenous variables and calibrated parameters. Focusing on a calibrated parameter that provides a measure of "institutional quality"[4], sensitivity long-run analysis reveals that further deteriorations in institutional

[3] See also e.g. Hillman and Ursprung (2000), Mohtadi and Roe (1998, 2003), Mauro (2004) and Park et al. (2005). In all these models, the "common pool" is (some type of) government assets.

[4] "Institutional quality" is measured by a calibrated technology parameter that translates individual rent-seeking efforts into actual extraction. In other words, this parameter measures the effectiveness of rent

quality will lead to substantial reductions in output. Specifically, the elasticity of output with respect to institutional quality is around 1 in the long run of our economy, which means that deterioration (resp. improvement) of institutional quality by say 2% will reduce (resp. increase) output by around 2%.

The third result is normative. We quantify the potential general equilibrium welfare gains from improvements in institutional quality. Applying a welfare criterion used frequently in micro-founded general equilibrium models (see e.g. Lucas, 1990), we find that even small improvements in institutional quality can result in substantial social welfare gains. For instance, an improvement of institutional quality by around 2% could raise long-term welfare by around 5%. This is a substantial gain relative to those typically found in the literature on policy reforms (see e.g. Lucas, 1990, and Cooley and Hansen, 1992).

The rest of the paper is organized as follows. Section 2 presents the theoretical model. A quantitative study is in sections 3 and 4. Welfare calculations are in section 5. Section 6 concludes and discusses limitations and extensions.

2. Theoretical model

2.1 Description of the model

The theoretical model is as in Angelopoulos et al. (2009). There is a large number of identical households and (for simplicity) an equal number of identical firms. Households own capital and labour and rent them to firms. They are also engaged in rent-seeking competition with each other for fiscal privileges.[5] Rent seeking can come at a

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seeking efforts. Improvements (resp. deteriorations) in institutional quality mean that ceteris paribus the same individual rent-seeking activities are translated into less (resp. more) actual extraction, which may reflect better (resp. worse) laws, legal systems, etc.

[5] We could assume that firms also rent seek like households. This is not important since households are firm-owners in this class of models. We could also assume that government officials (bureaucrats and politicians) rent seek. From the viewpoint of self-interest, government officials do not differ from other individuals so that by adding more types of rent-seeking individuals would not change our main results. On the other hand, if policy decisions are optimally chosen, introducing optimizing government officials - who choose inefficient policies and political favours in return for bribes, campaign contributions, political support, etc, where the latter are chosen by rent seeking private agents - would complicate the model considerably. Obviously, this is closely connected to lobbying and corruption, and the supply side of political favors in general. See the discussion in Hillman and Ursprung (2000, section 5).

private cost: it requires effort (i.e. non-leisure time) time.[6] Hence, in addition to consumption, leisure and saving, each household also chooses optimally how to allocate its non-leisure time between productive work and rent-seeking activities.[7] Firms produce a homogenous product by using capital, labour and public infrastructure. The government uses tax revenues and issues bonds to finance four activities: public consumption (that provides direct utility to households), public investment (that augments the stock of public infrastructure providing production externalities to firms), a uniform lump-sum transfer to each household and, finally, extra fiscal privileges to rent seekers.

Like in e.g. Becker (1983), we will focus on the demand side of rent seeking and its implications. The supply side of fiscal favors, e.g. why and how government officials and voters decide to offer these favors, and at what price, is not modeled. Thus, using the terminology of Hillman and Ursprung (2000, p. 204), the government is placed outside the population of rent seekers.

We now formalize this scenario. Before doing so, we give some examples of rent seeking competition from state coffers.

2.2 Examples of rent seeking from state coffers

One can distinguish two categories of rent seeking (not mutually exclusive). The first category includes privileged transfers, subsidies and tax treatments. For instance, there are direct transfers in cash (e.g. targeted subsidies and other benefits) and non-cash (e.g. private use of public assets like state cars, extra health services and child benefits, etc), as well as indirect transfers (e.g. measures that increase the demand for an interest group’s services). There are also measures that reduce tax burdens (e.g. tax exemptions and loopholes designed to favor special interests) coupled with a rise in the average tax rate to make up for the lost revenues. In addition to legal forms, there can also be illegal forms of rent seeking (e.g. tax evasion, theft of funds for public programs, use of fake documents to get a privileged treatment, etc).

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[6] Trade unionism, participation in strikes and demonstrations, lobbying, etc, are costly activities. In general, rent seeking (winning a contestable prize) requires the expenditure of private resources (time, money, or both).

[7] See also e.g. Krueger (1974), Murphy et al. (1991), Hillman and Ursprung (2000), Mauro (2004) and Park et al. (2005), where individuals decide how to allocate their time between work and rent seeking.

The second category of rent seeking includes privileged regulation and legislation that reduce competition (e.g. government-created barriers to entry, trade restrictions like tariffs and agricultural price supports), lead to disguised transfers (e.g. a public road may be planned to increase the value of certain pieces of real estate) or permit privileged avoidance of regulations intended to benefit the public. Again, there can be legal and illegal forms.

Obviously, this list is not exhaustive (see e.g. Tanzi, 1998, Mueller, 2003, chapter 15, and Hillman, 2003, chapter 6, for other examples). Although our setup is conceptually consistent with both categories, formally speaking, we model the first one.

2.3 Households

Each period t there are N_t identical households indexed by the superscript h, where $h = 1,2,...,N_t$. The population size, N_t, evolves at a constant rate $\gamma_n \geq 1$ so that $N_{t+1} = \gamma_n N_t$, where $N_0 > 0$ is given. The expected lifetime utility of household h is:

$$E_0 \sum_{t=0}^{\infty} \beta^{*t} u\left(C_t^h + \psi \bar{G}_t^c, L_t^h\right) \tag{1}$$

where E_0 denotes rational expectations conditional on the information set available at time zero, $0 < \beta^* < 1$ is a time discount factor, C_t^h is h's private consumption at time t, $\bar{G}_t^c$ is average (per household) public consumption goods and services provided by the government at t, and L_t^h is h's leisure time at t. Thus, public consumption goods and services influence private utility through the value of the parameter ψ (see e.g. Aschauer, 1985, and Christiano and Eichenbaum, 1992).

Concerning the instantaneous utility function, we use the form:

$$u(C_t^h + \psi \bar{G}_t^c, L_t^h) = \frac{\left((C_t^h + \psi \bar{G}_t^c)^{\mu} (L_t^h)^{1-\mu}\right)^{1-\sigma}}{1-\sigma} \tag{2}$$

where $0 < \mu < 1$ and $\sigma \geq 0$ are parameters.

Each household h saves in the form of capital, I_t^h, and government bonds, D_t^h. It receives interest income from capital, $r_t^k K_t^h$, and government bonds, $r_t^b B_t^h$, where r_t^k and r_t^b are respectively the gross returns to inherited capital and bonds, K_t^h and B_t^h. The household has one unit of time in each period and divides it between leisure, L_t^h, and effort, H_t^h; thus, $L_t^h + H_t^h = 1$ in each period. It further divides its effort time, H_t^h, between productive work, $\eta_t^h H_t^h$, and rent seeking activities, $(1-\eta_t^h)H_t^h$, where $0 < \eta_t^h \leq 1$ and $0 \leq (1-\eta_t^h) < 1$ denote respectively the fractions of non-leisure time that the household allocates to productive work and rent seeking; thus, $H_t^h = n_t^h H_t^h + (1-n_t^h)H_t^h$ in each period.[8] Finally, each household receives a share of profits, Π_t^h, and a share of lump sum government transfers, $\overline{G}_t^t$. Thus, the household's budget constraint is:

$$(1+\tau_t^c)C_t^h + I_t^h + D_t^h = (1-\tau_t^y)(r_t^k K_t^h + w_t Z_t \eta_t^h H_t^h + \Pi_t^h) + r_t^b B_t^h + \overline{G}_t^t + \frac{(1-\eta_t^h)H_t^h}{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}\theta_t R_t \tag{3}$$

where $0 \leq \tau_t^c < 1$ and $0 \leq \tau_t^y < 1$ are respectively consumption and income tax rates common to all agents,[9] w_t is the wage rate, Z_t is labour-augmenting technology common to all households that evolves at a constant rate $\gamma_z \geq 1$ so that $Z_{t+1} = \gamma_z Z_t$ where $Z_0 > 0$ is given**,** R_t denotes government tax revenue (specified below) and $0 \leq \theta_t < 1$ is the economy-wide degree of extraction (also specified below).

The budget constraint in (3) is standard except for the last term on its right-hand side. The idea behind this term is that, given a contestable prize denoted as $\theta_t R_t$, each self-interested agent attempts to extract a fraction of that prize, where the fraction depends on the amount of time and effort that an individual agent allocates to rent seeking relative to the time and effort allocated by all agents in the society. This is a

[8] Since both η_t^h and H_t^h are optimally chosen, this is equivalent to choosing how to allocate one's time to the three activities (leisure, productive work and rent seeking).
[9] We assume that returns on government bonds are not taxed.

widely-used rent seeking technology (see also e.g. Hillman and Ursprung, 2000, and Mueller, 2003, chapter 15), which is also similar to contest success functions used by the literature on property rights (see e.g. Hirshleifer, 1995). This standard model of rent seeking largely abstracts from institutional or political details.

Note that in (3) each household can receive both a uniform lump-sum (non-distorting) transfer and an extra (distorting) fiscal favour. The former reflects the idea that there are government programs independent of interest groups' pressure (this can be related to social and political norms). The latter depends on the effort individuals spend in rent seeking activities and reflects the idea that fiscal privileges are provided only if the beneficiaries of those privileges apply pressure.[10]

Private holding of government bonds evolves according to:

$$B_{t+1}^{h} = B_{t}^{h} + D_{t}^{h} \tag{4}$$

where the initial B_0^h is given.

Private holding of capital evolves according to**:**

$$K_{t+1}^{h} = (1-\delta^{p})K_{t}^{h} + I_{t}^{h} - \frac{\xi}{2}\left(\frac{K_{t+1}^{h}}{K_{t}^{h}} - \gamma_{n}\gamma_{z}\right)^{2} K_{t}^{h} \tag{5}$$

where the parameter $0<\delta^{p}<1$ is a depreciation rate, the initial K_0^h is given, and the parameter $\xi \geq 0$ captures internal adjustment costs on gross investment. This specification ensures that there are no adjustment costs in the long run (see below).

Each household h acts competitively by taking prices, policy and economy-wide variables as given.[11] Thus, each h chooses $\{C_t^h,\ H_t^h,\ \eta_t^h, K_{t+1}^h,\ B_{t+1}^h\}_{t=0}^{\infty}$ to maximize (1)-

[10] See e.g. Mueller (2003, chapter 21) and Hillman (2003, chapter 6) for interest groups, transfers and the size of the government. See also Persson and Tabellini (2000, chapter 7) for special-interest politics.

[11] Each individual h is small by taking economy-wide variables (θ_t, R_t and $\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h$) as given. We could alternatively assume that each h internalizes the effects of his/her own actions on aggregate outcomes by taking only the actions of other agents $j \neq h$ as given. This is not important regarding the features of a decentralized equilibrium. What is important is that there are (social) external effects.

(2) subject to (3)-(5), $L_t^h + H_t^h = 1$, $H_t^h = n_t^h H_t^h + (1-n_t^h) H_t^h$ and K_0^h, B_0^h given. The first-order conditions include the constraints and also:

$$\frac{\partial u_t(.)}{\partial L_t^h} = \frac{1}{(1+\tau_t^c)} \frac{\partial u_t(.)}{\partial C_t^h} \left[(1-\tau_t^y) w_t Z_t \eta_t^h + \frac{(1-\eta_t^h)}{\sum_{h=1}^{N_t} (1-\eta_t^h) H_t^h} \theta_t R_t \right] \tag{6a}$$

$$(1-\tau_t^y) w_t Z_t H_t^h = \frac{H_t^h}{\sum_{h=1}^{N_t} (1-\eta_t^h) H_t^h} \theta_t R_t \tag{6b}$$

$$\frac{1}{(1+\tau_t^c)} \frac{\partial u_t(.)}{\partial C_t^h} \frac{\partial I_t^h}{\partial K_{t+1}^h} = \beta^* E_t \left[\frac{1}{(1+\tau_{t+1}^c)} \frac{\partial u_{t+1}(.)}{\partial C_{t+1}^h} \left((1-\tau_{t+1}^y) r_{t+1}^k - \frac{\partial I_{t+1}^h}{\partial K_{t+1}^h} \right) \right] \tag{6c}$$

$$\frac{1}{(1+\tau_t^c)} \frac{\partial u_t(.)}{\partial C_t^h} = \beta^* E_t \left[\frac{1}{(1+\tau_{t+1}^c)} \frac{\partial u_{t+1}(.)}{\partial C_{t+1}^h} (1+r_{t+1}^b) \right] \tag{6d}$$

where

$$\frac{\partial I_t^h}{\partial K_{t+1}^h} = 1 + \xi \left(\frac{K_{t+1}^h}{K_t^h} - \gamma_n \gamma_z \right)$$

$$\frac{\partial I_{t+1}^h}{\partial K_{t+1}^h} = -(1-\delta^p) + \frac{\xi}{2} \left(\frac{K_{t+2}^h}{K_{t+1}^h} - \gamma_n \gamma_z \right)^2 - \xi \left(\frac{K_{t+2}^h}{K_{t+1}^h} - \gamma_n \gamma_z \right) \frac{K_{t+2}^h}{K_{t+1}^h}.$$

Condition (6a) is the optimality condition with respect to effort time, H_t^h, and equates the marginal value of leisure to the after-tax return to effort. Condition (6b) is the optimality condition with respect to the fraction of non-leisure time allocated to work vis-à-vis rent seeking, η_t^h. It implies that, in equilibrium, the return to work and the return to rent seeking should be equal. The next two conditions, (6c) and (6d), are standard Euler equations for K_{t+1}^h and B_{t+1}^h. The optimality conditions are completed by the transversality conditions for the two assets, namely $\lim_{t\to\infty}\beta^{*t}E_0\frac{\partial u_t(.)}{\partial C_t^h}K_{t+1}^h=0$ and $\lim_{t\to\infty}\beta^{*t}E_0\frac{\partial u_t(.)}{\partial C_t^h}B_{t+1}^h=0$.

2.4 Firms

There are as many firms as households. Identical firms are indexed by the superscript f, where $f=1,2,...,N_t$. Each firm produces an homogeneous product, Y_t^f, by using private capital, K_t^f, private labor, Q_t^f, and average (per firm) public capital, $\overline{K}_t^g$. Its production function is:

$$Y_t^f = A_t (K_t^f)^{\alpha}(Q_t^f)^{\varepsilon}(\overline{K}_t^g)^{1-\alpha-\varepsilon} \tag{7}$$

where $A_t>0$ is stochastic total productivity (see below for its law of motion) and $0<\alpha,\varepsilon<1$ are parameters (see e.g. Lansing, 1998, for a similar production function).

Each firm f acts competitively by taking prices, policy and economy-wide variables as given. Thus, each f chooses K_t^f and Q_t^f to maximize a series of static profit problems**:**

$$\Pi_t^f = Y_t^f - r_t^k K_t^f - w_t Q_t^f \tag{8}$$

subject to (7). The first-order conditions are simply:

$$\alpha\frac{Y_t^f}{K_t^f}=r_t^k \tag{9a}$$

$$\varepsilon\frac{Y_t^f}{Q_t^f}=w_t \tag{9b}$$

2.5 Government budget constraint

In each period, the government collects tax revenues, R_t, by taxing consumption and income at the rates $0\le\tau_t^c<1$ and $0\le\tau_t^y<1$ respectively. Rent seekers can grab $\theta_t R_t$, where the economy-wide fraction $0\le\theta_t<1$ is modelled below. The government uses the remaining tax revenues, $(1-\theta_t)R_t$, and issues new bonds, B_{t+1}, to finance public consumption, G_t^c, public investment, G_t^i, and lump-sum transfers, G_t^t. Thus, the within-period government budget constraint is:

$$G_t^c + G_t^i + G_t^t + (1+r_t^b)B_t = B_{t+1} + (1-\theta_t)R_t \tag{10}$$

where $R_t \equiv \tau_t^c \sum_{h=1}^{N_t} C_t^h + \tau_t^y \left(r_t^k \sum_{h=1}^{N_t} K_t^h + w_t Z_t \sum_{h=1}^{N_t} \eta_t^h H_t^h + \sum_{h=1}^{N_t} \Pi_t^h \right)$ is tax revenue. Notice that $\theta_t R_t$ can be read as both government revenue taken away (i.e. privileged tax treatments) and extra benefits recorded as expenditure (i.e. privileged spending subsidies). See Atkinson and Stiglitz (1980, p.16) for a discussion of this equivalence between "tax expenditures" and "spend expenditures".

Public investment, G_t^i, is used to augment the stock of public capital, whose motion is:

$$K_{t+1}^g = (1-\delta^g)K_t^g + G_t^i \tag{11}$$

where $0 < \delta^g < 1$ is a depreciation rate and initial K_0^g is given (for simplicity, we assume no adjustment costs for public capital).

2.6 Exogenous stochastic variables and policy instruments

The exogenous stochastic variables include the aggregate productivity, A_t, and five policy instruments, $G_t^c, G_t^i, G_t^t, \tau_t^y, \tau_t^c$. We assume that productivity and policy instruments (in rates) follow stochastic $AR(1)$ processes. Specifically, we first define $s_t^c \equiv \frac{G_t^c}{Y_t}$, $s_t^i \equiv \frac{G_t^i}{Y_t}$ and $s_t^t \equiv \frac{G_t^t}{Y_t}$ to be the three categories of government spending as shares of output and we then assume that $A_t, s_t^c, s_t^i, s_t^t, \tau_t^y, \tau_t^c$ follow univariate stochastic $AR(1)$ processes:

$$\ln A_{t+1} = (1-\rho_a)\ln A_0 + \rho_a \ln A_t + \varepsilon_{t+1}^a \tag{12a}$$

$$\ln s_{t+1}^c = (1-\rho_g)\ln s_0^c + \rho_g \ln s_t^c + \varepsilon_{t+1}^g \tag{12b}$$

$$\ln s_{t+1}^i = (1-\rho_i)\ln s_0^i + \rho_i \ln s_t^i + \varepsilon_{t+1}^i \quad (12c)$$

$$\ln s_{t+1}^t = (1-\rho_t)\ln s_0^t + \rho_t \ln s_t^t + \varepsilon_{t+1}^t \quad (12d)$$

$$\ln \tau_{t+1}^y = (1-\rho_y)\ln \tau_0^y + \rho_y \ln \tau_t^y + \varepsilon_{t+1}^y \quad (12e)$$

$$\ln \tau_{t+1}^c = (1-\rho_c)\ln \tau_0^c + \rho_c \ln \tau_t^c + \varepsilon_{t+1}^c \quad (12f)$$

where $A_0, s_0^c, s_0^i, s_0^t, \tau_0^y, \tau_0^c$ are means of the stochastic processes; $\rho_a, \rho_g, \rho_i, \rho_t, \rho_y, \rho_c$ are first-order autocorrelation coefficients; and $\varepsilon_t^a, \varepsilon_t^g, \varepsilon_t^i, \varepsilon_t^t, \varepsilon_t^y, \varepsilon_t^c$ are i.i.d. shocks.

2.7 Economy-wide extraction

To close the model, we specify the economy-wide degree of extraction ($0 \le \theta_t < 1$). Following e.g. Zak and Knack (2001), Mauro (2004) and Park et al. (2005), we assume that θ_t increases with per capita rent seeking activities, $\frac{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}{N_t}$. Using for simplicity a linear specification:[12]

$$\theta_t = \theta_0 \frac{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}{N_t} \quad (13)$$

where the parameter $\theta_0 \ge 0$ is a technology parameter that translates individual rent-seeking efforts into actual extraction. Higher values of θ_0 imply more "efficient" rent-seeking technology, which reflects poor laws, permissive legal systems and easy corruption. Thus, θ_0 is a measure of institutional quality, with higher (resp. lower) values meaning worse (resp. better) institutions. See below for further details.

2.8 Decentralized Competitive Equilibrium (DCE)

In a Decentralized Competitive Equilibrium (DCE): (i) Each individual household and each individual firm maximize respectively their own utility and profit by taking as

[12] We could use a non-linear specification, or treat θ_t as exogenous. This would not affect our main predictions.

given market prices, government policy and economy-wide outcomes. (ii) Markets clear via price flexibility.[13] (iii) The government budget constraint is satisfied. This equilibrium holds for any feasible policy. We solve for a symmetric DCE. Equilibrium quantities will be denoted by letters without the superscripts h (which was used to indicate quantities chosen by households) and f (which was used to indicate quantities chosen by firms).

The DCE is given by equations (1)-(13). Looking ahead at the long run where all components of the national income identity should grow at the same constant rate (the so-called balanced growth rate), we transform these components in per capita and efficient unit terms to make them stationary. Thus, for any economy-wide variable X_t, where $X_t \equiv (Y_t, C_t, K_t, B_t, K_t^g, G_t^c, G_t^i, G_t^t)$, we define $x_t \equiv \frac{X_t}{N_t Z_t}$. We also define $h_t \equiv \frac{H_t}{N_t}$ to be per capita non-leisure time. It is then straightforward to show that equations (1)-(13) imply the following stationary DCE:

$$\frac{(c_t + \psi s_t^c y_t)}{(1-h_t)} = \frac{\mu}{(1+\tau_t^c)(1-\mu)} \theta_0 \left(\tau_t^c c_t + \tau_t^y y_t\right) \tag{14a}$$

$$\eta_t h_t \theta_0 = \frac{\varepsilon(1-\tau_t^y) y_t}{\left(\tau_t^c c_t + \tau_t^y y_t\right)} \tag{14b}$$

$$\frac{\left((c_t + \psi s_t^c y_t)^{\mu} (1-h_t)^{1-\mu}\right)^{1-\sigma}}{(1+\tau_t^c)(c_t + \psi s_t^c y_t)} \frac{\partial I_t}{\partial K_{t+1}} = \beta E_t \left[\frac{\left((c_{t+1} + \psi s_{t+1}^c y_{t+1})^{\mu} (1-h_{t+1})^{1-\mu}\right)^{1-\sigma} \left[(1-\tau_{t+1}^y) \frac{\alpha y_{t+1}}{k_{t+1}} - \frac{\partial I_{t+1}}{\partial K_{t+1}} \right]}{(1+\tau_{t+1}^c)(c_{t+1} + \psi s_{t+1}^c y_{t+1})} \right] \tag{14c}$$

$$\frac{\left((c_t + \psi s_t^c y_t)^{\mu} (1-h_t)^{1-\mu}\right)^{1-\sigma}}{(1+\tau_t^c)(c_t + \psi s_t^c y_t)} = \beta E_t \left[\frac{\left((c_{t+1} + \psi s_{t+1}^c y_{t+1})^{\mu} (1-h_{t+1})^{1-\mu}\right)^{1-\sigma} (1+r_{t+1}^b)}{(1+\tau_{t+1}^c)(c_{t+1} + \psi s_{t+1}^c y_{t+1})} \right] \tag{14d}$$

$$(1 - s_t^c - s_t^i) y_t = c_t + i_t \tag{14e}$$

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[13] Thus, in each time period, $\sum_{f=1}^{N_t} K_t^f = \sum_{h=1}^{N_t} K_t^h$ in the capital market, $\sum_{f=1}^{N_t} Q_t^f = Z_t \sum_{h=1}^{N_t} \eta_t^h H_t^h$ in the labor market, $\sum_{f=1}^{N_t} \Pi_t^f = \sum_{h=1}^{N_t} \Pi_t^h$ in the dividend market, and $B_t = \sum_{h=1}^{N_t} B_t^h$ in the bond market.

$$y_t = A_t k_t^{\alpha} (\eta_t h_t)^{\varepsilon} k_t^{g\,1-\alpha-\varepsilon} \tag{14f}$$

$$\gamma_n \gamma_z k_{t+1}^g = (1-\delta^g) k_t^g + s_t^i y_t \tag{14g}$$

$$\gamma_n \gamma_z k_{t+1} = (1-\delta^p) k_t + i_t - \frac{\xi}{2}\left(\frac{\gamma_n \gamma_z k_{t+1}}{k_t} - \gamma_n \gamma_z\right)^2 k_t \tag{14h}$$

$$\gamma_n \gamma_z b_{t+1} - (1+r_t^b) b_t = (s_t^c + s_t^i + s_t^t) y_t - \left(1-\theta_0 (1-\eta_t) h_t\right)\left(\tau_t^c c_t + \tau_t^y y_t\right) \tag{14i}$$

where

$$\beta \equiv \beta^* \gamma_z^{\mu(1-\sigma)-1}$$

$$\frac{\partial I_t}{\partial K_{t+1}} = 1 + \xi\left(\frac{\gamma_n \gamma_z k_{t+1}}{k_t} - \gamma_n \gamma_z\right),$$

$$\frac{\partial I_{t+1}}{\partial K_{t+1}} = \delta^p - 1 + \frac{\xi}{2}\left(\frac{\gamma_n \gamma_z k_{t+2}}{k_{t+1}} - \gamma_n \gamma_z\right)^2 - \xi\left(\frac{\gamma_n \gamma_z k_{t+2}}{k_{t+1}} - \gamma_n \gamma_z\right)\frac{\gamma_n \gamma_z k_{t+2}}{k_{t+1}}.$$

We thus have nine equations in the paths of $i_t, c_t, y_t, r_t^b, \eta_t, h_t, b_{t+1}, k_{t+1}^g, k_{t+1}$. This is given the paths of productivity, A_t, and the independent policy instruments, $s_t^c, s_t^i, s_t^t, \tau_t^y, \tau_t^c$, whose motion has been defined in (12a-f) above.

3. Calibration and long-run results

We start by calibrating the model to the Greek economy. Our data come from OECD Economic Outlook. Data are quarterly and cover the period 1961:1-2005:4.

3.1 Calibration and long-run solution

Tables 1 and 2 report the average values of time-series in the data, calibrated parameter values and the resulting long-run solution. Our economy in the long run is presented in Appendix A.

[Tables 1 and 2 around here]

Table 2, column 1, reports the average values of c/y, i/y, h and b/y in the data, while the average quarterly real interest rate on public debt, r^b, is 0.011, which means an annual value of 0.044. The average value of hours at work in the data is $h = 0.3533$. The average values of tax rates in the data are in Table 1. The income tax rate, τ_0^y, is obtained as the ratio of the collected income tax revenue over GDP, while the consumption tax rate, τ_0^c, as the ratio of collected indirect tax revenue over private consumption. Data averages of the three government spending-to-output ratios are also reported in Table 1.

Our model includes some variables that - although clearly identifiable from a theoretical point of view - are hard to measure. Specifically, there are no data on the fraction of effort time devoted to rent seeking $(1-\eta_t)$ and thus on time devoted to productive work ($\eta_t h_t$). Also, public finance data do not distinguish between government spending arising from rent seeking activities and government spending independent of such activities; the data obviously contain both types, which means that G_t^c, G_t^i and G_t^t in the model (i.e. spending net of rent seeking) are unmeasured in the data.[14] To deal with these measurement problems, we assume (a) any effort devoted to rent seeking takes place while at work; (b) any spending favors take the form of redistributive transfers. Assumption (a) reflects the popular view that trade unionism, lobbying, etc, are at the cost of actual hours of work (we thus distinguish *hours at work* h_t, which is measurable, from *hours of productive work* $\eta_t h_t$, which is unobservable). Assumption (b) is consistent with e.g. Tanzi and Schuknecht (2000), who argue that in the past thirty to forty years government spending growth has mainly been driven by interest groups and has taken the form of transfers/subsidies. Technically, these two assumptions mean that, in Appendix A, only two equations, (A.v) and (A.viii), are left with unobservable variables and hence are not used for calibration purposes, and that the government budget constraint (A.vi) becomes (A.vi') which includes observables only.

[14] We are grateful to Harald Uhlig for pointing this problem out to us. This implies that in the government budget constraint in equation (10), if we use the available data on government spending to measure G_t^c, G_t^i and G_t^t, and in addition allow for rent seeking $(\theta_t R_t)$, we may have a double-counting problem. Note that since we use data on collected tax revenue, a similar problem does not arise in the case where rent seeking takes the form of tax favors.

Some parameter values in Table 1 are set on the basis of a priori information. Following usual practice, the curvature parameter in the utility function (σ) is set equal to 2. The parameter ψ, which measures the degree of substitutability/complementarity between private and public consumption in the utility function, is set equal to 0; as Christiano and Eichenbaum (1992) explain, this means that government consumption is equivalent to a resource drain in the macro-economy. The gross population growth in the data is $\gamma_n = 1.0014$. The private and public capital depreciation rates, δ^p and δ^g, are set equal to 0.0175 (or 0.07 annually) and 0.0075 (or 0.03 annually) respectively. The exponent of public capital in the production function ($1-\alpha-\varepsilon$) is set equal to 0.0338, which is the average public investment to output ratio (s_0^i) in the data (Baxter and King, 1993, follow the same practice for the US). Following Kydland (1995), we set μ (the weight given to consumption relative to leisure in the utility function) equal to the average value of h_t (see above). Both Z_0 (the initial level of technical progress) and A_0 (the level of long-run aggregate productivity) are scale parameters and are normalized to one (see also e.g. King and Rebelo, 1999). The growth rate of the exogenous labor augmenting technology, γ_z, is 1.0047, which is the average GDP growth rate of the USA over the same period.

The time discount factor (β) is calibrated from equation (A.iii). The capital share (α) is calibrated from equation (A.ii). Given the values of $\alpha = 0.3061$ and $(1-\alpha-\varepsilon) = 0.0338$, the labor share is residually found to be $\varepsilon = 0.6601$. The value of θ_0 (the extraction technology parameter) is calibrated from equation (A.i) giving $\theta_0 = 8.4788$. Note that these calibrated parameter values did not require any data on η.

For the simulations below, we will also need to specify the parameters (autoregressive coefficients and variances) of the stochastic exogenous processes in (12a)-(12f). The coefficients ρ_g, ρ_i, ρ_t and the associated standard deviations, $\sigma_g, \sigma_i, \sigma_t$, in (12b)-(12d) are estimated via OLS from their respective $AR(1)$ processes. Concerning (12a), we follow usual practice (see e.g. McCallum, 1989) by choosing the volatility of the Solow residual, σ_a, so that the actual and simulated series for GDP have the same variance. By the same token, we choose the persistence of the Solow residual, ρ_a, so that our simulated series of output mimics as close as possible the first-order autocorrelation of the actual series of output. These two properties are captured when $\sigma_a = 0.0212$ and $\rho_a = 0.675$ respectively. Finally, we treat τ_t^y and τ_t^c in (12e)-(12f) as constant over time. This is justified by the fact that the tax rates change infrequently via tax reforms rather than continuously (see also King and Rebelo, 1999). Table 1 summarizes all these results.

Table 2 reports the model's long-run solution. This solution follows if we use the parameter values reported in Table 1 into equations (A.i)-(A.v), (A.vi') and (A.vii)-(A.ix) in Appendix A and solve for the model's endogenous variables. In this solution, we set the annual public debt-to-output ratio to be 0.64 (or 2.56 on a quarterly basis), which is the data average and very close to the reference rate of the Stability and Growth Pact (0.60), and then allow the public consumption-to-output ratio, s_0^c, to be endogenously determined to satisfy the within-period government budget constraint; this gives $s_0^c = 0.0116$. In other words, in the long run of our model economy, government consumption as a share of GDP should drop from 0.1467 in the data to 0.0116 to get a well-defined long run. The long-run solution also gives $\eta = 0.8672$ and $\theta = 0.2550$. Thus, agents allocate only 86.72% of their effort time to productive work, while the rest 13.28% goes to rent seeking activities. As a result, rent seekers grab 33.13% of tax revenues. The latter translates to 42.79% of total transfers or 8.49% of GDP, denoted as $\theta r / g^t$ and $\theta r / y$ respectively in the tables. Although these numbers may look high at first sight, it is important to point out that total transfers as a share of GDP are as high as 19.85% in the data and also to remind the popular belief that, in many countries, a large part of transfers is the result of interest groups pressure. Moreover, our solution numbers are lower than previous estimates of rent seeking based on partial equilibrium and proxy calculations for other countries (see Mueller, 2003, p.355, for a review).

3.2 Sensitivity analysis of the long run solution

We now use the long-run solution to check sensitivity and comparative static properties. To save on space, we focus on the behavior of the degree of extraction

($0 \le \theta < 1$) and output (y), and how these two key endogenous variables are affected by exogenous variables and calibrated parameters. Specifically, we report the effects of small changes in the extraction technology parameter (θ_0), the income tax rate (τ_0^y), the consumption tax rate (τ_0^c), capital productivity (α) and the growth rate of labor augmenting technology (γ_z). Results are illustrated in Table 3.

[Table 3 around here]

An institutional deterioration (i.e. a higher θ_0) pushes individuals away from productive work to rent seeking (i.e. a higher θ) and damages the pie (i.e. a lower y). Increases in any of the tax rates (τ_0^y, τ_0^c) have similar effects, namely they lead to higher θ and lower y. Increases in capital productivity and labor augmenting technology (i.e. higher α or γ_z) lead to higher θ and higher y; that is, a higher pie triggers rent seeking, but, despite the adverse effects from rent seeking, the net output effect is positive.

It is useful to present more details about the exact effect of changes in the key parameter, θ_0. Results for long-run output are reported in Table 4. A deterioration of institutional quality by 2% (i.e. an increase of θ_0 by 2% relative to its calibrated value in Table 1) reduces output by 1.9647%, while an improvement of institutional quality by 2% (i.e. a decrease of θ_0 by 2% relative to its calibrated value in Table 1) increases output by 2.0367%. Thus, the elasticity of output with respect to institutional quality is around 1 in the long run of our economy. These changes are driven by the direct and indirect effects from rent seeking discussed in the Introduction.

[Table 4 around here]

4. Linearized model and simulation results

We continue with simulation results by studying second moment properties and impulse response functions. We start with the linearized decentralized competitive equilibrium.

4.1 Linearized decentralized competitive equilibrium

We linearize (14a)-(14i) around the long-run solution (see Appendix A for the long run). Define $\hat{x}_t \equiv (\ln x_t - \ln x)$, where x is the model consistent long-run value of a variable x_t. It is then straightforward to show that the linearized DCE is a system $E_t\left[A_1\hat{x}_{t+1} + A_0\hat{x}_t + B_1\hat{z}_{t+1} + B_0\hat{z} = 0\right]$, where $\hat{x}_t \equiv \left[\hat{i}_t, \hat{c}_t, \hat{y}_t, \hat{r}_t^b, \hat{\eta}_t, \hat{h}_t, \hat{b}_t, \hat{k}_t^g, \hat{k}_t, \hat{k}2_t\right]'$, $k2_t \equiv k_{t+1}$, $\hat{z}_t \equiv \left[\hat{A}_t, \hat{s}_t^c, \hat{s}_t^i, \hat{s}_t^t\right]'$ and A_1, A_0, B_1, B_0 are constant matrices of dimension 10x10, 10x10, 10x6 and 10x4 respectively. The elements of $\hat{z}_t$ follow the $AR(1)$ processes in (12a)-(12d) - recall that tax rates have been assumed to be constant. Thus, we end up with a linear first-order stochastic difference equation system in ten variables, out of which three are predetermined $(\hat{b}_t, \hat{k}_t^g, \hat{k}_t)$ and seven are jump $(\hat{i}_t, \hat{c}_t, \hat{y}_t, \hat{r}_t^b, \hat{\eta}_t, \hat{h}_t, \hat{k}2_t)$. To solve it, we use the solution methodology in Klein (2000). We report that, when we use the calibrated values in Table 1, all eigenvalues are real and there are three eigenvalues with absolute value less than one, so that the model exhibits saddle-path stability.

4.2 Second moment properties

We simulate our model economy over the time period studied and evaluate its descriptive power by comparing the second moment properties of the series generated by the model to those of the actual Greek data. To get the cyclical component of the series, we take logarithms and apply the Hodrick-Prescott filter with a smoothing parameter of 1600 for both the simulated and the actual data. We study the volatility, persistence and co-movement properties of some key variables, $y, c, i, h, w, k, k^g, \eta, \eta h$.

Tables 5, 6 and 7 summarize respectively results for standard deviations (relative to that of output), first-order autocorrelations and cross-correlations with output. This is done both for the simulated series and the actual data.

[Tables 5, 6 and 7 around here]

Inspection of the above three Tables reveals that our model economy does well in reproducing the key stylized facts of the post-war Greek economy. We also report that the model scores better than the same model without rent seeking,[15] especially in terms of volatility in hours at work.[16] It is worth pointing out that the model does well without incorporating extra frictions (e.g. nominal and real rigidities, imperfect competition, heterogeneity, etc) that typically help a DSGE model with the data.

4.3 Impulse response functions

We compute the responses of the key endogenous variables (measured as deviations from their model-consistent long-run value) to a unit shock to the exogenous processes. We examine temporary shocks to total factor productivity, government consumption and government investment. Results are reported in Tables 8a-c respectively.

[Tables 8a-c around here]

Table 8a reports the effects of a temporary shock to total factor productivity, A_t. As is standard, an increase in A_t leads to more time allocated to productive work (i.e. $\eta_t h_t$ rises). At the same time, in our model, an increase in A_t signals a larger contestable pie that pushes individuals to devote a larger fraction of hours at work to rent seeking (η_t falls initially). As a result, h_t has to overshoot its value relatively to standard RBC models.

The full story is as follows. An increase in A_t increases income and this supports a rise in both current and - via consumption smoothing - future consumption. Since leisure is also a normal good, both current and future leisure have the tendency to follow consumption, namely to rise (or equivalently h_t to fall). Nevertheless, a higher A_t also raises labor productivity and the real wage (as well as output, investment and capital) and

[15] A model without rent seeking is derived if we set $\eta_t = 1$ and hence $\theta_t = 0$ at all t. Results for this special case are available upon request from the authors.

[16] The full model does better because, once there is a shock, the fraction of total hours at work allocated to productive work and the hours of productive work move in opposite directions, so that total hours at work have to overshoot their value relative to standard RBC models. In other words, we distinguish hours at work as observed in the data (which can also include rent seeking activities like trade unionism, lobbying, etc) from hours of productive work. This becomes obvious when we present impulse response functions below, while details are in Angelopoulos et al. (2009) who provide a comparison of the full model with the same model without rent seeking.

creates a substitution effect that works in opposite direction by increasing the time spent in productive work, $\eta_t h_t$. Here the latter effect dominates so that the net effect on $\eta_t h_t$ is positive. This is as in most of the literature (see e.g. Kollintzas and Vassilatos, 2000). Here there is an extra effect due to rent seeking. Since η_t has fallen, h_t has to rise more relatively to standard models to support the higher value of $\eta_t h_t$.

Table 8b reports the effects of a temporary shock to government consumption as a share of output, s_t^c. An increase in s_t^c creates a negative wealth effect that reduces consumption, investment and (after the demand stimulant fades away) output. Concerning leisure, there are two opposite effects. On the one hand, because of lower income, leisure tends to fall (or equivalently h_t tends to rise) like consumption. On the other hand, a higher s_t^c lowers the return to labor (the wage rate) and creates a substitution effect that tends to reduce the time allocated to productive work ($\eta_t h_t$), which can be achieved by lower η_t and/or lower h_t. Here, as the impulses show, the former (i.e. income) effect dominates so that both h_t and $\eta_t h_t$ rise. The rise in hours of productive work ($\eta_t h_t$) is rather standard in the RBC literature. But here we have an additional effect: the lower return to productive work implies a lower η_t. In other words, individuals switch to rent seeking. Since η_t falls, h_t has to rise more relatively to standard models to support the higher value of $\eta_t h_t$.

Finally, Table 8c reports the effects of a temporary shock to government investment as a share of output, s_t^i. Although the response of the economy to a change in s_t^i resembles that to a change in s_t^c in the very short run, after some time private consumption, investment and capital all rise above their initial long run values. Output and wages are also higher all the time contrary to what happened with an increase in s_t^c. Thus, after some periods of time, a shock to s_t^i works like a shock to productivity (A_t) so that the qualitative effects on η_t, $\eta_t h_t$ and h_t in Table 8c are the same as those in Table 8a.

5. Institutional reforms and welfare implications

We finally quantify the welfare gains from potential reforms. We focus on institutional reforms that ceteris paribus reduce the value of θ_0. Recall that the value of θ_0 summarizes how easily rent-seeking attempts are translated into actual rent seeking, with reductions in θ_0 making it harder (see equation (13)). In other words, as said above, reductions in θ_0 reflect improvements in institutional quality.

To welfare compare the existing economy to a reformed one, we follow Lucas e.g. (1990) by computing the percentage compensation in consumption that the household would need under the existing calibrated structure to be indifferent between this structure and a fictional reformed one. This percentage compensation in consumption is denoted by ζ. The value of ζ provides a welfare measure that has a simple interpretation and is popular. We focus on the effects of such reforms upon long-run welfare. Details are in Appendix B.

We first solve the model and compute the resulting long-run welfare under the existing structure, we then do the same under an assumed lower θ_0, and finally find the value of ζ that equates welfare in the two regimes. Numerical results are reported in Table 9. Institutional improvement (i.e. fall) of θ_0 by say 1%, 2% and 3% could increase long-run welfare by 2.89%, 5.89% and 9.01% respectively. These are substantial gains. They are also within the range usually found in the literature on policy reforms. For instance, when Lucas (1990, section 4) compared long-run welfare under the actual tax structure in the US (where the average capital tax rate was 0.36) with long-run welfare under a Ramsey solution (where ceteris paribus the capital tax rate falls to zero), he found a welfare gain around 6% of private consumption.

[Table 9 around here]

6. Conclusions, discussion and extensions

This paper incorporated rent-seeking competition from state coffers into an otherwise standard dynamic stochastic general equilibrium model. It then calibrated the model to the post-war Greek economy. The main result is that rent seeking matters to, and hurts, the macro economy in Greece.

In our model, rent seeking was defined as the expenditure of private resources used to influence government policy in the form of tax-spending favors. Government assets were assumed to be a common property or common pool. Then, as in all common-pool models, socially suboptimal behavior (e.g. rent seeking) can result from the attempt of rational individuals to extract common property for their own benefit. In other words, rent seeking and other forms of socially unproductive behavior arise because of the possibility that rents can be extracted (see the positive value of θ_t in equation (3)). It is this possibility, jointly with decision making in a decentralized economy, which makes rent seeking optimal from an individual point of view. Behind this possibility, there is the implicit assumption of ill-defined property rights (see Drazen, 2000, p. 444) or, equivalently, the assumption that political decision-makers allow rent seeking in the first place (see Hillman and Ursprung, 2000, p. 204, and Hillman, 2003, pp. 457-8). As in most of the related literature, we took this possibility as given and studied its implications.

Individuals would be better off if they would cooperate (i.e. not rent seek). Nevertheless, for the reasons discussed above, although rent seeking is socially costly, it was privately rational from an individual point of view.[17] Rent seeking behavior would cease to be optimal for the individual, if common property becomes too low (with rent seeking inducing its fall), if trigger strategies could sustain a cooperative outcome, etc.

We close with some possible extensions. First, while we assumed that the technology of rent seeking (see θ_0 in equation (13) above) is given, such a technology can be affected by government policy, trust and social norms, imperfections, etc.

[17] See Drazen (2000, chapter 10) for various categories of models of the failure to make socially optimal changes. The model used here belongs to the category of common property or common pool models.

Focusing on the role of government policy, governments can affect θ_0 through higher expenditures on the maintenance of the rule of law (police, courts, tax inspectors, prisons, etc). Second, it would be interesting to include other types of rent seeking (e.g. legislative favours and tax evasion) and study how different types differ in hurting the economy. Finally, as always in DSGE models, it is challenging to endogenize tax-spending decisions and the behaviour of government officials. This is obviously related to the interaction between rent seeking individuals (who enjoy policy favours) and rent seeking politicians (who enjoy bribes, campaign contributions, political support, etc, in return for policy favours). Here, we focused on how competition among pressure groups, which demand tax-spending favors, affects the macro economy.

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APPENDIX

Appendix A: Long-run equilibrium of (14a)-(14i)

In the long run, there are no shocks and variables remain constant. Thus, $x_{t+1} = x_t = x_{t-1} \equiv x$, where variables without time subscript denote long-run values. Equations (14a)-(14i) imply:

$$\frac{(c+\psi s_0^c y)}{(\tau_0^c c + \tau_0^y y)} \frac{1}{(1-h)} = \frac{\mu}{(1-\mu)} \theta_0 \frac{1}{(1+\tau_0^c)} \tag{A.i}$$

$$\frac{y}{k} = \frac{1}{(1-\tau_0^y)\alpha} \left[\frac{1}{\beta} - 1 + \delta^p \right] \tag{A.ii}$$

$$r^b = \frac{1-\beta}{\beta} \tag{A.iii}$$

$$(1 - s_0^c - s_0^i) y = c + i \tag{A.iv}$$

$$y = Ak^{\alpha} (\eta h)^{\varepsilon} k^{g^{1-\alpha-\varepsilon}} \tag{A.v}$$

$$\left[\gamma_n \gamma_z - (1+r^b)\right] \frac{b}{y} + \left[\frac{\tau_0^c c + \tau_0^y y}{y} \right] = s_0^c + s_0^i + s_0^t + \theta_0 (1-\eta) h \left[\frac{\tau_0^c c + \tau_0^y y}{y} \right] \tag{A.vi}$$

$$\left[\gamma_n \gamma_z - 1 + \delta^g\right] \frac{k^g}{y} = s_0^i \tag{A.vii}$$

$$\eta h \frac{(\tau_0^c c + \tau_0^y y)}{y} = \frac{(1-\tau_0^y)\varepsilon}{\theta_0} \tag{A.viii}$$

$$\left[\gamma_n \gamma_z - 1 + \delta^p\right] = \frac{i}{k} \tag{A.ix}$$

which is a system in $y, k, c, k^g, i, h, \eta, b, r^b$. If we set the long-run b to be an exogenous fraction of output, then one of the other five policy instruments should follow residually to satisfy the government budget constraint (A.vi). We choose the long-run government consumption-to-GDP ratio (s_0^c) to play this role.

Since rent seeking takes the form of government transfers, (A.vi) can be written as:

$$\left[\gamma_n\gamma_z-(1+r^b)\right]\frac{b}{y}+\left[\frac{\tau_0^c c+\tau_0^y y}{y}\right]=s_0^c+s_0^i+s(d)_0^t \qquad \text{(A.vi)}$$

where $s(d)_0^t \equiv s_0^t+\theta_0(1-\eta)h\left[\frac{\tau_0^c c+\tau_0^y y}{y}\right]$ and $s(d)_0^t$ is the mean of the time-series of transfers in the data (equivalently, $G(d)_t^t \equiv G_t^t+\theta_t R_t$ in (10) in the text, where $G(d)_t^t$ denotes the time-series of transfers in the data). Therefore, the long-run system consists of equations (A.i)-(A.v), (A.vi') and (A.vii)-(A.ix). Only (A.v) and (A.viii) are left with unobservable variables.

Appendix B: A measure of welfare gains

Household's within-period utility function (2), written in stationary form, is:

$$u_t=\frac{M_t\left((c_t+\psi g_t^c)^{\mu}(1-h_t)^{1-\mu}\right)^{1-\sigma}}{1-\sigma}$$

where $M_t \equiv \gamma_z{}^{t\mu(1-\sigma)}Z_0{}^{\mu(1-\sigma)}$ includes exogenous variables only. For notational convenience, we define composite consumption as $\tilde{c}_t \equiv (c_t+\psi g_t^c)$.

Let us say there are two regimes, denoted by superscripts A and B, and let ζ be a constant fraction of consumption that serves as a compensating consumption supplement in regime B that makes the household indifferent between A and B. Thus, in each time period, $u_t{}^A=(1+\zeta)^{\mu(1-\sigma)}u_t{}^B$. Using the above expression for the utility function and solving for ζ, we have (from now on, we focus on the long run and drop time subscripts):

$$\zeta=\frac{\tilde{c}^A(1-h^A)^{(1-\mu)/\mu}}{\tilde{c}^B(1-h^B)^{(1-\mu)/\mu}}-1$$

If $\zeta > 0$ (resp. $\zeta < 0$), there is a welfare gain (resp. loss) of moving from B to A. We choose B to be the existing calibrated structure and A to be a fictional structure with better institutional quality, namely a lower θ_0.

Table 1. Calibration

parameter or exogenous Variable	Description	value	Source
α	private capital share in production	0.3061	Calibrated from (A.ii)
ε	labor share in production	0.6601	Calibrated as $1-a-s_0^i$
δ^p	private capital depreciation rate (quarterly)	0.0175	Data
δ^g	public capital depreciation rate (quarterly)	0.0075	Data
A_0	long run aggregate productivity	1.0000	Set
γ_z	growth rate of labor augmenting technology	1.0047	Set at USA average
ξ	capital adjustment cost parameter	4.2300	Set
μ	consumption weight in utility function	0.3533	Set equal to h
σ	curvature parameter in utility function	2	Set
γ_n	growth rate of population	1.0014	Data
β	time discount factor	0.9891	Calibrated from (A.iii)
ψ	substitutability between private and public consumption in utility	0	Set
θ_0	extraction technology parameter	8.4788	Calibrated from (A.i)
s_0^c	government consumption to output ratio	0.1467	Data average
s_0^i	government investment to output ratio	0.0338	Data average
$s(d)_0^t$	government transfers to output ratio	0.1985	Data average
τ_0^y	income tax rate	0.1600	Data average
τ_0^c	consumption tax rate	0.1300	Data average
ρ_a	persistence parameter of A_t	0.6750	Set
ρ_a	persistence parameter of s_t^c	0.9514	Estimation
ρ_i	persistence parameter of s_t^i	0.9722	Estimation
ρ_t	persistence parameter of s_t^t	0.9070	Estimation
σ_a	standard deviation of the innovation ε_t^a	0.0212	Set
σ_g	standard deviation of the innovation ε_t^g	0.0289	Estimation
σ_i	standard deviation of the innovation ε_t^i	0.0470	Estimation
σ_t	standard deviation of the innovation ε_t^t	0.0389	Estimation

Notes: (i) Quarterly data 1961:1-2005:4 (ii) Statistics for s_t^t are over the period 1980-2005 (iii) Statistics for hours at work are over the period 1983-2004 (iv) Statistics for the tax rates are over the period 1970-2004

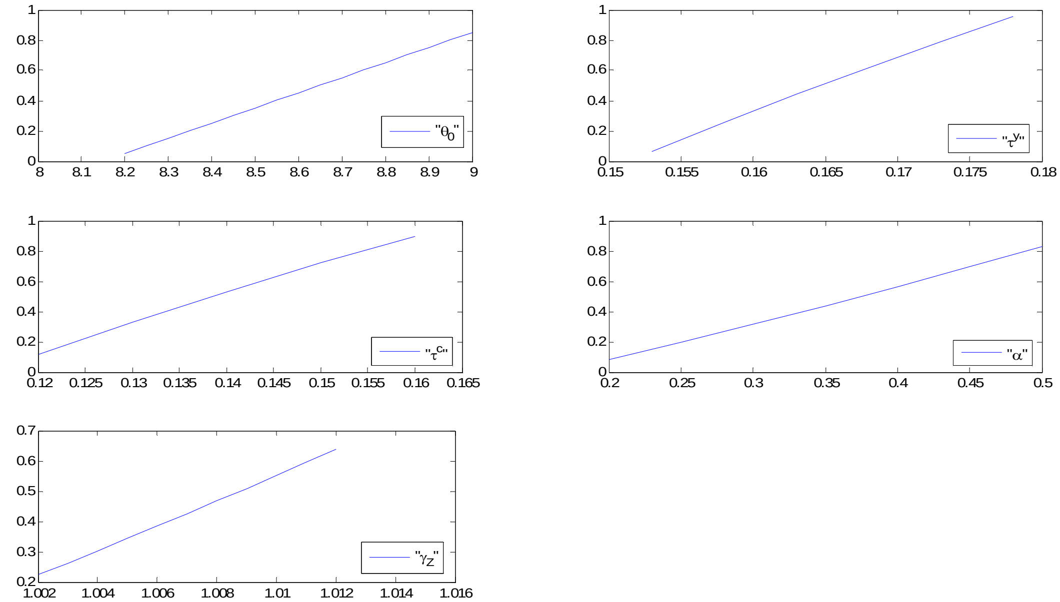
Table 2. Data averages and long-run solution

endogenous variable	Description	data averages	long-run solution
c / y	consumption to output ratio	0.6469	0.7416
i / y	private investment to output ratio	0.2130	0.2130
h	hours at work	0.3533	0.2941
n	fraction of hours at work allocated to productive work	Na	0.8672
nh	hours of productive work	Na	0.2550
θ	share of tax revenue extracted by rent seekers	Na	0.3313
$\theta r / g^t$	transfers due to rent seeking as a share of total transfers	Na	0.4279
$\theta r / y$	Transfers due to rent seeking as a share of output	Na	0.0849
k / y	Private capital to output ratio	9.039	9.0229
k^g / y	Public capital to output ratio	2.4881	2.4841
r^b	Return to bonds (quarterly)	0.011	0.011
b / y	public debt to output ratio (quarterly)	2.56	2.56
s_0^c	Government consumption to output ratio	0.1467	0.0116

Notes: (i) Na denotes non-available (ii) Quarterly series for private and public capital are constructed via the perpetual inventory method assuming a depreciation rate equal to 0.0175 (0.07 annually) and 0.0075 (0.03 annually), respectively. We choose the initial values for the two capital stocks such that the average ratio of the constructed series over output matches as close as possible the long run values implied by the model. (iii) In the long-run solution, we set the public debt to output ratio as in the data and allow government consumption to follow residually to satisfy the government budget constraint.

Table 3. Sensitivity of long-run solution

Behavior of the economy-wide degree of extraction ($0 \le \theta < 1$)



Behavior of output (y)

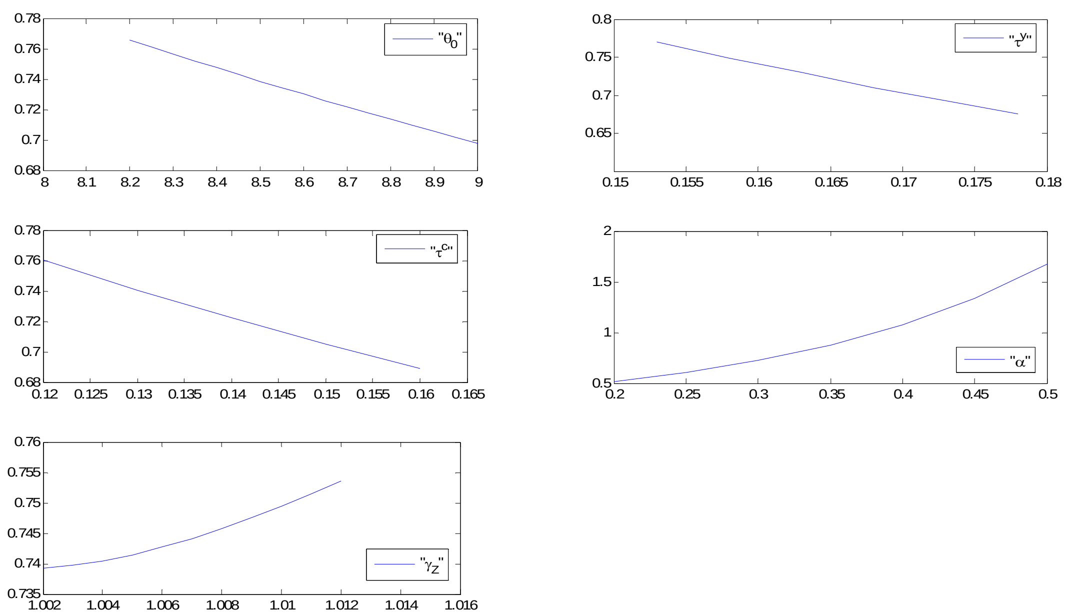


Table 4. Sensitivity of long-run solution for output as θ_0 changes

Percentage fall in θ_0	Percentage increase in long-run output, y
0.5	0.4984
1	1.0060
1.5	1.5187
2	2.0367
2.5	2.5600
3	3.0886
3.5	3.6228

Percentage increase in θ_0	Percentage increase in long-run output, y
0.5	0.5015
1	0.9941
1.5	1.4818
2	1.9647
2.5	2.4430
3	2.9165
3.5	3.3855

Note: The starting value of θ_0 is its calibrated value (8.4788) in Table 1.

Table 5. Relative volatility, $x \equiv s_x / s_y$

x	**Actual Data**	**simulated data**
c	0.6069	0.4513
i	2.9308	2.9323
h	0.4141	0.8370
w	1.4118	0.7920
k	0.3571	0.1678
k^g	0.2648	0.1158
n	Na	0.6268
nh	Na	0.2101
s_y	0.0270	0.0270

Table 6. Persistence $\rho(x_t, x_{t-1})$

x	**Actual Data**	**simulated data**
y	0.5144	0.5176
c	0.8712	0.5323
i	0.9173	0.5137
h	0.5114	0.5158
w	0.8754	0.5196
k	0.9568	0.9090
k^g	0.9581	0.9522
n	Na	0.5158
nh	Na	0.5158

Table 7. Co-movement $\rho(y_t, x_{t+i})$

	actual data			Simulated data		
x	$i=-1$	$i=0$	$i=1$	$i=-1$	$i=0$	$i=1$
c	0.4883	0.5314	0.4339	0.4817	0.9875	0.5483
i	0.5319	0.5392	0.4725	0.5306	0.9966	0.4952
h	0.0553	0.1065	0.0338	0.5371	0.9919	0.4832
w	0.3823	0.3766	0.3181	0.5110	0.9994	0.5253
k	-0.0277	0.1211	0.2517	-0.3286	-0.0996	0.3176
k^g	0.1966	0.2576	0.3011	-0.1153	-0.0467	0.0793
n	Na	Na	Na	-0.5371	-0.9919	-0.4832
nh	Na	Na	Na	0.5371	0.9919	0.4832

Table 8a. Response to aggregate productivity shock (A_t)

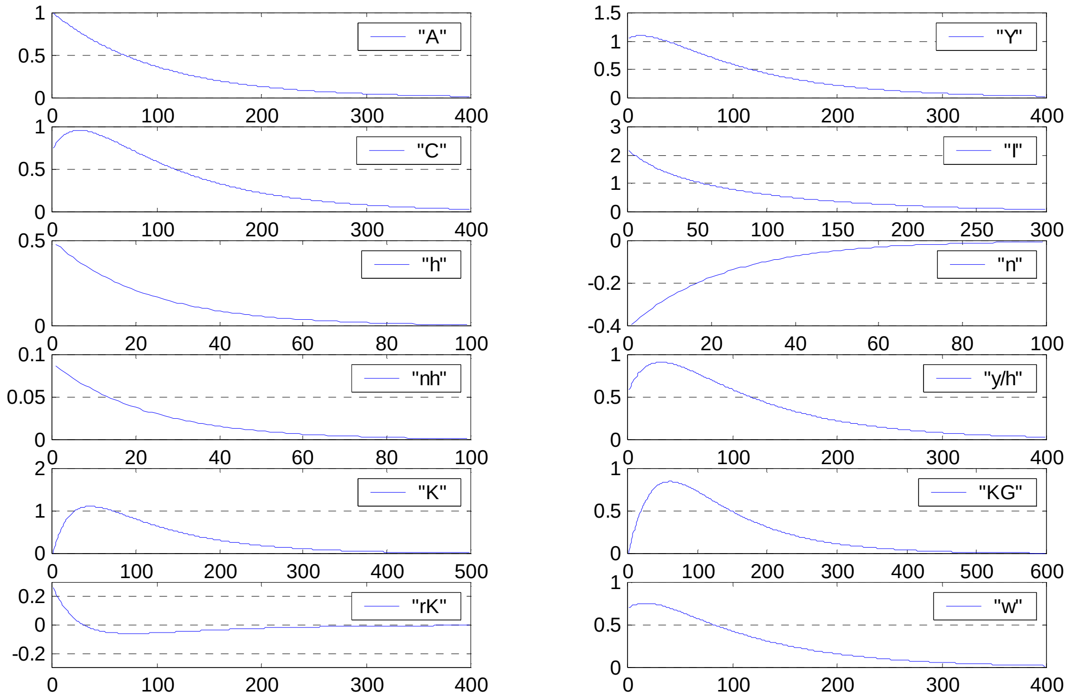


Table 8b. Response to government consumption shock (s_t^c)

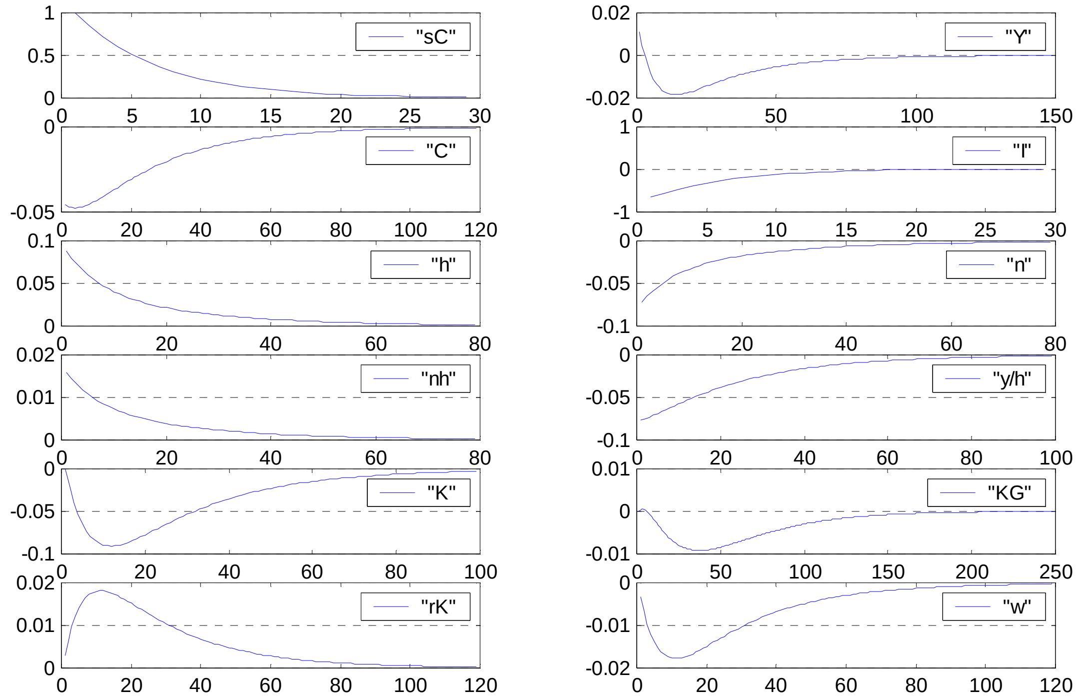


Table 8c. Response to government investment shock (s_t^i)

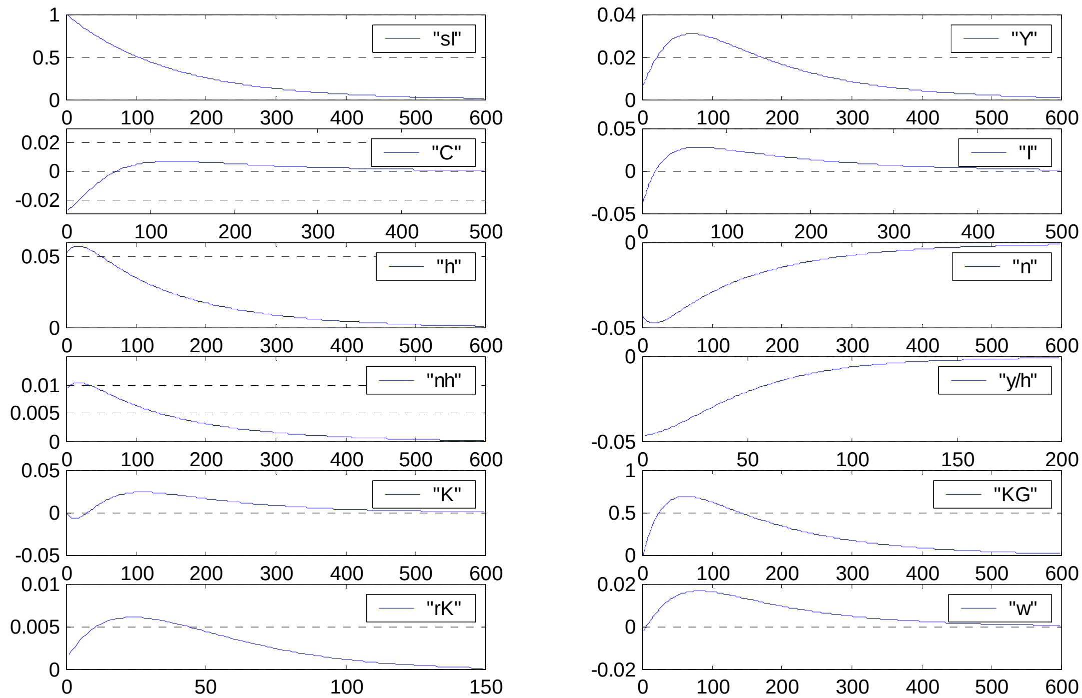


Table 9. Long-run welfare gains as θ_0 falls

Percentage fall in θ_0	**percentage welfare gain (ζ)**
0.5	1.43
1	2.89
1.5	4.37
2	5.89
2.5	7.43
3	9.01
3.5	10.61
4	12.25
4.5	13.92
5	15.63

Note: The starting value of θ_0 is its calibrated value (8.4788) in Table 1.

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