RENT-SEEKING COMPETITION FROM STATE COFFERS: A CALIBRATED DSGE MODEL OF THE EURO AREA

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Abstract

This paper incorporates an uncoordinated struggle for extra fiscal favors into an otherwise standard Dynamic Stochastic General Equilibrium model. This reflects the popular belief that interest groups compete for privileged transfers and tax treatment at the expense of the general public interest, and so the aggregate economy stagnates. The model is calibrated to the euro area over the period 1980-2003. Our results show that rent-seeking competition can contribute to explaining the European macroeconomic experience. We also get quantitative evidence of the fraction of collected tax revenues grabbed by rent seekers.

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1. Introduction

Rent seeking is the socially costly pursuit of winning a contestable prize. 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.[1] This is why rent seeking is also known as "misallocation of talent" (see Murphy et al., 1991). At the heart of this problem, there is a public good-prisoners' dilemma situation.

Rent seeking occurs mainly through the public sector. The monopoly rent, which the government creates via coercive taxation, spending, regulation, etc, generates a prize worth pursuing. Focusing on rent seeking through the public sector, an important form is competition for privileged transfers and tax treatment, or what we call rent-seeking competition from state coffers.[2] It is believed that the expanded size and role of the state in the post-1960 period has created a particularly fertile ground for such rent seeking behaviour (see e.g. Tanzi, 1998, Mueller, 2003, and Hillman, 2003). Among other things, this is related to the popular belief that interest groups (e.g. public sector unions, industrial associations, professional associations, religious groups, or even single companies and individuals with the right connections) compete with each other for extra rents at the expense of the broad public interest.

In this paper, we incorporate rent-seeking competition from state coffers into an otherwise standard Dynamic Stochastic General Equilibrium (DSGE) model. We then calibrate the model to the euro area over the period 1980-2003. We choose to apply the model to the euro area because it is widely believed that rent seeking through the public sector is one of the reasons behind Europe's recent poor performance (see e.g. the discussion in Heckman, 2003).[3] We thus expect that wrong incentives can contribute to explaining the European macroeconomic experience. We also aim to get quantitative evidence of the time spent on rent seeking activities and, more importantly, of the fraction of social resources extracted by rent seekers.

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[1] See e.g. Tullock (1967, 1980), Krueger (1974), Baumol (1990) and Murphy et al. (1991). For a review of the literature on rent seeking, see Mueller (2003, chapter 15) and Hillman (2003, chapter 6).

[2] It is useful to divide privileges into two categories. The first category includes privileged transfers and tax treatment. There are direct transfers in cash (e.g. targeted subsidies and other benefits) and non-cash (e.g. private use of public assets and extra health services). There are also indirect transfers (e.g. measures that increase the demand for an interest group's services) and disguised transfers (e.g. a public road may be planned to increase the value of certain pieces of real estate). Also there are 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. The second category includes privileged regulation and legislation that reduce competition (e.g. government-created barriers to entry, trade restrictions like tariffs and agricultural price supports). Obviously, this list is not exhaustive (see Tanzi, 1998, Mueller, 2003, chapter 15, and Hillman, 2003, chapter 6, for more examples). Our model can capture the first category. Note that rent seeking can also take illegal forms (e.g. use of fake documents to get a privileged treatment).

[3] See also articles in the economic press like *The Economist*.

A key feature of our model is that the state collects (income and consumption) tax revenues to finance public investment, public consumption and lump-sum transfers, but then each self-interested (i.e. utility-maximizing) individual uses a part of his his/her non-leisure (i.e. effort) time to extract a fraction of these revenues for his/her own personal benefit. The amount extracted by each individual is proportional to the effort he/she allocates to rent seeking relative to the total effort allocated to rent seeking by all individuals. In equilibrium, the total amount extracted from state coffers increases with per capita economy-wide rent seeking efforts. This redistributive struggle hurts the macro-economy both directly and indirectly: the direct effect arises because there are less resources available to finance public infrastructure and other socially useful services; the indirect effect arises because the possibility of extraction distorts individuals' incentives by pushing them away from productive work. Both effects reduce the prize that initiated the struggle in the first place.

We calibrate the model both to the euro area as a whole and to each individual EU-12 country (the European countries that have adopted the euro). The main results are as follows. Our model economy does well in reproducing the key stylized facts of the euro area without seriously failing in any aspect. Moreover, it scores better than the standard RBC model in terms of labor volatility, which is a statistic that the RBC model finds it difficult to match. This happens because rent seeking works as a substitute for work and leisure, which - in case of a shock - helps to produce a response of non-leisure time stronger than in standard RBC models. Our model also scores much better than a model with a public sector but without rent seeking. Concerning long-run values of the fraction of tax revenues grabbed by rent seekers, this is found to be 17.27% for the euro area as a whole. At individual country level, the Netherlands scores the best with only 4.3%, while Greece is the worst with 34.89% of tax revenues taken away being followed by Portugal, Italy and Belgium with 20.2%, 18.48% and 17.37% respectively. Finally, our impulse response functions reveal that a larger size of the public sector signals a larger pie pushing individuals to devote more of their time to rent seeking, and that this is ceteris paribus bad for macro performance.

In addition to the above economic arguments and quantitative results, a methodological contribution is the inclusion of a redistributive struggle (rent seeking competition) in a DSGE setup. Although the RBC methodology has been used by several authors to incorporate "non-Walrasian" features (see e.g. Danthine and Donaldson, 1995), here we use this parsimonious methodology to study a political economy phenomenon.

The rest of the paper is organized as follows. Section 2 presents the model. A quantitative study of the euro area is in Section 3. Section 4 concludes.

2. Theoretical model

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 extra fiscal privileges.[4] Rent seeking comes at a private cost.[5] Here, it requires time and effort. Thus, in addition to consumption and saving, each household also chooses optimally how to allocate its non-leisure time between productive work and rent seeking activities.[6] Firms produce an homogenous product by using capital, labour and public infrastructure. The government uses income and consumption taxes and also issues bonds in order to finance three activities: the provision of public consumption goods and services that provide direct utility to households, the provision of public investment that augments the stock of public infrastructure and provides production externalities to firms, and lump-sum transfers that augment households' income. However, a fraction of collected tax revenue can be depleted by rent seekers.

Thus, in our paper, the contestable prize is the monopoly rent that the government creates via coercive taxation. In turn, self-interested agents use their private resources (time, effort, initiative) to compete with each other for a share of this prize.[7]

Also note that each household can receive both a lump-sum transfer and an extra fiscal favour. The former is standard and reflects the idea that there are government programs independent of interest groups' pressure and lobbying (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 some transfers - especially those targeted to more narrow groups - are provided only if the beneficiaries of those transfers apply pressure as a group.[8]

In what follows, we solve the problems of individual households and firms and then the associated decentralized competitive equilibrium. This is for any feasible policy. Individuals are rational. Time is discrete and infinite.

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[4] We can assume that firms also rent seek like households. This is not important because households are also firm-owners in this class of models. We could also assume that government officials rent seek. This is trickier if government officials act optimally. But here we solve for any feasible policy (i.e. policy is exogenous). See the last section 4 for a discussion.

[5] Membership in trade unions, participation in strikes and demonstrations, lobbying, bribing, paying lawyers, campaign contributions, etc, are costly activities. In general, rent seeking (winning a contestable prize) requires the expenditure of private resources. As said already, rent seeking implies social costs too.

[6] This goes back to Baumol (1990), Murphy et al. (1991), Grossman and Kim (1996) and many others, where individuals decide how to allocate their activities between socially productive ones (e.g. work, innovation, entrepreneurship) and socially unproductive ones (e.g. rent seeking, poaching, breaking the law).

[7] See also e.g. Mohtadi and Roe (2003), Mauro (2004) and Park et al. (2005) for similar form of rent seeking. We could assume that the contestable prize is government expenditure, or that it also includes income from the issue of bonds; this is not important in a general equilibrium model.

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

2.1 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:

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

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, $\overline{G}_t^c$ is average (per household) public consumption goods and services provided by the government at t,[9] 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; when $\psi > 0$ (resp. $\psi < 0$), the marginal utility of C_t^h decreases (resp. increases) with an increase in $\overline{G}_t^c$.[10]

Concerning the instantaneous utility function, we assume the form:

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

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

Each household h saves in the form of capital, I_t^h, and government bonds, D_t^h. It receives interest income from accumulated 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, in each time period, $L_t^h + H_t^h = 1$. It further divides its non-leisure time H_t^h, between productive work,

[9] Thus, $\overline{G}_t^c \equiv G_t^c / N_t$, where G_t^c is total public consumption services.

[10] See also e.g. Christiano and Eichenbaum (1992). When $\psi > 0$, public and private consumption are substitutes (e.g. private security and state police). When $\psi < 0$, public and private consumption are complements (e.g. low quality public education requires additional time and money for private tuition). When $\psi = 0$, the household's preferences are lexicographic with respect to private consumption.

$\eta_t^h H_t^h$, and rent seeking activities, $(1-\eta_t^h)H_t^h$, where $0<\eta_t^h \leq 1$ and $0 \leq (1-\eta_t^h) < 1$ are 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 time period. Finally, each household receives a share of profits, Π_t^h, and a share of lump sum government transfers, $\overline{G}_t^t$.[11] Thus, the budget constraint is:

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

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,[12] 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 is total government tax income (specified below) and $0 \leq \Delta_t < 1$ is the economy-wide degree of extraction (specified below). Note that R_t and Δ_t are taken as given by each individual.

The budget constraint in (3) is standard except from the last term on the right-hand side. The idea behind this term is that a total amount $\Delta_t R_t$ can be taken away from the government (i.e. $\Delta_t R_t$ is the contestable prize) and then each self-interested agent attempts to extract a fraction of that pie, 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 standard rent-seeking technology (see e.g. Murphy et al., 1991, Mauro, 2004, Park et al., 2005, and for a survey Mueller, 2003, chapter 15; this is also the usual way of modeling extraction in the natural resources literature, see e.g. Dasgupta and Heal, 1979).

Private holding of government bonds evolves according to:

$$B_{t+1}^h = B_t^h + D_t^h \qquad (4)$$

where initial B_0^h is given.

Private holding of capital evolves according to:

[11] Thus, $\overline{G}_t^t \equiv G_t^t / N_t$, where G_t^t is total lump-sum transfers.

[12] We assume that returns on government bonds are not taxed.

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

where the parameter $0<\delta^{p}<1$ is a depreciation rate, 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.

Households act competitively by taking prices, policy and economy-wide variables as given.[13] Thus, each household 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)-(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:

$$\frac{\partial u(.t)}{\partial L_{t}^{h}}=\frac{1}{(1+\tau_{t}^{c})}\frac{\partial u(.t)}{\partial C_{t}^{h}}\left[(1-\tau_{t}^{y})w_{t}Z_{t}\eta_{t}^{h}+\frac{(1-\eta_{t}^{h})}{\sum_{h=1}^{N_{t}}(1-\eta_{t}^{h})H_{t}^{h}}\Delta_{t}R_{t}\right] \tag{6a}$$

$$(1-\tau_{t}^{y})w_{t}Z_{t}H_{t}^{h}=\frac{H_{t}^{h}}{\sum_{h=1}^{N_{t}}(1-\eta_{t}^{h})H_{t}^{h}}\Delta_{t}R_{t} \tag{6b}$$

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

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

where

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

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 the return to work and the return to rent seeking should be equal in equilibrium. The next two

[13] We could assume that each household h internalizes the effects of his/her own actions on aggregate outcomes. This is not important. What is important is that each h takes the actions of other agents $j \neq h$ as given.

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 $\lim_{t\to\infty}\beta^{*t}E_0\frac{\partial u(.t)}{\partial C_t^h}B_{t+1}^{h}=0$.

2.2 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 also e.g. Lansing, 1998, for a similar production function with constant returns to scale at the economy level).

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

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

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

so that profits are $\Pi_t^f = (1-\alpha-\varepsilon)Y_t^f$ per firm.

2.3 Government budget constraint

Each period the government issues bonds, B_{t+1}, and taxes consumption as well as income (from capital, labour and profits) at the rates $0 \le \tau_t^c < 1$ and $0 \le \tau_t^y < 1$ respectively. If rent seekers manage to take away a fraction $0 \le \Delta_t < 1$ of collected tax revenue R_t, then only a fraction $0 < (1-\Delta_t) \le 1$ of R_t remains in the hands of the government. On the expenditure side, the government provides public consumption G_t^c, public investment G_t^i, and transfer payments G_t^t. The budget constraint is:

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

where $R_t \equiv \tau_t^c \sum_{h=1}^{N_t} C_t^h + \tau_t^y \left(r_t^k \sum_{h=1}^{N_t} K_t^h + w_t Z_t \sum_{h=1}^{N_t} \eta_t^h H_t^h + \sum_{h=1}^{N_t} \Pi_t^h \right)$ denotes total tax revenue.

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.

2.4 Exogenous stochastic variables and policy instruments

The exogenous stochastic variables include the aggregate productivity, A_t, and the 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 (see also e.g. Baxter and King, 1993, and Kollintzas and Vassilatos, 2000).

Specifically, 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. We 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 of the form:

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

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

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

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

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

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

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.

2.5 Economy-wide extraction

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

$$\Delta_t = \Delta_0 \frac{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}{N_t} \tag{13}$$

where the parameter $\Delta_0 \ge 0$ can be thought of as a technology parameter that translates individual rent-seeking efforts into actual extraction. The value of Δ_0 reflects social norms (see below subsection 3.3. for details).

2.6 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 given market prices, government policy and economy-wide outcomes. (ii) Markets clear via price flexibility.[14] (iii) Individual decisions are consistent with economy-wide decisions. (iv) The government budget constraint is satisfied. (v) This equilibrium holds for any feasible policy. We will 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

[14] Thus, 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.

quantities chosen by firms). Obviously, since atomistic individuals have ignored externalities, the DCE is inefficient (see Park et al., 2005, for details).

Equations (1)-(13) give a DCE. Looking ahead at the long run where all the 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:

$$\frac{(c_t + \psi s_t^c y_t)}{(1-h_t)} = \frac{\mu}{(1+\tau_t^c)(1-\mu)} \Delta_0 \left(\tau_t^c c_t + \tau_t^y y_t \right) \tag{14a}$$

$$\eta_t h_t \Delta_0 = \frac{\varepsilon (1-\tau_t^y) y_t}{\left(\tau_t^c c_t + \tau_t^y y_t \right)} \tag{14b}$$

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

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

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

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

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

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

$$\gamma_n \gamma_z b_{t+1} - (1+r_t^b) b_t = (s_t^c + s_t^i + s_t^t) y_t - \left(1 - \Delta_0 (1-\eta_t) h_t \right) \left(\tau_t^c c_t + \tau_t^y y_t \right) \tag{14i}$$

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 therefore 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 for any paths of productivity, A_t, and the independent policy instruments, $s_t^c, s_t^i, s_t^t, \tau_t^y, \tau_t^c$.

2.7 Linearized Decentralized Competitive Equilibrium

We linearize the DCE in (14a)-(14i) around its long run (the latter is presented in Appendix A). 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 we end up with 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 $\hat{x}_t \equiv \left[\hat{i}_t, \hat{c}_t, \hat{y}_t, \hat{r}_t^b, \hat{\eta}_t, \hat{h}_t, \hat{b}_t, \hat{k}_t^g, \hat{k}_t, \hat{k}2_t\right]'$, $k2_t \equiv k_{t+1}$, $\hat{z}_t \equiv \left[\hat{A}_t, \hat{s}_t^c, \hat{s}_t^i, \hat{s}_t^t, \hat{\tau}_t^y, \hat{\tau}_t^c\right]'$ and A_1, A_0, B_1, B_0 are constant matrices of dimension 10x10, 10x10, 10x6 and 10x6 respectively. The elements of $\hat{z}_t$ follow the $AR(1)$ processes in (12a)-(12f) above. 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 presented below, there are three eigenvalues with absolute value less than one, so that the model exhibits saddlepath stability. We also report that all eigenvalues are real.

3. Empirical Results

We first calibrate the model to the euro zone area as a whole. Our data source is the (updated) AWM dataset constructed by Fagan et al. (2001). The data are quarterly and cover the period 1980:1-2003:4.[15] We also calibrate the model to individual EU-12 countries. In this case, we use annual data from the OECD Economic Outlook database. For comparison, we will also report some results for the US economy.

3.1 Calibration and long-run solution for the euro zone

Tables 1 and 2 below report calibration results, the long run solution and average values implied by the AWM dataset. Concerning the tax rates in Table 1, we use the ECFIN effective tax rates for the euro zone as reported in Martinez-Mongay (2001). The average (annual) income and

[15] This dataset starts in 1970. We follow Smets and Wouters (2003) in using data after 1980.

consumption tax rates, τ_0^y and τ_0^c, over the period 1980-2001 are 0.3717 and 0.2372 respectively.[16] Table 2 reports average values for c/y and i/y, while the average quarterly real interest rate, r^b, is 0.0089 which means an annual value of 0.036. The series of non-leisure time, h_t, is computed as in Correia et al. (1995).[17]

Tables 1 and 2 here

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 (we experiment with other values too). We assume away population growth by setting $\gamma_n = 1$. The private and public capital depreciation rates, δ^p and δ^g, are both set equal to 0.01 (this is a quarterly value implying 0.04 annually), which are the values used in the AWM for the construction of the series for private and public capital. The exponent of public capital in the production function ($1-\alpha-\varepsilon$) is set equal to 0.0295, which is the average public investment to output ratio, s_0^i, in the data (Baxter and King, 1993, do the same for the US). The parameter measuring capital adjustment costs, ξ, is set equal to zero (this is the value so that our simulated series of private investment mimics as close as possible the data in terms of volatility).

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, p. 954). The growth rate of the exogenous labor augmenting technology, γ_z, is found to be $\gamma_z = 1.0064$.[18]

The time discount factor, β, is calibrated from equation (A.III) in Appendix A. The capital share, α, is calibrated from equation (A.II). Given the values of α and $1-\alpha-\varepsilon$, the labor share is $\varepsilon = 0.6391$. No data is available for the fraction of non-leisure time devoted to productive work

[16] Martinez-Mongay (2001) reports annual country-specific and weighted euro zone averages of the effective tax rates on labour income, capital income and consumption (we use, respectively, the LITR, KITN and CETR rates). These effective tax rates are based on the methodology of Mendoza et al. (1994). Our income tax rate is then obtained as $\tau^y = \varepsilon * LITR + (1-\varepsilon) * KITN$.

[17] Total employment is equal to the employment rate multiplied by the labour force. On the assumption that there are 7x14 hours per week and the average working week is 40 hour, labour hours are obtained if we multiply total employment by the factor 40/(7x14).

[18] The AWM database reports two growing productivity series, namely real trend total factor productivity and labour productivity. In our model we have only one exogenous growing productivity variable, Z_t. Hence, we construct a series Z_t whose growth rate reflects the growth rate of both aforementioned series, as implied by our production function. This gives γ_z =1.0064.

relative to rent seeking, η, or the fraction of collected tax revenues extracted by rent seekers, Δ. We therefore calibrate the value of η from equations (A.I), (A.VI) and (A.VIII). This gives $\eta = 0.8098$. The extraction parameter Δ_0 is also calibrated from (A.I), (A.VI) and (A.VIII). In turn, given the calibrated values of η and Δ_0, we get $\Delta = 0.1861$. The weight given to consumption relative to leisure in the utility function, μ, is calibrated from (A.III). Note that this is the only parameter value that changes with the value of ψ.[19] Finally, the chosen values of γ_z, δ^p and δ^g yield from (A.IX) and (A.VII) respectively the values $k/y = 11.0172$ and $k^g/y = 1.7936$ for the two capital stocks as shares of output.[20]

For the simulations, we 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. Following usual practice (see e.g. McCallum, 1989), we choose 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. This is achieved when $\sigma_a = 0.0063$ and $\rho_a = 0.99$ respectively. Finally, we choose to treat τ_t^y and τ_t^c in (12e)-(12f) as constant over time. This can be justified by the lack of quarterly data and by the observation that the tax rates change infrequently via tax reforms rather than continuously (see the discussion in King and Rebelo, 1999). Table 1 summarizes all these results.

Table 2 also presents the long-run equilibrium solution as derived in Appendix A. In this solution, we have set the annual long-run public debt to output ratio to be 0.6, or 2.4 on a quarterly basis, which is the target of the Stability and Growth Pact. For this reason we allow the long-run public consumption to output ratio, s_0^c, to follow residually to satisfy the government budget constraint (see again Appendix A for details). It is worth noting that this solution, for the euro zone as a whole, gives $\eta = 0.8206$ and $\Delta = 0.1727$. That is, in the long run of this economy, individual agents allocate 17.94% of their non-leisure time to rent seeking activities, and as a result they grab 17.27% of collected tax revenue.

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[19] For ψ =[-1, -0.5, 0, 0.5, 1], we get γ =[0.3499, 0.4078, 0.4562, 0.4973, 0.5327].

[20] The AWM database does not report data on private and public capital. We choose to calibrate the two long-run capital output ratios rather than construct the respective series using e.g. a perpetual inventory method.

3.2 Sensitivity analysis of the long run solution for the euro zone

We use the long-run solution to report comparative static properties. We focus on the behavior of $0 < \eta \leq 1$ and how it is affected by the government spending-tax variables. Actually, as shown in Appendix A, the long run value of η is a function of $s_0^c, s_0^i, \tau_0^y, \tau_0^c$ and parameter values only. Numerical simulations shown in Table 3 reveal that an increase in any of $s_0^c, s_0^i, \tau_0^y, \tau_0^c$ leads to a monotonic decrease in η (at least in the range of parameter values we work with). In other words, as the size of the public sector increases (anyhow this is measured), there is a signal of a larger pie so that selfish individuals find it optimal to devote more time to rent seeking relative to work (see Park et al., 2005, for further discussion). Note that these long-run results are qualitatively similar to those implied by the impulse response functions studied below.

Table 3 here

3.3 Calibration and long-run solution for individual euro countries

To calibrate the model for each individual country, we follow exactly the same steps as for the average euro area. We use annual data from the OECD Economic Outlook database over the same period, namely 1980-2003 (some details about the data are provided in Appendix B).[21]

Table 4 presents the calibrated value of Δ_0 and the long run solutions of η and Δ for each country.[22] For comparison, we also provide three relevant "real world" indexes: two measures of the size of shadow economy as a percentage of GDP obtained from Schneider and Enste (2000), as well as the ICRG index which is a widely used measure of institutional quality.[23] Numbers in parentheses denote the ranking of countries with bigger numbers indicating worse performance.

Table 4 here

The parameter Δ_0 provides a measure of institutional quality (the higher is Δ_0, the easier a given rent seeking effort is translated into actual extraction). Conceptually, Δ_0 tells the same story as the ICRG index. The correlation between our calibrated value of Δ_0 and the ICRG index is -0.84 (higher numbers of the ICRG index denote better outcomes, hence the minus). Moreover, the ranking of countries according to Δ_0 is close to the ranking of countries according to the ICRG index. Apart from small differences, both measures classify countries into the same two subgroups. Using Δ_0, in the "good" subgroup, Finland scores the best being closely followed by Austria and the Netherlands. In the "bad" subgroup, Greece is clearly the worst with Portugal being the second-worst.

[21] For Germany, we use data for the post-unification period, 1990-2003, only.
[22] Details and calibration results for each country are in Angelopoulos (2006).
[23] For details, see the notes in Table 4.

Consider now our results for Δ (the share of total tax revenue eventually grabbed by rent seekers). The Netherlands scores the best, while Greece again is the worst with 34.89% of tax revenues taken away. To us, who live the Greek experience, this number is not surprising. Portugal, Italy and Belgium are the second-, third- and fourth-worst with 20.2%, 18.48% and 17.37% respectively. The results for the other countries also make sense. An exception is Spain, which scores paradoxically well relative to the rankings implied by the shadow economy and ICRG indexes as well as by Δ_0 (see below for further discussion).

Note that although Δ and the shadow economy indexes refer to different things (rent seeking can take legal forms, while shadow economic activities are mainly illegal), it is interesting to note that countries with rent seeking problems also suffer from shadow economic activities. It is also interesting to note that the group of countries with severe rent seeking (i.e. Greece, Portugal, Italy and Belgium) is also the group with high public debt-to-GDP ratios.

Finally, we report that we have also calibrated the model to US data over the same period, 1980-2003, using annual data from the OECD (some details about the data are in Appendix B). Following exactly the same steps as above, we find that both the calibrated value, as well as the long-run equilibrium solution, of η are practically one. Thus, according to our model, there is no evidence of rent seeking activities in the US. We believe this is consistent with the view that, if there is rent seeking in the US, it may happen through different channels, for instance through regulation, and not through spending/tax. A similar argument might also apply to the paradoxically low value of Δ found for Spain. Or, more possibly, and this is irrespectively of rent seeking, it is natural that a single model cannot account for each one of all these different countries.

3.4 Simulation results for the euro zone

In the rest of the paper, we continue with results for the euro area as a whole. We simulate our model economy over the period 1980-2003 and evaluate its descriptive power by comparing the second moment properties of the series generated by the model to those of the actual eurozone data. We will report results for the parameterization in Table 1. For comparison, we will also report the performance of two other models: (i) the same model without rent seeking (i.e. $\eta = 1$ and hence $\Delta = 0$); (ii) the baseline RBC model which is without public sector and without rent seeking (see e.g. King and Rebelo, 1999).[24] To get the cyclical component of the series, we first take logarithms (except otherwise stated) and then 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, specifically $y, c, i, h, y/h, \eta, \eta h$.

[24] See Canova (2006) for a recent rich review of the DSGE literature.

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

We start with relative volatility. Inspection of Table 5 reveals that our model does quite well in predicting the standard deviation of the key macroeconomic variables relative to that of output. Our model is somewhat better than the other two models in terms of consumption. More importantly, our model clearly outperforms the other two models in terms of labour.

Table 5 here

Recall that one of the weak points of the baseline RBC model is its difficulty with the labour market in general, and specifically its prediction that the hours worked are not enough volatile relative to output (see e.g. King and Rebelo, 1999, and Hall, 1999, for rich surveys). Of course, to increase the standard deviation of labour and so match the data, one could be tempted to simply use larger labour supply elasticity with respect to real wages. But this is not a way around because the typical elasticity implied by the baseline model is already at odds (too high) with the elasticity implied by microeconomic evidence. The RBC literature has therefore recognized the need for alternative resolutions, which can predict a higher labour volatility and at the same time smaller labour supply elasticity. Rent seeking does exactly this. By distinguishing between effort time devoted to productive work, $\eta_t h_t$, and effort time devoted to rent seeking, $(1-\eta_t)h_t$, we move the model economy to the right direction vis-à-vis the data.[25] This happens because, once there is a shock, the fraction of effort time devoted to productive work, η_t, and the total time devoted to productive work, $\eta_t h_t$, move in opposite directions, so that total effort or non-leisure time, h_t, has to overshoot its value relative to the standard RBC model (the channel becomes clear when we present impulse response functions in the next subsection below). This overshooting is reflected into higher labour volatility.

It is worth saying that the literature has always recognized the need for amplification mechanisms that help to produce a response of employment to a driving force stronger than in the baseline RBC model. The same literature has pointed out that one way to do so is to introduce a third use of time - in addition to work and leisure - that helps the model to come closer to a realistic explanation of employment volatility (again see King and Rebelo, 1999, and Hall, 1999). Our rent seeking activity plays this very role of a third use of time. Alternative third uses of time could be home production (see e.g. Greenwood et al., 1995) and human capital services (see e.g. Jones et al., 2005).

[25] Our full model implies a λ-constant (Frisch labour supply) wage elasticity of 1.2661. By contrast, in our case, the basic RBC model implies 1.63. The model without rent seeking implies a wage elasticity of 1.14 and fails to match labour volatility. Thus, the full story (with a public sector and rent seeking) helps with the data.

We continue with persistence results reported in Table 6. All three models do well by predicting high persistence, although not as high as observed in the data (except for that of y/h which is well-matched by all three models). The result that rent seeking does not affect the persistence behaviour is not surprising: the way we have modelled rent seeking does not add any new mechanism through which shocks propagate their effects over time.

Table 6 here

Concerning cross-correlations with output, as can be seen in Table 7, all three models give similar results. They all do well in terms of sign, and to some extent magnitude, although predicted contemporaneous cross-correlation coefficients are higher than in the data.

Table 7 here

To summarize, our model economy does well in reproducing several of the key stylized facts of the euro economy without seriously failing in any aspect. Moreover, it scores clearly better than the other models (namely, the basic RBC model and the model with public sector but without rent seeking) in terms of labor volatility. The latter is a statistic that the basic RBC model finds it difficult to match. The model with public sector but without rent seeking is the relatively worst.

3.5 Impulse response functions for the euro zone

We finally 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 focus on shocks to total factor productivity, government consumption and government investment. Results are reported in Tables 8a-c respectively.

Tables 8a-c here

Table 8a reports the effects of a temporary shock to total factor productivity, A_t. An increase in A_t signals a larger contestable pie and pushes individuals to devote a larger fraction of their effort time to rent seeking (η_t falls initially). As a result, h_t has to rise more relatively to standard DSGE models. The full scenario is as follows. As is typical in DSGE models, an increase in A_t increases both current and - via the consumption smoothing channel - future consumption. Leisure, both current and future, has the tendency to follow consumption, namely to rise (i.e. h_t to fall). Nevertheless, a higher A_t raises labor productivity and the real wage (as well as output, investment and capital) and creates a substitution effect that works in opposite direction by increasing the time spent in productive work, $\eta_t h_t$. If the latter effect dominates, the net effect on $\eta_t h_t$ is positive. This is what happens here (see also e.g. Kollintzas and Vassilatos, 2000). In addition, since η_t has fallen, h_t has to rise more relatively to the typical DSGE model in order 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 (like an increase in A_t) signals a larger pie pushing individuals to devote a larger fraction of their effort time to rent seeking (η_t falls). At the same time, an increase in s_t^c creates a negative income effect that reduces consumption (see also e.g. Canova, 2006). Concerning leisure, there are two opposite effects: on the one hand, leisure tends to fall by following consumption; on the other hand, a higher s_t^c lowers the wage rate (as well as output, investment and capital) and creates a substitution effect that tends to increase leisure. Here the former effect dominates so that leisure falls or equivalently total effort-time (h_t) rises. Since η_t has fallen, the time spent in productive work, $\eta_t h_t$, rises by less than total h_t.

Table 8c reports the effects of a temporary shock to government investment as a share of output, s_t^i. The response of the economy to an increase in the share of GDP that goes to public investment is more complicated than the corresponding response to an increase in the share that goes to government consumption. The qualitative effects on η_t, $\eta_t h_t$ and h_t are the same, but now the resulting increase in public capital increases the marginal productivities of all private factors. As a result, while the response of the economy to a change in s_t^i in the very short run resembles that of a change in s_t^c, eventually private consumption, investment and capital all rise above their initial long run values. Output is also higher all the time contrary to what happened with an increase in s_t^c.

4. Concluding remarks and possible extensions

The present paper has incorporated rent-seeking competition from state coffers into a Dynamic Stochastic General Equilibrium model. It then used the RBC methodology to calibrate the model to the euro area over the period 1980-2003. The main result is that rent seeking incentives matter to the macro economy in Europe. We also managed to get quantitative evidence for the fraction of social resources taken away by rent seeking interest groups.

We close with two possible extensions. First, it is interesting to include government expenditure on law enhancing activities (police, courts, tax inspectors, prisons, etc) and examine its quantitative implications. If this reduces rent seeking (this could happen by decreasing Δ_0 in (13) above), it will help the aggregate economy. Second, here we assumed that only private agents rent seek from state coffers. To the extent that we solved for any feasible policy (namely, policy was exogenous), this assumption was not really important. The strategic role of government officials, and their interaction with private agents concerning extraction from state coffers, will become important the moment government officials' behaviour is optimally chosen. But endogenizing policy in a DSGE model is beyond the aim of this paper. At this stage, we would just like to speculate that, although this would complicate the model considerably, adding more types of rent seeking optimising agents would not change our qualitative results. Government officials are also "human beings" that behave atomistically like private agents.

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. Thus, equations (14a)-(14i) imply:

$$\frac{c + \psi s_0^c y}{\tau_0^c c + \tau_0^y y} \frac{1}{1-h} = \frac{\mu}{1-\mu} \Delta_0 \frac{1}{1+\tau_0^c} \tag{A.I}$$

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

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

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

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

$$\left[\gamma_n \gamma_z - (1 + r^b)\right] \frac{b}{y} + \left[1 - \Delta_0 (1-\eta) h\right] \left[\frac{\tau_0^c c + \tau_0^y y}{y} \right] = s_0^c + s_0^i + s_0^t \tag{A.VI}$$

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

$$\eta h \frac{\tau_0^c c + \tau_0^y y}{y} = \frac{(1-\tau_0^y)\varepsilon}{\Delta_0} \tag{A.VIII}$$

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

which is a system in $y, k, c, k^g, i, h, \eta, b, r^b$. Notice that if we set $b = 2.4y$ (i.e. the public debt-to-GDP ratio is 60% on an annual basis, which is supposed to be the EU case in the long run), then one of the other five policy instruments should follow residually to satisfy the government budget constraint (A.VI). In that case, we choose the long-run government consumption-to-GDP ratio (s_0^c) to play this role.

It is straightforward to show that the above equations (A.I)-(A.IX) give a unique closed-form solution (details available on request). Here, we only report the solution for η, i.e. the fraction of non-leisure time allocated to work vis-à-vis rent seeking:

$$\eta = \frac{\varepsilon (1-\tau_0^y) \mu}{[\tau_0^c \Omega_1 + \tau_0^y] \mu \Delta_0 - (\Omega_1 + \psi s_0^c)(1+\tau_0^c)(1-\mu)}$$

where $\Omega_1 \equiv [1 - s_0^c - s_0^i - (\gamma_n \gamma_z - 1 + \delta^p)\Omega_2]$ and $\Omega_2 \equiv \dfrac{\alpha\beta(1-\tau_0^y)}{1-\beta(1-\delta^p)}$.

Appendix B: Data for individual countries

For individual EU-12 countries, we use annual data from the OECD Economic Outlook. Concerning the depreciation rates and the growth rate of the labor augmenting technology, we set (on annual basis) $\delta^p = \delta^g = 0.04$ and $\gamma_z = 1.026$ for each country (as we did for the euro area as a whole). Concerning tax rates, we again use the ECFIN effective tax rates for each country as reported in Martinez-Mongay (2001). For the real government interest rate, we use the "benchmark risk free" Treasury bill interest rate as implied by the World Bank's database World Development Indicators (the source is the IFS). Since this is not available for Austria and Finland, we use the euro zone value of 0.036 annually for these two countries. With respect to labor hours (h), we use data for average hours of work per week when available in the OECD Economic Outlook database. Since such data are not available for Austria, Greece and Portugal, for these countries, we work as in the euro zone above. Finally, for those countries with an average annual public debt-to-GDP ratio (b/y) higher than 0.6, we set $b/y = 0.6$ and let s_0^c to be endogenously determined in the long run, as explained in Appendix A above. For those countries with an average public debt-to-GDP ratio lower than 0.6, s_0^c is given by the data average and b/y follows.

For the US economy, we also use annual data from OECD (we have also used quarterly data from the Federal Reserve Bank of St. Louis, but the long-run results are very similar to those obtained from OECD data). Following King and Rebelo (1999), we set $\delta^p = \delta^g = 0.10$. We also set $\gamma_z = 1.029$ (which is the average growth rate of the US real GDP for this time period). We again use the ECFIN effective tax rates as reported in Martinez-Mongay (2001).

Table 1: Calibration

parameter or variable	description	value	source
α	private capital share in production	0.3314	calibrated from (A.II)
ε	labor share in production	0.6391	calibrated as $1-\alpha-s_0^i$
δ^p	private capital quarterly depreciation rate	0.0100	set
δ^g	public capital quarterly depreciation rate	0.0100	set
A_0	long run aggregate productivity	1	set
γ_z	growth rate of labor augmenting technology	1.0064	constructed data
ξ	capital adjustment cost parameter	0	set
k/y	private capital to output ratio	11.0172	calibrated from (A.IX)
k^g/y	public capital to output ratio	1.7936	calibrated from (A.VII)
μ	consumption weight in utility function	0.4562	calibrated from (A.III)
σ	curvature parameter in utility function	2	set
γ_n	population growth rate	1	set
β	time discount factor	0.9912	calibrated from (A.III)
ψ	substitutability between private and public consumption in utility	0	set
n	fraction of non-leisure time allocated to productive work	0.8098	calibrated from (A.I), (A.VI), (A.VIII)
nh	time allocated to productive work	0.3007	derived from n and h
Δ	economy-wide degree of extraction	0.1861	derived from n,h and Δ_0
Δ_0	extraction technology parameter	2.6356	calibrated from (A.I), (A.VI), (A.VIII)
s_0^c	government consumption to output ratio	0.2041	data
s_0^i	government investment to output ratio	0.0295	data
s_0^t	government transfers to output ratio	0.1731	data
τ_0^y	average income tax rate	0.3717	data
τ_0^c	average consumption tax rate	0.2372	data
ρ_a	persistence parameter of A_t	0.9900	set
ρ_g	persistence parameter of s_t^c	0.9933	estimation
ρ_i	persistence parameter of s_t^i	0.8477	estimation
ρ_t	persistence parameter of s_t^t	0.9871	estimation
σ_a	standard deviation of the innovation ε_t^a	0.0063	set
σ_g	standard deviation of the innovation ε_t^g	0.0121	estimation
σ_i	standard deviation of the innovation ε_t^i	0.0073	estimation
σ_t	standard deviation of the innovation ε_t^t	0.0071	estimation

Table 2: Long run

variable	data average	equilibrium solution
c/y	0.5694	0.5771
i/y	0.1812	0.1812
h	0.3713	0.3651
n	Na	0.8206
nh	Na	0.2996
Δ	Na	0.1727
r^k	0.01004	0.0301
k/y	Na	11.0172
k^g/y	Na	1.7936
r^b	0.0089	0.0089
b/y	2.3288	2.4
s_0^c	0.2041	0.2122

Notes: (i) Quarterly data over 1980:1-2003:4. (ii) na: non available.

Table 3: Comparative static properties in the long run:

Effects of policy instruments on η

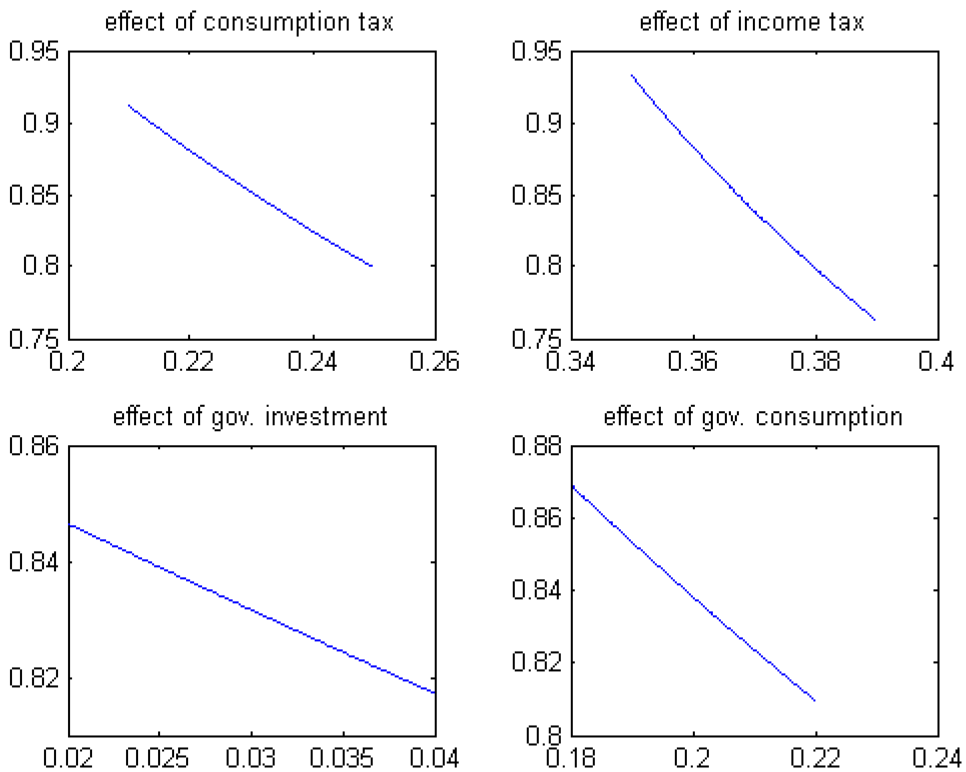


Table 4: Rent seeking results in member countries

country	Δ_0	η	Δ	*shadow economy index I*	*shadow economy index II*	*ICRG index*
Austria	2.0544 (2)	0.8161	0.1491 (6)	5.8 (1)	15.5 (5)	47.22 (5)
Belgium	2.2134 (4)	0.7595	0.1737 (8)	15.3 (6)	19.8 (8)	47.46 (4)
Finland	2.0277 (1)	0.7781	0.1559 (7)	na	13.3 (2)	48.76 (3)
France	2.2898 (5)	0.8455	0.1149 (3)	10.4 (3)	12.3 (1)	46.62 (6)
Germany	2.8344 (6)	0.8498	0.1328 (5)	10.5 (4)	14.6 (4)	48.92 (2)
Greece	3.7512 (11)	0.7641	0.3489 (11)	27.2 (10)	21.8 (10)	34.36 (11)
Ireland	3.5282 (9)	0.8934	0.1327 (4)	7.8 (2)	20.6 (9)	44.37 (7)
Italy	2.9589 (7)	0.8091	0.1848 (9)	20.4 (9)	19.6 (7)	40.90 (8)
Netherlands	2.0737 (3)	0.9274	0.043 (1)	11.8 (5)	13.4 (3)	49.40 (1)
Portugal	3.5336 (10)	0.8637	0.202 (10)	15.6 (7)	16.8 (6)	40.13 (10)
Spain	3.3895 (8)	0.9203	0.1025 (2)	16.1 (8)	22.9 (11)	40.40 (9)
Euro area	2.6356	0.8206	0.1727	na	na	na

Notes:

1. n and Δ are long run values, while Δ_0 is calibrated value. Luxembourg is not included.
2. Both shadow economy indices are as percentages of GDP and are taken from Schneider and Enste (2000, Table 6). Index I is based on a "currency demand" method, and index II on a "physical input" method. The former refers to the period 1990-1993 and the latter to 1990. Schneider and Enste provide a detailed discussion of these methods.
3. The ICRG index is based on annual values for indicators of the quality of governance, corruption and violation of property rights over the period 1982-1997. It has been constructed by Stephen Knack and the IRIS Center, University of Maryland, from monthly ICRG data provided by Political Risk Services. This index takes values within the range 0-50, with higher values indicating better institutional quality. Our reported numbers are the averages over 1982-1997. Knack and Keefer (1995) provide a detailed discussion of this index.

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

x	**data**	**full model**	**model without rent seeking**	**basic RBC model**
c	0.9578	0.6222	0.5650	0.5469
i	4.3504	2.4552	2.6715	3.0813
h	0.5206	0.4986	0.0927	0.3276
y/h	0.6357	0.5236	0.9103	0.6775
w	0.8307	0.8971	0.9103	0.6775
r^k	0.2228	0.0306	0.0305	0.0311
k	na	0.1415	0.1529	0.1803
k^g	na	0.1273	0.1251	
n	na	0.3930		
nh	na	0.1056		
s_y	0.0084	0.0084	0.0084	0.0084

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

x	**data**	**full model**	**model without rent seeking**	**basic RBC model**
y	0.8533	0.6859	0.6852	0.6859
c	0.8339	0.6887	0.6907	0.6996
i	0.8217	0.6691	0.6693	0.6802
h	0.9512	0.6838	0.6808	0.6793
y/h	0.6824	0.6905	0.6858	0.6929
w	0.8230	0.6864	0.6858	0.6929
r^K	0.7707	0.6839	0.6826	0.6793
k	na	0.9486	0.9479	0.9500
k^g	na	0.9511	0.9505	
n	na	0.6838		
nh	na	0.6838		

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

	Data			full model		
x	$i=-1$	$i=0$	$i=1$	$i=-1$	$i=0$	$i=1$
c	0.6725	0.8013	0.7396	0.6682	0.9910	0.6936
i	0.7541	0.8317	0.7115	0.6204	0.8929	0.6007
h	0.7324	0.8327	0.8700	0.6886	0.9771	0.6483
y/h	0.7401	0.8913	0.6256	0.6542	0.9793	0.6926
w	0.1102	0.2777	0.3643	0.6835	0.9997	0.6883
r^K	0.1823	0.1313	0.0958	0.7067	0.9898	0.6442
k	Na	na	na	-0.2285	-0.0351	0.2300
k^g	Na	na	na	-0.1371	-0.0371	0.1039
n	Na	na	na	-0.6886	-0.9771	-0.6483
nh	Na	na	na	0.6886	0.9771	0.6483

Table 7 (continued)

	model without rent seeking			basic RBC model		
x	$i=-1$	$i=0$	$i=1$	$i=-1$	$i=0$	$i=1$
c	0.6582	0.9810	0.6908	0.6558	0.9925	0.7156
i	0.5811	0.8319	0.5596	0.7024	0.9951	0.6545
h	0.6825	0.9710	0.6424	0.7080	0.9894	0.6372
y/h	0.6832	0.9997	0.6873	0.6699	0.9975	0.7042
w	0.6832	0.9997	0.6873	0.6699	0.9975	0.7042
r^k	0.7048	0.9881	0.6409	0.7109	0.9835	0.6233
k	-0.2036	-0.0212	0.2291	-0.2032	0.0110	0.3021
k^g	-0.1378	-0.0378	0.1035			

Table 8a: Response to aggregate productivity shocks (A_t)

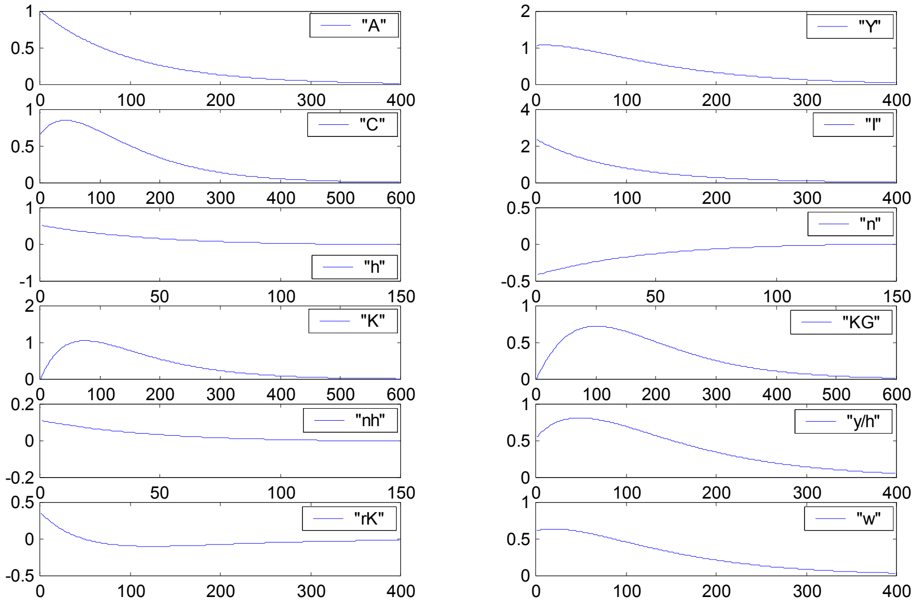


Table 8b: Response to government consumption shocks (s_t^c)

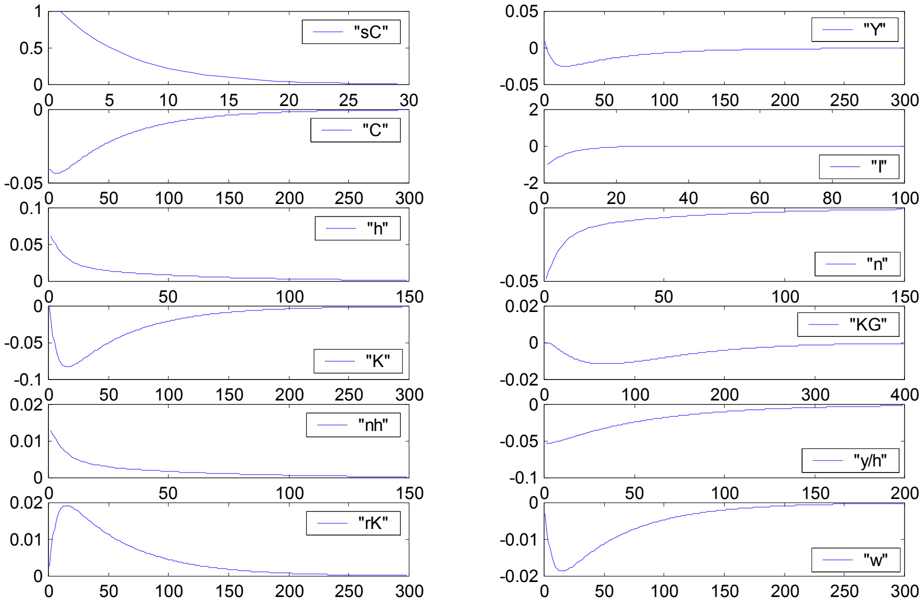
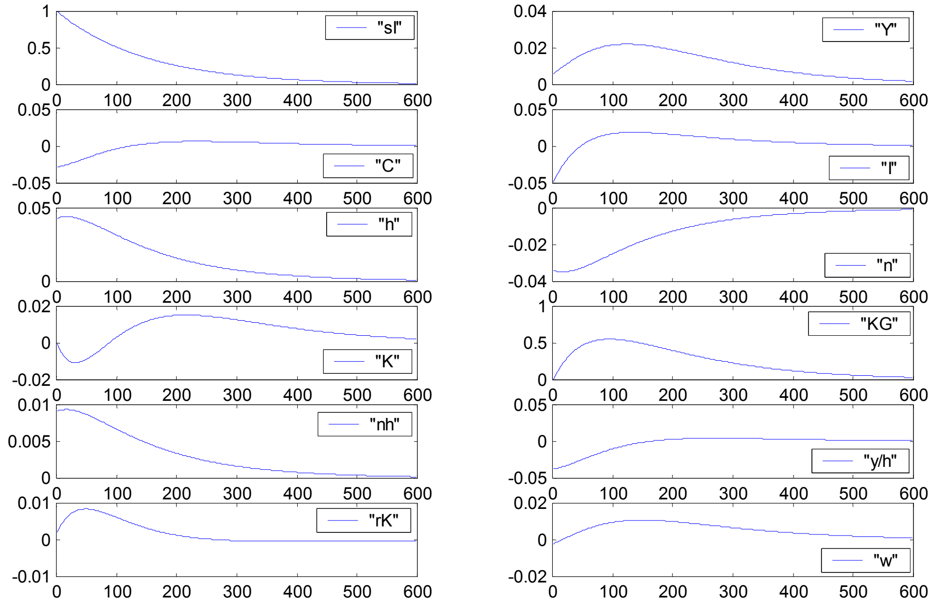


Table 8c: Response to government investment shocks (s_t^i)



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