Rent-seeking competition from state coffers in a calibrated DSGE model of the euro area

by

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Abstract: We incorporate an uncoordinated redistributive struggle for extra fiscal privileges into an otherwise standard dynamic stochastic general equilibrium model. The main aim is to get model-consistent quantitative evidence of the extent of rent seeking. Our work is motivated by the common belief that interest groups compete with each other for privileged transfers, subsidies and tax treatments at the expense of the general public interest. The model is calibrated to the euro area as a whole, and to individual euro member-countries, over the period 1980-2003. We find that an important proportion of tax revenue is appropriated by rent seekers and that the introduction of rent seeking moves the model in the right direction vis-à-vis the data.

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1. Introduction

Rent seeking is the socially costly pursuit of winning a contestable prize; or the case in which people use private resources to gain an advantage in dividing up the benefits of economic activity. 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. At the heart of the problem, there is a common pool, prisoners' dilemma situation.[1]

Rent seeking occurs mainly through the public sector. It is commonly believed that the monopoly rent that governments create - via coercive taxation, regulation, etc - generates a prize worth pursuing (see e.g. Tanzi, 1998, Mueller, 2003, and Hillman, 2003). 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, or what we call 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. We then calibrate the model to the euro area over the period 1980-2003. We expect that such political economy considerations can contribute to explaining the European experience in cycles and growth. We also aim to get quantitative evidence of the fraction of social resources extracted by rent seekers.

A key feature of our model is that the state collects tax revenue to finance public goods and services, but each self-interested individual uses a part of his/her non-leisure (i.e. effort) time to extract a fraction of that revenue for his/her own personal benefit.[2] The amount extracted by each individual is proportional to the effort he/she allocates to rent seeking relative to the aggregate 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 effort. This redistributive struggle can hurt 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 by pushing them away from productive work. This indirect effect is also known as "directly unproductive

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[1] See e.g. Tullock (1967, 1980), Krueger (1974), Bhagwati (1982), Becker (1983), Baumol (1990) and Murphy et al. (1991). For reviews of the literature on rent seeking, see Drazen (2000), Persson and Tabellini (2000), Mueller (2003) and Hillman (2003).

[2] This goes back to Becker (1983). Drazen (2000, chapters 10 and 11) reviews the literature on how interest groups compete with each other for extra transfers in dynamic setups. More recent papers include Mohtadi and Roe (2003), Mauro (2004) and Park et al. (2005). In all these models, the "common pool" is (some type of) government income.

profit-seeking" (see Bhagwati, 1982) or as "misallocation of talent" (see Murphy et al., 1991). Both effects can 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 individual EU-12 countries (i.e. the European countries that have adopted the euro). There are three main results.

First, we get quantitative information on the macroeconomic implications of rent seeking activities. For instance, in the euro area as a whole, rent seekers grab 18.07% of the collected tax revenue. This translates to 7.01% of output. In other words, redistributive transfers due to rent seeking (in the form of privileged spending subsidies and tax treatments) amount to 7.01% of output produced. At individual country level, Ireland and the Netherlands score the best (essentially zero rent seeking) being closely followed by Finland. At the other end, Greece, Portugal and Italy score the worst being followed by Germany (after the reunification), where the fraction of the collected tax revenue grabbed is respectively 53%, 52%, 32% and 26%. This amounts to 16%, 13%, 12% and 10% of each country's GDP respectively.

Second, sensitivity analysis can shed some light on the relationship between the size of government and the extent of rent seeking activities. In our model, the latter depends on almost all exogenous variables and calibrated parameters; the size of government is just one of them. For instance, despite their high tax rates and large public sectors, Finland and the Netherlands enjoy very low rent seeking thanks to their good "institutional quality" (where the latter is a calibrated model parameter defined below). Greece and Portugal do very badly because of poor institutional quality; their tax rates are low. Rent seeking in Germany seems to be driven by high tax rates; its institutions are not that bad. Thus, high tax rates and large public sectors are not bad per se.[3]

Third, the introduction of rent seeking incentives moves the model in the right direction vis-à-vis the data. In particular, our model does well in reproducing the key stylized facts of business cycles in the euro area and, more importantly, it scores better than the same model without rent seeking in terms of volatility in hours at work. The latter is a statistic that standard RBC models find it difficult to match (see e.g. the review papers by King and Rebelo, 1999, and Hall, 1999).

The rest of the paper is as follows. Section 2 presents the model. A quantitative study is in sections 3 and 4. Section 5 concludes.

[3] This may explain the non-conclusive evidence on the relationship between government size and measures of rent seeking activities. For instance, Park et al. (2005) provide evidence of a positive correlation between fiscal size and rent seeking in 108 countries, and Glaeser and Saks (2006) find a weak positive relationship between bigger governments and corruption using data for states in the US. On the other hand, Treisman (2000) reports that measures of government size are not significantly related with corruption in a world sample, and Fisman and Gatti (2002) report that a higher government share in GDP is reducing corruption in a sample of both developed and developing countries.

2. Theoretical model

2.1 Description of the 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 fiscal privileges.[4] Rent seeking can come at a private cost: it requires effort (non-leisure) time.[5] Thus, 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.[6] Firms produce a homogenous product by using capital, labour and public infrastructure. The government imposes income and consumption taxes, but a fraction of tax revenue can be grabbed by rent seekers. The government uses the remaining tax revenue, plus the issue of new bonds, to finance three standard activities: public consumption goods and services that provide direct utility to households, public investment that augments the stock of public infrastructure and provides production externalities to firms, and a uniform lump-sum transfer to each household.

It is worth pointing out two features of the model. First, the contestable prize is the monopoly rent or income that the government creates via coercive taxation. In turn, self-interested agents use their private resources to compete with each other for a share of this prize. Second, each household can receive both a uniform lump-sum (non-distorting) transfer and an extra (distorting) fiscal favour. The former is standard in the literature and 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.[7]

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[4] We could assume that firms 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 rent seek. Again, this is not important conceptually; 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. Nevertheless, if policy decisions are optimally made, introducing optimizing rent-seeking government officials would complicate the algebra considerably. Thus, like Becker (1983), we take policy decisions as given. See e.g. Persson and Tabellini (2000) and Eggert and Sorensen (2007) for optimal behaviour of "corrupt" government officials, although in simpler setups. See also Park and Philippopoulos (2004), Park et al. (2005) and Malley et al. (2007) for optimal fiscal policies.

[5] Trade unionism, participation in strikes and demonstrations, establishing connections, lobbying, paying lawyers and campaign contributions, etc, are costly activities. In general, rent seeking (winning a contestable prize) requires the expenditure of private resources (time, money or both). Note that instead of assuming that each individual devotes effort time to rent seeking, we could assume that it pays bribes to the government to influence fiscal favors in its favor; this is not important to the main results.

[6] This goes back to e.g. Baumol (1990), Murphy et al. (1991) 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 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.

In what follows, we formalize the above scenario. Before we do so, we discuss what we mean by privileges or favours.

2.2 What do we mean by privileges or favours?

We can classify privileges into two categories. The first 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. 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) or lead to disguised transfers (e.g. a public road may be planned to increase the value of certain pieces of real estate). Obviously, this list is not exhaustive (see Tanzi, 1998, Mueller, 2003, chapter 15, and Hillman, 2003, chapter 6, for more examples).

Although our model is conceptually consistent with both categories of privileges, formally speaking, we model the first category. Note that rent seeking can also take illegal forms (e.g. tax evasion, use of fake documents to get a privileged treatment).

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:

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

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, 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 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 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 $0\leq(1-\eta_t^h)<1$ 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 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 standard rent-seeking technology (see Mueller, 2003, chapter 15). As Mueller points out, this standard model of rent seeking largely abstracts from institutional or

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[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.

political details. Under this modeling, specific redistribution mechanisms are replaced by a "technology" of redistribution.

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**:**

$$K_{t+1}^h = (1-\delta^p)K_t^h + I_t^h \tag{5}$$

where the parameter $0 < \delta^p < 1$ is a depreciation rate and the initial K_0^h is given.

Each household h acts competitively by taking prices, policy and economy-wide variables as given.[10] 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)-(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:

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

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

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

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

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[10] 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.

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 provides public consumption, G_t^c, public investment, G_t^i, and lump-sum transfers, G_t^t. On the revenue side, it collects tax revenue 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 fraction $0 \le \theta_t < 1$ is modelled below. The government also issues new bonds, B_{t+1}. Then, the government budget constraint at t 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.

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 (see e.g. Baxter and King, 1993). Specifically, let us 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:

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

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

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

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

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

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

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.

2.7 Economy-wide extraction

To close the model, we specify the economy-wide degree of extraction ($0 \leq \theta_t < 1$). 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, $\dfrac{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}{N_t}$. Using for simplicity a linear specification:[11]

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

where the parameter $\theta_0 \geq 0$ is a technology parameter that translates individual rent-seeking efforts into actual extraction. Its value reflects social norms (see subsection 3.2 below for 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 given market prices, government policy and economy-wide outcomes. (ii) Markets clear via price flexibility.[12] (iii) The government budget constraint is satisfied. This equilibrium holds for any feasible policy. Note that since atomistic individuals have ignored social externalities, the DCE is inefficient vis-à-vis the social planner's solution where there is no rent seeking (see Park et al., 2005, for details).

[11] We could use a non-linear specification. Or treat θ_t as exogenous. This would not affect our main predictions (see Park et al., 2005, for details).

[12] 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.

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:

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

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

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

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

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

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

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

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

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

where $\beta \equiv \beta^* \gamma_z^{\mu(1-\sigma)-1}$. 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 above in (12a-f).

3. Calibration and long-run results

We start by calibrating the model to the euro zone area as a whole. Our data source is the updated AWM dataset constructed by Fagan et al. (2001). Data are quarterly and cover the period 1980:1-2003:4.[13] We also calibrate the model to individual EU-12 countries. In this case, we use annual data from the OECD Economic Outlook database.

3.1 Calibration and long-run solution for the euro zone

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

Tables 1 and 2 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 0.0089 which means an annual value of 0.036. Since data on hours at work are not available for the euro zone, the series of h_t is computed as in Correia et al. (1995) and Kollintzas and Vassilatos (2000) and its average value is found to be $h = 0.3713$.[14] 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 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 ($\eta_t h_t$). Besides, 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.[15] These measurement problems arise in the calibration process only. To deal with them,

[13] This dataset starts in 1970. We follow Smets and Wouters (2003) and Andres et al. (2006) in using data after 1980. See also Trabandt and Uhlig (2005) for a DSGE model of the European Economy.

[14] 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).

[15] 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. We thus have to deal with this

we assume that (a) any effort devoted to rent seeking takes place while at work; (b) in the data, any spending favors take the form of redistributive transfers. Assumption (a) reflects the popular view that trade unionism, etc, are at the cost of actual hours of work (thus, we 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. In practice, these two assumptions mean that, in Appendix A, only two equations, (A.v) and (A.viii), are left with unobservable variables and hence not used for calibration purposes, while the government budget constraint (A.vi) becomes (A.vi').

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. Since quarterly population data for the euro zone as a whole are not available, we assume away population growth, $\gamma_n = 1$. The private and public capital depreciation rates, δ^p and δ^g, are both set equal to 0.025 (implying 0.10 annually), which are the values also used by Smets and Wouters (2003). 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). 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 1.0088, which is the average GDP growth rate of the Euro zone member countries during 1960-2003.

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 $\alpha = 0.2503$ and $(1-\alpha-\varepsilon) = 0.0295$, the labor share is found to be $\varepsilon = 0.7202$. The value of θ_0 (the extraction technology parameter) is calibrated from equation (A.i); this gives $\theta_0 = 4.7593$. Note that these calibrated parameter values did not require any data on η. We also report that (A.ix) and (A.vii) imply respectively

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.

$k/y = 5.3169$ and $k^g/y = 0.8714$, which are the two capital stocks, private and public, as shares of output.[16] An implied value of η can follow from (A.viii) and is found to be 0.78.

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. All 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 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 values 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 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 reference rate of the Stability and Growth Pact, and allow the long-run public consumption-to-output ratio, s_0^c, to be endogenously determined; its solution is $s_0^c = 0.1557$. Thus, government consumption as a share of GDP should fall from 0.2041 in the data to 0.1557 to be consistent with the exogenous debt-to-output ratio. The long-run solution also gives $\eta = 0.8809$ and $\theta = 0.1807$. Thus, agents allocate only 88.09% of their effort time to productive work, while the rest 11.91% goes to rent seeking. As a result, rent seekers grab 18.07% of collected tax revenue. The latter translates to 34.60% of total transfers or 7.01% of GDP, denoted as $\theta r/g^t$ and $\theta r/y$ respectively in the tables.[17]

3.2 Sensitivity analysis of the long run solution

We now use the long-run solution to check comparative static properties. To save on space, we focus on the behavior of the economy-wide degree of extraction ($0 \leq \theta < 1$) and of long-run output

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

[17] Although these numbers may seem high, it is important to point out that total transfers as a share of GDP ($s_0^t \equiv g^t/y$) and total transfers as a share of tax revenue (g^t/r) are respectively as high as 0.2026 and 0.5378 in the data (these are data averages) and also to remind the popular belief that 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 (see e.g. Mueller, 2003, p. 355, for a review).

(y), and how these two key endogenous variables are affected by exogenous variables and calibrated parameters. Specifically, we report the effects of the income tax rate (τ_0^y), the consumption tax rate (τ_0^c), the extraction technology parameter (θ_0), capital productivity (α), the growth rate of labor augmenting technology (γ_z) and labor productivity (ε).

Numerical solutions are illustrated in Table 3. An increase in any of the tax rates (τ_0^y, τ_0^c) pushes individuals away from productive work to rent seeking (i.e. it increases θ) and damages the pie (i.e. it reduces y). An institutional deterioration (i.e. a higher θ_0) has similar effects, namely it leads 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; thus, a higher pie triggers rent seeking, but, despite the adverse effects from rent seeking, the net output effect is positive. A higher ε leads to lower θ and higher y; thus higher labor productivity pushes individuals away from rent seeking to productive work and this stimulates output.

Table 3 here

3.3 Calibration and long-run solution for individual euro countries

To calibrate the model for each individual euro country, we follow exactly the same steps as for the euro zone. 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).[18]

Table 4 presents the values of θ_0, η, θ, $\theta r / g^t$ and $\theta r / y$ (respectively, the calibrated value of the extraction technology parameter, and the long-run solutions of the fraction of effort time allocated to productive work relative to rent seeking, the share of tax revenue extracted by rent seekers, transfers due to rent seeking as a share of total transfers and transfers due to rent seeking as a share of output) for each country. Numbers in parentheses denote the ranking of countries with larger numbers indicating more rent seeking.

The same table provides the averages of four useful time-series in the data: the income tax rate (τ_0^y), the consumption tax rate (τ_0^c), government transfers as a share of tax revenue (g^t / r) and government transfers as a share of GDP (g^t / y). Finally, for comparison with the applied literature, we also present a relevant popular "real world" index, namely, the ICRG index which is a widely used measure of institutional quality (for this index, see the notes of Table 4).

[18] For Germany, we use data for the post-unification period, 1990-2003, only. Detailed calibration results for each euro country are available upon request.

Table 4 here

The calibrated values of the parameter θ_0 provide a measure of institutional quality in the sense that the higher is θ_0, the easier a given rent seeking effort can be translated into actual extraction (see equation (13) above). Conceptually, θ_0 tells the same story as the ICRG index. Indeed, the correlation between our calibrated value of θ_0 and the ICRG index is -0.81 (higher numbers of the ICRG index denote better outcomes, hence the minus). Apart from small differences, both measures seem to classify countries into two subgroups. Based on the calibrated values of θ_0, in the "good" subgroup, Finland scores the best being followed by Austria, Belgium and the Netherlands. In the "bad" subgroup, Portugal is the first-worst being followed by Greece and Spain.

Consider now some key endogenous variables of the model, namely the long-run solutions for η (the fraction of effort time allocated to productive work relative to rent seeking) and θ (the economy-wide share of tax revenue extracted by rent seekers). In terms of both η and θ, Ireland and the Netherlands score the best (essentially zero rent seeking) being followed by Finland where $\eta = 97\%$ and $\theta = 3\%$. At the other end, Greece, Portugal and Italy are the worst with 53%, 52% and 32% respectively for θ. Germany follows them with $\theta = 26\%$. The long-run solutions for $\theta r / g^t$ (transfers due to rent seeking as a share of total transfers) and $\theta r / y$ (transfers due to rent seeking as a share of output) deliver a similar message: in Greece, Portugal and Italy 16%, 13% and 12% of GDP are grabbed by rent seekers, while Germany follows with 10%.

As already noted, although some of our long-run solutions for θ, $\theta r / g^t$ or $\theta r / y$ may look high, note that total transfers as a share of tax revenue and as a share of output are also very high in the actual data (see g^t / r and g^t / y respectively). For instance, in Italy, total transfers as a share of output are 22% in the data, and then our model predicts that 12% is due to rent seeking, while in Germany the corresponding numbers are 25% and 10%. These results seem to confirm the belief that a large part of transfers arises from rent seeking activities.

Why do different countries differ? Let us focus on θ which is the key variable in our work. Obviously, as we discussed in subsection 3.2 and table 3 above, the value of θ depends on almost all exogenous variables and calibrated parameters. The same subsection can also give an answer to why different countries differ. For instance, the high values of θ in Greece and Portugal are mainly due to poor institutional quality (very high θ_0 in both countries). The high value of θ in Germany is mainly due to high tax rates, especially income tax rates (τ_0^y), because its institutions are not that bad. On the other hand, Ireland does well (i.e. it enjoys a very low θ) thanks to low tax rates (τ_0^y, τ_0^c) despite poor institutions (relatively high θ_0). The same happens in Spain to a smaller extent. Finland and the Netherlands enjoy low rent seeking mainly thanks to their good institutions (low θ_0) despite high tax rates.

4. Linearized model and simulation results

We continue with simulation results for the euro area as a whole. We study 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 for the euro zone

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 euro zone data. For comparison, we also report the performance of the same model without rent seeking (i.e. $\eta_t = 1$ and hence $\theta_t = 0$ at all t). 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, $y, c, i, h, y/h, w, k, k^g, \eta, \eta h$.

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 the model does quite well in predicting the standard deviation of the key macroeconomic variables relative to that of output. Specifically, the full model does a bit better than the same model without rent seeking in terms of consumption volatility (the latter is 0.9578 in the data, while the model with rent seeking and the same model without rent seeking predict respectively 0.7158 and 0.565) and somehow worse in predicting investment volatility (4.3504 in the data, 2.1482 and 2.6715 in the models with and without rent seeking respectively). But the full model does much better in terms of volatility of hours at work (the relative volatility is 0.5206 in the data, while the model with rent seeking and the same model without rent seeking predict respectively 0.4736 and 0.0927).

Table 5 here

The channel through which rent seeking improves consumption and hours volatility will become clearer when we present impulse response functions below. Nevertheless, it is useful to point out the following at this stage. One of the weak points of the standard RBC model has been the difficulty with its prediction that hours at work are not volatile enough relative to output (see e.g. the review papers by King and Rebelo, 1999, and Hall, 1999). The RBC literature has therefore searched for mechanisms that can predict higher hours volatility. Rent seeking provides such a mechanism by distinguishing between effort time devoted to productive work, $\eta_t h_t$, and effort time devoted to rent seeking, $(1-\eta_t)h_t$. As the impulse response functions below confirm, this happens because, once there is a shock, the fraction of effort time devoted to productive work, η_t, and the time devoted to productive work, $\eta_t h_t$, move in opposite directions, so that total effort time, h_t, has to overshoot its value relative to standard RBC models.[19]

We continue with persistence results reported in Table 6. Both 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). 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, extra mechanism through which shocks propagate their effects over time.

[19] The RBC literature has already pointed out that one way to increase the hours volatility is to introduce a "third use of time", in addition to work and leisure (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 (see e.g. Jones et al., 2005).

Table 6 here

Concerning cross-correlations with output, as can be seen in Table 7, both models give similar results. They do well in terms of sign and, to some extent, magnitude, although the 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. More importantly, it scores better than the same model without rent seeking in terms of hours at work volatility. Our 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.

4.3 Impulse response functions for the euro zone

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-8c respectively. We also report what happens in the same model without rent seeking (see Tables 9a-9c).

Tables 8a-8c and 9a-9c 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 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 9a reports the effects of the same productivity shock when there is no rent seeking. Inspection of Tables 8a and 9a reveals that in 8a private consumption (c_t) jumps initially more, and then falls more abruptly, relative to 9a. Thus, extraction from state coffers allows a temporary spending euphoria, of course only for private consumption to fall sharply afterwards when the adverse effects of rent seeking (see the Introduction for the social costs of the latter) start kicking. Note this can also explain the higher consumption volatility in Table 5. Rent seeking in Table 8a also produces a big jump in hours at work (h_t) relative to that in Table 9a (this is the overshooting effect discussed above). Note that this can also explain the higher hours volatility in Table 5.

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 $\eta_t h_t$.

Comparison of Table 8b to Table 9b reveals that the initial fall in consumption, c_t, is larger in 8b; this is because aggressive rent seeking activities (lower η_t) allows a smaller initial reduction in wealth. By contrast, h_t jumps much more in Table 8b than in 9b; this is due to the overshooting effect.

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.

Comparison of Table 8c to Table 9c tells the same story as with shocks to productivity and government consumption. Namely, because of the overshooting effect, h_t jumps much more in Table 8c than in Table 9c.

5. Concluding remarks and possible extensions

The paper has incorporated rent-seeking competition from state coffers into a dynamic stochastic general equilibrium model. It then calibrated the model to the euro area over the period 1980-2003. The main result is that rent seeking matters to the macro economy in Europe. We also obtained quantitative information about the fraction of social resources taken away by rent seekers and explained why different countries may differ in the degree of rent seeking.

We close with possible extensions. It is interesting to include government expenditure on law enhancing activities (police, courts, tax inspectors, prisons, etc) and examine its implications. If this can reduce rent seeking (this could happen by decreasing θ_0 in equation (13)), it will help the aggregate economy. It is also challenging to endogenize the policy decisions.

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,η,b,r^b. If we set $b=2.4y$ (i.e. the public debt-to-GDP ratio is 60% on an annual basis, which is the EU reference rate in the long run), 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.

As said in subsection 3.1, to cope with measurement problems, we assume that rent seeking takes the form of transfers. Then, (A.vi) changes to:

$$\left[\gamma_n\gamma_z-(1+r^b)\right]\frac{b}{y}+\left[\frac{\tau_0^c c+\tau_0^y y}{y}\right]=s_0^c+s_0^i+s(d)_0^t \tag{A.vi'}$$

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: Data for individual countries

For individual EU-12 countries, we use annual data from the OECD Economic Outlook to construct the data averages as for the euro zone case. Concerning the depreciation rates and the growth rate of the labor augmenting technology, we set (on annual basis) $\delta^p = \delta^g = 0.1$ and $\gamma_z = 1.035$ for each country (as we did for the euro area as a whole). 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 h, we use data for average hours at 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 follow residually, as explained in Appendix A. In those countries with an average annual public debt-to-GDP ratio lower than 0.6, we set b/y at its data average and again let s_0^c to follow residually.

Table 1: Calibration

parameter or variable	**Description**	**Value**	**source**
α	private capital share in production	0.2503	Calibrated from (A.ii)
ε	labor share in production	0.7202	Calibrated as $1-\alpha-s_0^i$
δ^p	private capital depreciation rate (quarterly)	0.0250	Set
δ^g	public capital depreciation rate (quarterly)	0.0250	Set
A_0	long run aggregate productivity	1.0000	Set
γ_z	growth rate of labor augmenting technology	1.0088	Data
μ	consumption weight in utility function	0.3713	Set equal to h
σ	curvature parameter in utility function	2	Set
γ_n	growth rate of population	1	Set
β	time discount factor	0.9912	Calibrated from (A.iii)
ψ	substitutability between private and public consumption in utility	0	Set
θ_0	extraction technology parameter	4.7593	Calibrated from (A.i)
s_0^c	government consumption to output ratio	0.2041	Data
s_0^i	government investment to output ratio	0.0295	Data
$s(d)_0^t$	government transfers to output ratio	0.2026	Data
τ_0^y	average income tax rate	0.2800	Data
τ_0^c	average consumption tax rate	0.1700	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

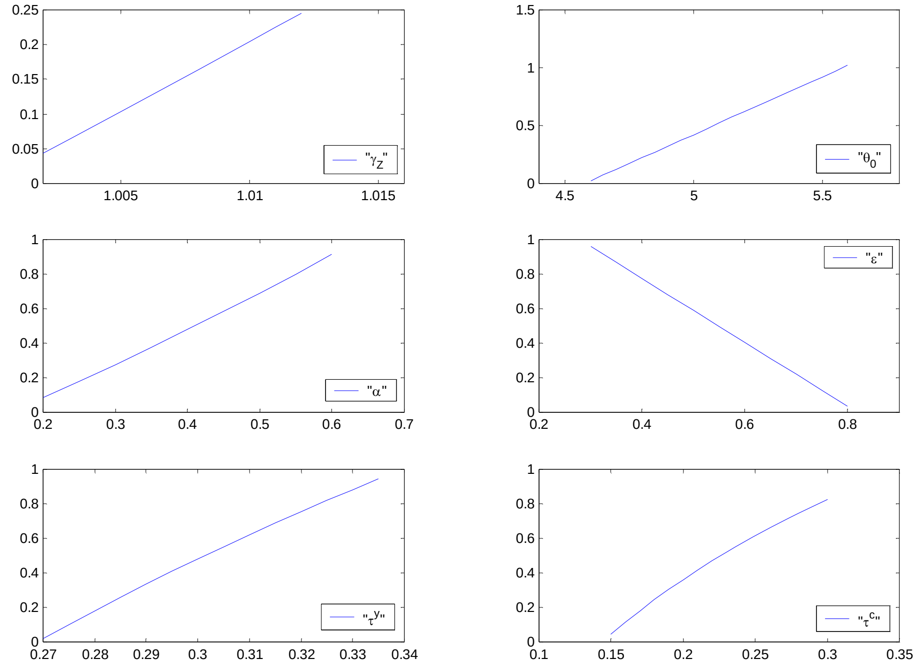
Table 2: Data averages and long-run solution

variable	Description	data averages	long-run solution
c/y	consumption to output ratio	0.5694	0.6348
i/y	Private investment to output ratio	0.18	0.18
h	hours at work	0.3713	0.3188
n	fraction of hours at work allocated to productive work	Na	0.8809
nh	hours of productive work	Na	0.2809
θ	share of tax revenue extracted by rent seekers	Na	0.1807
$\theta r/g^t$	transfers due to rent seeking as a share of total transfers	Na	0.3460
$\theta r/y$	transfers due to rent seeking as a share of output	Na	0.0701
k/y	private capital to output ratio	Na	5.3169
k^g/y	public capital to output ratio	Na	0.8714
r^b	return to bonds (quarterly)	0.0089	0.0089
b/y	public debt to output ratio (quarterly)	2.3288	2.4
s_0^c	government consumption to output ratio	0.2041	0.1557

Notes: Na denotes non-available.

Table 3: Sensitivity of long-run solution

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



Behavior of output (y)

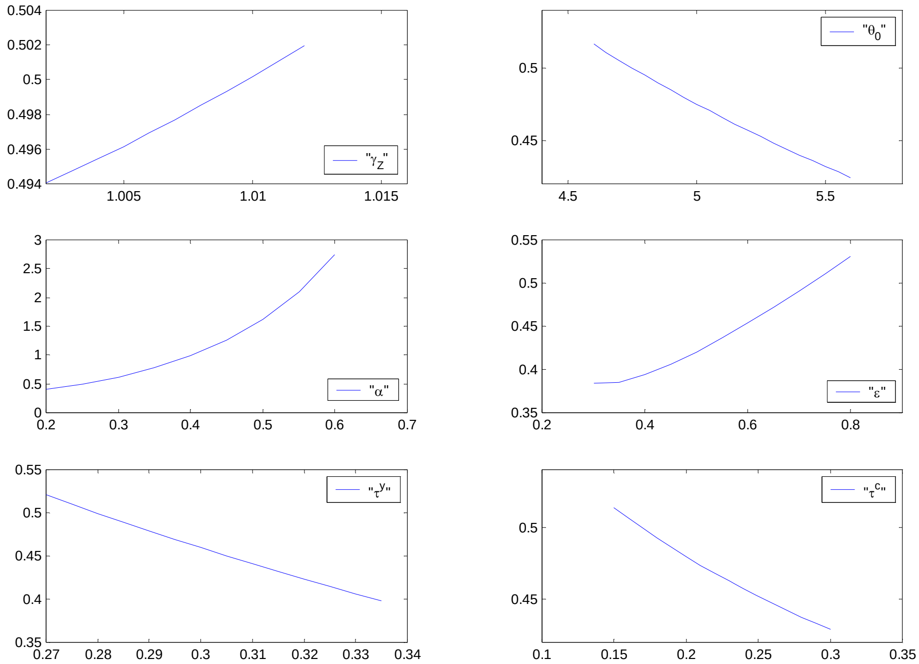


Table 4: Rent seeking results in individual euro countries

Country	θ_0	η	θ	$\theta r / g^t$	$\theta r / y$	τ_0^y	τ_0^c	g^t / r	g^t / y	ICRG
Austria	4.5 (2)	0.85 (6)	0.21 (7)	0.28 (5)	0.08 (6)	0.28	0.18	0.78	0.3	47.22 (5)
Belgium	4.9 (3)	0.84 (7)	0.20 (6)	0.36 (7)	0.09 (7)	0.32	0.16	0.57	0.23	47.46 (4)
Finland	4.45 (1)	0.97 (3)	0.03 (3)	0.05 (3)	0.01 (3)	0.3	0.18	0.67	0.26	48.76 (3)
France	5.47 (5)	0.92 (4)	0.1 (4)	0.16 (4)	0.04 (4)	0.28	0.19	0.65	0.25	46.62 (6)
Germany	5.6 (6)	0.82 (8)	0.26 (8)	0.41 (8)	0.1 (8)	0.29	0.18	0.64	0.25	48.92 (2)
Greece	7.36 (10)	0.8 (10)	0.53 (11)	0.77 (11)	0.16 (11)	0.19	0.14	0.7	0.20	34.36 (11)
Ireland	6.5 (8)	No RS (1)	No RS (1)	No RS (1)	No RS (1)	0.2	0.14	0.67	0.18	44.37 (7)
Italy	5.66 (7)	0.8 (10)	0.32 (9)	0.56 (9)	0.12 (9)	0.28	0.16	0.58	0.22	40.90 (8)
Netherlands	5.36 (4)	No RS (1)	No RS (1)	No RS (1)	No RS (1)	0.3	0.14	0.64	0.24	49.40 (1)
Portugal	7.58 (11)	0.81 (9)	0.52 (10)	0.71 (10)	0.13 (10)	0.18	0.11	0.74	0.18	40.13 (10)
Spain	6.56 (9)	0.9 (5)	0.19 (5)	0.28 (5)	0.05 (5)	0.22	0.1	0.69	0.19	40.4 (9)

Notes:

1. θ_0 is a calibrated value, while n, θ, $\theta r / g^t$ and $\theta r / y$ are long-run solutions. $\tau_0^c, \tau_0^y, g^t / r$ and g^t / y are data averages from OECD Economic Outlook. See the text for definitions.
2. 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.
3. Numbers in parentheses denote the ranking of countries in each column. A smaller number indicates less rent seeking.
4. The correlation between ICRG and $\left\{\theta_0, \eta, \theta, \left(\theta r / g^t\right), \left(\theta r / y\right)\right\}$ is $\{-0.81, 0.49, -0.78, -0.77, -0.66\}$.

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

x	**data**	**full model**	**model without rent seeking**
c	0.9578	0.7158	0.5650
i	4.3504	2.1482	2.6715
h	0.5206	0.4736	0.0927
y/h	0.6357	0.5717	0.9103
w	0.8307	0.9195	0.9103
k	Na	0.2499	0.1529
k^g	Na	0.2558	0.1251
n	Na	0.3882	
nh	Na	0.0854	
s_y	0.0084	0.0084	0.0084

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

x	**data**	**full model**	**model without rent seeking**
y	0.8533	0.6920	0.6852
c	0.8339	0.7011	0.6907
i	0.8217	0.6773	0.6693
h	0.9512	0.6798	0.6808
y/h	0.6824	0.7111	0.6858
w	0.8230	0.6938	0.6858
k	Na	0.9471	0.9479
k^g	Na	0.9505	0.9505
n	Na	0.6798	
nh	Na	0.6798	

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	0.6725	0.9906	0.7066
i	0.7541	0.8317	0.7115	0.6661	0.9361	0.6206
h	0.7324	0.8327	0.8700	0.6860	0.9474	0.6064
y/h	0.7401	0.8913	0.6256	0.6423	0.9643	0.7081
w	0.1102	0.2777	0.3643	0.6889	0.9996	0.6963
k	Na	Na	Na	-0.1504	0.0613	0.3413
k^g	Na	Na	Na	-0.1103	-0.0088	0.1302
n	Na	Na	Na	-0.6860	-0.9474	-0.6064
nh	Na	Na	Na	0.6860	0.9474	0.6064

Table 7 (continued)

	model without rent seeking		
x	$i=-1$	$i=0$	$i=1$
c	0.6582	0.9810	0.6908
i	0.5811	0.8319	0.5596
h	0.6825	0.9710	0.6424
y/h	0.6832	0.9997	0.6873
w	0.6832	0.9997	0.6873
k	-0.2036	-0.0212	0.2291
k^g	-0.1378	-0.0378	0.1035

Table 8a: Full model - Response to aggregate productivity shock (A_t)

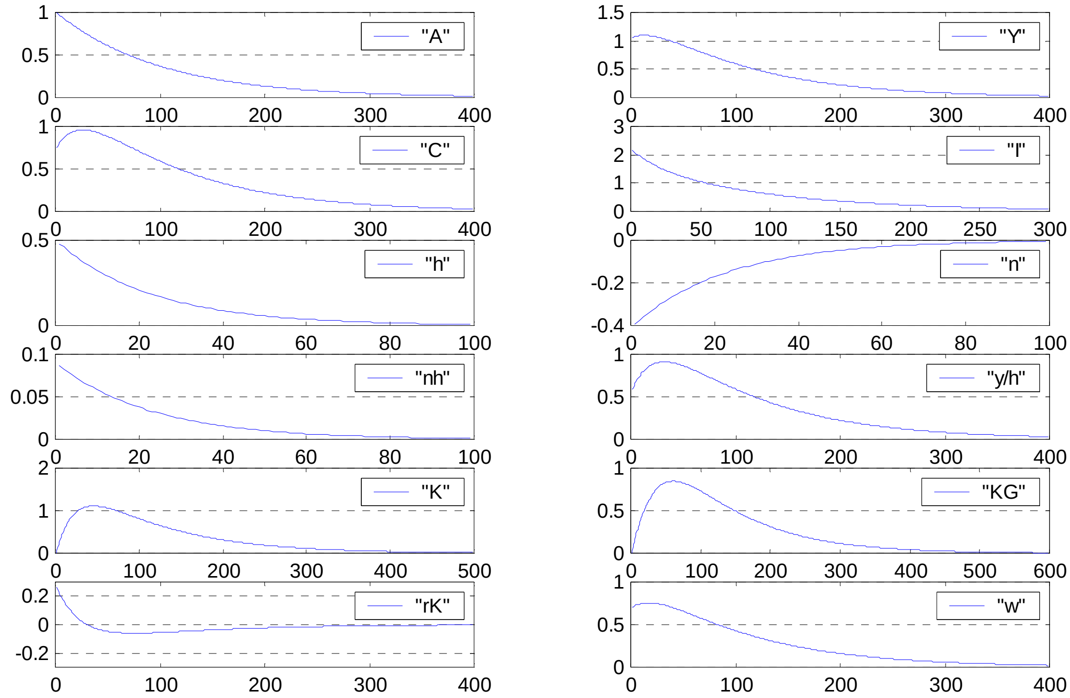


Table 8b: Full model - Response to government consumption shock (s_t^c)

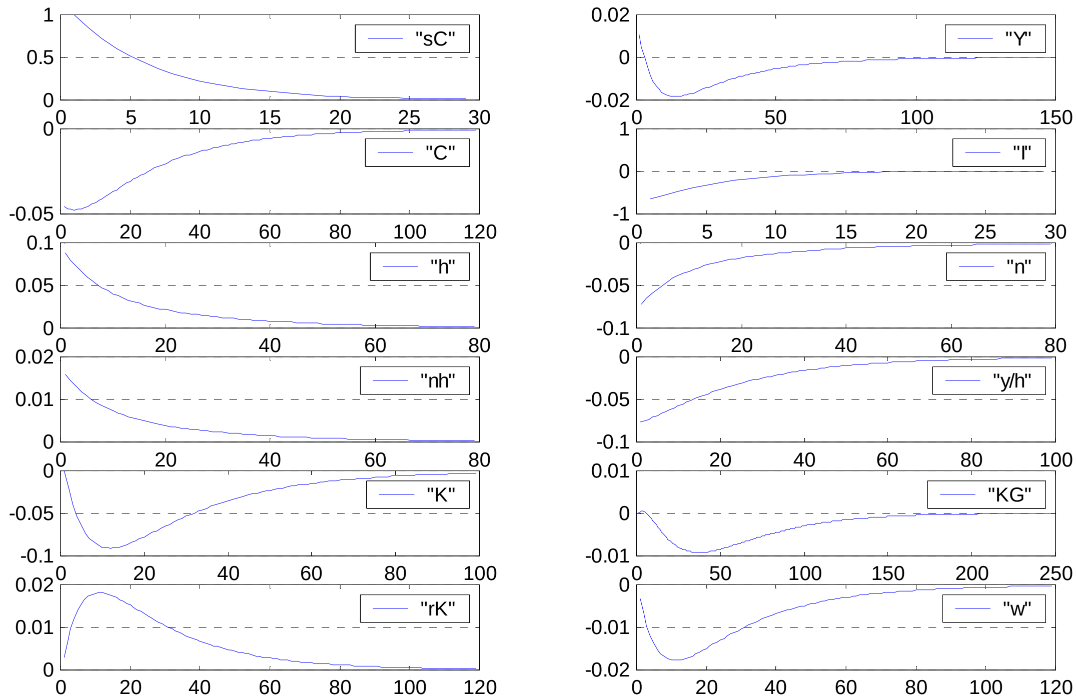


Table 8c: Full model - Response to government investment shock (s_t^i)

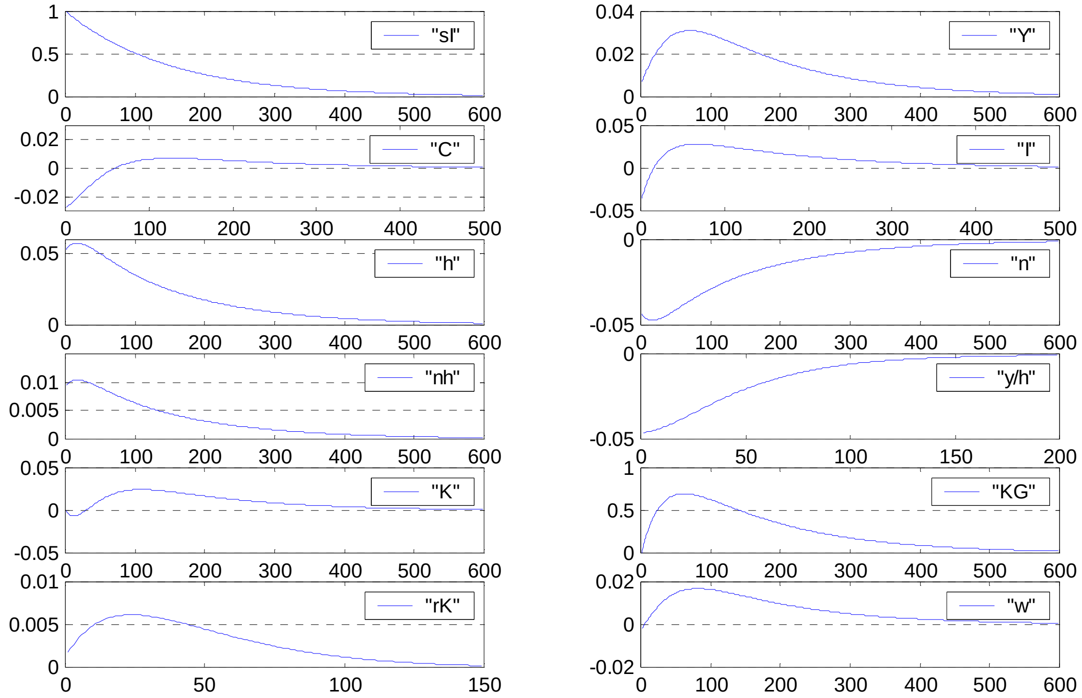


Table 9a: Model without rent seeking - Response to aggregate productivity shock (A_t)

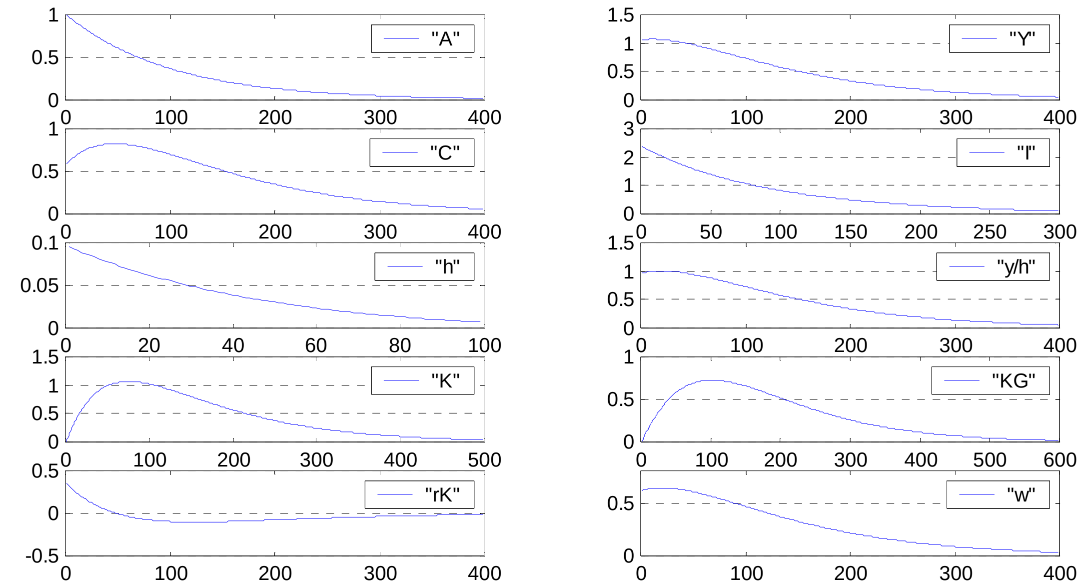


Table 9b: Model without rent seeking - Response to government consumption shock (s_t^c)

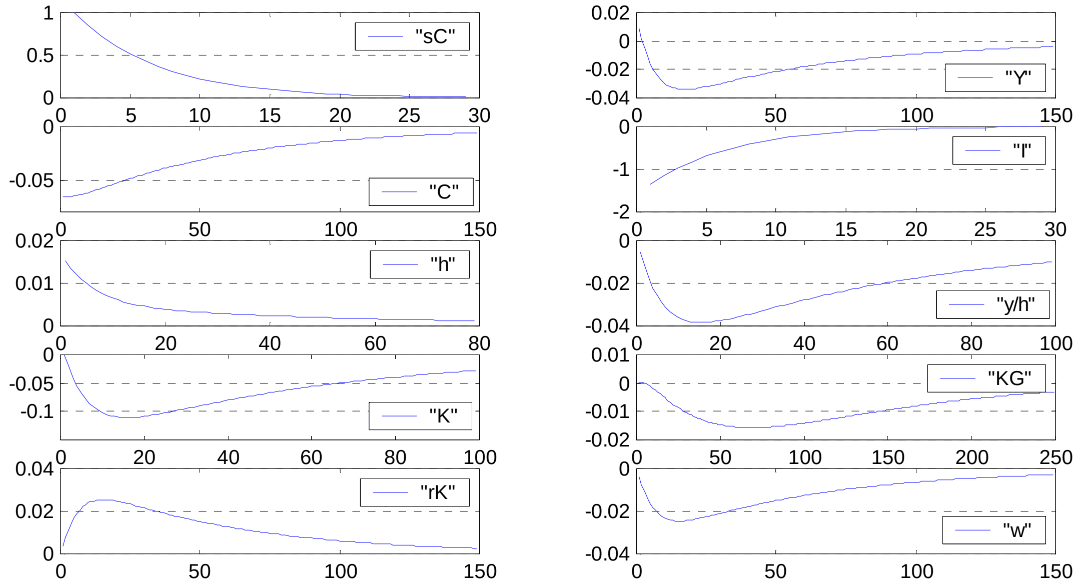
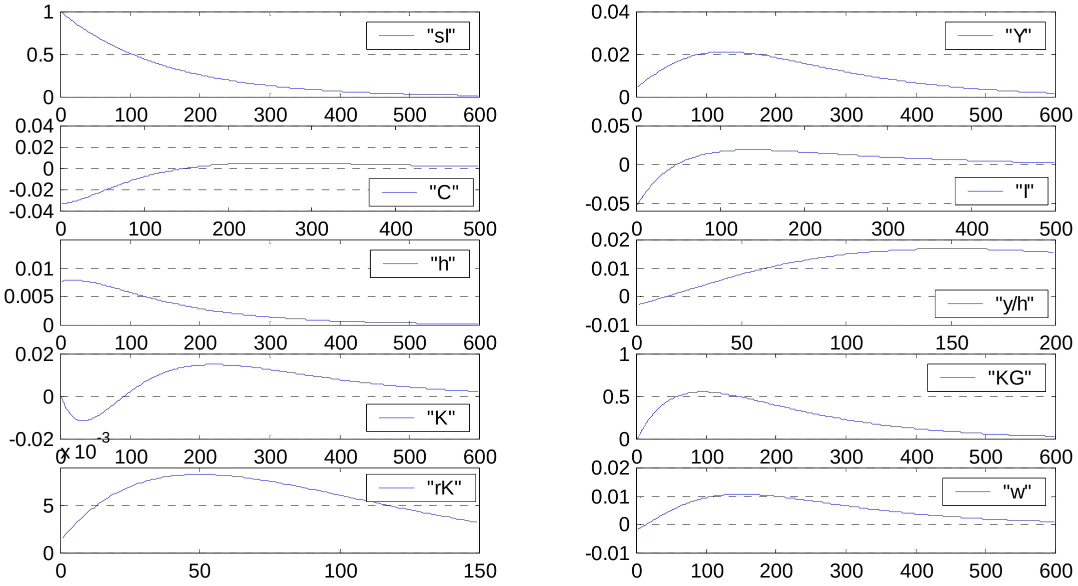


Table 9c: Model without rent seeking - Response to government investment shock (s_t^i)



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