Rent-seeking, capital accumulation, and macroeconomic growth*

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September 4, 2025

Abstract. We study the effects of rent-seeking on economic growth. The starting point is an overlapping generations model where growth is driven by human capital accumulation. In this setting we introduce a source of rent, namely monopolization of one of the sectors of the economy, and agents who are heterogeneous in their (intrinsically useless) rent-seeking ability. Agents can boost their income either by investing in human capital or by capturing a fraction of rent. Monopolization increases the growth rate. The effect of rent-seeking on growth is ambiguous, but it increases wealth inequality.

Keywords: Rent seeking, economic growth, capital accumulation, monopolization, wasteful competition.

JEL Codes: D72, E24, L12, O41, O43.

*This paper has benefited from the comments by Freddy Heylen, Klaus Prettner, and seminar attendants at the Vienna University of Economics and Business (May 28, 2025) and the 15th Viennese Conference on Optimal Control and Dynamic Games (July 12-15, 2022).

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1 Introduction

There is a general belief that rent-seeking, corruption, lobbying etc. are detrimental to economic growth (Murphy et al., 1991; Murphy et al., 1993) or, framed positively, that good institutions lead to better economic outcomes (Acemoglu et al., 2005). We examine the validity of this belief in an overlapping generations model with endogenous growth.

There are three factors that are crucial in understanding the effect of rent-seeking on the growth rate. First, there needs to be a source of rent. There are many possible choices but we take a cue from the classics (Tullock, 1967) and assume that rent-seeking leads to the creation of a monopolistic consumption good sector.[1] Note that changing the market structure of the economy in itself affects economic growth and, therefore, we need to account for this distortion in our analysis.

Second, there is the act of rent-seeking itself. We view rent-seeking as unproductive labor (Smith, 1976; Brooks et al., 1990). In our setting agents are homogenous in their productive capacities whether it be the marginal product of labor or the ability to increase their human capital levels, but there is heterogeneity in (intrinsically useless) rent-seeking ability. At the start of adulthood, agents face a tradeoff between working (a direct source of income), building up human capital (which increases their future wage rate) and spending time to capture a fraction of monopoly profits (i.e. rent-seeking).

The interaction between human capital formation and rent-seeking is especially of interest. Human capital is the growth engine of our model: agents inherit the average human capital of the previous generation and then invest to increase (average) human capital even further. When (unproductive) rent-seeking efforts displace human capital investments, it is detrimental to economic growth.

Third, it matters when agents reap the benefits from rent-seeking. We divide the lifespan of an agent into "young" (age 20-50) and "old" (age 50+).[2] It seems natural that rent-seeking efforts (establishing a network, obtaining a good (starting) position in a firm) happen at the start of the young agent's life and by the time the agent is fortyish (still young in our model) the benefits accrue. However we also consider the possibility that this only happens when the agent is old. This completely changes the intertemporal savings decision as labor is now the only source of immediate income for the young.

Our main results are the following. The creation of rent through monopolization increases the long-run growth rate of the economy. While this seems paradoxical, the reason is that monopoly profit is distributed among the young and this boosts aggregate saving in the economy.[3] Naturally the interest rate decreases and the returns on future labor income increases as

[1] As in much of the existing literature, we do not model the particular process by which rent-seeking leads to monopolization. Implicitly we postulate a regulation mechanism which ensures that monopolization only occurs if a positive amount of rent-seeking takes place. More realistically one might assume that the **probability** of monopolization is an increasing function of the total amount of rent-seeking effort.

[2] Note that there are no economic decisions during "childhood" (age 0–20).

[3] In life-cycle models, agents tend to smooth consumption over time: an (exogenous) increase in income early in life will, therefore, partially be used for future consumption and increase the savings rate.

a result. Hence, agents invest more in human capital and economic growth accelerates.

The effect of rent-seeking on economic growth is limited in comparison: although some very capable rent-seekers fully abandon any form of productive labor, on aggregate the wasted resources due to rent-seeking are small and economic growth barely drops. Its main effect is an increase in inequality among agents. Here we briefly address inequality, but our companion paper (Heijdra and Heijnen, 2024) provides a thorough analysis of the consequences of heterogeneous rent-seeking ability on inequality and efficiency (in a static general equilibrium framework).

Our results are altered if rent-seeking only pays off once the agents are old. Then the only immediate source of income for the young is labor. Consequently, the young work more and this crowds out both human capital formation and rent-seeking. Since human capital formation is directly linked to economic growth, growth levels drop below the benchmark rate for the case with no rent-seeking.

There is a substantial literature on rent-seeking and growth (Murphy et al., 1991; Murphy et al., 1993; Pecorino, 1992; Mork, 1993; Mauro, 1995; Barelli and Pessõa, 2012; Brou and Ruta, 2013). To show our contribution to this literature, let's have a closer look at Murphy et al. (1991, 1993), by far the most-cited work in this field. In their model, individuals differ by broadly-defined talent. In the absence of rent-seeking the most-talented individuals become entrepreneurs. Murphy et al. assume that economic growth is driven by the most-talented entrepreneur and they make it plausible that the introduction of rent-seeking causes precisely those most-talented individuals to shy away from entrepreneurship (which leads to lower growth rates).

Our contribution is then twofold. First, we explicitly embed the rent-seeking process in a dynamic model of economic growth. Second, we do not impose that an increase in an agent's rent-seeking activity necessarily reduces effort in activities that promote growth (entrepreneurship in case of Murphy et al., human capital formation in our setting). As a consequence we can give a much more detailed picture of how rent-seeking affects economic outcomes: when rent accrues relatively early in life, it stimulates human capital formation and economic growth. In that scenario, its main effect is to increase economic inequality.

In modeling the rent-seeking process, we draw inspiration from the contest theory literature: see Corchón (2007) or Konrad (2009) for surveys. As in Tullock (1980), the share of rent that each agent captures depends on the relative effort that they put into rent-seeking (as well as their natural ability). In fact, we have the same functional form for the contest success function. The major difference is that we have a continuum of agents and, therefore, the strategic interaction disappears: agents take aggregate rent-seeking effort as given. For a full analysis of rent-seeking in this setting, we refer to Heijdra and Heijnen (2024). One of the peculiarities is that, for common parametrizations of the contest success functions, agents either specialize in rent-seeking or abstain from rent-seeking altogether. Since we want agents to make a trade-off between human capital formation and rent-seeking, we use different parameter values than the rest of the contest theory literature.[4]

Both Aghion et al. (2007) and Júlio (2014) are complementary to our work. While we explore the effects of rent-seeking to create a monopolist from an existing firm, Aghion et al. (2007) introduce barriers that prevent new firms with lower cost of production to entering a market. The link to rent-seeking is implicit, but the height of the entry barriers could be linked to rent-seeking efforts. Unsurprisingly, in this setting rent-seeking lowers growth. Similar to Murphy et al. (1991, 1993), their question is to what extent does it lower growth. We, on other hand, explore whether rent-seeking is, by definition, something that lowers growth.

In Júlio (2014) rent is created through R&D licenses. The mechanism through which growth is stimulated has a similar feel to our mechanism. Monopoly profits are distributed to consumers. This increases aggregate demand and further drives up monopoly profits.[5] In turn, this gives firms an extra incentive to invest in R&D. Consequently, growth rates increase. As in our setting, the impetus of growth is the increase in income due to the redistribution of monopoly profits. This highlights that the creation of rent can have positive effects on economic growth through different channels.

Finally, we are aware that our work makes some very specific choices in the source of rent (monopoly profits) and in the growth engine (human capital). However, the mechanism where rent leads to higher human capital accumulation depends solely on the source of rent to be a windfall for the young generation. The specific type of rent is immaterial. Moreover in one of our extensions we show that a physical externality as the growth engine does not influence the results qualitatively. Additionally, we calibrate the model such that (only) 2.5% of the resources are wasted in rent-seeking. This is line with the empirical evidence (Laband and Sophocleus, 2019) and we think it also reflects the reality where a small fraction of society puts in a lot of effort to obtain far more than their fair share of the profits.

To summarize, we show that, when the whole rent-seeking process is incorporated in a macroeconomic growth model, the creation of rent has a large and positive effect on the long-run growth rate. In comparison, the act of rent-seeking mainly leads to an increase in wealth inequality.

The remainder of this paper is structured as follows. In Section 2, we introduce the model and we discuss the equilibrium in the absence of rent-seeking, both for the case where the consumption good sectors are competitive and the case where one of the sectors is monopolistic, as well as the transition path between the two equilibria. Section 3 adds rent-seeking and shows its effect on economic growth and inequality. Section 4 has several extensions that highlight the main mechanisms: while the precise specification of the rent-seeking function and the growth

[4] In two-player contests, the Tullock contest success function is

$$p_i = \frac{x_i^\varepsilon}{x_i^\varepsilon + x_j^\varepsilon},$$

where p_i is the probability that player $i = 1, 2$ receives the monopoly profit, x_i is the cost of effort for player i, $i \neq j$ and $\varepsilon > 0$. A typical value for $\varepsilon = 1$ or 2 (which in our setting leads to specialization). We set $\varepsilon = 0.08$ or 0.16 to avoid this issue.

[5] A Ford-effect that is also present in our model.

engine do not change our results qualitatively, it matters when in the life-cycle rent-seeking revenue materialize. Section 5 concludes. A detailed Supplementary Material (SM) appendix is available containing all derivations and further quantitative results.

2 A dynamic growth model with rent-seeking

We consider a Diamond-Samuelson overlapping-generations model with human and physical capital accumulation and endogenous growth. At each time t there are two (economically active) unit-sized generations; one old-age generation that was born in period $t-1$ and one young generation born in period t. Individual agents are identical in every respect except for their inherent lobbying skill η. There are no bequests so individuals (and thus generations) are disconnected from each other. In the spirit of Uzawa (1965), Lucas (1988), Azariadis and Drazen (1991), and Rebelo (1991) we assume that human capital accumulation (in combination with a constant returns to scale technology) forms the engine of endogenous growth in the economy. We describe the behaviour of individuals and firms in turn and then proceed to characterize the macroeconomic growth equilibrium.

2.1 Individuals

An individual of type η who is young (superscript 'y') at time t consumes goods, $x^y_{i,t}(\eta)$ (for goods indexes $i = 1, 2$), buys units of the existing capital good from the old, $k^y_t(\eta)$, or a newly produced investment good, $z^y_t(\eta)$, from the investment goods sector (both at price Q_t), engages in time-consuming lobbying activities that are aimed at capturing a fraction of monopoly profits in sector 1, and chooses the amount of time spent on schooling in order to augment his/her human capital stock. The education decision augments the individual's stock of human capital available at the start of the second period of life. The old (superscript 'o') sell their capital goods to the young, consume goods $x^o_{i,t}(\eta)$, and supply an exogenously given fraction λ of their human capital stock to the labour market. By assuming that $0 < \lambda < 1$ we capture the notion that old individuals will ultimately retire from the workforce.

The lifetime utility function of a young agent of type η is given by:

$$\Lambda^y_t(\eta) \equiv \ln c^y_t(\eta) + \beta \ln c^o_{t+1}(\eta), \tag{1}$$

where β is the discount factor representing time preference ($0 < \beta < 1$), and $c^y_t(\eta)$ and $c^y_{t+1}(\eta)$ are composite consumption aggregates defined as:

$$c^y_t(\eta) \equiv \left[\alpha x^y_{1,t}(\eta)^{1-1/\sigma} + (1-\alpha) x^y_{2,t}(\eta)^{1-1/\sigma}\right]^{1/(1-1/\sigma)}, \tag{2}$$

$$c^o_{t+1}(\eta) \equiv \left[\alpha x^o_{1,t+1}(\eta)^{1-1/\sigma} + (1-\alpha) x^o_{2,t+1}(\eta)^{1-1/\sigma}\right]^{1/(1-1/\sigma)}, \tag{3}$$

where σ (> 1) is the substitution elasticity between the two goods, and $0 < \alpha < 1$. The budget constraint during youth is given by:

$$P_{1,t}x^y_{1,t}(\eta) + P_{2,t}x^y_{2,t}(\eta) + Q_t\left[z^y_t(\eta) + k^y_t(\eta)\right] = I^y_t(\eta), \tag{4}$$

where $P_{i,t}$ is the price of good i and $I^y_t(\eta)$ is income:

$$I^y_t(\eta) \equiv W_t h^y_t(\eta)\left[1 - e_t(\eta) - l_t(\eta)\right] + s_t(\eta)\Pi^m_{1,t}. \tag{5}$$

In equation (5), W_t is the wage rate on standardized units of labour, $e_t(\eta)$ is the amount of time spent on lobbying activities, $l_t(\eta)$ is time spent on formal schooling, and $h^y_t(\eta)$ is the agent's human capital level at birth (see below). Furthermore, $s_t(\eta)$ denotes the share of sector-1 monopoly profits, $\Pi^m_{1,t}$, that is captured by the agent as a result of his/her lobbying activities.

Education time augments the stock of human capital in the next period (old-age) according to the following accumulation function:

$$h^o_{t+1}(\eta) = h^y_t(\eta)\left[1 + \phi_e \frac{l_t(\eta)^{1-\theta}}{1-\theta}\right], \tag{6}$$

with $\phi_e > 0$ and $0 < \theta < 1$. Following Azariadis and Drazen (1990) we assume that the young are 'standing on the shoulders' of the old generation, a phenomenon we capture by:

$$h^y_t(\eta) = \bar{h}_t, \tag{7}$$

where $\bar{h}_t$ is the average economy-wide human capital stock in existence at the start of period t.

The budget constraint during old-age is given by:

$$P_{1,t+1}x^o_{1,t+1}(\eta) + P_{2,t+1}x^o_{2,t+1}(\eta) = I^o_{t+1}(\eta), \tag{8}$$

where $I^o_{t+1}(\eta)$ is old-age income:

$$I^o_{t+1}(\eta) \equiv \lambda W_{t+1} h^o_{t+1}(\eta) + \left[(1-\delta)Q_{t+1} + R^k_{t+1}\right]\left[z^y_t(\eta) + k^y_t(\eta)\right], \tag{9}$$

where W_{t+1} is the future wage rate on standardized efficiency units of labour, and we assume that during old-age only a fraction λ of time is available for working, i.e. $0 < \lambda < 1$. By investing in period t, and owning $z^y_t(\eta) + k^y_t(\eta)$ at the start of old-age, the young agent plans to receive a rental payment R^k_{t+1} on each unit of capital in period $t+1$ (old age). Note that δ is the depreciation rate of physical capital. The remaining capital stock he/she can sell at price Q_{t+1} (to the then young). This implies that the 'nominal' interest rate can be written as:

$$1 + R^n_{t+1} \equiv \frac{(1-\delta)Q_{t+1} + R^k_{t+1}}{Q_t}. \tag{10}$$

Using (4)–(10) we can write the consolidated budget constraint in nominal terms as:

$$P_{V,t}c_t^y(\eta) + \frac{P_{V,t+1}c_{t+1}^o(\eta)}{1+R_{t+1}^n} = HW_t^y(\eta), \tag{11}$$

where $P_{V,t}$ and $P_{V,t+1}$ are the true price indices for, respectively, $c_t^y(\eta)$ and $c_{t+1}^o(\eta)$, and human wealth during youth is defined as:

$$HW_t^y(\eta) \equiv s_t(\eta)\Pi_{1,t}^m + W_t\bar{h}_t\left[1 - e_t(\eta) - l_t(\eta)\right] + \frac{\lambda W_{t+1}\bar{h}_t}{1+R_{t+1}^n}\left[1 + \phi_e \frac{l_t(\eta)^{1-\theta}}{1-\theta}\right]. \tag{12}$$

The young agent of type η chooses $c_t^y(\eta)$, $c_{t+1}^o(\eta)$, $l_t(\eta)$, and $e_t(\eta)$ in order to maximize lifetime utility (1) subject to the lifetime budget constraint (12), taking as given factor prices W_t and W_{t+1}, the nominal interest rate R_{t+1}^n, and nominal sector-1 profit $\Pi_{1,t}^m$. We find:

$$P_{V,t}c_t^y(\eta) = \frac{1}{1+\beta}HW_t^y(\eta), \tag{13}$$

$$\frac{P_{V,t+1}c_{t+1}^o(\eta)}{1+R_{t+1}^n} = \frac{\beta}{1+\beta}HW_t^y(\eta), \tag{14}$$

$$l_t(\eta) = l_t \equiv \left[\frac{\lambda\phi_e W_{t+1}}{(1+R_{t+1}^n)W_t}\right]^{1/\theta}, \tag{15}$$

$$W_t\bar{h}_t = \Pi_{1,t}^m \frac{\partial s_t(\eta)}{\partial e_t(\eta)}. \tag{16}$$

According to (13)–(14) implicit spending on composite consumption is in both phases of life proportional to human wealth. Equation (15) shows that (a) regardless of lobbying aptitude every agent chooses the same amount of schooling, and (b) optimal education time depends positively on wage growth, W_{t+1}/W_t, and negatively on the nominal interest rate, R_{t+1}^n. Finally, (16) shows that the optimal amount of lobbying time, $e_t(\eta)$, is such that the marginal cost of rent-seeking in terms of foregone labour earnings (left-hand side) is equal to the marginal benefit of lobbying (right-hand side).

In most of this paper we make use of the following functional form for the share function:

$$s_t(\eta) = \frac{\eta e_t(\eta)^\varepsilon}{E_t}, \qquad 0 < \varepsilon < 1, \tag{17}$$

where ε is a constant parameter, $\eta e_t(\eta)^\varepsilon$ represents the effective rent-seeking effort of an individual of type η, and E_t is the total amount of lobbying that takes place:

$$E_t \equiv \int_{\eta_0}^{\eta_1} \eta e_t(\eta)^\varepsilon dF(\eta), \tag{18}$$

where $F(\eta)$ is the distribution function of η. This specification incorporates two major features. First, because $s_t(\eta)$ is strictly concave in rent-seeking (as $\varepsilon < 1$), there are decreasing returns to rent-seeking time. Second, the entire profit is passed on to rent seekers, i.e. $\int_{\eta_0}^{\eta_1} s_t(\eta)dF(\eta) = 1$.

By using (17) in (16) we obtain, for each lobbying type η, the following explicit solutions for optimal lobbying time and the implied share of monopoly profits that is captured:

$$e_t(\eta) = s_t(\eta)\bar{e}_t, \tag{19}$$

$$s_t(\eta) = \frac{\eta^{1/(1-\varepsilon)}}{\int_{\eta_0}^{\eta_1} \eta^{1/(1-\varepsilon)} dF(\eta)}, \tag{20}$$

where $\bar{e}_t$ is the total (and average) amount of time that is lost as a result of socially wasteful (unproductive) rent-seeking activities:

$$\bar{e}_t = \frac{\varepsilon \Pi_{1,t}^m}{W_t \bar{h}_t}. \tag{21}$$

Finally, by aggregating (12) over all individuals and noting (15) and (21) we find that human wealth of the young generation as a whole can be written as follows:

$$HW_t^y \equiv \int_{\eta_0}^{\eta_1} HW_t^y(\eta) dF(\eta) = (1-\varepsilon)\Pi_{1,t}^m + W_t \bar{h}_t [1 - l_t] + \frac{\lambda W_{t+1}}{1 + R_{t+1}^n} \bar{h}_t \left[1 + \phi_e \frac{l_t^{1-\theta}}{1-\theta}\right]. \tag{22}$$

2.2 Firms

There are three distinct commodities that are produced in the economy. Two of these are consumption goods that are purchased by both young and old agents. Consumption goods are identical from a technological point of view. The third commodity is an investment good that is purchased only by young agents in order to build up their stock of physical capital. The two productive inputs, human and physical capital, are used in the production of all commodities and are perfectly mobile across sectors and firms.

2.2.1 Consumption goods

Consumption good i is produced with physical and human capital according to the following technology:

$$X_{i,t} = \Omega_x H_{i,t}^{\phi} K_{i,t}^{1-\phi}, \tag{23}$$

where Ω_x is a constant scaling factor ($\Omega_x > 0$), and $X_{i,t}$, $H_{i,t}$, and $K_{i,t}$ denote, respectively, aggregate production of good i ($i = 1, 2$), the human capital input, and the physical capital input. The efficiency parameter satisfies $0 < \phi < 1$ so that there are diminishing returns to both factors. Nominal profit in sector i is:

$$\Pi_{i,t} = P_{i,t} X_{i,t} - MC^x(W_t, R_t^k) X_{i,t}, \tag{24}$$

where $P_{i,t}$ is the price of good i, and $MC^x(W_t, R_t^k)$ is the marginal cost function:

$$MC^x(W_t, R_t^k) \equiv \left(\frac{W_t}{\phi}\right)^{\phi} \left(\frac{R_t^k}{1-\phi}\right)^{1-\phi} \frac{1}{\Omega_x}. \tag{25}$$

Recall that in (25), W_t is the rental rate on units of human capital and R_t^k is the rental rate on physical capital. The derived factor demands are given by:

$$\begin{aligned} R_t^k &= (1-\phi) MC^x(W_t, R_t^k) \Omega_x H_{i,t}^{\phi} K_{i,t}^{-\phi}, \\ W_t &= \phi MC^x(W_t, R_t^k) \Omega_x H_{i,t}^{\phi-1} K_{i,t}^{1-\phi}. \end{aligned}$$

Since good X_2 is always produced competitively (by assumption), it can be used as the numeraire commodity, $P_{2,t} = P_{2,t} MC^x(w_t, r_t^k)$, where $w_t \equiv W_t / P_{2,t}$ is the real rental rate on human capital, and $r_t^k \equiv R_t^k / P_{2,t}$ is the real rental rate on capital. It follows that $MC^x(w_t, r_t^k) = 1$, so that factor demands can be written in terms of real factor prices as:

$$r_t^k = (1-\phi)\Omega_x \kappa_{1,t}^{-\phi} = (1-\phi)\Omega_x \kappa_{2,t}^{-\phi}, \tag{26}$$

$$w_t = \phi \Omega_x \kappa_{1,t}^{1-\phi} = \phi \Omega_x \kappa_{2,t}^{1-\phi}, \tag{27}$$

where $\kappa_{i,t} \equiv K_{i,t}/H_{i,t}$ is the capital intensity in sector i. Excess profits in the competitive sector are eliminated, i.e. $\Pi_{2,t} = 0$.

The sector producing X_1 is run by a monopolist. Total demand, from the old and young generations together, is given by:

$$X_{1,t} = \frac{\alpha^{\sigma} P_{1,t}^{-\sigma}}{\alpha^{\sigma} P_{1,t}^{1-\sigma} + (1-\alpha)^{\sigma} P_{2,t}^{1-\sigma}} \left[\frac{HW_t^y}{1+\beta} + I_t^o\right], \tag{28}$$

where HW_t^y is defined in (22) above and $I_t^o \equiv \int_{\eta_0}^{\eta_1} I_t^o(\eta) dF(\eta)$ is total income of the old generation:

$$I_t^o = \lambda W_t \bar{h}_t + \left[(1-\delta) Q_t + R_t^k\right] K_t. \tag{29}$$

For future use we note that the (absolute value of) the price elasticity of demand, $\varepsilon_{d,t}^m$, is given by:

$$\varepsilon_d^m = \frac{\alpha^{\sigma} p_t^{1-\sigma} + \sigma(1-\alpha)^{\sigma}}{\alpha^{\sigma} + (1-\alpha)^{\sigma}} > 1, \tag{30}$$

where $p_t \equiv P_{1,t}/P_{2,t}$.

The monopolist takes as given HW_t^y, I_t^o, and $P_{2,t}$ and sets $P_{1,t}$ in order to maximize profit (defined in (24)) subject to the demand equation given in (28). This results in the usual markup rule for the monopoly price, $P^m_{1,t}$:

$$p_t \equiv \frac{P^m_{1,t}}{P_{2,t}} = \mu^m_t MC^x(w_t, r^k_t), \tag{31}$$

where μ^m_t is the gross markup:

$$\mu^m_t \equiv \frac{\varepsilon^m_{d,t}}{\varepsilon^m_{d,t} - 1} > 1. \tag{32}$$

But, since real marginal cost equals unity, $MC^x(w_t, r^k_t) = 1$, we find from (31) that $p_t = \mu^m_t = \frac{\varepsilon^m_{d,t}}{\varepsilon^m_{d,t}-1}$. By using this result in equation (30) we obtain an implicit function relating $\varepsilon^m_{d,t}$ to the structural parameters α and σ. It follows that the (profit maximizing) price elasticity, markup, and relative monopoly price are all time-invariant, i.e. $\varepsilon^m_{d,t} = \varepsilon^m_d$, $\mu^m_t = \mu^m$, and $p_t = p^*$.

Finally, the profit-maximizing level of monopoly profit in sector 1 is equal to:

$$\Pi^m_{1,t} = \Xi \left[\frac{HW^y_t}{1+\beta} + I^o_t\right], \tag{33}$$

where Ξ is a positive time-invariant proportionality factor:

$$\Xi \equiv \frac{\alpha^\sigma [\mu^m - 1]}{\alpha^\sigma \mu^m + (1-\alpha)^\sigma (\mu^m)^\sigma}, \tag{34}$$

with $0 < \Xi < 1$.[6] An important thing to note is that profit depends in part on itself because young agents consume part of it. Indeed, in view of (22) we note that HW^y_t appearing on the right-hand side of (33) contains $\Pi^m_{1,t}$ as one of its arguments. Hence, by combining (22) and (33) we can find the following expression for profits:

$$\begin{aligned}\Pi^m_{1,t} = \frac{\Xi}{1+\beta-(1-\varepsilon)\Xi} \Bigg[& W_t \bar{h}_t [1-l_t] + \frac{\lambda W_{t+1}}{1+R^n_{t+1}} \bar{h}_t \left(1 + \phi_e \frac{l_t^{1-\theta}}{1-\theta}\right) \\ & + (1+\beta)\left[\lambda W_t \bar{h}_t + \left[(1-\delta) Q_t + R^k_t\right] K_t\right]\Bigg]. \end{aligned} \tag{35}$$

We summarize the main findings in Useful Result 1.

Useful Result 1 *When the two consumption goods are identical from the production side and X_2 is the numeraire commodity, the following results can be established: (a) real marginal cost in both consumption goods sectors equals unity, $MC^x(w_t, r^k_t) = 1$; (b) the relative monopoly price, p_t, is time-invariant, i.e. $p_t = p^*$ for all t, where p^* is the solution to:*

$$p = \frac{\alpha^\sigma p^{1-\sigma} + \sigma(1-\alpha)^\sigma}{(\sigma-1)(1-\alpha)^\sigma};$$

[6] In the case with perfect competition in sector 1, we find that $P_{1,t} = P_{2,t} MC^x(w_t, r^k_t)$, so that $p_t = \mu^m = 1$ and $\Xi = 0$.

(c) p^* is increasing in α, $\partial p^*/\partial\alpha > 0$; (d) for α in the neighbourhood of $\alpha = \frac{1}{2}$, p^* is decreasing in σ, $\partial p^*/\partial\sigma < 0$; (e) the proportionality factor for aggregate profit in the monopolized sector, Ξ_t, is time-invariant, i.e. $\Xi_t = \Xi^*$ for all t; (f) the capital intensity is the same in the two consumption goods sectors, i.e. $\kappa_{i,t} = \kappa_{x,t}$ for $i = 1, 2$.

Proof. See SM (Section A.2.1). ■

2.2.2 Investment goods

The investment goods sector operates under conditions of perfect competition. Technology in that sector takes the following form:

$$Z_t = \Omega_z H_{z,t}^{\psi} K_{z,t}^{1-\psi}, \tag{36}$$

where Ω_z is a constant scaling factor ($\Omega_z > 0$), and Z_t, $H_{z,t}$, and $K_{z,t}$ denote, respectively, aggregate production of the investment good, the human capital input, and the physical capital input. The efficiency parameter satisfies $0 < \psi < 1$. Nominal profit in the investment goods sector is:

$$\Pi_t^z \equiv Q_t Z_t - MC^z(W_t, R_t^k) Z_t, \tag{37}$$

where Q_t is the price of the investment good and $MC^z(W_t, R_t^k)$ is the marginal cost function:

$$MC^z(W_t, R_t^k) \equiv \left(\frac{W_t}{\psi}\right)^{\psi} \left(\frac{R_t^k}{1-\psi}\right)^{1-\psi} \frac{1}{\Omega_z}. \tag{38}$$

Under perfect competition $Q_t = MC^z(W_t, R_t^k)$ and the derived factor demands, expressed in terms of the numeraire commodity, can be written as:

$$r_t^k = (1-\psi) q_t \Omega_z \kappa_{z,t}^{-\psi}, \tag{39}$$

$$w_t = \psi q_t \Omega_z \kappa_{z,t}^{1-\psi}, \tag{40}$$

where $q_t \equiv Q_t / P_{2,t}$ is the relative price of the investment good, and $\kappa_{z,t} \equiv K_{z,t}/H_{z,t}$ is the capital intensity in the investment goods sector.

2.3 Equilibrium

The model description is completed with the following identities and equilibrium conditions. The aggregate stock of physical capital evolves over time according to:

$$K_{t+1} = Z_t + (1-\delta) K_t, \tag{41}$$

where the equilibrium conditions in the markets for new investment goods and used capital goods are given by:

$$Z_t = \int_{\eta_0}^{\eta_1} z_t^y(\eta) dF(\eta), \tag{42}$$

$$(1-\delta)K_t = \int_{\eta_0}^{\eta_1} k_t^y(\eta) dF(\eta). \tag{43}$$

The equilibrium conditions in the rental markets for physical and human capital are:

$$K_t = K_{1,t} + K_{2,t} + K_{z,t}, \tag{44}$$

$$H_t = H_{1,t} + H_{2,t} + H_{z,t}, \tag{45}$$

where the aggregate stock of human capital is given by:

$$H_t = [1 + \lambda - \bar{e}_t - l_t] \bar{h}_t. \tag{46}$$

Finally, aggregate output expressed in terms of units of the numeraire commodity, X_2, is given by:

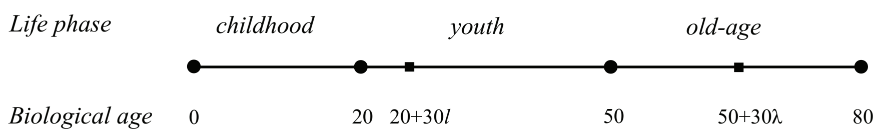
$$Y_t = pX_{1,t} + X_{2,t} + q_t Z_t. \tag{47}$$

The benchmark model is listed in Table 1. Equation (T1.1) shows how the future value of the key dynamic state variable, $K_t/\bar{h}_t$, follows from the savings decision by members of the young cohort. Equation (T1.2) shows how scaled profit in the monopolized sector, $\pi_{1,t}^m/\bar{h}_t$, is affected by the current (predetermined) value of that state variable as well as the other macroeconomic variables in the model. Equation (T1.3) shows how the amount of time units spent on rent-seeking activities, $\bar{e}_t$, is proportional to scaled profit, and decreasing in the real wage rate (the opportunity cost of time). Optimal education time is determined according to (T1.5) and its effect on growth of start-up human capital, $\bar{h}_t$, is stated in (T1.4), where γ_{t+1} is defined as:

$$\gamma_{t+1} \equiv \frac{\bar{h}_{t+1} - \bar{h}_t}{\bar{h}_t}. \tag{48}$$

The relationship between the real rate of interest, the rental rate of physical capital, and current and future relative investment good prices is stated in (T1.6). With both factors perfectly mobile across sectors, equations (T1.7)–(T1.10) help determine the capital intensities in the three sectors. The economy-wide capital intensity, $\kappa_t \equiv K_t/H_t$, depends on the sectoral capital intensities as well as the sectoral utilization rates of human capital as in (T1.11). The capital intensities and human capital utilization rates, of course, also appear in the scaled output expressions (T1.18)–(T1.20). Finally, note that (T1.16) is the implicit equation defining the relative monopoly price in sector 1 and that (T1.17) determines the resulting demand in that sector.

Figure 1: The individual life cycle



The endogenous variables are $K_{t+1}/\bar{h}_{t+1}$, γ_{t+1}, $\bar{e}_t$, $\pi^m_{1,t}/\bar{h}_t$, l_t, r_t, q_t, r^k_t, w_t, $x_{i,t} \equiv X_{i,t}/H_t$, $z_t \equiv Z_t/H_t$, $u_{i,t} \equiv H_{i,t}/H_t$, $u_{z,t} \equiv H_{z,t}/H_t$, $\kappa_t \equiv K_t/H_t$, $\kappa_{i,t} \equiv K_{i,t}/H_{i,t}$, $\kappa_{z,t} \equiv K_{z,t}/H_{z,t}$, Ξ, p, and $y_t \equiv Y_t/H_t$. Of these, the ratio between the two capital stocks, $K_t/\bar{h}_t$, is predetermined at time t. As we demonstrate below, the model is stable in a backward-looking sense and attains a steady state in which all endogenous variables converge to constants. It follows that along the balanced growth path H_t, K_t, $\bar{h}_t$, $\pi^m_{1,t}$, $X_{i,t}$, Z_t, $H_{i,t}$, $H_{z,t}$, $K_{i,t}$, $K_{z,t}$, and Y_t all grow at the constant exponential rate γ^*.

2.4 Parameterization

We adopt a two-step procedure to parameterize the dynamic rent-seeking model of Table 1. In the first step we consider a special case of (the steady-state version of) the model in which rent-seeking is absent and all sectors are perfectly competitive. In this first step we fix δ, λ, and ϕ a priori, set a number of targets for steady-state endogenous variables, and choose plausible values for β, ψ, θ, ϕ_e, Ω_x, and Ω_z such that these targets are met. In the second step we hold these parameters fixed and choose the remaining structural parameters (α, σ, and ε) after which the steady state rent-seeking equilibrium with a monopoly in sector 1 can be computed.

2.4.1 Step 1: Parameters of the competitive model

The steady-state competitive growth model is listed in Table 2, where starred variables denote steady-state values. We fix the following parameters a priori: the efficiency parameter of human capital in the consumption goods sectors ($\phi = 0.8$), the annual physical capital depreciation rate ($\delta_a = 0.06$), and the fraction of work time during old-age ($\lambda = 0.5$). Each adult period is of length $T = 30$ in years. In terms of the life-cycle setting illustrated in Figure 1 the value of λ means that people retire at biological age 65.

We postulate the following targets for a number of key (steady-state) endogenous variables: the annual real interest rate ($r^*_a = 0.05$), the annual real growth rate ($\gamma^*_a = 0.025$), the output intensity ($y^* = 1.00$), the relative price of investment goods ($q^* = 1$), the output share of investment ($z^*/y^* = 0.1165$),[7] the output share of wages ($w^*/y^* = 0.75$), and the time-share of education during youth ($l^* = 0.10$). In terms of Figure 1 this value for l^* means that people

[7]This is the value obtained in a one-sector version of the competitive growth model featuring a Cobb-Douglas production function with the efficiency parameter for human capital equal to $\phi = 0.75$.

Table 1: Rent-seeking and growth with a human capital externality

$$(1+\gamma_{t+1})q_t\frac{K_{t+1}}{\bar{h}_{t+1}} = \frac{1}{1+\beta}\left[\beta(1-\varepsilon)\frac{\pi^m_{1,t}}{\bar{h}_t} + \beta w_t\left(1-l_t\right) - \lambda\frac{w_{t+1}(1+\gamma_{t+1})}{1+r_{t+1}}\right] \tag{T1.1}$$

$$\frac{\pi^m_{1,t}}{\bar{h}_t} = \frac{\Xi}{1+\beta-(1-\varepsilon)\Xi}\left[w_t\left(1-l_t\right) + \lambda\frac{w_{t+1}(1+\gamma_{t+1})}{1+r_{t+1}}\right] + \frac{(1+\beta)\Xi}{1+\beta-(1-\varepsilon)\Xi}\left[\lambda w_t + \left(\left(1-\delta\right)q_t + r^k_t\right)\frac{K_t}{\bar{h}_t}\right] \tag{T1.2}$$

$$w_t\bar{e}_t = \varepsilon\frac{\pi^m_{1,t}}{\bar{h}_t} \tag{T1.3}$$

$$\gamma_{t+1} = \phi_e\frac{l_t^{1-\theta}}{1-\theta} \tag{T1.4}$$

$$l_t^\theta \equiv \frac{\lambda\phi_e w_{t+1}}{(1+r_{t+1})w_t} \tag{T1.5}$$

$$1+r_{t+1} \equiv \frac{r^k_{t+1}+(1-\delta)q_{t+1}}{q_t} \tag{T1.6}$$

$$w_t = \phi\Omega_x\kappa_{x,t}^{1-\phi} = \psi q_t\Omega_z\kappa_{z,t}^{1-\psi} \tag{T1.7)-(T1.8}$$

$$r^k_t = (1-\phi)\Omega_x\kappa_{x,t}^{-\phi} = (1-\psi)q_t\Omega_z\kappa_{z,t}^{-\psi} \tag{T1.9)-(T1.10}$$

$$\kappa_t = (u_{1,t}+u_{2,t})\kappa_{x,t} + u_{z,t}\kappa_{z,t} \tag{T1.11}$$

$$z_t = \left(\frac{1+\lambda-\bar{e}_{t+1}-l_{t+1}}{1+\lambda-\bar{e}_t-l_t}\right)(1+\gamma_{t+1})\kappa_{t+1} - (1-\delta)\kappa_t \tag{T1.12}$$

$$\kappa_t = \frac{1}{1+\lambda-\bar{e}_t-l_t}\frac{K_t}{\bar{h}_t} \tag{T1.13}$$

$$y_t = px_{1,t} + x_{2,t} + q_t z_t \tag{T1.14}$$

$$\Xi \equiv \frac{\alpha^\sigma p^{1-\sigma}}{\alpha^\sigma p^{1-\sigma}+\sigma(1-\alpha)^\sigma} \tag{T1.15}$$

$$p = \frac{\alpha^\sigma p^{1-\sigma}+\sigma(1-\alpha)^\sigma}{\left(\sigma-1\right)\left(1-\alpha\right)^\sigma} \tag{T1.16}$$

$$px_{1,t} = \frac{\alpha^\sigma p^{1-\sigma}}{\alpha^\sigma p^{1-\sigma}+(1-\alpha)^\sigma}\frac{1}{1+\lambda-\bar{e}_t-l_t}\left[\frac{1}{1+\beta}\left((1-\varepsilon)\frac{\pi^m_{1,t}}{\bar{h}_t} + w_t\left(1-l_t\right) + \lambda\frac{w_{t+1}(1+\gamma_{t+1})}{1+r_{t+1}}\right) + \lambda w_t + \left(\left(1-\delta\right)q_t + r^k_t\right)\frac{K_t}{\bar{h}_t}\right] \tag{T1.17}$$

$$x_{i,t} = u_{i,t}\Omega_x\kappa_{x,t}^{1-\phi}, \qquad (i=1,2) \tag{T1.18)-(T1.19}$$

$$z_t = u_{z,t}\Omega_z\kappa_{z,t}^{1-\psi} \tag{T1.20}$$

$$1 = u_{1,t}+u_{2,t}+u_{z,t} \tag{T1.21}$$

Notes The endogenous variables are $K_{t+1}/\bar{h}_{t+1}$, $\gamma_{t+1} \equiv (\bar{h}_{t+1}-\bar{h}_t)/\bar{h}_t$, $\bar{e}_t$, $\pi^m_{1,t}/\bar{h}_t$, l_t, r_t, q_t, r^k_t, w_t, $x_{i,t} \equiv X_{i,t}/H_t$, $z_t \equiv Z_t/H_t$, $u_{i,t} \equiv H_{i,t}/H_t$, $u_{z,t} \equiv H_{z,t}/H_t$, $\kappa_t \equiv K_t/H_t$, $\kappa_{x,t} \equiv K_{i,t}/H_{i,t}$ (for $i=1,2$), $\kappa_{z,t} \equiv K_{z,t}/H_{z,t}$, Ξ, p, and $y_t \equiv Y_t/H_t$. Of these, only $K_t/\bar{h}_t$ is predetermined at time t.

Table 2: The competitive steady-state growth model

$$q^*\kappa^* = \frac{w^*}{(1+\beta)(1+\lambda-l^*)}\left[\beta\frac{1-l^*}{1+\gamma^*} - \frac{\lambda}{1+r^*}\right] \tag{T2.1}$$

$$\gamma^* = \phi_e \frac{(l^*)^{1-\theta}}{1-\theta} \tag{T2.2}$$

$$l^* \equiv \left[\frac{\lambda\phi_e}{1+r^*}\right]^{1/\theta} \tag{T2.3}$$

$$(r^k)^* = (r^* + \delta)q^* \tag{T2.4}$$

$$w^* = \phi\Omega_x \left(\kappa_x^*\right)^{1-\phi} \tag{T2.5}$$

$$w^* = \psi q^* \Omega_z \left(\kappa_z^*\right)^{1-\psi}, \tag{T2.6}$$

$$(r^k)^* = (1-\phi)\Omega_x \left(\kappa_x^*\right)^{-\phi} \tag{T2.7}$$

$$(r^k)^* = (1-\psi)q^*\Omega_z \left(\kappa_z^*\right)^{-\psi} \tag{T2.8}$$

$$\kappa^* = u_z^*\kappa_z^* + (1-u_z^*)\kappa_x^* \tag{T2.9}$$

$$z^* = (\gamma^* + \delta)\kappa^* \tag{T2.10}$$

$$y^* = (1-u_z^*)\Omega_x \left(\kappa_x^*\right)^{1-\phi} + q^* u_z^* \Omega_z \left(\kappa_z^*\right)^{1-\psi} \tag{T2.11}$$

$$z^* = u_z^*\Omega_z \left(\kappa_z^*\right)^{1-\psi} \tag{T2.12}$$

Notes The endogenous variables are γ^*, l^*, r^*, q^*, $(r^k)^*$, w^*, y^*, z^*, u_z^*, κ^*, κ_x^*, and κ_z^*.

finish college at biological age 23. The values for r^*, γ^*, and δ reported in Table 3 are obtained by using the relevant compounding formulae, e.g. $r^* = (1 + r_a^*)^T - 1$, etcetera.

The structural parameters β, ψ, Ω_x, Ω_z, ϕ_e, and θ are now obtained sequentially. First, we note that $\kappa_x^* = (1 - \phi)w^*/[\phi(r^* + \delta)]$ and set Ω_x such that:

$$\Omega_x = \left(\frac{w^*}{\phi}\right)^{\phi} \left(\frac{r^* + \delta}{1 - \phi}\right)^{1-\phi}.$$

Second, the share of human capital used in the production of consumption goods is given by:

$$u_x^* = (\kappa_x^*)^{\phi-1} \left(\frac{y^* - z^*}{\Omega_x}\right),$$

from which we find $u_z^* = 1 - u_x^*$. Third, the value of ψ follows from:

$$\psi = \frac{u_z^* w^*}{z^*}.$$

Fourth, imposing $q^* = 1$ we find that Ω_z is given by:

$$\Omega_z = \left(\frac{w^*}{\psi}\right)^{\psi} \left(\frac{r^* + \delta}{1 - \psi}\right)^{1-\psi}.$$

Fifth, by combining (T2.2)–(T2.3) we find the values of ϕ_e and θ

$$\theta = 1 - \frac{(1 + r^*)l^*}{\lambda \gamma^*}, \qquad \phi_e = \frac{1 + r^*)(l^*)^{\theta}}{\lambda}.$$

Finally we note that $\kappa^* = z^*/(\gamma^* + \delta)$ and solve equation (T2.1) for β:

$$\beta = \frac{\lambda w^*/(1 + r^*) + (1 + \lambda - l^*)\kappa^*}{w^*(1 - l^*)/(1 + \gamma^*) - (1 + \lambda - l^*)\kappa^*}.$$

The resulting values for β, ψ, Ω_x, Ω_z, ϕ_e, and θ are reported in Table 3.

2.4.2 Step 2: Parameters of the rent-seeking process

There are three key structural parameters relating to the rent-seeking process, namely ε, α, and σ. In the absence of firm empirical evidence on these parameters we simply fix them a priori and verify that the general equilibrium rent-seeking model yields plausible values for the monopoly price, the level of monopoly profits, and the amount of rent-seeking time. The first of the rent-seeking related coefficients (ε) regulates the curvature of the influence function, ε. After some experimentation we set $\varepsilon = 0.08$. The share parameter α regulates the relative importance of the monopolized sector in consumer demand (and thus the size of the 'pie' to rent-seekers). In the base model we assume that $x_1^* = x_2^*$ in the competitive growth model, which results in setting $\alpha = \frac{1}{2}$. Finally the substitution elasticity between the two consumption goods, σ, regulates the degree of monopoly power, the magnitude of the gross price-cost markup, and the size of monopoly profits. We set $\sigma = 2$. In order to investigate the robustness of our quantitative conclusions with respect to alternative values for ε, α, and σ we conduct a sensitivity analysis in Subsection 3.3.

2.5 Macroeconomic growth without rent-seeking

2.5.1 Competitive steady-state equilibrium

The quantitative features of the parameterized competitive steady-state growth path are reported in Table 4(a). The output shares of total consumption and investment equal, respectively 0.8834 and 0.1165. The income share of labour is 0.75. Of the available stock of human capital, a fraction 0.9424 is employed in the consumption goods sectors and the remainder 0.0576 in the (relatively capital-intensive) investment goods sector (recall that $\phi = 0.8000 > \psi = 0.3708$). Finally, with perfect competition throughout the economy excess profits are zero.

2.5.2 Monopolistic steady-state equilibrium

Before turning to the cases for which the rent-seeking process produces a monopoly in the sector producing x_1, we first investigate the effects on the macroeconomic equilibrium of the monopolization in isolation. In the absence of rent-seeking, does the monopoly itself harm or stimulate steady-state economic growth in the economy? The results of this quantitative exercise are reported in Table 4(b). The comparison between columns (a) and (b) reveals several noteworthy features. First, and most importantly, the steady-state macroeconomic growth rate is actually increased as a result of the monopoly! Whereas the perfectly competitive economy grows at the (calibrated) annual rate of 2.50 percent, the monopoly model yields an annual growth rate of 3.03 percent. It is straightforward to understand what causes this paradoxical result. With $\alpha = 0.5$ and $\sigma = 2$, the monopoly price of good x_1 is set equal to $p^* = 1 + \sqrt{2} \approx 2.4142$ whereas real marginal cost in that sector is equal to unity. The large markup produces profits which accrue to the young generation, i.e. $(\pi^m_{1,t}/\bar{h}_t)^* = 0.2527 > 0$. The additional income received during youth boosts aggregate saving (see equation (T1.1) in Table 1) which leads to an increase in the relative capital stock, i.e. $(K_t/\bar{h}_t)^*$ increases from 0.0840 in the competitive equilibrium to 0.1105 for the monopoly case. The resulting reduction in the steady-state interest factor, from $r^* = 3.3219$ to $r^* = 3.0116$, increases the return to schooling which boosts both learning time and macroeconomic growth (see equations (T1.4)–(T1.5) in Table 1).

The second noteworthy feature is that aggregate steady-state output increases by more than twenty-five percent, from $y^* = 1.0000$ to $y^* = 1.2550$! This result may also appear paradoxical at first viewing but it is easy to understand intuitively. As expected, demand in the monopolized sector drops dramatically, from $x_1^* = 0.4417$ to $x_1^* = 0.1316$. The high monopoly price shifts demand to the competitive sector, where output increases from $x_2^* = 0.4417$ to $x_2^* = 0.7669$. But increased saving (see above) boosts output in the investment goods sector which increases from $z^* = 0.1165$ to $z^* = 0.1865$. In summary, the slight reduction in $p^* x_1^*$ is more than offset by the increase in spending on the remaining demand components, $x_2^* + q^* z^*$.

Table 3: Structural parameters of the competitive growth model

(a) *Coefficients*			
β	time preference parameter	c	0.7182
ρ_a	annual pure rate of time preference (percent)	i	1.1092
λ	proportion of working time in old-age		0.5000
ϕ	human capital efficiency parameter consumption good		0.8000
ψ	human capital efficiency parameter investment good	c	0.3708
δ_a	annual capital depreciation rate (percent)		6.0000
δ	capital depreciation factor	i	0.8437
Ω_x	scale factor production function consumption good	c	1.7430
Ω_z	scale factor production function investment good	c	4.2651
θ	curvature parameter of the learning function	c	0.2125
ϕ_e	scale parameter of the learning function	c	5.2998
T	length of each adult period in years		30
(b) *Steady-state equilibrium growth path*			
κ^*	aggregate capital intensity:		0.0600
$(K_t/\bar{h}_t)^*$	physical-human capital ratio:		0.0840
l^*	time share of schooling during youth		0.1000
γ^*	growth factor		1.0976
$\gamma_a^* \times 100\%$	annual growth rate (percent)	i	2.5000
r^*	real interest factor		3.3219
$r_a^* \times 100\%$	annual real interest rate (percent)	i	5.0000
w^*	wage rate		0.7500
$(r^k)^*$	rental rate on capital		4.1656
y^*	output intensity		1.0000
x_i^*	consumption intensity in sector i		0.4417
z^*	investment intensity		0.1165
q^*	relative price of the investment good		1.0000
u_1^*	human capital share in consumption sector 1		0.4712
u_2^*	human capital share in consumption sector 2		0.4712
u_z^*	human capital share in the investment sector		0.0576
κ_z^*	capital intensity investment sector:		0.3055
κ_x^*	capital intensity consumption sector:		0.0450

Note The parameters labelled 'c' are calibrated as is explained in the text. The ones labelled 'i' are implied by other parameters and variables. The remaining parameters are postulated a priori. Note that $\rho_a = \beta^{-1/T} - 1$, $r_a^* = (1+r^*)^{1/T} - 1$, $\gamma_a^* = (1+\gamma^*)^{1/T} - 1$, and $\delta = 1 - (1-\delta_a)^T$.

Table 4: Features of the steady-state growth path (TY case)

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
θ	0.2125	0.2125	0.2125	0.3000	0.2125	0.2125	0.2125	0.2125	0.2125	0.2125
ϕ_e	5.2998	5.2998	5.2998	5.2998	6.0000	5.2998	5.2998	5.2998	5.2998	5.2998
ε			0.0800	0.0800	0.0800	0.1600	0.0800	0.0800	0.0800	0.0800
σ	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	4.0000	2.0000	2.0000	2.0000
α	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.7000	0.5000	0.5000
ϕ (or ϕ_1)	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.6000	0.8000
ψ	0.3708	0.3708	0.3708	0.3708	0.3708	0.3708	0.3708	0.3708	0.3708	0.8000
y^*	1.0000	1.2550	1.2516	1.1359	1.1760	1.2482	1.1024	1.8768	1.1838	1.4268
x_1^*	0.4417	0.1316	0.1315	0.1192	0.1237	0.1315	0.1667	0.2693	0.0584	0.1523
x_2^*	0.4417	0.7669	0.7666	0.6946	0.7207	0.7662	0.7248	0.6195	0.8116	0.8874
z^*	0.1165	0.1865	0.1825	0.1357	0.1503	0.1787	0.1425	0.3721	0.1608	0.4202
l^*	0.1000	0.1420	0.1399	0.1388	0.1494	0.1378	0.1168	0.2198	0.1170	0.1805
$\bar{e}^*$			0.0254	0.0254	0.0253	0.0501	0.0106	0.0797	0.0174	0.0230
γ^*	1.0976	1.4467	1.4299	1.9004	1.7048	1.4130	1.2404	2.0405	1.2423	1.7477
$\gamma_a^* \times 100\%$	2.5000	3.0274	3.0037	3.6132	3.3724	2.9797	2.7253	3.7763	2.7282	3.4266
$\gamma_{ca}^* \times 100\%$	2.5000			3.1607	2.8531				2.0692	2.8427
w^*	0.7500	0.7820	0.7806	0.7080	0.7339	0.7792	0.7640	0.8238	0.7642	0.9691
$(r^k)^*$	4.1657	3.5250	3.5501	5.2461	4.5431	3.5757	3.8689	2.8612	3.8653	1.4941
r^*	3.3219	3.0116	3.0243	3.7919	3.4928	3.0372	3.1816	2.6562	3.1799	2.8122
$r_a^* \times 100\%$	5.0000	4.7395	4.7506	5.3619	5.1358	4.7618	4.8846	4.4162	4.8831	4.5617
p^*	1.0000	2.4142	2.4142	2.4142	2.4142	2.4142	1.4440	3.5386	3.7278	2.4142
$(mc^x)^*$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.6435	1.0000
q^*	1.0000	0.9143	0.9178	1.1317	1.0476	0.9213	0.9611	0.8175	0.9607	0.4087
u_1^*	0.4712	0.1346	0.1348	0.1347	0.1348	0.1350	0.1746	0.2615	0.0754	0.1257
u_2^*	0.4712	0.7845	0.7856	0.7849	0.7856	0.7867	0.7590	0.6015	0.8497	0.7325
u_z^*	0.0576	0.0808	0.0796	0.0804	0.0796	0.0783	0.0665	0.1369	0.0749	0.1418
κ^*	0.0600	0.0814	0.0803	0.0494	0.0590	0.0792	0.0684	0.1290	0.0771	0.1622
κ_1^*	0.0450	0.0555	0.0550	0.0337	0.0404	0.0545	0.0494	0.0720	0.1318	0.1622
κ_2^*	0.0450	0.0555	0.0550	0.0337	0.0404	0.0545	0.0494	0.0720	0.0494	0.1622
κ_z^*	0.3055	0.3764	0.3730	0.2290	0.2741	0.3697	0.3350	0.4885	0.3354	0.1622
$(K_t/\bar{h}_t)^*$	0.0840	0.1105	0.1072	0.0660	0.0782	0.1039	0.0938	0.1549	0.1052	0.2102
$(\pi_{1,t}^m/\bar{h}_t)^*$	0.0000	0.2527	0.2482	0.2251	0.2318	0.2439	0.1016	0.8209	0.1612	0.2792

Notes The steady-state equilibria without rent seeking are reported in columns (a) for the perfectly competitive case and (b) for the monopolistic case. Column (c) reports on the benchmark rent-seeking equilibrium. Columns (d)–(h) report on some alternative rent-seeking equilibria for different values of, respectively, θ, ϕ_e, ε, σ, and α. Column (i) reports the equilibrium when the efficiency parameters in the two consumption goods sectors (ϕ_i) differ, i.e. $\phi_1 = 0.6000$ and $\phi_2 = 0.8000$. See SM (Section A.1 and Table A.2) for the generalized model covering this case. In column (j) efficiency parameters in all sectors are equal, $\psi = \phi = 0.8000$.

2.5.3 Transition from the competitive to the monopolized equilibrium

In Figure 2 we depict the dynamic transition paths for some key variables. The economy starts out in the competitive steady-state (the thin dashed line in each panel) and a monopoly is established at shock-time, $t = 0$, which results in the new steady state reported in Table 4(b). At shock-time the relative capital stock, $K_t/\bar{h}_t$ is predetermined. As is illustrated in Figure 2(a), the adjustment in the relative capital stock is quite slow, with the growth rate of the physical capital stock outstripping that of average human capital, i.e. $\Delta K_{t+1}/K_t > \Delta \bar{h}_{t+1}/\bar{h}_t > 0$ during transition. Despite the fact that $K_t/\bar{h}_t$ is predetermined at impact, the aggregate capital intensity, $\kappa_t \equiv K_t/H_t$, increases at impact (see panel (b)) because there is a substantial increase in educational activities, i.e. l_t is boosted and H_t falls as a result of the shock (see equations (46) in the text and (T1.13) in Table 1).

At impact the capital intensities in the consumption- and investment goods sectors fall before rising to their higher steady-state levels during transition–see panels (c) for $\kappa_{x,t}$ and (d) for $\kappa_{z,t}$. Note that equations (T1.11) and (T1.21) in Table 1 can be combined to find that $\kappa_t = \kappa_{x,t} + u_{z,t}[\kappa_{z,t} - \kappa_{x,t}]$, so the impact increase in κ_t is consistent with the drops in $\kappa_{x,t}$ and $\kappa_{z,t}$ because the human capital share in the investment goods sector increases dramatically, see panel (f). At the same time human capital flows out of the monopolized sector and into the competitive sector, see panel (e).

The transition paths for relative prices are depicted in panels (g) and (h). Consistent with Useful Result 1 the relative price of the monopoly good features an immediate jump at impact (see panel (g)). The relative investment goods price, however, increases at impact before falling monotonically to its lower steady-state level during transition (see panel (h) and Table 4(b)). Factor price movements are depicted in panels (i) and (j). Consistent with the (implicit) factor price frontier, they display mirror image adjustment paths, with wages falling at impact and rising over and above the initial steady-state level and the opposite happening for the real interest rate.

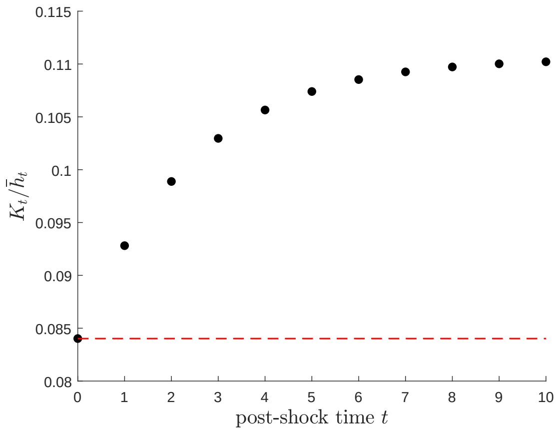
Finally, panel (k) shows that there is very little transitional dynamics in scaled monopoly profits, $\pi^m_{1,t}/\bar{h}_t$, whilst panel (l) reveals that the same holds for the macroeconomic growth rate, γ_{t+1}. The latter result follows readily from equation (T1.4) in Table 1 and by noting the fact that there is virtually no transitional dynamics in the amount of educational time, l_t (not drawn).

3 Rent-seeking, economic growth, and inequality

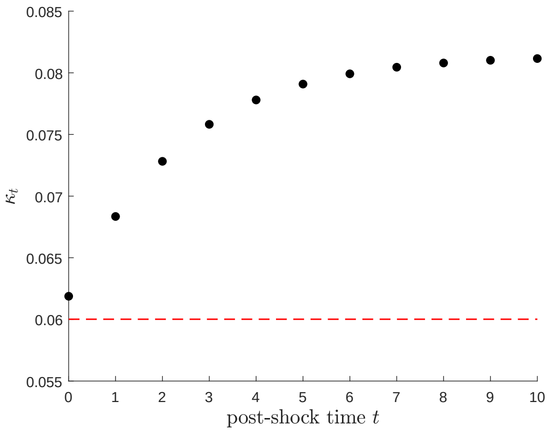
In this section we analyze the full model for which labour-using rent-seeking activities result in the establishment of a monopoly in the sector producing good x_1. In subsection 3.1 we investigate the macroeconomic effects of the switch from a perfectly competitive economy to one involving rent-seeking activities and a monopoly. In particular, we start out in a steady state competitive economy and assume that at shock-time $t = 0$ the rent-seeking process commences, i.e. all newborn individuals from that time on have access to the rent-seeking technology as formalized

Figure 2: Transitonal dynamics: from the competitive to the monopoly equilibrium

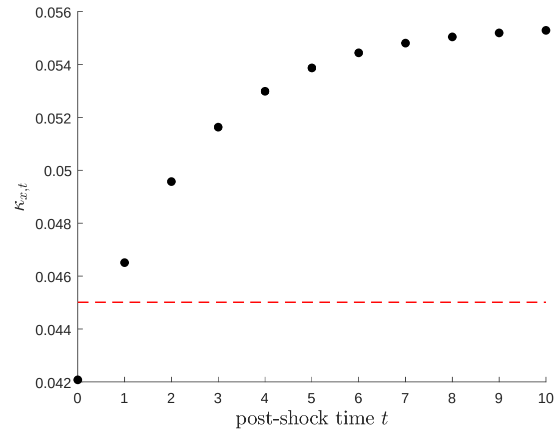
(a) Relative capital stock $K_t/\bar{h}_t$



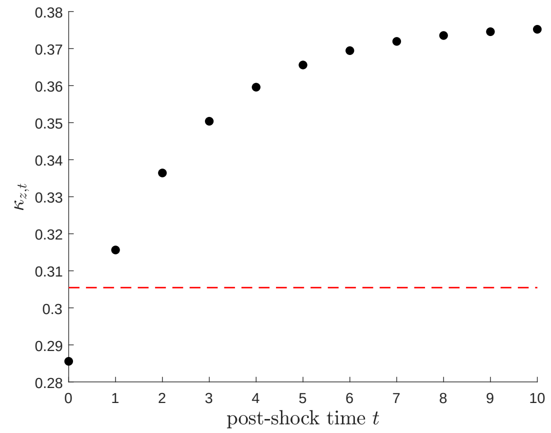
(b) Aggregate capital intensity κ_t



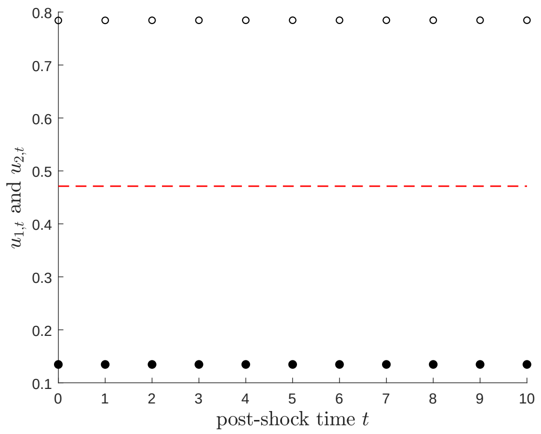
(c) Capital intensity $\kappa_{x,t}$



(d) Capital intensity $\kappa_{z,t}$



(e) Human capital shares $u_{1,t}$ and $u_{2,t}$



(f) Human capital share $u_{z,t}$

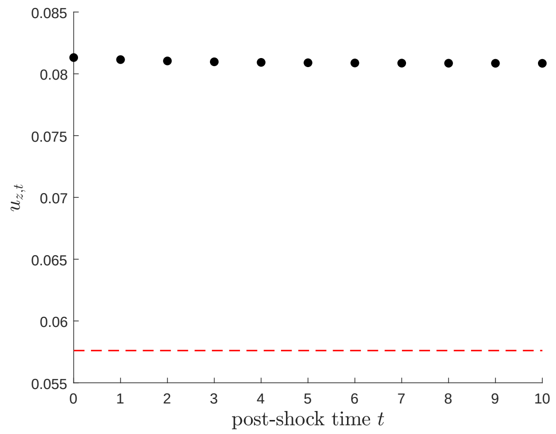
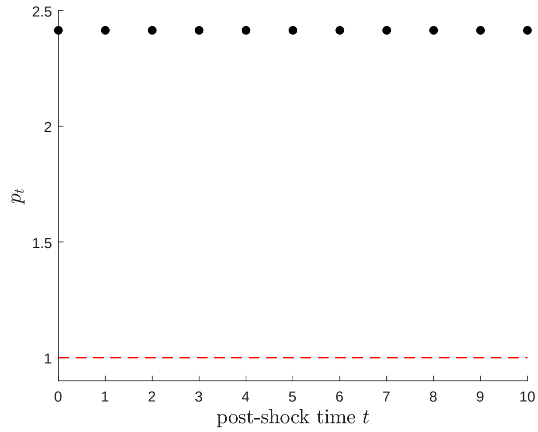
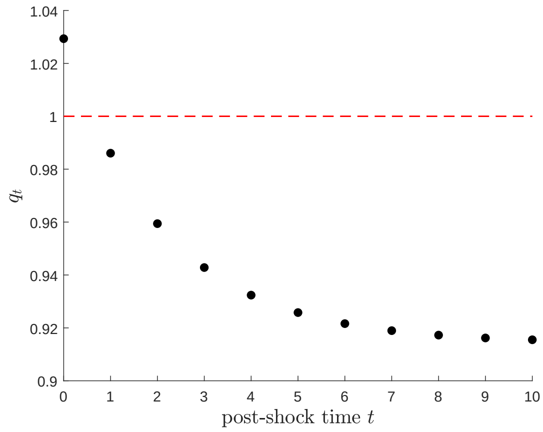


Figure 2, continued

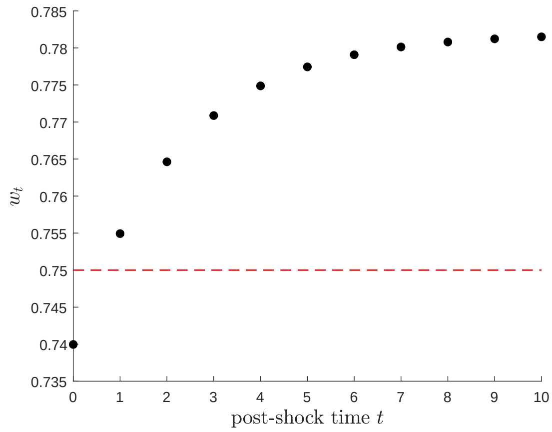
(g) Relative price p_t



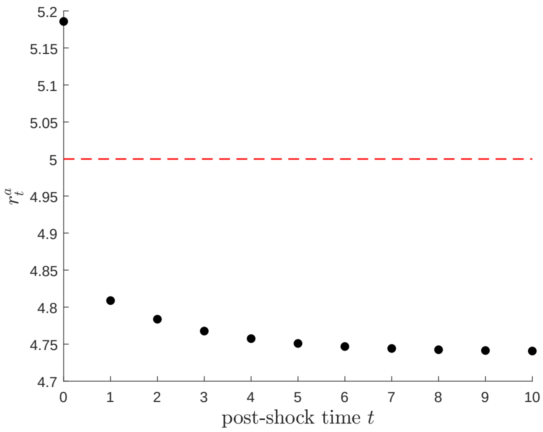
(h) Relative price q_t



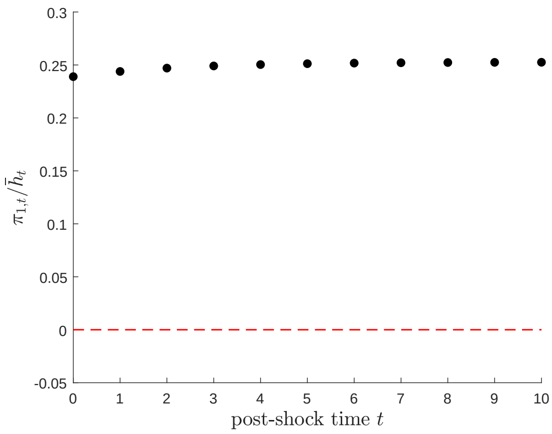
(i) Wage rate w_t



(j) Interest rate (annual) r_t



(k) Scaled monopoly profit $\pi^m_{1,t}/\bar{h}_t$



(l) Growth rate (annual) γ^a_{t+1}

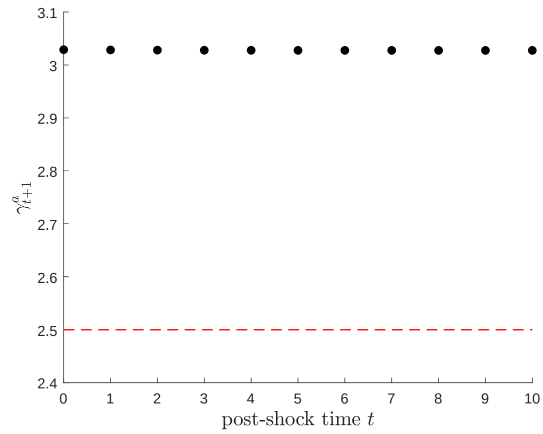
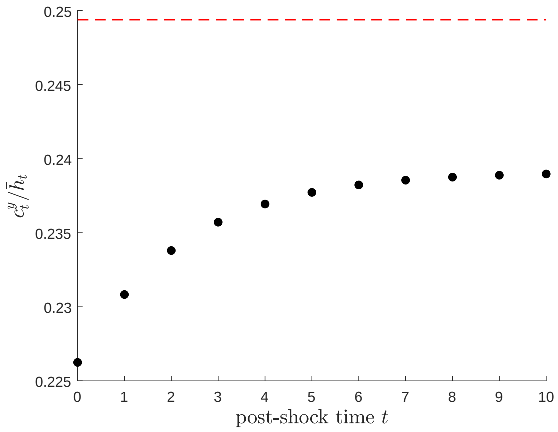
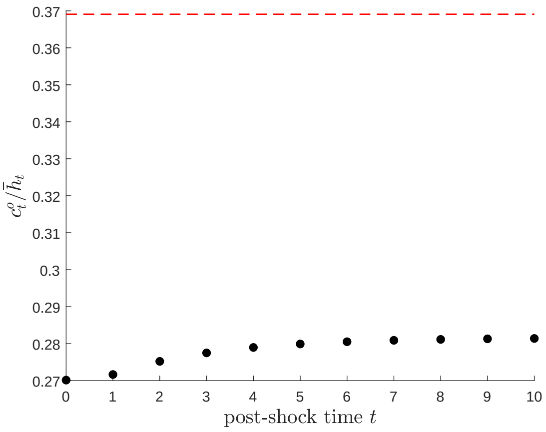


Figure 2, continued

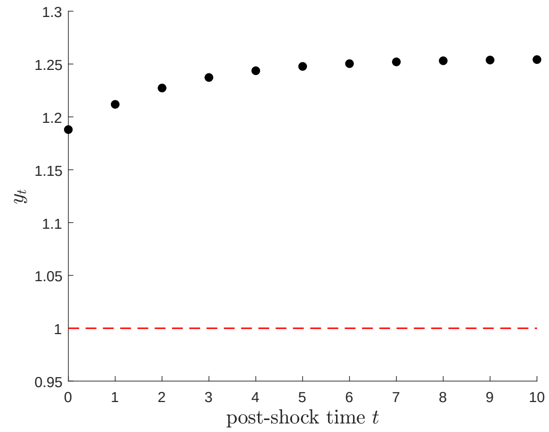
(m) Scaled youth consumption $c_t^y/\bar{h}_t$



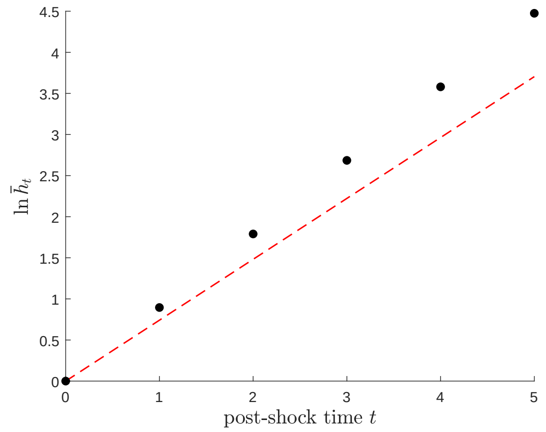
(n) Scaled old-age consumption $c_t^o/\bar{h}_t$



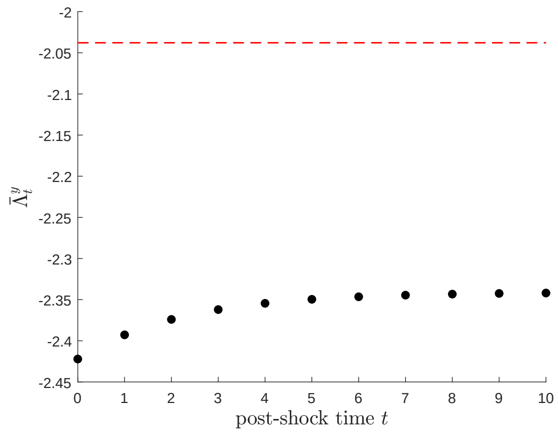
(o) Scaled output y_t



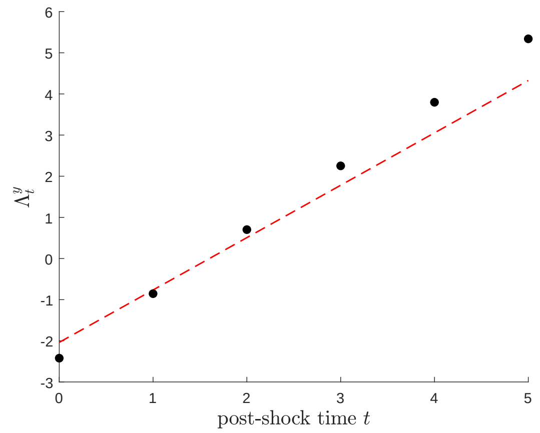
(p) Average capital stock $\ln \bar{h}_t$



(q) Welfare $\bar{\Lambda}_t^y$: stationary component



(r) Welfare Λ_t^y: total



in equation (17) above. Next, in subsection 3.2, we study the income and welfare inequality that emerges in a rent-seeking society. Finally, in subsection 3.3, we study the robustness of the conclusions regarding the macroeconomic effects of rent-seeking by adopting various alternatives values for the key structural parameters characterizing the economic process.

3.1 Macroeconomic effects

In Table 4(c) the key quantitative features of the benchmark rent-seeking steady-state equilibrium are reported. For the benchmark parameters about two and a half percent of the total time endowment of the young cohort is 'wasted' on rent-seeking activities, i.e. $\bar{e}^* = 0.0254$. Despite the fact that this represents a rather modest amount of time that is not available for production of goods or educational activities, it leads to the establishment of a monopoly in sector 1 which itself has large effects on the macroeconomic allocation as was explained in subsection 2.5 above. Interestingly, the comparison of columns (b) and (c) in Table 4 reveals that the monopoly equilibria without and with rent-seeking are virtually identical. This implies that the lost time due to rent-seeking has a minor effect on the equilibrium and that the bulk of the difference between columns (a) and (c) is accounted for by the effect of the monopoly distortion itself. From a purely macroeconomic perspective, modelling the rent-seeking process leading to the monopoly itself has limited value added. The 'socially damaging' effects of rent-seeking activities are to be found along a different dimension.

We summarize the main findings of this paragraph with Numerical Result 1.

Numerical Result 1 *(a) Compared to the perfectly competitive economy, an economy featuring a monopoly in the sector producing x_1 exhibits a higher steady-state growth rate, γ^*, more time spent on education, l^*, and a higher ratio between physical and human capital, $(K_t/\bar{h}_t)^*$. (b) In quantitative terms, the direct effect of the monopolization accounts for virtually all of the differences between the competitive and monopolized steady-state growth paths. The time spilled on rent-seeking activities has a minor effect on the macro-economy.*

Numerical support. See text and Table 4(a)–(c).

3.2 Inequality

By construction, in the competitive economy all newborn individuals are identical and thus make exactly the same decisions over their life-cycle. As a result, there is no inequality at all in this setting. In stark contrast, in a rent-seeking society, individuals are differentiated by their innate aptitude for lobbying and rent-seeking η, which, provided a rent-seeking technology is available, ends up causing inequality in the economy. Hence, the increase in the rate of economic growth comes at the price of income and welfare inequality.

Over time, in the competitive economy the paths for scaled consumption during youth and old-age of an individual of rent-seeking aptitude η are given by:

$$P_{V,t}\frac{c_t^y(\eta)}{\bar{h}_t} = \frac{1}{1+\beta}\frac{HW_t^y(\eta)}{\bar{h}_t}, \tag{49}$$

$$\frac{1+\gamma_{t+1}}{1+r_{t+1}}\frac{c_{t+1}^o(\eta)}{\bar{h}_{t+1}} = \frac{\beta P_{V,t}}{P_{V,t+1}}\frac{c_t^y(\eta)}{\bar{h}_t}, \tag{50}$$

where $P_{V,\tau}$ is the true price index:

$$P_{V,\tau} \equiv \left[\alpha^\sigma + (1-\alpha)^\sigma\right]^{1/(1-\sigma)}, \tag{51}$$

and where human wealth at birth is type-independent:

$$\frac{HW_t^y(\eta)}{\bar{h}_t} = \frac{HW_t^y}{\bar{h}_t} \equiv w_t\left[1-\left[\frac{\lambda\phi_e w_{t+1}}{(1+r_{t+1})w_t}\right]^{1/\theta}\right] + \frac{\lambda w_{t+1}(1+\gamma_{t+1})}{1+r_{t+1}}. \tag{52}$$

(For convenience we have substituted the optimal schooling choice–as stated in equation (T1.5) in Table 1–in the expression for human wealth.) Finally, in view of (49)–(50) and (52) it follows that $c_t^y(\eta) = c_t^y$ and $c_{t+1}^o(\eta) = c_{t+1}^o$ so that lifetime utility at birth is also type-independent and given by:

$$\Lambda_t^y(\eta) = \Lambda_t^y \equiv \bar{\Lambda}_t^y + (1+\beta)\ln\bar{h}_t, \tag{53}$$

where $\bar{\Lambda}_t^y$ is defined as:

$$\bar{\Lambda}_t^y \equiv \ln\left(\frac{c_t^y}{\bar{h}_t}\right) + \beta\ln\left(\frac{c_{t+1}^o}{\bar{h}_{t+1}}\right) + \beta\ln(1+\gamma_{t+1}). \tag{54}$$

In the remainder of this paper we refer to $\bar{\Lambda}_t^y$ as the *stationary* component of lifetime utility and $(1+\beta)\ln\bar{h}_t$ as the *growth* component.

In the rent-seeking economy (49)–(50) and (53) continue to hold but $P_{V,\tau}$ and $HW_t^y(\eta)$ are changed to:

$$P_{V,\tau} \equiv \left[\alpha^\sigma p_\tau^{1-\sigma} + (1-\alpha)^\sigma\right]^{1/(1-\sigma)}, \tag{55}$$

$$\frac{HW_t^y(\eta)}{\bar{h}_t} \equiv w_t\left[1-\left[\frac{\lambda\phi_e w_{t+1}}{(1+r_{t+1})w_t}\right]^{1/\theta}\right] + \frac{\lambda w_{t+1}(1+\gamma_{t+1})}{1+r_{t+1}} + s(\eta)(1-\varepsilon)\frac{\pi_{1,t}^m}{\bar{h}_t}, \tag{56}$$

where in (56) we have incorporated the fact that, with rent-seeking effort chosen optimally, the share of profits accruing to a type-η individual is time-independent, i.e. $s_t(\eta) = s(\eta)$, where $s(\eta)$ is given by:

$$s(\eta) \equiv \frac{\eta^{1/(1-\varepsilon)}}{\int_{\eta_L}^{\eta_H}\eta^{1/(1-\varepsilon)}dF(\eta)}, \tag{57}$$

so that $s(\eta) > 0$ and $\eta s'(\eta)/s(\eta) = 1/(1-\varepsilon) > 0$. Since human wealth at birth is type-dependent the same holds for type-dependent consumption plans. Indeed, by using (55) and (49)–(50) we find the following expressions relating type-dependent to economy-wide consumption plans:

$$\frac{P_{V,t}[c_t^y(\eta) - c_t^y]}{\bar{h}_t} = \frac{1}{1+\beta}[s(\eta) - 1](1-\varepsilon)\frac{\pi_{1,t}^m}{\bar{h}_t}, \tag{58}$$

$$P_{V,t+1}\frac{1+\gamma_{t+1}}{1+r_{t+1}}\frac{c_{t+1}^o(\eta) - c_{t+1}^o}{\bar{h}_{t+1}} = \beta P_{V,t}\frac{c_t^y(\eta) - c_t^y}{\bar{h}_t}. \tag{59}$$

Finally, type-dependent lifetime utility is given by:

$$\Lambda_t^y(\eta) \equiv \bar{\Lambda}_t^y(\eta) + (1+\beta)\ln \bar{h}_t, \tag{60}$$

with:

$$\bar{\Lambda}_t^y(\eta) \equiv \ln\left(\frac{c_t^y(\eta)}{\bar{h}_t}\right) + \beta \ln\left(\frac{c_{t+1}^o(\eta)}{\bar{h}_{t+1}}\right) + \beta\ln(1+\gamma_{t+1}). \tag{61}$$

Armed with these expressions we can conduct a number of welfare comparisons.

Intratemporal comparisons As was pointed out above there is no intratemporal inequality in the competitive economy. This result follows readily from equations (52)–(53). Since all components affecting lifetime utility are independent of η we find that $\Lambda_t^y(\eta) = \Lambda_t^y$ for all η.

In contrast, in a rent-seeking society lifetime utility at any moment in time is increasing in innate lobbying ability, i.e. $\partial\Lambda_t^y(\eta)/\partial\eta > 0$. This result follows in a straightforward fashion from equations (53)–(56) in combination with the fact that $s(\eta)$ is increasing in η and scaled monopoly profits are positive, i.e. $\pi_{1,t}^m/\bar{h}_t > 0$.

Figure 3 can be used to further clarify the key features of the model with and without rent-seeking. In Figure 3(a) the solid line plots the share function, $s(\eta)$, resulting from privately optimal decisions on rent-seeking effort under a uniform distribution for rent-seeking aptitude, i.e. $\eta \sim \mathcal{U}[\eta_L, \eta_H]$ with $\eta_L = 0$ and $\eta_H = 2$.[8] The dashed line in the figure plots the average share, $\bar{s} = 1$, and for future reference we define the critical rent-seeking ability, $\tilde{\eta}$, such that $s(\tilde{\eta}) = 1$. For the benchmark value of $\varepsilon = 0.08$ we find that $\tilde{\eta} = 1.0164$.

In Figure 3 we plot steady-state η profiles for scaled youth consumption, $[c_t^y(\eta)/\bar{h}_t]^*$, in panel (b) and planned old-age consumption, $[c_{t+1}^o(\eta)/\bar{h}_{t+1}]^*$, in panel (c). Again the thin dotted lines represent the outcomes under perfect competition whilst the solid lines depict the profiles in the rent-seeking equilibrium. Scaled youth consumption under rent-seeking is lower than with perfect competition for all but the highest ability rent-seekers who are more than compensated for the high monopoly price of good x_1 by a sufficiently large share of monopoly profits (see

[8] Using equation (57) we find that the share function under the uniform distribution takes the following form:

$$s(\eta) = (1+\nu)(\eta_H - \eta_L)\frac{\eta^\nu}{\eta_H^{1+\nu} - \eta_L^{1+\nu}},$$

with $\nu \equiv 1/(1-\varepsilon) > 1$.

Figure 3: The competitive versus the rent-seeking equilibrium

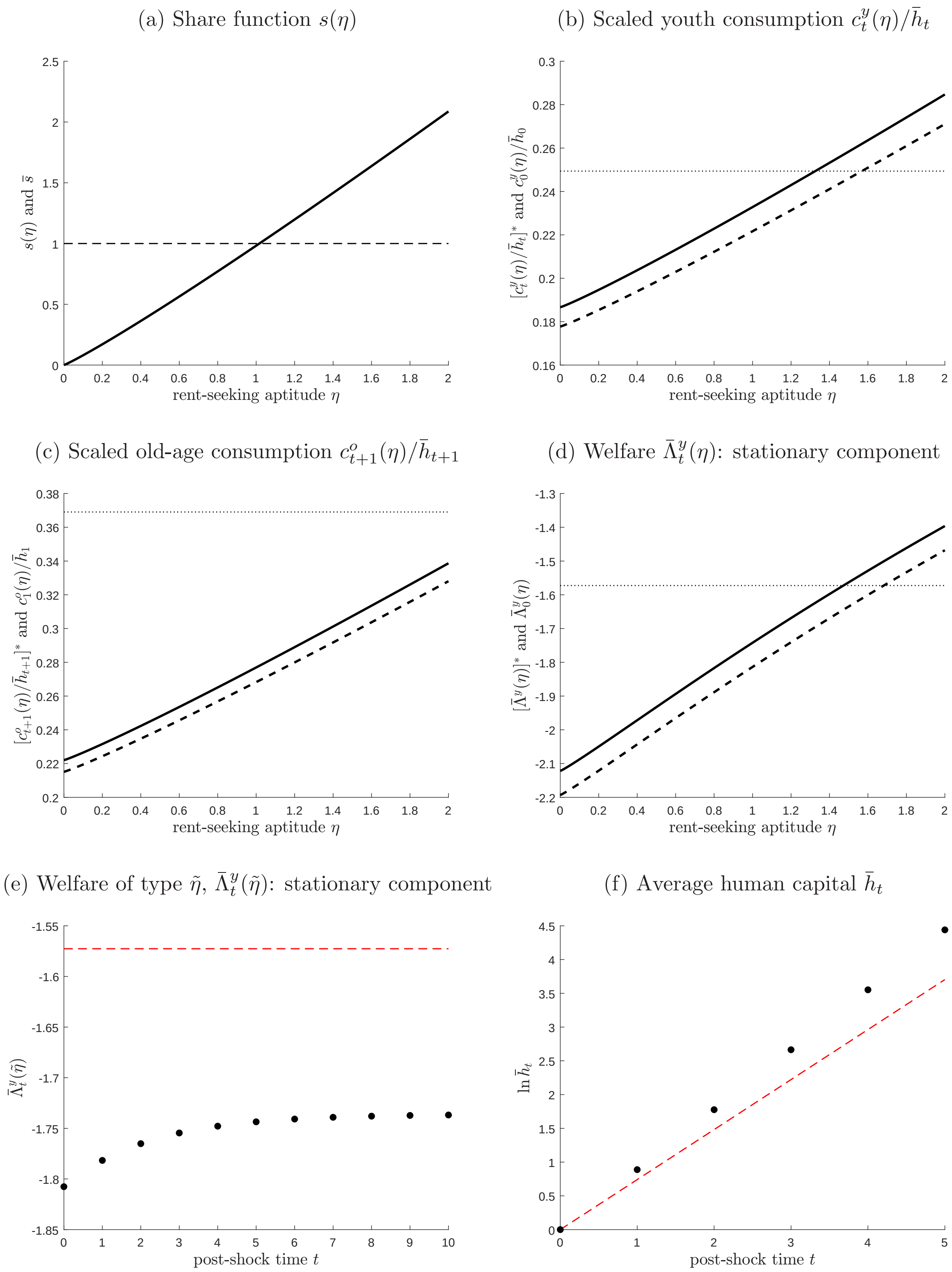
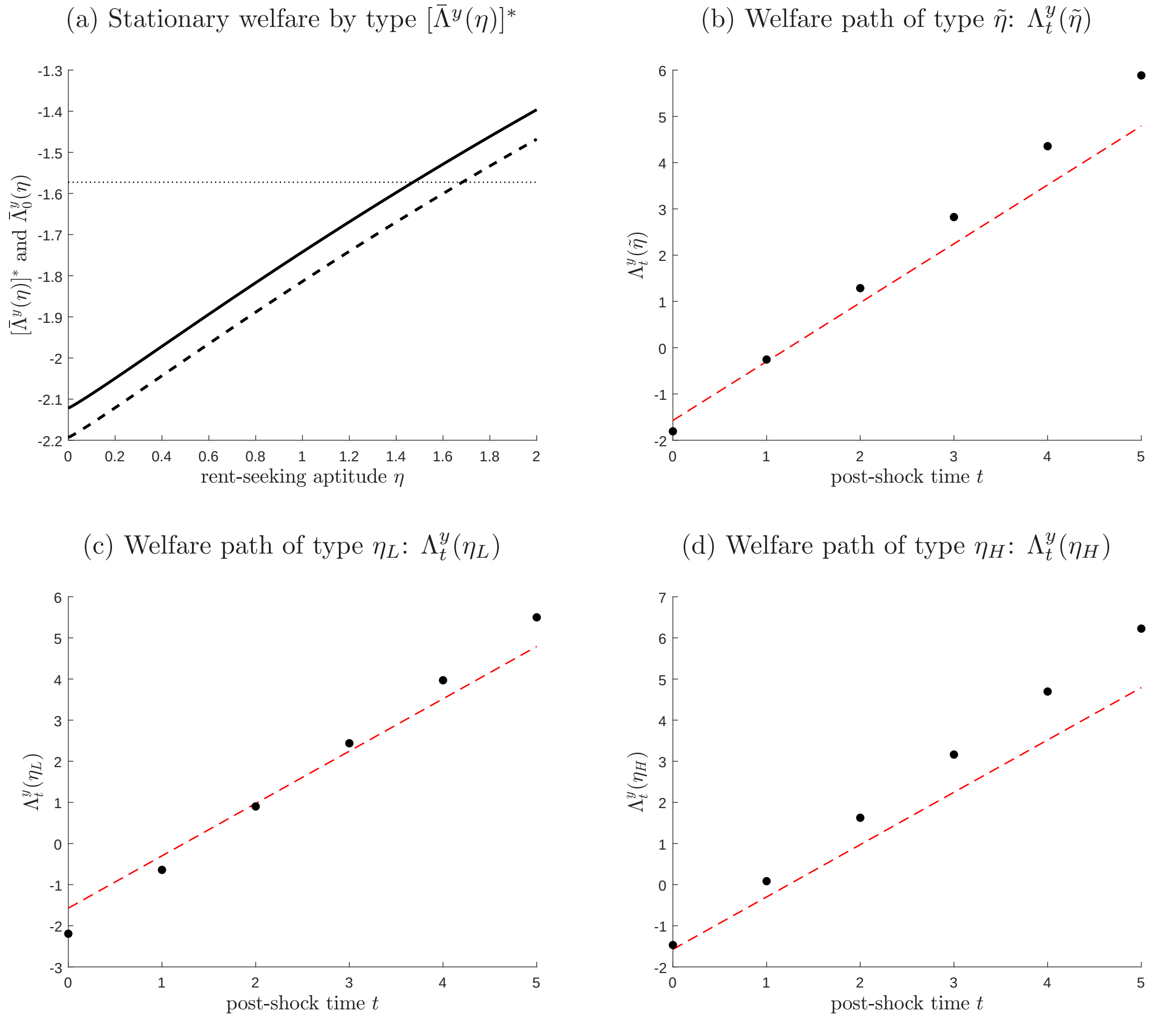


Figure 4: Welfare distribution in the rent-seeking equilibrium



panel (b)). Interestingly, scaled planned old-age consumption is lower under rent-seeking for all ability types. Intuitively, the large increase in steady-state growth in combination with a reduction in the interest factor leads to a sharp reduction in the growth-corrected interest factor, $(1 + r^*)/(1 + \gamma^*)$ which tilts the consumption Euler equation in favor of youth consumption.

Figure 3(d) depicts the steady-state stationary component of lifetime utility by rent-seeking ability, $[\bar{\Lambda}^y(\eta)]^*$, under perfect competition (thin dotted line) and in the rent-seeking equilibrium (solid line). Only the highly skilled rent-seekers (such that $1.4724 \leq \eta \leq 2$) have a higher stationary component of lifetime utility under rent-seeking than with perfect competition. All other types lose out on that account as a result of the high monopoly price of good x_1.

Up to this point the discussion has been focused on the comparison between steady-state equilibria. Of course, upon opening up the rent-seeking process at shock-time $t = 0$ the economy does not immediately settle at the new steady-state rent-seeking equilibrium as there exists slow transitional dynamics because the stocks of physical and human capital are only adjusted slowly over time. In Figures 3(b)–(d) the impact effects on scaled consumption and on lifetime utility have been depicted with dashed lines. Interestingly, at shock-time even fewer individuals have a higher stationary welfare component when the rent-seeking game starts (indeed, those such that $1.6821 \leq \eta \leq 2$ gain). All other individuals are worse off. As is illustrated in Figure 3(e), individuals with the critical rent-seeking ability $\tilde{\eta}$ feature a stationary component of lifetime utility that is lower under rent-seeking no matter when they are born–see the path for $\bar{\Lambda}_t^y(\tilde{\eta})$ which lies below the dashed line in the figure.

Of course, as is clear from the expressions in (60) and (61) above, for the shock-time young generation $\bar{\Lambda}_0^y(\eta)$ is all that matters as the initial average human capital stock is predetermined. In contrast, for future steady-state generations $\bar{\Lambda}_t^y(\eta)$ is only one component of their lifetime utility, the other being the time-varying path of $\ln \bar{h}_t$. So in judging the full effect on lifetime utility of the commencement of the rent-seeking process at time $t = 0$ it is necessary to combine the static and dynamic information contained in graphs like Figure 3(e)–(f).

Intertemporal comparisons The full welfare effects of the commencement of rent-seeking activities at shock-time $t = 0$ can be illustrated with the aid of Figure 4. Panel (a) in that figure just restates the steady-state information also contained in Figure 3(d). Panels (b)–(d) depicts the dynamic evolution of lifetime utility at birth of three key types of rent-seekers. Figure 4(b) the dots depict the time path for $\Lambda_t^y(\tilde{\eta})$, which represents lifetime utility at birth of the rent-seekers with critical ability $\tilde{\eta}$ (such that $s(\tilde{\eta}) = 1$). The dashed line is the path these types would have experienced in the pre-shock perfectly competitive world. Despite the fact that individuals of this type lose out at impact (see Figure 3(e)), from time $t = 1$ onward such agents are better off under rent-seeking as a result of the unintended dynamic 'growth bonus' that materializes from the increased macroeconomic growth rate.

As is illustrated in Figure 4(c), individuals with the lowest rent-seeking aptitude ($\eta = \eta_L$) also obtain the growth bonus but such agents are better off under rent-seeking only if they are born from time $t = 3$ onward. Intuitively, the static monopoly distortion harms them to the fullest extent (as $s(\eta_L) = 0$) and they have to 'wait' the longest of all types before the dynamic growth effect compensates for it.

Finally, as we show in Figure 4(d), individuals with the highest rent-seeking aptitude ($\eta = \eta_H$) are better off under rent-seeking from the time of the shock onward. The static monopoly distortion does not harm them at all but instead rewards them to the maximum extent because they receive the largest share of the 'booty' from rent-seeking, $(1-\varepsilon)\pi^m_{1,t}/\bar{h}_t$ (as $s(\eta_H) = 2.0870$).

We summarize the main numerical findings of this paragraph with Numerical Result 2.

Numerical Result 2 *(a) In the perfectly competitive economy there is no intratemporal welfare inequality because the innate differences in rent-seeking aptitude cannot be utilized. There exists intertemporal inequality because ongoing economic growth causes newborn generations to be richer the later in time they are born. (b) In the rent-seeking equilibrium there exists intratemporal inequality in that high-ability rent-seekers extract a much large part of the monopoly revenue than their less-skilled cohort members. (c) Upon the commencement of the rent-seeking game, virtually all individuals are worse off despite the fact that economic growth increases. Only the highest-skilled rent-seekers gain at shock-time. (d) As a result of the increased growth rate, individuals of all rent-seeking skill types η are better off than in the steady-state competitive economy provided they are born late enough in time.*

Numerical support. See text and Figures 3 and 4.

3.3 Robustness

We close this section by briefly investigating how the rent-seeking equilibrium depends on the various structural parameters. We abstract from considerations of inequality and restrict attention to the key features of the macroeconomic steady-state growth path. The quantitative results of our robustness analysis are reported in columns (d)–(j) in Table 4. Before discussing the individual cases, we note that for all cases considered steady-state economic growth is higher in the rent-seeking equilibrium than in the perfectly competitive world. Indeed, this property (which we summarize in Numerical Result 3) can be observed from Table 4 by comparing the annual growth rate, γ^*_a, to its competitive counterpart, γ^*_{ca}, for the same parameter values.[9]

Numerical Result 3 *Consider an economy featuring rent-seeking by the young and with proceeds from these activities accruing to the young generations. Such an economy will grow at a faster steady-state rate than the corresponding competitive economy.*

Numerical support. See text and Table 4.

In the remainder of this subsection we compare each case with the benchmark rent-seeking equilibrium reported in Table 4(c). In column (d) we increase the curvature parameter of the learning function from $\theta = 0.2125$ to $\theta = 0.3000$. Holding constant the real interest factor r^*,

[9]Note that the cases reported in columns (b)–(c) and (f)–(h) feature the same competitive steady state growth rate as in column (a).

this parameter change implies that both steady-state learning time and the growth rate increase, since:

$$\frac{\partial l^*}{\partial \theta} = -\frac{l^*}{\theta^2} \ln\left(\frac{\lambda \phi_e}{1+r^*}\right) > 0, \qquad \frac{\partial \gamma^*}{\partial \theta} = \gamma^* \left[\frac{1}{1-\theta} - \frac{1}{\theta^2} \ln\left(\frac{\lambda \phi_e}{1+r^*}\right)\right] > 0,$$

where the sign follows from the fact that $\ln\left(\frac{\lambda\phi_e}{1+r^*}\right) = \theta \ln l^* < 0$ since $0 < l^* < 1$.[10] The results in column (d) confirm that such is indeed the case for the growth rate in general equilibrium. Despite the fact that the real interest factor increases and learning time l^* decreases slightly as a result, the growth rate increases. Interestingly, the focus of household saving shifts from physical to human capital resulting in a decrease in investment z^* and the ratio between the two capital stocks, $(K_t/\bar{h}_t)^*$.

In Table 4(e) we increase the scale parameter of the learning function from $\phi_e = 5.2998$ to $\phi_e = 6.0000$. Holding constant the real interest factor r^* this results in more learning time and a higher growth rate, since:

$$\frac{\partial l^*}{\partial \phi_e} = \frac{l^*}{\theta \phi_e} > 0, \qquad \frac{\partial \gamma^*}{\partial \phi_e} = \frac{\gamma^*}{\theta \phi_e} > 0.$$

The results in column (e) confirm that both partial equilibrium effects also hold in general equilibrium. Just as for the previous case (of column (d)) investment z^* decreases and the ratio between the two capital stocks, $(K_t/\bar{h}_t)^*$, increases because household saving shifts from physical to human capital.

In Table 4(f) we increase the curvature parameter of the share function from $\varepsilon = 0.08$ to $\varepsilon = 0.16$. Since there are weaker diminishing returns to rent-seeking effort, the average amount of rent-seeking time increases drastically, from $\bar{e} = 0.0254$ to $\bar{e} = 0.0501$. Despite the fact that a little over five percent of the time endowment is wasted on rent-seeking efforts, the negative effect on economic growth is rather small, i.e. the annual growth rate falls from 3.0037 percent to 2.9797 percent (2.4 basis points). Since the parameters of the human capital accumulation function are held constant, the reduction in learning time l^* (resulting in lower growth) is fully accounted for by the general equilibrium effect on the real interest factor which increases by 1.12 basis points on an annual basis.

In Table 4(g) we increase the substitution elasticity between goods x_1 and x_2 in the subfelicity function from $\sigma = 2$ to $\sigma = 4$. This parameter change reduces the degree of market power that the monopolist possesses in the rent-seeking equilibrium. Not surprisingly, therefore, and in accordance with Useful Result 1(d) the gross markup of price over marginal cost falls dramatically, from $p^*/(mc^x)^* = 2.4142$ to $p^*/(mc^x)^* = 1.4440$. Scaled profits are more than halved, from $(\pi^m_{1,t}/\bar{h}_t)^* = 0.2482$ to $(\pi^m_{1,t}/\bar{h}_t)^* = 0.1016$ which reduces the attractiveness of rent-seeking

[10] Note that:

$$l^* = \left(\frac{\lambda \phi_e}{1+r^*}\right)^{1/\theta}, \qquad \gamma^* = \frac{\phi_e}{1-\theta}\left(\frac{\lambda \phi_e}{1+r^*}\right)^{(1-\theta)/\theta}.$$

activities, i.e. $\bar{e}^*$ falls from $\bar{e}^* = 0.0254$ to $\bar{e}^* = 0.0106$. As a result of general equilibrium interactions, the real interest rate increases by 15.7 basis points annually which causes a reduction in learning time and the growth rate.

In Table 4(h) we increase the share parameter of good x_1 in the subfelicity function from $\alpha = 0.5$ to $\alpha = 0.7$. This parameter change makes the monopolistic sector more important to consumers and increases the degree of market power of the monopolist. Indeed, in accordance with Useful Result 1(c) the gross markup of price over marginal cost rises substantially, from $p^*/(mc^x)^* = 2.4142$ to $p^*/(mc^x)^* = 3.5386$, causing an huge increase in scaled profits from $(\pi^m_{1,t}/\bar{h}_t)^* = 0.2482$ to $(\pi^m_{1,t}/\bar{h}_t)^* = 0.8209$. This, of course, increases the attractiveness of rent-seeking activities, i.e. $\bar{e}^*$ increases from $\bar{e}^* = 0.0254$ to $\bar{e}^* = 0.0797$. As a result of general equilibrium interactions, the real interest rate decreases by 36.8 basis points annually which causes a sharp increase in learning time and the growth rate.

In Table 4(i) we decrease the efficiency parameter of human capital in the production function of good x_1 from $\phi_1 = 0.8$ to $\phi_1 = 0.6$. The monopolistic sector is relatively capital intensive (compared to sector x_2) and, not surprisingly, the capital intensity increases from $\kappa_1^* = 0.0550$ to $\kappa_1^* = 0.1318$. At the same time, because goods x_1 and x_2 are no longer identical from the production side, real marginal cost increases from $(mc)^* = 1.0000$ to $(mc)^* = 1.6435$ and the gross markup of price over marginal cost falls, from $p^*/(mc^x)^* = 2.4142$ to $p^*/(mc^x)^* = 2.2682$. The reduced market power causes scaled monopoly profits to fall from $(\pi^m_{1,t}/\bar{h}_t)^* = 0.2482$ to $(\pi^m_{1,t}/\bar{h}_t)^* = 0.1612$. This, of course, reduces the attractiveness of rent-seeking activities, i.e. $\bar{e}^*$ decreases from $\bar{e}^* = 0.0254$ to $\bar{e}^* = 0.0174$. As a result of general equilibrium interactions, the real interest rate increases by 13.3 basis points annually which causes a decrease in learning time and the growth rate.

Finally, in Table 4(j) we increase the efficiency parameter of human capital in the production function of the investment good z from $\psi = 0.3708$ to $\psi = 0.8$. Apart from the scale factors (Ω_x and Ω_z) all goods are identical from the production side so that all sectors feature the same capital intensity. Real marginal cost in the consumption goods sectors again equals unity and in the investment good sector we find $q^* = (mc^z)^* = \Omega_x/\Omega_z = 0.4087$. Learning time and real investment increase dramatically, resulting in an increase in the scaled capital stock from $(K_t/\bar{h}_t)^* = 0.1072$ to $(K_t/\bar{h}_t)^* = 0.2102$ and an increase in economic growth of 42.3 basis point annually.

Numerical Result 4 *Consider an economy featuring rent-seeking by the young and with proceeds from these activities accruing to the young generations. (a) Equilibrium rent-seeking time $\bar{e}^*$ is larger the larger is ε (due to weaker diminishing returns to rent-seeking time), and the larger is α (as the monopoly good is more important to consumers). (b) Rent-seeking time is lower the higher is σ (due to a reduction in the monopolist's market power), and the higher is $1 - \phi_1$ (an increase in the capital intensity of the monopolized sector).*

Numerical support. See text and Table 4.

4 Investigating the main mechanisms

The general equilibrium model of rent-seeking and economic growth that is formulated in Section 2 and analyzed in Section 3 features (at least) three main mechanisms 'under its bonnet'. The first mechanism concerns the timing of the rewards accruing to rent-seeking time expended during youth. In the benchmark model the payoff occurs during youth and part of the proceeds are consequently saved for use later on in life. In Subsection 4.1 we study the key effects of relaxing this assumption by postulating that the rewards occur during old-age.

The second main mechanism considers the inputs used in rent-seeking activities. In the benchmark model raw units of time enter the share function (17) so rent-seeking time directly represents the wastage due to lobbying activities. In Subsection 4.2 we consider the alternative scenario under which the share function depends on the education level of the individual as measured by learning time during youth, $l_t(\eta)$.

The third main mechanism concerns the type of growth engine giving rise to ongoing economic progress. In the benchmark model human capital accumulation in combination with an intergenerational external effect cause individual education decisions to be translated into ongoing economic growth. In Subsection 4.3 we change the benchmark model by assuming that human capital formation is a purely private activity without external benefits and by postulating that ongoing growth occurs as a result of a physical capital externality.

4.1 Rent-seeking revenues accrue late in life

The basic idea investigated in this subsection is that rent-seeking occurs during youth (as in the benchmark model) but that the rewards are obtained during old age. Details of the full model are presented in SM (Section A.3) and the main changes to the benchmark case are briefly sketched here. First, the individual's income definitions are changed from (5) and (9) to:

$$\begin{aligned} I_t^y(\eta) &\equiv w_t h_t^y(\eta)\left[1-e_t(\eta)-l_t(\eta)\right], \\ I_{t+1}^o(\eta) &\equiv \lambda w_{t+1} h_{t+1}^o(\eta) + s_t(\eta)\Pi_{1,t+1}^m + \left[(1-\delta)q_{t+1}+r_{t+1}^k\right]\left[z_t^y(\eta)+k_t^y(\eta)\right]. \end{aligned}$$

As a result of the change in timing rent-seeking time spent during youth gives rise to a share of future (rather than current) monopoly profits. Rent-seeking becomes an intertemporal investment decision.

Second, redoing the derivations we obtain the alternative model which has been summarized in Table A.3 in SM. Compared to the benchmark model of Table 1 the following equations are changed:

$$(1+\gamma_{t+1})q_t\frac{K_{t+1}}{\bar{h}_{t+1}} = \frac{1}{1+\beta}\left[\beta w_t\left(1-l_t\right) - \frac{1+\gamma_{t+1}}{1+r_{t+1}}\left(\lambda w_{t+1} + (1+\beta\varepsilon)\frac{\pi_{1,t+1}^m}{\bar{h}_{t+1}}\right)\right] \qquad \text{(T1.1a)}$$

$$\frac{\pi_{1,t}^m}{\bar{h}_t} = \frac{\Xi}{(1-\Xi)(1+\beta)}\left[w_t\left(1-l_t\right) + \frac{1+\gamma_{t+1}}{1+r_{t+1}}\left(\lambda w_{t+1} + (1-\varepsilon)\frac{\pi_{1,t+1}^m}{\bar{h}_{t+1}}\right)\right]$$

Table 5: Rent-seeking equilibria under alternative scenarios

	(a)	(b)	(c)	(d)	(e)
$(Y_t/K_t)^*$	16.6627	15.5895	24.0974	19.8573	19.2956
$p^*(X_{1,t}/Y_t)^*$	0.4417	0.2537	0.2705	0.2543	0.2531
$(X_{2,t}/Y_t)^*$	0.4417	0.6125	0.6531	0.6139	0.6111
$q^*(Z_t/Y_t)^*$	0.1165	0.1339	0.0764	0.1319	0.1358
$\bar{l}^*$	0.1000	0.1399	0.0727	0.1716	
$\bar{e}^*$		0.0254	0.0112	0.0249	0.0255
$\gamma_a^* \times 100\%$	2.5000	3.0037	2.0792	3.3243	3.4616
$(w_t\bar{h}_t/K_t)^*$	8.9265	7.2849	10.8986	9.5095	8.9676
$r_a^* \times 100\%$	5.0000	4.7506	5.2371	5.1221	4.9535
p^*	1.0000	2.4142	2.4142	2.4142	2.4142
q^*	1.0000	0.9178	1.0845	1.0427	1.0000
$(H_{1,t}/H_t)^*$	0.4712	0.1348	0.1400	0.1350	0.1231
$(H_{2,t}/H_t)^*$	0.4712	0.7856	0.8158	0.7867	0.7175
$(H_{z,t}/H_t)^*$	0.0576	0.0796	0.0442	0.0783	0.1594
$(K_{1,t}/K_t)^*$	0.3534	0.0923	0.1114	0.0929	0.1231
$(K_{2,t}/K_t)^*$	0.3534	0.5379	0.6495	0.5413	0.7175
$(K_{z,t}/K_t)^*$	0.2932	0.3698	0.2391	0.3658	0.1594
$(\pi_{1,t}^m/Y_t)^*$	0.0000	0.1486	0.1585	0.1489	0.1483

Notes The perfectly competitive steady-state equilibrium (without rent seeking) is reported in column (a). Column (b) reports on the benchmark rent-seeking equilibrium. Column (c) reports the rent-seeking equilibrium with proceeds accruing during old age. Column (d) states the results for education-augmented rent-seeking. Column (e) states the results for the capital-externality based growth model with rent-seeking. In columns (a)–(d) w_t^* is constant whilst $\bar{h}_t^*$ and H_t^* grow at the annual rate γ_a^*. In column (e) $\bar{h}_t = 1$, H_t^* is constant, and w_t^* grows at the annual rate γ_a^*.

$$+\frac{\Xi}{1-\Xi}\left[\lambda w_t + \left((1-\delta)\, q_t + r_t^k\right)\frac{K_t}{\bar{h}_t}\right] \tag{T1.2a}$$

$$w_t \bar{e}_t = \varepsilon \frac{1+\gamma_{t+1}}{1+r_{t+1}} \frac{\pi^m_{1,t+1}}{\bar{h}_{t+1}} \tag{T1.3a}$$

$$px_{1,t} = \frac{\alpha^\sigma p^{1-\sigma}}{\alpha^\sigma p^{1-\sigma}+(1-\alpha)^\sigma}\frac{1}{1+\lambda-\bar{e}_t-l_t}\left[\frac{1}{1+\beta}\left(w_t\,(1-l_t)+\frac{1+\gamma_{t+1}}{1+r_{t+1}}\right.\right.$$
$$\left.\times\left(\lambda w_{t+1}+(1-\varepsilon)\frac{\pi^m_{1,t+1}}{\bar{h}_{t+1}}\right)\right)$$
$$\left.+\lambda w_t + \frac{\pi^m_{1,t}}{\bar{h}_t} + \left((1-\delta)\, q_t + r_t^k\right)\frac{K_t}{\bar{h}_t}\right] \tag{T1.17a}$$

Future profits feature *negatively* in the capital accumulation equation (T1.1a) but affect current profits positively in the current profit definition (T1.2a) due to the human wealth effect on the young. In addition, future profits help determine equilibrium rent-seeking time in (T1.3a). Finally, both current and future profit positively affect demand faced by the monopolist in (T1.17a).

Features of the steady-state growth path (as well as its dependency on the structural parameters , θ, ϕ_e, ε, σ, α, ϕ_1, and ψ) are reported in Table A.4 in SM. In order not to abuse the reader's patience, we focus here on the results for the benchmark parameters as given in Table 3 above.

In Table 5 we report a number of key endogenous variables in such a form that they all attain a constant steady-state value under all scenarios considered in this section. For reference purposes we report the features of the perfectly competitive steady-state equilibrium without rent-seeking in column (a) and the rent-seeking equilibrium in column (b). These columns contain the same information as Table 4, columns (a) and (c) respectively.

The first comparison we conduct is between the perfectly competitive equilibrium (Table 5(a)) and the monopoly-cum-rent-seeking equilibrium (Table 5(c)). In the latter case there is a modest amount of (socially wasteful) rent-seeking time and educational efforts are lower than under competition. Since rent-seeking during youth gives rise to consumable resources later in life the incentive to increase one's human capital are reduced. This results in a significantly lower steady-state growth rate in the rent-seeking equilibrium. The second comparison (between columns (b) and (c)) reveals why the growth conclusions for the benchmark and alternative scenario are so drastically different. When rewards accrue early in life growth increases whilst the opposite holds when the booty is obtained late in life. The intertemporal savings mechanism is crucially important in determining the effect of rent-seeking on the macroeconomic growth rate.

4.2 Rent-seeking function depends on education levels $l_t(\eta)$

The basic idea that is considered in this subsection is that education-augmented 'effective' lobbying time enters the share function in the rent-seeking game. Indeed, we change (17)–(18)

to:

$$s_t(\eta) = \frac{\eta\,[l_t(\eta)e_t(\eta)]^{\varepsilon}}{E_t}, \qquad 0 < \varepsilon < 1,$$
$$E_t \equiv \int_{\eta_0}^{\eta_1} \eta\,[l_t(\eta)e_t(\eta)]^{\varepsilon}\,dF(\eta).$$

Holding constant $l_t(\eta)$ and $e_t(\eta)$ for all η agents other than η', then all agents with aptitude η' will have an incentive to spend more time on rent-seeking activities *and* on acquiring education in order to capture a larger share of the monopoly profits. This subsection investigates to what extent this individual incentive to 'over-educate' oneself to get ahead in the rent-seeking game affects the steady-state macroeconomic growth equilibrium.

Details of the full model are presented in SM (Section A.4) and the main changes to the benchmark case are briefly sketched here. First, and most importantly, since learning time features in the share function, and individuals differ in terms of innate lobbying aptitude, the optimal amount of schooling is also type-dependent. Indeed, the first-order condition for optimal schooling changes from (15) to:

$$\frac{\Pi^m_{1,t}}{\bar{h}_t}\frac{\partial s_t(\eta)}{\partial l_t(\eta)} + \frac{w_{t+1}}{1+r_{t+1}}\lambda\phi_e l_t(\eta)^{-\theta} = w_t,$$

where we note that $\partial s_t(\eta)/\partial l_t(\eta) = \varepsilon s_t(\eta)/l_t(\eta)$. This, of course, implies that individual and aggregate growth rates differ in this education-augmented rent-seeking model:

$$\gamma_{t+1}(\eta) \equiv \frac{h^o_{t+1}(\eta) - \bar{h}_t}{\bar{h}_t} = \phi_e \frac{l_t(\eta)^{1-\theta}}{1-\theta},$$
$$\gamma_{t+1} \equiv \frac{\int_{\eta_L}^{\eta_H} h^o_{t+1}(\eta)dF(\eta) - \bar{h}_t}{\bar{h}_t} = \phi_e \frac{\int_{\eta_L}^{\eta_H} l_t(\eta)^{1-\theta}dF(\eta)}{1-\theta}.$$

Holding constant scaled profits and factor prices, $s_t(\eta)$ is increasing in η and the same holds for $l_t(\eta)$ and $\gamma_{t+1}(\eta)$. Education-augmented rent-seeking further boosts inequality in the economy on this account.

Second, redoing the derivations we obtain the alternative model which has been summarized in Table A.5 in SM. Compared to the benchmark model of Table 1 the following equations are changed:

$$\gamma_{t+1} = \phi_e \frac{\int_{\eta_0}^{\eta_1} l_t(\eta)^{1-\theta}dF(\eta)}{1-\theta}, \tag{T1.4b}$$
$$l_t(\eta) = \bar{e}_t \frac{\eta^{1/(1-\varepsilon)} l_t(\eta)^{\varepsilon/(1-\varepsilon)}}{\int_{\eta_0}^{\eta_1} \eta^{1/(1-\varepsilon)} l_t(\eta)^{\varepsilon/(1-\varepsilon)} dF(\eta)} + \frac{w_{t+1}}{(1+r_{t+1})w_t}\lambda\phi_e l_t(\eta)^{1-\theta}, \tag{T1.5b$_1$}$$
$$\bar{l}_t = \int_{\eta_0}^{\eta_1} l_t(\eta)dF(\eta) \tag{T1.5b$_2$}$$

where average education time $\bar{l}_t$ replaces l_t throughout Table 1.

Features of the steady-state growth path (as well as its dependency on the structural parameters , θ, ϕ_e, ε, σ, α, ϕ_1, and ψ) are reported in Table A.6 in SM. As in the previous subsection we focus here on the results for the benchmark parameters as given in Table 3 above. The results for the education-augmented rent-seeking model are reported in column (d) of Table 5.

Again, the first comparison we conduct is between the perfectly competitive equilibrium (column (a)) and the monopoly-cum-rent-seeking equilibrium (column (d)). In the latter case there is a modest amount of (socially wasteful) rent-seeking time but educational efforts are much higher than under perfect competition. The individual incentive to over-educate oneself also shows up in the macro outcomes. The higher educational efforts result in a significantly higher steady-state growth rate in the rent-seeking equilibrium. The second comparison (between columns (b) and (c)) reveals to what extent the growth conclusions for the benchmark and alternative scenario are different. Briefly put, the average amount of rent-seeking time differs little between the two cases and the difference in the growth rates is mostly accounted for by the higher educational efforts in the education-augmented rent-seeking model. Other than that columns (b) and (d) paint the same picture: growth is higher under the rent-seeking induced monopoly.

4.3 Physical capital externality

The basic idea that is considered in this subsection is that the macroeconomic growth engine operates via a physical capital externality. Individuals do not engage in educational activities (so that $l_t(\eta) = 0$ for all η) and individual and aggregate human capital are both constant ($h_t^y(\eta) = \bar{h}$ for all t and η). To make the competitive model compatible with the competitive human-capital based growth model we assume that the time endowments are $\lambda^y = 0.9$ (instead of 1) during youth and $\lambda^o = 0.5$ (as before) during old-age. Further details of the full model are presented in SM (Section A.5) and the main changes to the benchmark case are briefly sketched here. First, the individual's income definitions are changed from (5) and (9) to:

$$
\begin{aligned}
I_t^y(\eta) &\equiv w_t\bar{h}\left[\lambda^y - e_t(\eta)\right] + s_t(\eta)\Pi_{1,t}^m,\\
I_{t+1}^o(\eta) &\equiv \lambda^o w_{t+1}\bar{h} + \left[(1-\delta)q_{t+1} + r_{t+1}^k\right]\left[z_t^y(\eta) + k_t^y(\eta)\right].
\end{aligned}
$$

Second, all products are produced using the same technology and the production functions (23) and (36) are replaced by:

$$
X_{i,t} = \Omega_t H_{i,t}^{\phi} K_{i,t}^{1-\phi}, \qquad Z_t = \Omega_t H_{z,t}^{\phi} K_{z,t}^{1-\phi},
$$

where Ω_t is a time-dependent productivity term that is taken as given by individual firms but depends on the aggregate capital stock according to:

$$
\Omega_t = \Omega K_t^{\phi},
$$

where Ω is a constant. This formulation of Ω_t, first suggested by Romer (1989) and Saint-Paul (1992), constitutes the capital-externality which drives the macroeconomic growth process.

Redoing the derivations we obtain the alternative model which has been summarized in Table 6. Compared to the human-capital based models (including the benchmark model of Table 1), the physical-capital externality model differs in a number of ways. First, because human capital is constant and the real wage rate displays ongoing growth over time, all scaling is done with the aggregate capital stock, i.e. $\pi^m_{1,t}/K_t$ and w_t/K_t appear in various places in Table 6. Second, since the technology is the same in all sectors, the relative price of investment goods and real marginal cost are both equal to unity at all times, i.e. $q_t = mc^x_{1,t} = 1$ for all t. Finally, the aggregate growth rate is now defined in terms of the aggregate capital stock, i.e. $\gamma_{t+1} \equiv (K_{t+1} - K_t)/K_t$ instead of $\gamma_{t+1} \equiv (\bar{h}_{t+1} - \bar{h}_t)/\bar{h}_t$.

We recalibrate the model such that it yields a competitive steady-state growth path that is 'observationally equivalent' to the one obtained for the benchmark model. In particular we ensure that γ^*, r^*, etcetera are the same for both models. Details of this procedure are reported in Section A.5.5 of SM. In summary, the structural parameters are as given in Table 3 with the following exceptions:

$$\beta = 0.7182, \quad \phi_1 = \phi_2 = \psi = 0.75, \quad \Omega_1 = \Omega_2 = \Omega_z = 12.9464, \quad \phi_e = \theta = 0.$$

Features of the steady-state growth path (as well as its dependency on the structural parameters , ε, σ, α, and ϕ) are reported in Table A.8 in SM. As in the previous subsection we focus here on the results for the benchmark parameters as given in Table 3 above. The results for the capital-externality rent-seeking model are reported in column (e) of Table 5.

Again, the first comparison we conduct is between the perfectly competitive equilibrium (column (a)) and the monopoly-cum-rent-seeking equilibrium (column (e)). In the latter case there is a modest amount of (socially wasteful) rent-seeking time but the investment sector is substantially larger than under perfect competition. The higher investment spending results in a significantly higher steady-state growth rate in the rent-seeking equilibrium. The second comparison (between columns (b) and (e)) reveals to what extent the main conclusions for the human and physical capital models are different. Briefly put, the average amount of rent-seeking time differs little between the two cases but there is a significant difference in the growth rates. Other than that columns (b) and (e) yield the same conclusion: growth is higher under the rent-seeking induced monopoly.

5 Conclusions

In their influential studies Kevin Murphy, Andrei Shleifer, and Robert Vishny (1991, 1993) ask themselves the question "Why Is Rent-Seeking So Costly to Growth?" They argue that the resulting misallocation of talent is the 'culprit'. Indeed, in the presence of privately profitable but socially harmful rent-seeking opportunities, the smartest segment of society joins the lobbying

Table 6: Rent-seeking and growth with a physical capital externality)

$$1+\gamma_{t+1} = \frac{1}{1+\beta}\left[\beta\frac{(1-\varepsilon)\pi_{1,t}^m+\lambda^y w_t}{K_t} - \lambda^o\frac{1+\gamma_{t+1}}{1+r_{t+1}}\frac{w_{t+1}}{K_{t+1}}\right] \tag{T6.1}$$

$$\begin{aligned}\frac{\pi_{1,t}^m}{K_t} &= \frac{\Xi}{1+\beta-(1-\varepsilon)\Xi}\left[\lambda^y\frac{w_t}{K_t}+\lambda^o\frac{1+\gamma_{t+1}}{1+r_{t+1}}\frac{w_{t+1}}{K_{t+1}}\right]\\ &\quad+\frac{(1+\beta)\Xi}{1+\beta-(1-\varepsilon)\Xi}\left[\lambda^o\frac{w_t}{K_t}+1+r_t\right]\end{aligned} \tag{T6.2}$$

$$\frac{w_t}{K_t}\bar{e}_t = \varepsilon\frac{\pi_{1,t}^m}{K_t} \tag{T6.3}$$

$$r_{t+1}+\delta \equiv r_{t+1}^k \tag{T6.4}$$

$$\frac{w_t}{K_t} = \phi\Omega\zeta_t^{\phi-1} \tag{T6.5}$$

$$r_t^k = (1-\phi)\Omega\zeta_t^{\phi} \tag{T6.6}$$

$$z_t = \gamma_{t+1}+\delta \tag{T6.7}$$

$$\zeta_t = \lambda^o+\lambda^y-\bar{e}_t \tag{T6.8}$$

$$y_t = px_{1,t}+x_{2,t}+z_t \tag{T6.9}$$

$$\Xi \equiv \frac{\alpha^\sigma p^{1-\sigma}}{\alpha^\sigma p^{1-\sigma}+\sigma(1-\alpha)^\sigma} \tag{T6.10}$$

$$p = \frac{\alpha^\sigma p^{1-\sigma}+\sigma(1-\alpha)^\sigma}{(\sigma-1)\,(1-\alpha)^\sigma} \tag{T6.11}$$

$$\begin{aligned}px_{1,t} &= \frac{\alpha^\sigma p^{1-\sigma}}{\alpha^\sigma p^{1-\sigma}+(1-\alpha)^\sigma}\left[\frac{1}{1+\beta}\left(\frac{(1-\varepsilon)\pi_{1,t}^m+\lambda^y w_t}{K_t}+\lambda^o\frac{1+\gamma_{t+1}}{1+r_{t+1}}\frac{w_{t+1}}{K_{t+1}}\right)\right.\\ &\quad\left.+\lambda^o\frac{w_t}{K_t}+1+r_t\right]\end{aligned} \tag{T6.12}$$

$$x_{1,t} = \Omega\zeta_t^{\phi}u_{1,t} \tag{T6.13}$$

$$x_{2,t} = \Omega\zeta_t^{\phi}u_{2,t} \tag{T6.14}$$

$$z_t = \Omega\zeta_t^{\phi}(1-u_{1,t}-u_{2,t}) \tag{T6.15}$$

Notes The endogenous variables are $\gamma_{t+1} \equiv (K_{t+1}-K_t)/K_t$, $\bar{e}_t$, $\pi_{1,t}^m/K_t$, r_t, r_t^k, w_t/K_t, $x_{1,t} \equiv X_{1,t}/K_t$, $x_{2,t} \equiv X_{2,t}/K_t$, $z_t \equiv Z_t/K_t$, $u_{1,t} \equiv K_{1,t}/K_t$, $u_{2,t} \equiv K_{2,t}/K_t$, ζ_t, Ξ, p, and $y_t \equiv Y_t/K_t$. Note that $H_{i,t}/u_{i,t} = \zeta_t$ for $i \in \{1,2,z\}$.

Table 7: Features of the steady-state growth path (KE case)

	(a)	(b)	(c)	(d)	(e)	(f)
ε		0.0800	0.1600	0.0800	0.0800	0.0800
σ	2.0000	2.0000	2.0000	4.0000	2.0000	2.0000
α	0.5000	0.5000	0.5000	0.5000	0.7000	0.5000
ϕ	0.7500	0.7500	0.7500	0.7500	0.7500	0.6000
y^*	16.6627	19.2956	19.0425	17.7584	25.0668	18.3257
x_1^*	7.3607	2.0232	2.0015	2.6818	3.5961	1.9077
x_2^*	7.3607	11.7918	11.6657	11.6611	8.2706	11.1190
i^*	1.9413	2.6194	2.5447	2.2247	4.0713	2.6010
e^*		0.0255	0.0503	0.0107	0.0806	0.0315
γ^*	1.0976	1.7757	1.7009	1.3810	3.2275	1.7573
$\gamma_a^* \times 100\%$	2.5000	3.4616	3.3674	2.9339	4.9227	3.4386
$\gamma_{ca}^* \times 100\%$	2.5000					2.2658
$(w/K)^*$	8.9265	8.9676	9.0085	8.9435	9.0598	6.8518
$(r^k)^*$	4.1657	4.1086	4.0530	4.1419	3.9845	6.2511
r^*	3.3219	3.2649	3.2092	3.2981	3.1407	5.4074
$r_a^* \times 100\%$	5.0000	4.9535	4.9076	4.9807	4.8502	6.3872
p^*	1.0000	2.4142	2.4142	1.4440	3.5386	2.4142
$(mc^x)^*$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
q^*	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
u_1^*	0.4417	0.1231	0.1235	0.1619	0.2256	0.1221
u_2^*	0.4417	0.7175	0.7196	0.7038	0.5189	0.7115
u_z^*	0.1165	0.1594	0.1570	0.1343	0.2554	0.1664
H^*	1.4000	1.3745	1.3497	1.3893	1.3194	1.3685
H_1^*	0.6184	0.1692	0.1666	0.2249	0.2977	0.1671
H_2^*	0.6184	0.9862	0.9712	0.9779	0.6847	0.9737
H_z^*	0.1631	0.2191	0.2119	0.1866	0.3370	0.2278
$(\pi_1^m/K)^*$	0.0000	2.8612	2.8306	1.1908	9.1289	2.6979

Notes The perfectly competitive steady-state equilibrium (without rent seeking) is reported in column (a). Column (b) reports on the benchmark rent-seeking equilibrium. Columns (c)–(f) report on some alternative rent-seeking equilibria for different values of, respectively, ε, σ, α, and ϕ, contest instead of becoming innovative entrepreneurs pushing out the macroeconomic technology frontier and promoting economic growth.

In this paper we revisit the question posed by these authors using a general equilibrium macroeconomic endogenous growth model with microeconomic foundations. The question we ask ourselves is a slightly different one, namely "Is Rent-Seeking Always Costly to Growth?" Interestingly, the comparison between a perfectly competitive economy and one involving rent-seeking and a monopoly in one sector reveals that the latter economy features a higher growth rate. Our base model thus reverses the conclusion reached by Murphy et al. (1991, 1993). A relatively small amount of time that is 'wastefully' used for rent-seeking activities leads to the establishment of a monopoly which has a large (positive) effect on the macroeconomic growth path. Comparing the monopolized equilibria with and without rent-seeking we find that it is the monopoly itself which accounts for most of the quantitative effects. Hence, the macroeconomic effect of the rent-seeking process itself (lost time) is small. The microeconomic effects of rent-seeking in the form of increased inequality, however, are nontrivial.

We stress that rent-seeking is not always stimulating economic growth. Indeed, the main conclusion to be drawn from an extension to the base model is that the timing of costs (lost time) and benefits (share of profits) over the life-cycle of an individual has a major effect on the sign of the aggregate growth effects of rent-seeking. Indeed, if the costs are incurred early on in life and the benefits are only reaped much later on, then growth may well be hampered by rent-seeking.

Our paper thus shows that there is no unambiguous answer to the question we have posed ourselves in this paper. The link between rent-seeking and economic growth is a very complicated one with many different mechanisms working in opposite directions. On a positive note, there is one rather robust conclusion that we can draw on the basis of our analysis. Rent-seeking opportunities worsen economic inequality among *ex ante* identical individuals.

Declarations

Funding

The authors did not receive support from any organization for the submitted work.

Conflict-of-interest statement

Not applicable.

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