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Ben J. Heijdra, Pim Heijnen

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Rent Seeking, Capital Accumulation, and Macroeconomic Growth

Abstract

We study the effects of time-using rent-seeking activities on the macroeconomic allocation and the economic growth rate. We formulate a highly stylized three-sector general equilibrium model with overlapping generations of individuals. The production side features one sector producing the capital good and two consumption goods sectors. All sectors operate under constant returns to scale technology with human and physical capital as inputs. One of the consumption goods sectors is a monopoly, where a continuum of agents compete for a share of monopoly profits. Agents are heterogeneous in their (intrinsically useless) rent-seeking ability. In the benchmark model each agent decides during youth on how much time to spend on lobbying activities, education, and production work. An intergenerational human capital externality of the 'shoulders of giants' type ensures that the model features endogenous growth. The rewards to rent-seeking accrue during youth and part of the additional income is saved. Interestingly, a move from a perfectly competitive economy to one involving monopolization and rent-seeking increases the steady-state economic growth rate in the benchmark model. We identify three main mechanisms affecting the growth rate under monopoly and rent-seeking, namely (a) the phase of life at which the rent-seeking booty is received (youth or old-age), (b) the kind of inputs used in the rent-seeking competition (raw time or education level), and (c) the type of growth engine (human or physical capital externality). The conclusions for the benchmark model are robust to changes in the mechanisms for (b) and (c) but not for (a). If rent-seeking rewards accrue during old-age then the move from a perfectly competitive economy to one involving monopolization and rent-seeking decreases the steady-state economic growth rate.

JEL-Codes: D720, E240, L120, O410, O430.

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

Ben J. Heijdra
Faculty of Economics and Business
University of Groningen / The Netherlands
b.j.heijdra@rug.nl

Pim Heijnen
Faculty of Economics and Business
University of Groningen / The Netherlands
p.heijnen@rug.nl

*corresponding author

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1 Introduction

> "The term rent seeking is designed to describe behaviour in institutional settings where individual efforts to maximize value generate social waste rather than social surplus."
>
> James M. Buchanan (1980, p. 4)
>
> "...an individual who invests in something that will not actually improve productivity or will actually lower it, but that does raise his income because it gives him some special position or monopoly power, is 'rent seeking'."
>
> Gordon Tullock (1980, p. 17)
>
> "...a considerable part of the energies of business men is devoted to, and a considerable part of their earnings arise out of, activities of this kind. These activities are wasted. They contribute to private, but not to social, net product."
>
> Arthur C. Pigou (1932, p. 201)
>
> "But the cruelest of our revenue laws, I will venture to affirm, are mild and gentle, in comparison to some of those which the clamour of our merchants and manufacturers has extorted from the legislature, for the support of their own absurd and oppressive monopolies. Like the laws of Draco, these laws may be said to be all written in blood."
>
> Adam Smith (1976 [1776], p. 648)

Ever since economics became an academic field of study its practitioners have been aware of a phenomenon that we now often refer to as rent-seeking (or directly-unproductive) activities. Indeed, as the above quote demonstrates the founding father of economics, Adam Smith, complained about the undesirable behaviour of "merchants and manufacturers" that used the political system to create their "oppressive monopolies." In a similar fashion, Arthur Pigou hinted at activities of business men that are privately profitable but socially wasteful.

The modern literature on rent-seeking started in the 1960s and 1970s with influential papers by Tullock (1967) and Krueger (1974). The above quotes from both Buchanan (1980) and Tullock (1980) provide excellent definitions of what we consider to be the essence of rent-seeking activities. Individuals (or groups of people) engage in behaviour which enriches themselves but produces negative welfare effects on society as a whole. Over the last five decades a large literature on rent-seeking has emerged applying the concept to a broad spectrum of economic issues.

The objective of this paper is to contribute to the relatively underdeveloped branch of the literature which focuses on the effects of rent-seeking activities on macroeconomic growth. In a sense, by stressing the dynamic effects of rent-seeking we stay very close to the views of the Classical economists, of which Smith is of course the pre-eminent example. Indeed, as was pointed out by Brooks et al. (1990), "...the old Smithian distinction between productive and unproductive labor has reappeared in a new guise in the literature on rent-seeking." By adopting an explicitly dynamic framework we are able to consider not only the static distortion(s) caused by rent-seeking activities but also to investigate the consequences on macroeconomic growth of these distortions as well as the rewards that accrue over time to successful rent-seekers.

As was hinted at above, the literature on rent-seeking and economic growth is not very extensive. Examples include the papers by Murphy et al. (1991, 1993), Pecorino (1992), Mork (1993), Mauro (1995), Barelli and Pessoa (2012), and Brou and Ruta (2013). By far the most-cited work in this list is that by Murphy et al. (1991, 1993). They formulate a static model in which individuals differ by broadly defined talent (or ability) $\xi \in [1, \xi^{\max}]$ and make a career choice to either become an entrepreneur (and reap the profit from employing workers) or become a worker. In the absence of rent-seeking opportunities, there is a single cut-off ability level, ξ^*, such that all low-ability individuals (with $\xi < \xi^*$) become workers whilst all high-ability individuals ($\xi \geq \xi^*$) become entrepreneurs. They assume that the rate of macroeconomic growth is determined by the ability level of the highest-ability entrepreneur, denoted by ξ^h. In the absence of rent-seeking possibilities, they find that $\xi^h = \xi^{\max}$ so that the common growth rate in the economy is at its maximum feasible level.

Matters are changed dramatically if rent-seeking opportunities are available, and each individual faces a choice between three occupations. Indeed, depending on an individual's ability, he/she can become a worker, an entrepreneur, or a rent-seeker. Although Murphy et al. (1991, 1993) do not provide the full details of the general equilibrium for their model, they assert that it is quite possible under certain conditions for the most able section of the population to become rent-seekers instead of entrepreneurs. As a result, the growth rate of the economy is reduced because the highest-ability entrepreneur is less able than the highest ability individual, i.e. $\xi^h < \xi^{\max}$.

In summary, Murphy et al. (1991, 1993) see the static choice of occupation made by individuals as **the** key mechanism by which rent-seeking affects the macroeconomic growth rate. While we recognize that the occupation (or activity) choice by economic agents can be a relevant factor, we argue that their approach is less than fully convincing for a number of reasons. First, in our view the ability parameter ξ is "overworked" in their model in the sense that it represents no less than four conceptually different characteristics of an individual, namely his/her productivity as a worker, managerial skill as an entrepreneur, rent-seeking aptitude as a rent-seeker, and skill as the innovator for the entire economy. Second, the growth engine (a crucial building block for any theory of economic growth) is a rather ad hoc "black box" addendum translating the characteristic of the most-able entrepreneur into the macroeconomic growth rate. Finally, in their model the occupation choice is a static one, i.e. there are no consumption-saving decisions (all income is directly consumed).

In stark contrast to Murphy et al. (1991, 1993), the modern macroeconomic literature has adopted an explicitly dynamic general equilibrium perspective in order to study the phenomenon of economic growth. The objective of the current paper is therefore to integrate the key insights of Murphy et al. (1991, 1993) into a more conventional macroeconomic framework. In doing so we aim to solve the problematic features of their approach that are mentioned above. First, throughout the paper we adopt a dynamic general equilibrium approach which includes saving decisions. Second, in addition to time units we recognize two accumulable production factors that are standard in growth theory, namely physical capital and human capital. Third, we open the black box of technological progress by introducing a more elaborate growth engine, either via education and human capital accumulation (base model) or via a physical capital externality (model extension).[1] Fourth, just as in their work, we assume that the population consists of heterogeneous individuals. In contrast to their approach, however, we assume that agents differ in their lobbying ability but are equally productive at producing goods. Finally, our dynamic framework allows us to explicitly study the dynamic profiles for the costs and benefits of rent-seeking activities for each individual.

The paper proceeds as follows. In Section 2 we construct a simple dynamic general equilibrium (benchmark) model that we use to study the effects of endogenously determined and time-using rent-seeking activities on the macroeconomic allocation and the economic growth rate. This base model constitutes a highly stylized three-sector general equilibrium model with overlapping generations of individuals who live for two periods, namely "youth" and "old age". The production side features one sector producing the capital good (used for investment purposes) and two consumption goods sectors. All sectors operate under constant returns to scale technologies with human and physical capital as inputs. One of the consumption goods sectors is a monopoly, where a continuum of agents compete for a share of monopoly profits.[2] Agents are heterogeneous in their (intrinsically useless) rent-seeking ability, η. In the benchmark model each agent decides during youth on how much time to spend on lobbying activities, education, and production work. The rewards to rent-seeking accrue during youth and part of the additional income is saved. An intergenerational human capital externality of the 'shoulders of giants' type ensures that the model features endogenous growth.

Since the model is too complex to be solved analytically we adopt a quantitative-numerical approach. We use a two-step procedure to parameterize the model. In the first step we parameterize the steady-state model with perfect competition in all sectors (a special case). This allows us to determine plausible values for all structural coefficients, except the ones relating to the lobbying process (since rent-seeking opportunities are not present the competitive case). In the second step we postulate the three structural parameters relating to rent-seeking in the general model with one monopolized consumption good sector.

We finish our discussion in Section 2 by studying some key features of the model in the absence of rent-seeking. First, we compute and compare the steady-state equilibria under universal competition and under monopoly. Interestingly, the macroeconomic growth rate is highest in the monopoly model. The monopoly creates not only a distortion (since price exceeds marginal cost in one sector) but it also gives rise to a strong increase in aggregate saving thus causing higher growth.

[1] In this paper we abstract from R&D. Hence, two out of the three major macro growth engines are considered in this paper.

[2] Rent-seeking can take many different forms. In this and our companion paper (Heijdra and Heijnen, 2023) we choose to stay as close as possible to the original formulation of Tullock (1967) and many subsequent contributions.

Second, we compute and characterize transitional dynamics from a competitive steady-state to a monopolized economy. Since there are two slow-moving stocks in the benchmark model (viz. physical and human capital), the transition in scaled output, the capital intensities, and factor prices is rather slow. In contrast, there is very little transitional dynamics in the rate of economic growth.

In Section 3 we study the full model including endogenous rent-seeking. Interestingly, a move from a perfectly competitive economy to one involving monopolization and rent-seeking *increases* the steady-state economic growth rate in the benchmark model thus reversing the conclusion reached by Murphy et al. (1991). 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.[3] 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 in the form of increased inequality, however, are nontrivial as we show in the remainder of Section 3 and more extensively in our companion paper (Heijdra and Heijnen, 2023).

The findings of Section 3 prompt us to conjecture that there are three main mechanisms affecting the growth rate under monopoly and rent-seeking, namely (a) the stage of the rent-seeker's life cycle at which the rent-seeking booty is received (youth or old-age), (b) the kind of inputs used in the rent-seeking competition (raw time or education level), and (c) the type of growth engine that is postulated (human capital or physical capital externality).

In Section 4 we discuss three extensions to the basic model, each one zooming in on one particular key mechanism of the basic model. In the first extension, in Section 4.1, we continue to assume that rent-seeking takes place during youth but that the rewards are reaped in old-age. In this scenario rent-seeking activities during youth become an alternative form of intertemporal investment during youth (like educational activities). Because rewards are received during old-age the incentives to save are reduced. Interestingly, learning time, total rent-seeking time, and the macroeconomic growth rate are lower than in the base case. We thus reach the same conclusion as Murphy et al. (1991, 1993) though for an entirely different (life-cycle based) reason. The main insight is that the timing of costs and benefits of rent-seeking to an invidiausl has a major effect on the conclusions regarding aggregate growth effects of rent-seeking.

In the second model extension, in Section 4.2, we assume that the rent-seeking function depends on the education-weighted amount of time each individual spends on rent-seeking. Whereas the individual education decision is independent of η in the base case, with this alternative rent-seeking function there is a clear incentive to 'over-educate' oneself in order to get ahead in the rent-seeking contest.[4] At the macroeconomic level we find that while total

[3]Note that we implicitly assume that the rent-seeking activities result in a monopoly in sector 1 via some unspecified mechanism.

[4]During youth, all individuals are equally good students and have the same skills in production work, i.e. η is an intrinsically indicator for lobbying skills. In the base model this implies that learning time and real wage income are the same for all η. In contrast, with rent-seeking opportunities the education choice, $l(\eta)$, is increasing

rent-seeking time is hardly affected, the total amount of time spent on education is increased dramatically. The stronger incentive to accumulate human capital thus boosts the macroeconomic growth rate compared to the base scenario.

Finally, in the third model extension, in Section 4.3, we abstract from educational activities and human capital accumulation and assume that a physical capital externality forms the engine of endogenous growth. In the absence of human capital accumulation, the only way in which the young can save is by accumulating physical units of capital goods. We find that rent-seeking increases the incentives to accumulate physical capital and boosts the macroeconomic growth rate.

In Section 5 we conclude. 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 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 acculmulation 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, $x_{i,t}^{y}(\eta)$ (for $i=1,2$), buys units of the existing capital good from the old, $k_t^y(\eta)$, or a newly produced investment good, $z_t^y(\eta)$, 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 $x_{i,t}^{o}(\eta)$, 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:

$$\Lambda_t^y(\eta) \equiv \ln c_t^y(\eta) + \beta \ln c_{t+1}^o(\eta), \tag{1}$$

in η, as is future real wage income.

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

$$c_t^y(\eta) \equiv \left[\alpha x_{1,t}^y(\eta)^{1-1/\sigma} + (1-\alpha) x_{2,t}^y(\eta)^{1-1/\sigma}\right]^{1/(1-1/\sigma)}, \tag{2}$$

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

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

$$P_{1,t} x_{1,t}^y(\eta) + P_{2,t} x_{2,t}^y(\eta) + Q_t \left[z_t^y(\eta) + k_t^y(\eta)\right] = I_t^y(\eta), \tag{4}$$

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

$$I_t^y(\eta) \equiv W_t h_t^y(\eta) \left[1 - e_t(\eta) - l_t(\eta)\right] + s_t(\eta) \Pi_{1,t}^m. \tag{5}$$

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 $h_t^y(\eta)$ is the agent's human capital level at birth (see below). Furthermore, $s_t(\eta)$ denotes the share of sector-1 monopoly profits, $\Pi_{1,t}^m$, 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:

$$h_{t+1}^o(\eta) = h_t^y(\eta) \left[1 + \phi_e \frac{l_t(\eta)^{1-\theta}}{1-\theta}\right], \tag{6}$$

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:

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

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:

$$P_{1,t+1} x_{1,t+1}^o(\eta) + P_{2,t+1} x_{2,t+1}^o(\eta) = I_{t+1}^o(\eta), \tag{8}$$

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

$$I_{t+1}^o(\eta) \equiv \lambda W_{t+1} h_{t+1}^o(\eta) + \left[(1-\delta) Q_{t+1} + R_{t+1}^k\right] \left[z_t^y(\eta) + k_t^y(\eta)\right], \tag{9}$$

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 $z_t^y(\eta) + k_t^y(\eta)$ 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). 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:

$$P_{V,t}c^y_t(\eta) + \frac{P_{V,t+1}c^o_{t+1}(\eta)}{1+R^n_{t+1}} = HW^y_t(\eta), \tag{11}$$

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

$$HW^y_t(\eta) \equiv s_t(\eta)\Pi^m_{1,t} + W_t\bar{h}_t\left[1 - e_t(\eta) - l_t(\eta)\right] + \frac{\lambda W_{t+1}\bar{h}_t}{1+R^n_{t+1}}\left[1 + \phi_e\frac{l_t(\eta)^{1-\theta}}{1-\theta}\right]. \tag{12}$$

The young agent of type η chooses $c^y_t(\eta)$, $c^o_{t+1}(\eta)$, $l_t(\eta)$, 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^n_{t+1}, and nominal sector-1 profit $\Pi^m_{1,t}$. We find:

$$P_{V,t}c^y_t(\eta) = \frac{1}{1+\beta}HW^y_t(\eta), \tag{13}$$

$$\frac{P_{V,t+1}c^o_{t+1}(\eta)}{1+R^n_{t+1}} = \frac{\beta}{1+\beta}HW^y_t(\eta), \tag{14}$$

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

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

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^n_{t+1}. 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:

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

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:

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

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, $P_{1,t}^m$:

$$p_t \equiv \frac{P_{1,t}^m}{P_{2,t}} = \mu_t^m MC^x(w_t, r_t^k), \tag{31}$$

where μ_t^m is the gross markup:

$$\mu_t^m \equiv \frac{\varepsilon_{d,t}^m}{\varepsilon_{d,t}^m - 1} > 1. \tag{32}$$

But, since real marginal cost equals unity, $MC^x(w_t, r_t^k) = 1$, we find from (31) that $p_t = \mu_t^m = \frac{\varepsilon_{d,t}^m}{\varepsilon_{d,t}^m - 1}$. By using this result in equation (30) we obtain an implicit function relating $\varepsilon_{d,t}^m$ 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. $\varepsilon_{d,t}^m = \varepsilon_d^m$, $\mu_t^m = \mu^m$, and $p_t = p^*$.

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

$$\Pi_{1,t}^m = \Xi \left[\frac{HW_t^y}{1+\beta} + I_t^o\right], \tag{33}$$

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 $0 < \Xi < 1$.[5] 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_t^y appearing on the right-hand side of (33) contains $\Pi_{1,t}^m$ as one of its arguments. Hence, by combining (22) and (33) we can find the following expression for profits:

$$\Pi_{1,t}^m = \frac{\Xi}{1+\beta-(1-\varepsilon)\Xi} \Bigg[W_t \bar{h}_t [1-l_t] + \frac{\lambda W_{t+1}}{1+R_{t+1}^n} \bar{h}_t \left(1 + \phi_e \frac{l_t^{1-\theta}}{1-\theta}\right) + (1+\beta)\left[\lambda W_t \bar{h}_t + \left[(1-\delta) Q_t + R_t^k\right] K_t\right] \Bigg]. \tag{35}$$

We summarize the main findings in Useful Result 1.

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

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,* $MC^x(w_t, r_t^k) = 1$*; (b) the relative monopoly price,* p_t*, is time-invariant, i.e.* $p_t = p^*$ *for all* t*, where* p^* *is the solution to:*

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

(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:

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

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

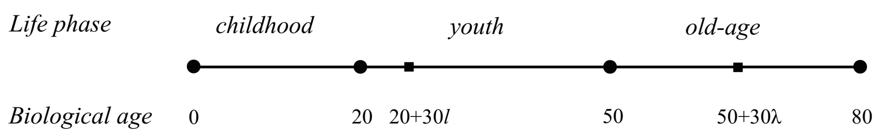
$$Y_t = pX_{1,t} + X_{2,t} + q_t Z_t. \tag{47}$$

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

Figure 1: The individual life cycle



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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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, $x_{i,t} \equiv X_{i,t}/H_t$, $z_t \equiv Z_t/H_t$, $u_{i,t} \equiv H_{i,t}/H_t$, $u_{z,t} \equiv H_{z,t}/H_t$, $\kappa_t \equiv K_t/H_t$, $\kappa_{i,t} \equiv K_{i,t}/H_{i,t}$, $\kappa_{z,t} \equiv K_{z,t}/H_{z,t}$, Ξ, p, and $y_t \equiv Y_t/H_t$. Of these, 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^*.

intensity ($y^* = 1.00$), the relative price of investment goods ($q^* = 1$), the output share of investment ($z^*/y^* = 0.1165$),[6] 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 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

[6] 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 $\phi = 0.75$.

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. $(\pi_{1,t}^m/\bar{h}_t)^* = 0.2527 > 0$. 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

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, $\psi = \phi = 0.8000$.

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, $x_2^* + q^* z^*$.

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, $\pi_{1,t}^m/\bar{h}_t$, 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).

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

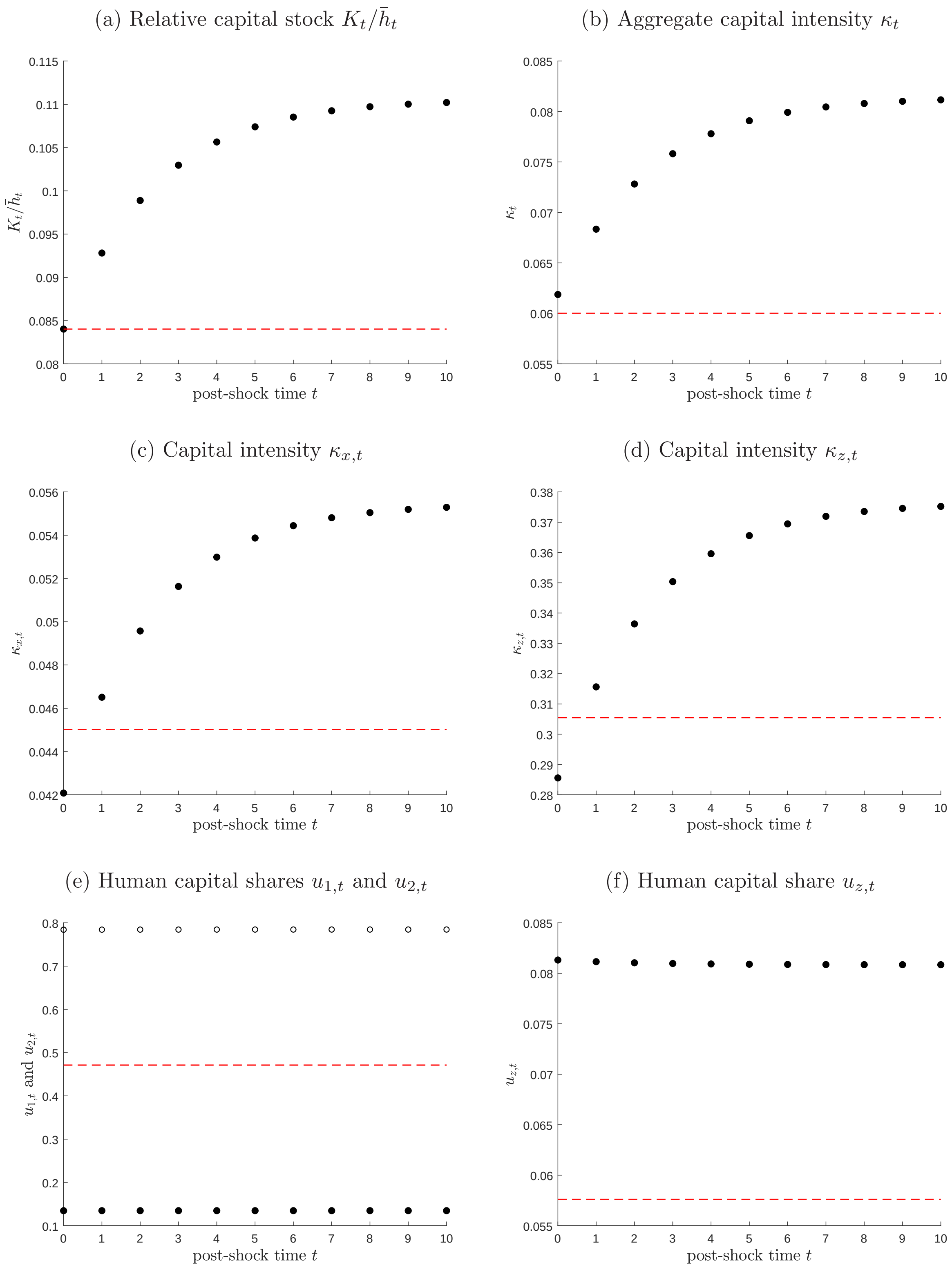
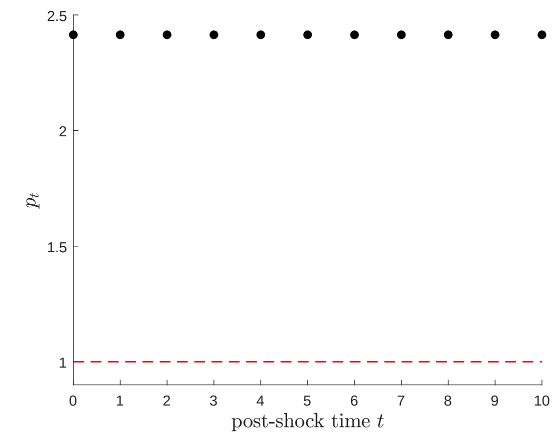
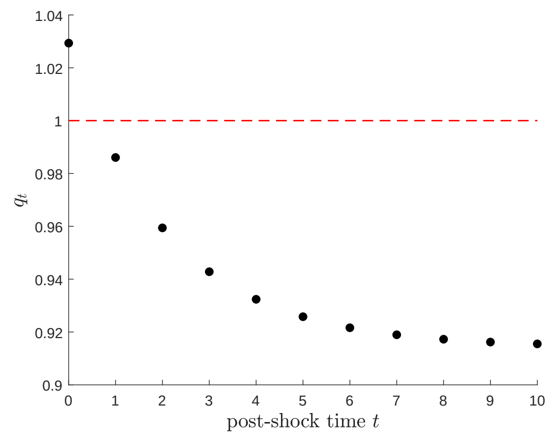


Figure 2, continued

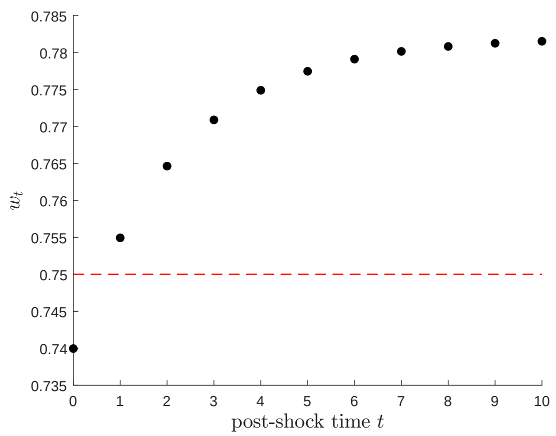
(g) Relative price p_t



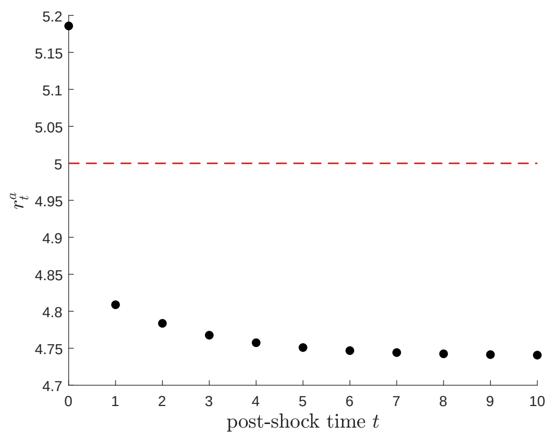
(h) Relative price q_t



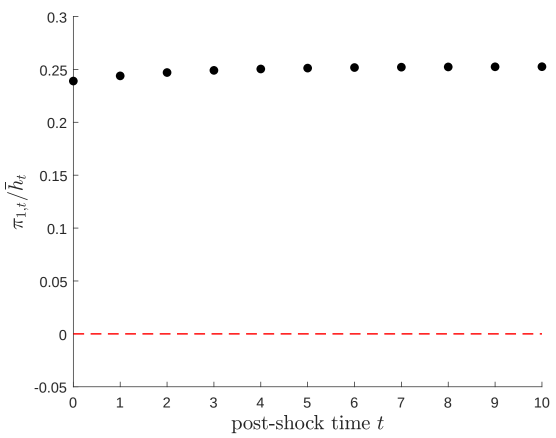
(i) Wage rate w_t



(j) Interest rate (annual) r_t



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



(l) Growth rate (annual) γ_{t+1}^a

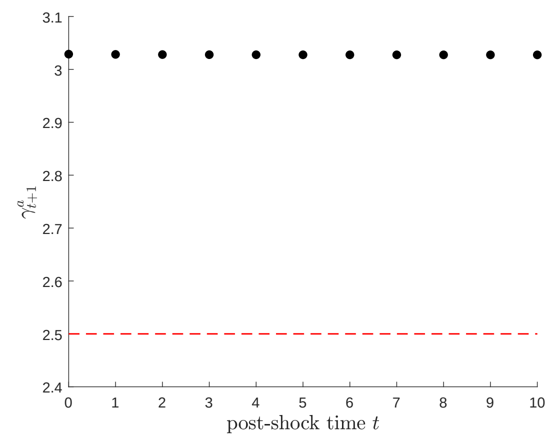
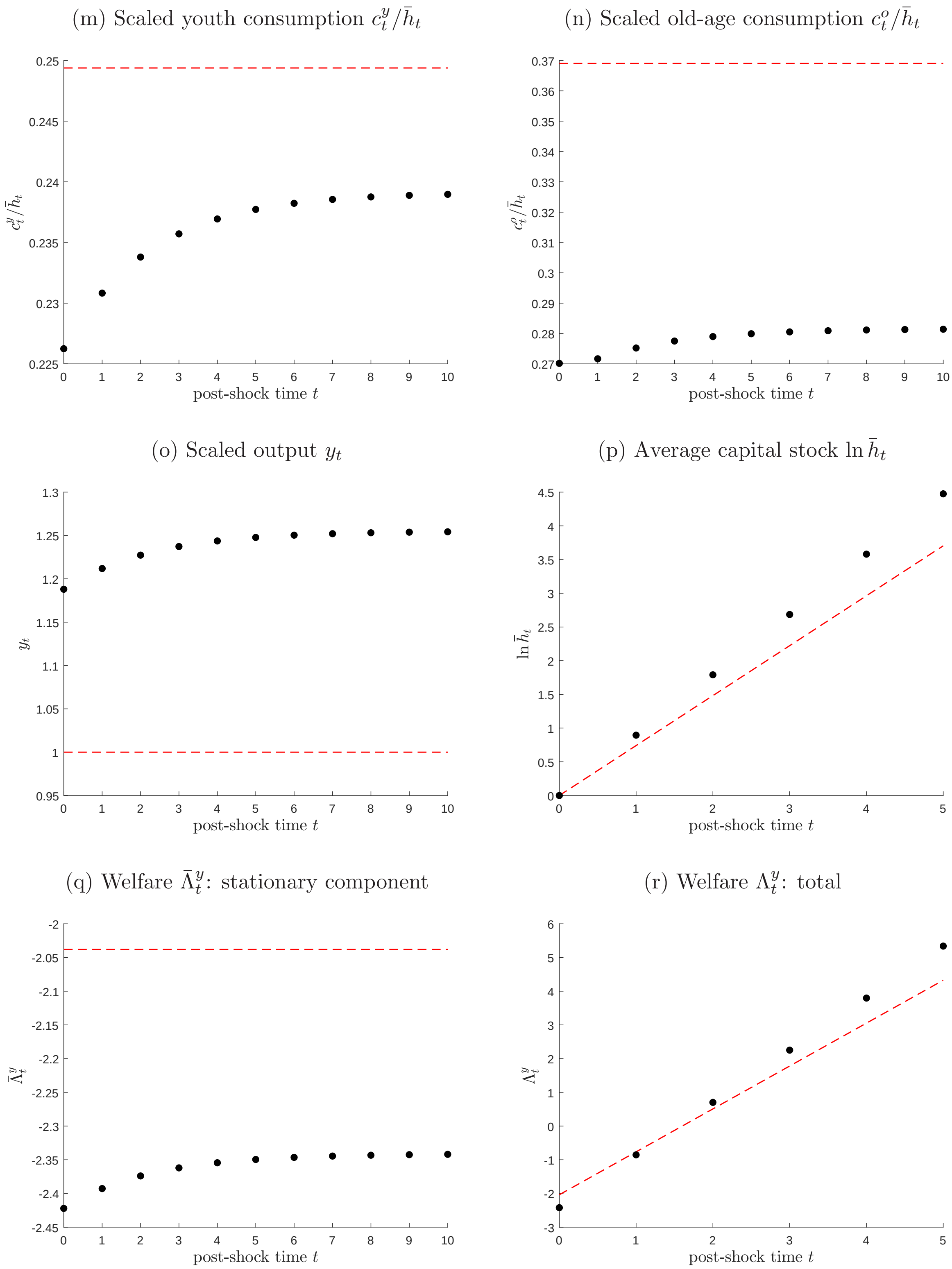


Figure 2, continued



(m) Scaled youth consumption $c^y_t/\bar{h}_t$

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

(o) Scaled output y_t

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

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

(r) Welfare Λ^y_t: total

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 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:

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

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 $\eta_H = 2$.[7] 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

[7]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

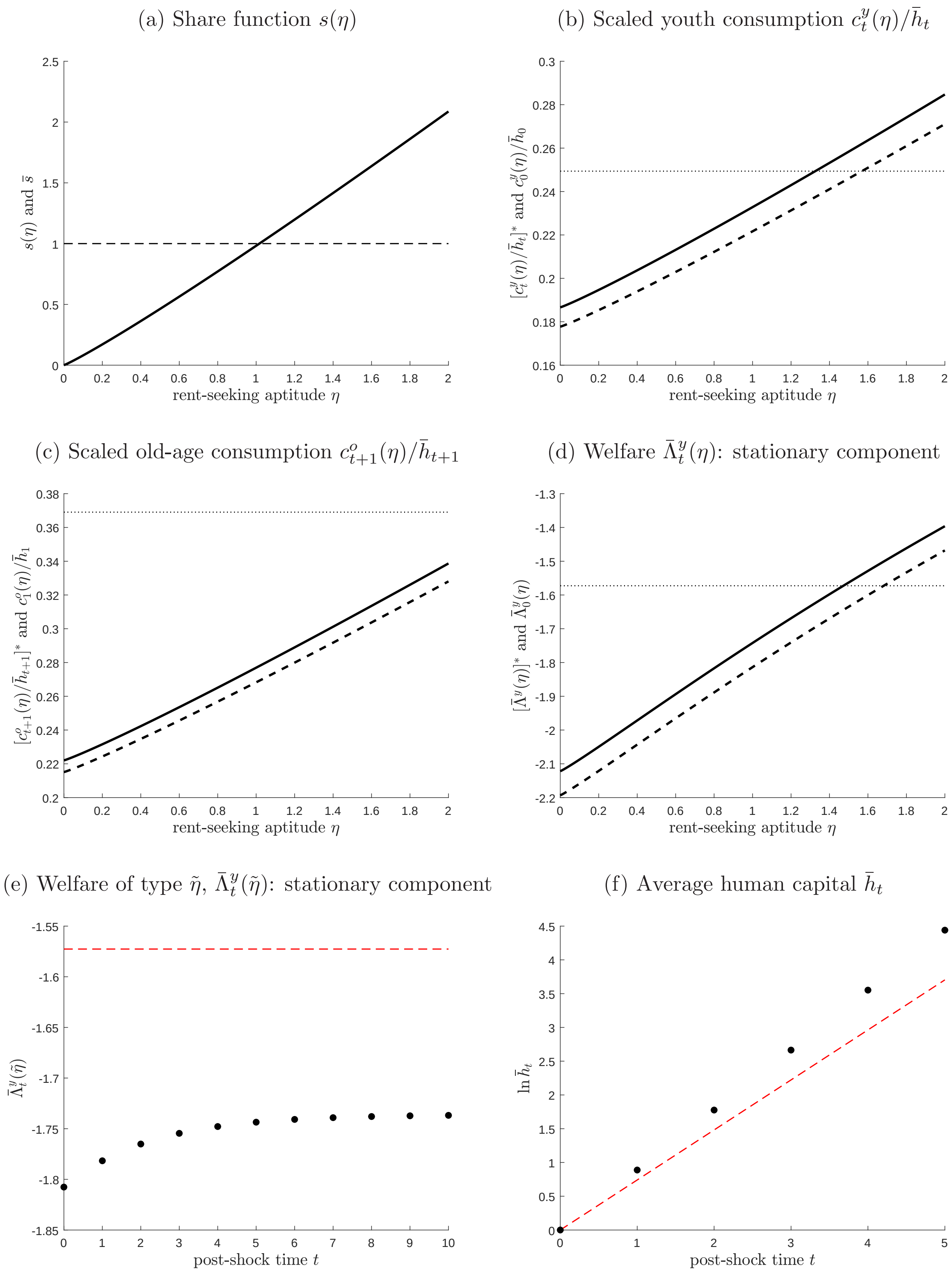
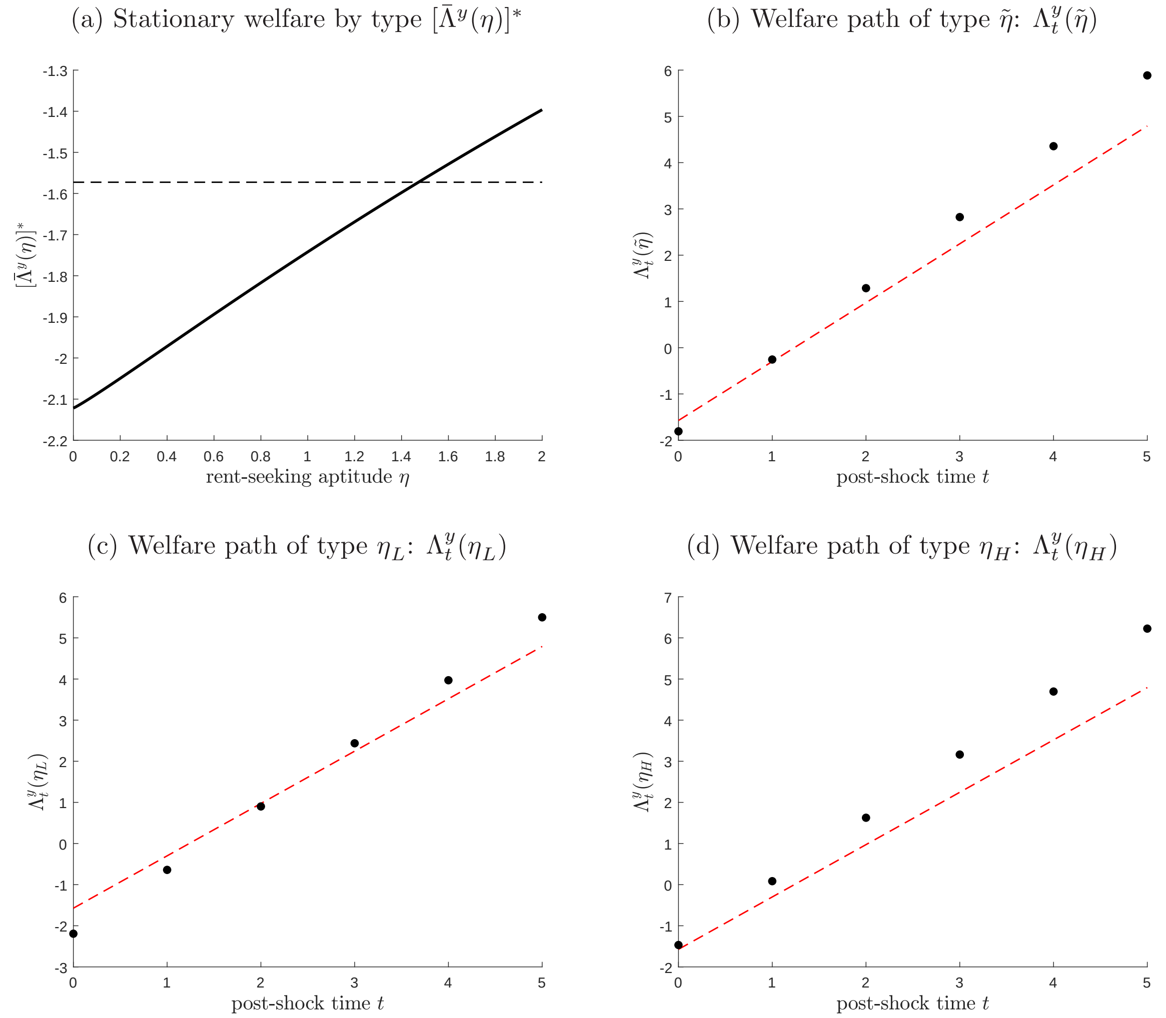


Figure 4: Welfare distribution in the rent-seeking equilibrium



(b) and planned old-age consumption, $[c^o_{t+1}(\eta)/\bar{h}_{t+1}]^*$, 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 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(f), 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 $\bar{\Lambda}^y_t(\tilde{\eta})$ 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 $\bar{\Lambda}^y_0(\eta)$ is all that matters as the initial average human capital stock is predetermined. In contrast, for future steady-state generations $\bar{\Lambda}^y_t(\eta)$ 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 $\Lambda^y_t(\tilde{\eta})$, 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.[8]

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.*

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

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^*, 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 $0 < l^* < 1$.[9] 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

[9] Note that:

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

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 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

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^*.

changed:

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

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

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

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

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:

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

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:

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

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:

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

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 educational-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 competive 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:

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

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. $\pi_{1,t}^m/K_t$ 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. $q_t = mc_{1,t}^x = 1$ 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Notes The endogenous variables are $\gamma_{t+1} \equiv (K_{t+1}-K_t)/K_t$, $\bar{e}_t$, $\pi^m_{1,t}/K_t$, r_t, r^k_t, 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 $i \in \{1,2,z\}$.

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 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.

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