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DYNAMIC COALITIONS, GROWTH, AND THE FIRM*

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Abstract

The implications of a dynamic coalition production technology are explored. With this technology, coalitions produce the current period consumption good as well as coalition-specific capital which is embodied in young coalition members. The equilibrium allocation is efficient and displays constant growth rates, even though exogenous technological change is not a feature of the environment. Unlike the neoclassical growth model, policies which influence agents' investment-consumption decisions affect not only the level of output, but also its constant growth rate. In addition to these growth entailments, the theory has equally important industrial organization implications. Specifically, in equilibrium there is no tendency for coalition (firm) size to regress to the mean or for the distribution of coalition sizes to become more disparate.

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In this study, we explore the implications of a dynamic coalition production technology in an equilibrium environment. There are three major implications. One is that, even without exogenous technological change, with this technology there can be sustained growth in an economy's per capita output. Economies that are identical except for their initial capital endowments grow at the same constant percentage rate; output in such economies does not tend to converge to the same level or to diverge. Another implication is that, while firm size is variable, it does not tend to regress to the mean size nor does the size distribution of firms tend to become more disparate over time. A final implication is that, in this environment, unlike in the neoclassical growth model, a policy which distorts investment-consumption decisions can affect an economy's equilibrium growth rate, not just its level of output.

Few models have been able to simultaneously account for both growth and firm size observations without resorting to exogenous technological change. Very briefly, the problem has been that to have sustained growth in per capita output, there cannot be diminishing returns to capital. But if returns to capital are not diminishing and labor is a joint input, then for any reasonable production function there are increasing returns to scale. And increasing returns are inconsistent with the existence of a competitive equilibrium.

In the environment we consider, there are no diminishing returns to investment, due to a key assumption: workers' productivities depend not only on their own human capital, but also on that of their co-workers. At any point in time, though, the rate of transformation in producing this capital and output for current consumption is nonlinear. In particular, Lucas-type adjustment costs (Lucas 1967) constrain the rate of investment. As a result, percentage growth rates rather than firm sizes are determined in equilibrium. (If this point is not clear now, it should become clear as we go through the formal analysis.)[1/]

Our environment is in most ways quite standard and simple: agents are identically endowed, live two periods, and have identical utility functions, defined on consumption today and tomorrow. The environment is nonstandard, however, in at least one important way: a firm is not defined by the technology to which it has access. Rather, our firms are coalitions of agents, and, as in Lucas 1978, all have access to the same blueprint technology. In Lucas 1978, agents are endowed with different managerial capabilities, and the distribution of these capabilities determines the size distribution of firms. Our agents, in contrast, are identically endowed but may choose to accumulate human capital in differing amounts. Thus, coalitions may differ too, depending on the human capital decisions of their members.[2/]

Another way our environment differs from most others is in the production technology. Here each coalition's output capability is determined by its capital and by the universally available production technology. Coalition capital is, by assumption, human capital and is partly organization-specific. But it is not just "firm-specific human capital" as others have used that term.

Let us be more precise. Recall that each agent lives two periods. Coalition capital is knowledge or expertise, and when created (in its first period), it is embodied in young, inexperienced coalition members. Next period they will become old, experienced members, and the coalition's production capabilities will be expanded commensurately. Moreover, the coalition's production capability is assumed to depend not only on the expertise of each individual member. It also depends on each member's knowledge of the expertise of other coalition members, and this can only be obtained by members working together when young. In other words, coalition capital is specific not to an organization but rather to a particular group of individuals that have worked and been trained together. A parametric example is included in the next section to elucidate this feature of the model.[3/]

The production technology formally specified in the next section attempts to roughly represent these sorts of interagent and intertemporal production relationships. Admittedly, the economy is highly stylized. It deals with a representative coalition (in all respects except size), there is neither the birth nor the death of coalitions, and there is no specialization of productive activity. Consequently, this study is best viewed as opening a line of inquiry that might prove useful in addressing some unresolved issues in development, industrial organization, and their intersection. We are optimistic, however, that the basic environment can be modified so that equilibrium is characterized by entry and exit of coalitions and specialization in production while still producing the key observations.

The study has three main parts. First we specify the environment. Then we define a constant growth equilibrium and present an existence and uniqueness proof. And finally we (briefly) investigate the effect of a tax policy on the steady-state growth rate. At the end we summarize the analysis and suggest some ways it might be profitably extended.

The Economy

Initially, there is some given number of old agents. Each period, that number of young agents are born, and they live for two periods. Thus, at all points in time there are equal numbers of young and old. Those born in period t for $t = 1, 2, \ldots$ have a utility function $u: R_+ \times R_+ \to R_+$:

$$u(y_t, z_{t+1}) = \ln y_t + \beta \ln z_{t+1}$$

where y_t is consumption when young, z_{t+1} is consumption when old, and β is a parameter, $0 < \beta < 1$. The utility function of an initial old agent is simply $\ln z_0$.

Coalition Technology for Producing an Intermediate Good

We consider first how old coalition members interact to produce services, which will be inputs for the production of the consumption good and new coalition capital. Our key result will be that a coalition can be indexed by the number M of experienced workers (or more precisely, the measure of experienced workers) and by the expertise of each of its members k, with the coalition's output of productive services being Mk. There will be costs to splitting coalitions and no gains from mergers. [Readers not familiar with measure theory, which is used in this subsection only, may want to skip to the subsection on joint production of the consumption good and coalition capital.]

The primitive in the analysis is a coalition, which is a set of experienced, or old, workers. Each member of a coalition is indexed by a, the member's own expertise, and by k, the accessible expertise of other coalition members. In order to exploit the expertise of others, old agents must know about it, and by assumption this can only be true if agents worked together when young.

More precisely, a coalition is a measure on the Borel sigma algebra of R^2_+. Let Ω be the set of finite countably additive set functions defined on this sigma algebra. For set A belonging to this sigma algebra and $\omega \in \Omega$, $\omega(A)$ is the measure (number) of coalition numbers with $(a,k) \in A$.

If two coalitions $\omega_1, \omega_2 \in \Omega$ merge to form a new coalition ω, then for all Borel sets A

$$\omega(A) = \omega_1(A) + \omega_2(A).$$

If a coalition of size M splits into coalitions ω_1 and ω_2 of size M_1 and M_2, respectively, then

$$\omega_i(\{x \leq a, y \leq k\}) = (M_i/M)\ \omega\big(\{x \leq a, y \leq (M/M_i)k\}\big)$$

for all $(a,k) \in R^2_+$. Measure ω_i is well defined because its value for this subcollection of sets uniquely determines its value for all sets in the Borel sigma algebra.

The motivation for the merging assumption is perhaps obvious; the assumption implies that the joining of two coalitions affects no member's own expertise or the expertise to which members have access. The motivation for the splitting assumption is less obvious. This assumption implies that if some percentage of a coalition is split off, then the own expertise of the coalition members who remain is unchanged, but their access to the expertise of others is reduced by that same percentage. Together, these two assumptions imply that there are no gains from merging coalitions, but if a coalition is split, there are costs: the total output of the two resulting coalitions is strictly less than the output of the original coalition. Thus, in this economy coalitions will not split in an equilibrium.

We assume that if all coalition members work together when young, each has accessible capital equal to the average expertise of the other members. We also assume that there is a coalition production function $\Phi: \Omega \to R_+$ that has this representation:

$$\Phi(\omega) = \int \phi(a,k)\, d\omega$$

where $\phi: R_+^2 \to R_+$ is strictly increasing, continuous, concave, and homogeneous of degree one. Further, ϕ is strictly concave in a. The value of the function Φ is the output of productive services of the coalition. Thus we are assuming that the coalition's output of productive services is the sum of the outputs of its members. Note that, unlike the neoclassical production function, this technology does not have decreasing returns to coalition capital. Proportional increases in everyone's a and k increase the output of productive services by the same factor. This technology does, however, have diminishing returns with respect to own expertise a. The output of productive services is normalized so that

$$\phi(k,k) = k, \text{ for all } k \in R_+.$$

☐ An Example: The Old's Choice Problem in Producing the Intermediate Good

To clarify the motivation for the assumed intermediate input production technology, we offer an example of how time can be allocated between two types of productive activity. Here we assume that old coalition members were together when young, so their accessible expertise of others is just the average expertise of the coalition.

A given old worker's contribution to the output of productive services is a function of that worker's own expertise services and accessed expertise services of other old agents. Old agents must decide how to allocate their time. We assume own expertise services are $(1-\tau)a$, where $(1-\tau)$ is the fraction of an agent's time allocated to using the agent's own expertise. Accessed expertise services of other agents are τk, where τ is the fraction of an agent's time allocated to interacting with others. An old agent's total output of productive services thus depends on the values a and k, which are determined by past decisions, and on the agent's current choice of τ. For this example, we assume individual output of productive services takes the functional form

(1) $$B(1-\tau)a^{\psi}(k\tau)^{(1-\psi)}, \text{ for } 0 < \psi < 1 \text{ and } B > 0$$

where ψ and B are parameters. The optimizing τ, which depends on neither k nor a, is

(2) $$\tau = (1-\psi)/(2-\psi).$$

Substituting (2) into (1) yields

$$BAa^{\psi}k^{(1-\psi)}, \text{ where } A = (1-\psi)^{(1-\psi)}(2-\psi)^{(\psi-2)}.$$

Without loss of generality, the units in which old agents' expertise k is measured are selected so that BA = 1 and

(3) $$\phi(a,k) = a^{\psi}k^{(1-\psi)}$$

is the output of productive services of an old worker with expertise a, who is a member of a coalition with old members who have accessible expertise k and who has chosen the optimal value of τ satisfying (2).

☐ Completing Specification of Intermediate Good Technology

To continue the specification of the technology, we assume that all agents who work together when young receive the same a and the same k and that units are selected so that a = k.

Again, since splitting coalitions is costly, splits do not occur in equilibrium. Consequently, the only relevant coalitions are those in which all members have the same own and accessible expertise, and own and accessible expertises are equal. Thus, coalitions place their entire mass M on some point set $\{(k,k)\}$, where the expertise of members $k \in R_+$ indexes the set. For these measures,

$$\Phi(\omega) = Mk. \tag{4}$$

Hereafter, we restrict attention to such measures and index a coalition with k and M rather than ω. This k is the value of both the M coalition members' own expertise and their accessible expertise.

Coalition Technology for Jointly Producing the Consumption Good and Coalition Capital

There is a constant returns to scale coalition production technology that produces a composite consumption good C and tomorrow's coalitions expertise Nk', which is embodied in today's young coalition members. The inputs are the productive services of the old Mk and the productive services of the young Nk. The average expertise of the experienced members enhances the productivity of both the young and the old members. The constraint defining the technology is

$$C \leq (Mk)^{1-\alpha}(Nk)^{\alpha} - Mk\, h[(Nk')/(Mk)] \tag{5}$$

where $0 < \alpha \leq 1/2$ and h is convex. Function h is strictly increasing, positive, and a continuously differentiable mapping. With N, M, and k fixed, investment in coalition capital k' is increasingly costly in terms of foregone current consumption C. Thus, this technology has the adjustment cost property, which constrains growth rates. The technology does not have diminishing returns to the accumulation of coalition capital. With N and M fixed, the set of feasible (C,k') pairs varies in direct proportion to k; that is, there are constant returns with respect to (C,k',k) if N and M are fixed.

The coalition's total output of the consumption good constrains the sum of current consumption of its young members yN and current consumption of its old members zM:

(6) $$yN + zM \leq C$$

where y and z are per capita consumption of young and old, respectively. Combining (5) and (6) and dividing by M yields the constraint

$$ny + z \leq kn^{\alpha} - k\, h(nk'/k)$$

where $n = N/M$ is the number of young in the coalition per old.

With the assumption that all coalitions start with the same initial k, we can deal with a representative coalition. This, however, does not require that all coalitions be the same size in terms of number of members. In addition, we make the following assumption.

Assumption. The function h, besides being increasing and convex, satisfies

$$h(0) = h'(0) = 0$$

and

$$h'(\delta) = \infty, \text{ where } \delta > 1.$$

[This implies

$$h\colon [0,\delta) \to R_{+}.]$$

That $h'(0) = 0$ implies that the cost of the first unit of k' is zero, so in equilibrium k' will be positive. That $h'(\delta) = \infty$ means the economy cannot grow at a rate faster than $\delta - 1$.

Constant Growth Equilibrium

In this section, first we conjecture that there exists a constant growth equilibrium which exhibits certain properties. Then we prove that conjecture. The derivation of equilibrium is essentially recursive, which, as will be shown, guarantees that the equilibrium is unique within its class.

The existence proof has three steps. The first is to find the sequence-of-markets equilibrium for an economy (unlike ours) in which capital is not embodied in coalitions and thus is tradable. In all other ways, this economy is identical to ours. The second step is to show that the amount of capital traded in equilibrium is zero. Consequently, this equilibrium allocation is also the equilibrium allocation for our economy. In the third step, the proof is completed by demonstrating that coalitions cannot design Pareto improving redistribution schemes between their current and future members.

We seek a constant growth equilibrium. In this context, constant growth means that the capital stock, the consumptions of young and old, and the real wage w_t all grow at a common (gross) rate x, while the price of new capital relative to current consumption, q, is constant. This is a growth economy without exogenous technological change. Unlike the neoclassical (balanced) growth model's steady-state growth path, which is independent of initial capital, our steady-state growth path is proportional to k_0. Summarizing the desired properties of constant growth:

(7) $$w_t = wk_0x^t$$

(8) $$y_t = yk_0x^t$$

(9) $$k_t = k_0x^t$$

(10) $$z_t = zk_0x^t$$

(11) $$q_t = q$$

where w, y, and z are--like x and q--parameters to be determined.

The Old's Choice Problem

All old agents are members of coalitions. They hire young agents at the real wage w and use their labor services to produce both capital K, which is sold at price q, and the consumption good, which has a price of 1. (The consumption good is the numeraire.) For convenience, we define K as the coalition's total output of capital, now assumed to be tradable, so that $K_t \equiv n_tk_{t+1}$. Defining π as profits per coalition member, we can write the old's maximization problem as

$$(12) \qquad \pi(k_t, w_t, q_t) = \max_{n_t, K_t \geq 0} \{k_t n_t^\alpha - w_t n_t + q_t K_t - k_t h(K_t/k_t)\}.$$

This implies that

$$\pi(k_t, w_t, q_t) = k_t \pi_1(w_t/k_t) + k_t \pi_2(q_t)$$

where

$$\pi_1(w_t/k_t) = \max_{n_t \geq 0} \{n_t^\alpha - (n_t w_t/k_t)\}$$

$$= [\alpha^{[\alpha/(1-\alpha)]} - \alpha^{[1/(1-\alpha)]}](w_t/k_t)^{[\alpha/(\alpha-1)]}$$

$$\equiv c_1(w_t/k_t)^{[\alpha/(\alpha-1)]}$$

and

$$\pi_2(q_t) = \max_{K_t/k_t \geq 0} \{q_t(K_t/k_t) - h(K_t/k_t)\}.$$

Solving the first-order condition $q_t = h'(K_t/k_t)$ for K_t yields

$$K_t = k_t s(q_t)$$

where $s(0) = 0$, $s(\infty) = \delta$, and the function s is both increasing and continuous. For constant growth,

$$(13) \qquad x = K_t/k_t = s(q).$$

The demand for young workers is determined by the first-order condition

$$\alpha n_t^{(\alpha-1)} = w_t/k_t.$$

Along a constant growth path $w_t/k_t = w$. Further, young labor is supplied inelastically in the quantity one per old person. Therefore,

(14) $$w = \alpha$$

along a constant growth path.

The Young's Choice Problem

Using (12), we can write the young's choice problem as

$$\max_{y_t, k_{t+1} \geq 0} \{\ln y_t + \beta \ln [k_{t+1}\pi_1(w_{t+1}/k_{t+1}) + k_{t+1}\pi_2(q_{t+1})]\}$$

subject to the budget contraint

$$y_t + q_t k_{t+1} \leq w_t.$$

From (7) and (11), we know that along a constant growth path $w_t = wk_0x^t$ and $q_t = q$. Letting $a = y_t/k_0x^t$ and $b = k_{t+1}/k_0x^t$, we can rewrite the young's maximization problem, again using (12), as

(15) $$\max_{a,b \geq 0} \{\ln a + \beta \ln b + \beta \ln [c_1(wx/b)^{[\alpha/(\alpha-1)]} + \pi_2(q)]\}$$

$$\text{subject to } a + qb \leq w$$

(save for an additive constant in the objective function).

The objective function is strictly concave in a and b since $0 < \alpha \leq 1/2$. The demand for b is a decreasing continuous function of q:

(16) $$k_{t+1}/k_t = b = d(q;x,w).$$

From the budget constraint (holding with equality) and the definition of a,

$$(17) \qquad y_t = k_t[w - qd(q;x,w)].$$

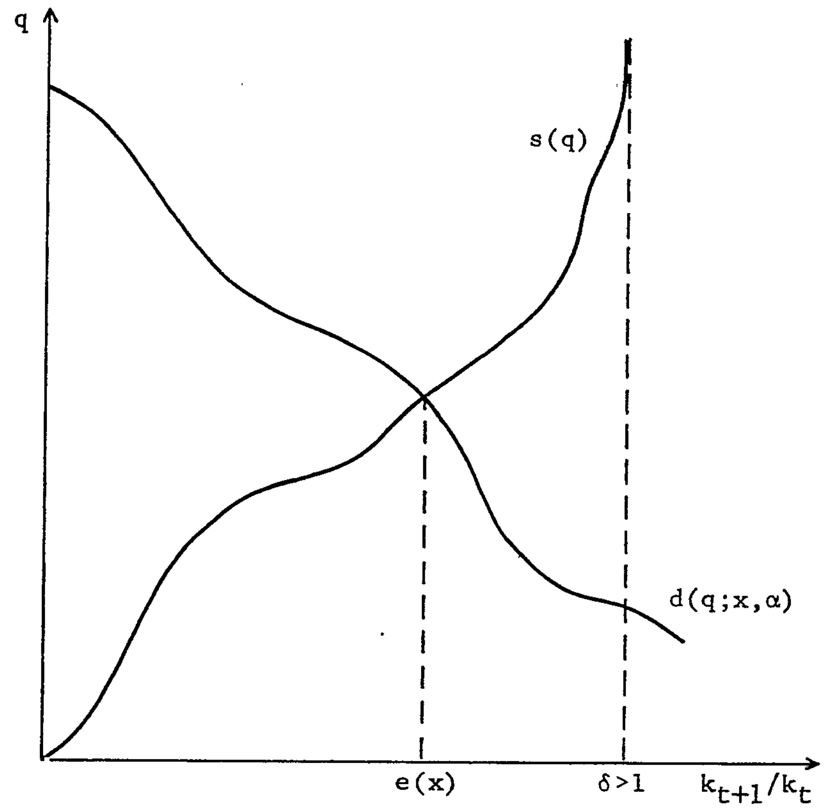
The market parameter w has already been determined. Given this w and x, "supply curve" (13), and "demand curve" (16), determine the actual (gross) growth rate k_{t+1}/k_t as a function of the expected growth rate x. Let this equilibrium relation be denoted as

$$k_{t+1}/k_t = e(x).$$

The final step in the proof is to find the x for which expected and actual growth rates are equal. The supply of capital curve (13) is invariant to x. Increases in x, however, shift the demand function down continuously.[4/] This implies that the function e(x) is decreasing, continuous, and strictly positive (see the figure). Consequently, function e has a unique fixed point x*. For growth rate x*, the expected and actual growth rates are equal.

Nothing assumed so far guarantees that growth will be positive, that is, that $x^* > 1$. We do know, however, that any growth rate less than δ will have an investment technology h for which that growth rate is the equilibrium rate. To see this, use the demand function $x = d(q;x,d)$ to determine the necessary price of capital q for x to be an equilibrium value. Then select h so that $h'(x) = q$.

Supply of and Demand for New Capital
Given the Expected Growth Rate x



In summary, the balanced growth path exists. The unique equilibrium value of w^* is α from (14); the equilibrium x^* is the unique fixed point of $e(x)$; (13) uniquely determines equilibrium q^* given x^*; equilibrium y^* equals $w^* - q^*d(q^*;x^*,w^*)$ from (17); and equilibrium z^* equals $\pi_1(w^*) + \pi_2(q^*)$. This is the only equilibrium constant growth path.

Efficiency

Sometimes competitive equilibria of the sequence-of-markets variety are efficient, and sometimes they are not. In overlapping generations settings, schemes which redistribute from young to old may Pareto improve upon the sequence-of-markets equilibrium. If this were true for our sequence-of-markets equilibrium allocation, the equilibrium concept would be inappropriate. That is, a coalition could and would institute any redistributional scheme among its current and future members which was Pareto improving. We now show that for the constant growth equilibrium allocation, no Pareto improving redistribution scheme exists.

A sequence-of-markets equilibrium for overlapping generations models is efficient if the present value of the sum of all generations' consumptions, calculated using the implicit interest rate, is finite. This condition is not necessary for efficiency, but is sufficient. For our constant growth path, the implicit gross interest rate (that is, the marginal rate of substitution between consumption when young and consumption when old) is $z^*x^*/\beta y^*$. If this number exceeds x^*, the present value of the sum of all generations' consumptions is finite.

To verify the efficiency of our equilibrium, we first note from (14) that a member of generation t's consumption when young is less than or equal to $w_t = \alpha k_t$ and when old it is at least $k_t \pi_1(\alpha) = (1-\alpha)k_t$. Thus, $y^* \leq \alpha$ and $z^* \geq 1 - \alpha$. The result that the gross interest rate exceeds x^* follows immediately once we note that $0 < \beta < 1$ and that $0 < \alpha < 1/2$. To summarize, no redistributional scheme Pareto improves upon the constant growth equilibrium path.

Equilibrium for the Economy With Nontradable Capital

To support the allocation, the market for capital is not needed because in equilibrium capital is not traded between coalitions. The quantity of new capital produced by a coalition is precisely equal to the investment of the young who join that coalition.

Without capital markets, an initial coalition forms a plan $\{z_t, y_t, n_t, k_{t+1}\}_{t=0}^{\infty}$. For a plan to be feasible, it must satisfy two sets of conditions:

(18) $$y_t n_t + z_t n_{t-1} \leq n_{t-1} k_t n_t^{\alpha} - n_{t-1} k_t h[(k_{t+1} n_t)/(k_t n_{t-1})]$$
for $t = 0,1,2,\ldots$ where $n_{-1} \equiv 1$

(19) $$\ln y_t + \beta \ln z_{t+1} \geq u_t^*,$$
for $t = 0,1,2,\ldots$ where $u_t^* = \ln y_t^* + \beta \ln z_{t+1}^*$

and where a star (*) denotes the equilibrium values of variables for the economy with tradable capital. Conditions (18) are the resource constraints while condition (19) is that all generations realize at least the utility level they could have obtained if capital were traded. The initial generation of the old maximizes its utility $\ln z_0$ subject to these feasibility constraints. Clearly, $\{z_t^*, y_t^*, n_t, k_{t+1}^*\}_{t=0}^{\infty}$ satisfies (18) and (19). Further, no other feasible plan exists which yields greater z_0 than z_0^*. If one did, the star equilibrium would not be optimal.

Next we note that no future generation can profit by modifying the plan. If generation s could modify the plan subject to feasibility for all $t \geq s$ and make itself better off, again the star equilibrium would not be a Pareto optimum. A resource feasible plan would then exist which increased generation s utility above u_s^* while providing utility levels of at least u_t^* for all other generations. Thus, no generation has an incentive to alter the star plan. This establishes that the equilibrium allocation with traded capital is also the equilibrium allocation when capital is embodied in the coalition and is not tradable.

The Effect of Tax Policy on the Equilibrium Growth Rate

Unlike the neoclassical growth model, this economy's balanced growth rate depends on the rate of savings by the young. Any tax policy that alters that savings rate will change the economy's growth rate forever. Increases in the tax rate on the old's incomes, for example, will reduce the economy's growth rate even if tax collections are distributed back to the old. To see this, consider the effect of a proportional tax $0 < \gamma < 1$ on the old's incomes and a lump sum transfer of π_0 to each old agent. The value of π_0 is the income tax collected per old agent, so the total amount collected equals the amount distributed. With this policy, the problem facing a young agent becomes

$$\max_{a,b>0} \{\ln y + \beta \ln (1-\gamma) + \beta \ln [bc_1(\dot{w}x/b)^{[\alpha/(1-\alpha)]} + \pi_2(q)b + (\pi_0/(1-\gamma))]\}$$

subject to

$$a + qb \leq w.$$

The effect of this policy is to reduce the marginal utility of b given x and q. Consequently, the demand curve $d(q;x,\alpha)$ falls, implying a smaller $e(x)$ function. This in turn implies a lower equilibrium growth rate x^*.

Summary and Extensions

To summarize, the equilibrium behavior of our economy displays three major properties. The economy experiences no exogenous technological change, yet it grows at a constant rate. It displays no tendency for coalition size to regress to a mean or for the size distribution to become more disparate over time. And, unlike the neoclassical growth model, this economy's growth rates are affected by policies that affect the savings rate. For example, a policy which decreases the savings rate also decreases forever the average rate at which the economy grows.

In the prototype structure studied here, the size distribution of coalitions is, admittedly, determined entirely by initial conditions. In a narrow sense, then, we have made no positive contribution to the theory of firm size distribution. At the same time, however, this structure does not result in the type of counterfactual entailments that have plagued most previous growth models, features such as a monopoly firm or all firms of the same size in equilibrium. Moreover, we are optimistic that our basic environment can be generalized. Introducing coalition-specific uncertainty, for example, could lead to a theory of firm size distribution that includes the birth and death of coalitions. With the approach of Lucas and Prescott (1974), the equilibrium would be an invariant distribution of coalitions, jointly indexed by their size, as measured by the number of coalition members, and their coalition capital.

This structure might also prove useful in addressing a set of interesting financial questions. If physical capital and private information were added, a coalition of experienced workers would have reason to enter into recursive contracts, not only with young workers, but also with workers who supply financial capital used to purchase physical capital needed for production. Both capital and contract theory considerations might be incorporated into tractable extensions of this construct and the model then used to account for phenomena in which both considerations play important roles.

Notes

[1] An alternative approach is to introduce externalities that cannot be internalized within firms, as has been done by Arrow (1962) and Romer (1984). Arrow simultaneously obtains increasing industry returns and constant firm returns by having a firm's production set depend on cumulative industry output. Romer assumes individuals' productivities depend on the average human capital of other members of society as well as their own.

Lucas (1985) obtains sustained growth by assuming a standard neoclassical production function for the production of goods and an individual-specific technology for production of that individual's human capital. The latter technology has constant returns to scale, with an individual's human capital as the input and increments to that individual's human capital as the output. Unlike Romer's (1984) economy, but like ours, there is constant rather than accelerating growth.

[2] We think the Lucas (1978) model is a good one of the typical small entrepreneurial firms that account for about half of output in the United States. It may be less appropriate for the large firms that account for the other half, however; our model is perhaps more appropriate for them.

[3] The notion that one component of an agent's human capital is information about co-workers (for example, what they know and what they don't know) has been stressed in recent studies of management in large corporations (Cox 1982, Kotter 1982). For managers, an important resource is knowledge of the abilities of

subordinates and peers. This "networking," as it is sometimes called, may involve hundreds of people. The point is that they are specific people, so the value of this information is to a considerable extent group-specific.

The productivity of a worker may also plausibly depend on the human capital of co-workers, as we assume here. For example, highly trained engineers are likely to be more productive when working with a group of similar individuals. The same holds true for such disparate professionals as, for example, artists, medical specialists, lawyers, and accountants, and even economists, who often choose to work in colonies, clinics, partnerships, and departments. Other examples abound.

Others have considered the joint production of information and output [Rosen (1972), for example]. The Prescott and Visscher (1980) model of organization capital uses statistical decision theory to explicitly capture this phenomenon and analyze the resulting industry equilibrium.

[4]/One can easily verify that in (15) the marginal utility of a is invariant to x whereas the marginal utility of b is decreasing in x.

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