Organization Capital

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The manner in which information is accumulated in the firm offers an explanation for the firm's existence. Information is an asset to the firm, for it affects the production possibility set and is produced jointly with output. We call this asset of the firm its organization capital. The costs of adjusting the stock of organization capital induce the firm to constrain its growth rate, thus explaining certain facts about firm growth and size distribution. Adjustment costs arise endogenously rather than being assumed.

Economists have puzzled for 2 centuries about the reasons for the emergence of firms. This paper extends our understanding of the nature of the firm. The firm is a storehouse of information, and within the firm incentives are created for the efficient accumulation and use of that information.[1] We can exploit this concept of the firm to explain certain facts about firm growth and size distribution.

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[1] Our theory is not incompatible with all other theories of the firm. We intend our abstraction to model best the behavior of the large corporation. In smaller, entrepreneur-run firms, the span of control of the manager (Penrose 1959; Lucas 1978) or the degree of risk aversion among potential entrepreneurs (Knight 1965; Kihlstrom and Laffont 1979) could be the important factors defining the nature of the

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Our model of the firm is dynamic. Information about employee and task characteristics that influence productivity is part of the firm's capital stock, and the firm maximizes its value by choice of current period inputs, outputs, and a rate at which to acquire such information. The process by which information is accumulated leads naturally to (1) constant returns to scale and (2) increasing costs to rapid firm size adjustment. These properties of technology seem consistent with observations. Constant returns to scale explain the absence of an observed unique optimum firm size (see Stigler 1958) and the lack of correlation between firm size and profitability (see Hall and Weiss 1967). Without costs of adjustment, the pattern of investment by firms in the face of a change in market demand would exhibit discontinuities we do not observe. Further, without a cost penalty to rapid growth, the first firm to discover a previously untapped market would preempt competition by usurping all profitable investments as they appear, thus implying monopoly more prevalent than it is (Prescott and Visscher 1977).

Information is an asset to the firm, for it affects the production possibility set and is produced jointly with output. We call this asset of the firm its organization capital. Growth in the firm requires proportional growth in the firm's stock of information if operating costs are to remain unchanged. In our theory, the cost of acquiring organization capital increases more than in proportion to the rate of accumulation of this form of capital; hence there is costly rapid adjustment. The technology set facing price-taking firms is a convex cone so there are constant returns to scale. Constant returns and internal adjustment costs along with some costs of transferring capital between firms yield an optimum rate of firm growth independent of the firm's size (Gibrat's Law; see Ijiri and Simon 1977).[2]

We explore three ways in which the firm invests in organization capital. In each case, the investment possibilities lead firms to grow at a common rate. In the first instance, organization capital consists of what the firm knows about the abilities of its personnel. Here, the potential for improving matches between employees and jobs by

firm. We stress constraints on information accumulation within the firm, and in that respect our model is related to those of Coase (1937) and Williamson (1975). Other authors who have emphasized the importance of information include Arrow (1962), Alchian and Demsetz (1972), Rosen (1972), and Marschak (1977).

[2] The regression fallacy makes interpretation of individual firm growth rates misleading, but a number of studies have corrected for this statistical problem and concluded Gibrat's Law holds (Hart and Prais 1956; Simon and Bonini 1958; Mansfield 1962; and Quandt 1966). The size distribution of firms can be successfully predicted assuming independence between growth rate and size. See Sherman (1974) for a discussion. We, therefore, take Gibrat's Law to be valid although Vining (1976) shows that very large firms grow slightly slower than the Law would require.

measuring performance in a screening task is the source of the decision to constrain the growth rate. Personnel information is also the source of organization capital in the second example. Here the firm learns about its employees to improve the match between employees working in teams. In the final example, organization capital consists of the human capital of the firm's employees. The potential for enhancing the human capital stock by on-the-job training gives the firm incentive to constrain its growth rate in this case. Each model requires the firm to trade off current output for additional organization capital, and it is this trade-off that generates restrictions on firm growth consistent with the evidence.[3]

I. Personnel Information as Organization Capital

Our first example of organization capital is information about the match between workers and tasks. The work force is not homogeneous: workers have different sets of skills and talents. Some tasks within the firm are performed better with workers of a particular aptitude, and the efficiency of the organization depends on how well individuals are matched to tasks at which they have a comparative advantage. Which task requires which type of individual is known, but which individuals are of which type must be determined. Unfortunately, the characteristics of employees are not observed perfectly. Workers do not have their aptitudes indelibly stamped on their foreheads. It is thus left to the firm to infer the type of each employee from whatever information can be gathered.

The most important source of information on worker aptitude is probably the worker's performance in tasks previously assigned. Somehow the maximizing firm must interpret a worker's performance and convert observations into a subjective estimate of the worker's aptitude. The better is the information obtained about personnel, the more likely is the organization to prosper.

Personnel information is an example of organization capital. What can be learned about personnel during this period will improve productivity in the next period. But augmenting next period's personnel information capital stock entails present period costs against which the value of the information must be weighed in choosing an information investment policy.

We demonstrate in this section that optimal investment in personnel information capital by profit-maximizing firms can lead each firm

[3] We emphasize that we focus on internal growth and that organization capital does not place restrictions on growth through acquisition.

to grow at the same rate and, thus, provide an explanation for Gibrat's Law. When personnel information capital is introduced, the firm does not adjust instantaneously to higher output levels when demand grows because that would require assigning workers about whom little is known to tasks in which costs are sensitive to the type of worker assigned. By growing slowly the firm saves adjustment costs by observing workers for longer periods of time in tasks providing measures of the assigned worker's characteristics that are either (*a*) better than that provided by other tasks in that more information is revealed per period or (*b*) cheaper than that provided by other tasks in that costs are less sensitive to the type of worker assigned.

Below we present a simplified example of an information processing technology that leads to equal growth rates among firms. Next, we generalize the example to show that the trade-off between better personnel information by Bayesian revision of the subjective distribution over a worker's characteristic and increased current production naturally provides a technological constraint that induces equal growth rates in firms of different size.

The Optimal Policy for Investment in Personnel Information

A simple example is designed here to demonstrate how equal growth rates can arise from the optimal investment in personnel information. In the example, costs of production depend on the quality of the match between workers and tasks. Attributes of workers are detected only by examining worker performance in the "screening task." The faster the rate of growth of the firm, the faster workers must be promoted from the screening task to other productive tasks. The number of periods each new worker spends in the screening task, therefore, decreases with faster growth; further assignments must then be made on the basis of less information about the worker's attributes. Less information about workers implies that a poor match between worker and task is more likely. Poor job matches increase costs; thus, rapid adjustment of the size of the firm is costly, and the firm is discouraged from growing too fast.

Suppose the value of some variable θ measures the aptitude of a worker for a particular kind of work. For example, workers with high values of θ may have a comparative advantage in tasks that require repeated attention to detail, whereas workers with a low θ may have a comparative advantage in work that requires the fulfillment of broadly defined duties and frequent adaption to new situations.

There is a pool of workers from which employees are drawn. Pool members have no better information about their own θ-value than do prospective employers who initially know only the distribution of θ in the worker population.[4] Let the population distribution of θ be normal with mean zero and precision (the inverse of variance) π.

Assume there are three tasks involved in the production of output. If q units of output are produced, assume that $\varphi_1 q$ workers must be assigned to task 1 and φq workers must be assigned to task 2 and to task 3. For task 1, the screening task, per unit cost of production is invariant to the θ-values of the individuals assigned. However, the larger a worker's θ, the larger is his product in task 2 relative to his product in task 3. Consequently, a worker with a highly positive θ is much better suited for task 2 while a worker with a highly negative value is much better suited for task 3.

We assume performance in task 2 or 3 cannot be observed at the individual level. In addition, variable factor prices are assumed constant over time so variable factor requirements and variable costs are equivalent concepts. More explicitly, the total (variable) cost of producing q units of output is $C(q) = c_1 q + (c_2 - \bar{\theta}_2)q + (c_3 + \bar{\theta}_3)q$ where c_1 is the average variable cost attributed to completion of task 1; $c_2 - \bar{\theta}_2$ is the average variable cost attributed to completion of task 2 if the average θ of those assigned to task 2 is $\bar{\theta}_2$; $c_3 + \bar{\theta}_3$ is the average variable cost attributed to completion of task 3 if the average θ of those assigned to task 3 is $\bar{\theta}_3$; and c_1, c_2, and c_3 are constants.

Another component of costs is payments to the workers. The implicit contract governing payments must provide at least the expected lifetime utility level as competing alternatives and must also be enforceable in the sense it will not be in the interest of the worker to quit. The precise form of this best contract depends on several factors such as costs of moving, publicness of information, and degree of worker's risk aversion.[5] Characterizing this contract is an interesting problem but one we shall finesse as follows: we assume the firm structures this contract to minimize the expected present value of wage payments subject to market constraints. When a worker is hired a liability incurred is this present value, which we denote as w, and is the "price of the worker."

Performance in task 2 or 3 is not observed at the individual level, but information about a worker's θ-value can be obtained from observing his performance in task 1, the screening task. Task 1 might be thought of as an apprenticeship position. The worker is closely monitored, and a value of z, an indicator of the worker's θ-value, is

[4] We assume workers know no more about their own θ than do the firms. This has a certain plausibility in that the firm has probably seen and compared more workers with similar observable characteristics than has the individual. If the worker does know his own θ, the contract with workers would be different (see Harris and Raviv 1978).

[5] Becker and Stigler (1974) and Mortensen (1978) have considered deferred compensation schemes to insure incentive compatibility of an optimal employment contract.

obtained. The expert supervising the apprentice determines a value of z each period based perhaps on the type of working environment (e.g., stable vs. changing) or the types of problem solving (e.g., theoretical vs. applied) at which the worker appears to excel or prefer. Assume the values of z obtained are normally distributed around the worker's value of θ with precision 1.[6] That is, $z_{it} = \theta_i + \epsilon_{it}$ for each worker i assigned to the screening task in period t. The ϵ_{it} are independently distributed $N(0, 1)$ over both i and t.

We can use the standard techniques of Bayesian revision (see, e.g., DeGroot 1970 or Zellner 1971) to calculate the moments of the subjective posterior distribution on an individual worker's θ-value after any number of observations of z for that worker. If the organization is large, the law of large numbers permits us to estimate the percentage of incorrect assignments to task 2 or 3 given the observations of z taken on each worker in task 1 prior to reassignment. Once assigned to task 2 or 3, no further disaggregated information on workers is obtained and costs of production are determined until there is turnover among the employees.

Suppose there are n observations on a worker in job 1, the screening job. The subjective posterior distribution of his θ is normal with the mean

$$m = \frac{1}{\pi + n} \sum_{k=1}^{n} z_k \tag{1}$$

and has precision $h = \pi + n$. Knowledge of an individual is thus completely characterized by a pair of numbers (m, h).

Ideally, we would like to let firms sample workers sequentially and make any assignments desired after each draw. The nonsequential assignment is easier to analyze, however, so we examine it instead. By nonsequential assignments we mean new employees are assigned to job 1, and employees longest in job 1 are the next to be assigned to job 2 or 3 depending on the sign of their m. Employees enter an assignment queue when they join the organization and strict queue discipline is maintained. Such an assignment rule can be justified perhaps as follows: early assignment would signal a large absolute value of θ and therefore a very valuable employee. Workers with greater expected product are likely to receive higher wages in order to keep them loyal to the firm. If so, the z of a worker assigned to the screening task reported by the supervisor affects that worker's wealth. With the sequential assignment there is then the problem of favoritism and cronyism, perceived or real, and even outright fraud.

[6] The precision of a normal distribution is the reciprocal of its variance. Its use simplifies the Bayesian updating formulae.

Perceived favoritism can reduce employee morale and adversely affect productivity. In any event, here we show that with the nonsequential rule, average costs decrease at a decreasing rate as the number of periods employees spend in job 1 increases. The intuition behind the assignment of the oldest vintage employees first is that the θ of employees on whom there are more observations can be inferred with greater precision than that of any employees on whom there are fewer observations. Further, the gain in information from keeping an employee about whom much is known in the screening task for another period is less than that possible from employees about whom little is known. More rapid growth of the firm implies that fewer observations per employee are made prior to assignment. Production costs, therefore, increase with more rapid adjustment in output of the firm, and this costly rapid adjustment is shown to imply equal growth rates among firms.

The precision of a cohort new n periods ago and assigned to job 1 in the interim will be $n + \pi$. Therefore, the distribution of m in a group of vintage n workers will be normal with mean zero and variance $n/\pi(\pi + n)$ by the definition of m in (1) and the distribution of θ in the workforce. To demonstrate increasing costs with rapid adjustment, we show that costs per unit decrease in n, and n decreases with increases in the growth rate.

Per unit costs of production assuming individuals with positive m are assigned to job 2 and those with negative m to job 3 after n periods in screening job 1 are[7]

$$c(n) = c_1 + c_2 + c_3 - E\{\theta \mid m > 0\} + E\{\theta \mid m \leq 0\}. \tag{2}$$

Because m is normally distributed, evaluation of the conditional expectation in (2) yields per unit costs as a function of n,

$$c(n) = c - 0.7978 \frac{n}{\pi(\pi + n)}, \tag{3}$$

where 0.7978 is $2\int_0^\infty t/(\sqrt{2\pi})\, e^{-t^2/2}\, dt$ and $c = c_1 + c_2 + c_3$. The function $c(n)$ decreases at a decreasing rate in n.

The greater the growth rate the smaller must be n, the time spent in job 1 before assignment to job 2 or 3. If γ is the growth rate of output, ρ is the quit rate, and y_i is the current number of vintage i employees, then: $(1 + \gamma)y_{i+1} = (1 - \rho)y_i$. Letting $\xi = (1 - \rho)/(1 + \gamma)$, from the above $y_i = \xi^i y_0$. Using the standard formula for the sum of geometric series, the fraction of present personnel with vintage greater than n is thus ξ^{n+1}. Given the nonsequential assignment rule, those employees

[7] A large number of workers is assumed, so average and expected per unit costs of production are equal by the law of large numbers.

with the greatest seniority are assigned to jobs 2 and 3. But the fixed coefficients technology requires a constant ratio between the number of personnel in jobs 2 and 3 and the number assigned to job 1; therefore

$$\xi^{n+1} = \frac{2\phi}{\phi_1 + 2\phi}$$

or

$$n(\gamma) = \frac{\log (2\phi) - \log (\phi_1 + 2\phi)}{\log (1 - \rho) - \log (1 + \gamma)} - 1 \text{ for } \gamma > -\rho.$$

The larger the growth rate γ, the less time, $n(\gamma)$, workers spend in the screening task. Consequently, per unit costs of production will be higher if growth is more rapid. This establishes increasing costs of rapid adjustment for nonsequential assignment. That increasing costs of rapid adjustment do indeed yield a unique optimum growth rate among firms in this example can now be shown as an extension of the market equilibrium analysis of Lucas and Prescott (1971).

Industry Equilibrium Analysis

Firm growth rates are independent of firm size in this example because the mathematical structure of the technology constraint is the same as that considered in Lucas (1967) except that the stock of organization capital is a vector rather than a scalar. Let k_i, the ith component of the beginning-of-period organization capital vector, be the number of employees on which the firm has i observations of z. The number of workers of type i assigned to task $j = 1, 2, 3$ is denoted by a_{ij} and the number of new hires by b. The technology constraints are as follows:

$$\sum_i a_{ij} = \phi_i q \text{ for } j = 1, 2, 3. \tag{4}$$

A sufficient number of workers must be assigned to each of the three tasks in order to produce output q.

$$\sum_j a_{ij} = k_i \text{ for } i \geq 1 \text{ and } \sum_j a_{ij} = k_0 + b \text{ for } i = 0. \tag{5}$$

All workers of type i are assigned to one of the three jobs.

$$a_{ij} \geq 0. \tag{6}$$

Assignments cannot be negative.

$$k_i' = (1 - \rho)(k_i - a_{i1} + a_{i-1,\,1}). \tag{7}$$

The prime denotes the next period value of a variable. This relationship holds because fraction ρ of the workers terminate employment at the end of the period and because type i workers assigned to job 1 become type $i + 1$ workers, while type $i - 1$ workers assigned to job 1 become type i in the subsequent period. The relationships (4)–(7) constrain the current period decision $\underline{x} = (q, b, a_{ij}$ for $i = 0, 1, 2, \ldots$ and $j = 1, 2, 3)$, beginning-of-period capital $\underline{k} = (k_0, k_1, \ldots)$, and next period capital $\underline{k}' = (k_0', k_1', \ldots)$. The set constraining $(\underline{k}, \underline{x}, \underline{k}')$ is denoted by T. It is a closed convex cone which implies constant returns to scale. Further, for fixed $\underline{k}$, $(\underline{x}, \underline{k}')$ is constrained to a compact set.

The bounded, downward-sloping, inverse industry demand function is $P_t = p(Q_t, u_t)$ where Q_t is the sum of output over all firms (capital letters will be used for aggregate variables) and u_t is a demand shock subject to a stationary Markov process. We assume for all possible u and sufficiently large Q that price would be less than costs even if θ were observable. We also assume that even if z were not observed or, equivalently, if assignment of workers to tasks was random, for all possible u and sufficiently small Q, price exceeds production costs. These assumptions insure that equilibrium industry output will be bounded from above and uniformly bounded away from zero.

With these assumptions the results of Lucas and Prescott (1971) insure that a competitive equilibrium exists and that any competitive equilibrium maximizes the expected value of discounted consumer surplus. The discounted consumer surplus is

$$\sum_{t=0}^{\infty} \beta^t \left\{ \int_0^{Q_t} p(y, u_t)dy - Bw - Q_t \Sigma_i[(A_{i2t} + A_{i3t})c(i)]/\Sigma_i(A_{i2t} + A_{i3t}) \right\} \quad (8)$$

where A_{i2t}, A_{i3t}, and B are obtained by summing a_{i2t}, a_{i3t}, and b, respectively, over all firms in the industry.

All the statements so far are equally applicable even if assignment of workers to tasks depends on the mean as well as the precision of a worker's θ (note that $h = \pi + i$ so i implies h and conversely). But for this more general problem, it is difficult to establish that there is a *unique* optimal decision for a firm and that firms with different capital configurations will over time converge to the same configuration save for a multiplicative factor. Our attempts to date, not yet totally successful, require the use of unfamiliar mathematics and do not add anything important to the special case for which firms are constrained to assign the most senior workers to task 2 or 3 and workers once assigned to task 2 or 3 cannot be later reassigned. With these additional constraints, once q is specified all the other decision elements of $\underline{x}$, the a_{ij} and b, are determined. Thus the decision problem in a given period reduces to choosing a point in a one-dimensional space.

The maximization of the discounted consumer surplus function (8) subject to $(\underline{k}_t, \underline{x}_t, \underline{k}_{t+1}) \in T$ for each firm is easily characterized. There is a seniority cutoff point, $n(u_t, \underline{K}_t)$, which depends upon the industry state ($\underline{K}_t$ is the sum of $\underline{k}_t$ over all firms). Workers with less seniority are assigned to task 1 and those with more, depending upon the sign of m, to job 2 or 3. The reason this is optimal is that assigning more senior workers reduces costs both in the current and future periods. Further, some fraction of the total industry workers of vintage $n(u_t, \underline{k}_t)$ are assigned to task 2 or 3 and the rest to task 1. There is a small indeterminacy of a firm's optimal decision with respect to the number of vintage $n(u_t, \underline{K}_t)$ workers it assigns to job 1.[8] For simplicity we assume all firms assign the same fraction of their $n(u_t, \underline{K}_t)$ workers to job 1. This establishes, except for the cutoff vintage problem, that there is a unique optimal output and, therefore, a unique work force given its capital $\underline{k}_t$ and the industry state $(u_t, \underline{K}_t)$. Furthermore, output and new hires will be homogeneous of degree one in the capital vector. Thus if two firms have organization capital vectors $\underline{k}$ which are proportional at a point in time, they will be proportional in all future periods; that is, growth rates are independent of firm size.

A second question is whether firms beginning with different organization capital configurations, that is, capital stock vectors that are not proportional, will converge to the same configuration. Under some general conditions the answer is yes, a result established as follows: Let the capital stock configuration be denoted by $\underline{a}_t = \underline{k}_t / \|\underline{k}_t\|$ where $\|x\| = \Sigma_i |x_i|$ is the l_1 norm. For each t there is a matrix, $B_t = B(u_t, \underline{K}_t)$, relating period $t + 1$ configuration to period t structure: $\underline{a}_{t+1} = B_t \underline{a}_t$. Consider two firms with initial capital configurations $\underline{a}_0$ and $\underline{b}_0$, respectively. The vector $\underline{b}_t$ is represented as the sum of $d\underline{a}_t$ and a residual vector $\underline{r}_t$, where d_t is the largest real number for which all the components of $\underline{r}_t$ are nonnegative. Because B_t maps nonnegative vectors of unit length with fraction $2\phi/(2\phi + \phi_1)$ of the workers assigned to task 2 or 3 into the same set, the sequence $\{d_t\}$ is nondecreasing and is bounded from above by one. Since the limit is one, with probability one, the limit of the $\{\underline{r}_t\}$ sequence is the zero vector also with probability one, which implies convergence to a common organization capital configuration.[9]

[8] For sequential assignment which is based on m as well as h or for continuous time when the measure of the number in any vintage is zero, there should be no such indeterminacy.

[9] With positive probability the fraction of workers with vintage $n(u, k)$ will not be zero or one; therefore, the k stage transition probability matrix is strictly positive for sufficiently large k. This is sufficient to insure the limit of the d_t sequence is not less than one with positive probability or, equivalently, d_t converges to one with probability one.

II. Team Information

Personnel information need not be valuable only because it facilitates the matching of workers to tasks. Another equally valuable use of personnel information is in the matching of workers to workers. What is important to performance in many activities within the firm is not just the aptitude of an individual assigned to a task, but also how well the characteristics of the individual mesh with those of others performing related duties. We might think of production tasks in the firm being accomplished by the combined efforts of a team of workers. The productivity of a team member is not simply a function of his individual contribution to output but is also a function of how well his attributes complement those of other team members.

Team information can be incorporated into a model that has the same structure as the personnel information example presented above. For instance, suppose workers are grouped into teams, and team i if assigned to a screening task has an observed productivity indicator z_{it}. The indicator has both a deterministic and a stochastic component. The deterministic component θ_i is directly related to how well the team workers are paired. The stochastic components ϵ_{it} are distributed $N(0,1)$ and independently over time: $z_{it} = \theta_i + \epsilon_{it}$. Consider a sample population consisting of all possible teams from the set of workers. Assume for simplicity that the θ from all possible teams are approximately independently and normally distributed $N(\mu, 1/\pi)$. Then, if there are n observations on team i, the posterior distribution on θ_i is normal with mean

$$m = \mu + \frac{1}{\pi + n} \sum_{k=1}^{n} (z_k - \mu)$$

and precision $h = \pi + n$.

If dissolution of a team also dissolves the accrued information about the θ of that team, the team information model is virtually the same as the previous example of personnel information. The mean of θ is now μ rather than zero. The unobserved contribution of a team to output (or cost reduction) in the now solitary nonscreening task is θ. Productivity in the screening task can remain independent of θ as before even though it is not essential for the conclusions. The (m, h) component of the firm's organization stock vector is the number (density) of workers with mean m and precision h at the beginning of a period. A team may be dissolved and the workers reassigned, but by assumption that is equivalent to assigning workers taken in a fresh draw from the worker population. Therefore, the technology displays constant returns to scale and, in addition, increasing costs of rapid adjustment;

more rapid growth implies fewer observations of z before assignment to a task in which productivity depends on θ.

III. Firm-specific Human Capital as Organization Capital

The capacity of the organization to function effectively as a production unit is determined largely by the level and meshing of the skills of the employees. Employee skills are our final example of organization capital. The case for the human capital of employees being a part of the capital stock of the firm is well established. Productivity in the future depends on levels of human capital in the future. But to acquire human capital for the future, a sacrifice in real resources is required in the present (see Becker [1975]).

In this section, we examine the choice of the firm between current output and the future stock of human capital among its employees. The work of Lucas (1967) suggests that the crucial characteristics of the technology set needed to produce equilibrium growth rates independent of firm size in models with physical capital are constant returns to scale and strict concavity in the transformation function relating the future capital stock and current output. If the capital of the firm is human, some aspect of the model must force an analogous technology.

For many empirically interesting production processes, output and skill enhancement should be thought of as joint products resulting from combination of labor inputs possessing different skill levels. The experienced and the inexperienced workers are combined in one of several available technical processes used to generate the firm's product, and in the process, the overall competence of the work force is improved. An assertion of a concave transformation frontier between output and capital can be sustained by an appeal to diminishing returns to effort in both production and learning. Movement from an extremely unbalanced bundle of production and learning activity to a more balanced bundle entails little sacrifice. In a workday consisting primarily of production activity, there are natural breaks in the routine. A limited attention span is part of our psychological makeup. A certain amount of shoptalk occupies casual periods in many work situations: coffee breaks, lunch, conversations in passing. These interludes are very productive in transmitting information and cost virtually nothing in output because the pauses and breaks in workers' concentration are necessary in any case. In a workday consisting primarily of learning, on the other hand, there are also diminishing returns and, hence, opportunities for pursuing a more balanced combination of activities with little cost.

An argument can be made that the processes available for producing the joint products of human capital and current output are linear homogeneous. If a single manager can supervise the work of four subordinates, two managers of comparable ability in similar surroundings can supervise the work of eight. If one professor can effectively direct four students' dissertations, two professors can direct eight dissertations. This is not to say that there are not optimum-size production teams and superior allocations of human talent within the firm. But once the strongest combinations of worker types are discovered, nothing prevents the firm from replicating those combinations with proportional gains in product. Hence, we believe that constant returns to scale within a wide range of output levels is a useful approximation.

If the transformation frontier between current output and future human capital is concave to the origin and the production function is linear homogeneous, the technology set defining feasible combinations of current and future human capital and current output is a closed convex cone with a vertex at the origin. This technology is sufficient for optimal proportional growth by firms as demonstrated by the industry equilibrium analysis in Section I.

IV. Costs of Transferring Organization Capital

If there were no cost in transferring organization capital from one firm to another, our model would not place constraints on the firm's growth rate. Because constant returns to scale is assumed in production, firms could then merge, divest, or pirate each other's personnel without a cost penalty and thus produce a pattern of growth not restricted by the model. Unless organization capital is to some degree firm specific, the growth rate of the firm is not constrained.

Organization capital is not costlessly moved, however, and this makes the capital organization specific. Moving from one locale to another is disrupting to both employee and family. Variety is the spice of life at some level of activity, but we resist major changes in life-style, by and large, unless compensated for their burden. Further, the information set that makes a person productive in one organization may not make that person as productive in another organization even if both firms produce identical output. Much information is firm specific: facility with a computer system at one firm, knowing whom to ask when problems arise, and rapport with buyers or sellers are types of organization capital in one firm that cannot be transferred costlessly to another.

For the structure analyzed in this paper, there are no net gains in improving the match between workers and organizations. Consequently, there is no labor turnover in the model even though turnover is conspicuous in the world. Nevertheless, we do not view this deviation of model from reality as a weakness. Our objective is to explain firm adjustment costs and growth patterns. The simplifying assumptions used to achieve this could be relaxed at the cost of complexity without obviating the main conclusion. For example, one could combine Jovanovic's (1977) theory of turnover, also an information theoretic equilibrium analysis, and our model of organization growth without increasing our understanding of either phenomenon.

V. Summary and Concluding Remarks

This paper focuses on forms of organization capital. In each case the organization capital is a particular kind of information in the firm. One example is information about employees possessed by the firm. Information about the comparative advantage of a particular employee requires observations on the employee's performance. The more rapid is the rate of growth in the firm, the faster must employees be promoted to positions either where their performance is less easily measured or where a bad job match is very costly. It might be added as an aside that in addition to explaining the constraints on firm growth, this form of organization capital also explains why firms often adopt a rule of first laying off the least senior personnel. More is known about older vintage workers, and that information has value to the firm. Another example of organization capital is information about teams of workers. This example has the same mathematical structure as that using information about comparative advantage. A final example is the human capital of the employees. Firm-specific information possessed by employees represents a scarce resource that can only be augmented by training or experience which becomes more costly the more rapid is the rate at which it is undertaken.

In addition to information gathered by the employees and information about both employees and teams of employees gathered for the firm, a form of organization capital which warrants attention is task information. From a sample of observations on the performance of different individuals in a task, the firm may infer how productive the average person is in the task. Information about tasks is costly to acquire but, when obtained, permits cost savings, for example, in the type and quantity of employee monitoring that is required. The value of obtaining task information may explain several phenomena in the conduct of firms; in particular, we expect it will give more explicit content to contract costs which are crucial to Williamson's (1975) theory of vertical integration. Constraints on merger, takeover, and integration must be explained before interesting policy questions such as the appropriate extent of antitrust activity can be addressed. Models embodying task information capital, unlike the forms of organization capital examined here, introduce scale economies and will be explored in another paper.

The goal of this paper is to embellish the theory of adjustment costs in a way that is consistent with observations about firm growth rates. The model we propose has other potentially testable implications. Although we predict that all firms should grow at the same rate, large firms should have growth rates that display less variance than do small firms. Large firms in the model are portfolios of smaller firms in essence. And if the growth rate chosen by each subunit in the firm has an error component that follows a stationary stochastic process, the variance of the growth rate in the whole will be less than the variance of the growth rate in each subunit if errors are less than perfectly correlated. This argument and corroborating empirical work are offered by Mansfield (1962) (see also Hymer and Pashigian 1962 and Simon 1964). A similar argument would appear to imply that the variance of profitability should be smaller in large firms than in small. Hall and Weiss (1967) present evidence for this proposition.

Perhaps the essence of "the nature of the firm" is tied to organization capital. The authors are each members of a firm. What distinguishes that relationship from others in which we offer our services for remuneration? We suspect that the organization known as the firm is successful primarily because it facilitates the transmittal of information. The firm is a structure within which agents have the incentive to acquire and reveal information in a manner that is less costly than in possible alternative institutions. If we ask what information is processed in the firm and how it is produced, we may extend our understanding of why firms behave as they do.

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