THE THEORY OF ECONOMIC ORGANIZATIONS†

Human Fallibility and Economic Organization

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Doctrines concerning what is a good way to organize a society have influenced human societies more deeply than any other set of doctrines. Specifically, beliefs that one way of organizing production and exchange is better than others have inspired a number of socioeconomic experiments leading to modern capitalist and socialist societies, with far reaching implications. Yet surprisingly, the central doctrines, though a source of continuing ideological debate, have been the subject of only limited scientific enquiry. The major proposition, the so-called Lange-Lerner-Taylor Theorem asserting the equivalence between competitive capitalist economies and decentralized socialist economies which make use of the price system, made a point in stressing that the issue of the ownership of the means of production might not be central in the comparison of economic systems. The theorem, however, was based on models both of capitalism and of market socialism in which the most important differences between the two systems were suppressed.

This paper describes a research program attempting to delineate some of the critical differences among alternative forms of economic organization. We contend that central to an understanding of these differences is an understanding of differences in the organization of decision making; of who gathers what information, how it gets communicated and to whom, and how decisions get made, both concerning what actions to take and who should fill decision-making positions. This view should be contrasted with the traditional economic paradigm in which decision making plays no role: the manager, for instance, simply looks up in a book of blueprints what the appropriate technique of production is for the given set of factor prices. In the conventional paradigm, moreover, mistakes are never made, either in gathering or transmitting information, or in making decisions, and indeed, there are no costs associated with these activities. By contrast, the view we take here is that "to err is human," and that different organizational systems differ not only in what kinds of errors individuals make in them, but also in how the systems "aggregate" errors. As a result, organizations differ systematically in the kinds of errors they make, and thus in their overall economic performance. Organizations also differ in the costs associated with information collection, with information communication and processing, and with decision making. Indeed, as we discuss below, perfect decision making can be achieved by arranging enough decision makers in an appropriate manner, no matter how fallible the decision makers are, provided their decisions are not purely random (or worse). What prevents perfect decision making is the cost.

We refer to the specification of the structure of information gathering, communication and decision making as an organization's *architecture*. The objective of our research program has been to construct stylized models of an economic organization within which the consequences of alternative organizational architectures can be examined.

Using these models, not only can we compare the performance of particular organizational forms but we can also ask, given a particular set of objectives and circumstances, what is the optimal structure (within

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a class of structures); for example, what is the optimal number of levels in a hierarchy. We have constructed both a positive and a normative theory. Thus our approach allows us to assess the validity of many of the traditional claims concerning the merits of alternative systems.

I. The Basic Model

To illustrate the basic principles at issue, we present the simplest possible formulation. Consider an organization facing the problem of choosing among a large number of available projects that are of two types: good projects with an expected return of x_1 and bad projects with an expected return of $-x_2$. A fraction α of the projects are good. With perfect information, all good projects, and no bad projects, would be undertaken. A decision maker makes a judgment about whether the project is good or bad based on whatever information he has. We assume that the information available to one decision maker cannot be fully communicated to others. Here we represent a polar form of this "limited" communication such that individuals within any organization convey to one another only whether they judge a project to be good or bad, even though they might have more information at their disposal.

All decision making is imperfect; we assume that the probability that a decision maker judges a good project to be good is $p_1 < 1$, and that the probability that he judges a bad project to be good is $p_2 > 0$; the fact that there is some filtering is reflected in $p_2 < p_1$.

We consider two different organizations, each consisting of two individuals. In a *polyarchy*, each individual has the right to accept a project and projects rejected by one are evaluated by the other. Thus, the probability that a good project is accepted is p_1 (the probability of acceptance in the first evaluation) plus $(1-p_1)$ (the probability of rejection in the first evaluation) times p_1, the probability of acceptance in the second review. The probability that a good project is accepted is thus: $f_1^P = p_1(2-p_1)$. Similarly, the probability that a bad project is accepted is: $f_2^P = p_2(2-p_2)$. The (expected value of the) output of the organization is $Y^P = \alpha x_1 f_1^P - (1-\alpha)x_2 f_2^P$.

By contrast, in a *hierarchy*, for a project to be undertaken, it must be approved by both levels of hierarchy; the probability of this for a good project is $f_1^H = p_1^2$, and for a bad project it is $f_2^H = p_2^2$. The output of the hierarchical organization is $Y^H = \alpha x_1 f_1^H - (1-\alpha)x_2 f_2^H$.

Two results immediately emerge: *polyarchical organizations accept more bad projects* ($f_2^P > f_2^H$); while *hierarchical organizations reject more good projects* ($f_1^H < f_1^P$). The fact that the two systems make different kinds of errors suggests that there will be circumstances under which one or the other performs better. We can ascertain those conditions by comparing the net output of the two systems:

$$(1) \quad Y^P \gtrless Y^H$$

$$\text{as} \quad \alpha x_1 p_1(1-p_1) \gtrless (1-\alpha)x_2 p_2(1-p_2).$$

Condition (1) has a natural interpretation. Assume that we conducted two tests of the project simultaneously; projects with both tests turning out positive should clearly be accepted, those with both tests turning out negative should be rejected (otherwise, there would be no reason to run the tests). The question arises what should we do in a split decision. The probability of a split decision for a good project is $2p_1(1-p_1)$ and for a bad project it is $2p_2(1-p_2)$. Thus, the expected value of projects with a split decision is $2[\alpha x_1 p_1(1-p_1) - (1-\alpha)x_2 p_2(1-p_2)]$. We accept projects with split decisions if their expected value is positive, and reject them if this is negative. But this is precisely the condition (1); if a project would have been accepted with a split decision, there is no point in having a second review; polyarchy is preferable to hierarchy. On the other hand, if a project with a split decision would have been rejected, then the second review is of value: hierarchy is preferred to polyarchy. Second reviews are also of greater value, in this context, when the ratio of bad projects to good projects is larger and when the losses from bad projects relative to the gains from good projects are greater.

There is another interpretation of our result, which becomes clearest when $\alpha x_1 = (1-\alpha)x_2$. Then the condition (1) is equivalent to the condition $p_2 \lesseqgtr 1 - p_1$ where p_2 is the probability of accepting a bad project (Type II error), $1-p_1$ is the probability of rejecting a good project (Type I error). In this central case, whether a polyarchy is better than a hierarchy depends on the relative likelihood of the decision maker making the two types of errors. (A more general formulation of this problem is examined in our 1984a paper.)

Committees: Another type of organizational architecture is a committee. Committees are collections of individuals with well defined rules for decision making (adoption of a project); for example, majority rule or complete unanimity. In a committee with n members which requires the approval of at least k members for adoption, the probability of acceptance of a project, for which the individual's probability of a favorable review is p, is $f^c(n,k,p) = \sum_{j=k}^{n} \binom{n}{j} p^j (1-p)^{n-j}$.

There is a formal similarity between a polyarchy and a committee in which only one individual needs to approve a project for it to be undertaken, and between a hierarchy and a committee in which all individuals in the committee need to approve the project. In our 1984b paper, we have examined the optimal size and decision rules for committees, and show, for instance, that for fixed n, output is a single peaked function of k; and that, for the symmetric case ($\alpha x_1 = (1-\alpha)x_2$), whether more or less than a majority consensus should be required depends simply on whether $p_2 \gtreqless 1 - p_1$.

II. Complex Organizations

It should be apparent that most organizations are not one of the pure forms (hierarchy, polyarchy, or committee) discussed above, but rather a mixture of organizational forms. We can build more complex organizations out of these basic building blocks. Consider, for instance, a polyarchy of hierarchies in which to be approved, a project must receive the approval of at least one of several decision units; but each decision unit is, itself, a hierarchy. This corresponds, rather loosely, to a market economy. If each unit has n hierarchical layers, and there are m such units in a polyarchy, the probability of a type i project being accepted is $f(n,m,p_i) = 1-(1-p_i^n)^m$. By an appropriate choice of n and m, we can ensure that $f(n,m,p_1) > p_1$ and $f(n,m,p_2) < p_2$; that is, the (n,m) polyarchy-hierarchy accepts more good projects and rejects more bad projects than a single decision maker. Moreover it rejects more bad projects than the simple polyarchy (for which $n=1$) and accepts more good projects than a simple hierarchy (for which $m=1$). We can construct a more complex organization in which the above polyarchy of hierarchies serves as a single unit, and a second level polyarchy of hierarchies is created using such units. With enough such levels to our complex organization, we obtain perfect screening. It is the cost of decision making that prevents perfect decision making. The cost of a multilevel organization rises rapidly with the number of levels, while there is diminishing returns to the increase in expected output. The balance between these two yields an optimal structure to the organization.

The intuition behind why, with enough layers, perfect screening can be obtained is simple. A hierarchy is successful in increasing the proportion of good to bad projects, but only at the expense of throwing out a lot of good projects. In a polyarchy, on the other hand, the stock of projects under consideration is "replenished." In fact, as the number of units in a polyarchy increases, the probability of a project, of any type, getting accepted goes to one. The sense of our result is that if we first filter the set of projects through a hierarchy, and then through a polyarchy, the set of approved projects is more "refined" than what could have been obtained by a single filter; repetition of such a procedure yields perfect selection.

We can use the analysis of complex organizations in the preceding section to prove other interesting results: for instance, if the organizational cost depends only on the number of managers, then *it is better to reorganize a very long hierarchy into two* (*or*

more) *polyarchies*: and *it is better to rearrange a very large polyarchy as two* (*or more*) *polyarchic subunits within a hierarchy.* (See our 1984b paper.)

III. Selecting Managers: Towards Organizational Dynamics

Among the most important decisions made within any organization are those concerning who will fill what jobs. The fact that such attention is focused on this problem suggests that it makes a difference; individuals differ in their abilities to acquire, communicate, and process information. For each organizational architecture, there is an optimal assignment of individuals with different characteristics. More importantly, the performance of some organizational forms is more sensitive than others to how these assignments are made, and the errors in assignment are themselves functions of the organizational architecture.

The "rules" by which an organization chooses its successors give rise to stochastic processes, describing the assignments of individuals with different abilities to different positions within the organization. We can analyze, say, the steady state of these stochastic processes for various organizational architectures, and compare their relative performance. We illustrate here how this may be done.

Assume that there are two types of individuals, competent (C) and incompetent (I). Further, suppose that each person in a polyarchy chooses his own successor, whereas the higher level hierarch chooses his own successor as well as that of his subordinate. Clearly, there are four states of a system: (C,C), (C,I), (I,C), and (I,I). We can show $Pr(C,I)$ and $Pr(I,C)$ are larger in a polyarchy, whereas $Pr(C,C)$ and $Pr(I,I)$ are larger in a hierarchy. If the average output of the two systems were the same, any risk averse society would prefer a polyarchy. (For details, see our 1984c paper.)

Alternative economic organizations also differ in their ability to correct selection mistakes. We suspect, therefore, that a still stronger case for polyarchy can be made once (evolutionary) mechanisms for eliminating deficient organizations are introduced (for example, bankruptcies in a market system).

IV. Extensions

The formulation presented here ignores three aspects of cost determination associated with organizational design: (a) time (the more levels to an organization, the greater the time required for decision making); (b) communication costs (not only the direct costs of communication, but also the errors which inevitably arise in the process of communication); and (c) the sequence of decision making (for instance, all individuals are assumed to review all projects in a committee, whereas the upper levels in a hierarchy review only those projects which have been sent up to them by lower levels). Since there are costs to review, the sequencing of the review process may have considerable effect on the resources spent on evaluation.

Elsewhere, we have explored these and other extensions of the basic analysis including (a) a more extensive treatment of the consequences of the use of Bayesian decision rules (though, given the information technology of our basic model, our analysis is Bayesian); (b) an analysis of the endogenous determination of the level of expenditures on information acquisition; (c) an analysis of the consequences of alternative organizational forms on the set of available projects (the mix of projects available to an organization itself is an endogenous variable, determined by the incentives provided to those who develop projects; this in turn is partly dependent on the likelihood of projects of different types being adopted, which differ markedly across organizational architectures); (d) an evaluation of alternative organizational forms faced with different problems, for example, choosing the best set of projects, rather than maximizing the expected profit; and (e) externalities. For instance, one organization's decision affects the productivity of projects undertaken by other organizations. Such interactions are important in certain circumstances, and they may strengthen the case for hierarchy.

V. Concluding Remarks

The differences in the nature of the errors made by different organizational architectures, though important, are not the only differences among organizational forms. We have not examined the widespread belief of a correspondence between economic architecture and political structures; for instance, the alleged correlation between hierarchies and authoritarianism. We have ignored some aspects of organizational comparisons which have already received extensive discussion in the literature. For example, the traditional models emphasize the computational advantages of decentralization (indeed, in some versions, the differences in organizational forms appear to be simply a comparison between alternative algorithms for solving a general equilibrium problem). The fact that the economy solves the problem in "real time" while the models solve for the equilibrium in pseudo time may mean that (at least as traditionally presented) this argument is of only limited relevance.

We have also ignored the problems of incentives, which have been so much at the center of recent discussions of organizational design. We believe these considerations are not only important, but also that the organizational structure may have a significant effect in determining the set of feasible incentives. For instance, when there is more than one decision unit, one can base rewards on relative performance; as the number of units increases, under certain circumstances, a first-best optimum can be achieved. (See Barry Nalebuff and Stiglitz, 1983.) We would argue, however, that organizations may perform badly, not only because of misguided intentions, as stressed in the incentive literature, but also from human fallibility. We have been concerned with showing how even in the absence of incentive problems, individual errors are aggregated differently under different organizational forms, leading to systematic differences in organizational performance.

One argument that can be raised against our analysis is that a hierarchy can always decentralize itself, but the converse is not true; it thus appears, almost tautologically, that hierarchies dominate polyarchies. Within this perspective, the question we have addressed is, under what circumstances should a hierarchy organize itself polyarchically. But we would argue that this perspective is at best misleading: with the right to intervention within a hierarchical structure goes the obligation to intervene when appropriate circumstances arise, and the concomitant necessity to obtain information to effectuate those interventions. Only if there are hard and fast commitments not to intervene, will a hierarchy be equivalent to a polyarchy. The analysis of these issues must, however, await another occasion.

In this paper we couch most of our analysis in terms of a comparison between alternative economic systems; but our results can be applied at a number of different levels of economic analysis (at the level of a firm or an industry as well as for the economy as a whole). Moreover, our results have direct and obvious implications in the context of political decision making, both for the organization of micro decision making (the rules by which committees should operate, or the managerial processes by which public project selection should be conducted) and for the organization of the state. Indeed, we hope our analysis of self-perpetuating organizations, of the problem that all organizations face in selecting those who are to be in decision-making positions, and the comparative sensitivity of organizational performance to the nature of the selection process, will help put into perspective some longstanding fallacies in political theory concerning the virtues and vices of alternative political structures. Classical discussions of the design of State systems (see Karl Popper, 1950) have essentially ignored the problems arising from human fallibility in decision making. Plato, for example, while arguing for the superiority of aristocratic rule, never considered the problems that would arise in choosing the members of the aristocracy over time, or the consequences (by now all too familiar) of the failure to choose well.

In this paper our objective has not been to present definitive results on the comparison

of economic systems. Rather, it has been to encourage a redirection of attention to what seems to us to be one of the most fundamental issues of economics, and to show how simple models can be constructed which provide considerable insights into some of the longstanding controversies concerning the relative merits of different economic systems.

REFERENCES

Lange, Oskar and Taylor, Fred M., *On the Economic Theory of Socialism*, New York: McGraw-Hill, 1964.

Nalebuff, Barry J. and Stiglitz, Joseph E., "Information, Competition and Markets," *American Economic Review Proceedings*, May 1983, *73*, 278–83.

Plato, *The Republic*, Oxford: Clarendon Press, 1968.

Popper, Karl, *The Open Society and Its Enemies, Part I—The Spell of Plato; Part II—The High Tide of Prophesy: Hegel, Marx and the Aftermath*, Princeton: Princeton University Press, 1950.

Sah, Raaj Kumar and Stiglitz, Joseph E., (1984a) "The Architecture of Economic Systems: Hierarchies and Polyarchies," Working Paper No. 1334, National Bureau of Economic Research, 1984.

_____ **and** _____, (1984b) "Economics of Committees," mimeo., Princeton University, 1984.

_____ **and** _____, (1984c) "Perpetuation and Self-Reproduction of Economic Systems: The Selection and Performance of Managers," mimeo., Princeton University, 1984.

_____ **and** _____, (1984d) "Human Fallibility and Economic Organizations: The Architecture of Economic Systems," mimeo., Yale University, 1984.