

Chapter 1

Introduction

A technique is a method or procedure for accomplishing some desired end. A recipe is a description of a technique for baking a cake or cooking a stew. There are techniques of playing the violin, making love and making war, teaching children to behave, weaving cloth, and driving automobiles. The activities of all social institutions are conducted by means of techniques. Our study is concerned with the techniques employed in the economic institutions of the USSR for the production of goods and services.

A set of techniques is known as a technology. Steelmaking technology consists of all techniques for producing steel, and the society's technology, in general, consists of all the technologies for the production of goods and services. Technological progress may be said to occur when a new technique is added to the set. The notion may refer either to the advance of the technological knowledge contained in the society or to the improvement of the technology actually employed in production. Since the focus of our study is the process of the incorporation of technological knowledge into production, we shall employ the latter meaning of the notion of technological progress. Technological progress will be said to occur only when the technology employed in production may be said to have improved. Advances in technical knowledge that have not yet been incorporated into production will not be regarded as instances of technological progress.

A full description of a technology consists of artifacts and procedures. The artifacts of steel technology are the ores, blast furnaces, rolling mills, and foundries that are employed in the production process, and the various types of steel shapes and products that comprise the outputs. The procedures are the ways in which the equipment and materials are used in the production of the outputs. In the common usage, however, the term technology is reserved for the artifacts alone, and this is the usage that will be employed here. Technological progress will be said to have occurred only when the artifacts employed in production may be said to have improved or when a new or improved product is introduced. Increases in output per unit of input that may be due to new procedures such as improved management techniques, methods of

economic planning, practices of production organization, quality control, and so forth, will not be regarded as instances of technological progress.¹ The subject of the study is therefore such things as machinery and materials and the products they produce.²

1.1. The Scope of the Study

The capacity of an economy to generate technological progress is a vast inquiry and we do not presume to undertake a study of that magnitude here. The scope of the study is limited in three ways: it deals not with the total Soviet economy but with one of its major sectors; it deals not with the total process of technological progress but with one major portion of it; and it deals not with all the factors that influence technological progress but with one major group of them.

The Focus on Industry

The study deals primarily with the civilian industrial sector of the economy. Innovation takes place of course in all sectors: agriculture, construction, transportation and communications, and so forth. Some of the same principles apply in all sectors, but each sector has special characteristics, and the larger the sectoral scope of the study the greater number of special considerations we should need to introduce. Industry, moreover, is the chief locus of innovative activity in a modern economy, for much of the innovation in the other sectors is based upon new products developed in the industrial sector, such as chemical fertilizers, construction and transportation equipment, and so forth.

There are of course differences within industry; among different branches of industry; between high priority and low priority industry; between producer goods and consumer goods industry; between large and small enterprises. Where the differences in innovational experience are substantial, account will be taken of them in the text. But on the level of the generalizations developed later, it is possible to regard all of industry as a reasonably homogeneous sector. The differences among groups within the industry sector may be regarded as variations around the central themes.

The Focus on Innovation

An instance of technological progress is a long chain of activities beginning with a new idea in the mind of man, proceeding through a variety of stages of research, experiment, development, design, production start-up, redesign, reengineering, and concluding with the attainment of

the designed capacity of the new product or process. Our study deals only with those last links in the chain that are referred to as innovation. The identification of innovation as a distinct process is an established tradition in the analysis of capitalist economies, and it occupies the central place in Joseph Schumpeter's influential theory of capitalist development.³ In that context innovation is distinguished from such other activities as invention and the ordinary management of enterprises; the power of the distinction is that it enables us to explain the troublesome notion of "profit" in a way that is more satisfactory than in the absence of the distinction.

It is not always the case that a category that has proved useful for the study of capitalist economies is also useful in the study of socialist economies, but this is such a case. The reason, however, is not because of any light it sheds on the notion of profit but because Soviet economic arrangements are such that the set of factors influencing the process of putting new products and processes into production are different from those that influence the earlier stages of the technological progress chain. The eminent physicist Professor Kapitsa has called attention to the use of the Russian word *vnedrenie*⁴ to refer to the process of transferring technological knowledge from the laboratory into production. The word "*vnedrenie*", he writes, "carries the meaning in Russian that a forward motion encounters resistance in the surrounding medium. We have become so used to the fact that every achievement of science and technology meets with resistance in the process of adoption that we have for a long time employed the word "*vnedrenie*," hardly noticing that with this word we are describing conditions that are not normal in the adoption of new technology."⁵ Nor are the problems associated with innovation a new thing; they are so deeply embedded in the structure of the economic system that scholars with long memories like Professor Kachalov recall *vnedrenie* as having been an issue in the early 1930s, when the basic economic arrangements of the Soviet economy were just taking form.⁶ And indeed the whole tenor of Soviet discussion of technological progress treats the process of innovation as involving a different set of considerations from those that characterize the earlier stages of the chain. Because the innovation process is governed by a set of factors that are to some extent unique to that process, it makes for a manageable subject of investigation. And because the innovation process is an important—one might say crucial—portion of the

chain, an understanding of that process is a contribution to the understanding of the total process of technological change.

The term "technological innovation" is sometimes used to refer only to the first appearance of a new product or process in the world. But it may also be used to refer to the first appearance of the new product or process in a country or in any enterprise in the country. We shall employ the last usage, for the interesting question is not merely the capacity of the system to introduce new products and processes for the first time in the world but also its capacity to promote the diffusion of innovations throughout the enterprises of the system. An act of innovation will be said to have occurred, then, whenever any enterprise introduces a product or process that it has never employed before. The term "innovation," unqualified, will refer to both products and processes; when the two need to be distinguished, they will be referred to as process innovation or product innovation.

One may imagine an economy in which innovation occurs rarely or not at all. The same products are produced year after year, although their quantities may increase and they may be produced in different proportions. And the same production processes are used, although they may be used in different combinations. One may imagine at the other extreme an economy in which innovation occurs at a very high rate. A large number of new and improved products pour forth year after year, and new and improved production processes are introduced with great frequency. The two economies differ with respect to what may be called their rates of innovation. It is the rate of innovation in Soviet industry that we wish to explain.

A satisfactory unit of measurement of innovation has not yet been devised. This unfortunately limits the possibility of testing quantitatively the propositions we shall offer in explanation of the Soviet rate of innovation, a matter to be discussed in Section 1.3. But for the main purpose of our study we do not require a precise quantitative unit. That purpose is to explain the ways in which certain properties of the economic system affect the innovation decision.

One such property, for example, is the price structure. Consider a group of enterprise directors faced with a choice between producing an established product next year or replacing it by a new one; assume for the moment that profit is a significant factor in making the choice. Then the decision to innovate will depend on the prices at which new

products can be sold relative to the prices of the older ones. If the pricing system generates high new-product prices relative to old, one would expect a larger proportion of the directors to innovate than will be the case if the pricing system generates low new-product prices relative to old. It is in this sense that we may say the rate of innovation depends on the price structure. For propositions of this form one does not require a precise measure of that rate. One needs only to demonstrate that the rate of innovation will be greater or less according to whether the economy exhibits one or another property.

The properties of the economic system affect not only the frequency with which innovations are introduced but also the distribution of innovations among industries, between consumers and producers goods, between processes and products, between small scale and large scale, between labor-saving and capital-saving advances, and so forth. From time to time we shall have occasion to take note of these distinctions, and we may therefore regard the object of study as both the direction and the rate of innovation. But for our main purpose the notion of "innovativeness" is sufficiently expressed in the broad sense of a rate of innovation.

The Focus on the Social Structure of the Economy

A very large number of factors would have to be taken into account in a full explanation of the rate of innovation in an economy. Our study is limited, finally, in that it deals with only one group of such factors. Our interest is confined to the "working arrangements for resource use"—to use Abram Bergson's felicitous expression—that constitute the "system" part of an economic system.⁷ It is the effects of the social structure of the economic system on the rate of innovation with which we shall be primarily concerned.

In limiting the study to economic structure, we must ignore the great many other factors that also influence the rate of innovation. Three groups of such nonstructural factors may be distinguished. One is the historical and cultural traditions of the society. Given the economic structure, a society with a long and honored tradition in science, technology, and enterprise may be expected to generate a higher rate of innovation than a society whose genius lay in other domains of human endeavor. Hence the innovative performance of the Soviet, or any, economy is no definitive test of the quality of the economic arrangements employed for allocating resources. The same economic structure

employed in different societies would generate better or worse outcomes.

A second group of factors consists of various technical properties of the society and its economy: the tastes and values that influence the structure of demand, the distribution of factor endowments, the age structure of the capital stock, the interindustry structure of the economy, and so forth. If the capital stock in a certain industry is of recent vintage and highly durable, for example, one would expect a lower rate of innovation of new processes than if the capital stock were older and approaching replacement. Again, therefore, the innovativeness of the economy reflects not only the quality of its social structure but also the nature of its various technical characteristics.⁸

A third group of factors consists of the policies employed in governing the economy. The performance of any system—social, biological, mechanical—depends not only on how it is built but also on how it is run. The poor performance of an automobile may be due not to a defect in its structure but to the ineptness of its chauffeur. In the case of the Soviet economy, for example, it has been shown that a great many of its unsatisfactory outcomes may be ascribed to the policy of excessive “tautness” in economic planning.⁹ With no change in the structure of the system, the economy would generate better outcomes if the governors did not strive to squeeze a greater output from it than it was capable of producing. Similarly, policies regarding the rate and direction of investment or expenditures on science and education affect the innovative performance of the economy.

The distinction between structure and policy is of crucial importance. “Down with the system” is the slogan of radicals, who believe that with the existing structure no policy changes could produce outcomes they would regard as satisfactory. To liberals, there is nothing wrong with the structure; it is because of inept or misguided policies that the outcomes are regarded as unsatisfactory. To conservatives, the outcomes are the best that can realistically be expected; neither policy changes nor structural changes are likely to make a better world. Differences in political positions reflect, to some extent, differences in values, in the degree to which a given set of outcomes is perceived as satisfactory or unsatisfactory. But they also reflect differences in beliefs about the nature of a social system—in the analytic “models” employed to explain and predict the changes in outcomes that may be associated with changes in structure and policies. Political positions are not easily influ-

enced by the results of social analysis. But to the extent that they are, there are few contributions that social analysis can make that are more important than the clarification of the nature of the dependence of social outcomes on the social structure and on the social policy of a society.

The distinction we have drawn between the structural and nonstructural determinants of innovation is merely heuristic. No strict lines are intended to be drawn, and whether one regards a particular feature of the economy as structural or nonstructural depends on one's analytic objective. In the next section we shall define in some detail what we will regard as the fundamental elements of economic structure. They are the independent variables, so to speak. The nonstructural factors are the parameters of our inquiry. The analytic problem may then be formulated as follows: *given* the kinds of people who manage the scientific, technological, and industrial establishments of the USSR; and *given* the age structure of the capital stock; and *given* the level of expenditures on science and technology; what are the effects of the structural properties of the economy on the rate of innovation? Or in a different but closely related formulation, how does the rate of innovation vary with changes in the structural properties of the economy? While the nonstructural factors are not the focus of our inquiry, from time to time they will be drawn into the discussion. In those instances we are fortunate to be able to draw on a variety of published research, particularly the authoritative OECD study on Soviet science policy.¹⁰

A full explanation of the rate of innovation in Soviet industry would require analysis of the influence of all factors just discussed: cultural and historical factors, technical characteristics, governing policies, and economic structure. In limiting this study to economic structure alone, we must renounce any claim to having explained *the* rate of innovation in Soviet industry. The study is intended rather as a contribution to that explanation by the light it sheds on one part of it: on the relationship between the structure of the economy and its innovative performance.

How much of the innovative performance of the Soviet economy is left unexplained by a study the scope of which is limited to the effects of the economy's structure alone? Were the microeconomic data freely available, we might design a statistical model with which to seek a quantitative answer. Having no such data, no quantitative answer can be offered. All that can be said, on the basis of the qualitative evidence pre-

sented throughout this study, is that the decision to innovate or not is heavily influenced by the structure of the economic arrangements within which such decisions are made. The influence is clearly sufficiently great to warrant study.

1.2. Economic Structure and Innovation

The rate of technological innovation depends in part on the nature of the social arrangements by which economic decisions are made. The set of arrangements may be thought of as the structure of the economy. One may imagine a set of structural arrangements that so encourages new products and processes as to generate a very high rate of innovation. At the other extreme one may imagine a structure that so inhibits technological change as to lead to a very low rate of innovation. The question is, what are the properties of economic structure that may cause such variations in the rate of innovation? The question is equivalent to asking what are the fundamental properties of an economic system.

If it were a capitalist economy with which we were concerned, we would know at the outset what structural property to look for in seeking to explain the rate of innovation. The two-hundred-year history of economic analysis has taught us to look at the structure of markets for the explanation of a great many outcomes. If the market structure is monopolistic, we expect a rate of output less than optimal and an inefficient allocation of resources; and if the market structure is perfectly competitive, we expect optimal levels of output and efficient allocation. If the market is oligopolistic, we expect a high rate of innovation, but if it is perfectly competitive, we expect a very low rate. The structure of the economy's markets is the fundamental structural property in the explanation of decision making and resource allocation in capitalist economies.

In approaching the analysis of socialist economies, it is often the practice to take as the point of departure the more highly developed theory of decision making in capitalist economies. It is a fruitful approach, because many of the categories of analysis of capitalist economies are sufficiently abstract (abstracted, that is, from the specific institutional arrangements of capitalism) to be readily adaptable to the analysis of socialist economies. Where this has been the case, the analysis of Soviet economic processes and performance falls readily into the mainstream of general economic analysis. The measurement of Soviet national in-

come and product, the analysis of its structure and its rate of growth, the estimation of the parameters of Soviet production functions, the measurement of aggregate factor productivity, the analysis of the input-output structure of the economy—in all these lines of research, the study of the Soviet economy is conducted in terms that differ little from the corresponding research on other economic systems.

But the concept of market structure is too specific to the institutions of capitalism to be readily adaptable to the analysis of the decision-making process under Soviet socialism. Hence in this central area of economic analysis, research on the Soviet economy has had to develop its own categories which, unfortunately, are rather specific to the institutions of Soviet-type economies. The result is an unhappy bifurcation in the field of economic analysis. One might have hoped that the understanding of economic systems in general would have been extended by the study of the Soviet species of economic system. But this has occurred to only a limited extent. The general economist continues to regard the Soviet economy as an aberrant case, perhaps a source of amusing anecdotes illustrating the surprising emergence of familiar economic principles here and there in that unexpected context but offering little instruction on ways of thinking about economic systems in general. Much research on the Soviet economy remains in a compartment by itself, containing its own language and its own categories.

We should like to show now that this unfortunate bifurcation is not necessary. It is possible to identify a set of structural properties that are common to all systems of economic decision making and that explain the outcomes of those systems. What distinguishes different economic systems is not that certain structural properties are present in some and not in others but that the precise form of those properties varies from system to system. Or in other words, all economic systems may be regarded as variations of the same set of fundamental structural properties, and variations in the outcomes of any economic system may be explained in terms of variations in those same structural properties. Those are the structural properties on which we shall draw in explaining the innovative process in the Soviet economy.

Prices and Decision Rules

The point of departure is the aforementioned seminal essay by Oskar Lange. The paper was a response to the argument that socialist societies could not allocate resources efficiently because they do not possess markets. Lange's contribution was to demonstrate that the question of

whether or not the economic structure is based on markets is not fundamental in evaluating its outcomes. The fundamental properties are rather the nature of (1) the set of prices that express “the terms on which alternatives are offered,” and (2) the set of rules that guide decision makers in choosing among alternatives. The markets of a private-property economy happen to be one type of social mechanism for generating prices, and the profit-maximizing objective of capitalists generates a set of rules for choosing among alternatives. But a system of markets is only one of many other possible ways of establishing prices and rules. If the socialist economy can establish the proper prices and decision rules, it has no need of the markets which are an element of economic structure unique to the historical stage of capitalism. Do not look for markets, says Lange, but look instead for the kinds of prices and rules that govern decisions in order to study the outcomes of economic activity. Following Lange, we shall regard the prices and the decision rules as the basic structural properties in our inquiry into the factors that determine the rate of innovation in the USSR.

Incentives

Lange was aware that prices and rules do not exhaust the explanation of the outcomes of a socialist economy. One may design an ideal price-setting mechanism and a perfect set of decision rules, and yet the socialist economy may fail to function in an optimal manner. But he did not pursue the search for the identification of those other structural properties that would explain the residual variation in the outcomes of economic activity. He limited his remarks to an expression of concern about the need to avoid somehow what he called “the bureaucratization of economic life,” but he did not expand on the structural properties implied in that notion.

On the basis of knowledge developed since his time on the ways in which real socialist societies function, it is now possible to give formal expression to the properties of socialist economies that he may have had in mind. One is the set of incentives. In a capitalist system, profit maximization provides both the rules for decision making, and the incentive to make economic decisions. In the absence of the profit-maximizing objective, the designers of a socialist society must take care to establish incentives that would elicit the desired effort on the part of workers and managers and would motivate them to attend to the prices and follow the established decision-making rules. A poorly designed set of incentives may cause the economy to generate unsatisfactory out-

comes, however well designed are its prices and decision rules. Incentives, then, are the third structural property to be studied in the search for the explanation of the rate of innovation.

Incentives must be distinguished from decision rules. A decision rule instructs the decision maker on the proper choice to make when confronted with a variety of possibilities. It may simply specify the objective to be pursued, leaving it to the decision maker to determine which possibility best attains that objective. Examples of such a rule would be "always make that decision that maximizes net profit," or "always choose that alternative that leads to the greatest percentage overfulfillment of the output plan." In other instances, the rule may be more specific, such as "choose that output at which marginal cost equals price," or "replace an obsolete machine by a new one when marginal cost on the old machine exceeds average cost on the new machine." A full set of decision rules is like a guidebook that contains an entry for every possible kind of decision that an enterprise may be expected to make, along with the recommended choice to be made in each case. The incentives may be thought of as another guidebook that lists all possible sets of results that an enterprise may attain and the rewards that the enterprise is entitled to claim for any listed set of results.

It is important to note that the rules and incentives are independent properties of the structure of an economic system. It is entirely possible to change the rules without changing the incentives, and vice versa. The rewards for certain results may be doubled, for example, without changing any of the decision rules. Or the rule may be changed from "maximize gross output" to "maximize profits," without changing the rewards available for all attained levels of output and profit. Thus a great many sets of incentives may be employed in conjunction with a great many sets of decision rules.

However, the design of a joint set of incentives and decision rules requires some careful attention. For they must articulate and be consistent with each other, else they will not lead to the desired kind of behavior. If the decision rule requires that a certain decision be made, but the incentives provide the major rewards for making some other kind of decision, the decision maker will be placed in an awkward position. As we shall see, the integration of decision rules with incentives is one of the most difficult problems faced by the designers of the Soviet economy.¹¹

Prices, rules, and incentives may be regarded as three fundamental and

independent properties of economic structure. But each of them is a complex set of relationships, and each may therefore be regarded as having its own structure. That is, when the relative prices of products change, we may regard it as a change in the structure of prices. Similarly, when some or all of the decision rules have changed, the structure of rules may be said to have changed. And when the relative amounts of the rewards for particular results have changed, the structure of incentives may be said to have changed. The structure of the economic system may be said to have changed whenever there has been a change in the structures of its prices, rules, and incentives.

Organization

The adequacy of incentives was part of Oskar Lange's concern about the danger of "bureaucratization" of a socialist system. But there was more to his concern than incentives alone. Empirical research on Soviet-type economies has devoted a great deal of attention to a set of problems that are clearly of central importance in understanding economic behavior in such systems but which have not yet been given adequate theoretical formulation.¹² They are the problems associated with the great complexity of the system of economic planning as it affects the enterprise, with the difficulties enterprises face in the purchase of inputs from other enterprises, with the pressures on enterprises to violate rules, falsify reports, neglect the quality of output, conceal information from the planners, and so forth. Much of that kind of economic behavior may be accounted for by the structure of prices, rules, and incentives. But there is a residual portion that remains unexplained, in the sense that even with perfect prices, rules, and incentives, certain of those activities would continue to occur. We propose to explain this behavior by reference to a fourth structural property, which may be called the organizational structure of the economic system.

By the organizational structure of a system we have in mind the units that comprise the system and the ways in which they relate to one another. A socialist (or any) economy may be organized in many different ways. There may or may not be a central planning board, and if there is, it may be assigned many different kinds of functions. There may or may not be organizational units called ministries, and if there are, they may also have many different kinds of functions. There may or may not be money and banks, and if there are, there are many ways in which the money supply may be regulated. In fact, in the history of the Soviet economy, many such organizational variations have been tried at one time or another.

It is a general assumption in the study of social systems that their performance varies with the way in which the systems are organized. We do not always know precisely how the outcomes may be expected to vary with variations in organizational structure, but that is very often the objective sought in the pursuit of knowledge. In the experimental study of small groups, for example, there are reasonably predictable ways in which the performance of groups (in solving some problem, for instance) will differ, according to whether the communications among the members are organized according to one plan or another. The performance of groups can be made to vary by varying properties other than their organizational structure: one can vary the sex or age of the players, or the nature of the problem requiring solution, or the incentives for solving the problem. The organization of the system is only one of the structural properties that affect performance.

While the empirical literature on the Soviet economy has dealt at great length with problems that are fundamentally organizational in character, there have been very few efforts at providing a theoretical framework for formalizing the organizational structure. David Granick proposed the first organizational model we are aware of, and Benjamin Ward's *The Socialist Economy* is the first monograph-length contribution to a formal organizational study of socialist economic systems.¹³ We present no formal organizational model here, but in distinguishing the strictly organizational influences on innovation from those accountable for by the other structural properties, we hope to have made some contribution toward the development of an understanding of organizational problems.

One must emphasize again that the structure of a system's organization is independent of the system's other structural properties. One may abolish ministries and replace them with regional councils, without changing the price structure in any way. Or one could change the incentive structure without changing the organizational structure. Any change in any structural property, however, may be expected to change the outcomes of economic activity, and, we hope to show, in a predictable way. One can combine any organizational structure with any incentive structure in the design of an economic system, much as one can combine any number of eggs with any amount of flour in baking a cake. Some recipes yield inedible cakes, however, and some combinations of structural properties yield unworkable economic systems—with zero or very low outcomes. The art of social design, like that of engineering design, requires an understanding of the system structure, so

that the structural elements chosen may be expected to yield satisfactory outcomes. Our formal knowledge of social structure is so much less sure than our knowledge of engineering structure that we must stand in awe of the task set for themselves by the designers of the Soviet economy. And if we find extensive defects in the design, they should be viewed in the light of the boldness of the task.

The Central Role of the Enterprise

One of the reasons that the study of decision making in the Soviet economy has not articulated with the corresponding study in capitalist economies is that the locus of decision making has been thought to be different in the two systems. In the capitalist economy the study of how economic decisions are made centers on the individual enterprise. The theory of the firm and the theory of markets (including demand) exhaust the explanation of the allocation of resources, at least in the pure laissez-faire economy. But in a Soviet-type economy an understanding of enterprise-level decision making may appear to contribute very little to the explanation of the allocation of resources, at least in the pure centrally planned economy. The major allocation decisions are made by the central government, and while enterprise-level decisions may affect the final allocation in some small ways, they are not a major part of the explanation. It is for this reason that theoretical work on centrally planned economies deals mainly with central decision making; with the efficiency of the balancing methods used by Soviet planners to obtain consistent input-output targets, for example, and with the methods of calculating economic returns to investment that are used in the central planning agencies. There have been a number of efforts to formalize enterprise-level decision making, sometimes cast in the same mathematical language that is used for capitalist enterprises; Lagrangian constrained maximization techniques, for example, and linear programming techniques.¹⁴ Such analyses have offered some imaginative explanations of the observed behavior of Soviet enterprises, but they are rarely productive of significant propositions about the economic system. They are rather elaborate efforts to explain curious forms of economic behavior which, however, appear not to count for much in the overall allocation of resources in that economy. It would seem that there is little place for a theory of the firm in the analysis of the Soviet economy, and no place for a theory of central planning in the analysis of a market economy. This asymmetry has been one of the obstacles to the development of a comparative economics of capitalism and socialism.

The approach adopted here is a departure in that it places the enterprise at the center of the decision-making process in the Soviet economy, and therefore coordinate with the place of the enterprise in the capitalist economy. The allocation of resources is determined jointly by enterprises and the central planning apparatus, parallel to the joint behavior of enterprises and markets in the capitalist economy. This elevation of the role of the enterprise requires some justification. First, the location of the center of decision making in the central planning apparatus has never provided a fully satisfactory explanation of how resources actually do get allocated in the Soviet economy. The great mass of familiar evidence about managerial maneuverability within and around the planned magnitudes is a perpetual denial of the view that when one has explained what Moscow decides, one has explained it all. In rejecting that approach, then, we are rejecting an explanation that has never been fully satisfactory, and has always to be accompanied by a qualification of unknown magnitude—"except that enterprises may not respond in the planned way." The behavior of Soviet enterprises is not a mass of "random noise," however. It follows systematic rules, as we shall show, and ought not be regarded merely as a set of disturbances in a pattern of allocation basically determined by the central plan. More parts of the puzzle fall into place if we view the outcomes of Soviet economic processes as the result of the joint behavior of central planners and enterprises than if we regard the enterprise as simply carrying out the instructions of the planners "with certain exceptions."

Second, the instructions or "commands" issued to the enterprise by the central planners are not strictly exogenous to the enterprise's own decision-making behavior. There are many known ways in which enterprises themselves influence the instructions that are later handed down to them by the central planners. We know, for example, that enterprises respond to the "ratchet" principle of planning in such fashion as to influence the level of the targets that will eventually be assigned to them by the central planners.¹⁵ But more important, a fundamental component of the planning process is the drawing up of draft plans by the enterprises, on the basis of a set of broad directives, or "control figures," issued by the central planners. The draft plans are then coordinated by the central planners and returned as final instructions to the enterprises. But the decisions made by the central planners are heavily influenced by the proposals made by the enterprises in the draft plans. If an enterprise, for example, decides to reduce costs by substituting material B for material A, it presents the decision tentatively in its draft

plan. Ordinarily the central planners will accept the enterprise's decision, and the final plan will contain an instruction to undertake the recommended substitution. If the central planners resist the recommendation (either because they regard it as a poor decision; or because the total demand for material B exceeds the supply in the summary of the draft plans, and some enterprises must be denied the increase in its use they applied for), the enterprise may fight for it nonetheless, for we know that the process of hammering out final plans involves a great deal of bargaining.¹⁶ In the end, the final official targets—the instructions—may not differ greatly from those originally decided upon by the enterprise and presented in its draft plan. There is no way of knowing how extensive enterprise influence is in this respect, but it appears that a great deal of central decision making turns out to be enterprise-level decision making; the enterprise is commanded to do what it had originally decided to do. This does not apply, of course, to such macroeconomic magnitudes as the overall rate of investment or its allocation among major sectors (although they too are affected by enterprise activity), but it does apply to a large range of year-to-year decisions on resource allocation. Hence, the structural elements that influence enterprise decision making explain more than simply the variations around the targets issued from above; they explain also a substantial proportion of those very targets. And for the same reason, the designers of a centrally planned economy, who must be expected to concentrate their efforts on the design of the central-planning decision-making process, must be careful not to neglect the decision-making process of enterprises. Defects in the latter process will have a substantial influence on the quality of the centrally made plans.

Third, the concern of this study is not economic decision making in general but a particular decision—the decision to innovate. One may conjecture that in a matter like innovation, the role of enterprise-level decision making may be relatively more important than in the normal static allocation decisions of management. It will be argued later, for example, that the slower the rate of technological change, the greater the effectiveness of central allocation; and in a world with no technological change, the central planners could eventually make every decision, leaving none at all to be made by enterprises. But the greater the rate of technological change, the less the capacity of central planners either to promote it or to plan it, and the greater the extent to which innovation is governed by the incentives, prices, and other structural

properties of the system that govern the decisions of enterprises. Therefore, since innovation is the outcome that is the center of interest in this study, the case for taking enterprise decision making as the point of departure is somewhat stronger than if our concern were with the general allocation of resources.

Finally, the models that have been fashioned by Western analysts to explain the operation of the Soviet economy were designed in the early postwar period. The patterns of decision making they sought to explain were based on data collected largely from prewar Soviet sources. Among the countless ways in which the Soviet economy of the seventies differs from that of the thirties is that of sheer size. In the first year of the first five-year plan the Soviet industrial sector consisted of some 10 thousand enterprises, employing about 4 million workers and 137 thousand engineers and technicians, with a total fixed capital stock of about 3.3 billion rubles (at 1955 prices). Toward the end of the sixth five-year plan (1969), the number of workers in industry had increased sevenfold, the number of engineers and technicians twenty-sevenfold, and the stock of capital is officially estimated to have grown more than sixtyfold. The number of individual state industrial enterprises reached a peak of 212,000 by 1954, but subsequent mergers brought the number down to about 50,000 in 1969.¹⁷

It is reasonable to expect that as the scale of a centralized system grows the effective control by the center over the units decreases. One may imagine a number of enterprises so small that the outcomes are totally determined by the decisions of the center. As the number of enterprises increases, some small portion of the decisions begin to be made by (or increasingly influenced by) the enterprises, but the outcomes are still largely explained by the decision of the center. As the number of enterprises continues to grow, the portion of the outcomes explained by central decisions continues to diminish, and the portion explained by enterprise decisions increases. Indeed, somewhere further along in the process of growth a point may be reached at which the portion of the outcomes due to enterprise decision making may exceed that due to direct central decision making. From that point on a model designed to explain centralized decision making may be less useful for the explanation of economic outcomes than one designed to explain the decisions of both central planners and enterprises.

When one reads the monographic literature on Soviet industry based on the evidence of the thirties, such as David Granick's *Management of*

the Industrial Firm in the USSR, one gets the impression that at that time "Moscow" had a fairly intimate knowledge of the operations of their enterprises.¹⁸ The industrial ministers maintained close contact with their major enterprises, and the heads of their chief administrations supervised the others closely. But by the fifties the center's knowledge of what their enterprise managers were actually doing was greatly reduced. Evidence of the concern over this creeping decentralization was the 1957 reorganization of the whole system of economic administration. The Moscow-based industrial ministers were abolished, and their functions transferred to some hundred-odd newly formed regional economic councils. The reorganization reflected the view that effective central control over the economy had grown weaker over time, and the shift to regional economic councils was an attempt to reassert that control.¹⁹ The attempt appears to have been unsuccessful, and in 1965 the regional council system was abolished and the older ministry system restored. But the problem that motivated the 1957 reorganization has not vanished and has probably grown more severe as the scale of the economy has continued to expand.

Hence, in seeking to explain the process of resource allocation in the early period, the notion of the centralized "command economy," as it was named by Gregory Grossman, provided a successful explanatory model.²⁰ But we may have now approached the time when that model explains less about how the system really operates than one designed to explain the joint behavior of planners and enterprises. We shall not attempt here to construct a formal model of that kind. But our study of the effects of enterprise decision making on innovation may be a contribution toward such a model.

Summary: The Structural Hypothesis

The argument of this section may be expressed in the form of a hypothesis: given the cultural and historical traditions, the technical characteristics, and the policies of government, the outcomes of any economy are fully explained in terms of four fundamental properties of economic structure: prices, decision rules, incentives, and organization. In statistical terms, the hypothesis states that the variability among the economic outcomes of various possible states of a given economic system, or of various economic systems, that is not explained by nonstructural differences, is fully explained by the four structural variables. The hypothesis has been expressed in its strongest terms not in the belief that it could be sustained in that form but in order that its form stand

forth clearly. Loosely speaking, the hypothesis is that these four structural properties explain most of what it is that one wants to explain in seeking to understand how different kinds of economic arrangements work. It is an expression of what is believed to be "important," or what one ought to look for, in seeking an explanation of such economic behavior as innovation.

In the opening remarks of this section, it was noted that if it were a capitalist economy with which this study were concerned, one would know what structural property to look for in explaining innovative behavior—namely, the structure of markets; but that in examining a socialist economy, one does not quite know what to look for. The structural hypothesis presumes to provide the answer. It specifies the structural properties to examine in explaining behavior, in both socialist and capitalist economies. In the latter case one would still turn to market structure if the objective of the analysis were to understand that economy alone. But for the purposes of comparing capitalist economies with others, market structure will not do. One requires some more fundamental structural elements that are not specific to the capitalist economic arrangements. The four structural properties are proposed as precisely those elements. The "market structure" of a capitalist economy may be regarded as a name given to certain historically-specific forms of the same general structural properties; monopoly, for example, is an economic arrangement in which the decision rule is "produce that output at which marginal cost equals marginal revenue"; the price exceeds marginal cost by a specifiable amount; the incentive is profit; and the organizational structure is one in which the enterprise is a single seller in a market with many buyers. The enterprise in a centrally planned economy differs from this only in that it is characterized by different specific forms of each of the same structural properties. Thus the hypothesis proposes a set of universal elements in terms of which economic systems may be readily compared. Because these four properties are thought to be of universal applicability, it may be hoped that the analysis of the Soviet economy to follow will not be regarded as specific to the structure of a Soviet-type of economy but as a contribution to the understanding of economic systems in general.

The study proposes to show that the innovation decision in the USSR is fairly completely accounted for in terms of these four structural properties of the economic system. But how can one prove a proposition of this sort? And by what kind of evidence can it be supported?

There are indeed certain problems in verifying propositions of this kind in the case of the Soviet economy that require some discussion in this introductory chapter.

1.3. The Quantitative Study of the Soviet Economy

One can be said to “understand” a system when one has a theory about it. The basis of a theory is the specification of those factors or variables that account for the outcome one wishes to explain or predict. The preceding section provides the basis for a theory of the innovative performance of the Soviet economy. It states that to explain the rate of innovation in the USSR, one must look at four properties of the structure of the economy: its prices, decision rules, incentives, and organization.

The basis of a theory tells us only that some outcome is affected by a certain set of factors, but it does not yet tell us precisely how the explanatory factors affect the outcome. A proper theory consists of a set of propositions, testable it is hoped, specifying precisely how the outcome may be expected to vary under various conditions or values of the explanatory factors. A number of such propositions are developed in the text. They take the form, for example, of the assertion that the higher the prices of new products relative to those of established products, the greater the rate of innovation of new products; or the greater the material incentive for producing new products relative to established products, the greater the rate of product innovation will be.

Up to this point the strategy of research on the Soviet economy takes the same form as that of economic research in any society. But it is in the attempt to test behavioral propositions that one faces a serious obstacle in the case of the Soviet economy that does not arise in the case of many other societies. Ordinarily one would seek to test behavioral propositions by gathering statistical data in order to see whether one can infer from the data the existence of the postulated relationship among the variables. In the best of cases one can estimate the values of the parameters that relate the variables, and those values can be employed with other data for predicting the behavior of the variables. The data are ordinarily published by government or trade associations or research organizations. If the data are not available in the form needed for the research, the analyst generates them himself if he can find the funds. If he requires data on the innovation experience of enterprises, he may circulate a questionnaire and often succeeds in collecting the data in the form in which he needs them.

The unfortunate fact is that the data needed for undertaking serious quantitative research on Soviet enterprises are generally lacking. The Soviet government publishes a variety of quantitative data of a macroeconomic nature: on the national income and its main components, on the production levels of a great variety of commodities, on foreign trade, on financial flows of various kinds. The data permit certain kinds of macroeconomic quantitative study of the Soviet economy; one can study aggregative production functions, and one can develop national income accounts with some degree of disaggregation among the main components and sectors of origin. But virtually no data are available that can be used for quantitative microeconomic study of the economy. One finds occasional reports of surveys of the experience of enterprises, and scattered data on individual enterprise performance. But it is impossible to assemble data with which to test propositions of a microeconomic nature. If one wished to test propositions on the effect of enterprise size on the rate of innovation, or on the effect of various incentive schemes on innovation, one cannot expect to do so on the basis of quantitative data on the experience of individual enterprises.

If it were a more open society, the analyst could circulate questionnaires among enterprises and reasonably hope to enlist their cooperation in providing the data needed to test propositions on managerial behavior. The student of the Soviet economy looks with envy at the depth of analysis achieved in such work as that of Edwin Mansfield on the United States economy and C. F. Carter and B. R. Williams on the British, both based on data collected by surveys of enterprises.²¹ The collection of survey data in the USSR is obviously impossible for the outside analyst, although Soviet researchers apparently are able and do collect certain data of this kind. But there is another reason why the quantitative testing of propositions is much more difficult in the microeconomic analysis of the Soviet economy. The reason is that the organization of enterprises is established by the state, and when a certain organizational arrangement is decided upon it tends to be applied to all enterprises. The managerial organization of enterprises tends to be the same everywhere, with slight exceptions to take account of special conditions in individual industries. The incentive systems tend also to be the same. But to test hypotheses on behavior, one requires a certain scatter of points so that one can compare, for example, enterprises with one type of managerial structure with those of another, or one type of incentive system with another. Because of the uniformity of organiza-

tional properties even if the data were available, satisfactory tests of behavioral propositions would often be impossible to conduct.

Hence the analyst who insists on quantitative microeconomic research must ply his trade somewhere other than on the study of the Soviet economy. But if one's objective is to understand the Soviet economy, one must be content with something less than the kind of data he would require if he were working on the economy of another country. In particular, the kinds of propositions we shall develop here must be tested by standards that fall short of those one would employ in studying the economy of a more open society. The tests must depend upon such evidence as the published accounts of the decision-making process by officials of Soviet enterprises and by economists and others who have greater access than foreigners to the experience of their own country. The evidence is generally qualitative, occasionally supported by scattered quantitative data that must be regarded as illustrative rather than sufficiently systematic to support genuine quantitative tests of propositions. One must rely further on the logic of the propositions in the light of the qualitative evidence—whether they “make sense,” or what historians and jurists refer to as the “weight of evidence.” These are not proofs as we would use the term if one were fortunate enough to be able to apply statistical and econometric tests. But they are the best that can be done.

1.4. Outline of the Argument

The first structural property with which the study begins is the structure of organization. Chapter 2 describes the organizational units that comprise the economic system, with particular attention to those that are most directly involved in the innovation process. The other chapters of Part I study the effects of that organizational structure upon the enterprise's decision to innovate. The effects of organizational structure are transmitted to enterprises through both the supply of its inputs and the demand for its output. Chapter 3 examines the effects of organization structure on the enterprise's supply of materials and equipment, Chapter 4 deals with the supply of research and development services, Chapter 5 with the supply of labor, and Chapter 6 with the supply of financial resources. The question asked in each chapter is: What is the effect on the enterprise's decision to innovate, of the ways in which the Soviet economy organizes the supply of these inputs to its enterprises? Chapter 7 concludes Part I with the corresponding question regarding

the demand for the enterprise's output: the effect on innovation of the ways in which the economy organizes the selling, or distribution, of the enterprise's output. Throughout this part it is assumed that prices, incentives, and decision rules are given.²²

Part II deals with the influence of the price structure on the innovation decision. The general problem, discussed in Chapter 8, is that the profit rates on new products tend to be lower than those on older products. The source of the problem is to be found in part in the cost behavior of new products, which is discussed in Chapter 9. Chapters 10 and 11 examine various special pricing methods that have been introduced to take account of the unique cost behavior of new products. Product improvement, an important form of innovation, presents certain pricing problems of its own, which are taken up in Chapter 12. This part concludes with the effects of the methods of price administration, as distinct from the principles of pricing, on the innovation decision.

Given the structure of organization and prices, managers follow certain rules in choosing among alternative production programs. The rules of choice and the incentive structure from which they are derived are the subject of Part III. Chapter 14 discusses the incentives and rules that govern decision making in general. Certain special incentives established to encourage the decision to innovate are examined in Chapter 15. Chapter 16 evaluates the general effect of the structure of incentives on the innovation decision. The concluding chapter summarizes the strengths and weaknesses of the economic structure and offers some observations on the prospects for accelerating the rate of innovation.

Notes

1. "Social innovations" of that kind, however, may have the effect of increasing the rate of technological innovation. In the present study, such social arrangements are our independent variables, while technological progress is the dependent variable. The objective is to study the influence of social arrangements on the rate of technological progress.
2. Improved or new services such as faster and safer transportation will be regarded as instances of technological progress only if they are the product of improved technology such as aircraft.
3. Joseph Schumpeter, *The Theory of Capital Development* (Cambridge: Harvard University Press, 1936).
4. The usual English translation is "introduction," as in the expression "introduction of new technology into the economy."
5. P. L. Kapitsa, *Teoriia, eksperiment, praktika (Theory, Experiment, and Practice)* (Moscow: "Znanie," 1966), p. 7.
6. Cited in Alexander Korol, *Soviet Research and Development: Its Organization, Personnel, and Funds* (Cambridge: The MIT Press, 1965), p. 5.
7. Abram Bergson, *The Economics of Soviet Planning* (New Haven: Yale University Press, 1964), Chap. 1.

8. The expression "structure of the economy" is very broad and may refer to any of a great number of structural properties. Those listed earlier may be called "technical" structural properties. The "technical" structure of the economy may be distinguished from its "social" structure, the latter referring to the social arrangements for producing and distributing goods and services. In this study the expression "structure of the economy" will refer to its social structure.

9. Holland Hunter, "Optimum Tautness in Developmental Planning," *Economic Development and Cultural Change*, Vol. 9:4, July 1961, pp. 561-572.

10. E. Zaleski, J. A. Kozlowski, H. Wienert, R. W. Davies, M. J. Berry, and R. Amman, *Science Policy in the USSR* (Paris: OECD, 1969).

11. The problem of integrating incentives and decision rules does not arise in the classical capitalist economy in which the decision maker is an autonomous owner entrepreneur. His incentive is profit, and he has no reason to follow any rules other than those that maximize his profit. Incentives and decision rules are therefore automatically integrated. In the Soviet economy, however, as in the modern capitalist corporation, enterprise decisions are made by hired managers. The "owners" must inform the managers about the decision rules they are to follow, and an incentive system must be designed that will motivate the managers to follow those rules. In any artificially designed social system there is ample room for error, and one ought not expect a perfect articulation of the structural elements.

12. See, for example, Joseph S. Berliner, *Factory and Manager in the USSR* (Cambridge: Harvard University Press, 1957); David Granick, *Management of the Industrial Firm in the USSR* (New York: Columbia University Press, 1954); Janos Kornai, *Overcentralization in Economic Administration* (London: Oxford University Press, 1959).

13. David Granick, "An Organizational Model of Soviet Industrial Planning," *Journal of Political Economy*, Vol. 67, April 1959, pp. 109-130; also *Soviet Metal-Fabricating and Economic Development* (Madison: University of Wisconsin Press, 1967), Chap. 7; Benjamin Ward, *The Socialist Economy: A Study of Organizational Alternatives* (New York: Random House, 1967).

14. Edward Ames, *Soviet Economic Processes* (Homewood, Ill.: Irwin, 1965).

15. If an enterprise overfulfills a plan target in a given period, the central planners often raise the required target for the next period to the level attained in the given period. This has been called the "ratchet" principle (Berliner, *Factory and Manager*, pp. 78-79). Managers, aware of this practice, tend therefore to avoid overfulfilling plan targets by too large an amount. In this way, the enterprise can influence the level of the target assigned to it for next period.

16. Berliner, *ibid.*, pp. 224-230.

17. TsSU, *Strana sovetov za 50 let (The Land of the Soviets After Fifty Years)* (Moscow: Statistika, 1967), pp. 34, 36, 62; TsSU, *Narodnoe khoziaistvo SSSR v 1969 godu (The USSR National Economy in 1969)* (Moscow: Statistika 1970), pp. 45, 165, 497; TsSU, *Narodnoe khoziaistvo SSR (The USSR National Economy)* (Moscow: Gosstatizdat, 1956), p. 42.

18. David Granick, *Management of the Industrial Firm in the USSR* (New York: Columbia University Press, 1954).

19. Another objective of the reorganization was to remove the dysfunctional effects of ministerial "empire building" and of the departmental barriers that had been erected among ministries.

20. Gregory Grossman, "Notes for a Theory of the Command Economy," *Soviet Studies*, Vol. 15, October 1963, pp. 101-123.

21. Edwin Mansfield, *Industrial Research and Technological Innovation* (New York: Norton, 1968); C. F. Carter and B. R. Williams, *Industry and Technical Progress* (London: Oxford University Press, 1957).

22. In the analysis of each structural property it is assumed that the others are given. That assumption weakens the generality of the conclusions, for the structural properties are probably not linearly independent. That is to say, the effect of a given organizational structure on the

decision to innovate is not independent of the kind of incentive structure or price structure with which it is conjoined. The effects of interdependence are noted and discussed at various places in the text; for example, Sec. 4.3 (The Problem of Monopoly) and Sec. 7.3 (The New Sales Rule).