The Market As A Procedure for Discovery and Conveyance of Inarticulate Knowledge

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The purpose of this essay is to elaborate on F. A. Hayek’s argument that the competitive market is a procedure for the discovery and conveyance of decentralized knowledge, and to wield this argument against a particular body of “market-socialist” central planning theory that has variously been called “plannometrics” (Wilczynski), “Computopia” (Neuberger) or “Mechanisms for Resource Allocation” (Hurwicz). Despite the growing acceptance of Hayek’s theory of the price system as a transmitter of decentralized knowledge, it will be argued that one aspect of his analysis has not been adequately appreciated: the “inarticulate” nature of much of the knowledge is meant the knowledge of how to do something successfully (e.g. ride a bicycle) without the further knowledge of how to explicitly say how the thing is actually accomplished such as that in order to keep one’s balance on a bicycle it is necessary to compensate for a given angle of imbalance, by steering the bike so as to make a curve of which the radius \( r \) should be proportionate to the square of the velocity over the angle of imbalance.\(^2\)

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1 Useful surveys of much of this literature have been supplied by Arrow and Hurwicz (1977), Hurwicz (1973) and Benjamin Ward (1967a, 1967b) and of some closely related literature by Takashi Negishi (1962).

Professor Hayek has recently indicated that he does not consider the Hurwicz type models to be any better in their treatment of “the knowledge problem” than Lange’s models had been (1982, p. 141).

2 This example comes from Michael Polanyi (1969, p. 144), who has supplied the most extensive defense of the necessary role of unarticulated knowledge in all sciences. See Polanyi (1958).

Origins of the idea that there are necessary limits to articulability seem to have come from the discipline of mathematics, especially the contributions of Georg Cantor, Alonzo Church, and especially Kurt Godel. Both Polanyi (1958, pp. 259-260) and Hayek (1962, p. 62) have referred to Godel’s work as a special case of a general limit to articulability.
The main contention of this paper will be that businessmen under capitalism, to use the terminology of Gilbert Ryle, "know how" to operate their business relatively efficiently even though they do not "know that" what they are doing amounts to the selection of a production technique that to some extent adheres to the efficiency standards of theoretical economics. It will be argued that the competitive market system can make use of such inarticulate knowledge in a way that the market-socialist models of resource allocation, by their very nature, cannot.

The seminal contributions to economics and knowledge that were made by Hayek in the late thirties and forties developed out of his encounter with Oskar Lange and others in the "Calculation Debate," the most important theoretical controversy in the field of comparative economics. It was primarily his attempt to answer the early market-socialist models, that had in turn been formulated in response to Ludwig von Mises' famous 1920 challenge, that led Hayek to focus on the market as a process for the discovery and dissemination of decentralized knowledge. One could say it was only in the dialectical process of countering the claims of such market-socialists that Hayek was able to so sharply articulate what Mises had left largely implicit: the way the competitive system acts as a knowledge-dispersal mechanism. There is no doubt that the Mises-Hayek position benefited enormously by being forced to confront the Langean variant of market-socialist models.

Market-socialist models, because they aim at achieving the beneficial results of competitive markets without relying on the property rights institutions that underlie them, do seem to be ideally suited as foils for a positive analysis of the functioning of such institutions. Thus it may be appropriate to begin this essay with an examination of the modern descendants of the market-socialism Hayek had criticized, using these modern models as a point of departure for an elaboration of the role of knowledge in competitive markets. Part I will briefly describe these "mechanisms for resource allocation" emphasizing not the details of the models, but rather their historical origins in the famous debate and the general claims that have been made as to the nature of their present and potential contribution to economics. I will contend that although these models claim to have learned an important lesson from Hayek’s critique of the Lange-type models of the thirties, they all still make an impermissible assumption about the articulability of economic knowledge that Hayek then and since warned against.

The obvious question this critique of market-socialist models raises is: How, then, does a genuinely competitive system manage to make use of knowledge that its own participants cannot even articulate? If private property institutions can do no better, then the critique of these models would be empty. To try to meet this objection, Part II will outline an analysis of the way competitive markets are able to effectively discover and use knowledge without requiring its articulation.

Richard Nelson (1981) has perceptively observed that Hayek’s knowledge-dispersal argument is really an entirely different kind of justification for "private enterprise" than the welfare economists’ notion that perfect competition represents an ideal state of efficiency. In a sense one might say that the argument is not that competition gives us the optimal combination of resources
but rather that competition represents a procedure for the discovery and dissemination of information that would otherwise not be available in any usable form. The point is not that markets produce a perfectly competitive rather than, say, a monopolistically competitive equilibrium, but rather that markets provide an equilibrating or coordinating process. It can be argued that the standard for judging the cogency of this Hayekian thesis should not properly come from within the usual realm of welfare economics but should conform to the standards of the contemporary analysis of the growth of knowledge within the very different discipline of the philosophy of science. To lend some plausibility to the argument of Part II, then, Part III will develop an analogy between the kind of economic discovery process Hayek describes and the modern analysis by philosophers of science of the process by which science progresses. It is not the aim of this part to prove that this philosophical approach to scientific discovery processes is valid, although I think that it is, but rather to show that Hayek’s theory of the market is remarkably similar in structure.

Professor Nelson’s purpose was not to defend the Hayek type of argument but only to point out that it is in fact different from the standard argument of microeconomic theory and thus requires its own justification. My purpose will not be to supply that full justification here but to discuss the basic form such a justification should take. It is in the spirit in which he ended his challenging article that I begin mine:

Our well worked out theoretical ideas [orthodox welfare economics] are not particularly relevant, and the ideas that may have some relevance [such as Hayek’s] are at a most rudimentary stage of development. We have collected some empirical information which bears on the issues, but not very much. It is time to get on with the task (p. 110).

I. “Market-Socialist” Models of Mechanisms for Resource Allocation

The models to be commented upon here are attempts to design mechanisms for the centrally planned allocation of resources that nevertheless endeavor to use knowledge that exists in decentralized form. The aim of these highly theoretical “market-socialist” models is to construct a method for using price information in resource allocation without relying on the rivalrous clash of private owners in competition as the mechanism by which prices are adjusted. Thus unlike the market-socialist reform movement in Eastern Europe with which these models are sometimes associated, these theoretical market-socialist models do not propose the dilution of centralized economic power and the introduction of genuinely competitive profit and loss criteria in lieu of central planning. They are rather attempts to reconcile the price system with planning by the formulation of mathematically sophisticated procedures for adjusting prices toward equilibrium.\(^3\)

\(^3\)The distinction between these two varieties of “market-socialism” is complicated by the fact that many of the leading representatives of the theoretical approach discussed here (e.g.,
These theoretical models, it should be stated at the outset, are most definitely not descriptive of any real economies of either the East or the West. Although the East European economic literature and western comparative economics seem preoccupied with these models, nowhere has any of them found economy-wide implementation. Indeed this has been the source of some embarrassment to the developers of these models who have had to justify their efforts on the grounds that the continued extension of these models may one day make their practical realization possible.

The key difference between these theoretical models and the real world, both "capitalist" and "socialist," is in their process of adjusting prices. Real world price adjustment occurs as a consequence of the clash of mutually inconsistent plans, and thus entails trading at "false prices." Because exchanges are made at disequilibrium prices, production projects are begun that, in the nature of the situation, cannot possibly be completed. These theoretical models, on the other hand, aim at discovering an equilibrium configuration of prices in advance of any actual production activity. They seek to pre-coordinate plans before launching any projects, whereas in the real world plans are post-coordinated by the calculation of profit and loss during and after the implementation of production projects. It may be granted that if it is possible to organize an economy by such pre-coordination, this would in many ways be a superior way of rationalizing economic activity to the crude coordination that takes place in historical economies of "socialist" or "capitalist" varieties.

These models, then, despite their purely theoretical nature, are very significant in one respect that is not often recognized. They are proposals aimed at achieving what was historically the primary economic goal of socialism and is still implicit in most socialist critiques of capitalism: the replacement of rivalrous competition as the ordering mechanism of social production with conscious, pre-coordinated central planning. All actual attempts at "central planning" have reneged on this promise. They have had to rely on competitive forces, profit and loss indicators, the use of money in private exchange; in short they have resorted to what Marx disparaged as "anarchic" production. In practice the central plan regulates and intervenes in the production process but does not subsume this process under conscious, deliberate control, as the classical socialists had hoped. Thus nothing less than the chief economic raison d'etre of the socialist movement, the major political-economic movement of our century, stands or falls, on the success or failure of these theoretical models. Their failure to date to find anything resembling real-world implementation has already seriously eroded the main rationale for central planning as a replacement for "anarchic" production. Their success could resuscitate that desire for central planning, just as a convincing argument demonstrating the impossibility of their implementation could deal central planning a fatal blow.

The earliest forms of these models (Dickinson, Lange, Lerner, Durbin)

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Oskar Lange, Leonid Kantorovich, and Janos Kornai have also been leading advocates of the liberal reform movements in their respective countries (Poland, the Soviet Union, and Hungary).

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For a clear exposition of this classical aspiration of central planning and an explanation of its abandonment in the Soviet Union, see Paul Craig Roberts (1971).
simply formulated "rules" that plant managers were to be instructed to obey involving some variation on the imperative: "Set output at that level where marginal cost of production equals marginal revenue." The prices the plant manager was to use to carry out this order were to be treated by him as "parametric" and set by the Central Planning Board (CPB) by a virtually unexplained procedure named "trial and error". F. M. Taylor said as much about "trial and error" in his thirteen page address to the American Economic Association in 1928 as any of the later and more elaborate treatments of market-socialism in the thirties and forties. And all he said was that the CPB should take a random stab at the price of a certain good, wait to see if stocks of the good would pile up or run down, and then adjust the price down or up accordingly.

In the thirties and forties it was apparently assumed that so simplistic a price adjustment method was enough to get the prices to approximate or even reach equilibrium. The great virtue of the modern descendants of these models is that they now recognize how problematic the question of equilibration really is. Extremely restrictive assumptions have to be imposed on these models to get them to converge to an equilibrium. This is surely an advance over the cavalier treatment this issue received in the hands of the first market-socialists.

An opinion that is widely held in the field of comparative economic systems is the view that both of Hayek's arguments against central planning (which I will call the "computation problem" and the "knowledge problem") were satisfactorily answered by the Lange-type model and have been conclusively met by modern extensions of that model. One of the leading contributors to the modern market-socialist literature, Leonid Hurwicz, describes the first of these arguments:

It should be recalled that one of Hayek's (1935, p. 212) chief points in summing up the state of the debate concerning the feasibility of a centralized socialist solution was that the number of variables and equations would be "at least in the hundreds of thousands" and the required equation solving "a task which, with any of the means known at present, could not be carried out in a lifetime. And yet these decisions would . . . have to be made continuously."5

Numerous contemporary commentators on the calculation debate have referred to this "computation argument" as one of Hayek's main arguments and then gone on to remind the reader that since 1935, of course, with the development of high-speed electronic computers, this objection is now completely obsolete.6 Although the confident dismissals of Hayek's comment have not been supplemented by any clear demonstration that even the largest and most sophisticated modern computers could master the required computation problem, it should be admitted that this problem does not seem nearly as

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5Hurwicz (1973, p. 5).

6See e.g. Lange (1967, p. 158) who regrets that he did not have the example of computers to offer in the debate, in which case he says he could have more easily refuted Hayek's challenge. See also Cave (1980, p. vii).
forbidding today as it must have in 1935. Nevertheless, it is rarely acknowledged that even then Hayek treated this computation problem not as one of his “chief points” but as a secondary part of his critique of the market-socialist models because he doubted that anyone could have seriously advocated solving equations as a procedure for central planning.  

In any case, by 1936, long before the development of computer science, Oskar Lange had answered this “computation problem” in another way, by breaking up the information processing task of the central planners with his system of marginal cost pricing rules. These can be viewed as rudimentary versions of what have today come to be called “decomposition algorithms,” according to which the tremendous computational problems facing the CPB can be parcelled out to separate decision-makers, i.e. the plant managers. Thus in these market-socialist schemes it is never necessary for the central planners alone to tackle this monstrous system of simultaneous equations. Instead it can be solved “in pieces” by the cooperation of planners and plant managers in a kind of “simulated market.”

But, as Hurwicz points out. Hayek’s challenge to central planning was not only that the computation of solutions to the equations would be a task far beyond the algebraic capacities known at the time. He had also made the more fundamental argument, the “knowledge problem,” that the information necessary to formulate the equations could not be effectively gathered into the central agency. As Hurwicz (1973, p. 5) puts it, this second Hayekian argument refers to “the difficulty of placing all the relevant information in the hands of a single agency because information is dispersed throughout the economy.” Since the relevant information is scattered in bits and pieces any attempt to relay all of it to a single agency before it starts its calculations “is regarded as either impossible (in the sense that much information would be lost) or too costly in relation to the existing accuracy requirements.” Hurwicz refers in this context to Hayek’s 1945 essay “The Use of Knowledge in Society” and thus appears to be addressing the central issue of knowledge-dispersion.

As an answer to this second objection the market-socialist models of Lange’s

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7 Immediately after mentioning the famous “hundreds of thousands” of equations Hayek (1935, p. 213) wrote

It is improbable that anyone who has realized the magnitude of the task involved has seriously proposed a system of planning based on comprehensive systems of equations.

In fact H. D. Dickinson originally did claim that such equation-solving was a viable method of planning but retreated from this position after Hayek’s critique. Immediately after dismissing this notion, Hayek proceeded to spend the bulk of his analysis on a “trial and error” solution similar to the one Lange was to elaborate a year later, which Hayek thought must have “actually been in the minds” of the market-socialists.

8 See, e.g., Dantzig and Wolfe (1961).

9 Below it will be argued that Hurwicz’s paraphrasing of Hayek seriously misrepresents the latter’s whole point. Hayek was not talking about costs of transmitting known bits of data, either in the sense that some known data would be lost, or in the sense that some of its accuracy would be sacrificed.
day were not so successful. The burden of “finding” by “trial and error” the optimal configuration of prices fell entirely on the shoulders of the CPB in Lange's model, and no definite mechanism was specified by which plant managers could communicate with the CPB to help it locate equilibrium prices. This, then, has been the main aim of the descendants of the Lange model, to devise detailed procedures to marshall decentralized and dispersed knowledge through a minimum of information transfers in order to deliberately set prices at (or near) their equilibrium levels without resort to private competition.

To answer this “knowledge problem,” modern market-socialists have designed procedures that assume that the knowledge available to each participant is strictly localized. As Hurwicz (1973, p. 5) put it, “A natural assumption is that, initially, each economic unit has information about itself only: consumers about their respective preferences, producers about their technologies, and resource holders about the resources.” The Central Planning Board in most of these models is never assumed to know the production functions that are known only by the individual producers themselves. Furthermore, in some of these models the producers are assumed to “know only certain parts of their production functions” with which they have had experience rather than all possible techniques corresponding to any set of prices. This dispersed knowledge is then used by the CPB through a series of questions it poses to the localized producers.

The only data that need to be communicated in this way are strictly prices and quantities, since, as Hayek’s work on knowledge and economics is understood to have demonstrated, prices are an "informationally efficient" summary of more detailed knowledge. Decision-makers, as Hayek’s famous example illustrates, need not know whether demand for tin has risen or the sources of supply have shrunk; they only need to know that the price has gone up and therefore that they should economize in their use of tin. This presumably shows that the only information the CPB has to disperse in these models is a list of prices and that the only response they need to elicit from suppliers is output quantities supplied and input quantities demanded at those prices. The number of numbers that would have to be transferred for a market-socialist system would not pose a serious problem for modern communications networks.10

A great variety of procedures have been developed along these lines each specifically suited to certain assumptions about the shapes of the relevant locally-known production functions, and each formally proving that the system will converge to an equilibrium within some finite number of “iterations.” In most of these models the CPB postulates a set of prices of all goods and services to which plant managers respond with how much of their product they can produce (and which configuration of inputs they would thereby require) at these prices while keeping marginal costs equal to marginal

10Benjamin Ward (1967b, p.61) comments that, Hayek’s criticism notwithstanding, “communication between sectors and plan bureau . . . cannot be a bottleneck to extension of the schemes” because such communication only “involves at each round sets of numbers that should not exceed n² for any one unit, where n is the number of sectors, and is generally much less.”
revenues. From these quantities submitted by all plant managers the CPB then revises the set of prices and asks again, how much of each product would be produced and what inputs would be demanded at these prices. The "dialogue," as it is called, continues until an equilibrium, or in some cases a feasible approximation to equilibrium, is attained.

If this were a proper interpretation of Hayek's second criticism of central planning, there can be no question but that there has been steady progress in the development of increasingly sophisticated responses to it. The earliest models assumed smooth strictly concave economies (with diminishing marginal utilities and diminishing returns to scale). In the 1950s, procedures were developed for linear economies using the simplex method and then extended to more involved linear programming techniques in the early sixties. These were in turn extended to nonlinear models and then to cases of nonconvexity (increasing returns), and strict concavity. Still more elaborate mechanisms are being formulated using the notion of the gradient approach to the saddle point of the Lagrangian expression.

Although, as even the most enthusiastic contributors to this literature admit, these procedures are only valid for rather specialized models under very stringent assumptions, nonetheless they do appear to be relaxing some of these assumptions and slowly advancing toward somewhat more realistic ones. Hurwicz (1973 p. 27) rather modestly concludes his survey of these allocation mechanisms by suggesting that we should view them "somewhat like synthetic chemicals: even if not usable for practical purposes, they can be studied in a pure form and so contribute to our understanding of the difficulties and potentialities of design." But several other authors boldly suggest that one day, perhaps upon the further development of computer science and technology or of data collection methods, these models might actually control a modern economy.11 Even on their own terms these designed mechanisms for resource allocation are only in their infancy and are nowhere near any serious consideration of actual implementation in the real world, despite some phenomenal advances in mathematics and computer science that it had been hoped might accelerate their utilization. But in spite of the immense difficulties they face, the market-socialist models continue to suggest to their supporters at least the remote possibility of realizing the original ambition of socialism to bring society's production under genuinely conscious and deliberate control.

But is this really even a remote possibility? Have the market-socialists posed for themselves the right question? Even in his earliest critique of socialist models Hayek had stressed not only that the relevant knowledge is scattered but also that it is not in any articulated form that is amenable to communication to the CPB.

It is hardly necessary to emphasize that this [concentration of knowledge] is an absurd idea even in so far as that knowledge is concerned which can properly be said to "exist" at any moment of time. But much of the knowledge that is actually utilized is by no

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means "in existence" in this ready-made form. Most of it consists in a
technique of thought which enables the individual engineer to find
new solutions rapidly as soon as he is confronted with new con-
estellations of circumstances (1935, pp. 210-211).

Thus the essence of the "knowledge problem" argument is not simply that
plant managers know things that the CPB does not, or that communication of
this knowledge by the former to the latter would, as Hurwicz said, entail the
cost of losing some data or accuracy. The problem is rather that the relevant
knowledge is inarticulate. The producers know more than they can explicitly
communicate to others. While the market marshalls this dispersed knowledge
without requiring its articulation all these market-socialist models necessarily
require the full articulation of the localized knowledge to the CPB during the
"dialogue." The plant manager must be able to say which production
 technique, including specific quantities of all the inputs needed, he will use for
any of the configurations of tentative prices suggested to him at each iteration
of the dialogue. I do not believe a plant manager can do this.

Thus if this argument concerning inarticulate knowledge can be sustained,
the whole corpus of market-socialist models for resource allocation will be
subject to the criticism that they cannot in principle be implemented. Their
shortcoming would not merely be a matter of insufficient development but
instead a basic and inherent aspect of the whole research program.

A possible response to this argument might be an outright denial of the
legitimacy of the notion of "inarticulate knowledge." If the plant manager
cannot say how much of his product he would produce at a certain
configuration of prices, then, it could be argued, he does not really know. If he
is only guessing then the present economic order is sustained by wild stabs in
the dark by ignorant producers, and socialism could easily simulate that
procedure. But, it might be argued, if there is more to the producer's decisions
than guesswork he must genuinely know the best production techniques for the
prices he faces, in which case he should be able to explain these to the CPB. The
only issue that remains is whether the plant manager would be properly
motivated to tell the truth. But assuming dedicated managers it would in this
case have to be agreed that there is no knowledge problem for the market-
socialist models that is not equally a problem for competitive market systems.\(^\text{12}\)

In Part III, I will return to this question of the logical status of the notion of
inarticulate knowledge, but for now I will simply assert that I think there must
be a more promising line of criticism open to the market-socialists than this. To
me, the empirical fact that non-physicists ride bicycles would seem to be an
effective counterargument.

A less hazardous strategy for the market-socialists would be to try to deny
that any justification for the relative efficiency of capitalist institutions can be
constructed without also relying on the assumption that the relevant
knowledge is articulable. This strategy may be especially tempting since the
standard perfect competition analysis upon which most neoclassical econ-

\(^{12}\)Dickinson (1939, pp. 97-98) should be credited with having recognized that a business-
man's decisions often involve "unconscious judgments," although he did not seem to think
that it would be particularly difficult to simulate this "guesswork" under socialism.
omists base their defense of capitalism can indeed be shown to depend on the assumption of articulable knowledge. However, the rest of this essay will try to show that another kind of defense of capitalism is possible that can dispense with this questionable assumption.

II. Rationalism and Evolution: Knowledge Viewed as an Individual or as a Social Product

The usual way neoclassical economists discuss the role of prices in the market is by arguing that competition pushes prices to their equilibrium values and then showing how decisions about the allocation of resources that are informed by these equilibrium prices must be optimal. It is generally conceded that, strictly speaking, this argument can only be made under conditions of perfect competition in which the market participant cannot influence prices but must treat them as parameters. Price movements are somewhat mysteriously accomplished by a Walrasian "auctioneer." When critics understandably object that the assumptions underlying perfect competition are unrealistic, neoclassical economists respond by contending that the model predicts well and should be accepted "as if" its underlying assumptions held.

This perfect competition defense of the market may not be very convincing to the skeptic, and has opened the door to a counter-argument which neoclassically trained socialists in the Lange tradition have employed with a vengeance. Why cannot a central planning bureau "find" equilibrium prices and then let plant managers be guided by these, in exactly the same way as entrepreneurs are guided by equilibrium prices under capitalism? Granted that, as was pointed out in Part I of this paper, the problem of finding an entire configuration of equilibrium prices is not as easy a task as Lange seemed to think. But still, there should in principle be no reason why equilibrium prices could not be at least as closely approximated under socialism as, say, perfect competition with its auctioneer is approximated by real world capitalist institutions.

The case for the market that is about to be outlined in this part will be fundamentally different from this perfect competition argument. It is not necessary in what follows to assume that there be an infinite number of competitors, or that products be homogenous, or that knowledge be perfect, or even that equilibrium prices be attainable in the market order. And not only will the perfect competition assumption that market participants be pure "price takers" be unnecessary, its opposite will be required. Prices are actively changed, both deliberately and undeliberately, by market participants and it is this very fact that imparts the advantageous characteristics to the market.

But the most significant difference in this description of the market is that its basic approach is "evolutionary" rather than "rationalistic." This distinction comes from Hayek and has been lucidly described by Thomas Sowell in his most Hayekian book, Knowledge and Decisions (1980, pp. 102-103):

[T]he philosophy of rationalism . . . accepts only what can "justify" itself to "reason" — with reasons being narrowly conceived to mean

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13More complete presentations of this analysis can be found in the contributions of the Austrian school of economics, especially Ludwig Mises, Friedrich Hayek and Israel Kirzner.
articulated specifics. . . . Rationalism is at one end of a spectrum with evolutionism at the other. The evolutionary process sees the determining rationality in a process — unarticulated in whole (animals) or in part (humans) — not in the individuals involved in the process.

The formal models of perfect competition and their offshoots, the models of "market-socialism," have in common the assumption that for the system as a whole to function rationally it must be driven by market participants who "know what they are doing." In both conceptions the basic decision-maker is assumed to "know" his production function so that he can use it to plug in equilibrium prices given to him by either the "auctioneer" or the CPB, and thereby compute his optimal decision. In both conceptions the best production process is deliberately, rationally decided upon by individuals. By contrast, in the description of the market that follows the "determining rationality," as Sowell puts it, is located in an unarticulated social process. Articulation, like any conscious choice, is necessarily an individual activity, but knowledge as a whole, including its inexplicit foundations, is, according to the evolutionist approach, necessarily a social product. Through the interaction of intelligent beings in a social context, the society as a whole attains a kind of "intelligence" that is far greater than the sum of its parts.

We should begin the analysis with a very simple economy in which prices and markets have not yet emerged. The production process of even such primitive economies, although it is simple enough to be amenable to deliberate planning, was never consciously conceived but spontaneously emerged by an evolutionary process by which those societies survived that adopted more effective methods. Such diverse social theorists as Karl Marx and Ludwig Mises were both fond of pointing out that rationalism as we know it is itself a product of the emergence of market relations. Deliberate choice of production technique, to the extent that it ever really occurs, only became possible with the development of markets, money, the price system, and the division of labor. The individual within the primitive society becomes conscious of having a choice about methods of production only gradually and only after having had a particular workable technology, usually hunting or agricultural, bestowed upon him, along with his culture, law and language, by the traditions that had been preserved in his society. Powerful taboos against violations of tradition are not irrational in such an economy; they are the very means by which working methods of production are preserved. Societies that lack sufficiently powerful forces of tradition lose their "social memory" of the effective production process that kept them going and thus lose in biological competition with other animals and other human societies. On the other hand, where tradition holds too powerful a grip over the member of a society it becomes unable to cope with environmental changes and fails by virtue of its rigidity. The "determining rationality" of the system is socially imposed by natural selection in an evolutionary process in which the traditions that fit the economic circumstances and thus the societies that adhere to such effective traditions survive.

The development of market relations drastically changes the mode of this evolutionary process but does not alter its fundamental nature as a social process in which effective methods of production are selected through a
rivalrous struggle in which better methods survive. The mode is now economic rather than biological competition, and there can be no question that the former is a preferable procedure for eliminating inappropriate methods of production. Instead of a whole community being starved to death because of its inability to adequately maintain or revise its productive traditions, with a market economy a particular method of production that becomes ineffective simply brings economic losses to its controller. Of course if those who make losses are very resistant to change this method of selection could, in the limit, become equivalent to the biological one. But considerably more latitude is permitted to (and usually exercised by) individuals to revise bad habits before reaching the starvation level.

What is of more interest in this account is not the undeniable and very significant differences but the underlying similarity of the economic and biological varieties of evolutionary processes. Both survive or fail by incremental adjustments to regularized habits of productive technique that are passed down to them by the example of previous producers. Neither really allows individuals to decide deliberately what method of production to employ, but each rather permits more or less discretion to individuals to try to change some small part of his regularized habits. Such habits are “passed on” the way a skill is passed on to an apprentice, without the need for any systematic articulation of exactly what is being done.

The far greater discretion that economic competition permits to individuals gives them the ability to experiment with a much wider variety of production methods and substantially speeds up the operation of the evolutionary process. It makes changes in production technique easier; it makes ineffective changes less risky (loss rather than death), and effective changes more rewarding. It thus hastens the refinement and rationalization of productive methods and brings about an unprecedented revolution in productivity.

What emerges from this development is the appearance of a completely rationalized production process. As the sciences of engineering make our understanding of the production methods we already use increasingly articulate we come to think that we really “know” how to produce every good and service supplied in our economy. But this is an illusion. In fact our knowledge is fundamentally premised on our being embedded in a social process about the working of which we have only the crudest conception.

It is the price system with its profit/loss test that enables society to advance from biological to economic competition. The practice of accountancy with double-entry bookkeeping that preceded and stimulated the science of economics is what made possible the rapid technological transformation of production that is our modern heritage. The way we produce goods and services, like our heritage of scientific knowledge, is not something anyone designed or could design but is the outcome of a long history of incremental revisions to habitual modes of activity. Each modification is influenced by the configuration of relative prices at the moment of the change and is preserved whenever it proves successful in the profit/loss test. Changes in the constellation of relative prices close off some previously viable methods and make others possible, but never unambiguously determine which method of production is optimal. Scope for innovation in production processes is always
available within the constraints imposed by the existing set of prices. Changes in these prices occur both as a result of initiative by innovators in production methods and as a result of responses to previous changes in other prices. Prices in this way act as the articulated information that coordinates market participants with one another into a vast network of interdependent decision-makers.

The telecommunication system provided by the market does not, as is supposed in the perfect competition model, supply definite information of what techniques must be optimal, but rather continuously redraws the boundaries of what is economically feasible, within which boundaries economic decision-making takes place by incremental adjustments to established habits. Production methods are not so much known as simply practiced, revised and occasionally abandoned in a continuously changing flux of competitive activity.

The number of technologically feasible ways to produce any desired good in a modern economy is virtually infinite, but the subset of these which represent production methods that are also relatively economical is much smaller. Without the benefit of a price system, decision-makers who are faced with the bewildering variety of technologically possible methods of production would hit upon a set of economically feasible methods only by the most bizarre accident. The likely outcome of production that is carried on in the absence of price-guidance is that so little would be produced that society would revert to the simple methods of primitive societies.

Thus the aid provided by prices is a reduction of the overwhelmingly numerous possibilities of production methods to a handful that appear profitable ex ante. Of course, only some of these will, as prices continuously change, actually prove profitable ex post and thus survive through time as regularly employed habits of producers. But by reducing to a manageable size the mind-boggling variety of conceivable methods of production, the price system performs an indispensable service. Just as Hayek argues more generally about unconscious rules that guide our behavior, the unarticulated ways in which prices influence our actions are mostly negative. They keep us from even considering production techniques which would be technologically feasible but are unlikely to be economically viable.

While the market-socialist models of Part I acknowledge that decision-makers must refer to prices in order to make rational decisions, they depend upon a rationalistic method of finding out what prices should be set to. The CPB must play the role of the Walrasian auctioneer and move the prices which individual decision-makers treat as 'given.'

No such rationalistic assumption underlies the present account of the market process. Entrepreneurs, guided by prospective profits, bid against one another for command over resources, and it is this active bidding up or down of prices that pushes them in equilibrating directions, that is, that imparts rationality to the price system. Any such bid reflects a commitment of wealth by the bidder to a particular project and thereby reflects his prospective belief in the profit-

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14 See Hayek (1962, pp. 56-57): "Like scientific laws, the rules which guide an individual's action are better seen as determining what he will not do rather than what he will do."
grammar that permit a child to speak correctly, no less than the inexplicit rules by which a scientist decides what he is trying to say must remain in inarticulated form.

To reject these inarticulated elements of knowledge simply because they are inexplicit would be to abandon all scientific knowledge. Thus the goal of complete articulation of all knowledge can no longer be held as the aim of science. But to say this is not to deny that the way science advances is necessarily through attempts at careful articulation. The point is not to reject articulation as the primary aim of science but simply to recognize that in the final analysis the judgment scientists make about whether to accept this or that attempt at articulation ultimately rests on an unarticulated foundation.

The most eloquent proponent of the philosophy of science I am alluding to has been Michael Polanyi, and it is no coincidence that he has noticed an important analogy between this scientific discovery process and the manner in which economic competition takes place in a market economy.\(^{15}\) Whereas Polanyi used an analogy with the market in order to clarify his description of the way science evolves, the remainder of this essay will try to use an analogy with scientific evolution to clarify the description in Part II of the way the market economy evolves.

Before this analogy is employed a warning of its limitations might be advisable. As with any analogy, one can take this comparison of science and markets too far. One of the main points Hayek has made about knowledge for which he has been justly praised was his distinction between “scientific knowledge” and the “knowledge of the particular circumstances of time and place” which constitutes the more important data of economic activity.\(^{16}\) While the former is general, abstract and timeless, the latter is specific, concrete and of only fleeting validity or interest. Nothing I am about to say about the similarities between science and markets is intended to minimize the importance of this insight about the difference in the kinds of knowledge that are generated by scientific and market processes. The thrust of the argument will instead be that the discovery processes themselves, not the knowledge that results from them, are very similar, and thus that the justification of the validity of the respective kinds of knowledge may also be similar.

It might be useful to begin the analogy by noting that the two kinds of limitations to scientific articulability I have called the “static” and “dynamic” limitations have counterparts in the case of market processes.

With respect to the first, “static” limitation on articulability, one can argue that just as an articulated statement only carries meaning to other people because of a shared definitional background in unarticulated assumptions about the use of language, so too do articulated prices only carry meaning to those who calculate with them because of a shared background in unarticulated assumptions about the characteristics of the priced goods and services. Just as articulated statements in science comprise an indispensable aid to our advancement of a largely inarticulate understanding of the world, so too do

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\(^{15}\)See Polanyi (1962).

\(^{16}\)See Hayek (1945, p. 80).
ability of that project. This wealth commitment is not so much explicit, articulated knowledge as it is an educated guess, a hunch based on an intricate set of inexplicit "clues" that guide the entrepreneur's attention. The rationality of the system as a whole does not depend on the correctness of any particular guess, but rather depends on the struggles among rival commitments. The resulting "social intelligence" cannot be gauged by the standards applicable to the rationality of a single mind.

III. The Analogy with Science

It is from the conclusions that have only recently been derived from the general study of how scientific progress occurs that the "evolutionary" approach outlined in the previous section gains some of its firmest support. Since the work of Popper, Kuhn, Lakatos, and Polanyi it is now widely accepted that progress in science conforms to no set of explicit rules, that indeed most important discoveries in science have occurred by breaking rules that were once thought necessary for legitimate science. In short, no scientist can spell out the necessary and sufficient conditions for judging a purported scientific contribution as "good science" or "bad science." In the final analysis, the deciding factor is actually the inarticulable judgment by the scientific community; that is, the "determining rationality" is again not in articulate form but is located in the society as a whole, in the shared assumptions of the scientific community which Lakatos calls the "hard core."

As Michael Polanyi puts it, the only force that keeps science from becoming arbitrary is the commitment on the part of the members of the scientific community to honestly pursue, that is, to employ their inexplicit judgments in service of, the truth. The driving force of scientific progress is in the interplay of criticism among scientists who necessarily share a foundation of, at least temporarily, unquestioned assumptions about the nature of reality, and about legitimate methods of analysis. Science could not advance without frequently rejecting in advance of any serious consideration certain theories or methods that contradict the overwhelming consensus of the community of scientists. Careful consideration of every claim, however bizarre, would be so costly that scientists would never have time to pursue the avenues to truth that they suspect may be fruitful. Yet is is only by disagreeing with portions of what science assumes, that scientists can make new discoveries. The inarticulable component of our knowledge is the unquestioned turf we have to stand on in order to undertake the criticism of other intellectual territory.

It may be helpful to distinguish two kinds of limitations to articulability which inevitably require us to stand on some "unquestioned turf": a "static" and a "dynamic" limitation. The static limitation is the fact that any particular articulated statement acquires meaning only by reference to an unarticulated background of beliefs implicitly held by the scientific community. Attempting to define and defend all the concepts and theories being relied upon would mire the analysis in an infinite regress.

The second or "dynamic" limitation to articulability is in the fact that the very process by which an articulated statement is formulated must itself remain inarticulate. If an attempt is made to articulate this process, then the process by which that attempt is made itself remains inarticulate. The unconscious rules of
articulated prices provide an indispensable service to our largely inarticulate production activities. But neither articulated statements nor posted prices have any meaning when divorced from their inarticulate foundations.

The articulate information supplied by prices is only informative because they are juxtaposed against a wide background of inarticulate knowledge gleaned from a vast experience of habitual productive activity. A price is not just a number. It is an indicator of the relative scarcity of some particular good or service of whose unspecified qualities and attributes we are only subsidiarily aware. Yet were these qualities of a good to change in the slightest respect this could change incremental decisions about the uses of the good just as significantly as a change in price. As Professor Sowell reminds us, what we mean by an apartment or a can of peas is not always clear even to ourselves; but if any of the unspecified features of either were to change we would substantially alter our demand for it.

There has been a great deal of attention in recent years to Hayek’s conception of the price system as a mechanism for the transmission of information. As interpreted through orthodox economists’ lenses, Hayek’s idea is rendered as the claim that a market economy is “informationally efficient” in that prices contain all the information needed for decision-making. In the market-socialist modeling literature discussed in Part I, this view has led to the calculation of the number of prices that have to be communicated back and forth between plant managers and the CPB during the “dialogue” and the confident conclusion that the number of numbers that have to be passed around is small enough to be manageable. Now it is true that one of Hayek’s main points (illustrated by his tin example above) was that prices act as an economical summary of information by allowing decision-makers to respond to changes in relative scarcities without knowing the causes of such changes. But Hayek was not contending that prices as numbers are the only pieces of information that the market transmits. On the contrary it is only because of the underlying inarticulate meaning attached to the priced goods and services that prices themselves communicate any knowledge at all.

There is also a counterpart in the market context to the second or “dynamic” limitation to articulability. Just as the process of constructing or using a formal system or scientific statement involves a creative imagination that necessarily lies outside of the framework of the formal system itself, so does the construction or use of a configuration of prices rest on knowledge that is not contained in that set of prices. Just as the acceptance or rejection of a scientific theory rests on the personal commitments of members of the scientific community to truth, so does the ‘survival’ of a posted price or a particular production project rest on the personal commitments of market participants to profit.

The willingness of a scientist to adhere to a theory or of an entrepreneur to a production project depends on his whole set of personally held and unarticulable beliefs about other theories or other production projects with which the presently contemplated theory or project must be complementary. The entrepreneur’s subjective expectations about the future course of demand and supply for all the related goods and services determine his decision, yet, like the ideas of the scientist about what constitutes “good science,” these expectations
are unarticulable. Profit and truth are not so much seen as imagined, not so much grasped as pursued.\textsuperscript{17} The role controversy plays in ferreting out less defensible belief in science has its counterpart in the role rivalrous competition and the calculation of profit and loss play in eliminating less economically viable methods of production. It is the challenge of fellow scientists or of competing producers that applies the ‘pressure’ that keeps each of these social processes going.

Thus market participants are not and could not be “price takers” any more than scientists could be “theory takers.” In both cases a background of unquestioned prices or theories are subsidiarily relied upon by the entrepreneur or scientist, but also in both cases the focus of the activity is on disagreeing with certain market prices or scientific theories. Entrepreneurs (or scientists) actively disagree with existing prices (or theories) and commit themselves to their own projects (or ideas) by bidding prices up or down (or by criticizing existing theories). It is only through the intricate pressures being exerted by this rivalrous struggle of competition (or criticism) that new workable productive (or acceptable scientific) discoveries are made and that unworkable (or unacceptable) ones are discarded.

Without the “pressure” that such personal commitments impart to science and to the market, each would lose its “determining rationality.” It is precisely because the scientist has his reputation, and the capitalist his wealth, at stake that impels him to make his commitments for or against any particular direction of scientific or productive activity. Thus private property and the personal freedom of the scientist play analogous roles. When either form of personal commitment is undermined, for example when scientific reputation or economic wealth depend on loyalty to a Party line rather than to a personal devotion to truth or a pursuit of subjectively perceived profit opportunities, each of these great achievements of mankind, science and our advanced economy, is sabotaged.\textsuperscript{18}

If this account of the way rationality gets imparted to market activity is accepted, then the problem with the market-socialist models of planning is much more serious than its practitioners have yet acknowledged. It may have to be admitted that it is no more possible to achieve a technologically advanced economy without de facto private property than it would be to achieve scientific progress without independent scientists genuinely devoted to the

\textsuperscript{17} Of course the point here is not to equate these two pursuits, of truth and of profits, as equally admirable intrinsically, but rather to suggest that each form of personal commitment is a necessary component of social-evolutionary processes the results of which most of us cherish.

\textsuperscript{18} The implication of this “knowledge problem” for the conduct of empirical work in comparative systems, e.g. the comparison of the US and the USSR, is that we ought to pay more attention than is often paid to the question of the degree to which plant managers or owners are permitted discretion and genuine independence in the two countries. This is closely related to the theme of the “property rights” approach to comparative systems exemplified in the work of Svetozar Pejovich. This approach suggests that while the US economy exhibits substantive political obstacles to the independence and discretion of decision-makers, the Soviet Union obstructs the decision-making significantly more, and that this explains the relatively gross inefficiencies so often reported in Soviet anecdotes.
truth. The independence of producers from political influence and their free rivalry among one another for profit would prove to be as necessary for economic progress as the independence of and controversy among scientists is for intellectual progress. And the notion of a truly planned economy, an economy that dispenses with the "anarchic" forces of competition and brings the price system under the deliberate control of experts in linear and nonlinear programing, would be exposed as not just a difficult task awaiting further developments in computer technology but an impossible dream.

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