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ECONOMIC COMPETENCE AS A SCARCE RESOURCE - An Essay on the Limits of Neoclassical Economics and the Need for an Evolutionary Theory

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Comments are welcome.

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Contents

Introduction

Most economists agree that one of the main tasks of their profession is to study scarcity. This essay argues that there is a limit beyond which this task cannot be pursued by means of neoclassical analysis. It is the neoclassical optimization postulate which is accused of being the main limiting factor.

More precisely, what I wish to show is that this postulate hinders the study of an important kind of scarcity. This is the scarcity of *economic competence*, defined as the ability to organize, plan, and conduct economic activities, including the very ability to optimize. While misallocation of this resource may cause enormous social losses, neoclassical economics has serious difficulty in seeing them. It is not only that an essential part of this scarcity can directly be obscured by the optimization postulate. Moreover, this scarcity implies an intriguing logical problem which subverts the entire axiomatic building which neoclassical economics erects on the postulate. This is the problem that economic competence is not only a scarce resource to be allocated, but also the very instrument for allocating all scarce resource, including itself.

When addressing the question of how to overcome this limit, I will argue that this must be done by means of an evolutionary theory. The clue is that evolutionary theorizing is the only known way to study a world where scarce competence can emerge and develop, without needing any other competence to pre-exist and be in charge.

The essay thus relates to two current debates. One is about the neoclassical optimization postulate, with main references to Simon (1955 and 1979), Boland (1981), and Heiner (1983). The second debate is about evolutionary economics, as pioneered by Schumpeter (1934, 1942) and Alchian (1950), and more recently developed by Winter (1971, 1975) and Nelson and Winter (1973, 1982). Of course, the second debate is always closely linked to the first. As there would hardly be any evolution to study, if optimization abilities were already as abundant and widespread as the postulate implies, the advocates of evolutionary economics cannot help criticizing the postulate as well. Winter's 1975 paper on optimization and evolution makes this link particularly clear.

My present objective - to criticize the optimization postulate and to make out a case for evolutionary economics - is indeed identical to

Winter's. In contrast to him, however, my criticism of the postulate is much narrower. I do not attack it on empirical grounds, nor for the infinite regress which the consideration of calculation costs might cause.[1] Instead, I start from the opposite position, taking the side of its most radical defence.

The strength of this position, probably best expressed by Boland (1981), is that it defends the postulate in the weakest meaning. The postulate is not defended as empirical truth, but only as a methodological device, saying nothing more than that each agent can be viewed as optimizing *something* under *some* constraints. I do not only recognize - as Winter and Heiner also do - that this defence is formally effective against both of the above-mentioned attacks. I also readily admit - and on this point I seem to disagree with most of the postulate's critics - that this meaning, far from being a worthless tautology, may often be a significant help to analysis. After all, if physics finds it helpful to ascribe optimizing behavior even to inanimate objects - such as a light ray, supposed to minimize its travelling distance, or a falling body, supposed to minimize its potential energy - it would be surprising if this methodological device could not also be helpful in many economic problems. The necessary condition is, of course, that the use of this device will not obscure any important part of the problem studied.

Rather than *a priori* opposing the postulate, what I want to do is to search for the limit to which it can be used, before this condition is violated. It is on the set of resources whose scarcity a theory can study that this search is to focus. In the history of economic analysis, this set has been extended in several steps. Initially, under the influence of the 19th century physics, only tangible material objects and energy were included. Later on, several less tangible items were added - such as services, technological information, and the know-how of human factors of production (human capital). But for a long time, economic information was kept out. The traditionally studied cases of economic agents optimizing the use of a given set of scarce resources under perfect certainty require indeed that economic information itself be abundant - that is, that the information about elements of the set be not included in the set.

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1. The latter attack is developed in an interesting but not sufficiently conclusive way by Mongin and Walliser (1987).

The rapid development of information technologies and theories in the 40's and 50's was probably the decisive impetus which made many economists finally recognize that all kinds of information, even the economic one, might be scarce. Pioneered in two somewhat different directions by Marschak (1954) and Stigler (1961), neoclassical theories of economic information began to flourish. At first, no reason was seen why the neoclassical framework should be abandoned. While the set of scarce resources was extended to include even economic information, the optimization postulate was apparently saved by regarding any lack of such information as an additional constraint under which optimization could still be assumed to take place. In other words - and this is, in fact, an early variant of Boland's defence - economic agents were simply assumed to do their best under the constraint of whatever incomplete information they might possess.

Soon, however, suspicion appeared that the notion of scarcity cannot be mechanically extended to economic information. To admit that information about scarcity might also be scarce was a prime suspect of hiding the embarassing problem of self-reference, which had subverted so many axiomatic structures in mathematics - for instance, as Russel's paradox or, in its most developed form, as Gödel's Theorem.[2] When Winter showed this suspicion to be true, the difficulty in recognizing economic information as scarce, while simultaneously maintaining the optimization postulate, appeared enormous, indeed. But, as Chapters 2 and 3 will discuss in more detail, this difficulty is at least partly surmountable. Although Boland neglects the problem of self-reference, his defence can still be pursued for some time, even when the presence of this problem is recognized.

To search for the limit of the defence, this essay will take two further steps: (1) it will focus on the scarcity of economic competence, regarded as the deepest economic information which is embodied in the very structure of economic agents and organizations; and (2) it will proceed beyond the problem of one-agent private optimizing, to which the optimization postulate controversy has mostly been limited, and focus on

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2. See, for instance, Kleen (1952) or Hofstadter (1979); the latter is particularly interesting for inspiring interpretations of Gödel's Theorem in empirical context.

the problem of *social optimizing*, as studied by theoretical welfare economics.

It is these two steps that are to lead to the limit. With the help of Gödelian reasons, for which no consistent system can entirely refer to itself, neoclassical economics is to be forced to choose either to renounce the study of a socially important kind of scarcity or to stop being neoclassical.

A note is also in order about the evolutionary theory which will appear as the main candidate for replacing neoclassical analysis on the other side of the limit. My argument will be that this theory must be more general than the evolutionary economics connected with the names of Schumpeter, Alchian, Nelson, and Winter. Whereas that economics is nearly exclusively concerned with selection by capitalist markets, the theory needed here will have to study how economic competence can evolve in different market and non-markets environments.

To consider also other evolutionary environments than capitalist markets is essential, indeed. Much of the problem of scarce economic competence remains hidden as long as attention is limited to such environments only. However far from any ideal a real capitalist market might be, and however poorly it might promote the best available competence, it nearly always does a good job at demoting incompetence, thus easily giving the false impression that incompetence is relatively rare or harmless. One probably needs a close look at a real socialist economy, where market competition, if allowed at all, is deprived of most of its competence-selection role, to realize how widespread economic incompetence may become and how enormous social losses it may cause.[3]

The essay is organized as follows. Chapter 1 strives for terminological clarity. In particular, it explains the meaning which will be given to the terms "information", "economic information", "economic data", and "economic decision methods."

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3. Friedman's (1953) way to justify the optimization postulate thus appears to be a great disservice to his favorite cause of capitalist market economy. By referring to market selection only to justify the postulate, to be then taken for a *universally valid* methodological principle, he obscures what may well be the greatest *specific* advantage of capitalist markets, and the greatest obstacle to efficient socialist planning. It is indeed by the validity of the postulate, unsupported by any market selection, that all proofs of possible efficiency of socialist planning stand or fall.

Chapter 2 surveys the neoclassical theories of scarce economic information, showing that they are concerned with economic data only. Chapter 3 turns to the problem of scarcity of economic decision methods, suggesting that this problem might be studied by analogous neoclassical theories, which would paradoxically assimilate, rather than oppose, some of the most vigorous attack on the optimization postulate. The conclusion of the two chapters is that as long as attention is limited to one-agent economic problems, the optimization postulate can be defended as an impeccable methodological device.

Preparing the discussion of the social allocation problem, Chapter 4 defines economic competence as the ultimate informational constraint on individual optimizing, and simultaneously as a scarce and hidden resource whose allocation in society is a matter for social optimizing. Chapter 5 introduces the view that economic competence is a property not only of individuals, but of all organization which have some economic problems to solve - including multipersonal firms and entire economies. It then suggests a composition principle, which makes it possible to relate the economic competence of an organization to the economic competence of its member-agents.

Chapter 6 states the general social allocation problem which arises when economic competence is included among the scarce resources to be allocated to their best social uses. It is in this chapter that the intriguing double role of this resource is exposed and its consequences examined.

The question of how the general resource-allocation problem could be studied is addressed in Chapter 7. It is there that the main findings of the essay - the limits of neoclassical analysis and the need for an evolutionary theory - are presented. The essay is then concluded by a brief discussion of what kind of analysis such an evolutionary theory might fruitfully employ and what kind of results it might eventually reach.

1 ECONOMIC INFORMATION

Much of this essay builds on the terms "information", "economic information", "economic data", and "economic decision methods." Although they sound familiar, their meaning has not always been well defined, nor all of their connotations properly noted. The task of this chapter is to explain in what meaning and with what connotations they will be understood here.

1.1 Information must relate to a question

The meaning which "information" has been given in cybernetics - in particular as introduced by Ashby (1956) - seems the most fruitful for the present purposes. In this meaning, information is always about a set of possibilities, pointing to some of them at the exclusion of others. As Ashby emphasizes, one cannot appreciate the information in any specific message if one does not know the set of all possible messages which could have been sent instead. His example of a prisoner sending the message "I am well" makes this point clear. The information is obviously different if the prisoner can choose between "I am well", "I am slightly ill", and "I am seriously ill", than if "I am well" is the only message allowed.

It is often helpful to view such a set of possibilities as the set of possible answers to a given question. Information then is what determines, or contributes to determine, the right answer, and/or eliminates, or contributes to eliminate, the wrong ones.

A question typically needs a system - e.g., a person, an organization, or a machine - which asks it. It is then to both a question and a system that any information must be related. In other words - and this is a summary of the present view - *information is the content of a message which helps a given system answer a given question.*

This view can be applied to a wide variety of cases, provided a broad understanding of the term "question." The most important questions are about what should be done - as in decisionmaking or regulation, where a system is to choose one course of action from a set of alternative courses - or about what is true - as in an inquiry, where a system is to adopt one hypothesis from a set of alternative hypotheses. Strictly speaking, all questions can be reformulated as questions about what is true - for

instance, "which action to choose?" can become "is it true that the best effect would be obtained by choosing action x?".

It is by no means necessary to limit attention to an isolated question. Several questions, more or less closely related to each other, can be taken into consideration. For instance, one can study cases where the same message helps answer different questions, or where the answer to one question helps answer another question. Strictly speaking - and this point underlies much of the following discussion - such thing as an isolated question does not even exist. Any question which is asked is, in fact, the answer to a more fundamental question of which question to ask.

What must be kept in mind is that if several questions are considered, each of them defines its own kind of relevant information; if the same message helps answer different question, it is different information it contains for each of them. An example, important for the following discussion, is a description of a technology. This is a message which helps answer the technical question of which physical principles make the technology work, as well as the economic question of how valuable for a firm or a society the technology is. But although the message is the same, the information it brings to each of these questions is different. And even if it may be the same person who asks them both - such as the Schumpeterian inventor-innovator - the distinction between the two kinds of information remains valid and important.

Although the present discussion will remain qualitative, it is instructive to note that the idea of relating information to a question can also be found behind the classical definition of information quantity by Shanon and Weaver (1949). They consider the set of alternative messages which a given information source can send. The ignorance about the actually sent message is measured as "entropy" - which is the higher, the more possible messages there are and the more equal chances they have to be sent; if it is certain that one is sent and the others not, the entropy is zero. A message is then said to contain as much information as it decreases the entropy - that is, as it helps dispel the ignorance. Clearly, such information can be regarded as a help in answering the question of which of the possible messages was actually sent.

In comparison with other existing views of information, this one may appear more restrictive in one sense and broader in another. Restriction may be seen in the requirement that information be always related to a

system and a question. This means that information is no "objective substance", existing in an absolute sense - contrary to what is sometimes assumed.

On the other hand, broadness is in the great variety of forms under which such a help may appear. They include observations of some rapidly changing variables, knowledge of some more permanent truths, and also methods for extracting the answer saught from both data and knowledge. This means - contrary to what is sometimes done - that information and knowledge are not considered mutually exclusive notions. Rather, any form of message which helps a given system answer a given question - be it observations, knowledge, or methods - will be said to contain information.

1.2 Fields of information

For the present purposes, an important advantage of this view is to allow for a clear classification of information into different fields and subfields. When information is related to questions, it is not necessary to classify the messages which carry it - such as specific strings of spoken or written symbols - which would often be an impossible task. All that is needed is to classify the relevant questions, for which conventional classification criteria can be used.

With the above example of a description of a technology in mind, it is possible to divide the information studied in economic literature into two main fields. One, whose study was pioneered by Arrow (1962), Demsetz (1969), and Hirschleifer (1971), is *technical* or *technological* information, which is to help answer *technical* questions. For instance, these are the questions asked by engineers and workers about the physical properties of products and production processes, which economic decision-makers usually must know about, but do not directly work with. Examples of economically interesting problems about technical information include the allocation of resources for invention, the efficiency of research and development, the advantages and disadvantages of patents, and the significance of technical progress for economic growth.

The other field, pioneered by Marschak (1954), Stigler (1961), and Marschak and Radner (1972), is *economic* information - such as information about prices, quantities, and other conditions of supply and demand - which is to help answer *economic* questions. These are the questions asked by economic agents about the economic decisions to take - such as what and

how much to buy, to sell, to produce, or to save. Economic information may concern an isolated economic agent, solving the Robinson Crusoe problem, or members of an organization, trying to coordinate their decisions and actions. In the study of a single agent, the usual objective is to find out how much economic information the agent should obtain, given the expected costs and benefits of the information for the agent. In the study of an organization - e.g., a team - the usual objective is to find out which informational exchanges (communication channels) should be organized, given their costs and expected benefits for the organization.

There are many more fields of information which may be distinguished. For instance, another one may be "information as a consumption good", demanded by consumers to satisfy their idle curiosity or other needs and desires to receive information as such - e.g., in the form of art or news. From an economic point of view, such information contributes to individual utility and social welfare as any other consumption good. Note again that several kinds of information may be contained in one message. For instance, the same news may satisfy curiosity - that is, carry information as a consumption good - and at the same help in taking a decision about production or investment - that is, carry economic information.

1.3 The peculiarity of economic information

Among all fields of information, it is the economic one which an economist must be most careful about. As already Knight (1921) emphasized, it is important to distinguish economic problems, the subject proper of economic analysis, from technical problems, which call for the competence of natural scientists and engineers. As it is the answers to economic problems which require economic information, this field of information is more intimately tied to economic analysis than any other field.

A comparison with technical information is again instructive. This information can easily be treated as a factor of production, or capital good, whose production and allocation can be studied in a formally similar way as the production and allocation of any other capital good. To be sure, it is a rather peculiar kind of good - riskier to produce, richer in external effects, more difficult to own and allocate, and of a more profound impact on economic growth than most other capital goods - which fully justifies the development of specialized literature for dealing with it. But from a purely logical point of veiw, it is as distant from economic

analysis as a machine or a piece of steel: only its costs, its utility, and the efficiency of its allocation - but not the technical details of its production and use - are of interest for an economist.

In contrast, economic information is the very subject of economic analysis. This is the information of which economic calculus itself is made, to be found in the inputs, outputs, and computing methods of all economic decisionmaking. When an economic theory studies how economic agents behave, or should behave, it is in fact deeply involved with the question of how they use, or should use, economic information. This closeness puts *economic* analysis of *economic* information in front of some troublesome logical problems, which will play an important role in a later discussion.

Three notes are in order. First, the relationship between economic and technical information may need one more clarification. It may sometimes seem, in particular in studies of technical progress, that economic agents base their decisions on both economic and technical information, thus giving the impression that the two cannot be clearly distinguished from each other. But this is not so. What is used, in such a case, is not technological information as such, but *economic information about technological information* - e.g., about the private or social costs and benefits of a new technology. Such economic information is used to decide about the production and use of technological information much like economic information about steel is used to decide about the production and use of steel. Clearly, such information is different from technological information proper, describing the physical parameters which make the technology work. Such parameters - like the physical parameters of any other good - are of interest to an economist only as far as they also provide economic information about the technology's costs and benefits.

Second - and this is a point which will be developed in Sections 2.4 and 3.4 - there may also be *economic information about other economic information*. For instance, this may be information about the costs and benefits of an economic forecast, which is itself economic information. It may even build multilevel hierarchies where economic information of one level is about economic information of another level, which is about economic information of a yet another level, and so on. The only thing to be said about such a hierarchy now is that the information of all of its levels is classified as economic.

Third, as what is meant by "economic" information depends on what is meant by "economic" questions, the latter calls for some explanation. As will become clear in Chapter 6, neoclassical economics has been limited to questions about the allocation of scarce resources within given structures - e.g., about the prices and quantities of the goods exchanged by given firms through given markets. But this does not exhaust all the questions which can be regarded as economic in the sense that they belong to the subject of an economic theory. In particular, the kind of evolutionary economics advocated in Chapter 7 will include also questions about the evolution of structures - e.g., about the organization, reorganization, and dissolution of firms and markets.

1.4 Economic data v. *decision methods*

When information is related to a system and a question, the prerequisite is that the system *already knows* how to recognize and use the information relevant to the question. This means that the system must already have some information about how to deal with new information.[4]

Although elementary, this prerequisite is rarely noted by economists. Heiner (1988) probably comes closest to it by emphasizing the difference between information and the ways of using information (one only needs to add that the ways of using information are also information). The main reason why the prerequisite usually escapes the economists' attention seems to stem from the optimization postulate. Although - as Chapter 3 will make it clear - this is not necessary, the postulate is usually assumed to say that even if an agent may lack information about some economic variables, he has all the necessary information to understand and use any of the scarce information, as soon as it becomes available. Paraphrasing Heiner, only new information is allowed to be imperfect, or scarce, whereas the ways of using it are assumed perfect, or abundant.

For the present argument, to note the prerequisite and to realize its consequences is of prime importance. The point is, in essence, that

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4. An instructive example is the teasing problem of how to communicate with extraterrestrials. Any message must be accompanied by instructions how to understand it, which must be accompanied by instructions how to understand the instructions, and so on. The upshot is that all communication ultimately depends on some pre-existing information which both sides must have in common and which, itself, cannot be communicated.

information in any system is a multilevel phenomenon, where information of any level reposes on, and is conditioned by, some information of a deeper level.

To make this point clearer, it is convenient to borrow and adapt a well-known distinction from computer science - the one between *data* and *programs*. The information which provides the answer to a given question can then be viewed as consisting in part of input data about relevant variables, and in part of a program guiding the use of the data. All the information needed to recognize, understand, and interpret input data, and to operate with them to obtain the desired answer, or output data, can then be viewed as contained in the program. It is then possible to say that data are used, or treated, or operated upon, according to a program, or that a program guides, or governs, the use of data.

This distinction is not as unusual in economic theorizing as it might seem; most current views of economic decision problems contain it in an implicit form. The notion of data is implicit in information on economic variables - such as prices, quantities, and qualities of goods - which describe the world around the decisionmaker ("input data") and the decisions taken ("output data"). The notion of program is implicit in decision methods, or functions, or rules, or algorithms, or routines - the usual terms describing the ways of using input data to produce the desired decisions. The only unusual step is here to view not only economic data, but also the programs for dealing with them as economic information.

Since in an ordinary language, the term "program" is often mistakenly assimilated with a deterministic, if not mechanistic procedure, let me emphasize that this need not at all be the case. For instance, even what is called "discovery process" or "creation" can be said to be guided by a program. For instance, such a program may define a lottery from which a more or less random conjecture is to be drawn, and indicate how to test it and use the result of the test to answer the given question, or to modify the lottery from which the next conjecture is to be drawn.[5]

To see clearly what kind of information is contained in programs, it is important, following Section 1.1, to identify the relevant systems and

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5. Such advanced programs are extensively studied in the field known as Artificial Intelligence. For a non-specialist, one of the best introduction probably still is Simon (1969), in particular the discussion of problem-solving.

questions. Each program can then be found to refer to a set of basic operations which can be performed within the relevant system. Given a main question which the system is ultimately to answer, the program is to answer the auxiliary question of how to use these operations - that is, in which order to perform them - to produce the answer to the main question.

One more aspect of programs is important to realize. To perform the basic operations is the task of parts of the system - some of which may be specialized in one basic operation, and others may be able, when suitably instructed, to perform different operations at different times. As a program determines the order in which the basic operations are to be performed, it must thus also determine the spatio-temporal arrangement of the corresponding parts of the system. In other words - and this idea will play an important role in a later discussion - the information contained in a program, to become effective, must also be embodied in the system's structure (suitably defined).

Although clear in principle, the distinction between data and programs may sometimes seem unclear in detailed applications. One may encounter messages which appear to be both. For example, consider the well-known case of automatic programing, during which a computer elaborates its own detailed program for a given problem. Such a program first appears as the output data of a preliminary programing stage, and later as the program guiding the solution of the problem proper.

But clarity can always be regained. The point is - and this is a variant of the relativism with which information itself was defined - that the distinction is not to be applied to messages as such, but to the roles they play in answering a given question. That the same message may contain different information for different questions was already noted; it only remains to be added that also the roles may be different.

For instance, in the example of automatic programing, it suffices to realize that two different questions are involved: "what is the answer to the given problem?" and "what program to use to find that answer?" The same message - a string of symbols referring to the computer's elementary operations - can then be the answer, or the output data, for the second question, as well as the program for the first. To make the picture complete, let me add that the second question also has a program, but a different one; this is the compiler, stored in advance in the computer, which guides the elaboration of the detailed program, using as input data a

global description of the program by a human programer in a given programing language (e.g., Basic, Fortran, or Pascal).

To apply the distinction in economics, one must be careful in choosing one's terms. The term "data" is easy to adopt. It is quite in agreement with the usual meaning of words to define "economic data" as messages about the state of economic variables, describing the world in which economic decisions are to be taken - e.g., prices and qualities of goods - as well as the decisions actually taken - e.g., the quantities actually bought or sold.

It is the term "program" which causes difficulties. An "economic program" usually means quite a different thing. To avoid misunderstanding, it is necessary to use either the rather long "programs for economic decisionmaking" or quite another term. In most of the following discussion, it is the one of "economic decision methods" which will be used in this sense.

Undoubtedly, the reader familiar with Gödel's Theorem already knows why it is so important to count economic decision methods, which are to deal with scarcity, as economic information, which may itself be scarce. The principle is clearly analogous to the Gödel-numbering of propositions about numbers. Much like this numbering is to allow the number theory to include itself into its subject, to regard methods dealing with scarcity as possibly also scarce is to allow them to deal also with themselves. Recalling that what Gödel proves is that no number theory can be both consistent and complete, the main strategy of the present argument thus becomes clear. Roughly speaking, the consistent axiomatic building of neoclassical economics is to be shown as necessarily incomplete in the sense that it cannot study all relevant scarcity. But before considering what neoclassical theory cannot do, let me first turn to what it has actually done and could potentially do.

2 NEOCLASSICAL THEORIES OF ECONOMIC DATA

Since the pioneering works by Marschak (1955) and Stigler (1961), the idea that even economic information may be scarce and thus raise economically interesting problems has become widely accepted. Based on this idea, neoclassical economics has been enriched by incresasingly sophisticated theories - for instance, about search for information on prices or wages, or about contracts and transactions between asymmetrically informed agents. But although this theoretical development has been impressive, it has also been uneven. While some problems of economic information have been studied in growing depth, others have been largely neglected. In terms of the distinction between economic data and decision methods, it is the scarcity of the former which has received nearly all of the attention. This chapter is to survey the main principles of such neoclassical theories of scarce economic data. Its ultimate purpose is to provide a basis for the later discussion of what neoclassical analysis can, and cannot, do.

2.1 Scarcity of economic data

Consider the usual allocation problem of an economic agent - to find the best use of given scarce resources, in order to maximize a given utility (objective) function. There are three alternative assumptions about the economic data the agent can use:

A1) The data are *complete* - i.e., the agent knows the state of all relevant variables, thus able to decide under perfect certainty.

A2) The data are *incomplete in a constant way*, forcing the agent to decide under a given risk or uncertainty, on which nothing can be changed.

A3) The data are *incomplete in a variable way*, allowing the agent to obtain more of them at a cost, and thus diminish the initial risk or uncertainty in exchange for some of the initially given resources.

Clearly, all these assumptions are compatible with the neoclassical optimization postulate. To optimize under A1 is the traditional case, in which the agent must solve the well-known marginal equations - e.g., by using linear or quadratic programming, or Lagrange's method.

To optimize under A2 is typically a more complex task. If the agent's environment is neutral, or non-strategic - such as nature or a perfectly competitive market - this tasks usually leads to a statistical decision problem requiring a more or less advanced probability calculus. If the environment is strategic - that is, containing agents which are malevolent or benevolent *vis-à-vis* the agent considered - game theory must be applied. But in spite of increasing so much the difficulty of optimizing, A2 preserves an important property of A1 - it does not raise any economically interesting problem about economic information. The point is that in both cases the available data are given, the agent having nothing to decide about their supply.

In contrast, A3 does raise such a problem, which is what neoclasssical theories of economic information are about. Besides the initial problem of how to allocate the given scarce resources to optimize the given utility function, the agent must now also decide how much of these resources should first be allocated to obtaining data. What the theories show is, in essence, that to optimize in such a situation means to obtain all the data, and only such data, which do not cost more than what they help the agent ultimately gain. Such gains are usually measured by considering the expected gain (payoff) for the agent under the initial uncertainty, and by counting the increase of the gain under the new uncertainty, diminished by the data obtained.

In such a situation, the optimization postulate implies that all agents can always make the best out of however iperfect data they might be able to obtain, no matter how advanced probability calculus this might require - or, in Heiner's words, that they know "the perfect ways of using imperfect information". This is also what shows that neoclassical theories of economic information are indeed about the scarcity of economic data, while decision methods are assumed abundant.

2.2 Economic data about economic data

But not even such a limited view of scarcity of economic information is problem-free. As mentioned, a theory which admits that some economic information is scarce while maintaining the optimization postulate risks to be spoiled by an infinite regress. To see why this is so and how such a regress can be avoided, note that A3 cannot be the end of the story. If an agent is to optimize the additional allocation problem of which data to

obtain, it needs to know their costs and the expected gains from having them - that is, it needs economic data about economic data. This brings back the question of what should be assumed about the availability of such second-level data. Possible assumptions are then of the same three types as before:

A1') The second-level data are *complete* - i.e., the agent knows the costs of and the expected gains from all first-level data which can be obtained, thus able to choose the right ones with perfect certainty.
A2') The second-level data are *incomplete in a constant way*, forcing the agent to choose the first-level data under a given risk or uncertainty, on which nothing can be changed.
A3') The seond-level data are *incomplete in a variable way*, allowing the agent to obtain more of them at a cost, and thus to diminish the initial risk or uncertainty concerning the choice of the first-level data in exchange for some of the initially given resources.

The entire reasoning concerning assumptions A1, A2, and A3 can now be repeated for assumptions A1', A2', and A3'. To choose either A1' or A2' - as most existing theories do - means that no additional problem about economic information is raised, but also that such a theory is limited to one-level economic data. Far from being about economic information in general, it is not even about economic data in general.

For example, Marschak's theory chooses A1': what it studies is, in essence, how much data of perfectly known costs and benefits an agent should buy for a given decision problem. On the other hand, Stigler's theory, on which most of the modern search theories are based, chooses A2'. More precisely, the costs of additional data - e.g., the costs of visiting an additional seller to discover the price he charges - are still assumed to be known perfectly, but the benefits only probabilistically. What is assumed to be known is the lottery from which data of different benefits can be drawn. For instance, in the search for the lowest price, the agents are usually assumed to know only the probability distribution of prices. They cannot thus be sure whether the visit of an additional seller will yield a useful datum - a new lowest price - but can calculate the probability with which this can happen.

2.3 Hierarchies of economic data

The way to a more general theory of economic data must obviously lead through the choice of A3'. This raises a third allocation problem - namely, how much of the initially given resources should be used for obtaining second-level data. But to solve this problem, an agent needs again data about such second-level data - that is, third-level data. In the search for the lowest price, for instance, these may be data informing about the sellers which are likely to have lower prices than other sellers - but without informing about the prices themselves.

Clearly, A3' cannot be the end of the story either. It brings back the question of what should be assumed about the availability of such third-level economic data, together with the same three types of possible answers - say, A1", A2", and A3". As before, the choice of A1" or A2" does not raise any new allocation problem, making room for a theory of economic data of two levels. As to A1", there seems to be no theory choosing it; to assume that an agent which lacks data of the first two levels would then be perfectly informed at the third level is probably too difficult to believe even for a theoretical economist. But A2" is a more plausible alternative. Two interesting examples of such a two-level theory, choosing A2", are due to Telser (1973) and Axell (1974).

On the other hand - and the continuation is now evident - the choice of A3" raises a fourth allocation problem, requiring fourth-level data for its solution. By repeating the choice of $A3^{(n)}$ for increasing n, one can make room for theories embracing increasingly high hierarchies of economic data. Each such theory can be characterized by a series of assumptions about the availability of economic data of an increasing number of levels - beginning with n assumptions ($n \geq 1$) of the third type, and ending with an assumption of the first or the second type, $A1^{(n)}$ or $A2^{(n)}$. For example, Marchak's theory can be characterized by (A3, A1'), Stigler's by (A3, A2'), and Telser's and Axell's by (A3, A3', A2"). As nth-level data are the *basis* for using (n-1)th-level data, the intuitive meaning of increasing n is that of increasing "depth" (rather than "high").

Recalling the problem of infinite regress, together with the main references to Winter (1975) and Mongin and Walliser (1987), one can now clearly see that it is limited to a theory which would aspire to study the optimal allocation of economic data of *all* levels. Such a theory would have

to repeat the choice of $A3^{(n)}$ for ever, thus making the series (A3, A3', A3", ...) infinite, indeed.

On the other hand, a more modest theory, limited to a finite number of levels of data, need not have any logical difficulty with the optimization postulate. Such a theory would be characterized by a finite series of n assumptions of the third type, ended by $A1^{(n)}$ or $A2^{(n)}$ - that is, (A3, A3', ..., $A1^{(n)}$) or (A3, A3', ..., $A2^{(n)}$). To be sure, $A1^{(n)}$, assuming that all agents have complete data of the nth ("deepest") level, is increasingly incredible with increasing n. But $A2^{(n)}$, admitting that such deepest data may be incomplete, can hardly raise objections. The scarcity of these data, which the agent cannot influence, can then be simply included among the constraints under which the agent is to optimize.

2.4 The ultimate data constraints

While neoclassical analysis can thus be defended as able to study the scarcity of at least *some* economic data, it has been disclosed as limited in one respect - the deepest data must remain out of its reach. Regardless of how deep data a theory is ready to consider, it must accept the deepest ones as the *ultimate constraint* which cannot be included among the economic variables studied.

But this limitation is not serious. On the contrary, neoclassical economics can transform it into a virtue which faithfully reflects a feature of the real world. Namely, the data collection abilities of all economic agents appear to be empirically limited by some deepest data whose supply the agents cannot influence - such as genetically given parameters for individuals. Consequently, a neoclassical economist might very well argue that there is no point in trying to overcome this limitation - that is, in trying to study the economics of some even deeper data, which are thus under no one's control.

To visualize the role of such given deepest data, one can see them as determining the first question by which an agent's search for more data is to start. For example, if a theory is limited to two levels, they may determine the belief in a certain probability distribution of prices, implying the question of what the true price is. If one more level is added, they may determine a belief in a certain probability distribution of such price distributions, implying a deeper question of what the true price distribution is. Moreover, such deeper data may (and sometimes must)

include what may be called "coefficients of conservatism", indicating how much, or how little, a new observation is to modify initially held beliefs (cf. Axell, 1974). They may also include what may be called "parameters of curiosity", pointing to some more or less randomly chosen data as worth obtaining - whether this is true or not - which may be necessary to prime an important search.

Given some deepest data, the optimization postulate implies that each agent faces a possibly difficult, but nevertheless logically consistent task. If the deepest data are of the nth level, an agent is to optimize a series of n allocation problems - (n-1) problems about which data of (n-1) levels to obtain, and finally about the use of the remaining resources, after all data costs have been paid, given the agent's objective function. The endowment of the deepest data can thus indeed be regarded as just another constraint - added to the contraint of initial resource endowment - under which optimization can, at least conceivably, take place. The disadvantage of starting with a poor data endowment appears indeed analogous to the disadvantage of starting with a poor resource endowment; in both cases, neoclassical theory can conceive of optimization methods which would make the best out of such constrained situations.

3 SCARCITY OF ECONOMIC DECISION METHODS

At first sight, to admit that even economic decision methods may be scarce - that is, that economic agents may not always know how to optimize with the data available - seems to make the optimization postulate outright untenable. This may be the reason why neoclassical economists prefer not to see this kind of scarcity, limiting their interest in economic information to the scarcity of economic data. Upon closer inspection, however, the postulate proves more robust. Up to a certain limit, the scarcity of economic decision methods can very well be studied within the neoclassical framework with the postulate preserved, albeit in a somewhat attenuated form. To examine this kind of scarcity and the possibilities of neoclassical analysis to study it is the task of this chapter.

3.1 Economic decision methods as parts of economic theories

For a good understanding of what is so special about the scarcity of economic decision methods, a few notes about their close relationship to the very contents of economic theories are useful.

Much of microeconomics can indeed be regarded as seeking to describe the decision methods which an optimizing consumer, an optimizing producer, or an optimizing investor would employ. Such a method may often be very sophisticated, a pride of the theorist who has found it. A paradox then arises when such a method, which the best graduate students may find difficult to understand, is assumed, by the optimization postulate, to be applied freely, whenever needed, by any economic agent, possibly without any economic education.

At this point, the importance of distinguishing economic information from other kinds of information (cf. Section 1.2) reappears. For instance, consider the technical decision methods, used by people in their roles of human factors of production - such as the workers and engineers running the production processes within a firm, once they sold their labor on the labor market. The scarcity of such decision methods, which are not classified as economic information, can easily be studied by neoclassical theories - as the well-known theory of human capital amply demonstrates. The reason is that an economic theory is to deal only with their scarcity but not with their contents. The problem with economic decision methods is precisely that it is in the first place their contents that economic

theories are about. Now, if also their scarcity is to be studied, the problem of self-reference will emerge in a somewhat more troublesome variant than the one of optimization taking into account its own costs, as pointed out by Winter (1975) and elaborated by Mongin and Walliser (1987). The problem involved is not only of costs, but also of the very knowledge of how to make the right cost calculations.

As an example, consider what would happen with the theory of human capital, if this capital were to include the knowledge of economic decision methods. To recall, what this theory does is, in essence, to describe the decision method used by an optimizing investor, to decide on how much to invest in learning *other* decision methods (skills), given the costs of learning them and the returns from mastering them. The implicit assumption is that in other roles than those of economic agents - such as the ones of workers, engineers, or scientists - different people may be of different qualities, which they can improve at a cost. But to admit that they may also be of different qualities as economic agents - here, in particular, as investors - is bound to cause difficulties. In this case, instead of studying the usual case of a perfectly competent investor, optimizing his investment in the study of engineering, the theory of human capital would have to study an incompetent investor, trying to optimize his investment in the study of the economics of investment. The difficulty is on a par with Catch 22: such a person cannot optimize, with all the necessary data about the education's costs and benefits available, before having received much, and possibly too much, of this education!

3.2 Optimizing with scarce decision methods

But not even in the face of such difficulties need neoclassical analysis give up entirely. It is still possible, for some time, to follow Boland's defence and to affirm that something, under some constraints, is optimized anyway. In the above example, one can simply say that the initial lack of economic education is nothing else than an additional constraint under which a person still optimizes - that is, does her best under given circumstances.

As a more advanced example, consider two well-known attacks on the optimization postulate - that of Simon's (1955) and that of Heiner (1983). As the present argument will draw on these attacks, in particular on Heiner's, this example is instructive also for a later discussion.

Roughly speaking, Simon points out that most decision problems in the real world are too complex for any straightforward optimizing and must be solved by search. He also point out than a real agents is only "boundedly rational", in the sense that his cognitive and computation capacities are limited and costly to use. Simon's argument then is that an agent would better satisfice rather than optimize - that is, put up with the first satisfactory solution encountered, rather than insist on searching until an optimal solution is found. Using the same logic as the theories of search for economic data - or, given the time of publication, one should rather say that these theories use the same logic as Simon - he specifies that a solution should be regarded as satisfactory and accepted, as soon as the cost of further search exceeds the expected gain from finding a better solution.

Heiner points to a complementary obstacle to optimizing. He globally denotes the problem-solving abilities of an agent as "competence", relating them to the difficulty of the decision problem to be solved. Up to a certain difficulty, a given competence allows for optimal solutions. For more difficult problems, however, a competence-difficulty gap appears, making the agent likely to commit costly errors, and thus be unable to optimize. According to Heiner, the way out of this difficulty is to forego optimization by obeying an *a priori* fixed rule. Such a rule - e.g., a moral principle or taboo - simplifies the problem and nullifies the gap by reducing the set of permissible solutions. Although solutions which would be optimal under certain favorable circumstances may thus be somewhat dogmatically excluded, in the long run the rule may nevertheless be worth obeying. More precisely, Heiner shows that the rule is worth obeying, if these solutions are too harmful to the agent in other circumstances, and if the limited competence of the agent does not allow for recognizing the favorable circumstances with sufficient reliability.

But in spite of the great value of both these attacks, Boland's defence of the optimization postulate effective. The postulate can still be saved by including the bounded rationality or, alternatively, the limited competence of an agent among the constraints under the agent can be said to optimize. And ironically enough, optimizing in this more general sense turns out to be precisely the satisficing according to Simon, respectively the obeying of a wise fixed rule according to Heiner. Simon's and Heiner's theories can thus be interpreted as neoclassical optimization theories

which say, in essence, that it may be optimal not to try to optimize in all circumstances, in particular not in those where the agent lacks the right decision methods and/or the computing capacities to use such methods.

3.3 The room for neoclassical theories

Thanks to this defence, neoclassical economics has a certain potential - although largely unused thus far - to make optimization theories even of scarce economic decision methods. Formally, these theories might correspond to the theories of scarce economic data, as surveyed in the previous chapter. But as they do not yet exist, what I will now present is not a survey, but rather an outline of a possible research program for neoclassical economics.

Recall the case of an agent which is to solve, with some limited resources and data, a series of allocation problems about acquiring more data and maximizing a given objective function. Now, consider moreover that the decision methods which the agent knows and can effectively apply may be limited as well.

At this point, the difference between the costs of computing and the knowledge of decision methods should be emphasized. Many economists, when explaining why available data may not be used in the best way, think only of limited computation capacities and raising computation costs. But as all computer users know, this is only a part of the problem. To improve the use of available data, it is important not only to enlarge the computation capacities and lower the computation costs, but also to know the right methods. Otherwise even the most powerful computation capacities cannot help working in the so often criticized "garbage-in-garbage-out" fashion.

Although the problem of computation capacities and costs will not be ignored, the focus will be here on the knowledge of decision methods. In principle, the limited and costly computation capacities of an agent - e.g., as measured by the number and kinds of logical and mathematical operations which he can perform per a unit of time, and by the costs of performing them - will be regarded as part of his limited physical resources. Of course, this means that his task is further complicated; among the allocation problems which he is to solve and for which possibly scarce economic data and methods are needed, there is now also the one pointed out by Winter (1975) and Mongin and Walliser (1987) - how much resources to allocate to the use of these capacities. The knowledge of decision methods

thus also becomes more complicated, having to include a method of choosing among alternative ways of using the capacities, without forgetting that they must also be used for running this very method. But in spite of these complications, the present focus remains on the methods, and not on the costs.

The focal question can be stated as follows. There is an agent with limited resources and data, and with possibilities to obtain more data at the cost of some of the resources. The question is how to allow a theory to regard his decision methods as possibly also limited, and still be able to claim that he optimizes.

A convenient way to examine this question is to follow the same logical scheme as employed in the previous chapter. This means to begin with three alternative assumptions about the economic decision methods available to an agent, reminiscent of the assumptions A1, A2, and A3 about available economic data:

B1) The decision methods are *perfect* in both essential aspects - they do no cost anything to run and they always yield the optimal solutions to all the allocation problems the agent might ever face.

B2) The decision methods are *imperfect in a constant way*, imposing certain computation costs and/or yielding suboptimal solutions, or errors, which result in certain expected losses.

B3) The decision methods are *imperfect in a variable way*, allowing the agent to improve them - in the sense of diminishing the computation costs and/or the expected losses due to errors - at the cost of some of the initially given resources.

The problem of decision methods is, however, somewhat more complicated than that of data. All these assumptions raise secondary decision problems about the best use of the above - let me call them "primary" - decision methods. To see what these problems are, compare the decision methods available to an agent to a library of computer programs. Clearly, the agent then also needs a program for using the library.

In the case of B1 - the usual version of the neoclassical optimization postulate - the secondary decision problem is trivial. The optimization methods available are assumed so powerful and cheap to run, that they can

be used carelessly, without any economizing. But in the other two cases, the secondary decision problems are significant.

In the case of B2, the secondary decision problems are, in fact, what Simon's and Heiner's theories are about. These theories can be regarded precisely as providing optimization methods for these problems - the former to cope best with computation costs by limiting the length of search, and the latter to cope best with losses from errors by *a priori* simplifying the primary decision problems. Recalling the earlier discussion of A2, the role of Simon's and Heiner's theories can thus be compared to the role of Bayesian and game theories: while the latter state what is best to do with given incomplete data, the former state what is best to do with given imperfect decision methods.

Of course, to apply Simon's and Heiner's theories also requires data. To determine when it is best to stop a search and/or which fixed rule is best to follow, an agent needs economic data about the expected costs and benefits of continuing the search and/or of obeying alternative fixed rules. But this only leads to the already discussed problems of search for data, under the constraint of given deepest data. Regardless of what data an agent is then able to obtain - it may just be some more or less false deepest beliefs - they form the data constraint under which the agent can again be said to optimize in Boland's sense. At whatever point the search is actually stopped and/or whatever fixed rule is actually obeyed, the agent can again be said to make the best out of both the given scarce methods and the given deepest data.

The case of B3 is more complicated. In this case, the secondary decision problems are not only about the use of given feasible methods, but moreover about the acquisition of new, more powerful and/or cheaper to use methods. For instance, such methods can be learned, at a cost, from own search and experience and/or under the guidance of an instructor, or bought as instruction books or computer programs.

Some additional complications stem from the increased number of alternative uses among which the initially given resources must now be allocated. The cost and benefits of acquiring new methods become a new item in the agent's budget, to be weighed with the costs and benefits of using old methods, acquiring data, and - not to forget the ultimate purpose - using resources to maximize a given objective function.

Further complications stem from the fact that any system, to be able to acquire new methods, must first be endowed with methods for acquring methods - e.g., programming programs, or learning methods. Such methods, depending on how powerful they are, determine the costs of acquiring new methods. Moreover - and this is often forgotten - they also constrain the set of new methods which their owner can ever effectively acquire in an absolute sense, regardless of costs. And although some learning methods might also be improved by learning, such meta-learning would again require, and be constrained by, some pre-existing meta-learning methods. These would again imply some costs as well as absolute limits of such meta-learning. Hence for each system able to learn new methods, some learning methods must initially be given, determining the system's learning potential, or *talents*, in an irrevocable way.

3.4 Hierarchies of economic decision methods and ultimate constraints

The next question is what can be assumed about the decision methods for the secondary problems - that is, the problems of how to use and/or enlarge the library of methods for the primary problems. Clearly, the alternatives are of the same three kinds as in the first step. Denoting them B1', B2', and B3', they correspond, respectively, to the assumptions that such methods are perfect, or imperfect in a constant way, or imperfect in a variable way.

As is now easy to guess, the story of scarce economic decision methods can be continued in a way analogous to the above story of scarce economic data. In this way, room can be made for neoclassical theories of scarce economic decision methods of several levels. They can be described by a series which begin with assumptions of the third type and end, if infinite regress is to be avoided, by an assumption of the first or the second kind - that is, (B3, B3', ..., $B1^{(m)}$), or (B3, B3', ..., $B2^{(m)}$). The more plausible second alternative allows for theories combining Simonian satisficing and/or Heinerian obeying of a fixed rule at several levels. For instance, such a theory may consider an agent searching for a satisfactory method to search for a satisfactory solution to the primary problem, while simultaneously excluding some conceivable methods by an *a priori* fixed rule, to steer clear of potentially costly errors.

The earlier discussed hierarchies of scarce economic data, built on given endowments of deepest data, can thus be accompanied and intertwined with analogous hierarchies of scarce economic decision methods, built on

given endowments of deepest methods. And as long as attention is limited to single agents facing one-person allocation problems, Boland is again right that the optimization postulate can be saved: an agent, however poorly endowed with methods and data, can indeed be said to do *his* best under the constraint of the two given endowments.

4 ECONOMIC COMPETENCE AS TACIT AND HIDDEN INFORMATION

Thus far, most of the optimization postulate controversy has been limited to one-agent decisionmaking and *private* optimizing. As the two previous chapters have shown, in that case the postulate can, at least formally, be defended. But the postulate has an important role to play in other areas of economics as well. It is in the area of theoretical welfare economics, studying social allocation of resources and *social* optimizing, that the viability of the postulate is now to be examined. In this area, the first question is, which scarce resources, including scarce information, can effectively be transferred from one agent to another. The purpose of this chapter is to show that there is scarce economic information - to be defined as *economic competence* - on which the transferability of all other economic information depends, but which itself cannot be transferred, and not even reliably measured.

4.1 Hierarchies of economic information

While the distinction between economic data and decision methods remains important, much of the following discussion can abstract from it, speaking of both of them as economic information. As the two previous sections have shown, there are indeed many properties which economic data and decision methods have in common. In particular, they build similar hierarchies, where higher levels repose on deeper levels, with the deepest level constituting the ultimate constaint. As a result, the problems of their scarcity form similar patterns which can, at least in principle, be handled by neoclassical analysis in similar ways with similar kinds of results.

Moreover, when considering economic data and decision methods at the same time, their respective hierarchies appear not only similar, but also closely intertwined: to deal with data of a certain level requires both a method and deeper data, and to deal with a method of a certain level requires both data and a deeper method. This makes it possible to consider them jointly, as hierarchies of one kind - those of economic information. The conclusions which have been reached for each of them can then be synthesized by the two following propositions:

- An agent, to deal with any economic information, must alredy be endowed with some deeper economic information.

- An agent's endowment of the deepest information is the ultimate constraint which limits his abilities to deal with all other information.

Note the agreement with the initial definition of information (Section 1.1): without some preexisting information, no new information can make sense - or, more precisely, exist at all. An important implication then is that communication between two agents is possible only to the degree that they have some preexisting information in common - such as the knowledge of a common language, including both a common vocabulary ("data") and a common grammar ("method"). The problem of communication with extra-terrestrials (cf. Note 4 above) illustrates this point.

In pure logic, one migh build arbitrarily deep hierarchies of economic information, relegating the ultimate constraint to ever deeper levels. For instance, one might say that if an agent needed some economic information, he could buy it on a market, and if this required some deeper information, he could buy it on another market, and if this required some even deeper information, he could buy it on yet another market, and so on. While one can never escape the Gödelian catch that, ultimately, some economic information cannot be bought, but must be intrinsic to the buyer, one might dodge it indefinitely.

However, when one keeps in mind that economic agents are human beings, or organizations of human beings, the depth to which one can reasonably descend is limited empirically. One must then accept as the deepest information the enormous but nevertheless limited potential of human brains to handle all other information, as it stems, with individual variations, from the historically given biological and cultural evolutions.

4.2 Communicable v. *tacit information*

As mentioned, the question of transferability of resources, including communicability of information, is of particular importance for the problem of social optimizing. For information at the deepest levels, this question is related to self-awareness, in the sense of introspection and articulation about one's own mental operations. In present terms, this is the question of which part of the hierarchy of information with which human brains actually work they can moreover effectively describe and communicate about.

Accordingly, a hierarchy of economic information can be divided into two parts:

(1) communicable economic information, consisting of the economic data and decision methods which an agent can effectively communicate to another agent, provided (finite) communication costs are paid and the sender as well as the receiver are motivated by suitable incentives to do so;

(2) the information which is necessary to handle the communicable information, but which itself is impossible to communicate, regardless of the costs and incentives one might be willing to pay; it is this information which will be termed here *economic competence*.

There are two kinds of reasons why not all economic information can be embraced by (1). On the one hand, there is rich psychological evidence showing that people use information and take decisions in ways which they are often unable to account for entirely - that is, are guided by some information which they cannot describe and communicate. A chess master, able to play excellent chess, but unable to explain in all relevant details how he does it, is a case in point. On the other hand, there are the purely logical Gödelian reasons, for which no consistent system can entirely refer to itself. Hofstadter (1979) offers probably the best discussion of how these reasons relate to the limits of self-awareness of human brains.

To be sure, the dividing line between the two parts may be difficult to localize accurately. One difficulty may be that the abilities to introspect and articulate, on which the line depends, may be different for different individuals, and thus too complex to measure and describe in all details. Moreover, the line may occasionally move - for instance, because the research in Artificial Intelligence succeeds in making communicable, in the form of a sophisticated computer program, a problem-solving method which no one was able to communicate before. But what is important here is only the fact that this line must exist, *somewhere*, regardless of its precise location.

Recently, economic literature has paid a growing attention to information which people use but cannot communicate. Following Polanyi (1962), such information is usually referred to as "tacit knowledge" - e.g., in Nelson and Winter (1982), Murnane and Nelson (1984), and Williamson

(1985). Although most of this literature is about technical information, there is no reason why this term could not be used for economic information as well. It is in this sense that economic competence, as defined above, will be said to be *tacit*.

Since decision methods are usually more difficult to describe and communicate than data, one can expect most of economic competence to consist of the former, and most of communicable information, of the latter. But as some data may nevertheless be tacit, while some decision methods are clearly communicable, economic competence does not consist of *only* decision methods, nor of *all* decision methods.

For example, many decision methods - such as described in instruction books or computer programs - can be communicated between agents, possibly subject to market transactions. Such methods, then, do not count as economic competence. Yet economic competence is needed even in such cases. This is the non-negligible competence which such books and programs always require, if they are to be correctly understood, evaluated, and applied.

To visualize how tacit data and tacit decision methods mix to form economic competence, one may think of how parameters mix with mathematico-logical operations in computer programs. The data - such as initial beliefs - may be compared to such parameters, intervening in chains of computation and inference, as prescribed by the methods. That both are important is obvious: unsound beliefs may spoil even the most ingenious inference and possibly be as disastrous as faulty inference based on reasonable beliefs.

The double role of economic competence can now be made clear. Recall the familiar picture of an agent solving an economic problem under the constraint of available resources, including information. As a kind of economic information, economic competence is a part of the constraint. But as it determines how the agent will use all other economic information and, with its help, all other scarce resources, economic competence is also the very way in which the problem will be solved. In this sense, it can be said to determine the agent's *behavior* - possibly visualized as a decision or response function, with all parameters specified.

4.3 Acquiring economic competence

Obviously, if all communicating of economic information requires economic competence, each agent must always posses more economic information than

it can communicate and/or acquire by communication, the difference being precisely his economic competence. The question then is: By what other means, if not by communication, can economic competence be acquired?

The first thing to note is that economic competence itself may consist of several levels of information. Clearly, not only the deepest data and methods, but possibly also some less deep information may be impossible to communicate. In such a case, economic competence is there to handle not only communicable information, but parts of itself as well. More precisely, it is its deepest levels which determine how to handle - by what is usually called adaptation or learning - the less deep levels. Such deepest levels must then include some of the deepest (meta-)learning methods, as mentioned in Section 3.3 above. Hence one part of the answer is that some economic competence, with the exception of the deepest levels, can be acquired by own learning.

To depict the main features of such a situation, it is often sufficient to consider only two such levels. One, denoted as *current*, contains the less deep data and decision methods which determine how an agent uses communicable information and solves economic problems in the short run. In the long run, the current competence is allowed to vary by the agent's own learning. To make this possible is the task of economic competence of the second, deepest level - conveniently denoted as *economic learning competence* or *economic talents* - assumed invariant even in the long run.

By limiting attention to adults, one can avoid the still heated nature v. culture controversy. The economic talents of an individual - e.g., determining how competent entrepreneur, investor, or manager he might ever become - can then be ascribed to an unspecified mixture of his inborn talents and more or less early education.

Note, however, that if this case were to be examined in detail, it would be necessary to admit that more than two competence levels may be involved - that is, that a person's economic learning competence may be the result of some meta-learning during her early education. The necessity to base such meta-learning on some even deeper competence would then reappear. Of course, such meta-learning competence may be quite broad, concerning the abilities to learn several fields of competence, and not just the economic one. But provided the adjective "economic" is understood in a non-exclusive way, any learning competence which provides for learning of economic

competence can be denoted as "economic", even if it allows for learning of other kinds of competence as well.

The entire answer to the above question can thus be summarized as follows. *Each agent must be given at least a part of his economic competence initially, and may acquire another part by own learning, subject to the constraint of the initially given part.* This means that what an agent can learn depends not only on his learning environment - e.g., on the possibilities to observe and imitate other agents - and on the investment he is willing to spend on learning, but also on his initially given economic talents, or the competence to learn economic competence. The talents thus constrain the maximum current competence which an agent might ever learn in an ideal learning environment with maximum efforts.

As concern for equity makes many economists reluctant to recognize individual differences in economic talents, and the corresponding need for their efficient social allocation, two notes may be useful.[6] First, to make the idea intuitively appealing, it may be helpful to think of all the other fields of human activities where the crucial role of talents for top performance is uncontested - such as in musik, mathematics, or chess playing. For instance, to recognize that not everyone could become as competent conductor as von Karajan, as competent mathematician as Gödel, or as competent chess player as Kasparov, can make it easier to recognize that not everyone could become as competent entrepreneur, planner, and investor as Ford, Bata, or Wallenberg.[7]

Second, it may be helpful to realize that this recognition means no obligation to become an advocate of high income inequalities. The income distribution issue is quite different from the present one - that of the *productive* use of economic competence in society. Even if some efficiency-

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6. At a recent conference, this kind of differences was refused to be recognized even by some of the participants who were otherwise strongly critical of neoclassical economics just for its way of assuming all economic agents to be so similar.

7. An interesting study which deals with this kind of differences is Lucas (1978). Postulating a distribution of persons by what he defines as managerial talent, Lucas studies the corresponding size distribution of business firms. For the present argument, it is of interest not only what he studies, but also what he does not; this is the allocation mechanism by which the right firms of the right sizes could form and be connected to the right managerial talents.

equity tradeoff is recognized as inevitable - and Section 8.4 will return to this point - its terms must be expected much worse for an economy where the tasks of organizing, planning, and administering production and production investment are assigned without discrimination according to economic competence and talents, than for an economy where a suitable form of such discrimination is applied.

4.4 Measuring economic competence

For social allocation of resources, another important question is, how to measure the stocks of the resources which are under the control of different agents. That it is difficult to measure the stocks of economic information was already noted by Marschak (1954). To mesure the stocks of economic competence involves an additional difficulty.

Marschak's solution gives a useful clue. Given a specific decision problem, his idea is to compare the expected payoffs which can be obtained with and without a given piece of information. The difference is then said to be the value of that information for that problem.

This suggests that economic competence may also be measured by its performance in given economic problems, in terms of the gains or losses which its application would cause. Heiner (1983, 1988), by his focus on *competence-difficulty gaps* (cf. Section 3.2 above), seems to be closest to following this suggestion. The costs of the errors committed when a certain competence is employed for solving a certain problem of a certain difficulty seem indeed to provide a good measure of this kind. For instance, for a perfect optimizer, and also for any less perfect agent whose problems are not more difficult than what his competence allows him to handle, these costs would be zero. As the following chapter will show, it is in the study of economic organizations that the costs of such errors, and the underlying notion of competence-difficulty gaps, prove particularly helpful.

The additional difficulty in measuring economic competence is that its very owners are often unaware of how much of it they posses. The frequent cases of overestimation or underestimation of one's own competence demonstrate this point empirically. It is in this sense that economic competence will be said to be *hidden*.

This property imposes a severe constraint on the ways in which economic competence might efficiently be allocated in society. In

particular, all the usual allocation mechanisms which require that the stocks of the resources allocated be known at least to their owners are ruled out.

There seem to be only two principles of measuring economic competence on which efficient allocation mechanisms can be built. One is *relevant economic competition*, through which stocks of economic competence are measured according to their *relative* performance in the same kind of economic problems in which they are to be used also in the future. This is in contrast with other kinds of competition - such as political or rhetorical. The intuitive idea is that the competence to play a certain game is best measured by tournaments in *that* game, and not by tournaments in other games, nor by interviews with the players about how good they think they are.

The other principle is *qualified guessing*, which can yield, often faster and cheaper, as good results as relevant competition, but - and this is the catch - *only if done with sufficiently high competence*. By itself, this principle is, therefore, insufficient. While it can be a great help for important parts of the social competence-allocation problem, it raises a difficult competence-allocation problem of its own - the one of how to recognize and efficiently allocate the scarce competence that its own application requires.

5 THE QUESTION OF COMPOSITION

Although it was not specified who, or what, was the agent whose economic competence was discussed, the natural interpretation was to think of an individual. But this is by no means necessary. Even multipersonal organizations, including entire economies, can be said to have economic problems to solve - such as maximization of profits or of social welfare - and to use for this purpose hierarchies of economic information, of which only a part can be described and communicated to outsiders. This suggests that even such organizations can be viewed as endowed with certain economic competence, on which their success, or failure, in solving their respective problems will depend. To elaborate this view is the task of the present chapter.

5.1 Economic competence of multipersonal organizations

That an organization is a repository of specific information (knowledge) which determines much of its activities, but cannot be expressed and transmitted to another organization, has been observed by several authors. In the study of business organizations, an example of such information is what Nelson and Winter (1982) call a firm's *routines*. More precisely, it is those of the routines which determine the firm's business skills - as opposed to the ones which determine its technological know-how - that are virtually identical to what is called here economic competence. In somewhat different terms, the existence of such firm-specific information is also pointed out by Eliasson (1974).

Recall that economic competence determines how all other economic information is used, which in turn determines how all other scarce resources are used. In other words, ecoomic competence is what determines the performance of its owner, under the constraint of available scarce resources, including communicable economic information. In the case of an individual, it was already noted that his economic competence corresponds to his optimization abilities, and is thus the basis of his economic rationality. To extend this reasoning from individuals to multipersonal organizations leads to an interesting and somewhat surprising view.

If economic competence is still to correspond to optimization abilities, the economic competence of an organization must be the basis of the organization's efficiency - such as allocative, or Pareto efficiency of an

economy, or the productive, or x-efficiency of a firm.[8] The three well-known notions of theoretical economics - the rationality of individuals, the Pareto efficiency of economies, and the x-efficiency of firms - traditionally regarded as qualitatively different, are thus exposed as having an important unifying property in common: they all reflect the economic competence of the economic unit in questions. The term "economic competence" can thus be viewed as equivalent to both "rationality" and "efficiency".

But to recognize that both organizations and their individual members are each of certain economic competence raises the difficult question of composition: *How does the competence of an organization depend on the competence of its members?*

Traditionally, neoclassical welfare economics has studied this question for the special case of a possibly incompetent organization made of perfectly competent members - that is, an economy which may fail to be efficient, but whose member-agents never fail to be equally perfect optimizers. But if economic competence is recognized as scarce at any level, including that of individuals, other cases must be studied as well. In general, it is necessary to consider that more or less competent ("efficient") organizations can be made of more or less competent ("rational") members. Note that this must also include the diametrally opposite case to the one usually considered in economics - the Weberian bureaucracy as a highly competent organization made of boundedly competent individual members. The rest of this section is to present all these cases

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8. To denote the performance of a firm by the term "x-efficiency" was suggested by Leibenstein (1966). His argument that a firm could be less than fully "x-efficient" was contested, in particular by Stigler (1976), in what can be regarded as an extended controversy about the optimization postulate. While using this term here, I do not *a priori* subscribe to either side of that controversy. To be precise, I even use it in a somewhat different meaning than Leibenstein. He refers to several reasons, emphasizing possible lack of motivation and discipline of the employees, to explain why a firm may fail to use its non-human factors of production in the most efficient way. Here, in contrast, only the firm's economic competence is in question. In agreement with standard theory, the kind of labor supply is assumed given, with whatever preferences over work, leisure, and discipline the potential employees may have, and counted as part of the contraints under which the firm is to optimize. Any failure to select the (relatively) most suitable actual employees and/or to motivate them by the most suitable incentives is fully ascribed to the firm's inadequate economic competence.

as neoclassically as possible, in order to give neoclassical economics a fair chance to try to study them.

5.2 The structure of an organization

Neoclassical economics, much like all modern natural sciences, is reductionist. It is based on the principle that the properties of a whole are determined by the properties of its parts and by the arrangement which links these together - much like the performance of a machine is determined by the performance of its parts and by its overall design. .

That the arrangement of the parts is recognized as one of the determining factor should perhaps be emphasized. Reductionism has often been criticized for "seeing a whole as nothing more than a simple sum of its parts." But this is a careless and unfair criticism. The term "simple sum" is a pure invention of the critics themselves which no serious reductionist would ever think of employing. Regardless of what this term might mean, to take into consideration also the arrangement of the parts is a clear sign that a whole is recognized as something "more" than a "simple sum of parts."

Applied to the present question, the reductionist principle says that the economic competence of an economic organization - such as a large firm, or an entire economy - is determined by the economic competence of the member-agents and by their arrangement. To state this idea more precisely, let me define the structure, S, of an economic organization as the set of its member-agents M, the vector of their behaviors, (b_i), and the matrix of their arrangement, $[A_{i,j}]$:

$$S \equiv \{[A_{i,j}], (b_i), \text{ for } i,j \in M\}.$$

In the arrangement, $A_{i,j}$ denotes the set of transfers of (control over) resources, including communication of information, from agent i to agent j, from which the actual transfer, $a_{i,j}$, must be chosen - that is, $a_{i,j} \in A_{i,j}$. A suitable name for such a set is "exchange channel", generalizing the well-known notion of "communication channel". The channels depend on, but are not uniquely determined by, the prevailing institutional rules. Such rules - to be discussed in more detail in the next chapter - determine which channels and arrangements are institutionally permissible, but leave open the question of which of these will actually be established.

Examples of arrangements are a set of established markets, an established hierarchy, or a mixture of the two, for which the prevailing institutional rules - such as a certain form of property rights and corporate and antitrust laws - make room. Note that if a channel is to allow for voluntary transfers, as is typical for channels of which markets are made, the set $A_{i,j}$ must include zero. Otherwise, the channel implies some obligatory transfers, as is typical for channels constituting a hierarchy. The set may also be a function of time - e.g., certain transfers may, or must, be conducted only in certain periods - or of other transfers - e.g., upon the delivery of a voluntarily ordered good, an obligatory payment must follow. Both arrangements and rules are sometimes referred to as institutions (cf. Langlois 1985: 18-19), but I find it preferrable to have different terms for different things.

To include also the channels from and to the environment of the organization - such as nature and other organizations - the environment can be counted, as is often done, as agent "0", which allows such channels to be denoted as $A_{0,i}$ and $A_{i,0}$, respectively.

As mentioned, an agent's behavior, b_i, can be viewed as a decision or response function. Since the optimization postulate was shown to hold for private optimizing, b_i can be said to maximize i's utility function, u_i, under the constraint of i's actual control over scarce resources, x_i, and under the constraint of the prevailing institutional rules (often needed to define in the first place what "control over resources" means). As usual in the theory of revealed preferences, u_i is then assumed unknown to an external observer, allowing for the familiar tautological inference that i does what he prefers and prefers what he does, under the two constraints.

Note that thus far, the definition has done nothing more than give a name to a concept which neoclassical economists often have in mind. Sometimes they refer to it as a "resource-allocation mechanism," but most of the time they leave it without any particular name. Clearly, the set of given economic agents, of given maximizing behavior, arranged into a given set of markets or, alternatively, into a given hierarchy of planning, on which neoclassical welfare theorizing always reposes, is nothing else than a structure in the above sense.

Note also that the term "structure" is sometimes used in a close but not quite identical meaning. For instance, when Stiglitz (1984) speaks of "organizational structures", or Williamson (1985) of "governance structures",

they have in mind what is defined here as "arrangements" - that is, structures without specified member-agents. On the other hand, what is defined here as the structure of an organization - with both the arrangement and the member-agents specified - is often interpreted as *the* organization. But this interpretation has the serious drawback of forbidding all organizations to make even the slightest change in their arrangements or memberships, under the penalty of losing their identity.[9]

5.3 Structure-behavior analysis

An important property of the above definition is to make the structure of an organization include all the factors which determine the organization's global behavior - that is, the ways in which the organization responds to its environment, under the constraint of its global resource undowment (i.e., the resources under the control of at least one of its agents). Hence the definition makes true an important relationship which has proved fruitful in much of modern science and engineering - that, at least in a stochastic sense, *structure determines behavior*.[10]

Of course, to predict what behavior a given structure will actually have may pose difficult analytical problems, which for many structures are still far from being solved, and for some of them may even be impossible to solve. It is also usual that the behavior cannot be predicted in detail,

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9. An interesting term which is closely related to "structure" in the present sense is "network", as defined by Marschak and Radner (1972). A network can be regarded as a structure unfolded in time, where every instance of an agent performing an operation figures as a separate element of the network, so that the same agent can correspond to several elements. Symmetrically, a structure can be regarded as a network collapsed into an atemporal construction - such as a "machine" or "mechanism" - where each agent figures only once, but can operate many times. The difference thus is that a structure can contain "feedbacks" - such as chains of operations coming back to agents previously involved - whereas a network cannot. This also means that a structure without "feedbacks" is identical to a network.

10. This causal relationship should not be confused with its opposite - the teleological assumption that behavior determines structure. The latter presumes the existence of a creator or a perfectly optimizing evolutionary process which always makes sure that for any desirable behavior, a structure able to perform it is automatically formed. To question this assumption and to show that the formation of such structures, far from automatic, involves an intriguing resource-allocation problem is one of the tasks of the present argument.

but only globally characterized by some of its properties. Moreover, the structure is often not known in detail either. In such cases, the scope for structure-behavior analysis is limited to predicting only some properties of the behavior from only some properties of the structure. But even when limited, this kind of analysis is important; this is often the only effective way we have to learn how we and the world around us work.

It is easy to verify that such a structure-behavior analysis has also been conducted by neoclassical welfare economics. Its main result - the famous twin theorem - can indeed be viewed as making such a prediction. What it says is, in essence, that the structure of an economy which contains only perfectly optimizing agents, arranged only into perfectly competitive markets, will behave - under the well-known convexity conditions - in a Pareto-efficient way. In a similar vein, neoclassical comparative economics seeks to discover the potential for Pareto efficiency in the behavior of different market and non-market structures, into which such perfectly optimizing agents might alternatively be arranged. At the level of firms, examples of structure-behavior analysis are the economic theory of teams, as elaborated by Marschak and Radner (1972), the principal-agent theory, as pioneered by Ross (1973), and Williamson's (1975) comparison of markets and hieararchies.[11]

With such familiar cases in mind, it is easy to see which other cases must moreover be included in the subject of analysis. In general, what must be done is to admit that not only entire organizations, but also their parts might be more or less imperfect. That fatal mistakes can be committed when parts of a large unit are assumed to be of a better quality and/or more homogeneous than what they actually are is the basic wisdom which every engineer must learn as soon as possible. The question now is, how to spread this wisdom also to theoretical economics.[12]

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11. Of course, Williamson's analysis cannot be regarded as neoclassical, for it drops the optimization postulate. But although the agents involved are assumed only boundedly rational, the possibility that the rationality of different agents might be bounded in different ways and degrees is not explored. Therefore, neither this analysis comprises all the cases relevant to the present problem.

12. An interesting step in this direction is the literature on job-assignment (see, e.g., Waldman, 1984), where different individuals, assumed of different qualities, are to be assigned to different jobs within an organization. But this literature remains about as remote from the present

5.4 The Composition Principle

At this point, a traditional welfare economist might object that his task is not to study qualities of individuals, but only the properties of different market and non-market arrangements by which individuals are, could be, or should be, related to each other. It is therefore important to emphasize that on this point, the task of economic theory is not to change. It is not qualities of individuals as such, but the ways in which different arrangements take these qualities into account that is the main novelty to be studied. More precisely, each arrangement is to be examined also for the economic competence it demands from the participating individuals, compared to the competence they can effectively supply.

That this a significant property of arrangements which neoclassical analysis has thus far omitted to examine is easy to illustrate. For instance, when assessing different market and non-market arrangements, that analysis has never taken into consideration the fact that some of them - such as the highly sophisticated incentive-compatible procedures of informationally decentralized planning - demand much more economic competence from their agents than others. The significant fact which is thus overlooked - with potentially disastrous policy implications - is that such sophisticated arrangements, in spite of their optimality in the theoretical world where economic competence is abundant, may grossly fail in the real world where this competence is scarce, likely to be inferior to some much simpler second- or third-best arrangements whose demands for the agents' competence are better adjusted to the available supply.

To see more clearly on which point the new analysis is to depart from the traditional one, recall that the behavior of each economic is determined, by definition, by the unit's economic competence. Moreover, the behavior of a multipersonal organization is also determined by its structure. Hence for an organization, its competence must be contained in

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problem as the literature on human capital (cf. Section 3.1 above). Namely, the qualities in question are those of factors of production in a technological organization, rather than those of economic agents in an economic organization. And even if some of the quality differences may be related to economic decisionmaking - such as those of managers - they concern other things - such as motivation and disutility of effort - but not rationality bounds or optimization abilities. Moreover, at least one economic agent - e.g., the manager who appoints the other employees, or the owner who appoints the manager - is always assumed to be perfectly competent and already perfectly appointed.

its structure. Intuitively, one can view the economic competence of an organization as embodied in its structure, much like the competence of a computer to handle software is embodied in its hardware. With the help of the idea that "structure", "behavior" and "competence" are in this sense equivalent, the above definition of structure can be rewritten into the following Composition Principle:

$$C \equiv \{[A_{i,j}], (c_i), \text{ for } i,j \in M\},$$

where C is the economic competence of an organization, and c_i is the economic competence of its ith member-agent. What the Principle says is, in plain words, that the economic competence of an organization is determined by the economic competence of its member-agents and by their arrangement.

Formally, the Principle is an equivalence, where the right side is a detailed description of, or the recipe for, the left side. Moreover, it may also be viewed as a function which is to determine, given the competence of the agents and their arrangement, what the competence of the organization will be. Of course, for any real organization, the difficulty with this function is that it would be computable only *in vivo*, by the organization itself, and not *in vitro*, by means of mathematical analysis or simulation techniques. But this diffulty is in full agreement with the present argument. What it suggests is precisely that also the economic competence of organizations is tacit and hidden: tacit in the sense that it cannot be separated from the organization itself and communicated to another organization, and hidden in the sense that it cannot be directly measured. It thus leaves, as possible means for being measured, the same two principles as the economic competence of individuals - relevant economic competition and qualified guessing (cf. Section 4.4 above).

5.5 Competence-difficulty gaps in organizations

Although, for all practical purposes, the Composition Principle is incomputable, this does not makes it useless. A theory can gain not only from computing what can be computed - as most of modern economics has been doing - but also, and sometimes above all, from realizing what cannot. If there are real economic problems which cannot be computed, it is an important question which economic theory should also seriously address, how

should such incomputable problems be efficiently handled by individuals as well as by society. Even such problems are, then, useful to state.

Moreover, the Principle has some simple implications which are not without interest. Two of them help precisely in clarifying how the task of economic analysis is now to be enlarged:

(1) The same agents can form differently competent organizations, if put into different arrangements.
(2) The same arrangement can result in differently competent organizations if filled with different, or differently permuted, agents.

While (1) refers to the traditionally studied cases, (2) points to the new ones. Note that they are new not only for the existing neoclassical theories, but also for Williamson's. Clearly, as long as all agents are assumed to be of the same economic competence - be it equally perfect or equally bounded - they can be exchanged or permuted *ad libidum*, while the competence of the organization remains the same.

An example showing the potentially great significance of the latter cases is the puzzle of similarly looking but differently performing hierarchies - such as superficially similar firms in similar conditions of which some succeed and other fail. To cope with this puzzle, it must be recognized that the performance of different markets and hierarchies will also depend on the tacit and hidden economic competence of the individuals involved. For instance, it is then possible to admit, in agreement with empirical observations, that even an extremely large hierarchy may outperform the corresponding markets, but only if extremely competent individuals - such as the most talented managers in the sense of Lucas (1978) - kept occupying its top. Clearly, this is the less likely, other things being equal, the larger is the hierarchy. And let me add - as Chapter 7 will discuss in more detail - that the other things include the prevailing institutional rules under which such hierarchies form and grow, and which may substantially influence the probability that large efficient hierarchies will appear and remain efficient.

The Principle also provides a useful guideline for studying organizations in Heiner's terms of competence-difficulty gaps (cf. Sections 3.2 and 4.4 above), which I believe particularly fruitful for that purpose. Although initially introduced to study one-person decision problems, Heiner

(1988) takes an interesting step towards using them also in the study of organizations. Considering that people in general suffer from competence limits, he shows - in what can be seen as a modern justification of Max Weber's view of bureaucracy - that organizations with internal rules and specialized roles are efficient ways for dealing with such limits. The Principle suggests to take a further step by considering that different people may suffer from different competence limits. It thus leads to the problem of architecture of organizations, as stated, in slightly different terms, by Stiglitz (1984): Consider a set of differently competent individuals which are to form an organization containing differently difficult decision tasks. Abstracting from the process by which the organization could actually form, find out what its optimal structure would be.

The main idea is to consider the set of individuals, described by the vector of their individual competences, (c_i), and match it with the vector of the difficulties of their respective decision tasks in the organization, say (d_i). The result is a vector of competence-difficulty gaps, say (g_i), which offers an interesting description of the organization.

Note that the vector of difficulties, (d_i), directly follows from the matrix of arrangement $[A_{i,j}]$. The difficulty of the ith task is clearly determined by the ith row and the ith column of the matrix. The former showswhat kinds of output must be decided upon, and the latter shows what kinds of input are supplied for this purpose.

The vector of gaps, (g_i), is interesting in that it suggests a way to construct a useful performance indicator for the organization. For this purpose, it would have to be complemented by a vector of weights, say (w_i), showing the impact of different decision tasks on the organization's gains or losses. In particular, these weights would have to translate expected levels of decision errors into expected losses for the organization. Roughly speaking, the idea is to express the total expected losses of the organization as a weighed sum of the kind $\Sigma w_i g_i$.

Of course, several difficult problems would have to be solved, before this idea could be elaborated with rigor. But even in such a rough form, it offers an interesting insight. It shows that the design of decision tasks and their assignment to specific individuals are complementary problems, whose solutions must be adapted to the competences of the individuals available.

5.6 Arrangements as a scarce resource

As for each organization, it is its arrangement which determines both the design and the assignment of decision tasks, arrangements must be regarded as economic information which brings answers to economic problems of these two kinds. Recalling from Section 1.1 that any information must be related to the entire set of possible answers, let me roughly indicate what the set contains in this case.

Consider an organization on a given set of individuals, of given individual competences. If the organization need not involve all of them, its alternative arrangements may differ in one or several of the following aspects: (1) the size of its membership; (2) the design of the corresponding number of decision tasks; (3) the assignment of each of the members to one of the tasks.

The number of possible arrangements - which are what the set of possible answers is made of - is clearly enormous in all practical cases. For instance, they include arrangements for organizations of all different sizes, organizations whose tasks are more or less poorly designed, and those whose well-designed tasks are more or less poorly assigned. Consequently, any specific arrangement - that is, a specific choice from such an enormous set - must be regarded as containing an enormous amount of information.

To be sure, not all individual arrangements need be distinguished. In most cases, only payoff-relevant subsets, in the sense of Marschak and Radner (1972), are of interest. This means, for instance, that permutations of decision tasks among individuals of about the same competence need not be considered as separate cases. Also, as Stiglitz (1984) notes, some arrangements may be less sensitive to how their tasks are assigned than others. Using Heiner's terminology, these are the arrangements where even the most difficult tasks are sufficiently easy not to create too costly competence-difficulty gaps even if assigned to the least competent individuals.[13] But even then, the information likely remains enormous.

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13. Note that in spite of this advantage, such arrangements may be far from optimal. They may miss the possibly substantial gains from allowing some tasks to be difficult - provided, of course, that these are assigned to sufficiently competent individuals. The weighing of the expected losses from oversimplifying all tasks against the expected losses from misassigning some highly difficult tasks seems to lead to a familiar kind of analysis.

This information, contained in an arrangement itself, should be carefully distinguished from the one which the arrangement, once implemented, allows to be treated within the organization. The difference between the two is clearly germane to the difference between economic competence and communicable information - the former providing for the ways in which the latter can be used.

As economic competence consists mostly of decision methods, it is also instructive to compare the information in an arrangement, given a set of member-agents, to the information in a decision method (program), given a set of elementary operations (cf. Section 1.4 above). The task of arranging a given set of elementary operations to compose a complex decision method is clearly comparable to the task of arranging a given set of member-agents, each with his characteristic competence, to compose the competence of a multipersonal organization.

That an arrangement is a kind of economic competence also follows from the Composition Principle. We can see there that this is the economic competence with which individual economic competence is allocated within the organization, thus composing the global economic competence with which the organization will then allocate all other scarce resources.

Identified as part of economic competence whose scarcity is to be studied, the arrangements of organizations must thus also be considered scarce. Intuitively, this idea is easy to accept. The world does not abound in well organized firms and economies, and the idea that organization, in the sense of arrangement, is an important (scarce) factor of production has often been mentioned. But to give this idea a precise form is more difficult. To do so, the social resource-allocation problem must be restated in a more general way, allowing the production and use of arrangements to be treated in a comparable way as the production and use of any other scarce resource.

6 A GENERALIZED RESOURCE-ALLOCATION PROBLEM

To show how the traditional resource-allocation problem will change when economic competence is included among the resources to be produced and/or allocated, a convenient way is to focus on the production sector of an economy, into which given individuals of given individual competence are to be arranged. Such a sector will be depicted as a two-level structure, where the individuals are arranged into a set of firms and agencies, which in turn are arranged into the sector. The generalized allocation problem will then be shown to impose an apparently paradoxical task on the structure: to allocate also its own parts.

6.1 The structure of production

The main advantage of focusing on production is that no significant part of the new allocation problem is lost, while two controversial issues can be avoided. One is the value-loaded issue of social welfare function. Regardless of what private and public demands should be met, all attention of analysis can focus on the question of where the production frontier will be located. Since misallocation of economic competence within the production sector is bound to push the entire frontier inwards, thus worsening the terms of *all* welfare trade-offs, significant welfare conclusions can be drawn in a relatively value-free fashion - that is, relevant to a large category of quite different social welfare functions.

The second controversial issue avoided is the one of the economic competence of consumers. According to the principle of revealed preferences - as often contested as defended - an external observer cannot know consumers' preferences otherwise than from the choices the consumers actually make. Consequently, the borderline between economic competence and preferences becomes unclear. Provided the rules of transitivity are not violated, one cannot tell about any apparently unreasonable consumer choice whether it is due to a lack of competence or to peculiar preferences.

In contrast, when the focus is on production, the borderline becomes much sharper. Only the effort level which a producer chooses to develop in response to given incentives - such as short-term wage scales or long-term career possibilities - can be ascribed to subjective preferences for different kinds of effort and leisure. But as all productive effort moreover has an identifiable impact on social welfare, they are also subject

to some more objective evaluation criteria. For instance, if one can measure the social value of the inputs used and the outputs produced - which is often the case - one can then distinguish producers who are competent, but lazy, from those who are diligent, but incompetent: while the former produce little, the latter waste much.

For the present purposes, the discussion can further be simplified by abstracting from demographic changes, and assuming, as is often done, that the economy considered involves a once for all given set of individuals. It is then their economic competence - the current one in the short run, and the one they can potentially learn in the long run - which constitutes the given initial endowment of this scarce resource for the economy.

Among other things, this assumption makes it clear that efficiency in the allocation of economic competence is far from implying elimination of the economically incompetent individuals. Roughly speaking, they are only to be kept away from socially important *economic* decisions - such as those of large-scale investors, managers, and planners. But as many of them may be highly competent in other fields - such as the natural sciences, technology, or arts - they may still have to play important roles in an efficiently organized production sector. Moreover, even those who cannot become highly competent in any field need not suffer in terms of final consumption. Conceivably, they might be compensated for any lack of talents by a redistribution scheme along the lines of Roemer (1987). But as any redistribution scheme puts high demands on the economy's production performance, this would only make it more important to prevent economic incompetence from undermining the society's production possibilities.

This assumption thus points out precisely the problem of arrangement. As follows from the Composition Principle, if individuals with their respective economic competence are given, the only variable on which the global competence of the production sector depends must be the arrangement which relates them to each other, by defining and assigning their respective decision tasks.

6.2 How many levels?

The next question is how to depict the structure of the production sector in a relatively simple way while allowing for a meaningful study of the allocation of economic competence. Neoclassical economics has thus far offered two alternative pictures, both of one level only. The older one

considers the member-agents to be entire firms and agencies, neglecting their internal structures. On the other hand, the more recent individual transaction picture focuses on individuals, but neglects firms and agencies. These are depicted as mere bundles of individual contracts, while little attention is paid to the fact that each such bundle moreover forms an organization with a specific behavior - and thus also competence - of its own.

In contrast, as will become clear below, the study of allocation of economic competence requires that both multipersonal production units and the individuals which consitute them be considered. In other words, in agreement with Simon's (1969) view of the architecture of complexity, it will be necessary to depict the production sector as involving more than one level of organization. For the present purposes, it suffices to consider only two such levels, depicting the given individuals as more or less competently arranged into a set of firms and agencies of possibly different sizes, which in turn are more or less competently arranged into the production sector.

For example, such a two-level picture can be visualized as a mixture of markets and hierarchies in the sense of Williamson (1975). The firms - each with its internal hierarchy, possibly also mixed with some internal markets - can be seen as arranged into a set of markets - possibly classified according to different industries. In economies with industrial policy and/or planning, there are moreover government agencies, each with an internal hierarchy of its own, supplementing and/or replacing the inter-firm markets by elements of supra-firm hierarchies.

Among other things, such a two-level picture makes it possible to distinguish clearly between national and corporate planning, and between exit of firms and exit of individuals - two apparently simple distinctions which have nevertheless confused even some famous writers. Moreover, in policy analysis, this picture makes it clear in theory what has always been known in practice - that if an economy performs poorly, this may be due not only to failures of the markets or planning among existing firms, but possibly also to failures within the firms themselves. Of course, social policy can hardly concern these failures directly; as the next chapter will briefly explain, expected lack of relevant economic competence is precisely one of the most important reasons why government should abstain from firm-specific intervention. But the picture points to interesting indirect

policies, thus far neglected by theory, by which such inter-firm failures can conceivably be alleviated. Roughly speaking - and the next chapter will return to this point - such policies work with the institutional rules under which firms form and survive, trying to make sure that failing firms are forced to improve or close down, and that new superior firms are not prevented from entry.

Of course, an obvious drawback of multilevel analysis is its potential complexity, which seems to be the main reason why economic theory has been avoiding it. But this complexity can be kept within reasonable limits, if analysis can use a unique, sufficiently flexible framework which can be recurrently applied to each of the levels considered. Here another advantage of the Composition Principle appears. As its validity is not limited to any particular level, it can provide for such a framework. For instance, it can show how the economic competence of the production sector is composed of the competences of the incumbent firms and government agencies, as well as how the competence of each of these firms and agencies is composed of the competences of the individuals involved.

In contrast, traditional analysis is much less flexible, and it is instructive to realize why. An analytical framework, to be recurrently applicable to more then one level, must allow both organizations and their member-agents to be of less than perfect economic competence. If only organizations, but not for their member-agents, are allowed to be imperfect, the transition from one level to another is made impossible, indeed. An imperfectly competent organization at one level must then be the end of the story, for it cannot be taken for a perfectly competent member-agent of an organization at a higher level.'[14]

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14. This may well be one of the main reasons why Leibenstein's argument that firms may be x-inefficient was so vehemently opposed from the point of view of standard theory (cf. Note 8 above). From the present point of view, this argument is opposed not for admitting that multipersonal firms may be imperfect, but for presenting their imperfections as quite different and much more complicated creatures than imperfections of economies. The basis of the present argument is that both of these imperfections - x-inefficiency of firms as well as allocative inefficiency of economies - are only particular cases, at different levels of organization, of the same general problem.

6.3 Resource-allocation mechanisms which also allocate their own parts

The general resource-allocation problem which recognizes also economic competence as a scarce resource to be allocated can now be exposed in a relatively clear way. Two observations are crucial. On the one hand, structures are the mechanisms which allocate scarce resources. On the other hand, they embody the economic competence for doing so, composing it from the economic competence of their member-agents. Now, if economic competence is recognized as one of the scarce resources to be allocated, the additional problem is that *structures must allocate also their own more or less competent parts, to compose the competence with which to allocate.*

At first sight, this problem may appear paradoxical: it says that the economic competence of a structure is what the structure initially needs, in order to be able to allocate resources, as well as part of the outcome which it is ultimately to produce. As paradoxes of this kind were recently misused for violent attacks on reductionist analysis, and on the very foundations of all logical reasoning, let me emphasize that the paradox is only apparent. The key is not to forget time, and to admit that the economic competence with which a structure begins may be different from the one it eventually produces. More precisely, economic competence must be given a time index and, at any moment, its future allocation recognized as depending on its allocation achieved thus far.

To be sure, this constitutes a substantially more complicated resource-allocation problem than the one neoclassical analysis has studied thus far. In principle - and I describe the situation in more detail elsewhere (cf. Pelikan 1985, 1987 and 1988) - the behavior of economic agents must be enriched by a new dimension. The traditionally considered transactions of resources along some already established exchange channels - e.g., through existing markets and/or existing hierarchies - are no longer sufficient. Analysis must now also consider actions by which such exchange channels can be formed, modified, or dissolved - that is, by which agents associate with each other to form and reform arrangements of different forms and sizes. It is such *associative* actions which the agents need to take, if they are to be able to to modify, from within, the arrangemewhich composes them into a structure of a certain global competence. In other words, it is through associative actions that the agents' scarce economic competence is allocated to specific uses in society.

To visualize associative actions in a more vivid way, it may be helpful to think of what different agents must do, in order to make markets and hierarchies form, reform, grow, integrate, divide, contract, or dissolve. Of course, associative actions may simultaneously appear among the transactions which take place through some already existing parts of a structure - such as the markets for labor and capital, where the bundles of contracts which form and reform the hierarchies of capitalist firms are being concluded. But associative actions, allocating economic competence, differ in several respects from the usually studied transactions, allocating all other scarce resources. They have their own specific constraints - such as limited spans of control or limited trust - and involve their own specific preferences - such as personal sympathy or antipathy, the taste for empire-building, and valuations of alternative arrangements *per se*. And most importantly, associative actions not only allocate and reallocate a particular scarce resource, but moreover modify the very structure which will decide on further allocation of all scarce resources, including parts of its own economic competence.

Of course, a structure which changes its economic competence - and this is another complication - must also change itself, thus becoming a more or less different structure from the one it was before. On the one hand, this raises the question of how an economic organization can preserve its identity, which will be briefly considered in a moment. On the other hand, such succesive changes - if they are, as is most usual, sensitive to random disturbances and not strictly deterministic - are likely to become path-dependent, and thus amplify, rather than neutralize, the influence of some past random events. For instance, if a hierarchy happened to have exceptionally competent founders, able of exceptionally competent task-designing and assigning, it is likely to grow increasingly competent, whereas an accidental incompetence of a key person may switch an otherwise similar hierarchy on a path towards increasing incompetence.

Without speaking of path-dependence, but with many amusing details, Parkinson (1957) offers an excellent example of the latter case by describing what he calls *Injelitis* - a disease affecting an entire organization, initially caused by a single incompetent and jealous person.

When properly interpreted, none of these complications appears to lead to holistic mysteries. It is my working hypothesis, for which I have not yet found a single case of refutation, that even the generalized resource-

allocation problem fully remains within the scope of modern reductionist theorizing.[15] But this does not mean that it must also remain within the scope of neoclassical economics, which is only a very special case of reductionist theories.

15. Excellent examples of how a reductionist analysis can explain some intricate macrobehavior of wholes in terms of microactions of parts can be found in Shelling (1978).

7 THE LIMITS OF NEOCLASSICAL ANALYSIS AND THE NEED FOR AN EVOLUTIONARY THEORY

For neoclassical economics, to be able to accomodate the generalized resource-allocation problem, a necessary condition is that the optimization postulate can still be defended as a methodological device. Showing that this is no longer possible, this chapter will establish the need for another economic theory, if scarcity is to be studied in its full extent. It will argue that this must be a general evolutionary theory, containing neoclassical economics, as well as the existing theories of evolution through market selection, as special cases. To conclude, the chapter will briefly discuss the possibilities for such a general theory to be developed in a fruitful way, arriving at significant results different from the neoclassical ones.

7.1 The dilemma of neoclassical welfare economics

Recall from Chapter 3 that for one-agent private optimizing, the optimization postulate can be defended even when economic competence is recognized as scarce. To be sure, the economic competence of an agent is the way the agent has to solve his economic problems, and if it is in short supply, it may lead him far from the *objectively* best solutions to these problems. But as he has no other way to solve them, this must indeed be *his best way* - which is what allows the postulate to be saved.

In the context of social optimizing, however, this can no longer be the end of the story. Instead, the difference between the two kinds of solutions - reminiscent of the difference between procedural and absolute rationalities made by Simon (1976) - must be admitted as a new important variable into welfare economics. Clearly, if an economic problem, important for social welfare, might be alternatively solved by different agents - as is typical for economic problems within production - welfare economics is not helped by saying that each of them has his own optimal way to do so. The relevant question then is which of the different ways of private optimizing is closest to social optimizing.

Of course, possible differences between private and social optimizing are nothing new for neoclassical welfare economics. But thus far only some of them have been studied - namely those due to an imperfect arrangement of the economy. Most often, the focus has been on an imperfect market

arrangement which fails to provide some perfectly optimizing agents with correct incentives and/or sufficient communicable information, as is the case of the well-known market failures due to externalities or asymmetric information. In contrast, the general resource-allocation problem calls attention to another kind of differences between private and social optimizing - those due to a lack of economic competence of agents, causing more or less incorrect responses even to perfectly correct incentives and information.[16]

As an example, consider an economic decision task of a great importance for social welfare - such as the one of a key investor, the manager of a large production unit, or a central planner. If such a task is assigned to an individual of low economic competence, he can, of course, be said to optimize privately - in particular, if his salary exceeds his share of the social losses he will cause - but certainly not socially. A simple Pareto-improvement is then conceivable: to keep paying him the salary, but to assign the task to a more competent person.

It is at this point that the optimization postulate can no longer be defended, not even as a pure methodological device. If, with the same communicable information, different agents are able to solve the same problem in different ways, ending differently far from its socially best solution, they cannot be equally perfect social optimizers - contrary to what the postulate should imply for welfare economics. Instead, their optimization abilities must be recognized as different - for instance, to paraphrase Simon, their rationality must be recognized as bounded in different ways and/or degrees, or, to paraphrase Heiner, their competence-difficulty gaps must be recognized as being of different shapes and/or sizes.

There is yet another way to show why the optimization postulate has no room in a welfare economics which is to include economic competence among the scarce resources to be allocated. It is this way which is closely related to Gödel's Theorem. Its main idea is to view the postulate as reserving, within the set of scarce resources, an inviolable enclave where the ultimate tools for dealing with all other scarce resource are assembled,

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16. Heiner (1988) points out a similar difference by speaking of imperfect decisions as opposed to imperfect information.

postulated never to be scarce themselves. From the point of view of formal logic, such an enclave is crucial for making the axiomatic building of neoclassical welfare economics paradox-free. But considering the scarcity problems of real economies, such an enclave constitutes a blind spot, hiding the possibility that the tools themselves might be scarce and seriously misallocated. Once this possibility is pointed out - as this essay has tried to do - neoclassical welfare economics is put in front of a difficult dilemma: either to preserve such a blind spot, and thus keep ignoring the causes of some possibly important social losses, or to drop the optimization postulate and thus stop being neoclassical.

While the former alternative is hardly acceptable because of its obscurantism, the latter is feared by many theoretical economists as a step into the unknown, where their entire profession might be endangered. Undoubtedly, the old warning of J.S. Mills that without rational agents no economics is possible still has strong traumatizing effects on the profession. In the rest of this essay I wish to dispute this warning by presenting some evidence that there is life for economics even after the death of the optimization postulate.

7.2 The need for a general evolutionary theory

At first sight, economic processes without preexisting agents of guaranteed rationality, where rationality itself is a scarce resource, may seem absurd, indeed. They are similar to organization processes without a preexisting rational organizer, which for a long time were also considered absurd. But although these processes are not yet understood in their entirety, at least since Darwin they must be recognized as a legitimate subject of scientific inquiry.

The Darwinian hypothesis of evolution of life through random mutations and natural selection provides indeed a first rough idea of how such economic processes could be studied. And as Nelson and Winter note (1982, p.9), economists need not even worry about borrowing ideas from biology, for Darwin himself has an important intellectual debt to our predecessor Malthus. To make the problem of scarcity and rationality explicit, one can say that *the evolutionary hypothesis describes a plausible way to produce scarce rationality where previously there were none.*

In a sense, economics has an easier task than biology; as a social science, it need not start in a world with no rationality at all. Entering

at the moment when the evolution has already produced the design for human brain, economics may take for granted that much rationality already exists, and only be careful not to assume it more abundant and more equally distributed than as it has actually evolved.

That the evolutionary hypothesis can fruitfully be applied to a situation with an initially uneven distribution of rationality (economic competence) has been shown in several economic studies, the classical ones being those by Alchian (1950) and Winter (1971). Admitting that initially the optimization hypothesis need not hold, such studies usually consider a market where different firms may at first display different, not always optimizing behaviors. The market is then examined as a selection device which, *under certain favorable conditions*, will in the long run preserve only those firms whose behavior is optimizing.

While such studies are often interpreted as mere justifications of the optimization hypothesis, on which neoclassical theory can then continue to repose undisturbed, this is, as Winter (1975) makes particularly clear, a mistaken interpretation. Their true message is that neoclassical theory ignores an essential function of the market. While this theory carefully studies the price competition among profit-maximizing firms, it only assumes, without any serious examination, that the market selection has already worked so well that no other firms are left. But - as many authors have noted - there is no *a priori* guarantee that market selection must always work that well. The upshot is that once the optimization hypothesis is viewed as a result of market selection, one of the main tasks of economic theory must be to examine *how the market selection actually works*.

Pioneered by Schumpeter (1934, 1942), the work on this task has been probably most advanced by the evolutionary theory of Nelson and Winter (1982). But although undoubtedly a step in the right direction, the evolutionary theories which only deal with market selection cannot embrace the problem of allocation of economic competence in its entirety. As indicated by the above examples of allocation of economic competence in hierarchies, there may also be other important processes at work, calling for an evolutionary theory of a greater generality. While there is no space for developing such a new theory here - and I must admit that I am still far from being able to develop it properly even outside any space constraint - let me conclude the paper by a brief outline of how I believe

it could be developed and what kind of significant results, different from the neoclassical ones, it might eventually reach.[17]

But before I do so, let me emphasize that the new theory is to extend, rather than reject, neoclassical analysis. In many cases, this analysis is to be recognized as fully adequate - such as when the economic problems studied are simple enough to allow nearly everyone to solve them nearly optimally, or in normative studies of one-person decision problems, when it is the task of the theory itself to find out, for a given economic agent within a given structure, what decision method, no matter how sophisticated, he *should* use, to find the optimal solution to his problem.

Considering the entire field of theoretical economics, it is only a relatively small area where neoclassical analysis must definitely make room for the new theory. But from the point of view of social application, this area is extremely important. This is the area of policy analysis with normative implications for political actions - in particular those concerning the choice of economic system, and of economic policy within a given system. It is in this area that serious social losses can be caused by policy advice which neoclassically disregards the scarcity of economic competence and the problem of its efficient allocation in society.

7.3 From Darwinism to general evolutionary economics

To explain in which sense the new theory is to be more general than other evolutionary theories, the two stages of the Darwinian evolutionary hypothesis - random mutations and natural selection - provide a convenient starting point. In principle, the evolutionary processes through which economic competence is allocated, and which are to be studied by the new theory, can be divided into similar two stages. But they are more general in the sense that the mutations need not be entirely random, and the selection need not be entirely natural. With general trial-and-error processes in mind, they can be though of as generation of trials and correction of errors.[18]

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17. In a more detailed way, including some tentative results, such a theory is outlined in Pelikan (op. cit.).

18. Thinking of Schumpeter, one could also call them "creation" and "destruction."

Within each of these stages, evolutionary processes of several kinds and levels must further be distinguished. For instance, trials to change the allocation of economic competence may be conducted through internal reorganization within existing firms, or through entries of new firms. As to errors, they may be corrected voluntarily - provided their authors are able to perceive them and motivated to correct them - or forcefully, by budgetary constraints of different levels, such as those forcing the exit of an unsuccessful firm through its bankrupcy.

An important distinction is between the evolution of structures under given institutional rules - such as the Schumpeterian creative destruction *under capitalism* - and the evolution of institutional rules themselves, including the origins of capitalism and the possiblities of its transformation into another, more or less different institutional regime - such as discussed by Hayek (1973) or North (1982). In a sense which I make precise elsewhere (Pelikan, 1988), the former evolution can be compared to ontogeny - the development of an organism under a given genetic message of a given species - and the latter to phylogeny - the evolution of genetic messages of different species. Leaving the latter aside as a subject which may interest above all economic historians and social philosophers, let me say a few more words about the former - the evolution of structures under given institutional rules.

The sense in which mutations of structures are not entirely random and their selection not entirely natural can now be clarified by referring to the prevailing institutional rules. Of course, these are not the only ordering factors. Undoubtedly, the fact that people can make more or less competent predictions of eventual outcomes and/or have more or less selective associative preferences will also influence the choice of the mutations actually tried out under any institutional rules. But the point is here that most institutional rules impose additional constrains which trials are allowed. For instance, in capitalism such rules include corporate law, defining the institutionally permissible forms of firms, whereas socialism strongly constrain the set of permissible trials by the very prohibition of private ownership of capital.[19]

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19. Balcerowicz (1986), one of the rare writers studying the evolution of structures outside capitalism, speaks of such rules as organizational rights and notes several ways in which these rights are restricted and centralized even in otherwise decentralized forms of socialism.

In a similar fashion, institutional rules can make selection (error-correction) artificial, rather than natural. For instance, market selection can be institutionally conditioned by different variants of bankrupcy law, or by a law providing for firm-specific industrial policy, entitling government to subsidize failing firms. Within hierarchies, market selection is often entirely suppressed, replaced by selection through decisions of superiors.

The additional problem then is that as soon as a specific agent is allowed to intervene in selection, the question of his own economic competence must be raised, and the way he was selected for that position must be studied.[20] It is then also necessary to consider that a hierarchy which alleviates or suppresses market selection within itself is typically subject to selective pressures of some higher-level markets - such as national and international markets for a firm, or international markets for a centrally planned economy. The way in which its internal selection is institutionally arranged then often becomes decisive for its eventual success or failure in such a higher-level selection.

7.4 What analysis? What results?

While the above picture of evolutionary processes may very well be recognized as pointing to some real and important economic problems, a theoretical economist may nevertheless worry about its potential to provide for fruitful analysis. Let me therefore conclude by a few words about the analytical methods which might be employed and the results which might be reached.

Regarding equilibrium analysis, which many theoretical economists believe to be the only truly scientific method, its use is likely to be limited, though not entirely excluded. As Winter (1971) demonstrates, equilibrium analysis can be conducted even in an evolutionary context. In principle, it is quite possible to study the question of whether or not a structure, evolving under given institutional rules in a constant

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20. When discussing social policies to correct for imperfections of pure market selection, many evolutionary theorist tend to forget that even the policy-making agencies must be the product of some evolution, which may suffer from imperfections of its own. But let me emphasize right away - and I return to this point below - that this remark is far from implying that there is no social policy by which a pure market selection could be improved upon.

environment, would eventually stabilize itself in an equilibrium state, implying a certain equlibrium allocation of economic competence, which in turn would imply a certain equilibrium allocation of all other scarce resources.

But although not without interest - and Winter makes it quite clear - this question is of only limited importance for evolutionary analysis. This is particularly true of the area of policy analysis, where, as I argued, evolutionary analysis is definitely to prevail. In this area, the most important question often is how to keep an economy free of crises, by helping it out of the ones in which in may happen to find itself, without causing it to fall into others, possibly even more serious ones. Comparable to the medical question of how to keep the patient free of diseases, it may be fruitfully handled without knowing much about any equilibria which the economy could or should reach - just as the medical profession can cure an increasing number of diseases while still unable to define what perfect health is.

To deal with policy questions of this kind, two avenues appear particularly promising for evolutionary analysis. One is to develop and employ simulation models, of which several interesting examples are offered by Nelson and Winter (1982). Of course, the main drawback of simulating evolutionary processes is that different simulation runs may yield more or less different outcomes. But this drawback can at least partly be compensated by making many independent runs for each policy alternative considered. In a way which may distantly remind of statistical testing of new drugs, one can thus learn about the evolutionary effects of each alternative in terms of a statistical distribution.

Although much cruder, the second avenue - which I explore in my quoted papers - also appears to lead to interesting results for policy applications. Extending the well-known notion of market failures in resource-allocation, this avenue is to examine alternative institutional regimes (sets of institutional rules) for the failures they are likely to cause in the evolution of the corresponding structures. One advantage of such a comparative failure analysis is that it need not predict in detail how the evolution will actually unfold under any particular regime, but can content itself with finding out which regime will cause *relatively* less serious evolutionary failures than its alternatives.

The main results to be expected consist of qualifications and corrections of neoclassical policy advice. As hinted by some of the earlier examples, neoclassical analysis may easily overlook possibly important perverse effects of its policy recommendations, because it omits to check them for their often crucial impact on the evolution of structures, while often grossly overestimating the true supply of economic competence.

As an elementary but important example of such a result, let me use the one which I discuss in more detail in my 1988 paper. This is to expose some otherwise invisible perverse effects of government planning and firm-specific policy-making, including the most sophisticated informationally decentralized and incentive-compatible arrangements, as devised and proved optimal by mathematical neoclassical analysis. This result is so much more important that the case for this kind of government intervention can often be strenghtened, and its perverse effects thus even more obscured, by the apparently plausible pragmatic argument that the headquarters of a large multidivisional firm may successfully conduct a similar kind of planning or policy-making *vis-à-vis* its divisions and plants.

The main idea is to show that such arrangements are likely to suffer from prohibitively large competence-difficulty gaps of both the management of the production units and the central planning or policy-making agency. On the one hand (cf. Section 5.4 above), such arrangements usually demand more economic competence from their participants than the market - for instance, the production units must be able not only to maximize their profits in one actual situation, but moreover to imagine how they would maximize their profits in several hypothetical situations, and to communicate about such imaginary maximization in terms of defined parameters. On the other hand, the competence supplied is likely to be lower than on the market, for the market competence-selection role is weakened or suppressed for the production units, and can never be used for the central agency.

The competence-difficulty gap of the central agency proves crucial. Without it, the other gaps could be kept small by hierarchical competence-selection guided by the agency - much like the headquarters of a multi-divisional firm can keep the gaps in the rest of the firm small by guiding the selection of lower-level managers. The crucial point is that *evolution through market selection proves necessary - requiring a certain minimum competition with open entry on both the product and the capital markets -*

to make and keep the headquarters themselves sufficiently competent for this task.

This example also illustrates the strength and the nuances of such a general evolutionary analysis, in comparison with the more radical arguments that markets always *function* better than large-scale planning.[21] Whereas the credibility of such arguments is often weakened by their too radical attack on nearly all government economic policies, and by their inability to explain the success of large-scale corporate planning, evolutionary analysis can avoid both of these weaknesses. It admits that large-scale planning may succeed, provided it is the product of the right evolution, and it is not *a priori* hostile to government economic policies. To be sure, the importance of competitive markets, and in particular of competitive markets for capital and for corporate control, for the efficiency of the economy is emphasized. But the focus it on their *competence-selection role in the evolution of both market and non-market structures*, rather than on the usually studied role in the allocation of other scarce resources.

As to the nuances, this analysis fully admits the possibility of market failures - and even extends their traditional list by possible failures in competence-selection. Consequently, it can also recommend a non-negligible agenda for government economic policies. But even at that point it introduces a qualification of the traditional views. Since government is recognized as a product of a particular kind of evolution, where *politico-administrative* selection plays a dominant role, its expected *economic* competence is exposed as relatively low. This limits the recommended agenda to only those economic policies - still non-negligible - which are better conducted with relatively low economic competence than not conducted at all.

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21. Initially due to von Mises and Hayek, these arguments were recently restated and developed by Lavoie (1985).

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