THE ROLE OF INFORMATION IN CHOICE

Toward an Economic Theory of Knowledge

and Decision Making

by

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Chapter One

INTRODUCTION

> Whoever believes there are irrevocably true equations describing the universe is better equipped intellectually to watch T.V. espionage series than to engage in serious scientific endeavors.
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> --Richard Bellman[1]

> Science does not rest upon solid bedrock. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or given base; and if we stop driving the piles deeper, it is not because we have reached firm ground. We simply stop when we are satisfied that the piles are firm enough to carry the structure, at least for the time being.
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> --Sir Karl Popper[2]

The Role of Information in Choice

Information is the medium of decision making. When a decision-maker considers alternatives, which he must if a decision is to be made, it is not the alternative actions themselves that he will evaluate and choose from. It is

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[1] Some Vistas of Modern Mathematics, University of Kentucky Press, 1968, p. 59.

[2] The Logic of Scientific Discovery, Harper Torchbooks, Harper and Row, New York, 1959 (1968), p. 111.

rather his information about those alternatives that is considered and chosen from. Decisions are made from informational images[3] of alternatives rather than the alternatives themselves. The physical counterpart of the information image cannot exist in the mind; an ordinary brick would take up all the space available.

When an economist assumes perfect information or a homogeneous distribution of information, he usually assumes that each decision maker's information images correspond exactly to the actual characteristics of the items or situations that the information is supposed to represent. In such circumstances, each individual decision maker, whether acting independently or as a member of a coalition, will make the best choice possible from his alternatives, given his goals and the real constraints upon his actions. Operating within this context, an economist who knows something about the goals and real constraints faced by a decision-maker can predict this decision-maker's behavior. He can predict it perfectly if he has complete information

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[3]The term "information image," is used here somewhat differently from the way Kenneth Boulding used the idea of an information image in The Image, (Ann Arbor: University of Michigan Press, 1959). Boulding uses information image as a synonym for world view. The term information image as used in this dissertation refers to a "piece" of one's world view, an individual's conceptualization of some feature of his experience: a "tree," a "rock," a "good time," an "opportunity," a "price," the "possible," etcetera . . . .

about the individual's goals and constraints, provided that the universe in the area of interest is completely deterministic. Predictively, individuals facing budget constraints will each purchase one of the clearly defined best bundles within their means. A profit-maximizing decision-maker facing differentiable total cost and total revenue opportunities will choose an action (output target) that equates his marginal costs and marginal revenues.

It is choices made in these kinds of circumstances with which the economics literature has been primarily concerned. This has also been the case in the recent "economics of information" literature which includes a role for neither information nor incomplete information of other than a narrow kind. The departure from perfectly informed models has primarily been to consider areas that are not completely deterministic. Individuals in such a world are viewed as being perfectly informed about the range of possible states the world can take and their likelihood of occurrence, but not the actual events that will occur. Clearly individuals possess less information than they would were they to know precisely which events are going to happen at every point in time. However, given that the occurrence of the precise events is in most of these "information" considering models the result of a random process, the individual possess all of the information that it is possible to possess in this

kind of "universe" or economy. In this sense, therefore, such models are full-information models of choice in a non-deterministic setting.[4]

This dissertation will attempt to model choice in imperfectly informed circumstances. A decision maker is considered imperfectly informed if his information images of the "real" do not correspond perfectly with the real world. He may lack images of real possible outcomes or have less than precise images of the items his images represent, or, more commonly, some combination of these two information imperfections. Choice in these circumstances will be different from choices made in perfectly informed circumstances. In making a decision, one can consider only the information images that one has available to him at the point of decision. Since one's images will be less than perfect, decisions made will often appear to be less than perfect when contrasted with the decision one would have made in the abstraction of perfectly informed circumstances. An action or a plan of actions which is developed from imperfectly informed circumstances will be the plan or action that is believed to be best among the ones that one is aware of,

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[4]Examples of economic models of this genus include: G. Debreu, Theory of Value (New Haven: Yale University Press, 1959):98-102; G. Stigler, "The Economics of Information," Journal of Political Economy 69(June 1961):213-226; and J. Hirshleifer and J. G. Riley, "The New Economics of Information," mimeographed (Los Angeles: University of California, 1976).

rather than the "best possible" one, as a decision made in perfectly informed circumstances would be.

This "failing" of choice from imperfectly informed circumstances is in no way inconsistent with the standard optimizing paradigm. It is rather a consequence of the paradigm when the cost of being perfectly informed is included as a consideration of the choice process. In fact, given the costliness of being perfectly informed, the assumption that individuals are perfectly informed becomes the aspect that is incompatible with the usual optimizing paradigm.

For this reason, the attempts of economists concerned with adaptive expectations models to maintain that imperfect information and information processing constraints destroys the usefulness of the rationality assumption seem misguided.[5] The weakness perceived by these economists is not a weakness in the optimization paradigm itself, but rather a weakness in the usual specification of the constrained optimization problem facing a decision-maker. The choices made by individuals in imperfectly informed circumstances are "sub optimal" results of "bounded rationality" in the sense that

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[5]Several papers in this vein appear in Adaptive Economic Models, edited by H. Day and T. Groves (New York: Academic Press, 1975). An especially insightful piece by S. Winters appears in this volume on pages 119-136.

one's consideration of alternatives is "bounded" by one's informational images of those alternatives, and the choice ultimately made is not the same choice that one would have made under perfectly informed circumstances. An optimizing choice is not the selection of a global maximum. It is rather, the best course of action that is feasible given one's circumstances, a constrained maximization. A decision made from imperfectly informed circumstances is exactly this.

Rational Ignorance

In order to add to one's stock of information images, one takes partially refined information and processes it. Partially refined information consists of information images that have "implications" which have not been completely examined or conceived. The process of further refining partially refined information images requires in most circumstances the use of resources controlled by the individual decision maker. For this reason, information processing has an economic opportunity cost to an individual who controls only finite resources. Predictively an individual facing positive information processing costs will tend to economize on information processing. An individual will tend not to devote all of his resources to information processing; he thus will quite rationally possess less than the most highly refined information images possible.

Processing partially refined information images is not the only cost of enlarging one's collection of information images. Sources of partially refined information images may be costly as well. Sensory information often serves as partially refined information images, subject to further refining. The reader by glancing at this point in space receives sensual information about white and black spots which are processed into words and referent concepts. Sources of sensory information, referred to here as data, have only one use: to be transformed into information. The value of data to an individual therefore is the value of the refined information acquired by processing the data less the opportunity cost of processing the data. "Good" data can often reduce the cost of information processing considerably and so, other things being equal, an individual will prefer good or highly refined data to relatively unrefined data. Whenever collecting data has a positive opportunity cost, individuals will economize on data as they would on other economic goods. When data acquisition is a costly endeavor, predictively, individuals will choose to have less than the best data within their means.

Given the above description of acquiring new information, there are two sources of "rational ignorance": (1) the costly nature of information processing causes individuals to process their stocks of partially refined

information less than to the extent possible;[6] (2) the collection of data as a source of partially refined information images may have a sufficient opportunity cost to cause individuals to collect less than the "best" data within their means. An individual may be rationally ignorant because he chooses to make decisions without a complete analysis of his collection of information images and because his collection of partially refined information images is less than complete. Individuals make decisions from a position of less than perfect information because, quite simply, the opportunity cost of being perfectly informed is too high.

Economists who have begun to examine the importance of information costs in economic decision making have focused their attention entirely upon the cost of data acquisition. The models of choice developed by Stigler, Alchian, Warskett[7] and other "optimal search" or "optimal stopping" theorists

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[6]This is not meant to imply that one could conceptually "completely process" information if one were to devote all of one's resources to information processing. Casual observation suggests that the resource constraints of individuals are such that complete information processing is impossible. With a different set of constraints, complete information processing may or may not be possible depending upon the complexity of the universe, a matter that lies beyond the scope of this dissertation.

[7]G. Stigler, "The Economics of Information"; A. Alchian, "Information Costs, Pricing, and Resource Unemployment," Microeconomic Foundations of Employment and Inflation Theory, E. Phelps et al. (New York: W. W. Norton and Co., 1970):27-52; G. Warskett, "Market Equilibrium Under Imperfect Information," mimeographed (Kingston, Ontario: Queens University at Kingston, 1976).

are models concerned with optimal data acquisition. Others, spurred by the work of Michael Spence,[8] have examined the choice problem of individuals who supply data (signals) to others at a very low cost in an interdependent setting, with a view toward enhancing their opportunity set (receiving higher wages). The associated cost of processing the acquired data has been entirely overlooked by these theorists. These theorists have also failed to note the various levels of refinement that data can have. In their models the data sought by individuals are of uniform quality, for example, single prices or single ability levels.

It is not surprising that theorists who neglect information processing costs also neglect differences in the quality of data. The importance of various levels of refined data is apparent only when one realizes that data are valuable only because they can be further refined. The data collected by individuals in economic models of data acquisition require little processing to be useful, and it may have seemed to these theorists that information processing costs could be overlooked. On the other hand, the low information processing costs of the particular kinds of data considered may have caused the theorist to overlook the cost of

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[8]M. Spence, Market Signaling: Information Transfer in Hiring and Related Processes (Cambridge, Mass.: Cambridge Press, 1974).

information processing. Neither of these actions on the part of the economic theorist can be explained without explicit consideration of information processing costs. This fact, itself, may give an inkling of the importance of information processing costs.

Purpose and Method

The purpose of this dissertation is to model choice in circumstances in which both information processing and data acquisition are activities that have a positive opportunity cost, and to discuss some of the implications of the model of choice developed. In order to develop an adequately general model of choice in these circumstances, special attention must be given to the usefulness of information, the nature of information processing, and the role of time in a model of choice which attempts to capture the role of information.

The model developed does not emphasize mathematical rigor as orthodox models tend to, but rather conceptual precision. The model as formulated can be represented mathematically and the mathematical consequences examined. However, it is the conceptual difficulties of dealing with imperfect information which is the focus of this dissertation, an area overlooked by the majority of economists interested in the "economics of information." The lack of

conceptual clarity is a great weakness to many mathematically "rigorous" models which greatly reduces their usefulness.

Economists have approached the problem of imperfect information with the tools developed for use in perfectly informed circumstances. For the most part these tools require the assumption of perfect or homogeneously distributed information for their logical validity. A case in point is the usual representation of an individual's opportunity set. An opportunity set is usually represented as the set of all trades that are objectively possible given known prices. Each good has a single price or exchange ratio. However, when information itself is costly and individuals quite rationally acquire less than the usually assumed omniscience, goods will not have a single price nor will an individual's range of possible exchanges be describable as all objectively possible exchanges. Single prices are the natural result of individual purchases when traders have complete price information. In such a setting, individuals will only purchase goods at the lowest price, eliminating any price differences. However, when individuals lack information about selling prices, different prices may and do occur even at the same location and at the same point in time. With the existence of multiple prices, the clear specification of an opportunity set vanishes. Beyond this technical point, individuals in general will not know all of the goods which can be

exchanged. For mathematical purposes, goods which a person does not consider can be regarded as goods in the lowest indifference class, although the idea of tastes or preferences is conceptually muddied by this "solution." In this formal sense, one can have changing tastes as the existence of previously unrecognized goods "comes into being," even if, in another sense, the individual considers his tastes entirely unchanged. This conceptual confusion between tastes and opportunities seems to suggest that an individual does not know his own tastes, or that the mathematical representation of tastes is simply a construct which is valid only at an instant in time. The latter view greatly limits ability of such models to predict behavior through time; while the former view seems to create only additional confusion about the nature of choice. In either interpretation the need for additional conceptual clarity is evident.

The specification of decision making used in this dissertation is as follows: individuals have abstract goals which they seek to realize, but they must learn or acquire information about the means which can be used to further these goals. The means to further one's goals are discovered and/or created through time as a result of allocating resources to data collection and information processing. An individual chooses the course of action that appears to be best among the ones that he is aware of at the time the

decision is made, and modifies his decisions as additional information becomes available. An individual's choice is from his set of information images of alternatives, and specified within the chosen course of action are his efforts to acquire new information.

This model differs little from orthodox models of choice. The modifications are minor, being the existence of an informationally constrained opportunity set, and explicit consideration of informational choices. However, the consequences contrast sharply with those of orthodox models: by focusing upon informational processes and the role of information in choice, the ongoing processes of decision making and trade can be explained. Because a role for information is included as a catalyst to plan revision, the existence of equilibrium in the usual sense is ruled out so long as information "matters." Because choice itself is an act of information processing, individuals will choose to economize upon choice. By explaining the existence of imperfect information, the conventional optimality criterion becomes difficult to apply, and when applied, misleading. These inferences are developed at length in the body of the dissertation.

The discourse of this dissertation may properly be regarded as less an attempt to develop a model, than an attempt to develop an analytical framework and vocabulary to

approach the task of modeling choice in circumstances characterized by costly information processing and data collection. The framework is developed and some of the important consequences are elaborated. To articulate all of the consequences of the framework advanced is beyond the scope of this dissertation, and may be impossible in principle. It would certainly be inconsistent with the thesis of the framework; complete information is so costly to acquire that it will neither be provided nor sought. Thus it will not be provided here.

The framework of choice developed in this work is a framework of individual choice, an exercise in what Von Mises would call Praxeology.[9] The subject matter of Praxeology borders on the shadowy corners of the fields of economics, psychology, and philosophy. The perspective of the analysis finds a more natural resting place in economics than the other fields, although psychological and philosophical issues are addressed in the course of the discussion. The framework developed is compatible with any view of human action which sees man as motivated (purposeful) and able to learn from experience. The framework is compatible with any view of knowledge which allows the existence of inductively

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[9]Ludwig von Mises, Human Action, 3d rev. ed. (Chicago: Henry Regency Co., 1963).

derived concepts. The focus upon choices rather than mental states or epistomology suggests that the analysis is more closely aligned with the goals of economics than those of psychology or philosophy.

The overall goal of this dissertation can be expressed in the words of Popper cited at the beginning of the chapter. The goal is to drive "the pillars of 'economic knowledge' deeper into the mud," to provide a stronger foundation for the superstructure of economic theory, and a more general microeconomic foundation for economic theory.

The Organization of the Dissertation

The remainder of the dissertation is divided into four chapters. Chapter Two focuses upon the usefulness of information. In this chapter it is argued that information can be used in several important ways generally ignored by economists. It can be used in production, for consumption, as a means of payment, and as a store of wealth. All of these uses depend to some extent upon the most important use of information as a catalyst for the formation of new plans. In Chapter Three, the methods of information acquisition are discussed. It is argued that information processing plays the most important role in information acquisition. Information processing is broken into three modes: autonomous, determinate, and indeterminate, each of which is discussed

in detail. In Chapter Four, the static implications of costly information processing and data collection are developed. The model developed in this chapter is analogous to the "single decision" models which dominate economic analysis. The general static properties of the model are developed and examined for optimality. A new concept of optimality is introduced which seems more appropriate for circumstances of imperfect information than the conventional optimality concepts. In Chapter Five decision making through time is examined in a setting which allows for and predicts plan revision. It is argued that economizing man will adopt flexible plans rather than rigid plans in such circumstances and that plan modifications through time will be discontinuous "leaps" rather than a series of infinitesimally small steps. Further it is suggested that the inclusion of information changes which affect one's plan of action in effect rules out the existence of equilibrium and the usual "benchmark" use of Paretian Criteria. In Chapter Six, the dissertation is summarized and further applications are suggested.

Chapter Two

INFORMATION, DATA, AND THEIR USES

Introduction

The purpose of this chapter is (1) to define and develop the distinction between information and data used through this dissertation, and (2) to discuss their usefulness. Information and data are often used as verbal equivalents which seems to have contributed to needless conceptual haziness about the properties of information. By articulating the distinction between information and data, it is hoped that some of the confusion can be eliminated about the value and costliness of both data and information. The costliness of acquiring data and/or information will be discussed in the next chapter. In this chapter, the value or usefulness of information and data will be articulated after first discussing their differences.

The use of the term "information" in this dissertation should not be confused with the specialized notion of information developed by C. E. Shannon[1] and widely used

[1]C. E. Shannon and W. Weaver, The Mathematical Theory of Communication (Urbana, Illinois: University of Illinois Press, 1949).

(with minor variations) by other information theorists. Shannon's information construct was created in order to develop a theory of communication channels which completely separates the concept "information" from the concepts of "meaning" and "interpretation."[2] As such, it is more closely related to the concept of data developed here than to the term information as used throughout the dissertation. The analysis here, in contrast with the work of those using Shannon's information construct, emphasizes meaning: for it is "meaning" which influences behavior, and the determination of "meaning(s)" that makes the collection of information in Shannon's sense worthwhile.

Information and Data

Information is defined here to be the collection of remembered impressions, ideas, and "facts" that exist in an individual's mind.[3] Information exists only in the mind of

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[2]This position is developed clearly by D. M. Mackay in his book, Information, Mechanism, and Meaning (Cambridge: M.I.T. Press, 1969).

[3]This analysis does not focus upon memory capacity constraints and the resultant costs of remembering information in order to simplify the exposition. The importance of the memory constraint is that it makes information processing even more important. In principle, the memory constraint is similar to the constraint faced by an individual who attempts to store physical items in a warehouse of limited size. One stores images which are constantly used in places of convenient accessibility, as when storing physical items, one stores those items frequently used in places of easy, low cost, access. One "throws out" information

a decision maker. It is the medium of thought and action. Data, in contrast, are external potential sources of information. Data forms the interface between an objective world, the subjective nature of an individual's experience in it and his world view developed as a result of his experience (and the objective nature of the individual as a being). Impressions about the world are formed by converting data to information. The reader, by reading, converts the data stored on this page into information, mental images.

Both information and data exist in various states of refinement and usability. A bit of data or some piece of information tends to be more refined the more it has been processed and the more sophisticated the processing used. The more sophisticated concept conveyed by some piece of writing, the more refined is the data embodied within the pages read and the more refined the information image formed.

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images which seem unlikely to be useful in much the same way (conceptually) that one cleans debris from one's warehouse.

The existence of a memory constraint enhances the importance of information processing in two ways: (1) costly recollection and limited storage makes new information, information which has been recently processed, relatively more important than old information (since old information may have been discarded or stored in a relatively inaccessible location); (2) one may choose to store items which can be "unfolded" into more information at a relatively low cost to economize on storage space, which explains part of the importance of theory as a memory and extrapolative device--such theories being important examples of highly refined information.

A highly refined bit of data or information may be extremely useful or it may be nearly worthless. Although individuals will tend to devote processing resources to creating data and/or information only if they expect the result to be useful and valued over the cost of the processing, the result may not accord with their expectations, as is often the case. In addition, highly refined information may be useful to some individuals and not to others because of their tastes or opportunities.

Data may be refined by computers or other electronic or mechanical means, but information can be created only in the mind of the decision maker by what is referred to in this dissertation as information processing. One can, in effect, use data to refine information or information to refine data. A writer draws on his stock of information to create a story or an article, which is refined data as it is stored on paper or microfilm. In this way highly refined data is created by drawing on an individual's stock of information as an input. One who reads the story or article draws upon the printed version of the story or article as a means to creating information. The speckled white rectangle of cellulose is transformed into information by information processing. (In fact, the categorization of a printed page as a speckled white piece of cellulose already embodies refined information, that is, interpretation of the raw information provided by one's senses.)

Information, being mental images, can only be stored in one's mind, although one can use information as a source of data (for example, notes) which reduce greatly the cost of reconstructing some bit of information. Data, on the other hand, being external, can only be stored externally. A library contains data but no information. Magnetic tape can store data but not information. Data becomes information only as an individual acquires it (or is exposed to it) and converts it into information.

Information and data are similar in that they each may embody "knowledge," but they differ fundamentally in the directness that they are possessed and, more importantly, in their relationship to the process of choice. Information is directly possessed and can directly influence an individual's decision-making process. In contrast, data are, in a sense, indirectly possessed and can only indirectly affect an individual's decision-making process. Data can be possessed as a result of greater physical power or as a result of institutionally defined rules and rights of possession, a less direct form of possession than that of information which depends only upon the integrity of an individual's mind. Data can be a public good, information can not,[4] for

[4]An example of the conceptual haziness which often results from failing to distinguish between information and data is found in John Marshall's otherwise good piece "Private Incentives and Public Information," American Economic Review 64 (1974):373-390. Information can not be "public," only data can be public. Marshall's distinction between "news" and "information while useful, misses this point completely.

information exists only in the minds of decision makers. Information is the medium of decision making. The range of alternatives considered, the constraints that bound the "possible," and the anticipated value of alternative courses of action are all informational items considered (and to some extent created) in the process of choice. Information is thus central to the decision-making process, it provides the subject matter of choice. Data, on the other hand, has no greater direct influence on the decision-making process than any other good or service. Data affects choice only indirectly as they may be transformed into information. This indirect effect is an important one, for much of the information that one posseses is the result of having processed data in the past.

The Uses of Data and Information

The usefulness of data and information differ substantially. Data, themselves, are useless and valueless. They are useful only insofar as an individual can derive useful information from them. Information, on the other hand, can be intrinsically useful, as an insight may be pleasing in and of itself, apart from any subsequent "usefulness." Because information exists only in the mind of an individual, it can not be bought and sold directly as data can be. However, information can serve as a source of

marketable data and/or other marketable services which gives information indirect market importance in the conventional sense as a scarce resource.

Because data have only a derived value, their usefulness can only be indicated indirectly by discussing the usefulness of information which can be derived from them. Information and data are sought as are any other items because they are expected to further one's abstract goals (which in this analysis are presumed to be unchanging elements of one's "soul" or genetic "make up"). One will devote resources to some endeavor only when one anticipates furthering one's goals in a way not exceeded by any other course of action. Consumption, in the sense used here, is the goal of human action--the desire for consumption experiences and the wish to avoid their opposites. It is abstract and intuitive and has to do with consuming real items only insofar as such actions yield consumption experiences. Because human experience is entirely informational, consumption in the sense used here is entirely informational. Goods or actions which "cause" pleasure, "avoid" pain, or seem satisfying have these properties only as the raw information of the senses are processed and categorized as "desirable" in some sense.

In this sense all actions are motivated by a "demand" for information. However, not all information generates consumption experiences, nor is all information sought

directly for this end. Information can further an individual's goals (enhance lifetime consumption) by: (1) providing direct consumption, (2) extending the range of consumption opportunities in the present, and (3) extending the range of possible consumption opportunities in the future.

Information and Current Consumption. Information can be a consumption good. (Indeed, all consumption goods yield information which is consumptive.) Information can be processed and categorized as "desirable" of and by itself. Although the direct consumption use of information is of minor economic importance (except descriptively), it is a not uncommon use of information. Much of the information gleaned from a daily newspaper is valued in itself as "interesting" trivia. Achieving some sought-after insight often yields satisfaction as one of its consequences. The taste for highly refined information appears to vary widely across individuals quite apart from their abilities to acquire information. It is unsurprising to find that individuals who have both a taste for highly refined information and a greater than average ability to create it tend to specialize in information related services, for example academicians.[5]

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[5]Information may generate fundamental consumption benefits. Some psychologists have suggested that the desire for information may be a fundamental source of motivation apart from the desire for food, shelter, and sex. See for example J. McHunt, "Intrinsic Motivation: Information and Circumstance," Personality Theory and Information Processing, edited by H. M. Scroder and P. Suedfeld (New York: Ronald Press, 1971):85-130.

Information images may enhance current consumption indirectly rather than directly by acting as a precondition for consumption rather than as a source of consumption itself. A collection of information images often allows one to engage in consumption activities which would be difficult without the necessary information images. Without a stock of information about the "black dots" scattered about this piece of paper, an individual would be unable to read and enjoy reading this piece or any other work written using similar black dot symbols. Information can suggest a method of filtering data which makes consumption possible in cases where without specialized filtering the data would be unrewarding, as an individual with no understanding of the symbols of Chinese would have difficulty enjoying prose recorded in Chinese symbols.

The importance of information as a precondition or complement for consumption extends well beyond reading or decoding written words. Images of the style or method of some activity makes many consumption alternatives possible. A game of chess might appear uninteresting to an individual who thought that the moves of the game were simply aimed at creating visual patterns on a two-colored board. Interpretation of individual actions as "well done," "heroic," "kind," or "excellent" implies that the observer possesses or can easily create the categories which are necessary to draw the

satisfying or entertaining conclusions. Information images of "how" to consume or use opportunities play an important role in an individual's ranking of consumption alternatives. A set of golf clubs or a violin is clearly capable of yielding greater consumption benefits to one who has an image of their potential usefulness than to one who views them as peculiarly shaped scraps of metal and wood.

To the extent that information images which enhance current consumption possibilities are learned or acquired rather than innate, an individual's preference ordering of "real" opportunities will be directly affected by changes in his stock of information. New information can in effect transform the nature of goods in the eyes of consumers. This information alters neither the good itself nor the consumer's goals, but it does directly affect the perceived usefulness of the item considered. Knowledge of the visual symbols of a language can in effect transform "dirty" sheets of paper into prose without altering the sheets of paper or the individual's tastes. While the economics discipline has not been unaware of the fact that preferences over real objects and actions change as time passes, needless confusion about both the process of change and the thing changed has been caused by failing to focus upon the role of information in choice.

Information and Future Consumption. Information images can enhance an individual's future consumption stream in ways not directly related to their effects on one's current consumption possibilities. (1) Information can enhance one's ability to produce consumption opportunities themselves. (2) Information can enhance one's purchasing power and thus enhance one's ability to purchase consumption "inputs." (3) Information can be used to conceive and implement plans of actions which yield preferred consumption streams. In the course of performing the first two functions, information serves as a productive input, an investment good and a store of wealth. The third function gives rise to the other uses and for this reason it may be considered to be the most important aspect of information. Without the ability to use new information to improve one's plan of action, the value of information would be limited to its pure consumption use.

Information can enhance one's ability to produce valuable goods and services. In this manner information can enhance one's ability to produce consumption "inputs" themselves as well as enhance one's potential purchasing power. It serves both as a precondition for production and as a productive input in the course of rendering these services.

In the absence of an information image of a production process, a production process can not be used;

information is a precondition of production. Information images of a production process include the "how to" and the "what for" of production. A production process is little more than a list of inputs and outputs along with a description of the method used to obtain outputs from inputs. One can possess all of the resources of the world and yet not have a single production opportunity if one lacks information about the possible uses of those resources. One cannot produce an item without some view of the item to be produced along with some image of means and method sufficient to allow production to take place.

Given a single image of a way to produce a good, additional information about the production process can cause increased levels of output, and so functions as a possible factor of production. As a production process is refined or improved, output increases for a given level of inputs. Outstanding examples of improved information about production processes include innovation and technological change.[6] However, productive information changes need not be as dramatic as Schumpeterian innovation, nor does a productive change in an information image have to affect the production process as a whole. Such changes are far more common than

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[6]The economic importance of innovation is perhaps most clearly stated by J. Schumpeter in his Capitalism, Socialism, and Democracy, 3d ed. (New York: Harper Torchbooks, Harper and Row, 1962):81-107.

orthodox views of innovation and technological change would tend to suggest.

As an individual gains experience with a production process, it is common for him to improve his information image of that part of the production process to which his actions contribute. This improved conception of the "local" production process allows him to produce more with his resources (time, effort and tools) and is precisely a productive increase in information. Of course, one need not be "on the job" in order to acquire productive information, although information acquired "off the job," via some sort of formal training, is less likely to be immediately productive. Clear evidence of the productiveness of information is the premium paid to workers who are "experienced" or who come "pre-equipped" with a stock of information about a sought production process. The process of acquiring information about a production process is sometimes called acquiring productive human capital.[7] In principle, specilization itself is little more than acquiring productive information about a sought production process. The reason that specialization is a desirable course of action will be discussed later, but the essence of specialization is the

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[7]G. Becker, Human Capital (New York: National Bureau of Economic Research, 1964).

collection of a highly refined, closely related set of information images about a relatively small number of production processes. The collection of productive information is a common event and an important consideration of most production processes.[8]

Information images can serve as a source of marketable commodities when individuals stand willing to give up purchasing power in order to acquire some bit of information or information related service. These will be sought for their direct or indirect productivity, for their direct or indirect consumption value, or for their potential ability to facilitate effective planning. However, information images themselves can not be directly purchased, they can only be provided indirectly as data or as information-related services as, for example, consulting services tend to be. Thus information can provide only an indirect source of purchasing power, a potential source of marketable information services rather than information per se. For example, a teacher possesses information which can be used as a source of marketable services and data (called lectures).

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[8]Changing stocks of information about production processes provides one rationale for some of the current stochastic models of production; further, it suggests that production functions will not be stationary through time. The empirically observed instability of production "function" parameters across time periods is thus a predictable consequence of this line of analysis.

He cannot directly transfer an information image from his own mind to that of another individual, but he can influence the likelihood and cost of another's acquisition of the information image by providing highly refined data in the form of a lesson or lecture. The marketable value of instruction and other educational services exists only because information images are scarce. As will be argued later, information is scarce because information processing is costly; and because, as a consequence, highly refined information that reduces information-processing costs is also scarce. Other informationally related services are made scarcer by the resultant cost and lack of highly refined data.

Information has value beyond that of its current direct consumption use only because it can be stored through time,i.e., remembered in some sense. One will invest resources today for acquiring information for its other uses only because it can be of value, and it can be so only in the future. To invest in an item which can not be "used" in the present or in the future would be an obvious waste of resources. The ability to store information for later use makes it a possible store of wealth, that is, an item which enables one to transfer the ability to further one's goals from one time period to a later time period. This is a more general notion of a store of wealth than the usual

source of future purchasing power, and a useful one. In this sense information images are one of the most important stores of wealth, if not the most important one.

The potential of information as a store of wealth is a fundamental property of information. Without recourse to information images acquired in the past, individuals would have to begin anew at every instant, without even genetically transmitted information. In such circumstances, life itself would be nearly inconceivable. (In order to exist, life would have to evolve from lifeless material to living matter in every successive instant of time. The notion of life is so intimately connected with the ideas of time and continuity that such a "creature" would not normally be considered a life form.)

The importance of information as a store of wealth is similarly central to the usual concept of wealth. The increased "wealth" that western society enjoys today is less a matter of material resources than an accumulation of useful information images! The material resources available to man have not changed significantly in modern times; what has changed is the collection of information images which allows individuals to utilize the physical resources which have existed for all of the ages of man. Individuals must possess an information image of a use for resources before

they can make use of resources. Resources which are considered useless normally are not considered wealth. To possess wealth one must not only control physical resources, but have an image of a valued use for those resources. One can not use a bar of gold as a store of wealth unless one knows of some future use for the gold (or is reasonably certain of finding one), be it an exchange for other goods or some other value in use.

The importance of information images as wealth or as a store of wealth becomes clearer in the context of high information costs. It should be sufficient to note that society itself consists of little more than a common heritage of information images. A society is identified by its "culture," and this is no more or less than the wealth of information images transmitted through generations. A society may be better identified by its "shared" information images than by its physical boundaries or institutional structure. The continuation of a society is to a large extent dependent upon its ability to transfer its heritage of information images from one generation to the next. One can well imagine the reduced wealth of a group of individuals who lacked such a heritage of information images, and so possessed no common language, rules of behavior, or cosmology. In such circumstances each individual would have to interpret the world without access to the refined data

assembled by past generations. The opportunities of such a group of individuals would clearly be dramatically reduced, and accordingly their consumption through time would be greatly diminished. In this very real sense, the wealth of a society consists not of physical resources, but of useful information images possessed by individuals in that society.

The bulk of information images sought by individuals are sought not for their value as consumption goods, but because such information can indirectly enhance one's consumption possibilities. The highly refined data transmitted from generation to generation by a society is not primarily useful because it is entertaining. Information images are primarily useful because they can be used to create better plans of action than would be possible without them.

Information and Plan Revision. The value of information is intimately linked to an individual's ability to alter his plans. Were plan revision impossible, the process of transmitting information from generation to generation and the endeavors of individuals to collect and process data would be, for the most part, unproductive. Were individuals unable to modify their plans in light of new information, they would be in a position similar to that of individuals who possess no heritage of highly refined information. In this case, the individuals would possess the information images (or could possess the inherited information images)

but they would be unable to use the information for any purpose beyond pure consumption, i.e., as trivia. Their actions would not be influenced by information except insofar as information was a pure consumption complement or substitute. Plans of action would continue as originally conceived, without revision, and without improvement as information was obtained which implied the existence of better actions than those called for in one's original plan.

Choice in these circumstances would be exactly as modeled in conventional economic models. In time-period "one," all individuals would create complex contingent plans and adhere to them throughout their lives. There would be no forces in this model which would cause "markets to clear" or for plans to be consistent, but were the original plans "equilibrium plans" they would persist; as any other plan would, for there is no mechanism for an individual to revise his plans in such models or in the circumstances outlined above. The role of information in such circumstances is precisely that of any other consumption good, and so for the purposes of analysis could be ignored.

However, information has value beyond that of an ordinary consumption good precisely because new information often allows an individual to improve his plans. The uses of information discussed above, other than the pure consumption use, are possible primarily because information can

cause individuals to alter their plans of action in ways which seem advantageous to them at the moment of decision.

As a consumption complement, new information makes consumption activities possible and/or desirable which were formerly ignored or considered and rejected. New information images can catalyze the formation of new consumption plans by improving the ability of various activities to provide consumption benefits. New images which appear to enhance one's productivity or sphere of action are valuable because they allow an individual to alter his planned use of resources to make better use of them. Discovery of a previously unexploited desirable opportunity tends to be valuable in part for its pure consumption value, but primarily because one can modify his plan of action to exploit the "new" opportunity. Discovery of a previously unnoticed restaurant is interesting to some extent in itself, but primarily valuable because one may modify his plan of action to include eating at the restaurant. Clearly even the use of information as a store of wealth would be less advantageous were one unable to use the information stored to alter one's plans. One could not use newly acquired information as a source of purchasing power, for to do so would involve altering one's planned provision of productive services and one's anticipated consumption stream. One could not lecture on a topic or tell an entertaining story based upon acquired information, for such actions would involve refining one's

initial plan of action. The value of information as a store of wealth would be only its pure consumption effect, and even this effect could generate no behavioral change.

The ability to use new information to revise one's plan of action clearly must play an important role in any model which focuses upon the role of information in choice. The use of information as a catalyst to the formation of plans is an important and essential property of information. This role for information must be preserved if information is to play an important ongoing part in the model of choice constructed here. One should note that it is this role which has heretofore attracted the least attention from economists.

Chapter Three

INFORMATION PROCESSING AND DATA COLLECTION

Introduction

The purpose of this chapter is to discuss the nature of information processing and data collection, the means of acquiring information, in order to provide a basis from which to examine and explain the choice problem faced by an individual possessing only imperfect information. The choice problem itself will be developed in the next chapter. In this chapter, the nature of information acquisition is explored in order to (1) provide an understanding of the processes of information acquisition, and (2) to provide the conceptual basis of the costly nature of information and thus explain its scarcity. In the process of discussing information acquisition, it is argued that (1) the costly nature of information processing is of greater importance than that of data collection, and (2) that economists have failed to note the costly nature of information processing and have, instead, focused upon the less economically important cost of collection of data. The chapter is divided into two sections. The first section is devoted to discussing the costly and unpredictable nature of information acquisition. The second section focuses upon information

processing, dividing it into three modes so that the autonomous, determinate, and indeterminate modes of information processing can be identified. Great care is devoted to develop what might seem to be "obvious points" in order that confusion about the nature of information processing can be avoided in the next two chapters in which the nature of information processing plays a crucial role.

Information Processing and Data Collection

An individual can acquire additional information in two ways. (1) He can process information that he already possesses in order to create new, more highly refined information (information processing being defined as the process by which information can be further refined). Or (2) he can collect data (data collection being defined as the process by which data is transformed into raw sensual information). The information possessed by an individual at any point in time reflects his choices about the information "worth" processing and the data "worth" collecting (collecting data may or may not require purchasing or acquiring it) as well as his skills at information processing and the data available to him. The natural limitation on the information that one can possess is determined by an individual's innate abilities at information processing and data collection and the highly refined data available to him which allows one to collect

more information per unit of data and which can enhance the development of skills related to information processing and data collection. Because refined data is always directly or indirectly a product of refined information, the constraint on the information that can be possessed by the members of a society depends ultimately upon their innate skills at information processing (from the mythical origins of their society to the present) and upon their informational interests which jointly determine the collection of highly refined data that will be developed and "passed" on to succeeding generations. While data collection is not without importance, individuals rarely have the resources or will to process completely the "wealth" of data available at a single point in time, and never to process all of the data collected in the course of a lifetime. In this sense, data is superabundant. It is the costly nature of information processing which serves as the effective limit to the information assimilated by an individual rather than any bounds on potentially refinable data. Although highly refined data will often command a positive price, its scarcity is a consequence of scarce refined information.

The costly nature of acquiring information is a direct consequence of the existence of capacity constraints for information processing and data collection and the fact that an individual can use his limited informational capacity

in more than one way. One can decide to process some collection of information instead of some other, and/or he can decide to collect some particular set of data rather than another. Given this, information acquisition becomes an economic decision variable, a matter of choice--not an externally specified aspect of existence as it is conceived to be in a purely adaptive model. The possibility of using "non-informational" resources to enhance information acquisition (for example by purchasing books or lectures or a "thought provoking atmosphere") adds another dimension to the cost of acquiring information--that of foregoing non-informational activities (for example, investing in physical capital).

Although the costs of acquiring-information greatly influence the kind of information that one will tend to acquire and the kind of choices one will make, these costs have been largely ignored by economists, with the exception of the recent economics of search literature which, unfortunately, considers only the costs of data accumulation, the less economically important of the two means of acquiring information. The cost of information processing has been totally ignored. The consequences of costly information processing are important ones and shall be developed in the next three chapters. Suffice it to say that without focusing upon the costs of information processing, one can not begin

to explain why the current physical wealth of western society was not the state of affairs two thousand years ago, the physical means existed but not the information required to utilize them.

Acquiring information differs from acquiring an ordinary economic good, as conventionally conceived, in that one can not know beforehand precisely what it is that one is acquiring. There is an inherent uncertainty about the exact nature of the bit of information one seeks, or one would already possess the information of interest and would not have to invest resources in order to obtain it. One may have an idea about the range and likely nature of the information one will acquire, but its precise nature must remain unknown to be worth seeking. One may expect that by enrolling in a class about scuba diving, he will learn something about safety and the use of specialized equipment, but he would not already possess the information he expects to learn or it would not be worthwhile to enroll in the course for its purely informational content (which is provided indirectly via data in the form of lectures and literature). When one attempts to develop or to refine some idea or theory one does not fully anticipate the results or he would not devote resources to determining them. Though information is, in this sense, always partially a result of chance, it is, nevertheless, a result of intent and an economic decision to

acquire information (with the single exception of information acquired by autonomously processing some bit of previously possessed information).

While economists seem to have ignored the costs of information processing they have not neglected the fact that uncertainty necessarily accompanies information acquisition. However, there seems to be some confusion about the kind of uncertainty that exists. Search theorists essentially assume that one is only uncertain about the location of data which will yield some piece of valuable information, usually the lowest price for some well conceived economic good. The information sought is clearly conceived, and the search is efficiently organized. Isreal Kirzner, on the other hand, argues that the information of importance is not information sought deliberately but rather that which is acquired "spontaneously."[1] Some useful light can be shed upon this disagreement by noting the existence of two extremes: (1) information which is clearly imagined and sought, as that information sought by individuals in models of optimal search; and (2) information which is obtained gratuitously, without any activity aimed specifically at acquiring it. Kirzner categorizes the first as deliberately acquired information and the second as spontaneously acquired information. However, these categories may be more accurately

[1] I. Kirzner, "Knowing About Knowledge: A subjectivist View of the Role of Information," Mimeographed (New York: New York University, 1977).

considered end points of a continuum of acquirable information conceived by individuals with greater or lesser precision.

When one attempts to develop information images, an individual does not seek a particular good or service as is the case in conventional economic decision making, he seeks some category of information. The extremes mentioned above do not differ only in the degree of uncertainty involved but, more importantly, differ in the kind of uncertainty. In each there is the uncertainty of which particular bit of data one will obtain, but in the case of "spontaneous" information, one is uncertain about the category of information as well.

The spectrum between these two extremes is determined by the extent to which an individual clearly defines the category of information sought, what might be called its categorical variance. The category may be clearly defined or narrow, as a price of a definite commodity at a certain time and place is a narrow category (whatever the variance of prices within that category might be); or the category may be vaguely defined or broad, as the category "new and useful" information is. Whenever one acquired information that has a positive opportunity cost, the information obtained is the result of intent, however vague or uncalculated the intent might appear to be. When an individual calls his stock broker to find out the closing price of some stock, the information acquired is clearly the result of

intent. Information received from an unsolicited phone call is no less a result of intent although the category of information sought is clearly vague and ill-defined. To the extent that picking up and listening to the telephone is not the result of a pure reflex, it is the result of intent and reveals a demand for some category of information however obscure. The confusion which can result from labeling such information acquisition "spontaneous" can be most easily avoided by focusing upon the categorical clarity of the demand for information of interest rather than upon its "spontaneity." Information which is acquired because of a demand for "useful" information may be better described as the result of alertness than carefully planned search, but it is no less a result of intent. In the next chapter, it is argued that careful planning is a costly endeavor, and one economized upon. Thus it seems likely that the information of most value to an individual is the result of alertness rather than some carefully articulated pattern of search, but as a result of optimizing rather than a lack of intent.

Three Modes of Information Processing

Information processing is essentially the activity through which individuals create and refine informational images. Information images are largely created by inductive processes and refined by further induction and

deduction.[2] One can think of information processing as the act of searching out and synthesizing regularities from a pool of experience.[3] Theories, in this sense, are simply information images. They are attempts to develop "principles" which will explain their experience and help anticipate the future. The focus, skill, and method that one brings to this task are essentially informational images developed by past efforts. The information that one tends to acquire reflects one's image of that to be acquired, although it is not determined by them,[4] it does determine the information which is sought. The information that is acquired includes images of relationships between categories, and images of the character of useful categories. This paragraph is designed to give the reader data which he will

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[2]See, for example: John Venn, The Principles of Empirical or Inductive Logic (New York: Lennox Hill Publishing and Distributing Co., 1972)(originally published in 1907), pp. 374-402; Karl R. Popper, Objective Knowledge, An Evolutionary Approach (Oxford at the Clarendon Press, 1972).

[3]Popper's more formal description of this process is conjecture and corroboration.

[4]This feature when combined with high information costs gives rise to the phenomena described by Thomas Kuhn in The Structure of Scientific Revolutions (Chicago: Chicago Press, 1962). The steadfastness of belief in the face of contradicting evidence is not so much a matter of ignorance as of the high costs of restructuring one's collection of information images and the anticipated minor gains of doing so.

interpret as an information image of the concept of information image used in this dissertation. The process which the reader will use to create this image is complex and will draw upon his inductively derived referents created from experience with words and thought. Although the conventional categories of the philosophy of knowledge, induction and deduction, do describe information processing, these categories do not isolate the features of interest here.[5]

For the purposes of this dissertation it will be useful to divide the category information processing into three sub-categories--hereafter referred to as information processing modes: autonomous information processing, determinate information processing, and indeterminate information processing. Consideration of these three modes will clarify the nature of information processing and contribute to the conceptualization of the information processing decision which is discussed in the next chapter.

Autonomous Information Processing. Autonomous information processing is, as the name implies, essentially automatic or spontaneous information processing. Autonomous

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[5]This discussion bears a close relationship to the work of F. A. Hayek in theoretical psychology; although the characterization here is more closely liked with decision making. F. A. Hayek, The Sensory Order (Chicago: The University of Chicago Press, First Phoenix Edition, 1963).

information processing requires no special allocation of resources and so has no opportunity cost. Examples of autonomous information processing include both the subconscious and reflexive formation of information images. To a large extent, consumption experiences, in the sense used here, are a result of autonomous information processing. If all information were capable of being completely processed via the autonomous mode of information processing individuals would possess complete, perfect information. Most neo-classical models of choice implicitly assume information is costless and homogeneously distributed. In the terminology here, this assumption is equivalent to the assumption that autonomous information processing is complete and instantaneous. On the other hand, were autonomous information processing less than complete and instantaneous, individuals would continuously adapt their plans to continuously changing information images. If no resources were devoted to the other modes of information processing, individuals would behave along the lines suggested by abstract models of adaptive expectations.[6] Information, itself, would not be a decision variable although data

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[6]See for example: H. A. Simon, "Rational Choice and the Structure of the Environment," Psychological Review, Vol. 63 (1956):129-138; Richard H. Day, "Adaptive Process and Economic Theory," Adaptive Economic Models (New York: Academic Press, 1975):1-39.

acquisition might be. Individuals would simply react to changing circumstances as information images change without any decision or cost affecting the information processing performed.

Although economists have generally focused entirely upon the information processing which is costless, this focus seems to have no particular merit beyond simplifying analyses. To the extent that the decision to simplify the analysis was consciously made, this decision itself implies that information processing is costly and, hence, becomes an important feature of decision making. A decision to simplify one's analysis implies that the analyst considers the cost of additional complexity or completeness to be too high. The cost is an information processing cost, either the analyst's or that of his expected audience. The costly elements of information processing are found in both the determinate and indeterminate modes; each of which is influenced by the resources devoted to it and each of which is consequently influenced by allocative decisions.

Determinate Information Processing. The determinate mode of information processing is analogous to the orthodox conceptualization of a production function: that is, by devoting resources to determinate information processing, one is assured of an output of further refined information. As a method, this mode of information processing is

influenced by one's image of the process to be used as is any effort of production. However, this mode differs from a production function in that one does not know beforehand exactly what the output will be. In the usual formulation of a production function, the output is clearly defined--a clear image of the output is presumed to exist. In contrast, information processing is the means of acquiring information, and the information sought will not be that which is already possessed. One cannot know the precise information beforehand that one will acquire even by determinate information processing.

The information processing used in most economic models of efficient search is of the determinate mode, although the costs of the determinate information processing are ignored. The essence of the usual search model is the following: (1) individuals attempt to learn some feature of the world (usually some price) by collecting data and processing them according to some well defined procedure; (2) individuals collect data rationally; until the anticipated gains of additional data are less than or equal to the opportunity cost of acquiring them. The reason individuals collect data in these models is typically to find the lowest price of some well defined commodity.[7] The information

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[7]Perhaps the first and most important of these approaches is: G. J. Stigler, "The Economics of Information," The Journal of Political Economy, Vol. LXIX, No. 3 (June 1961).

processing used by individuals in these models is determinate, consisting of a review of the data collected to determine the minimum price in one's sample. The cost of determining this price is ignored. One does not know this price before processing the data. The more resources that one devotes to information processing, itself, the more refined the information will be and the better will be one's estimate of the lowest available price. One can examine the list of numbers obtained in detail or superficially. This aspect of a search for the lowest price is in many ways similar to the collection of data; that is, one will continue to process the data until the anticipated costs of additional processing exceeds the anticipated gain. The method of information processing in the simple quest for the minimum number of a list is determinate and direct, but it should not be ignored and assumed costless.

Determinate information processing is not limited to the clearly defined procedures of information processing used by optimal search theorists. Conceptually, determinate information processing includes any procedure in which one's informational resources are necessarily increased as a result of devoting efforts to the activity. As such, it includes: simple manipulation of mathematical formulae, direct uses of the rules of logic, the application of rules or conventions to familiar problems, most forms of direct

communication, etcetera . ... . And thus it plays an important role in much of an individual's "bread and butter" information processing.

Indeterminate Information Processing. There are many information images which are acquired by allocating resources to information processing but which bear little or no relationship to the specific investment of resources toward acquiring them. One may seek the solution to a problem, a new exciting idea, or some amusing insight by devoting resources toward "speculative thinking," but the mere allocation of resources does not deterministically assure that such information images will be acquired. These images and others will not be assured by devoting resources generally toward creating them as would be the case for an exercise in determinate information processing. Instead, allocating resources toward acquiring these images increases the likelihood that they will be acquired. Information of this type is acquired by the indeterminate mode of information processing.

Allocating resources toward indeterminate information processing does not assure an increase in information, but rather influences the probability of acquiring an information image. One might, for example, increase the probability of an economic insight by reading some piece known to be thought"provoking"; that is, one might allocate the

time and resources necessary to acquire and ponder an article in order to increase the likelihood of an insight spurred by the refined data contained in the article. Such insights are not guaranteed by this action, but one is more likely to acquire them in an "atmosphere" conducive to this mode of thought.

Economists have not overlooked the non-deterministic mode of information processing, although they seem to have ignored the influence of resources on this mode. Professors Shackle, Kirzner, and Schumpeter have referred to examples of this mode of information processing as variously: inspirational knowledge, entrepreneurial alertness, and innovation. Each of these economists has accorded this mode of information processing a central role in his view of economic process, although their emphasis on the economic importance of what might be called creativity seems to have little effect upon the main-stream neo-classical view of economic process.[8]

This mode of information processing imparts an important creative and unpredictable aspect to decision making

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[8]G. L. S. Shackle, Decision Order and Time in Human Affairs, Second Edition (London: Cambridge at the University Press, 1969):6-7 (and elsewhere); Israel Kirzner, Competition and Entrepreneurship (Chicago: The University of Chicago Press, 1973):35-36 (and elsewhere); J. A. Schumpeter, The Theory of Economic Development (New York: Oxford University Press, 1974):57-94. (Original English 1934)

not included in the conventional neo-classical models of decision making. The importance of this mode thus remains uncaptured by main-stream models of economic activity. It is this mode of information processing which accounts for the evolutionary character of knowledge and society--for it represents a non-genetic source of mutation, the creation of information images not directly determined by past experience. Schumpeter and Kirzner each accord this mode of information processing a more appropriate emphasis by regarding it as the driving force of economic development and progress. The dominant view, in contrast, views information processing as essentially deterministic and of only moderate importance.

Whatever their views of the importance of information processing modes, economists have without exception failued to mention or consider explicitly the costly nature of information processing. This is unsurprising since economic theories have failed to distinguish between the cost of data acquisition and the cost of information processing. Economists have always accorded an important role to innovation and other information, but they have failed to incorporate any method of innovation of information acquisition into their models. It is not surprising that models so conceived cannot explain why the current wealth of

western society was not the state of affairs one or two thousand years ago. The physical resources were available but the information necessary to exploit them was not. It is information processing costs which account for this, not the costs of data or a lack of physical resources.

While it is somewhat surprising that economists, with their ever present awareness of cost, have heretofore ignored the cost of information processing, it is less surprising that theorists, given their interests, have tended to consider only single modes of information processing. It is not surprising to find that economists interested in the "sub-optimality" problems of imperfect information, or skeptical of the weak economic rationality assumption, tend to focus upon autonomous information processing methods. The results of any simple adaptive process is likely to be sub-optimal when compared to decisions made from a vantage point of complete information. Nor is it surprising that economists who approach information imperfections from an equilibrium perspective prefer to focus upon the determinate mode of information processing with its clear potential for "search equilibria" of one sort or another. Similarly, economists who are less interested in questions of economic equilibrium and more interested in economic development place their emphasis upon the indeterminate mode of information processing which seems to accord well with the

difficulty of predicting precisely the path taken by an economy through time, especially as regards the composition and distribution of output. In a sense, this study reflects more sympathy with this last view than the others.

However, there seems to be no rationale for examining only one or two of the information processing modes. In principle, information processing usually has elements of all three modes. Pure cases of determinate or indeterminate information processing are very rare, although there are many situations in which one particular mode of information processing will be especialy important.

To the extent that there is always an element of indeterminateness, or insight in information processing, changes in an individual's collection of information images will not be completely predictable. The unsystematic component of information acquisition is likely to be reflected in individual decisions that appear less than systematic as plans are revised in light of new and somewhat unsystematic changes in an individual's perceptions of his possibilities. The extent to which one can accurately predict the actions of individuals will be limited by one's own information about their goals and information. The existence of indeterminate information processing implies that some part of an individual's behavior will be unpredictable even given complete

information about his goals, circumstances and information processing modes. The extent of this unpredictable component will depend upon the relative importance of indeterminate information processing and the combined importance of autonomous and determinate information processing.

Chapter Four

COSTLY INFORMATION AND CHOICE AT A POINT IN TIME

Introduction

This chapter contains an examination of the choice problem facing an individual at a point in time and of the likely choices which will be made. This analysis should be regarded as the first step toward an analysis of decision making through time which is discussed in Chapter Five. The analysis of this chapter limits itself to consideration of a single choice, which may be regarded as a member of a sequence, or as the analytical parallel to the single decision models used by most economists. The chapter is divided into two sections. The first examines the optimization problem facing an individual at the moment of choice and articulates the costly nature of choice itself. The second section discusses some general characteristics of "solutions" to the optimization problem characterized in the first section. The model of choice developed may be classified as a household production model,[1] although the

[1]This genus has its analytical roots in: G. Becker, "A Theory of Re Allocation of Time," Economic JOurnal 75(1965):493-517; also, K. Lancaster, "A New Approach to Consumer Theory," Journal of Political Economy (1960):132-57.

"household production" of interest here has an informational character which has not been heretofore focused upon. It is the informational aspect of decision making and decisions which is the central subject matter of this chapter.

Choices made from circumstances of costly information will differ from those made when information is costless. A pauper does not have access to many of the opportunities of the wealthy. Individuals who lack the boundless wealth of perfect information will economize over information related activities as individuals in orthodox models of choice do over physical goods and services. They will seek less than the best information; they will rely heavily upon :pre-processed" data and economize upon the decision making process itself. The actions of individuals in such circumstances may well be, in a sense, sub-optimal. They will, in general, be less than the best which is physically possible, the preferred choice in circumstances of perfect information. Information is the medium of decision making and for this reason it clearly has an important influence upon the kind and extent decisions an individual will make.

Information-Constrained Choice

The model of choice developed in this section extends the conventional optimization paradigm to circumstances in

which information processing and data collection are costly activities. Individuals contrive and implement plans of action which appear to be the best available given their informationally constrained opportunity set. An individual's tastes or ultimate goals are considered to be unchanging although information may change his preference ordering over physical actions. In addition to the usual constraint of physical resources, individuals face informational constraints. There are bounds to the information that he possesses at a point in time and limits upon the amount of information that can be acquired through time. An individual can not choose to do that which he is unaware of nor may he accomplish a result which he lacks the resources to accomplish (although he may attempt such a feat).

There are three elements to decision making as modeled here: the selection process; the goals of the individual; and the informationally constrained opportunity set. To choose a course of action an individual selects a series of actions from his informationally constrained opportunity set which he believes will further his goals at least as well as any other considered. The plan of action selected will naturally bear the mark of the individual's aspirations, the process of evaluating alternatives, and the range of alternatives that can be considered at that point in time. Before

discussing the choices which will actually be made, it will be useful to examine each of the elements in greater detail.

The Selection Process. The selection process consists of processing information images of the possible in order to determine the course of action which will best further an individual's goals. It is a process of evaluating and comparing alternatives in order to contrive a plan of action which "best" furthers one's goals. In order to do so, an individual must imagine how physical and mental actions further abstract, subjective goals. The technique used will reflect his experience, his past successes and failures, and tend to call upon all three modes of information processing. The images that will be contrasted and the extent to which comparisons will be made will be influenced by the information images possessed at the onset of the decision-making process. For these will affect the costs of imagining alternative actions and their consequences, suggest actions worthy of consideration, and provide methods to evaluate those actually considered. One will make his selection or choice based upon information which emerges during the decision process as he arrives at a view of the worthiest course of action. The ordinary meaning of the word choice is precisely this evaluation process. Thus choice is itself an exercise in information processing,

constrained by information processing constraints and optimized as are other informational activities.

Goals versus Preference Orderings. An individual does not know the best plan of action at the onset of the decision-making process. He may have an image of the plan but he does not know that it is the best plan of those to be considered. His preference ordering of possibilities is yet to be determined and will be, to some extent, determined by the evaluation process. The best course of action will be determined, although this may not require that a complete preference ordering over all possibilities be determined.

This is not to say that one's tastes are determined by the selection process. An individual's tastes or abstract goals are considered known in this.dissertation, but how actions serve one's goals is not. It is this which is determined during the evaluation process. Individual goals are presumed to be abstract and subjective, the fundamental motivators of individual action. It is not asserted that the goals of all individuals are identical, although goal similarity at an abstract level determines to some extent whether an individual is human or not. It is asserted that there is an underlying theme to an individual's actions which remains unchanged as time passes. This theme is the

consequence of unchanging tastes or goals in the sense used here. One's preference ordering over real actions may change dramatically but in this model such changes are construed to be information changes rather than changes in the individual's ultimate objectives. One may be at different points in time a Communist, a Marxist, a Fascist, and a Libertarian, all in an entirely consistent quest for social justice; the apparent inconsistency being simply the result of changing information about the means to justice and the physical state which best can be described as just.

The models of choice used by economists, when viewed in this light, are not models of choice at all. The assumption of well defined preference orderings precludes choice. The evaluation process itself, the process of choice, is assumed completed. The models of choice used by economists are, in this sense, ex post models; the best alternative is already known for any considered economic context. This fact in itself should not be surprising. Economists are, after all, primarily concerned with the consequences of decisions rather than the decision-making process itself.

However, one can, by explicitly considering the decision-making process, gain useful insights about the kinds of decisions which will in fact be made. The fact

that decision making is an information processing activity which is itself costly implies that individuals will economize upon the decision making process itself. The fact that goals do not directly imply a (best) course of action, given one's physical circumstances, suggests that attention should be directed toward understanding an individual's perception of his circumstances and his appraisal of what consequences follow from various courses of action. By doing so one may gain a greater understanding of human action than could be attained by a naive application of "revealed preference." Beyond this, by focusing upon goals rather than preference orderings, one may be able to predict changes in individual preferences as information changes in fairly predictable ways.

The Informationally Constrained Opportunity Set. Information constraints are the highest order of constraint, in that one's collection of information constrains all other activities. One cannot choose to do that which one is unaware of. One cannot consider consequences which are beyond one's imagination. The set of information images that one possesses represents the range of activities that one can consider and choose among. An individual's images of the resources at his command and their possible uses limit his conception of the "possible" to a subset of his collection of information images. This subset becomes an individual's

informationally constrained opportunity set. It represents the range of possibilities which can be considered and acted upon by an individual, for it is the range of "possibilities" that he is aware of.

An individual whose range of information images included all possible combinations of consumer goods, who considered only exchange opportunities, and who possessed a clear image of all possible exchange relationships would face the conventional economic opportunity set. However, such an extensive list of consumption alternatives is unlikely to be possessed, and it would be an unusual individual who considered only simple exchange opportunities. The cost of acquiring such a complete list of alternatives tends to cost more than it returns, and limiting oneself to simple exchange opportunities is likely to reduce one's lifetime consumption.

An individual will possess a bounded set of information images because one's ability to process information is constrained and one's initial allotment of information is relatively small. Any level of resources will yield only finitely many information images. For any amount of resources one can collect only a finite quantity of data, limited by the physiological capacity of the senses. For any level of resources devoted to information processing, one will acquire information images which are limited by

one's ability to assimilate, analyze, integrate, and organize one's stock of partially processed information, an ability which is clearly bounded. Casual observation does tend to support the contention that individuals will possess only a bounded collection of information images. Completely informed individuals are rare to the point of nonexistence. The time spent by the reader interpreting the black dots on this page is a testimony both to the costly constrained nature of information processing and the incomplete nature of one's collection of information images.

The capacity constraints of both information processing and data collection are such that one aspect of the opportunity cost of some bit of data or some information image is always some other bit of data or information image. Information processing and data collection are not (as suggested by the search literature)[2] things which are done up to a point. Data are always being collected and information is always being processed. One does not have an optimal stopping point; although one will devote resources to these activities only up to the point where the expected gain from further information acquisition is less than the expected gain from other uses of resources. Information processing

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[2]See for example: G. Stigler, "The Economics of Information," Journal of Political Economy (June 1961): 213-225.

which requires no resources may still have an opportunity cost; processing other information. And data collection will always have an opportunity cost, namely collecting other data.

The distinction between information which is acquired without the explicit use of non-informational resources and information that is truly costless has been the source of some confusion. Isreal Kirzner argues that the information of importance for individual decisions is not information sought in the sense of the search literature, but rather information that is acquired spontaneously, i.e., costlessly, without intent. What Kirzner appears to mean is that the information of most importance is information which is sought as a very broad category and which is acquired without the use of non-informational resources.[3] It is surprising that such a sophisticated economist would mistake resource cost for opportunity cost. While these data and subsequent information images may have low costs, they are far from costless.

An informationally constrained opportunity set differs from the usual conceptualization of an opportunity set in several ways. (1) Physical resources are unimportant.

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[3]I. Kirzner, "Knowing About Knowledge: A Subjective View of the Role of Information," (New York: New York University, 1977) (mimeographed).

They are important only insofar as they provide data to an individual about his range of possibilities. (2) The individual's collection of information images is embodied in the constraint as formulated. The constraint for decision or planning purposes are all informational and thus "subjective." (3) An individual's wealth, in the sense discussed in the last chapter, can be increased without any direct or indirect transfer of resources from one individual to another. Increasing an individual's collection of information can be done without transferring it from another individual's endowment of information. (4) Prevailing market prices are important only insofar as an individual is aware of them and considers them an important part of the cost of some good, service, or activity. (5) The wealth of a group of individuals can be increased: production possibilities increased and/or consumption opportunities increased, by actions allowed within the constraint. That is, the informationally constrained opportunity set can be moved by individuals acting within the constraint; new technology and ideas can be conceived. (6) The constraint is only binding at a point in time. As an individual acquires new information images the informationally constrained opportunity can and often does change. This differs dramatically from the usual lifetime budget constraints which an individual is assumed to face. While each constraint is, in a

sense, a lifetime constraint, the informationally constrained opportunity set changes as an individual learns new, useful information. (7) Activities included within the informationally constrained opportunity set include informational ones. One can plan to plan. One can plan to acquire data and process information. One can attempt to innovate. (8) An individual can make plans which are contingent upon acquiring bits of information at a later date--one can plan to bring an umbrella if it "looks like" rain. Such planning is limited by one's stock of information about categories of information that one expects to acquire. Responses to totally unimagined events or to events which have not been fully considered are limited to plan revising activities. A decision maker cannot plan non-informational activities for contingencies he is unable to specify. (9) The individual's conceptionof of his informational limits are embodied in the informationally constrained opportunity set. One will not attempt to acquire information which he feels to be beyond his ability and/or resources to acquire. (He may, of course, be incorrect in this appraisal.) (10) The informationally constrained opportunity set, as conceived here, allows activities which are excluded under the usual conception of the opportunity set other than informational ones. One can plan to reform institutions, to monopolize, to fool others, to exercise coercion or any other human activity which

conceptually can be intentional. The informationally constrained opportunity set includes all of the activities that one can consider given his information images of the possible.

Choice Consequences

The three elements of the choice problem combine to specify a model of individual optimization which includes a pervasive and important role for information. The choices made in this model will, as in other economic models, exhibit properties which are greatly affected by the constraints faced by individuals. Because information is accumulated as the result of past actions, an individual's current constraints are greatly influenced by past decisions. This sequential aspect of decison making will be taken up in the next chapter. This section of Chapter Four focuses upon the informational aspects of a single decision.

There are four basic informational consequences which will be considered. (1) Individuals will economize upon the decision process itself because it is a costly exercise in information processing. (2) Individuals will, in order to reduce information processing costs, rely heavily on "pre-processed" data. (3) As a result, individuals will often make decisions which are not the best course of action; that is, a type of informational sub-optimality can result.

(4) The usefulness of information is generally related to future refinement of plans of action. Thus, time must play an important role in any satisfactory model of the role of information in choice. Specifically, the model must allow for sequential decision making. The consequences of this modification will be discussed at length in Chapter Five.

Economizing on Decision Making. Decision making is costly, to the extent that one foregoes alternative activities by engaging in this activity. Efficient allocation of resources to decision making occurs when the perceived benefit of devoting additional resources to decision making is more than offset by alternative uses of one's resources. By allocating resources to the decision-making process, one expects to obtain a more accurate determination of one's best course of action. As one does so, an individual necessarily foregoes alternative uses of his information-processing, data-collection, and physical resources, and his time. The process of evaluation is costly, and an individual will rationally attempt to avoid wasting resources on this activity. The minimum effort that one can devote to this task is that required to make a decision to continue the plan of action currently being implemented. Beyond this an individual will attempt to allocate resources efficiently to this task. One will choose the extent to which this form

of information processing will be engaged in and the extent to which non-informational resources will be devoted to such future efforts. One will contrive a contingent plan to plan.

In order to economize on his resources, an individual will strive to make his decision making process as efficient as possible. He will aim for the best decisions possible for every level of inputs. There are obvious steps that an individual can take to make effective use of his decision-making efforts. (1) An individual can adopt a transitive decision rule which can be easily and fairly accurately applied to estimate the best course of action. (2) An individual can consider and rank fewer than all of his perceived opportunities. (3) An individual can specify plans of action which do not specify well defined precise actions for all contingencies. An individual will not strive for the "best" plan but rather for the best plan that is worth developing.

A decision maker can economize on decision-making effort by using some decision rule which does not truly correspond to his tastes but which corresponds closely enough to his tastes so that the reduced decision making costs of the decision rule more than compensates for the reduced accuracy of his decisions. An individual may adopt a rule of thumb which allows him to make "quick" decisions which are known to be inaccurate, but which reduces decision costs

sufficiently to compensate for the inaccuracy. One might, for example, adopt a decision rule which called for carrying an umbrella whenever the sky is cloudy, and save the effort of calculating the expected gain or loss of carrying an umbrella by assigning a probability to each of the variety of cloud mixes possible. Or one might conceivably adopt a utility function for use in decision making even though one's true preferences would not have properties entirely compatible with such a utility function. Or one might adopt lexicographic tastes as a construct for decision making purposes, even though one's preferences were compatible with indifference curves. The ease of applying each of these decision rules or rules of thumb can, in many settings, more than offset their inaccuracy. One trades the greater accuracy of better decision rules for the reduced cost of applying the rule to make a decision. One reaches a decision which makes less effective use of one's resources but which has required the use of fewer resources in order to be reached.

Choice of an effective decision rule will be influenced by an individual's tastes, his perception of the usefulness of possible rules, and the range of rules considered. In general, the less important accuracy seems, the simpler and less accurate the decision rule will be. An individual may choose from among several very similar items or outcomes almost at random. He may engage in "impulse" purchases of relatively inexpensive items. Resources are in

a sense wasted as the variety of rules of thumb used by managers and engineers "waste" resources, but the "waste" in the eyes of the decision maker must be considered less than the waste of achieving accuracy for the decision rule to be adopted.[4]

A second method of economizing on decision making, which might be considered an aspect of a decision rule, is to consider fewer than all of the opportunities that one is aware of, and not to rank all of those considered. It will rarely, if ever, be to an individual's advantage to consider all of the opportunities that he is aware of. Nor will a complete rank ordering of all one's opportunities be of particular value. The costs of these two activities would be enormous in any reasonably complex circumstance and the anticipated benefits relatively minor.[5]

Consider the cost of allocating time simply to construct a list of all the possible actions that one could perform during the next twenty-four hours. One could travel

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[4]The idea of adopting a decision rule is not new. Similar ideas can be found in R. H. Strotz, "Myopia and Inconsistency in Dynamic Utility Maximization," Review of Economic Studies 23 (1956):165-180.

[5]The costs of a complete ordering could, of course, be reduced by considering decisions in which one's opportunity set is very small, for example, consisting of only two alternatives. These circumstances seem quite uninteresting for analyzing human decision making in general.

to a wide variety of locations and at each one participate in a wide variety of activities; one could engage in consumption; observe the scenery, commit some crime, produce some good or service, etcetera. Constructing the list would take an imaginative individual a lifetime. Clearly the cost of constructing the list would exceed any gains one could realize.

The advantages of imagining possibilities diminish rapidly as the list of possibilities grows. The opportunity cost of allocating resources to this activity tends to increase as the collection of possibilities grows. Thus an effective list of opportunities will be an incomplete one. Instead of a complete list one might consider a few alternatives "near" the one which will ultimately be chosen. These few alternatives are not constructed from the aforementioned list, but selected largely from one's past experience, i.e., an individual's accumulated information images. One does not contemplate purchasing groceries at each of the several million locations where groceries may be purchased, but rather considers only a few grocers close to home. One does not really consider all of the words which could be the best way to describe some item of interest but instead considers just a few words "similar" to the word sought.

Of the alternatives considered, only the best one is of particular interest; the second or eighth best alternative is of only passing interest. In order to determine the best alternative, one does not have to establish a complete ordering of the alternatives considered, or have to consider each possibility in detail. It will generally be inefficient to do so.

The cost of achieving a complete ordering becomes apparent if one considers that there are 3,628,800 possible strict preference orderings for just ten bundles of goods. One could completely order ten alternatives by making 45 binary comparisons, but to find the best of these ten alternatives requires only 9 binary comparisons.[6] One can clearly economize on information processing by less than completely ordering these ten bundles. As the number of alternatives rises, the number of binary operations necessary to determine a complete ordering [N(N-1)/2] rises for

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[6]There are ten factorial possible orderings of ten bundles of goods which equals 3,628,800, ignoring possible indifferent combinations. One can completely order ten items by first finding the extremal of the group, then the extremal of those items remaining and so on. In this way one finds the best of ten, then nine, then eight and so on, which amounts to finding the best, second best, third best, etcetera. To find the best of ten requires nine binary comparisons, to find the best of nine requires eight comparisons and so forth. Thus, to completely order ten items, requires 9+8+7+6+5+4+3+2+1 binary comparisons (i.e., 45).

faster than the number of binary operations required to determine the best of the alternatives considered [N-1]. To the extent that the cost of information processing is an increasing function of the number of binary operations necessary to perform some task, the cost of a complete ordering will always be larger than that of determining the best alternative, and the difference in cost will increase as the number of alternatives increases. This suggests that the larger the range of alternatives considered, the less likely that an individual will find a complete preference ordering worth his effort. In light of this, the usual conceptualization of a utility function misrepresents the outcome of the evaluative process, for a necessary condition for the specification of a utility function is the existence of a complete preference ordering (for the range of alternatives considered). It will rarely if ever be in an individual's interest to determine his preference ordering.

Because of the costs of information processing, an individual will tend not to consider in detail or to rank all of his recognized alternatives. The alternatives not considered and the ignored aspects of the goods considered are of little economic importance. For most practical purposes, the range of alternatives actually considered and the alternatives focused upon provide sufficient detail

about an individual's opportunity set. Those opportunities and details which are ignored during the decision-making process will not be directly embodied in the resultant evaluations, although they are an aspect of one's optimization problem. Their relevance here is that this feature of choice implies a possibility of imprecision. Those details neglected and the opportunities which are ignored may include things which could potentially affect an individual's decision. The subset considered may lack some important aspect or element.

The third way an individual can economize on the decision-making process is to specify the contingencies or physical goals of the chosen plan in less than complete detail. Such plans will require generally less information processing to conceive and implement. In planning to exit a room an individual may fail to specify the precise location of his feet after every footstep, and he may fail to specify a contingent reaction for the event that there is an earthquake measuring 7.1 on the Richter scale while on his way to the door. In many circumstances, such efforts would be an inefficient use of an individual's resources. In general, an efficient plan of action will have only that level of precision which seems to be worthwhile. That is, one will want to increase the precision and generality of one's plan only so long as the marginal benefit of doing so

exceeds the opportunity cost of increasing the content of one's plan in these ways. As a rule, plans will be less than complete in this sense. One will not specify precise physical actions for every conceivable circumstance. One will not specify precise physical actions for every conceivable circumstance. One will not specify an action to the limits of detail which are possible, but to the limits of which it is profitable.

Actions within economic models are usually very precise: individuals demand quantities of items to the smallest possible unit, presumably the molecule; their plans completely specify actions for a lifetime, with every contingency planned for. Rarely is this behavior observed in actual decision makers. Instead, the intentions of individuals are often hazy or imprecise and their plans reflect this. Their plans include precision only to the extent that seems desirable for the tasks before them given their perception of those tasks. This level of detail is usually far less than that implied by most analytical models of choice. In fact, the use of imprecise models ("over precision" implies imprecision) by economists reflect their own decision calculus, and resultant decisions to economize upon information processing by abstracting the most "important" details and ignoring the "less important" elements of choice. Thus, the

process of economizing upon information is left out of their models because it is central to their own decision-making process!

The imprecision of plans is apparent in most individual actions, including that of economists, although this imprecision is ignored in formal models of choice.[7] Individuals do not request a glass of water filled with 213 milliliters of water in it; they request a glass of water. If the glass of water varies greatly from their image of a "glass of water," steps would be taken to improve the situation.[8] An individual will not add up the prices of the a la carte items he orders at a restaurant to the last penny, although the order of magnitude may be estimated. In principle, this kind of imprecision extends to every level of decision making. In general, the more costly the

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[7]To some extent the imprecision is embodied implicitly in the construction of formal models. One considers a group of similar items to be a collection of identical goods which allows one to quantify items which are not precisely quantifiable. Models often deal with choice among general categories of items such as consumption and saving, automobiles and trucks, fruits and vegetables, and oranges and apples, which are themselves not composed of equivalent and hence quantifiable items. The notion of an economic good is nearly always an imprecise abstraction.

[8]This line of argument provides an optimizing rationale for the idea of satisficing developed by H. A. Simon, "Theories of Decision Making in Economics and Behavioral Sciences," American Economic Review 49 (June 1959). Satisficing or aspiration levels are viewed as the joint specification of imprecise goals and a range of tolerable results; and is considered an aspect of economizing on information processing, i.e., optimizing.

additional precision and the lower its anticipated benefits, the fewer are the resources that will be devoted to achieving accuracy.[9] One may of course obtain greater precision than anticipated, as a rough estimate may sometimes yield the same result as a careful calculation. But the accuracy sought will reflect the solution to the individual's cost benefit calculation and tend to be an increasing function of the resources actually devoted toward obtaining it, other things being equal.

To summarize briefly: an individual will economize upon decision making itself when it is costly. The primary consequence of economizing on the selection process is that decisions become "less accurate" as individuals: (1) adopt less accurate decision procedures; (2) fail to consider all of their alternatives; and (3) choose plans of action which are not precisely conceived. The fundamental trade-off faced by individuals in these circumstances is that between information processing and increased accuracy. The optimal plan is not the most accurate plan. It is rather the plan which best promotes one's goals. Awareness of methods to economize upon the selection process will influence the range

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[9]This general line of reasoning has been used before and is found most often in discussions which center about the Downsian-Tullockian voting paradox in the public choice literature. See, for example: A. Downs, The Economic Theory of Democracy (New York: Harper and Row, 1953).

and extent of decisions that an individual will attempt to make. He might willingly choose a course of action which seems to require more resources to achieve a given end, but which is, nonetheless, efficient because the costs of decision making have been reduced by making "inaccurate" decisions.

The particular economizing techniques used by individuals are not of special importance for the purposes of this dissertation. A variety of decision cost reducing steps is clearly predicted, and the general consequence of reduced "accuracy" is clearly indicated. Both are easily observed.

Reliance Upon Refined Data. Access to highly refined data can often reduce information processing costs. An idea which seems obscure or which would require much effort to develop independently can often be rendered crystal clear with a short explanation. When the costs of information processing are relatively high, an individual can simultaneously increase the extent of his information and reduce the costs of information processing by collecting highly refined data. In practice the costs of information processing are extreme, and the use of highly refined information is correspondingly widespread. The high cost of information processing makes highly refined data economically scarce, for such data is not inherent in raw data but requires information processing, directly or indirectly, of raw data. That a market for

for refined data, given widespread demand and economic scarcity, exists is hardly surprising. It may be surprising that economists have scarcely noted this market's existence or the behavioral consequences of a heavy reliance on "pre-processed" data.

Economists have not entirely neglected behavior which can easily be explained as consequences of costly information processing, but they have failed to find a systematic explanation for such behavior. Friedrich A. Hayek focused to some extent upon the heterogeneous distribution of information in his classic piece, "Economics and Knowledge,"[10] but failed to focus upon the reason that information tends to be so distributed. Individual skills that may be acquired play a prominent role as "human capital" in modern theories of wage determination, but the reason such skills are scarce is not considered.[11] The existence of "signalling" is noted but its connection to the "bandwagon

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[10]F. A. Hayek, "Economics and Knowledge," Individualism and Economic Order (New York: Henry Regnery Company, Gateway Edition, 1948):33-36. Also see: F. A. Hayek, "The Use of Knowledge in Society," American Economic Review (September 1945):519-530.

[11]See for example: G. Becker, Human Capital (New York: National Bureau of Economic Research, 1964).

effect" and the "aping" of the leisure class is not provided.[12]

Focusing upon the costly nature of information processing and the resultant heavy reliance by individuals on pre-processed data provides a systematic explanation for all of these activities and others which have previously been discussed independently of one another. Recall that in a setting where information acquisition is costly, individuals will have less than complete information because they face information processing constraints. Furthermore, individuals will possess less information than they are capable of achieving because it will be profitable to devote one's resources to activities other than information acquisition per se. Beyond this, individuals will tend to accumulate differing collections of information images for any or all of the following reasons: (1) they possess different abstract goals or tastes; (2) they may control different quantities of resources which can be devoted to information acquisition; (3) they may as a result of chance acquire different data; (4) their innate abilities to collect data

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[12]M. Spence, Market Signaling: Information Transfer in Hiring and Related Processes (Cambridge, Mass.: Cambridge Press, 1974); H. Leibenstien, "Bandwagon Snob, and Veblen Effects in the Theory of Consumer Demand," Quarterly Journal of Economics (February 1948):165-201; T. Veblen, The Theory of the Leisure Class (New York: The New American Library, Inc., Mentor Book, 1953):33-80.

may vary (i.e., vision, hearing, etc.); (5) their innate abilities at the three modes of information processing may vary (i.e., more or less ability at logic, intuition, memory, etc.); (6) they may have different insights as a result of the indeterminate mode of information processing; (7) they may have faced circumstances in which the cost of collecting refined data varied. As a result, information tends to be heterogeneously distributed across individuals, although the extent of the variation is limited somewhat by access to a "common" cultural heritage which provides an important common ground and basis for interaction.

Individuals, of course, tend to be aware of the heterogeneous distribution of information, which gives rise to several predictable kinds of activities. (1) Individuals will tend to use the behavior of others that they believe to be well informed as proxies for what they themselves would do if well informed, thus saving the cost of being informed themselves. (2) There will exist markets for a wide variety of information related services. (3) There will be an element of resource allocation which is strictly informational and apart from the usual elements of tastes and physical wealth. Only the first two results will be dealt with in this section of Chapter Four, and these will be discussed only to the extent that they reflect an individual's high

reliance upon refined data of one kind or another.

An individual demands refined data not for itself, but because it can be used to economize upon information processing. In attempting to acquire information efficiently, an individual will not willfully waste resources on data collection. He will demand not the best data available, but rather that data which seems best suited to his purposes. Such data will often be relatively imprecise as an individual trades off the opportunity cost of collecting the data and the anticipated gains of additional precision. To seek data which are more refined or more accurate will generally be possible but not "worth" the effort.

Data which are readily available and inexpensive to acquire, as a consequence, tend to make up the greater part of the data one collects. Such data form the basis for most of the information images that one possesses and thereby greatly influence one's decisions. Perhaps the most important example of low-cost readily-available data is one's cultural heritage. Much of one's cultural heritage is readily available and passed on by word of mouth and absorbed simply by living in a society. One is exposed to sophisticated views and examples of life styles, values, and institutions. Refined data provided by the efforts of others can often make it easy to grasp concepts which took lifetimes to develop. Individuals do not, of course, have low-cost

access to all of the refined data collected by a society through the centuries, but even given this, an individual's collection of information images is both greatly enhanced and influenced by this huge stock of refined data. As with any other source of data an individual will not choose to refine or consider all of it equally, but will instead process data which seems most likely to be of value. In this sense one's behavior is not so much molded by society as derived and selected from it. An individual may choose a life style "offered" by his society not because it is necessarily the "best" one, but because the cost of contriving a better one seems to be greater than the likely improvement.

Data which individuals rely heavily upon are not only low cost, but also tend to be less accurate than the best available. Individuals economize on the cost of data collection by relying heavily upon proxies. Proxies are data sources which are easily observed which tend to be related to some variable of interest which is more costly to determine. The extent of the relationship varies widely; some proxies predict movements of the variable of interest with great accuracy and others are scarcely related. Individuals will use the best proxy that they are aware of at every cost level and will not be willing to sacrifice more for one proxy rather than another unless it seems to be more accurate. Thus the costs of increments in accuracy tend to increase,

while the advantages of increased accuracy tend to decrease. Individuals will quite rationally use proxies which are less accurate than the best available. This is often the case.

An individual might, for instance, use price as a proxy for quality, or use the view of the "good life" promoted by his peer group or that promoted by the leisure class as a proxy for his own preference ordering (i.e., the closer to this proxy "ideal" the better). Doing so may well lead to less than the best possible results, but the tremendous potential saving in information processing and data collecting may well make it a good individual strategy. The great efforts of advertisers to associate their product with the "good life" is evidence (evidence is often itself a proxy) which suggests that individuals do indeed use such proxies.

Knowledge that individuals use proxies brings forth predictable responses by those who supply data to others in the hope of influencing behavior. The data supplied tend to be targeted at individual proxies. This activity has been called signalling.[13] This kind of activity clearly goes beyond the examples of labor market signalling used by Spence. It tends to be true, for example, in advertising, political rhetoric, in product design, and in virtually every form of

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[13]Spence, Ibid.

information supply where one individual attempts to influence the behavior of another who uses proxies. It is used by con men who seek to defraud others and it is used by theologians who hope to save the souls of others. Signalling in this general sense enhances communication, although it sometimes reduces the value of proxies to those being "signalled."

Not all proxies are easily obtained or unsophisticated. One will find costly sophisticated proxies of value in many circumstances, as is evidenced by their widespread use in virtually every branch of science. Determining whether relatively low-cost or high-cost proxies are of greater importance for economic behavior is a task beyond this dissertation, although one should note the tendency for sophisticated proxies to become less expensive through time as they become widely used. It is sufficient here to note the widespread use of proxies and to provide an economic rationalization for their use.

The existence of proxies or other highly refined data which can not be simply collected provides a basis for a market for refined data and other informational services. Often one can reduce one's overall cost of acquiring an information image by seeking more highly refined data than that which is available for the taking. One may, for example, willingly give up resources in order to listen to a

good lecturer instead of simply going to a library and doing one's own research on the lecture topic. Or, one might give up resources to acquire a complete economic time series which was developed from readily available data sources. Thus the existence of "inaccessible" highly refined data combined with a heterogeneous distribution of information images gives rise to potential gains to trade and markets to exploit these potential gains.

Whenever it is possible to "communicate" an information image by providing some highly refined data to an individual so as to reduce the receiver's cost of obtaining an information image, trade may be advantageous, depending upon the opportunity cost of supplying the data and the anticipated value of the reduced information processing. Trade may be a simple exchange of ideas or trivia, as in a conversation, or an exchange of physical resources for refined data, as formal training tends to be, or some complex arrangement involving both data and physical resource transfers. Individuals, of course, are not seeking the data themselves, but useful information images which they hope can be derived from the data. The observed markets for data and other informational services act as surrogate markets for information images costless to acquire or, once acquired, costless to reproduce.

Individuals use much of the refined data that they acquire without being able to understand the method used to create them. When an individual purchases refined data from a consultant, he will rarely understand the diagnostic procedure used to acquire the information used by the consultant as a source of data. Individuals follow customs without understanding their derivation or rationale, as one will plan on having three meals a day without considering the merits of ten or some other number of meals. Students use theorems which they accept on faith, and patients rely heavily upon their doctor's advice without understanding the reasoning behind the advice. Individuals rely heavily upon information images formed from data which they do not understand. That they do so is a source of personal insecurity and efficiency. They are uncertain about that which they "know," yet know more than they would otherwise find useful to assimulate and synthesize. Such behavior is fully rational and to be expected when one recognizes the cost of information processing.

Informational Sub-optimality. As a result of costly information there are two types of informational sub-optimality which can be expected. The resultant planning state can be Pareto sub-optimal in the usual sense, and it can be informationally sub-optimal in a sense which will be developed in this section of Chapter Four. Only

the second of these forms of sub-optimality seems to have policy relevance.

It has been argued above that costly information processing implies that individuals will, in general, be less than perfectly informed and that their choices will be, in a sense, inaccurate. Individuals will rely upon refined data which events and actions make easily accessible. Individuals will possess information images only to the extent that they imagine it worthwhile to develop them. They will often find it advantageous to collect a relatively narrow collection of information images yielding that unfortunate narrowness that Adam Smith associated with specialization.[14] While such individual behavior may be in a sense "sub-optimal," this is not the case in the usual meaning of the word optimal. Individuals make the best decisions that their circumstances permit, it is simply that their circumstances include the fact that information is costly to acquire and create. Thus, given their circumstances, individual decisions are optimal in the sense that they represent the solution to an optimization problem.

Economists usually consider an allocation of resources inefficient if one could costlessly reallocate

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[14]Adam Smith, The Wealth of Nations (New York: Random House, Inc., The Modern Library, 1937):734-735.

resources so as to ensure that at least one person is made better off while making no one worse off. In a perhaps trivial sense, resources will be inefficiently allocated whenever information acquisition is costly. It will generally be possible to provide one person with information which exists within the economy in a way which makes him better off and others no worse off. One could, for example, provide some information which improves someone's household production. Of course, costless transfer of information or any other resource is itself impossible and thus this form of inefficiency is without policy implications.

One does not gain a policy relevant criterion simply by including consideration of the costs of transferring resources within the economy. In perfectly informed circumstances every mutually advantageous action will be exploited, thus the resulting allocation of resources will be necessarily Gareto efficient.[15] In situations in which information is costly, individuals will exploit all the worthwhile opportunities that they are aware of. Individuals will alter institutions which they agree to be less effective than some other known possibility. Public goods will be supplied

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[15]Results to the contrary exist because of a very limited specificationof an individual's opportunity set. Clearly an individual's opportunity set includes more than the conventional activities of consumption, production, and exchange. If individuals are aware of all potentially advantageous actions, no truly beneficial actions will go unexploited.

by organizations which are "cost effective" to organize, and so on. In circumstances of perfect information the allocative result will be one not dominated by any other. In contrast, the allocative result when information is cosely will be one which is dominated by no other known alternative. Each will be economically efficient given the costs of resource re-allocation.

There remains one other criterion which does have potential policy relevance. It seems entirely plausible to consider as sub-optimal plans which are not as effective as they could be. In circumstances of costly information, it will often be the case that the plan of action chosen by an individual (or agreed to by a group of individuals) will be less than the best method of furthering their goals even though such a plan will be the best that he (they) is (are) aware of. Plans which are less than the most effective way of furthering an individual's goals shall be referred to here as informationally sub-optimal plans. The obvious corrective policy is to induce individuals to improve their plans.

The problem faced by policy makers is also obvious, they too possess imperfect information. In particular, they lack information about the plans of others and about the best way to induce plan improvement. Individuals who seek "information sub-optimalities," for whatever purpose, can not be

sure that they have discovered one if they too lack perfect information. To determine whether or not a true informational sub-optimality exists in the world as well as in the imagination of the "discoverer" some kind of corroborative experiment must be performed. Perhaps the strongest test of informational sub-optimality is that of providing low-cost highly-refined data to those with sub-optimal plans about the nature of the hypothetical sub-optimality. If the advice is taken, one has simultaneously affirmed the existence of an informational sub-optimality and eliminated it! If, on the other hand, individuals do not "correct" their plans in light of the data provided, one can not simply reject his hypothesis. The "theorist" may be incorrect or he may have supplied data insufficiently refined to convince the affected individuals of the ineffectiveness of their plans.

The role of the welfare theorist becomes clear in this context. The task of the welfare theorist exists only because information is imperfect and because individual plans can be improved. The role of the welfare theorist is to discover informational sub-optimalities and to provide data about the unrealized gains to the relevant decision-makers. The role of the welfare economist is thus rhetorical;[16] it

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[16]J. Buchanan, "Positive Economics, Welfare Economics, and Political Economy," Journal of Law and Economics 2 (1959):124-138.

is to provide data (and thereby information) to decision makers so that they might improve their plans. This has been, of course, the actual role of welfare theorists all along, although they seem not to have been aware of it, or to have provided for such a role in their view of economic process. Empirical welfare theorists must be prepared to eliminate their problem in order to demonstrate its existence. Their hypotheses can be confirmed only by eliminating the hypothesized informational sub-optimality.[17]

Information, Time and Decisions. To this point, the nature of the costs associated with information processing and the rationale for devoting resources toward non-consumption uses have been largely ignored. For the purposes of this dissertation it has been sufficient to leave the costs of information acquisition abstract, and the rationalization for allocating resources to non-consumption uses implicit rather than explicit. Individuals will allocate resources to non-consumption activities only when there is a future in which the fruits of non-consumption activities can be realized. Individuals will rationally live for today when it is known with certainty that there is no tomorrow. Information

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[17]This test contrasts sharply with tests of hypotheses as usually conceived. In the usual test of a hypothesis, one can only determine its falsity with certainty. Tests performed to determine whether or not informational sub-optimality exists can only determine the truth of the hypothesis with certainty.

will be sought for non-consumption purposes only when an individual anticipates some future benefit. The planning discussed has implicitly been multiple-period planning, the selection of plans which include consideration of future consequences. However, even in this limited model of choice, time must play a more important role than it plays in conventional models of intertemporal resource allocation. It is this importance which is focused upon in the remainder of this chapter.

In the usual models of economic decision making, time serves as little more than an attribute of goods. An action may be done sixty days or sixty years hence. The act of choice is the same; one chooses to buy oranges with characteristic 1978 or with attribute 2138. The role of time as a scarce resource or as an "arrow" plays little role in such models, beyond indirectly determining the exchange rates between goods with one time characteristic and those with another. Using time as an attribute of goods or services serves as a clever device which allows one to apply the conventional model of decision making to intertemporal planning.

However, in models which include a role for information beyond that of a consumption good, time must be generalized to allow multiple decisions as well as multi-period planning. The primary non-consumption usefulness of

information is that it allows plans of actions to be improved, that is, for new plans to be chosen. In addition, time must play a role as a scarce resource. Time is, or one's ability to accomplish things at a point in time, the primary cost of information acquisition. Were there no time-connected capacity constraints (upper bounds on flow rates) or were time unlimited, information would be superabundant. Individuals would be either perfectly informed or indifferent between being perfectly informed and remaining at current levels of ignorance.[18]

A model of choice which includes a role of information processing costs must include time as an arrow ordering decisions and as a constraint limiting the range of alternatives. That is, individuals will be able to do only so many things during a specified time duration, and have only so much time available. Until very recently, economic models of choice have been single decision models,[19] in

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[18]It would be more precise to say that in the case of unlimited time individuals could approach a perfectly informed state or one which they consider no worse than being perfectly informed if one ignores any possible memory constraint, or assumes that perfect information can be "compressed" to fit within whatever memory constraints that exist.

[19]See for example: R. H. Strotz, "Myopia and Inconsistency in Dynamic Utility Maximization," Review of Economic Studies (1956):165-180. More recently there has been an emerging "temporary equilibrium" literature, for a good survey of this literature, see: J. M. Grandmont, "Temporary General Equilibrium Theory," Econometrica 45 (April 1977):535-572.

which time had either the constraint element, as in Becker's theory of the allocation of time,[20] or models in which time served as an attribute of goods, as is the case in most life cycle models.[21] In a model of choice which attempts to capture the role of information in choice, time must play both roles and, in addition, the model must call for multiple decision making, i.e., must allow plans to be chosen and modified through time.

Summary

In this chapter, the important considerations and consequences of a single choice have been discussed. Time has served as an attribute of goods and services and as a constraint upon the informational opportunity set of the individual. It has been argued that information plays an important role in these circumstances; that individuals will consider a wide range of informational alternatives and costs. Decisions will be made that represent the best alternative considered by the individual, rather than the best feasible alternative. Individuals will economize upon

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[20]G. Becker, "A Theory of the Allocation of Time," Economic Journal (1965):493-517.

[21]Perhaps the clearest example of a "time as an attribute" model is: G. Debreu, Theory of Value (New Haven: Yale University Press, 1959)(sixth printing 1975):28-37.

the decision process itself with the result that choices will be well chosen only to the extent that the benefits of more accurate selection will more than offset the imagined opportunity cost of additional information processing. As a result, an individual will choose the best plan of action that he is aware of which may not be the best within his grasp.[22]

The primary contribution of the analysis has been to articulate clearly the importance of the role of information in choice. A clearer explanation has been given to many commonly observed economic phenomena. The model

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[22]The idea that plans can be more or less effective implies that some plans are better than others. Some plans will be better conceived than others, and some individuals will be better at conceiving effective plans than others. In this context, the word rational can be applied in its formal and in its common meanings. In the formal sense of the word rational, individuals will rationally prefer more effective plans to less effective ones. Plans which are more effective or better conceived are plans which are more rational in the usual sense of the word rational, i.e., well reasoned.

Rationality in the ordinary sense may be regarded as an aesthetic concept, i.e., more rational plans are better than less rational plans, or it can be used as an ethical norm which is stronger than the usual Paretian criteria used by economists, that is, more rational plans should be sought by individuals. It is very often used in both ways by both policy makers and welfare theorists. Of relevance here is the fact that the more rational a plan is,the less likely an individual will be able to demonstrate its informational sub-optimality. On the other hand, the better conceived that a plan is, the more likely that actions called for within the plan can convince others of the informational sub-optimality of their own plans.

predicts that individuals will engage in information-related activity which would be peculiar in circumstances of "perfect" information. While it is true that the analysis implies little that can not be captured in an "informationless" model with a suitable specification of individual tastes, this analysis provides a richer explanation of many significant activities.

Chapter Five

INFORMATION ACQUISITION AND DECISION MAKING THROUGH TIME

Introduction

This chapter provides an economic--optimization--rationale for the selection of flexible plans of action and thereby adaptation through time. Plan revision is considered an exercise in information processing, and the adoption of flexible plans by individuals is a direct consequence of relatively high information processing costs. As individuals acquire new information, they will often revise their plans of action in light of it, with each alteration improving the efficacy of their plans--at least in their own eyes.

The chapter is divided into two sections. The first, by building upon the analytical framework developed in the last chapter, provides an optimization rationale for adaptation and examines the nature of that adaptation. The second focuses upon fundamental changes in economic behavior through time that are mandated by consideration of the role of information in choice. Although the optimization paradigm can be extended readily to include the process of information acquisition, such an extension cannot be accomplished without transforming many fundamental ideas about economic

behavior through time. Orthodox notions of revealed preference, optimality, equilibrium, and economic efficiency are all modified, in both content and importance, by the inclusion of informational elements of the choice problem developed in this dissertation.

Information Costs, Flexibility and Adaptation

Information must be assured of playing at least some minor role whenever individuals are unable to specify the events which will occur at every point in the future. At a minimum, information must be acquired that allows a decision maker to determine which particular contingency has occurred so that he may implement his plan of action. Often it will be to an individual's advantage to "plan to plan" if a certain class of contingencies arises (for example, the ones not anticipated). In such cases, information acquisition not only allows one to implement his plan of action, but catalyses the formation of new plans.

In this section of Chapter Five, it is argued that it will nearly always be to an individual's advantage to specify plan revision as a contingent course of action--that is, to adopt flexible plans. Such plans can greatly reduce the costs of contingent planning and enhance the quality of the "plan" ultimately enacted. Under a flexible plan, one will make a series of decisions as events unfold rather than

a single rigid decision which mandates specific actions, other than information processing, for all time. Flexible plans will be chosen whenever a decision maker anticipates acquiring new information which will enhance his overall consumption stream in a way not completely imagined. Individual behavior under such plans can appear to be inconsistent and discontinuous efforts to accomplish disharmonious goals, even though the individual had at every instant clear and consistent images of the end sought.

Information Costs and Flexible Plans. Planning is an exercise in foresight and imagination. As is true of all intentional activities, there are both costs and benefits associated with planning. By planning for more than the "next" instant, one can often determine a series of actions which are, in a sense, complementary. That is, a series of actions can often further goals in ways superior to a series of "optimal" short-sighted steps. The best way to climb a mountain may involve climbing downhill for some part of the route. To maximize profits, one may have to bear short term losses. To get the most consumption value for one's dollars, one might have to save them for a while. By planning ahead, one can often be prepared for some future contingency and so be able to avoid some loss or realize some gain that one would otherwise have to bear. By anticipating events and planning accordingly, one can respond to changing

circumstances in a more considered and deliberate fashion than one would have time to develop in the absence of foresight. One can plan to "sell" when a stock price falls to some level and thus not be left trying to decide what to do at a moment's notice. One can prepare for a catastrophe and so be relatively comfortable in what would have otherwise been a personal disaster. The benefits of additional planning are surely greater, the more complementary the series of actions intended, and the more likely the circumstances in which they are to be enacted. The marginal benefits of additional planning will tend to decrease as one's efforts turn to contingencies which are less and less likely and series of actions which are less and less complementary. On the other hand, the opportunity cost of additional planning will rise as one draws resources from increasingly valuable alternative uses. It is thus costly information processing which leads to an optimal level of planning which is less than than conceptually possible, and the possibility of a complementary series of actions and/or limits on one's capacity to make affective decisions quickly which leads to a level of planning greater than zero.

Although the planning engaged in by individuals will be less than exhaustive, the plans which are developed will define a specific response for every circumstance. However, the response called for will not always, or even generally,

be a specific concrete action; it will often be to engage in plan revision. If an event occurs which has not been fully considered, or perhaps even imagined, one does not cease to exist or act as having reached some undefined region of one's plan but, rather, one engages in plan revision. The extent of the plan revision called for, naturally, depends upon the circumstances which have arisen: some events will call for complete dramatic changes in one's plans and others minor extensions. Some unanticipated life-or-death matter, obviously, can call for greater plan revisions than finding an unexpected penny or two in one's pocket. In general, the greater the change in one's perceived opportunities, and the less anticipated and more radical the change the more resources one will devote to plan-revising activity. That individuals who consider information costs plan to plan rather than to act makes their plans flexible and adaptive rather than rigid and unchanging, but it does not make their plans any less complete than those conceived with perfect foresight and providing a specific action for every possible contingency.

Individuals will develop plans of action which are flexible, in part, because of necessity, and in part, because flexible plans over a fairly wide range of circumstances are more effective ways to further one's goals. Individuals recognize their own limited ability to form accurate images

of future events. They admit the possibility of events which they have not even conceived. If one admits the possibility of "surprises," however unlikely, one's plans cannot be completely rigid; they will necessarily include some role for plan revision and thereby be, at least to a limited extent, flexible plans.

Individuals will choose plans which are more flexible than this limiting level whenever there seems to be advantages to doing so. This is often the case. By planning to revise one's plan, an individual can often simultaneously reduce the overall costs of decision making and enhance the overall effectiveness of his plan. Decision-making efforts can be transferred efficiently to future time periods because one anticipates acquiring information that enables one to make better and/or less costly decisions. Such information may reduce the number of contingencies that one will find useful to consider as many contingencies are eliminated from consideration by the events which actually occur and as one's understanding of events and methods improve with time. When decision making is transferred to the future, knowledge of one's location in time and space no longer have to be imagined: the course of events will provide the data necessary to make this determination. By postponing decisions, one can often expect to bring more skill and information to them and thus choose more effective plans than one could choose with the information and skill currently possessed.

Rather than attempting to develop a detailed contingent plan for the rest of one's life, it will often be effective to consider only the general outlines of such a plan and to contrive details as events unfold, as one's skill at decision making increases, and as one's knowledge of ways to further one's goals increases. One does not plan for the placement of each footstep as one walks across a room, but instead places one's next footstep in front of the last one, given its location and a current view of where one is going.

Transferring planning and decision-making efforts to the future is not without cost. Each transfer of planning effort increases the risk that one will forego some desirable result which required some complementary series of actions. By planning to plan after reaching some destination, one may forego valuable alternatives along the way or reach one's destination ill-prepared to exploit the opportunities available there. A firm may lack the necessary "know how" to exploit a profitable opportunity, or a consumer may have "forgotten" some items which would have added greatly to his consumption experience; for example, a "coat and tie," a swim suit, or sufficient funds. These problems can be avoided to some extent by doing more planning in the present and less in the future; flexibility can be included by allowing resources for minor plan review. One can conceive and select fairly detailed plans which are continually revised in light of new

information. Such plans will always be, in a sense, more effective, but as planning occurs both in the present and in the future, the overall costs of planning rises commensurately.[1]

The level of flexibility embodied in an individual's plans will be neither the largest nor smallest level that is possible. One can easily imagine plans which are "too" flexible, or "too" rigid; plans which waste resources by constantly reconsidering one's general plan of action and plans which devote too few resources to exploring new possibilities as they emerge. The degree of flexibility incorporated into one's plan will, naturally, vary from individual to individual, as skills at information processing, confidence at planning, and the range of activities considered all tend to differ. The particular degree of flexibility chosen by individuals is not of particular importance for this dissertation. It is sufficient to conclude that individual plans will exhibit some flexibility, that is, that the plan chosen provides for contingent plan revision and thereby assures that information acquisition

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[1]Note that elements of rigidity or precommitment can be effective ways of economizing on information processing. By committing to some series of general actions or choosing some goal one can focus one's attention upon a narrower and simpler range of alternatives, thereby reducing information processing costs and increasing the risk of foregoing some desirable but relatively large plan revision.

plays a role beyond that of allowing preconceived plans to be implemented. Casual observation suggests that individuals choose plans which have important flexible elements; plan revision is not at all uncommon--indeed, it appears to occur nearly continuously--which implies that information acquisition plays an important and ongoing role in both individual planning and decision making.

Information Costs and Adaptation. In flexible plans, individual judgment and creativity are particularly important. Flexible plans call for plan revisions in which the roles of personal judgment and creativity cannot be ignored as they can be in the case of rigid plans.[2] The course of action that will, eventually, be followed is not specified within the plan, but rather, is one which is discovered or invented as a result of the plan. In order to predict or duplicate the choice of a decision maker, one must be able to understand his goals, his view of the possible, and more importantly, be able to construct his thought (information processing process).

Some general characteristics of the series of choices that an individual will make can be determined without a

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[2]The very idea of individualness or of free will is closely related to the role of judgment in flexible plans and the unpredictability of plan revision. If the actions of an individual cannot be duplicated by another or by some analytical process, the importance of the individual and his "free will" are affirmed.

precise description of these elements. Given the costly nature of information processing, one can predict: (1) that plan revisions will tend to have some random character; (2) that minor plan revisions are more likely than major ones; (3) that the process of plan revision will not be complete until a plan is developed which defines a specific action for every circumstance one encounters and which dominates all others considered. Plan revisions, themselves, represent changes in behavior; changes which may conceptually be gradual or abrupt according to the significance of the information which causes one to adopt new plans. As an individual walking toward a fixed object at a distance can smoothly alter his course to match the location of his target or leap suddenly to one side to avoid some unanticipated obstacle, so may an individual alter his plans and behavior as the result of new information images which suggest a better method of furthering one's goals. Successive decisions by individuals are the end-results of a changing collection of information images. As such, the sequence of decisions will exhibit properties that are implied by the methods of information acquisition, information processing and data collection, and the costs associated with them.

Information that is acquired by individuals is never precisely foreseen and is often acquired by chance. One is unaware of the precise information image that one will

acquire, because attempting to acquire information that is already possessed tends to be wasteful of one's resources. Seeking some fact or idea that one already possesses will not be attempted unless it serves some non-informational purpose. The information that one acquires tends to be information not already possessed, and thus not precisely imagined. The process of acquiring it tends to have a random character as a result of the unforeseeable nature of the image acquired, the creative nature of developing an information image, and the often random element in data collection. To the extent that an image is the result of creative insight or imagination, it is a partial result of indeterminate information processing, and thus it is a product of a process which has an important random component. Beyond the random component of information processing itself, data collection often exhibits a sizeable random element. Data may be acquired randomly as the result of intentionally choosing to do so, as scientists often seek an "unbiased" sample of one sort or another, or by chance as one attempts to remain alert for new unimagined profitable opportunities. Often one acquires data not as a result of a clearly defined search, but as a consequence of looking left rather than right, or up rather than down, without any clearly imagined category of data in mind for no particular purpose beyond the vague possibility of acquiring some useful bit of data

rather than not acquiring any data at all (say by closing one's eyes or totally ignoring one's surroundings).

The random character of information acquisition affects plan revision in two ways. (1) Because the informational events which call for plan revision are unimagined and often random, plan revision will tend to occur at unanticipated times which will be to some extent randomly distributed. (2) The activity of plan revision is inherently an informational activity, a plan or plan modification are, after all, only information images of future actions and events; thus the process of plan revision, being an information processing activity, will exhibit the general properties of the process of information acquisition. A particular revised plan cannot be foreseen; for if one had imagined the revised plan and the contingency under which the modification would be made, no plan revision would be necessary--it would already be incorporated into one's contingent plan. To the extent that plan revision is a creative act and thus a result of indeterminate information processing, the process of plan revision itself will exhibit randomness. Further randomness can be caused by the random acquisition of data which has direct planning relevance, even if the information processing required to transform the data into information is completely determinate. In this case the plan revision process is not random, but the plan revision adopted is the consequence of

a random process, i.e., data collection. One may discover a better way to cross a stream as a result of a nearly spontaneous insight or by stumbling across a map which lists a convenient place to ford it. In either case the plan revision itself is unforeseen, and the consequence of a process or processes which have large random components. Consumption plans may be changed as the result of glimpsing a billboard; production processes may be forever altered by a sudden insight; the creative and chance elements of plan revision tend to be present in nearly every change of plans regardless of the extent of the modification performed. There are circumstances in which one's response is implied by the circumstances; an unforeseen extraordinarily profitable opportunity will not go unexploited, but the method of exploitation often requires judgment and/or imagination on the part of the decision maker and thus tends to reflect to some extent the chance nature of information processing.

The random aspect of plan revision implies that individual actions, being derived from plans, will not be entirely predictable. Given complete information about an individual's circumstances, one would still be unable to predict an individual's behavior because of the creative non-determinate aspect of plan revision. Plans are constantly evolving as the result of experience and insight; with each action an individual's information changes, and

with each change the possibility of plan revision occurs. If a plan is found to be satisfactory and no information is acquired which suggests a better one (given the resources allocated to performing this evaluation), it will be continued. But often information acquired during an action or series of actions will suggest ways to enrich one's plan. The random aspects of both acquiring information and using it to form new plans assures that neither the decision maker himself, nor anyone else, can predict exactly the decisions that he will make through time--for it is conceptually impossible.

However, the costly and constrained nature of information processing, and hence plan revision, allows one to analyse the range and likelihood of various plans and actions through time. The range of plan revisions possible, being informational in nature, is limited by the information one possesses and one's skills at the various modes of information processing insofar as they relate to the process of plan revision. The information that one possesses provides a source of previously considered plans which may be worthy of further consideration, and a stock of partially refined information which may serve as the basis for developing new plans of actions or new refinements to formerly considered plans. At an instant in time, the resources devoted to information processing and plan revision and the informational

base that is available to be processed determine the range of possible plan revisions that one could conceptually consider and choose. This range is not as concretely bounded as the usual economic formalization of an opportunity set. It merely suggests the likelihood of various plan revisions. The plan chosen will depend upon the creative insights of the moment as well as the other determinate elements. If one assumes that large insights are rarer than small insights, then, given the costly nature of information processing in general and plan revision in particular, it follows that small plan revisions are more likely than large ones. To acquire a greater break with one's past behavior would require a longer and more costly period of speculative thought. If one also assumes that the costs of considering great modifications tends to be greater because of the required great costs of imagining new actions, new consequences, and evaluating them, then large plan modifications become correspondingly even scarcer. Small adjustments are commonly less costly to make, as adding spices to an already prepared meal requires less calculation than deciding to transform the food prepared into a totally different culinary delight. An individual is less likely to develop a new mode of transportation than to use one already existing in a slightly original manner. Entrepreneurs

are less likely to conceive of a radically new product or production method than to modify an existing one. The information costs of large plan revisions are large and well understood, the gains of attempting such a revision are, while potentially large, at best highly uncertain.

While this argument suggests that large plan revisions tend to be costly, the random components of information acquisition suggest that occasionally one may, essentially by chance, acquire low-cost information that spurs one to adopt a relatively radical change in plans. Information that convinces an individual that the "world" will end a week from Tuesday may cause him to alter dramatically his consumption and investment plans. An insight about the best way to pursue one's goals may cause an individual to change his lifestyle dramatically. However, such crystal clear dramatic information is rarely acquired; the nature of one's daily experience changes at a somewhat slower, less dramatic pace, and one's insights tend to require less than the complete abandonment of one's current life style. In fact, the rareness of such events reinforces their relative unlikeliness. One tends to dismiss doomsday prophecy out-of-hand, without considering the merits of the particular prophet. Experience leads one to believe that such consideration is very likely to be a waste of time, that is,

returns value lower than one's opportunity cost. Similarly, very imaginative but incomplete views of alternative life styles tend to be regarded as "flights of fancy." Past consideration of such insights has tended to affirm such categorizations of dramatic restructuring of one's life style. Thus, while dramatic shifts in behavior are possible in this model and are, in fact, occasionally observed, the forces of information costs and previous experience tend to make such changes generally unlikely. In principle, the more regular one's experience, the less information processing ability one possesses, and the more risk aversion that one exhibits, the less likely one is to suddenly alter one's life style, other things of course being equal.

This is not to say that the smaller a change in behavior is, the more likely it is to occur. Very small modifications while less costly than large changes tend to have relatively minor benefits associated with them. To be worthwhile, a plan modification must yield an anticipated overall increase in one's consumption stream; that is, the increased consumption of the modified plan must more than offset the cost of performing the information acquisition associated with adopting the plan. Infinitesimal changes yield benefits which also tend to be infinitesimal, while the cost of evaluating the change is relatively small, it is

more than infinitesimal. Conceptually, the cost of considering two very similar modifications are also similar, to consider the value of relocating a piece of furniture one foot or one millionth of an inch involves essentially the same kinds of calculation and evaluation, but the anticipated benefits tend to differ--a movement of a millionth of an inch can hardly be noticed, yet that of an inch can at least potentially be found advantageous. In general, the costs of considering every possible minute change in plans would be astronomical and the benefits relatively minor. This suggests that plan revisions will tend to be <u>discrete</u> changes rather than a process of continuous or infinitesimal adjustment. Information processing costs imply that an individual's sequence of decisions will be discontinuous, but will exhibit some general continuity, the adjustments tend to be small but finite.

Individuals will make plan revisions through time as information is acquired. These choices will have determinate and "continuous" components but will <u>not</u> in general be determinate or continuous. Decision making is an adaptive-plan-revising process, influenced greatly by the uncertain and costly nature of information processing. It is, in a sense, a process of adapting to changing circumstances, but the circumstances that change are one's informational images of the possible, a joint consequence of

discovery, analysis and imagination. The implementation of each successive plan is an experiment to test a hypothesis about the best way to achieve one's ends, and plan refinement is the consequence of "experimental evidence" obtained in the course of time.[3]

Economic Implications

The model of intertemporal decision making developed here is a model of adjustment and plan revision, in contrast to the usual models of intertemporal choice, which is a process of determining a single rigid plan of action which will be implemented without revision as time passes.[4] The

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[3]For the purposes of description, one can summarize this model mathematically as a general Markov process. The plan of action one chooses at time t depends upon the information that one possesses at that time and one's goals, $A_t^i = g_i(I_t)$. If the external world is deterministic, then each action by an individual yields a single result which is jointly determined by the actions of other individuals and the physical state of the world, $O_t = o_t(A_t)$. The information that one obtains from this outcome depends upon the resources devoted to data collection and information processing embodied in the plan and the actual insights of the moment (C_t), $I_{t+1} = i(A_t, O_t, I_t, C_t)$. Since A_t is is determined by I_t given one's goals and since O_t is determined by A_t given the state of the world, a composite function can be found such that $I_{t+1} = i^*(I_t, C_t)$. The random character of C_t makes the series I_t a Markov process. The mathematical properties of such functions, while not of particular interest here, may be found in: A. T. Bharucha-R Reid, Elements of the Theory of Markov Processes and Their Applications (New York: McGraw-Hill, 1960).

[4]Nearly all models of intertemporal choice rely upon such a construction, for a sophisticated example, see: R. Radner, "Competitive Equilibrium Under Uncertainty," Econometrica 36 (January 1968):31-58.

general economic implications of a model which includes consideration of the role of information in choice also differs from those obtained in models which ignore the informational and/or costly aspects of decision making.[5] In this section of Chapter Five, these general implications are discussed and contrasted with those of orthodox models. As has been the case throughout this dissertation, the discussion will be limited to a few fundamental areas of importance rather than attempting to provide an exhaustive catalogue of the implications of costly information acquisition.

Because the analysis of this dissertation has been directed toward developing a model of individual decision making and not a model of individual interdependence and interaction, the economic consequences that follow directly from the model are individual choice consequences rather than market consequences per se. While this model does have market consequences, these consequences are largely beyond the scope of this dissertation, and will be dealt with only briefly in the concluding chapter. Fortunately, this narrower scope does not eliminate the economic relevance of

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[5]There has emerged a "temporary equilibrium" literature which attempts to reconcile equilibrium and continuous decision making. This literature, while very sophisticated and insightful, also ignores the costs of information processing. For a survey of this literature, see: J. M. Grandmont, "Temporary General Equilibrium Theory," Econometrica, 45(3)(April 1977):535-572.

this model for economic analysis normally relies upon some specification of the individual choice problem as a basis for its analytical rigor and as a source of fundamental concepts. The reformulation of the choice problem offered here provides a new basis for analytical development and modifies many central economic concepts in both importance and applicability.

Positive Economic Consequences. There are two fundamental analytical implications of the model developed here which differ from orthodox models of intertemporal allocation. (1) Individuals will allocate resources to plan-revising activities. (2) As a consequence, plans will be revised through time in light of new information. These two results provide an explanation for much observed (but usually discounted) economic behavior and strike at the conceptual roots of equilibrium-oriented analysis. Because individuals alter their plans through time, equilibrium at the individual or market level is unlikely to exist in any meaningful sense. Change--not equilibrium--is the central feature of a model of individual adjustment. The existence of equilibrium plans is of interest only as these may be limiting cases toward which individual plans of action may eventually converge. As individuals revise their plans in light of new information, their behavior through time may appear to be inconsistent or poorly thought out, but rather

than being a result of irrationality or changing tastes, this behavior can be considered the quite rational outcome of economizing on information acquisition.

A definition of equilibrium suggested by Hayek[6] in 1937 indicates the contrast between models of equilibrium choice and the model developed here. It states that "actions of a person can be said to be in equilibrium in so far as they can be understood to be part of one plan." Individuals will be in equilibrium only if their plans are no longer being revised; thatis to say, only if all new information is foreseen and of value for implementing plans rather than catalyzing the formation of new plans. Equilibrium models cannot explicitly consider the use of information as a catalyst for plan revision. An equilibrium plan is inherently a rigid plan, a plan that will simply be enacted as time passes without further revision. A model of choice that includes consideration of the costs of planning thereby implies that in any reasonably complex setting plan revision will occur, and occur as a result of optimizing behavior. The selection of a rigid plan becomes a form of sub-optimizing

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[6] F. A. Hayek, "Economics and Knowledge," Economics, 4(1937):35-54. (reprinted in: Individualism and Economic Order (Chicago, Henry Regnary, 1948).

behavior in such circumstances.[7]

In a setting of costly information, individual behavior may often appear inconsistent: decisions may be changed abruptly, attempts to acquire data may appear to others as erratic behavior, newly acquired information may cause one to abandon basic methods of furthering one's goals, individuals may give up one life style for another. An overly hasty consideration of these "revealed" preferences may lead one to the conclusion that individual tastes are inconsistent or peculiar. In many cases, these conclusions are more accurately considered the direct results of economizing on information processing, given an individual's skill at its various modes. For example, one might observe an individual purchasing three different automobiles in three successive years and hastily reach the conclusion that because no ordinary economic considerations had changed (income, wealth, prices), this individual's tastes had either changed three times or he is indifferent among the three. While this is possible, the observed behavior is more likely to have an informational character. The individual may have discovered something about automobiles in each of the years

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[7]In principle, the usual economic formulation of the individual choice problem is little more than a perfectly rigid plan, i.e., engage in that course of action that maximizes some well defined function (utility, profit, vote, budget) in the currently known circumstances.

which changed his evaluation of them, or he may have discovered some other activity which affects the relative usefulness of various types of automobiles, or he may be collecting data about the characteristics of the three by driving each one a year so that he can determine their relative value. These explanations require neither erratic goals nor peculiar tastes; they only require that one examine the informational character of decision making and action.

While this aspect of revealed preference analysis has not been overlooked by economists, models of individual decision making have not been constructed to include these aspects of individual behavior. One can usually detect consistency in a superficially inconsistent series of actions by considering both the costliness of information and the informational nature of choice. A theorist who does so and revises his opinion about the consistency of some series of actions will appear to be "inconsistent," yet his actions consistently reflect his quest for correct opinion or truth. Extensive plan revisions require no modification of goals, but often such revisions may call for extensive changes in the method and direction used to further one's goals. The resulting behavior may strike observers as odd or inconsistent; not because the behavior itself is inconsistent, but because the observers have failed to consider the changing

informational circumstances which induces the person to revise his plans.

The underlying consistency of plan revisions is of importance for two reasons. (1) By including consideration of an individual's changing information one may be able to predict the plan revisions that are referred to as "taste changes" by the majority of economists and so be able better to predict economic behavior. (2) As an individual's experience stabilizes, his plan of action may tend to converge toward some equilibrium plan. The existence of advertisers, proselytizers, salesmen, and con men suggest that it is widely believed that one can, to some extent, predict changes in another's plan of action or "tastes" that can be and are induced by changes in their stock of information. Of greater interest here, however, is the possibility that individual plans of action may converge through time to some locally stable equilibrium plan.

The logic of plan convergence is straightforward. If individuals face circumstances in which their range of experience is not expanding, for whatever reason, their plan revisions will tend to converge to the next plan of action given that experience. As the data base for plan revision stabilizes, plan revision occurs as a result of

further consideration of information already possessed.[8] Further adaptation depends entirely upon the skills and efforts devoted to information processing and subsequent plan revision. The only possibility of "escaping" the determinate implications of the data is one's own imagination or skill at the indeterminate mode of information. The only possibility of discovering these same determinate implications is to devote resources toward that end. The wider is one's range of experience the less likely it is that an individual will, as the result of an insight, move "outside" his range of experience (other things being equal). As one adopts plans which are ex ante considered improvements, the remaining improvements tend to be smaller and smaller and converge to the best plan of action given one's experience. Individuals will not seek this "best" plan, instead they will seek the best plan which is worth developing. As individuals experiment with smaller and smaller plan revisions, the increased consumption benefits tend to get smaller and smaller. Thus, with rising costs of determining a plan improvement, individuals will rationally abstain from finding the "best" plan of action. As when using

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[8]Note that the condition of recurrent data is insufficient to guarantee the existence of informational equilibrium, contrary to the usual assertion of search theorists concerned with the existence of equilibrium. The possibility of information processing implies that information can be acquired without an increase in the data available for consideration.

a computerized search routine to discover the maximum of some complex function, it will rarely be desirable to strive for complete accuracy--often it will be impossible to realize such accuracy--and it will nearly always cost more than is worth troubling about.

Casual observation reveals many instances of individuals who approach such planning equilibria. Stable life styles are very common among "adults"; indeed stability is often used as a defining characteristic of "adultness," while the behavior of young individuals is often characterized as erratic. That many individuals become increasingly rigid with age is frequently remarked upon (particularly by the young and "young at heart"). The wider one's range of experience, the less likely an additional bit of data is to cause one to modify one's plan of action, and the less likely that an insight will occur that illuminates some alternative superior to those already considered. Individuals learn as time passes what actions or combination of actions best further their goals and quite rationally conceive plans which are less and less flexible.[9]

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[9]A study by Arnold A. Weinstein suggests that preferences become more transitive as age increases which tends to affirm the increasing stability of individual behavior as time passes. Arnold A. Weinstein, "Transitivity of Preference: A Comparison Among Age Groups," Journal of Political Economy 76 (March/April 1968):310.

The mere possibility of equilibrium does not imply that all individuals will eventually reach an equilibrium state. In any reasonably complex set of circumstances, the plan-revision-catalyzing influence of information remains rather than disappearing as it must at such equilibria. Circumstances often change in ways unanticipated and unplanned for. Important insights remain possible, if unlikely, as time passes. Some flexibility remains in every set of plans which must confront an unknown world. The completely rigid plans of an equilibrium world or model exist only as limiting cases in a world or model which includes consideration of the role of information in choice. Of greater interest than the existence of equilibrium is the stability of individual behavior through time. Consideration of the costly nature of information processing implies that while the behavior may at times appear inconsistent, there will be considerable stability to individual behavior, a stability which tends to increase over time.

Normative Economic Implications. Economists who have focused upon the economic aspects of information have, as a rule, been interested in drawing welfare conclusions. Is a state of the economy improved or worsened by some change in the distribution of information? The resultant hurry to answer "yes" or "no" has led to great confusion, both about the "yes" or "no" answer and about the proper meaning of

efficiency in a costly-information context. The standard Paretian efficiency norm applies to a collection of identifiable states and orders them; the Paretian efficient states being those states which cannot be "moved" from without injuring some individual. To apply this criterion to a model of intertemporal choice requires that one be able to identify all possible time series of the economy in complete detail, and then to order the states using another Pareto norm, Pareto superiority. In an economy which is complex, particularly the economy which includes the activities of the economic theorist attempting the analysis, it will not be possible to list all of the possible activities which may occur, nor will it be possible to order them. The information processing costs faced in such an endeavor are enormous, and the results are probably beyond the ability of any human analyst. One does know that the series of actions taken by individuals will be the best actions that they are aware of; no known gains from trade will go unrealized at any point in time. The series will not be the best physically possible, as it would be in circumstances of perfect information, but it would be the best that is worthwhile to consider given individual informational constraints. It would be informationally Pareto optimal if not Pareto efficient.

The imperfect and heterogenous distribution of information which exists in circumstances of costly information acquisition allows the possibility of improving the future path of an economy. In contrast to decisions made from the imaginary circumstances of costless information, in a setting of imperfect information, recommendations can be made which lead to an overall improvement of economic efficiency. It will be possible to suggest some action or change in circumstances that will be Pareto superior to what would have been without the recommended change. Ordinarily, economists who use this Pareto criterion rely upon some benchmark or reference point as a contrast to their proposal or simply as a basis to compare alternatives. It is establishing this benchmark which causes much of the great confusion found in the "new welfare economics."[10]

First, one cannot choose the benchmark of "perfect information"; in a model of costly information such information is properly regarded as infeasible. One reaches few surprising welfare conclusions if one contrasts a world without scarcity to one in which there is scarcity. A

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[10]This phrase is used by Stanley Reiter in his survey of the information literature presented at the 1976 meeting of the American Economic Association in Atlantic City, New Jersey titled "Information Incentive and Performance in the (New) Welfare Economics."

second alternative, one widely used, is the use of the initial state or status quo as the benchmark, where the initial state is considered to be the mental states of individuals, and/or the distribution of wealth that obtains at the "initial" point in time. Unfortunately, in a model which includes a role for time and information processing, the status quo is not a feasible state for a future time period. One cannot prevent time from passing, nor can one prevent the changes in individual mind states and resources that accompany time: learning and entropy continue unimpeded by the models of welfare theorists (and occasionally enhanced by them). The status quo will not generally be a feasible state for individuals or economies as time passes; so it cannot serve as a reasonable benchmark. One cannot call for a policy change or some other change in order to realize a result which is completely impossible; and a norm with no implied behavior pattern is perhaps better considered an exercise in aesthetics than ethics. While Pareto superiority is the conventional welfare criterion for comparing two states, it cannot be applied in the usual way to situations which include consideration of time and information acquisition. Attempts to do so can easily yield results which are confusing or misleading. A benchmark should, in order not to be misleading, be some alternative future instead of the present or some unrealizable ideal state.

The Wicksellian interpretation of Pareto superiority, as advocated by James Buchanan,[11] provides the analytical basis for the use of a benchmark. This interpretation states that if one can obtain unanimous agreement to move from one position to another, then this move is, ex ante, a Pareto superior move. In this context, some analytical reference point is used only to determine whether or not a consensus would exist for some move without having to resort to an explicit and costly agreement process. Genuine unanimous agreements between all affected parties are, after all, extremely rare, while moves which conceptually could be unanimously agreed to are somewhat less rare. When there is general agreement about the nature of the alternatives available and there is some readily available method of determining individual preferences among the altenatives, the opportunity cost of a move (the relevant benchmark) is easily determined and the results of a voting process can be reproduced without bearing the cost of actually holding the election. In such cases the analytical non-election approach yields results which are superior to the literal voting procedure conceptually mandated; the costs of holding the election are avoided, thereby reducing the costs of Pareto

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[11] J. Buchanan, "Positive Economics, Welfare Economics, and Political Economy," Journal of Law & Economics 2 (1959): 124:138.

superior moves and preserving resources for other uses.

However, when general agreement about the nature of the alternatives is at issue, and no readily accessible method of determining individual preferences among the alternatives is available, only an explicit voting process can assure accuracy. Appraising the opportunity cost of each individual in such circumstances is difficult if possible at all, and the policy conclusions reached by imagining another's circumstances and "determining" his best course of action are obviously suspect. If information acquisition is costly and the resulting distribution of information is heterogeneous, the ability of welfare theorists to specify policy improvements by purely analytical means will be very limited--unless some stronger policy norm than Pareto superiority is used, i.e., some form of ethical elitism. The images of the theorists will often differ from those whose actions will be affected by some offered policy change. The theorist would tend to economize on information by ignoring the "facts of the small" and those affected will tend to economize by ignoring the "facts of the large." The potential for disagreement is unambiguous and the likelihood of unanimous agreement is correspondingly small. Disagreement about the alternative to some policy and/or the likely consequences of enacting the policy can often lead to disagreement even though the goals of the individuals are

entirely compatible or even identical. A theorist might recommend the "solution" to some apparent "prisoner's dilemma"--i.e., the affected parties should cooperate; but those involved in the game may believe that their occasional large benefits from "off diagonal" wins more than compensates them for their uncooperative strategies. In fact, the continuing dilemma reveals the latter to be the case; were cooperation unanimously agreed to be a better strategy (including the costs of reaching and enforcing the cooperative agreement) it would be the prevailing behavior. In these circumstances, an imposed solution would not, in the absence of transfers, be an ex ante Pareto superior move or for this reason yield an increase in economic efficiency.

In a setting of costly information, the usual benchmark method of using the criterion of Pareto superiority becomes difficult, as parties differ on issues in ways which cannot be costlessly known or assumed away. There often will be no natural benchmark or clear perception of the opportunity cost of a particular course of action and thus no straightforward way of applying this criterion analytically. To be assured of unanimity in such cases, the unanimity must be genuinely obtained by some voting or agreement process. Unanimity, thus obtained, does not imply a general agreement about the nature of the policy or its alternative; it implies only that the policy is regarded superior to its alternative

as each is conceived by consenting individuals. The image used by each individual may be, of course, incorrect and the resulting move can be incorrectly approved or rejected; but given the current distribution of information and the goals of individuals, it is the only way of assuring that a move is ex ante Pareto superior in circumstances of imperfect information.

The absence of agreement does not necessarily rule out the possibility that a proposal is a Pareto improvement. It means that the proposal is not perceived to be one and individuals may be incorrectly perceiving the costs and benefits of the recommended change. In principle, what matters in circumstances of imperfect information is ex post agreement rather than ex ante agreement; for ex post agreement affirms the previously imagined desirability of some course of action. "Facts" acquired during the execution of some plan often influence one's evaluation of the plan as one "learns from past mistakes." Ex ante agreement in circumstances of perfect information implies ex post agreement, but ex ange agreement in circumstances of imperfect and costly information only increases the likelihood of ex post agreement. It does not guarantee it, but it is the best that can be reliably done before the act to ensure agreement after the fact.

In the absence of agreement, a "reformer" can do

three things. (1) He can change his proposal in light of information obtained since his suggestion was made. (2) He can provide low cost highly refined data (engage in rhetoric) to those affected to change their evaluation of his suggestion or that of its alternative. (3) He can rely upon coercion to force the change in the paternalistic hope that those affected will afterwards unanimously agree to policy enacted. Success at any of these three actions will tend to increase economic efficiency in the Paretian sense. The first two yield ex ante agreement with no great likelihood of reducing efficiency. The third, if successful, yields ex post agreement, although the informational problems of detecting such moves makes the risk of decreasing overall welfare relatively large. The risk associated with the coercive course of action makes it, in this author's opinion, the least desirable of the three in any but the simplest cases (for example, pushing some well-liked individual out of the way of a speeding automobile in order to avoid his imminent injury).

A Pareto superior move can only be realized by changing the currently prevailing perception of possibilities. All currently known advantageous moves will be exploited by individuals pursuing their goals in the best way that they are aware of. A Pareto improvement in circumstances is the result of some change in individual

perceptions of their alternatives; it is possible only because individuals can alter their plans of action in the face of new information. The designs of individuals are more closely related to furthering their own goals than in determining whether or not some move is Pareto superior or not. While this does increase the difficulty of applying the criterion and raises a perhaps inescapable dilemma[12] it does not make it impossible. Imperfect information makes the Paretian criterion more difficult to use but it also allows the possibility of efficient moves; moves which are ruled out in circumstances of perfect information. While the abstract analytical application of Paretian criteria do provide useful insights and are an excellent rhetorical device, such applications in circumstances of imperfect information do not adequately demonstrate the true Paretian nature of a move. Welfare losses detected in this way must,

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[12]The true dilemma of imperfect information may be that individuals will fail to adequately consider some suggestion for reaching "utopia" which is actually effective. Past experience at considering alternative utopian prospects may have convinced them that such efforts are invariably a waste of time. As individual reformers tend to realize this, they may, instead of relying upon persuasion, rely upon coercion. Whether their action is correctly perceived or is the result of poor analysis, the resulting reciprocal response of force by those coerced seems likely to damage each without furthering either--an informationally sub-optimal state. The combined problems of well-meaning coercers and resisters and the difficulty of testing utopian plans given their expected payoffs seem to be the true social dilemmas.

at best, be considered untested hypotheses about the world; at worst they may be considered subtle "con games" or rhetorical devices to convince individuals (or those with the power to act) to move in directions favored by the rhetorician. As such, they must be explicitly tested, and tested in a manner that, if successful, eliminates the hypothesized problem.

Chapter Six

CONCLUSION: TOWARD A NEW PARADIGM

Summary

This dissertation has developed an analytical framework for the examination of choice in settings of costly information. It has been argued that because information plays a central role in choice, the consequences of costly information are far reaching and of fundamental importance for economic analysis. The framework developed in this dissertation can be viewed as a synthesis of several heretofore independent lines of analysis: economic development, the theory of entrepreneurship, adaptive expectations, the economics of search, and temporary equilibrium theory. That it may be so considered is evidence of the generality of the theory developed here. The framework itself is both a basic extension of the optimization paradigm and a first step towards a new economic paradigm.

This dissertation establishes several important points at a very general level. (1) It is argued that one's information affects both one's perception of one's opportunities and one's perception of their relative value. (2) Because one is constantly processing and economizing

upon information processing, as time passes, information will be acquired which will cause plan modifications. Individuals in a setting of costly information will rationally opt for flexible rather than rigid plans. (3) The consequence of including the possibility of multiple decision making and the role of information in plan modification is that equilibrium as usually conceived will not exist (so long as information "matters"). Information will, in such circumstances, cause individuals to modify their plans through time. A factor is included within the model that causes individuals to change their behavior in ways not consistent with a single plan of action, precluding the existence of equilibrium as usually conceived. (4) Plan revisions will not involve infinitesimally small modifications, but instead will be discrete "jumps" or adjustments, limited by the imagination, experience and tastes of the individual. (5) As an individual's experience stabilizes (ceases to provide important unforeseen events), an individual may approach a stable locally optimal plan of action or life style. As an individual approaches a stable life style, the non-consumption uses of new information become less and less important, and the creative leap necessary for plan revision becomes larger and less likely. This explains the observed increase in the stability of individual life styles as individuals pass through time.

Throughout this dissertation the importance of information processing costs has been emphasized and accorded a central role in establishing the results listed above. It has been argued that economists have, by neglecting informative processing and concentrating upon the costs of data acquisition, improperly modeled the role of information in economic allocation, that they have to some extent misrepresented the problem, and that they have to a large extent accorded information less than its true importance. The role of information in choice is central to the decision process. It can be ignored or neglected but the effects of limited information will be felt and observed even without direct consideration. Indeed the lack of consideration given to information processing can best be understood as an effort by economists to economize upon their own information processing.

While this is perfectly rational behavior and predicted by the model developed in this dissertation, it seems likely that an informational failure of sorts exists here. The purpose of this dissertation is perhaps best understood as an effort to rectify this perceived informational suboptimality.

Perspective on Economic Process

The model developed in this dissertation provides a micro-economic foundation for a dynamic theory of economic process. The fundamental "unit" of static economic theory is the individual equilibrium--the fundamental unit offered here is the process of individual adjustment. It is this fundamental unit from which a dynamic theory of economic process can be constructed.

Viewed in light of the model of individual plan revision developed in this dissertation, an economy is seen as an experimental laboratory. The testing in this laboratory is done by individuals, who either learn by themselves or who try to assist the learning process of others. Experimental success occurs to the individual when his hypothesized "best" plan of action yields results compatible with this hypothesis. Experimental success occurs to the observer-reformer when a hypothesized informational suboptimality is corrected, when individual plans are revised. The work of Isreal Kirzner and Joseph Schumpeter[1] on the theory of entrepreneurship and economic development approach this view of the economy very closely, although the range of

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[1] I. M. Kirzner, Competition and Entrepreneurship (Chicago: University of Chicago Press, 1973); J. A. Schumpeter, The Theory of Economic Development (translated by Ledvers Opie)(London: Oxford University Press, 1934 (1961)).

"experiments" considered by them is somewhat narrower than the range suggested by this framework.

Prices in this view of economic process are not externally imposed. They are, rather, aspects of individual plans. Nor are prices the overworked "informational source" of many other models. Current prices are considered to be an aspect of "yesterday's plans." The information they provide about one's future opportunities is useful to the extent that individual plans (pricing stragegies) have not been changed. In this sense "current" prices are likely to provide better information than old prices, because fewer plans are likely to have been altered during the interim. However, in many circumstances the price of a good may be a small part of its cost to the individual; many other factors affect an individual's selection of a plan of action. In an environment of on-going plan revision, prices themselves may appear to be moving unsystematically if one ignores information. However, when information is included in one's analysis, it is perfect price stability which would cause the theoretical dilemma.

The time path of an economy with individuals who engage in constant plan revision will not in general be perfectly predictable or perfectly smooth because the behavior of individuals will not be perfectly predictable or continuous. The constantly changing coefficients of

of macro-economic models seems better explained by the process of plan revision than the alternative "changes in economic climate." It is a bit perplexing that little empirical work has been done attempting to link parameter changes with informational changes; although this is less surprising when one considers the equilibrium underpinnings of most empirical work, which appear to perform satisfactorily save for the unexplained changes through time of model parameters.

There remains much work to be done in this area. The framework developed in this dissertation has been general and abstract so that the topic could be reduced to a manageable scale, but a more concrete, less general model of information acquisition and plan modification is clearly on the agenda. On the agenda as well is the expansion of this model of individual choice, which yields a dynamic systems approach to economic process. The task here has been to prepare this agenda, to establish foundations for such future analysis.

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VITA

Roger D. Congleton was born on November 13, 1951 in Newton, New Jersey, the first child of James and Dorothy Congleton. He attended grammar school at Andover Regional School and high school at Newton High School. After graduating from high school in June of 1970, he attended Virginia Polytechnic Institute and State University where he received a B.A. in economics in 1974, a Master of Arts in economics in 1977, and, with the completion of this dissertation, a Ph.D. in economics in 1978. Upon completing the requirements for a Ph.D. he became Adjunct Assistant Professor of Economics at Albion College in Albion, Michigan.

THE ROLE OF INFORMATION IN CHOICE

Toward an Economic Theory of Knowledge and Decision Making

by

Roger Douglas Congleton

(ABSTRACT)

This dissertation develops an analytical framework for the examination of choice in settings of costly information. Throughout the dissertation the importance of information processing costs are emphasized and used as a basis for establishing several points at a very general level. The framework developed in this dissertation can be viewed as a synthesis of several heretofore independent lines of analysis: economic development, the theory of entrepreneurship, adaptive expectations, the economies of search, and temporary equilibrium theory. The framework itself is a basic extension of the optimizing paradime to include the costs of collecting data and information processing. The consequences of this extension contrast in many ways with conventional applications of the paradime.

In the framework developed, information is distinguished from data. Information is defined to be images within an individual's mind, and data is defined to be external, potential sources of information. Information is

assumed to be costly and to be able to affect an individual's perception of his opportunities and their relative value (which are themselves information at the moment of decision). The process of decision-making is characterized as an exercise in information processing which is itself costly. Given this specification of the individual choice problem, it is argued that individuals will choose flexible plans, plans which an individual anticipates modifying, rather than rigid plans. Given the existence of reasonably complex circumstances, it is argued that information will be acquired by individuals that causes them to revise their plans. It is argued that a model which includes such information can not be an equilibrium model in the usual sense in any reasonably complex circumstances.