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INSTITUTIONS AND COMMON PROPERTY EXTERNALITIES:
THE ASSURANCE PROBLEM IN ECONOMIC DEVELOPMENT

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**A thesis submitted to the Graduate School of the University of Wisconsin-Madison in partial fulfillment of the requirements for the degree of Doctor of Philosophy**

**by**

Carlisle Ford Runge

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# INSTITUTIONS AND COMMON PROPERTY EXTERNALITIES: THE ASSURANCE PROBLEM IN ECONOMIC DEVELOPMENT

by

Carlisle Ford Runge

A thesis submitted in partial fulfillment of the requirements for the degree of

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1981

To my parents

and

Susan

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## A NOTE ON NOTATION

Mathematic notation used in this study is numbered within each chapter. For example, Chapter I contains equations and inequalities numbered (1) to (14). Wherever possible, notation has been kept consistent with that of original sources.

CFR

Looking back over his life, any man will admit that his well being has depended not only on the actual quantities of goods and services consumed and rendered, but also on his anticipations, at any time, of what he believed he would consume and render in the future -- and not on his anticipations alone, but also on the confidence with which they were held.

J. de V. Graaff
Theoretical Welfare Economics

# PREFACE

Economic affairs proceed on the assumption there will not be revolution in the morning. The problems of economic development are not only scarcity of resources, insufficiency of income, or inferiority of housing, education and health care. A major difficulty is uncertainty over all these things, the result of institutions which fail to provide the security of expectation upon which development must proceed.

Economic development efforts concentrate on quantitative targets without sufficient attention to the qualitative institutional foundation upon which these attributes of economic development depend. Nations in the early states of economic development, especially where technology and institutions are introduced from outside via colonial influence or development aid, find that a sense of uncertainty or lack of assurance respecting the institutional structure leads to failure in the pursuit of more quantitative development goals.

Recent experience suggests that a variety of institutional issues may dominate the ability of policy-makers to promote development in terms of emphasis on economic growth. Western technical development assistance has promoted economic growth at the same time it

has undermined traditional institutions. Although generally considered "constraints" to economic development, these institutions will not be pushed aside. Sometimes, as suggested by the recent experience of the United States in Iran, traditional institutions reassert their primacy in a surprisingly short time. Not only in the Moslem world but in the Far East, Asia, Latin America and Africa, traditional institutions often are at odds with many approaches of Western economic development experts. A failure to recognize the power of these traditional institutional structures can lead to crisis and dislocation. The result may be nearly wholesale rejection of modern technology, and resulting losses in levels of production. This experience suggests that technical gains cannot be achieved and sustained without careful attention to institutions and their role as the basic framework within which economic and technical progress must be won.

The focus of this study is the role of institutions in economic development. "Institutions" are defined as a public system of rules. These rules specify certain forms of action as permissible, others as forbidden. They provide for certain penalties and defenses, and the like, when violations occur. An institution may be thought of in two ways (Rawls, p. 55). The first is an

abstract object, as a possible form of conduct expressed by a system of rules. The second is as the actual realization in the thought and conduct of certain persons of the actions specified by these rules.

Operationally, institutions guide the behavior of people with respect to each other, and to their own and others' belongings, possessions, and property. As Dorner notes, institutions may serve as aids or obstacles to development. Either way, they provide "the unifying bonds which hold a society together, give it a unique character, and assure a degree of security with respect to the accepted procedures of human interaction and response" (Dorner, 1974, p. 1). In this way, institutions play a crucial role in setting expectations, and hence in conferring expected value to the stream of future benefits associated with economic activity. By defining rights and privileges, responsibilities and obligations, and the exposure of individuals to the rights and responsibilities of others, institutions set parameters on people's expectations of the future (Commons, 1924).

These parameters result from a set of rules which provide an environment of increased certainty regarding the likely actions of others. Institutional rules act to reduce uncertainty in the realm of human interaction,

making possible greater cooperation and coordinated action. This increased coordination may be crucial to confronting other forms of uncertainty in the economic or physical environment, especially where subsistence agriculture faces the vagaries of wind, weather, and water availability. Institutions confront these vagaries like a group "tool" which, as in the technical innovation of a hoe or plow, extends the attainable set of possible solutions to problems of production and allocation. The distinction between technical innovations, such as a hoe, and institutional innovations, such as a system of revolving credit, is often overlooked. Technical innovations are nearly always compatible with individual incentives for increased production. Institutional innovations, by contrast, depend for their existence on cooperative rules which are compatible with the incentives of the group. They are wielded by the group as a whole.

The crucial relationship between institutions and expectations is also easily overlooked. By setting the "rules of the game," institutions provide <u>assurance</u> respecting the actions of others, and give order and stability to expectations in the complex and uncertain world of economic relations. By parameterizing individual expectations, they provide a comparative measure of

stability, order and security respecting the future. These are matters of considerable importance to market economies, and may even be argued as a sine qua non in economic development.

Institutional rules may be imposed from outside the group, or may emerge as endogenous responses to uncertainty inside the group or society which adopts them. The importance of this distinction will be a major theme of this study. Solutions imposed from outside have certain disadvantages compared with those evolved by the group to suit its own needs. Although the main focus of this study is on situations in which institutions have failed to provide a requisite level of security of expectation, it is also true that institutions may parameterize expectations to such a degree that they stifle creativity and invention. Too much assurance is as possible as too little. This is especially true in cases where institutional rules are imposed from outside the group. Thus, depending on their relationship to other dynamic elements in society, such as technology, institutions may act as obstacles to change or may permit change by altering people's views of the likely consequences of certain actions.

The purpose of this study is to render, much more precisely than has been the case, a formal theory of

institutions in certain problems of economic development. Orthodox economic theory has had little to say on institutional matters. A loosely defined group of institutional economists, acting as a sort of academic fifth column, has attempted to deal with many of these issues but has tended to eschew formal methods. These efforts do not provide a rigorous treatment, capable of close evaluation for logical consistency.

The following study attempts the beginnings of such a treatment. This is not to suggest that the theory will be constructed entirely in mathematical terms, which alone are insufficient for the purpose. The approach employed does, however, have mathematical foundations derived from the theory of games and collective economic behavior under uncertainty. Since the problems addressed are in the main qualitative ones, formal characterizations do no more than provide a framework for analysis. Often, these characterizations must give way to what is, hopefully, clarity of language. The thesis may be expressed in terms of six major claims.

(1) Expectations of others' actions may be well-ordered.

(2) Institutions, as a public system of rules, order expectations, providing assurance respecting the actions of others.

(3) The particular ordering of expectations is an adaptive response to the resource environment and past history of the group which innovates them.

(4) Different environments and histories imply different orderings of expectations.

(5) Where one ordering is imposed on another, a lack of congruence between the orderings can reduce the overall level of assurance, and create disorder in the expectations of a particular group.

(6) This disorder is to some extent a necessary part of change. But too much disorder can lead to economic failure.

This study is part of a recrudescence of institutional economics. Recent work by Andrew Schotter (1980) and E.A. Thompson and Roger Faith (1981) suggest growing interest inside economics in the theory of games applied to institutions. In the literature on economic development, public choice theory has also recently been applied in an attempt to come to terms with important institutional issues (Russell and Nicholson, 1981). Although the focus here is on problems of grazing representative of larger issues of externalities and public goods pro-

vision, the applicability of the theory is somewhat general. The study may be understood as a general theory of institutions and institutional change, set out in terms of some rather specific issues and problems. Depending on the problem, the specific conclusions reached may be modified. The overall conclusions, however, I believe are applicable to a wide range of institutional issues .

The institutions with which I am primarily concerned are property institutions, both because of their importance to any developing ecnomy, and because they have tended historically to command the attention of writers on institutional rules. Consistent with the definition above, "property institutions" are a public system of rules specifying permissible and forbidden actions in relation to ownership, use-rights, responsibilities and obligations of individuals and groups pertaining to any tangible thing owned, notably land (Bromley, 1978).

Land is an example of a special type of productive asset. It provides a stream of benefits and costs falling in varying degrees on those in a position to decide on its use. At any point in time, property institutions order expectations over the incidence of benefits and costs which will flow from a particular

piece of land. "Land-use" is a direct function of the structure of property institutions channelling the stream of expected costs and benefits.

A number of other terms used in this study require definition. "Private property" is defined as the individual right to exclude others from using the thing owned (MacPherson, 1973, p. 123; Demsetz, 1967). "Common property," in contrast, is defined as the bundle of joint use-rights held by individual members of a well-defined group respecting the thing owned. Common property is created by the guarantee to each that he or she will not be excluded from the use or benefit of something. Both private and common property are guarantees to individual persons, and are therefore individual rights. Hence, it does not follow that enforceable individual claims to property are logically confined to private property (MacPherson, 1973, p. 124).

Another term, often confused with common property ownership, is "open access" (Ciriacy-Wantrup and Bishop). In contrast with common property, open access is defined as the absence of individual use-rights, and/or the absence of a well-defined group with use-rights respecting the thing owned.

Related terms appearing in the economics literature are "public goods" and the "free rider hypothesis."

Public goods (also called "collective goods") are characterized by jointness of supply. They are consumed within a well-defined group, such that within the group, exclusion of individual use or consumption is not possible. A cooperative consumption decision inside the group is therefore necessary to provide the good efficiently (Meuller, p. 13; Musgrave, pp. 9-12, 86; Head). The free rider hypothesis has been defined in both "weak" and "strong" versions (Brubaker, 1975). The weak version states that the voluntary provision of public goods by groups will be suboptimal; the strong version argues that no public goods will be provided through voluntary means.

Finally, the term "assurance" requires definition. Although its basis is the "assurance problem" (Sen, 1967), the term is also used more generally. Assurance is defined as the absence of uncertainty (i.e., certainty) respecting the actions of other members of a well-defined group. It is equivalent to security of expectation regarding these actions. Assurance may be total, or partial, depending on the degree of uncertainty associated with these actions. Uncertainty is assumed to include risk.

This study will develop a formal theory of property institutions designed to complement traditional micro-economic analysis, notably the theory of externalities and public goods. Yet in order to gain a proper perspective, certain assumptions in orthodox microeconomic theory, resulting from its individualistic antecedents, must be relaxed. Specifically, the notion of strictly independent choice must be removed from the behavioral postulate that man is a rational utility maximizer. By allowing for choice interdependence, it is shown that cooperative collective action in the form of institutional rules emerges as a solution to market failures and problems of public goods provision. The result is to extend the attainable set of solutions to problems of economic allocation, particularly when externalities are present due to the interdependent actions of economic agents. Property institutions are the rules of the game which make this collective behavior possible, and are argued to be adaptive response mechanisms which may take many forms designed to reduce uncertainty and provide greater security of expectation.

The theory of property institutions in economic development is applied to several major issues. These issues involve the impact of economic agents on one

another in the form of externalities. The focus is on problems of overgrazing and water depletion of range lands. In areas faced with such problems (notably Southern Africa and the Sahel), the combined forces of population growth and economic development are imposing pressure on scarce resources which may result in substantial negative welfare effects, and even undermine the process of development itself. The application of institutional analysis to these issues yields different policy prescriptions than those associated with current economic theory and practice, suggesting that the inclusion of these institutional considerations in economic theory is crucial to modeling problems of public choice in economic development.

Chapter I provides the elements of a theory of institutions in economic development. Beginning with the "tragedy of the commons" (G.Hardin, 1968), it argues that current approaches to common property externalities are in error. Treating common property as a "prisoners' dilemma" fails to capture the interdependent nature of individual choice. The "property rights paradigm," by assuming the independence of choice, misses the essence of the problem: uncertainty over others' actions.

Institutions which reduce this uncertainty can coordinate individual choice and solve the problem of externalities for the group. The "assurance problem" demonstrates that these institutions are not restricted to private property, and may include a variety of common property arrangements.

Chapter II takes up a number of technical issues in the game theory literature, demonstrating the futility of extensions in the prisoners' dilemma game. These extensions, termed "prisoners' dilemma supergames" because of the repetition of single games over time, are shown to be inadequate as models of individual interdependence.

In Chapter III, the assurance problem is taken up in detail. A decision theory framework is developed which demonstrates that voluntary contributions to solve externalities and public goods problems are consistent with rational, self-interested utility maximization. Institutional rules affect the decision whether to contribute voluntarily, by increasing the accuracy of prediction regarding the likely contributions of others. They provide prior information to Bayesian decision makers. Institutions are also subject to

change and degradation over time. A definition of institutional equilibrium is advanced, and a definition of the transactions costs of maintaining it. Finally, a simple model is developed which shows how institutional rules may dictate compliance through reputation inside the group, without outside enforcement, if the utility function of the individual is dependent on institutions and vice versa.

Chapter IV takes up the general issue of strategic compliance with institutional rules, demonstrating the theoretical weakness of the "strong" free rider hypothesis. Experimental results supporting the "weak" free rider hypothesis are adduced and explained inside the structure of the assurance problem, highlighting the function of institutions in setting expectations regarding the actions of others.

Chapter V considers the impact of these findings on current theories of public choice. It argues that Arrow's Theorem is restricted by the assumption of independent choice, which leads to the same need for imposed rules as in the prisoners' dilemma. The history of the idea of rational independent choice is

traced to Hobbes, and its relation to private property to Locke. This tradition is contrasted with collectivist explanations. A concept of "collective individualism" is proposed consistent with the broadened definition of rationality resulting from the assurance problem.

Chapter VI concludes the study by drawing together the implications of the assurance problem for economic development. These include a defense of local-level and informal rules as the foundation of development efforts, the minimization of "top-down" enforcement on the grounds of costs, and the importance of free flows of information. Institutions must be adapted to the resource base. The key role of endogenous institutions as responses to uncertainty is contrasted with the earlier work of Schultz. The "supply and demand for income streams" (Schultz, 1964) is given a new interpretation, in which transitory income is a critical determinant of agricultural decisionmaking. Technological and instutitional responses to uncertainty are discussed in this light, leading to insights into "dual economies."

Finally, a brief case study is presented of pastoral grazing and development policy in Botswana. The assurance problem and its lessons for development are employed as analytic tools to describe the problems

and prospects of institutional change in the African grazing context.

In summary, the study examines the theoretical implications of interdependent choice for institutional problems in economic development, and the prescriptions for appropriate property institutions which result. The main result is the existence and stability of a much wider array of institutional responses to problems of public choice. Property institutions can take on numerous forms besides private, exclusive use-rights, and still solve the problem of negative external effects. Indeed, alternative institutions predicated on principles of cooperation are often more appropriate to the limited resources available, and may be more successful in promoting development than previously supposed by economists and planners.

# CHAPTER I

# IS THE COMMONS A TRAGEDY? EXTERNALITIES, GAME THEORY, AND PROPERTY INSTITUTIONS

## 1. Introduction

The purpose of this chapter is to provide a theory of institutions in economic development. The point of departure is a class of problems known to economists as common property externalities, in which the actions of one agent result in external effects imposed on other agents (Mishan). The classic example is the "tragedy of the commons" (G. Hardin, 1968), in which overgrazing results from the independent decisions of agents who do not consider that what is good for each of them individually is a "tragedy" for the group or society as a whole. This analytic structure has been used to describe problems of overgrazing, free rider behavior resulting in a wide range of problems of resource overexploitation, as well as problems of public goods generally.

I will argue that the analytic structure of the tragedy of the commons is mistaken -- that by failing to account for the interdependence of decisions made by economic actors, it leads to a misdiagnosis of problems

of resource overexploitation. The tools which allow this misdiagnosis to be clearly shown are drawn from the theory of games and economic behavior. It is shown that the non-cooperative structure of the tragedy of the commons leaves no room for cooperative solutions, since it assumes that each actor in the system is an independent agent. Properly formulated as an N-person cooperative "assurance game" or "coordination problem," the commons is not inevitably a tragedy. Whether resource overexploitation occurs depends on the nature of rules binding each individual's range of choice. These rules (or more generally, institutions) provide a mechanism of self-imposed social control which can prevent resource overexploitation.

In the variety of rules, norms, or conventions defined as institutions, the most prominent in matters of resource exploitation are property rules. For this reason, the analysis of this first chapter focuses on varieties of property institutions. Many adherents of the conventional analytics of the tragedy of the commons assert the superiority of private property institutions, arguing that common property will always lead to overexploitation. The position defended here is that by misdiagnosing the problem as a non-cooperative outcome of independent actors, many advocates of private

property rules have failed to recognize the wide range of institutional alternatives available to those who seek solutions to problems of externalities. One such solution may be common property.

## 2. The Problem of Common Property Externalities

Externalities in production or consumption lead to non-optimal market allocations. The literature is filled with examples of "market failure" arising from the divergence, due to externalities, of private from social cost (Bator, Coase, 1960, Meade, Buchanan & Stubblebine). The "tragedy of the commons" (G. Hardin, 1968) arising from grazing too many cattle on too little land has been widely noted as an important case of externality. The private benefits of grazing an additional head of cattle on a common range exceed the private costs. Since part of the cost is incurred by the entire group, individuals do not bear own costs. Individuals are given false signals, and resource overexploitation results.

This example of a common property externality is only one of a large number of structurally similar problems. These include overexploitation of common fishing grounds, extraction of oil and natural gas from

a common underground reservoir, hunting or trapping on common ground, deforestation of common lands for fuel-wood, drawing water from underground sources, and in some cases pollution problems of common air and water resources (Dasgupta & Heal).

Scholars from many disciplines have struggled to find appropriate analytic and technical tools to model these important problems, which, as shown in later chapters, have proved deeply disturbing to the notion of rational collective choice (Edney). Among the more promising avenues of investigation is the theory of games. Before treating these issues in game theoretic terms, however, it is important to lay out the prevalent approach to common property externalities, which argues that common property will always result in tragic over exploitation of resources.

## 3. The Property Rights Paradigm

Many economists argue that the proper prescription for overgrazing of common range is to internalize it by making the public aspects of the range private. The result of instituting a scheme of private rights, if they are properly enforced, is to create a market in the private rights to graze.

This approach led Demsetz (1967), among others to argue that the mere existence of common property rights over a scarce resource will always lead to a tragedy of the commons, due to a failure to internalize the social costs of grazing the last head of cattle (Cheung, Alchian & Demsetz, Coase, 1960, Furubotn & Pejovich, Gordon , Bottomley). The appropriate solution is argued to be the enforcement of private exclusive use-rights to the resource, so that the internalized cost to each user is equal to the benefit, in total and at the margin. The origins of this claim in the economics literature may be traced to Gordon's (1954) assertion with respect to common fishing grounds that common property is really no one's property. Since use-rights are attenuated, they cannot be assigned, defined, or transferable (Johnson). Individuals cannot be excluded from use of the common. Hence common property is treated as synonymous with open access to the resource. This is alleged as the cause of over-exploitation of grazing lands, fisheries, hunting grounds, forests, indeed nearly any commonly controlled resource. This is referred to as the property rights paradigm or private property rights school. It has spawned a large literature devoted to proving the comparative efficiency of privately owned resources.

De Alessi (1980) provides a summary of these claims, including recent applications in areas ranging from oyster fisheries (Agnello and Donnelley) to garbage collection (Bennett and Johnson). Garrett Hardin's contributions to the political science literature have supported and amplified the views of the private property rights school. In the Hobbesian tradition, tragedy may be overcome only through coercive enforcement of use-rights, preferably private ones. The conclusion of both these lines of analysis is that common rights, defined as open access to resources, weaken the incentives to conserve them (De Alessi, p. 40). This approach is currently reflected in policies by U.S. Interior Secretary Watt to put public lands in private hands.

To defenders of this view, the importance of exclusive private property institutions is argued to be so significant that without them, economic development cannot proceed. The most sweeping assertion of this position is the historical argument by Douglass North and colleagues (North, 1966; North & Thomas, 1970, 1971, 1973, 1977). They argue as an historical matter that the existence of common property institutions, due to their non-exclusive or "public good" character, forestalled the coming of the Neolithic Revolution in

agriculture some 8000 years ago. The rise of agriculture depended on private, exclusive property rights. This institution provided incentives sufficient to encourage the development of cultivation and domestication (North & Thomas, 1977, p. 230). North and Thomas argue that:

> When common property rights over resources exist, there is little incentive for the acquisition of superior technology and learning. In contrast, exclusive property rights which reward the owners provide a direct incentive to improve efficiency and productivity, or, in more fundamental terms, to acquire more knowledge and new techniques. It is this change in incentive that explains the rapid progress made by mankind in the last 10,000 years in contrast to his slow development as a primitive hunter/gatherer (1977, p. 241).

The same argument is also made by adherents of this paradigm in connection with common property in developing countries. In a recent article, Ault and Rutman (1979) argue that the development of private property rights is a necessary condition for the efficient use of land and water resources in tribal Africa. Echoing the analysis of Demsetz, North, and other members of this school, these authors state that without private, exclusive use-rights, free rider behavior will inevitably lead to a tragedy where common property is concerned. Ault and Rutman describe the problem in the following terms:

> Each African livestock owner holds a non-exclusive right to the use of the communities grazing land. He cannot exclude other livestock owners by charging a price equal to the cost of using the land. If the individual African were to sell or limit the size of his herd in order to improve its quality by decreasing the livestock-to-land ratio, there is no guarantee that his neighbors will not increase the size of their herds (an example of the "free-rider" problem). Given that he cannot capture the benefits, the African livestock owner will not attempt to improve the quality of the grazing land by planting the pasture with a more highly productive species of forage. The individual has little incentive to invest his wealth in this way because his neighbors share the benefits but bear none of the costs (p. 166).

The analytic structure of this argument, like the historical claims of North and Thomas, is that common property fails to provide individual incentives to contribute to the collective good, in this case the quality of the common range. This is the same structure as in Garrett Hardin's analysis of the tragedy of common property. As he argued in his original article on the tragedy of the commons:

> The rational herdsman concludes that the only course for him to pursue is to add another animal to his herd. And another. . . . But this is the conclusion reached by each and every rational herdsman sharing the commons. Therein is the tragedy. Each man is

> locked into a system that compels him to increase his herd without limit--in a world which is limited (Hardin and Baden, p. 20).

The key features of this analytic structure often go unnoticed. They are, first, individual maximizing behavior in which each individual chooses to graze an additional head of cattle independent of the actions of others. Curiously, it is this independence which "locks them in" to the tragedy, since each person pursues his own interests regardless of the actions of others. The second, implicit feature is that collective attempts to formulate cooperative strategies will fail due to the incentive by each independent agent to free ride. As a result, a need for enforcement exists. The third feature is the inevitable outcome that all are made worse off.

Consistent with these features, the appropriate solution to the tragedy is argued to be the imposition of private, exclusive use-rights. Exactly how these use-rights are to be imposed is often unclear, but their imposition suggests a need for enforcement by some sovereign authority. Once private exclusive property rights have been imposed and enforced, the incentive structure is shifted to create a situation in which each individual ostensibly bears own costs.

Private use-rights allow each agent to retain independence from the others; but since they no longer face the problem of providing for a collective good, there is no incentive to free ride. By creating a private market in rights to graze, orthodox theory suggests that an efficient allocation of resources results. The common property externality therefore is internalized. The approach implicitly assumes, heroically, that private use-rights are a sufficient condition for resource conserving rates of extraction consistent with some social rate of time preference.

A related proposal from the fisheries literature is "limited entry." This alternative has some characteristics of private property and some of common property. These help to clarify the distinction between open access and common property. In limited entry, a group of users exclude those outside the group from access to the resource. Inside the group, joint use of the resource makes it common property, although it is generally assumed that the group acts "as one" (see Chapter IV, Section 3). This retains the underlying independence of choice by assuming uniformity of interests within the privacy of the group, and total exclusion of those outside it. Even

this mixed case shows, however, that common property is not necessarily "no one's property." The importance of this will be developed in the sections below.

Private property rights thus reflect a key feature of the analytic structure of the tragedy of the commons analysis and property rights paradigm: the independent decision calculus of individual actors or groups of actors acting as one. Since cooperative strategies designed to overcome the tragedy are ruled out by this independence, some form of private use-rights are the only superior institutional alternative available. Private property is the institutional complement to independent choice.

## 4. Common Property: The Empirical Case

Before analyzing the theoretical components of this approach to common property externalities, it is useful to look briefly at the empirical basis of the argument. This historical and contemporary record tends to controvert the claim that common property inevitably results in tragic overexploitation.

Historically, the existence of common property in Western society may be traced at least to Graeco-Roman times. It was an important property institution throughout Europe from the pre-feudal period up to and even beyond the enclosure movements which began in the fifteenth and sixteenth centuries (Vassberg). Its status as an institution of longstanding was given expression in Roman law, which distinguished between situations in which no use-rights for a given parcel of land were specified (res nullius) and common property arrangements (res communes) in which use-rights were well defined but extended to an entire group or village (Ciriacy-Wantrup & Bishop).

Record indicate that in the sixteenth century, common property continued in Europe as an important institutional form of property use-rights. In a recent careful reconstruction from ownership records in 16th Century Castile, David Vassberg noted:

> Community property was by no means peculiar to Castile. Similar practices and institutions existed in most of Europe from medieval times down to the nineteenth century. As in Castile, the extent of public ownership varied widely from place to place. Communal practices thrived and decayed at different periods, depending on local conditions; but they seem to have remained generally strong until the middle of the eighteenth century, after which most governments began encouraging a transition to private ownership, on the grounds that the

> change would bring about an improvement in agriculture (p. 401).

The survival of common property, and its ebb and flow depending on conditions, suggests a rather different historical pattern from North's assertion that private property took hold and altered incentives beginning nearly 8000 years ago. To the contrary, it appears that agricultural production was practiced under common property arrangements until such times as governments sought to impose and enforce private property rules in the name of the sovereign. The resilience of common property institutions is also supported by the fact that vestiges of these common property systems survive in Europe today (Ciriacy-Wantrup and Bishop, Netting, Stevenson).

Other historical investigations have also raised doubts concerning the alleged inefficiency of common property arrangements. In a recent study of the "open" or common field system which dominated England until the imposition of the enclosure laws, Dahlman has supported the claim that common property field ownership existed as a stable and efficient institution for at least a millenium. It was, according to Dahlman, the <u>dominant</u> form of ownership in such diverse cultures as

the Slavic, Germanic, Gallic, Anglo-Saxon, and Celtic (Dahlman, 1980, p. 96). The stability and survival of these institutional arrangements, if they inevitably gave rise to free rider behavior and resulting tragedy, seems odd. The longstanding existence of common property institutions raises questions regarding the validity of the independent free rider behavior and resulting inefficiency of common property which prevailing theory supports.

The application of the private property rights approach to contemporary problems of resource allocation in developing economies is also increasingly questioned on empirical grounds. Although private use-rights have emerged in recent centuries as the dominant institutional form in much, though by no means all of Western Europe and North America, common property arrangements continue to dominate use-rights to resources in many developing economies. That these patterns of use are inherently inefficient is increasingly questioned by observers. In a broad survey of pastoral common property use-rights of grazing lands in Niger, Mali, Senegal, Upper Volta, Chad, and Camaroon, a recent study team concluded that the many attempts to impose private individual use-rights, consistent with the property rights notion of internalizing

a common property externality, have met with abject failure (Brokensha, Horowitz & Scudder). In discussing pastoral grazing strategies, the team reported:

> The fact that pastoralists, with distinct cultures and histories, exploiting arid and semi-arid habitats in widely dispersed parts of the globe, have elected not to develop private ownership of land (though they have individualized ownership of animals and often of water), suggests that their systems are ecologically sounder than their critics would suppose. What are needed are facts, and facts are not available. 'There has been no empirical assessment of the ecological efficiency of pastoral systems' (Western). The logic of the 'tragedy of the commons' position is seductively attractive. But it is not necessarily empirically correct (Brokensha, et. al., p. 12).

Although common property may be a stable pattern of resource use in traditional societies, the impact of population growth, technological change, or rapid change in climate can destabilize traditional institutions. Today, especially in areas of the Sahel and Southern Africa, the breakdown of common property institutions has led to serious overgrazing (Hitchcock, Picardi & Seifert, Glantz).

Many economic consultants and planners have called for the imposition of private property rights to halt this apparent "tragedy of the commons" (Picardi).

Consistent with the tradition of enclosure of common grazing lands, as well as U.S. experience with measures such as some sections of the Taylor Grazing Act of 1934 (Foss), efforts have been made to improve private property schemes to internalize a common property externality.

Many of these approaches have failed very seriously (Hitchcock, p. 66). Not only have they failed to stop overgrazing; they have also contributed to inequality in what are already highly unequal distributions of wealth. Lands formerly held in common are being transferred to individuals in positions to exercise influence in the allocation of use-rights, such as high ranking government bureaucrats (Hitchcock).

A final empirical point is the importance of distinguishing between situations of open access, in which no use-rights over a resource are specified, and situations of common property (Ciriacy-Wantrup & Bishop). Often, what appears to the outside observer to be a case of open access may in fact be a situation of joint use by individuals according to a series of rules. This is common property. Both historically and in contemporary examples, the commons is not generally available as a free good to all, carrying no corresponding obligations or duties. Common

property institutions are institutional innovations which lie between the two extremes of non-existent rights and fully exclusive private rights to the resource (Randall, 1978). The private property rights analysis tends to assume that only these two extrema are possible. This limited view results in claims that in the absence of individual private rights, no comparably efficient institutional alternatives exist. All situations of common property are treated as if no rights of access were in force (Gordon). In this polarized state of nature, the imposition of individualized rights seems to be the only institutional alternative to anarchy.

The historical and empirical record suggests that it is possible for a complex set of rules to exist which specify use-rights other than private exclusive ones. Formal and informal norms, customs, and conventions within a group are powerful limiting influences on individual behavior. In the historical examples cited above, this was evidently the case. As R.H. Tawney's authoritative history of the sixteenth century enclosure law states:

> In the earlier period the word common implies common exclusiveness quite as much as common enjoyment. The value of a common to the commoners consisted precisely in the guarantee given them by custom that no one might use it except holders of tenements which since time out of mind had a right thereto, and that no one might use it to a greater extent than the custom of the manor allowed (1912, p. 238).

This view is supported by the distinguished historian, Jerome Blum, in his analysis of early European common property rights.

> Even the least rigorous of communal organizations imposed certain limitations on the individual's control of his own holding, and especially over his rights in the collective property of the community (which in some places comprised half or more of the villages territory). To ensure that all shared fairly in the use and benefits of these resources the commune imposed regulations which limited the number of animals each member could pasture on the common grassland, the amount of timber he could take from the forest, and the amount of meadow he could mow (1971, p. 168).

With reference to common property institutions in developing countries today, the study team cited above concluded on the basis of extensive ethnographic research that "while in general there is no individual tenure to pasture, it is not true that any herdsman has an operable claim on land being used by any other. . . . In the broadest sense, access to pasture is constrained

by ethnic membership. . . . Customary law courts try cases in which the contenders dispute each other's jural claims to pasture" (Brokensha, et al., pp. 14-15).

These examples suggest that institutional alternatives to private ownership are complex and varied -- that common property is one type of alternative that may be adapted to many different conditions and needs. The empirical cases examined suggest a wide institutional opportunity set. As Dahlman notes, "private ownership rights may prove an efficient alternative to collective rights; but there are cases in which private rights are not a practical alternative. Private rights are not a panacea" (1980, p. 75).

On empirical grounds alone, then, the limited view of institutional alternatives supported by the "tragedy of the commons" analysis and private property rights paradigm is controverted. By failing to recognize the efficiency of institutional alternatives to private use-rights, this approach restricts the institutional opportunity set. The underlying cause of this narrow approach to institutional alternatives is a theoretical one. It is to this theory which I now turn.

## 5. Game Theory: Independent and Interdependent Choice

The key features of the tragedy of the commons analysis were identified above as first, independent individual maximizing behavior; second, a failure of individual incentives in which free rider behavior leads to a need for enforced private property; and third, an outcome in the absence of exclusive use-rights in which all are made worse off.

There are three things wrong with this analysis. First, it fails to distinguish between situations of open access and those of common property, in effect arguing that they are the same. The result is an assertion respecting the inevitable overexploitation of common property which, as shown in the previous section, is historically and empirically untrue. Second, it treats the common property externality as a case in which the actions of each individual are taken to be independent, so that no successful cooperative interaction between individuals is possible. Third, because individuals are assumed to act independently, it abstracts from the crucial problem of each person's uncertainty respecting the actions of others.

The first of these problems is an empirical issue. The second two are theoretical, and require further

elaboration. This elaboration may be provided using the familiar game known as the prisoners' dilemma. It has been widely and erroneously assumed that common property externalities arise for reasons associated with this famous game theory paradox (Edney, Ophuls, Muhsam, Weintraub, Bacharach, Meuller, Orbell & Wilson, Furubotn & Pejovich, R. Hardin). By examining the formal structure of the prisoners' dilemma, it is possible to pinpoint the flaws in the analytic structure of the tragedy of the commons analysis, and to illustrate the narrow institutional focus of the private property rights paradigm. An alternative game-theoretic formulation of common property externalities is then presented, known as the "assurance problem" (Sen, 1967). Assurance problems have important implications for a theory of institutional rules, especially where common property externalities, or more generally, issues of public goods provision exist.

When generalized to more than two actors, the prisoners' dilemma is also known as the isolation paradox, in reference to the independent decision calculus leading to a sub-optimal result (Sen, 1967). The basic result is that collective decisions by independent actors produce inferior outcomes, unless an enforceable

rule is imposed from the outside by a sovereign authority. To the property rights school, this rule is in the form of private, exclusive use-rights to the resource.

The prisoners' dilemma has also emerged in a different guise to confound students of public choice. As I will show in later chapters, Arrow's celebrated "impossibility theorem" is an axiomatic description of the same result (Arrow, 1951). Together, the prisoners' dilemma and the impossibility theorem have cast doubt on the ability of independent agents to formulate stable rules for collective action without enforcement from some outside authority or sovereign. These results, which share the key feature of independent individual maximizing behavior, have led to treatments of common property externalities, and of collective or public goods generally, which are mistaken. They are mistaken because they fail to allow for the interdependence of economic actors, and the coordination of individual choices which can result from this interdependence. This coordination, when codified as a series of rules, may be shown to model the evolution of institutions, as the discussion of assurance problems

below will demonstrate. Before considering these matters, however, we must start with the simple structure of the prisoners' dilemma.

## 6. The Prisoners' Dilemma Paradox: Independent Choice

The prisoners' dilemma paradox takes the form of the following gain-loss table.*

| First Prisoner | Second Prisoner: Not Confess(1) | Second Prisoner: Confess(0) |
|---|---|---|
| Not Confess(1) | (1,1) | (10,0) |
| Confess (0) | (0,10) | (5,5) |

"Confess" or "not confess" represent the choices (or strategies) open to each of two prisoners. The ordered pairs indicate the number of years in prison which will result from a particular coincidence of choices. Imagine that the prisoners are being interrogated.

*Gain-loss tables show games in their "extensive form." This form will be used throughout this study for expositional clarity. Each game may also be represented in "characteristic form," showing its formal mathematical properties. The extensive form is sufficient for a basic apprehension of the argument, and lends itself to graphical presentation.

Both know that if neither confesses, they will receive a short sentence and spend a year in prison (1,1); but if one confesses and turns state's evidence, he will be released, and the other will receive a particularly heavy term of ten years (0,10), (10,0). If both confess each gets five years (5,5). In this situation, assuming mutually disinterested motivation, the most reasonable course of action, represented by the pair (1,1), is unstable. To protect himself, if not to further his own interests, each has a sufficient motive to confess, whatever the other does. "Rational" decisions from the point of view of each lead to a situation where both prisoners are worse off. Even if a contract is struck between them to observe choice (1,1), both have an incentive to break it. Even in repeated plays and with communication, the incentive is to defect (Weintraub, Rapoport & Chammah). Therefore, the non-cooperative equilibrium is the Pareto-inferior pair (5,5).

How these results relate to the tragedy of the commons discussed above may not be obvious at first sight. A more formal way of expressing them is in terms of an ordering of the payoffs resulting from each possible outcome (Sen, 1969). Two players, 1 and 2,

each have a choice of exactly one of two strategies, namely, 0 and 1, and 0 and 1, respectively. The payoff $P^k$ to each player, with k = 1, 2, is a function of the combination of strategies used by both persons. If we write i for the strategy choice of player 1 and j for the strategy choice of player 2, we may express the results formally as:

$$(1) \quad P^k = F^k(i,j) \qquad \text{for } k = 1, 2; \; i = 0, 1; \text{ and } j = 0, 1.$$

The ordering of the four possible combinations, or two sets of payoffs of the two players are the following, where > indicates a strict choice ordering. For player 1:

$$(2.a) \quad F^1(0,1) > F^1(1,1) > F^1(0,0) > F^1(1,0);$$

For player 2:

$$(2.b) \quad F^2(1,0) > F^2(1,1) > F^2(0,0) > F^2(0,1).$$

Note that here the ordered pairs represent strategy pairs, rather than the payoffs associated with these strategies, as in the gain-loss table shown above.

The following results are worth emphasis. First, of the four possible outcomes, three are Pareto-

Optimal. These are (0,1), (1,1) and (1,0). One is Pareto-Inoptimal: (0,0). This follows from the fact that, by (2.a) and (2.b), $F^k$ (1,1) > $F^k$ (0,0), for k = 1 and 2.

The second result worth noting is that the Pareto-Inoptimal outcome (0,0) is also the unique "equilibrium point." Since the structure of the game is non-cooperative, it follows that there is a unique (Nash) equilibrium, since $F^1$ (0,0) > $F^1$ (1,0) and $F^2$ (0,0) > $F^2$ (0,1) from (2.a) and (2.b). This also implies that (1,0) and (0,1) are <u>not</u> equilibrium points. Also, (1,1) is not an equilibrium point since $F^1$ (0,1) > $F^1$ (1,1) and $F^2$ (1,0) > $F^2$ (1,1).

The third result of note is that there is a "strictly dominant" strategy for each player: 0 for player 1 and 0 for player 2. That is, the prisoners always have an individual incentive to confess <u>no matter what the other does</u>. For player 1, 0 is a "dominant" strategy because $F^1$ (0,j) > $F^1$ (1,j) for j = 0 and 1. The situation is analogous for player 2. <u>This strict dominance of individual strategy is a key result in the application of this analytic structure to problems of common property externalities</u>.

The fourth and final result worthy of note is that the non-cooperative equilibrium (0,0) can be avoided

only through a rule to observe choices other than (0,0). This rule is inherently unstable, however, in light of (2.a) and (2.b). Therefore, it must be enforced from the outside by some sovereign authority. Stable institutional rules cannot arise from "inside the group" of prisoners, even with communication. Since an incentive exists to break them, they must be imposed and enforced from the outside.

Now imagine the more complex case in which a group of persons must graze cattle on a common range of fixed size. Consistent with the distinction drawn above between open access and common property, assume that there exist barriers to entry to those outside the group. The group is of a certain size, say N. To be outside the group is to be a non-grazing third party. Assume that it is possible to partition the N person group into two groups and to select two representative individual grazers, one from each group, given as 1 and 2. Each individual formulates the choice for group grazing independently. Although realistically, a whole range of grazing pressure can be exerted on the common range by adding and subtracting cattle, assume

for the moment that each individual has a choice of doing one of two things. The first is grazing at a level which amounts to "holding back" on the number of cattle grazed -- known as "stinting." The second is grazing at a level in which no attempt to hold back is made, which while more profitable in the short run, is known to result in exploitative overgrazing in time. This second strategy, corresponding to "free rider" behavior in orthodox descriptions, will be termed "defecting."

Expanded to many actors, if each formulates his decision independently, the result is an N-person version of the prisoners' dilemma. If we think of each individual's costs and benefits, the cost of grazing to each is a function of the grazing decisions of all N individuals.

If all cooperate and stint, then the common range is preserved and cattle remain healthy. But independently, each individual has an incentive to defect and graze at a level most advantageous to himself in the near term, leading to a situation in which the range is overexploited. In other words, each individual believes he will receive a higher profit if he grazes at an exploitative level than if he stints. Since each formulates his strategy independently, it

does not matter what strategy the others choose. Because of this we say that the strategy of grazing at an exploitative level strictly dominates stinting for each individual.

Because of the strict dominance of individual strategy, the likely behavior of others does not affect the behavior of a given individual. Therefore, uncertainty regarding the expected behavior of others does not arise. It is assumed that one is certain of one's own choice. Therefore, the tragedy of the commons is simply the result of costs and benefits to the independent, individual, maximizing agents in an environment of certain gains and losses. No question of uncertainty enters the analysis.

This is the claim made by Garrett Hardin in his original article on the tragedy of the commons. He argues that the rational herdsman concludes that the only sensible course is to add another animal to his herd -- the conclusion reached by each and every "rational" herdsman sharing the commons. What is not explicit in this treatment is that it is the independent character of rational choice which locks each herdsman into a system which "compels him to increase his herd without limit -- in a world which is limited" (Hardin and Baden, p. 20). The formal representation

of the tragedy of the commons as an N-person prisoners' dilemma allows this implicit assumption to be pinpointed. In game theoretic terms, the "tragedy" arises from the independence of rational individual choice, and the strict dominance of individual strategy which emerges from the structure of the prisoners' dilemma. The strict dominance of individual strategies also obviates the problem of uncertainty, since in formulating one's own strategy it does not matter what others do.

The prisoners' dilemma also allows an explicit treatment of the claim that internalizing the common property externality can only occur where private property rights are imposed and enforced. Recall the claim of the property rights school that the incentive structure prevailing in a situation of common property will inevitably lead to free rider behavior, as each individual sees it in his interest to defect and graze at an exploitative level. This may be translated to the game-theoretic claim that in a situation of independent choice, a Pareto-Inoptimal outcome (of overgrazing) will result as a non-cooperative equilibrium from the collective decisions of N independent agents. This non-cooperative equilibrium can be

avoided only through a rule to observe resource-conserving (stinting) behavior. However, such a rule is inherently unstable, since even if it is in force, each has an incentive to break it and become a free rider on the range. Therefore, no incentive exists to formulate cooperative rules; they must be imposed and enforced from outside the group by a sovereign authority such as the state.

In this structure, the appeal of private, exclusive use-rights is twofold. First, they can be imposed and enforced by sovereign authority, as was true in the enclosure movements, or as is the case in the imposition of private rights in developing countries today. Second, private individual use-rights are the only institutional alternative consistent with the implicit postulate of independent individual choice, and the resulting strict dominance of individual strategy. In this sense, they retain the orthodox view of the problem as one of costs and benefits in an environment of certainty. Each man is an island, free to maximize benefits and minimize costs, unto himself.

The irony of this result is that private exclusive use-rights, justified on the grounds of individual freedom and choice, require the imposition and enforcement of rules from above by a sovereign authority. In this

sense, they fall prey to the abuses inherent in any institutional rule which has the exogenous quality of being imposed from above, as in the classic treatment of Hobbes' Leviathan. As Ophuls has noted, tragedies of the commons formulated as prisoners' dilemmas must result in coercive rules imposed from outside the system, if anarchy and oblivion are to be escaped (Ophuls, 1973). The need for "mutual coercion" (Hardin, 1968) has also been likened to the analytic structure giving rise to Rousseau's distinction between the suboptimal outcome of the will of all, and the need to impose and enforce the dictates of the General Will (Runciman and Sen). Like Rousseau, advocates of private property rules tend to justify them in the name of liberty: people must be "forced to be free."

The main results of treating common property externalities as a variation of the prisoners' dilemma, or isolation paradox, may be summarized as follows (Sen, 1967).

(1) Pareto-Inferior outcome: Each individual will independently prefer to graze at an exploitative level, leading to a situation in which all are made worse off. All are led toward the non-cooperative equilibrium.

(2) Strict dominance of individual strategy: Due to the independent character of individual choice, the result of overgrazing arises without regard to the expectation of each individual respecting the actions of others. Since the actions of each are assumed to be independent, there is no problem of uncertainty regarding the actions of others.

(3) Need for enforcement: Even if an agreement is struck which specifies that all will stint on the range, the strict dominance of individual strategy makes such an agreement unstable. Without compulsory enforcement imposed by some outside authority, such as a system of private use-rights, any such agreement is unstable because each prefers that the others stint, while he defects and grazes exploitatively.

In summary, even if individuals attempt to make cooperative rules to stint, they cannot resolve their problems, since nobody has an incentive to keep such agreements. With independent agents, and dominant strategies, rules of cooperation cannot solve the free rider problem. As a result, an enforceable rule must be imposed from outside the group. Institutional rules are modeled as exogenous to the problem at hand. Private property rights are consistent with this formula-.

tion because they can be imposed from outside. Physical demarcations such as fences divide property into individual plots. The separable character of the property allows enforceable division into mine and thine. This division provides an institutional structure consistent with individual independence abstract from cooperative agreement, which is unstable. Since this approach starts from the (not always obvious) presupposition that individuals pursue their strategies independent of the expected actions of others, the appropriate decision unit must be the private individual user. Of course, the rational individual is assumed to act in a husbanding and resource-conserving way with respect to his own private range area.

Despite the logical appeal of formulating common property externalities in this way, there is something troubling about an analytic structure which abstracts from the observable interdependence of individual agents, and their resulting uncertainty respecting the actions of others. It is also discomforting that the institutional solutions arising from the analytic structure of the prisoners' dilemma are limited to those which are imposed from outside the group, and treat individual agents as Robinson Crusoe's, capable

of adapting only through imposed, exclusive, private use-rights. More peculiar, even to the casual empiricist, is the alleged instability of all cooperative solutions. This is controverted by the wide array of empirical cases of stable common property institutions cited above.

Are our institutional alternatives in cases of common property externalities, and more general problems of public goods provision, really bleak choices between "Leviathan or oblivion"? (Ophuls). Or is there something wrong with the theoretical formulation of the tragedy of the commons?

One objection mentioned already is that the tragedy of the commons/private property rights approach tends to confound situations of open access with those of common property, since its non-cooperative assumptions leave no place for cooperative rule structures unless they are imposed from outside the system. There are two more important objections to the model of the prisoner dilemma paradox. The first is a non-cooperative game structure which treats externalities as arising from the independence of individual cattle

grazers, who behave as if they were all Robinson Crusoe's. This implies "separability" of the individual cost functions. I will show below that this is extremely implausible. The second objection is that by assuming the independent formulation of each individual's strategy, the prisoners' dilemma fails to deal with the essential problem of uncertainty regarding the actions of others. I will argue that uncertainty is the major motivating force in overexploitation. To do so, it is necessary to look more closely at the implications of independent choice for common property externalities.

## 7. External Costs: The Separable Case

Imagine two representative cattle owners, as before, each of whom grazes cattle on a common range.* In a competitive situation, each individual cattle owner has a cost function for grazing on the common given as

$$(3) \qquad C_1 = C_1(q_1, q_2) \text{ for cattle owner 1}$$
$$C_2 = C_2(q_1, q_2) \text{ for cattle owner 2}$$
$$\text{where } q_1 = \text{head of cattle grazed by 1}$$
$$q_2 = \text{head of cattle grazed by 2.}$$

*This section is adapted from Davis and Whinston (1962).

These owners are related through their individual cost functions due to external diseconomies of grazing. Increases in cattle grazed by 1 impose additional costs on 2, and vice versa. If each individual is assumed to maximize profits from cattle holding, then they will equate price with marginal cost.

$$(4) \qquad p = \frac{\partial C_1}{\partial q_1} = \frac{\partial C_2}{\partial q_2}$$

The welfare associated with cattle production on the common can be measured by the difference between social benefit and social cost. In a competitive situation, social benefit can be measured for the two owners by their total revenue.

$$\text{Total revenue} = p(q_1 + q_2)$$

Social costs can be measured by total costs.

$$\text{Total costs} = C_1(q_1, q_2) + C_2(q_1, q_2)$$

To maximize welfare, the joint profit function of the two individuals must be maximized, where joint profit is given as below.

$$\pi = \pi_1 + \pi_2$$

Joint profits are thus

$$(5)\quad \pi = p(q_1 + q_2) - C_1(q_1, q_2) - C_2(q_1, q_2)$$

First order conditions for a maximum are:

$$(6)\quad \frac{\partial \pi}{\partial q_1} = p - \frac{\partial C_1}{\partial q_1} - \frac{\partial C_2}{\partial q_1} = 0$$

$$\frac{\partial \pi}{\partial q_2} = p - \frac{\partial C_1}{\partial q_2} - \frac{\partial C_2}{\partial q_2} = 0$$

Second order conditions for a maximum are:

$$(7)\quad \frac{\partial^2 \pi}{\partial q_1^2} < 0 \qquad \frac{\partial^2 \pi}{\partial q_2^2} < 0$$

$$\frac{\partial^2 \pi}{\partial q_1^2} \cdot \frac{\partial^2 \pi}{\partial q_2^2} > \left(\frac{\partial^2 \pi}{\partial q_1 \partial q_2}\right)^2$$

The evidence of externality arises when either

$$(8)\quad \frac{\partial C_2}{\partial q_1} \neq 0 \qquad \text{or} \qquad \frac{\partial C_1}{\partial q_2} \neq 0$$

since with these external effects conditions (4) and (6) will not coincide. Profit maximization by each individual will not give the greatest net social benefit possible, due to the external effects of one's cattle on another's costs. In this case, for complete-

ness, it should be noted that the external effects are diseconomies, so that

$$\frac{\partial C_2}{\partial q_1} > 0 \quad \text{and} \quad \frac{\partial C_1}{\partial q_2} > 0$$

This much is standard.

A function is said to be separable if and only if

$$(9) \quad f(x_1, x_2) = f_1(x_1) + f_2(x_2).$$

In words, separability means that it must be possible to express the function as a sum of two functions each of which involves only one variable in its argument. Consider the case in which the cost functions of the individuals are interrelated by external diseconomies but are separable in their arguments.

$$(10) \quad \begin{aligned} C_1(q_1, q_2) &= A_1 q_1^{\,n} + B_1 q_2^{\,m} \\ C_2(q_1, q_2) &= A_2 q_2^{\,r} + B_2 q_1^{\,s} \end{aligned}$$

Profit maximization, as before, is given by

$$(11) \quad \begin{aligned} p &= \frac{\partial C_1}{\partial q_1} = nA_1 q_1^{\,n-1} \\ &= \frac{\partial C_2}{\partial q_2} = rA_2 q_2^{\,r-1} \end{aligned}$$

The key result is that marginal cost to each individual in the separable case is given entirely in terms of <u>own</u> cattle: $q_1$ for 1 and $q_2$ for 2. Davis and Whinston have shown that this result is logically equivalent to the strict dominance of individual strategy. Consistent with the non-cooperative nature of the prisoners' dilemma, if each individual formulates his decision independently, then his appropriate decision rule for profit maximization is "price equals marginal cost," as given in (11). This is so regardless of the actions of others. Uncertainty regarding the actions of others is therefore not a problem.

A separable cost function shares this result with the prisoners' dilemma. Since marginal cost to each individual is defined entirely in terms of <u>own</u> cattle, whatever the actions of the other individual(s), there is a unique number of cattle which maximizes each individual's profit. To repeat, this is logically equivalent to the strict dominance of individual strategy. In sum, separability implies the dominance of individual strategy (Davis & Whinston).

In graphical terms, separability may be expressed easily (see Figure 1.1). The effect of externalities in grazing is simply to shift the total cost curve of any individual grazer by a constant: from $C_o$ to $C_{ex}$,

equal to the magnitude of the external effect. Since the marginal conditions are unaffected, the optimal number of cattle for each individual remains the same: $q_o = q_{ex}$. A tax or subsidy scheme may be used to fill

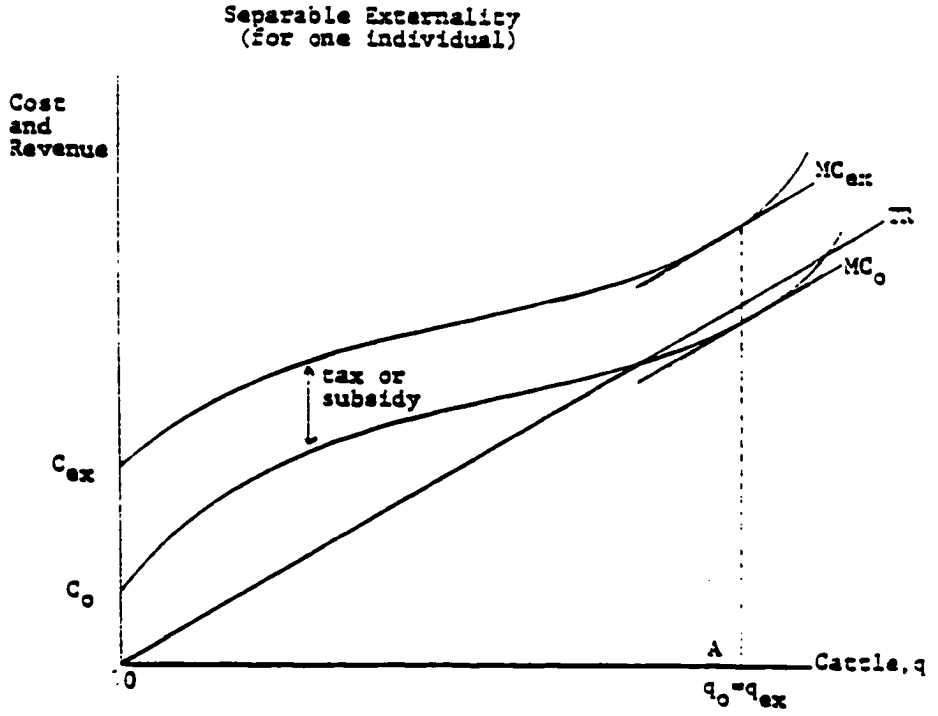



Figure 1.1

this gap and correct the price system. Figure 1.1 shows a continuous case. This result has an exact parallel in the discrete case. Profit maximization, given by the tangency of marginal cost and price, yields a unique solution for cattle grazed by the individual at A, regardless of the externality imposed by others. This is logically equivalent to the strict dominance of individual strategy.

Davis and Whinston note that "the typical cases (of externality) with which the classical analysis [of Pigou, Marshall, and Meade] has been concerned have, in fact, assumed the condition of separability" (p.245). My purpose in treating separability in such detail is to show that approaches based on the strict dominance of individual strategy are in fact also assuming such a condition, consistent with the notion of independent individual choice.

When the assumption of separability is dropped, there is inevitably introduced an element of interdependence and uncertainty which becomes difficult to deal with in terms of traditional tools and concepts. Noting again the equivalence of separability and the strict dominance of individual strategy, it is clear that dropping the assumption of separability is tantamount to a recognition of the interdependence of

individual choices, in which each individual bases the decision to graze cattle on the expected actions of others.

## 8. The Nonseparable Case

The assumption of separability treats choices as the result of the simple aggregation of the independent decisions of N Robinson Crusoe's. The actions of others do not enter into the decision calculus of these "windowless monads" (Elster). They are independent maximizing agents, without a hint of sociality or interdependence in the exercise of their choices. That this model is implausible as a description of human behavior in grazing (as well as more generally) is apparent. Baumol (1976) claims that nonseparable externalities are not only implausible, but, strictly speaking, impossible (p. 381).

The decision to graze a certain number of cattle on a common range is not made by each cattle owner in a vacuum. It is conditioned on an expectation of the likely behavior of others. The common range has tied their welfare, and decision making, together. In the nonseparable case, the externality enters the cost function of each individual in a "multiplicative"

rather than an "additive" way. In formal terms, we write

$$f(x_1, x_2) \neq f_1(x_1) + f_2(x_2). \tag{12}$$

For example, consider two cost functions for representative cattle owners of the following form.

$$C_1(q_1, q_2) = A_1 q_1^{\,n} + B_1 q_1 q_2^{\,m}$$

$$C_2(q_1, q_2) = A_2 q_2^{\,r} + B_2 q_2^{\,t} q_1^{\,s} \tag{13}$$

Profit maximization by each individual implies that

$$p = \frac{\partial C_1}{\partial q_1} = nA_1 q_1^{\,n-1} + B_1 q_2^{\,m}$$

$$= \frac{\partial C_2}{\partial q_2} = rA_2 q_2^{\,r-1} + tB_2 q_2^{\,t-1} q_1^{\,s} \tag{14}$$

Note that in contrast to the separable case, here marginal cost is defined not only in terms of the variable the individual can control (own cattle), but also the other individual's cattle. Since each person's <u>marginal</u> conditions for profit maximization are affected by the grazing decisions of others, there is no well-defined decision rule for each individual. In

graphical terms, this situation means that externalities will not simply shift total cost by some constant, as in the separable case. Instead rotation or twisting of total cost curves will result, since the changed marginal cost of each individual due to the actions of others will alter the slope of total cost along the length of the curve. This is more plausible, since we would not expect that grazing on a common range of limited size would involve a constant externality, regardless of how many cattle are put on the range. It is the interdependence of choice which is the most important characteristic of nonseparable externalities in grazing. A decision by one cattle owner to graze cattle will generally depend on his expectation of the behavior of other owners (Baumol).

The wider applicability of this multiplicative (non-separable) model has been recognized in treating qualitative data of the sort likely to be encountered in situations such as overgrazing. A leading methodologist has noted that additive (separable) models appear "to have little justification, either empirically, logically, for interpretability, or for generalizability" (Lindsey, p. 48).

In game theoretic terms, the strategic interdependence of nonseparable models of externalities implies

that the strict dominance of individual strategy associated with the separable case no longer holds. Each individual must take into account the actions of others in formulating a decision to graze cattle on the commons. There is no dominant strategy. The result is to redefine the problem of the commons as one of decision making under uncertainty.

In this situation, there is no unique solution for each individual. A multiplicity of solutions are possible. Because of the interdependence involved, and the resulting changes in the marginal conditions for profit maximization, the classical tax-subsidy solution to externality breaks down due to twists in the total cost curves. The imposition of private property, its appeal based on the strict dominance of individual strategy, can no longer be justified on these grounds since the strict dominance of individual strategy no longer holds.

In the nonseparable case, the imposition of private property amounts to an attempt to impose separability on an inherently nonseparable externality, by forcibly separating individual cost functions. In practical terms, this amounts to the assertion that building fences will solve the problem of overgrazing. More generally, the analytics of private property

involve creating a whole set of isolated, independent units out of a community of individuals, if they are to succeed. While this may be one in a set of institutional rules designed to solve the problem, the absence of strict individual dominance does not comment it as the only one. And the transactions costs likely to be incurred will not be trivial (Dahlman, 1979, 1980). While transactions costs are an important element in the argument, they will be treated at a later stage, in terms of the more general issue of the costs of information.

The only other possibility for a well-defined equilibrium in the nonseparable case would be a variety of the Cournot solution in which each cattle owner expected that no one else would change the number of cattle they currently graze on the commons, thus obviating the problem of uncertainty and letting $q_2$ be treated as datum to 1 etc. But this is not a rational expectation if 1 expects that he will change his grazing pattern in response, unless he thinks he is unique (Muth).

Hence nonseparabilities arising from the interdependence of individual choice suggest that the main problem of common property externalities is uncertainty

over the expected actions of others. This view has recently been confirmed by Dasgupta and Heal, who note that "contrary to what is often claimed, the problem of 'the common' and the resulting suboptimality of the market equilibrium are not formally identical to an N-person version of the prisoners' dilemma game" (p. 59). They argue, as shown, that the independent choice of the prisoners' dilemma is erroneous because it is characterized by dominant strategies on the part of each agent. Properly formulated, they show that the commons problem involves the interdependence of agents in which no dominant strategy exists, leading to a cooperative situation in which it is in the interest of each agent to restrict output (or, in our case, to stint on the range) if that is the way to get the other agents to do likewise. In their words, "the guilty party is not the profit motive per se. Rather, it is the economic and legal environment in which the profit motive is allowed free play" (p. 63).

This renewed emphasis on the economic and legal environment places the problem in its institutional context. It also provides the basis for a reformulation of the problem of the commons. The interdependence of individual choices arising from nonseparable external-

ity makes the problem one of selecting the appropriate institutional rules which will assure each respecting the actions of others, reducing their uncertainty concerning these actions (Marchand and Russell). This problem of coordination may be given a proper game-theoretic expression, known as the "assurance problem."

## 9. The Assurance Problem: Interdependent Choice

The assurance problem is an amended version of a game called "the Battle of the Sexes," discussed by Luce and Raiffa (1957). Before relating the analytic structure of this game to the problem of common property externalities, it is useful to build an intuitive sense of how it differs from the prisoners' dilemma. Therefore, the original "Battle of the Sexes" game will be introduced, then adapted to the problem of the commons, following the same procedure as in the treatment of the prisoners' dilemma above. The individuals in this two-person cooperative game have the following gain-loss table.

| Man | Woman | |
|---|---|---|
| | Ballet(1) | Dogs(0) |
| Ballet(1) | (1,2) | (-1,-1) |
| Dogs(0) | (-1,-1) | (2,1) |

As before, the table represents the gains and losses of two individuals. In this case, the problem is one of a couple. The man wishes that they could go together to the dog races; the woman wishes they might go to the ballet. But each of them prefers to go to either of these activities together, rather than to separate entertainments. Let (1) represent the choice of the ballet, and (0) going to the dogs. This game of pure strategy pairs has two equilibrium points, corresponding to the cases in which both go to the ballet, or both go to the dogs (Bacharach).

As in the presentation of the prisoners' dilemma, it is possible to express these results in terms of an ordering of the payoffs resulting from each possible outcome (Sen, 1969). As before two players, 1 and 2 (a man and a woman) each have a choice of exactly one

of two strategies, namely, 0 and 1, and 0 and 1, respectively. Repeating the results of the prisoners' dilemma to facilitate comparison, we have the following orderings of payoffs over the alternatives for the two games.

$$(1) \quad P^k = F^k(i,j) \qquad \text{for } K = 1,2; \; i = 0,1; \text{ and } j = 0,1.$$

Prisoners' dilemma ordering

For player 1:

$$(2.a) \quad F^1(0,1) > F^1(1,1) > F^1(0,0) > F^1(1,0);$$

For player 2:

$$(2.b) \quad F^2(1,0) > F^2(1,1) > F^2(0,0) > F^2(0,1)$$

Battle of the Sexes ordering

$$(3.a) \quad F^1(0,0) > F^1(1,1) > F^1(0,1) = F^1(1,0);$$

For player 2:

$$(3.b) \quad F^2(1,1) > F^2(0,0) > F^2(1,0) = F^2(0,1).$$

In order to simplify the analysis, suppose that the man and woman recognize an unambiguous "best" outcome,

i.e., that they would rather go together to the ballet than to the dogs. In this case, the assurance problem takes the form which we will employ hereafter, in which the orderings of payoffs in the two-person example are:

For player 1:

(4.a) $F^1(1,1) > F^1(0,0) > F^1(0,1) = F^1(1,0)$;

For player 2:

(4.b) $F^2(1,1) > F^2(0,0) > F^2(1,0) = F^2(0,1)$.

This is the assurance game which forms the basis of much of the analysis to follow. The following points are worth noting (Sen, 1969). First, of the four possible outcomes, only one is Pareto-Optimal (1,1). The rest are Pareto-Inoptimal. This is so since (1,1) is the preferred outcome in both players' orderings, by (4.a) and (4.b).

Second, there are two "equilibrium points" (0,0) and (1,1). (0,0) is an equilibrium point since $F^1(0,0) > F^1(1,0)$ from (4.a) and $F^2(0,0) > F^2(0,1)$ from (4.b). Likewise, (1,1) is such as point, since $F^1(1,1) > F^1(0,1)$ from (4.a) and $F^2(1,1) > F^2(1,0)$ from (4.b). For the same reasons it follows that (1,0) and (0,1) are not equilibrium points.

Third, there is no strictly dominant strategy for each player. If each player seeks to maximize his minimum possible payoff (according to the so-called maximin criterion) (Luce and Raiffa, p. 278) so that the optimal choice is the "best worst state," then each will choose strategy 0 (Sen, 1969). Although this is Pareto-Inoptimal it is not a dominant strategy. Either (0,0) or (1,1) may arise as equilibria.

Fourth, through a collective contract, or institutional rule, each player can be better off than if they followed the maximin strategy. If each is assured that the other will follow the optimal strategy (1,1), then they will follow it too. In the prisoners' dilemma, the equilibrium point is Pareto-Inoptional, and there exists a need for enforcement if it is to be avoided. In the assurance game, by contrast, if assurance is provided respecting the behavior of others, no enforcement is necessary to achieve a Pareto-Optimal result. To follow a cooperative agreement is its own reward.

These results are more readily apprehended if the payoff matrix is expressed graphically. Figure 2 represents the "attainable set" of solutions in the assurance problem. Point L represents the Pareto-Inoptimal outcome of separate entertainments. Point J

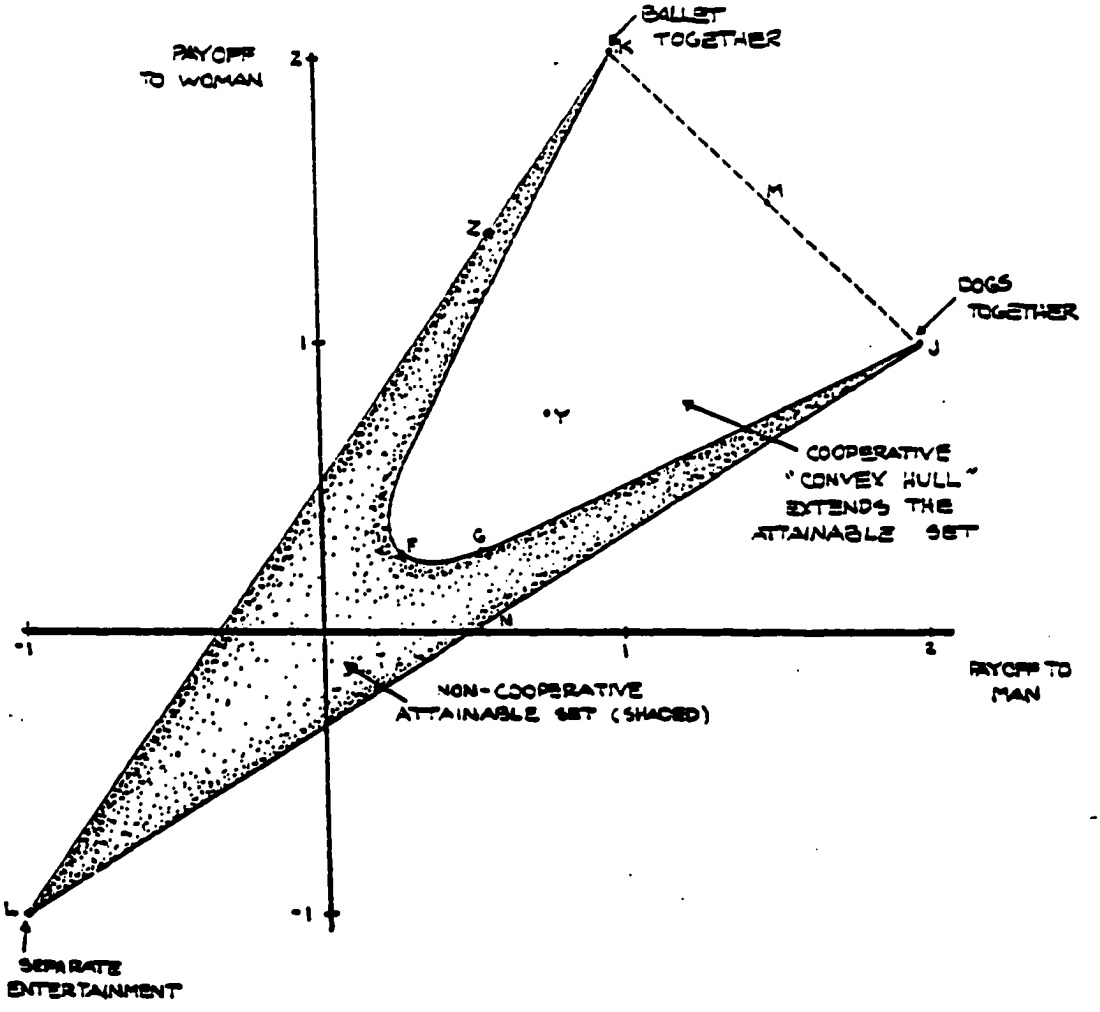



Figure 1.2

represents going to the dogs together; point K represents going to the ballet together.

The assurance game is not one of conflict, like the prisoners' dilemma. It is a cooperative game. The problem is assurance respecting the other person's intended action. The man and woman must coordinate their strategies and cooperate by some agreement which will assure them that they will go to the ballet together.

Suppose for a moment that the actions of the man and the woman are independent, as was true in the isolation paradox. By formulating what are known as the "mixed strategies" of the two, and their associated payoffs, it is possible to trace out the "convex hull" shown in Figure 1.2 (Bacharach). For example, suppose that she goes to the dogs and he picks at random from his two choices. Then his and her payoffs are given by the line LJ. Say that she plays (0) and goes to the dogs and he plays (1) and (0) with probabilities half and half. His expected payoff is

$$1/2 \times 2 + 1/2 \times (-1) = 1/2.$$

Her payoff is

$$1/2 \times 1 + 1/2 \times (-1) = 0.$$

This gives a payoff pair of (1/2, 0), shown as the point N. Alternately, suppose that each tosses an unbiased coin and goes to the dogs if it comes up heads. Then each of the four pure strategy pairs shown in the payoff matrix has a probability $(1/2)^2 = 1/4$. His expected utility and her's are the same, given as

$$1/4 \times 2 + 1/4(-1) + 1/4(-1) + 1/4 \times 1 = 1/4.$$

This gives the payoff pair (1/4, 1/4) at point F. The process can be continued to trace out the convex hull. The important point is that when the choices of each are made independently, as in the prisoners' dilemma, it can be formally shown that the attainable set is restricted to the shaded region shown in Figure 1.2. This is the non-cooperative attainable set(Bacharach).

However, cooperation leading to coordinated strategies enlarges the attainable set to include the entire area bounded by LKJN. In the assurance problem, the attainment of cooperative solutions such as point K in Figure 1.2 requires coordinated strategies. Coordinated strategies can arise only where the players are interdependent, and can devise a rule ("we shall go to

the ballet") which provides assurance regarding the expected actions of others. The assurance problem is a problem of coordination according to a set of rules (Schotter).

What is the significance of this coordination game for common property externalities? The assurance problem provides a formal way of looking at interdependence and the accompanying problem of uncertainty. Cooperative strategies are responses to this situation which evolve inside the structure of the game. In this sense, they model institutional rules which, in providing assurance regarding others' actions through coordinated choice, extend the attainable set of possible solutions to problems of allocation. By providing security of expectation, or assurance, institutions are endogenous responses to the uncertainty of social and economic interaction.

The endogenous formulation of rules which coordinate individual choices is much more familiar than this abstract analysis suggests. Recall the famous case of Holmes and Moriarty on separate trains, neither directly in touch with one another, each having to choose whether to get off at the next station. Like the "Battle of the Sexes" game above, both would

prefer to get off at the same station, and one station is preferred above the others, much like "going to the ballet." Their interdependence results from the crucial role of expectation: the best choice for either depends on what he expects the other to do, so that their mutual expectation will determine the outcome. Clothing styles and motor car fads, habits of speech and religious and social conventions are all rules which can be considered an an analogous way (Schelling). The case of coordinated grazing expectations is one in such a class of institutional rules. By specifying rules which provide crucial information regarding the expected behavior of others, institutions act to coordinate individual choice, to the benefit of the agents involved.

In the original development of this approach to interdependent choice, Thomas Schelling observed that:

> The coordination game probably lies behind the stability of institutions and traditions and perhaps the phenomenon of leadership itself. Among the possible sets of rules that might govern a conflict, tradition points to the particular set that everyone can expect everyone else to be conscious of as a conspicuous candidate for adoption; it wins by default over those that cannot readily be identified by tacit consent. The force of many rules of etiquette and social restraint, including some (like the rule against ending a sentence with a preposition) that have been divested of

> their relevance or authority, seem to depend on their having become 'solutions' to a coordination game: everyone expects everyone to expect everyone to expect observance, so that non-observance carries the pain of conspicuousness (p. 91).

The problem of assurance respecting the actions of others differs markedly from the tragedy of the commons modeled as a prisoners' dilemma. The key feature of coordination problems is uncertainty respecting the actions of others, to which coordination of expectations provides the solution. The rules or institutions arising from the game are endogenous responses resulting from attempts to establish reciprocal expectations. Hence, "the players must jointly discover and mutually acquiesce in an outcome or mode of play that makes the outcome determinate"; in other words, "they must together find rules of the game or together suffer the consequences" (Schelling, p. 107).

In the context of the problem of common grazing lands, and common property externalities generally, this approach suggests a substantive challenge to the inevitability of free rider behavior due to individual defection and overgrazing. If individuals can devise an institutional rule which coordinates their behavior, then overgrazing may be averted. Therefore, as a recent critic of the free rider hypothesis has sugges-

ted, "it is not the desire to ride free at the expense of the group, but the wish to be assured that the others will make an appropriate contribution that may constitute the dominant motivation" (Brubaker, p. 152).

A final analytical point concerns the issue of enforcement, which will be taken up at length in the chapters to follow. Quite unlike the non-cooperative case of the commons problem described as a prisoners' dilemma, the assurance problem does not, in principle at least, require enforcement to avoid a Pareto-Inferior result. This may be somewhat confusing. In the prisoners' dilemma, the independent decision calculus and resulting strict dominance of individual strategy makes a contract of mutual non-confession unstable unless enforced by a sovereign authority with power over <u>both</u> prisoners, since each has an incentive to defect, no matter what the other does. In the assurance problem, by contrast, the achievement of cooperative solutions via a coordinating rule or institution makes such enforcement from outside by a third party unnecessary -- <u>to the extent that the coordinating institutional rule succeeds in providing assurance</u>. With "perfect" assurance or coordination of expectations, each agent's expectations are mutually

reinforcing, so that there is no need for an overseer imposing a rule from outside the group. If the rule is less than perfect, in the sense described, it may be necessary to appeal to an outside authority. But insofar as coordinated expectations can be achieved, this enforcement is not a necessary feature of a Pareto-Optimal solution (Sen, 1967, 1969).

A response to this position is that there will always be some persons with unusual tastes who will be attracted by the pecuniary or possibly perverse satisfaction gained from breaking institutional rules. This is why, as the quotation from Schelling cited above suggests, institutional rules are such that non-observance carries the "pain of conspicuousness." The social sanctions implicit in the formulation of institutional rules involve a loss of reputation from breaking them. This cost, as measured against the benefits of conforming to the rule, will be the subject of Chapter III. There it will be shown, consistent with a recent proof provided by Akerlof (1980), that with a certain level of assurance, such defection need not occur. Hence, the endogenous evolution of institutional rules, by providing security of expectation respecting the actions of others, results in no need for enforcement. Unlike the prisoners' dilemma, it is

not a necessary condition for cooperation. Perhaps more importantly, the level of enforcement necessary where coordinated expectations have provided a high degree of assurance is much less than in the independent, non-cooperative structure of a prisoners' dilemma approach to problems of common property externalities.

## 10. Institutions, Assurance, and Common Property

This section presents a detailed analysis of overgrazing of common grazing land, and the way in which the cooperative structure of the assurance problem may be applied to the problem. Recall that in the N-person prisoners' dilemma, a Pareto-Inferior outcome of overgrazing resulted from the strict dominance of individual strategy, carrying with it a need for enforcement via private property rules imposed from outside the group. Private property institutions, by excluding others from grazing on each individual's rangeland, are the institution most consistent with strict individual dominance.

It has been shown that the nonseparable character of common property externalities challenges the notion of strict individual dominance. It is more plausible

to treat these externalities as problems of interdependence, and therefore of uncertainty. This leads to the cooperative game structure of the sort represented by the assurance problem.

In the prisoners' dilemma, N individual cattle owners could make one of two choices, given as "stinting" or the individually beneficial but long-term degrading strategy of overexploitative grazing. The non-cooperative structure of the prisoners' dilemma may be transformed into a cooperative assurance problem simply by dropping the assumption that individuals formulate their choices independent of the expected choices of others. Analogous to the Battle of the Sexes game discussed above, in those cases in which each individual expects everyone else to stint, that individual will gain from extensions in the attainable set of range quality by stinting too. Lacking this assurance, if each expects the others to graze exploitatively, then they may also seek to "get while the getting is good." In order to achieve the Pareto-Superior outcome of stinting, a coordinated strategy must be devised according to a set of rules, or institutions.

Although very similar to the isolation paradox, the results of the assurance problem are very different. The strict dominance of individual strategy no longer holds. Consistent with the nonseparable common property externality, expectations of others' choices must be entered as a formal part of the determination of one's own choice. No individual can decide what his grazing strategy will be before he has evaluated whether all others will stint or not. The Pareto-Inferior outcome of the isolation paradox no longer holds either. If everyone is assured that the others will stint, then it is in his/her mutual interest to do likewise. This outcome is not Pareto-Inferior, since stinting is preferred by all in such a situation. If some assurance respecting the actions of others is provided, via an institutional rule developed for the purpose, it is possible to achieve multiple equilibria in the extended area of the attainable set.

Modelled as an assurance problem, common property externalities involve the search for an institutional rule which will successfully coordinate the expectations of the cattle owners so that they are reciprocally confident of the non-exploitative behavior of others grazing on the commons. It is not possible to

say, a priori, which institutional rule among a set of alternatives will emerge as the solution to the problem, except insofar as that institutional rule will be selected in order to provide a requisite level of assurance and coordination. What level is regarded as "optimal" in this sense will depend on a number of variables influencing the evolution of norms in the society concerned, including the willingness of cattle owners to forfeit certain individual claims in return for the provision of the collective good. This decision, as shown in Chapter III, may be described as a judgment involving the costs and benefits of "donating" to the provision of the collective good, in this case the common range.

From an empirical point of view, the emergence of institutional rules or "coordination norms" (Schotter, Ullman-Margalit) may be seen as an endogenous response to the environmental exigencies facing cattle owners, and can be expected to fit with the overall pattern of societal norms and customs which describe the full set of institutions in force at any time and place. Hence, if the overall pattern of social custom emphasizes individual rights, one would expect the institutional rules respecting collective goods such as common

grazing developed in the society to reflect this emphasis. Alternately, if social customs favor communal sharing behavior, then this emphasis will be reflected in the coordination norms describing institutional grazing rules (Buchanan, 1975, p. 21). The mosaic of institutional rules observed across cultures may be understood as the alternative adaptations of individuals to their physical and social environments and the history of institutional responses evolved by their forebears. This is notably true of property institutions regulating grazing rights to common lands. It is implausible to expect these institutional adaptations to be uniform across time and place.

If a cooperative solution respecting common grazing rights can be arrived at, there is no need for compulsory enforcement or the imposition of rules from outside the group. A total lack of the need for enforcement would correspond to the situation in which each individual was completely assured respecting the actions of others. This is a limiting case, of course, requiring perfect information (Elster, pp. 20-23; Wunderlich). Perfect assurance implies perfectly coordinated expectations of others' grazing actions,

possible only through a "perfect" institutional rule, in which no uncertainty surrounds the expected behavior of others.

In cases in which grazing strategies are imperfectly coordinated (i.e., inside the convex hull of describing the cooperative opportunity set, such as point Y in Figure 1.2), it will be necessary for some enforcement to exist if the individuals seek to move beyond these solutions. In cases of imperfectly coordinated expectations, where further gains from cooperative institutional rules cannot be achieved, Pareto-Superior solutions may be sought by enforcement of rules from outside the group. In the case of common grazing lands, the inability of cattle owners to coordinate their grazing to an extent necessary to provide a requisite level of assurance (however determined), may require that a state agency or other sovereign authority interpose its authority. This authority may interpret and enforce juridical claims to common grazing lands, for example. On the other hand, groups may innovate complex patterns of use-rights, including common property institutions, requiring little or no outside enforcement.

The key to this analysis is that this need for enforcement results from imperfect coordination, such that the level of uncertainty regarding the expected actions of others is deemed to be too high. Further "information" respecting these actions is required, which may be provided via authority imposed from without or through greater coordination within, yielding increases in the overall level of assurance.

Serious problems arise if enforcement from outside the group is seen as the only possibility for a stable rule structure, however, as in the prisoners' dilemma. This, the approach arising from the analytic structure of the private property rights paradigm, falls prey to a variety of difficulties. The most important practical difficulty is the cost of enforcing an inherently unstable contract. The strict dominance of individual strategy makes it in the interest of each to gain at the expense of all, and to seek to subvert the coercive rules of the sovereign authority. At an empirical level, it is unclear why institutional rules which are not enforced from outside the group have evolved if the non-cooperative incentive structure of the prisoners' dilemma is in fact the prevailing one. In addition, the notion that free rider behavior

dominates common property arrangements in the absence of enforcement begs an important question, involving the sufficiency of enforcement from outside the group. The authority vested in a sovereign enforcement agency is itself a public good. What is to stop the enforcers from free riding themselves? These important issues will be considered in greater detail in Chapter IV.

## 11. Summary

This chapter has challenged the prevailing approach to common property externalities represented by the tragedy of the commons/property rights paradigm. The independent decision calculus leading to inoptimal provision of public goods, such as the quality of common range, has been shown to be implausible. Non-separable externalities, such as problems of common property, require an approach which accounts for inter-dependent decision making. One such approach is the cooperative game structure of the assurance problem.

The assurance problem suggests that the key issue is one of uncertainty regarding the expected actions of others.

Solutions to the assurance problem designed to reduce uncertainty through coordinated expectations model the function of institutional rules. Institutional rules emerge as endogenous responses to problems of resource allocation. Exogenous imposition of rules and enforcement of such rules from outside the group is neither necessary nor sufficient where cooperative rules providing assurance are possible. In Chapter III, these issues are given expression in a formal model of institutional rules, described as adaptive responses to resource overexploitation.

Before taking up the formal analysis of Chapter III, Chapter II considers several alternative approaches to externalities in the game theory literature. These approaches bear certain similarities to the one presented here, notably with respect to a rejection of the simple prisoners' dilemma as an appropriate analytic framework. These models attempt to describe interdependence as the result of the passage of time, by treating cooperation as a response to a recurring prisoners' dilemma game. Despite this innovation, they fail to provide a plausible description of the evolution of

cooperative institutional rules as solutions to externalities and the provision of public goods.

# CHAPTER II

## ON SUPERGAMES AND STRATEGIC INTERDEPENDENCE

In the previous chapter, institutional rules were described as solutions to assurance problems. This approach is unique in the current literature on common property externalities and public goods provision, although it has been suggested in a broader context by others (Elster; Schelling; Schotter; Valavanis). The approach of Chapter I is not, however, the only attempt to identify the failures of the prisoners' dilemma as a model of free rider behavior. A number of authors have provided a rationale for cooperation within the confines of the prisoners' dilemma by introducing the dynamic element of time. These authors (Taylor, Schotter, Berman and Schotter, Axelrod, Axelrod and Hamilton, Shubik) have approached cooperative institutional rules as non-cooperative "supergames." This chapter will consider and reject this approach when it is based on the prisoners' dilemma, laying the groundwork for an alternative dynamic approach in Chapter III based on the assurance game. The discussion will be in terms of public goods provision, of which common grazing is an example.

## 1. Taylor's Model

The most influential example of this recent work is Michael Taylor's Anarchy and Cooperation (1976). Taylor agrees with the analysis above that the prisoners' dilemma is an inadequate model to describe the provision of public goods. He argues, however, that the appropriate manner in which to approach public goods provision is an N-person prisoners' dilemma supergame. This supergame is simply a prisoners' dilemma iterated many times. By repeating the game, the non-cooperative strategies which are dominant for each individual allegedly break down. In this section, I wish to briefly describe Taylor's approach, and then demonstrate its limitations vis-a-vis the assurance game presented above. Since the publication of Anarchy and Cooperation, several other authors (Berman and Schotter; Schotter, Axelrod and Hamilton, Axelrod) have followed Taylor's lead in describing a variety of cooperative rule structures as the outcome of iterated prisoners' dilemmas. It is important that the limitations of this approach be identified.

A prisoners' dilemma supergame is simply a sequence of "ordinary" prisoners' dilemma games. Like a single such game, the supergame is non-cooperative. As

Weintraub has observed, with a finite number of iterations (t), the dominant strategy of defection during the $t^{th}$ iteration implies that defection should also be chosen in the penultimate $(t-1)^{th}$ iteration, and therefore the $(t-2)^{th}$, and so on back to the first game (Weintraub, p. 38).

To deal with this weakness, writers who use supergames to model cooperative responses to problems of public goods have generally presented the problem as one of infinite length (Taylor, Berman and Schotter, Schotter). An alternative formulation, to be discussed below, has been to treat the supergame as of limited duration, but where there exists a certain probability, w, that the participants in the game will meet again (Axelrod and Hamilton, Axelrod).

When the prisoners' dilemma supergame is of infinite length, Taylor argues that cooperation may be a rational strategy, so that enforcement from outside the group may be unnecessary. Specifically, Taylor claims that because the players are assumed to know the strategy of all other players in previous games, the supergame allows for choices made <u>conditional</u> on the choices of others. Conditional strategies in the supergame therefore model the players' temporal interdependence.

This temporal interdependence is restricted by the non-cooperative characteristics of the prisoners' dilemma, however. Simply by iterating a prisoners' dilemma, one has not removed the non-cooperative assumptions leading to a failure to account for cooperative rules. Although cooperative rules may emerge in this analysis, they remain highly tentative, since each player must await cooperation in order to cooperate himself. As Taylor notes, "In the supergame, a player can, for example, decide to cooperate in each ordinary game if and only if the other player(s) cooperated in the previous ordinary game" (p. 11). Previous cooperation is therefore required to maintain the cooperative equilibrium. Once the pattern is broken, so is the cooperative equilibrium. Like the simple prisoners' dilemma, the prisoners' dilemma supergame leads to the instability of cooperative institutional rules. Only a record of cooperation over time can prevent defection from emerging as the dominant strategy.

Although Taylor's attempt to model cooperation goes part way, by recognizing interdependence as the key to cooperative rules, his argument is weakened by a failure to acknowledge that the interdependence of the players is not just a function of time. The non-cooperative prisoners' dilemma supergame cannot account for inter-

dependence existing at any point in time. Acknowledgement of nonseparability of this sort leads to an assurance problem, rather than a non-cooperative prisoners' dilemma. Although an infinite number of iterated prisoners' dilemmas opens the possibility of multiple cooperative equilibria, these supergame equilibria are not robust. In each iteration or "ordinary game," the choices of the players are still modeled as independent. Extensions in the attainable set due to cooperation in any particular iteration are therefore unachievable, since independent choice has restricted the attainable set in each iteration to the non-cooperative area, shown above in Figure 2 of Chapter I.

Thus the interdependence of the supergame is described only in terms of the single dimension of time. Although undoubtedly of major importance, this dimension is not sufficient to allow a description of cooperative rule-making. Even if Robinson Crusoe was aware of the passage of time, his perception of the prior actions of others, and a decision to base his choices on these actions, would require a game in which the strict dominance of individual strategy was absent. As long as strict dominance characterizes each ordinary game, institutional rules are unstable.

What is needed is a broader definition of interdependence, in which extensions in the attainable set are possible via cooperative rules at each point in time. Because of the possibility of coordinated choice, other people matter, as do their choices to cooperate or not to cooperate. The uncertainty arising from this interdependence and the gains to be had in the present, as well as in future periods from cooperation provide a clear rationale for the evolution of institutional rules.

In fact, Taylor has implicitly added more to the prisoners' dilemma than the simple passage of time. The conditional strategies of the supergame are based on the prior choices of others, and on expectations of future choices. This implies the absence of a dominant strategy for each agent, which by the argument of Chapter I, sections 7 and 8, further implies nonseparabilities between individual agent's choices. Hence interdependence and expectation enter Taylor's analysis not only in terms of the passage of time, but also between agents in time. This suggests that the analytic structure proposed by Taylor cannot be a prisoners' dilemma game, characterized by strictly dominant strategies. It must be something else.

In order to see the problems which this inconsistency causes, it is only necessary to examine the extreme fragilty of Taylor's conditions for cooperative equilibrium. First, note that such cooperative equilibria are described as a direct function of coordinated expectations of the choices of others, implying nonseparability and the absence of dominant strategies. Taylor states:

> An equilibrium, then, is such that, if each player expects it to be the outcome, he has no incentive to use a different strategy. Thus, if indeed every player expects a certain equilibrium to be the outcome, then it is reasonable to suppose that this equilibrium will in fact be the outcome. But a player may have reasons for expecting that a certain equilibrium will not be the outcome. Then he might not use his equilibrium strategy and the equilibrium will not be the outcome (p. 30).

Note that the reasons for players to hold these expectations cannot be a function of time alone, but must be the result of the expected actions of other players. This suggests that the supergame must be composed of ordinary games which cannot be characterized by strictly dominant strategies, since the expected actions of others must enter the first-order conditions of the players in each ordinary game. Therefore, the ordinary games cannot be prisoners' dilemmas.

Elster has summarized the inconsistency involved in noting:

> [T]he conditions under which this [Taylor's cooperative] equilibrium point, assuming it to be the solution, will actually be realized are such as to make it likely that the underlying game will have been transformed into something different from the Prisoners' Dilemma. The conditions which ensure a way out of the dilemma also do away with the dilemma itself (p. 143).

Elster argues that the cooperative structure of the assurance game holds greater promise as a description of the problem at hand (Elster, pp. 18-40).

Hence, although Taylor asserts that it is time which does the work of generating cooperative equilibria, it is apparent that it is coordinated expectations, or assurance, which allows such a result. Yet because the presumption of a prisoners' dilemma structure is retained, the cooperative equilibrium arising from concerted expectations proves fragile, if achievable at all.

To see this more formally consider the strategies open to players of Taylor's prisoners' dilemma supergame in the two-person case:

$A_\infty$: Cooperation (C) is chosen until the other player defects (D), after which defection (D) is chosen in all succeeding iterations.

$A_k$: Where k is a strictly positive integer, cooperation (C) is chosen in the first game and thereafter so long as the other player chooses (C) in the previous game; if the other player defects (D), then (D) is chosen for k games, after which C is chosen again until the other player defects, after which D is chosen for k+1 games. The point is that the number of games in which the other player is punished for defection increases by one each time, after which there is a return to C. $A_k$ is assumed to include $A_\infty$.

B: Cooperation (C) is chosen in the first game; thereafter the choice in each game is that of the other player in the preceding game.

B': Defection (D) is chosen in the first game; thereafter the choice in each game is that of the other player in the preceding game.

$C^\infty$: Cooperation (C) is chosen in every game.

$D^\infty$: Defection (D) is chosen in every game.

Strategy $A_\infty$ involves an attempt to "teach" others to cooperate, at least until wronged, after which the player is vengeful and defects. This strategy is assumed to be a subset of strategy $A_k$, however. Strategies B and B' are often known as "tit for tat" strategies (see Axelrod and Hamilton, Axelrod, Rapoport). In these strategies, no attempt to "teach" is made. $C^\infty$ and $D^\infty$ are the strategies familiar from the discussion of the prisoners' dilemma in Chapter I. $A_k$ is a modified "tit for tat" strategy with the extra provision of punishment for defection. The prisoners' dilemma payoff matrix facing each player in each iteration is as follows:

| | | Player 2 | |
|---|---|---|---|
| | | C | D |
| Player 1 | C | x,x | z,y |
| | D | y,z | w,w |

where $y > x > w > z$.

The last, critical element introduced by Taylor is pure time preference. The value at time t=0 of a payoff $X_t$ to be made at time t (at the end of the $t^{th}$ game) is $X_t(a)^t$, where (a) is the discount parameter and (1-a) the discount rate for a given player, such

that $0 < a < 1$. The introduction of pure time preference acts as the apparent foundation of Taylor's claims. After a lengthy technical analysis, Taylor shows that the "tit for tat" strategies $A_k$ and B offer the possibility, in combination, for cooperative equilibria. Cooperative equilibria can be achieved <u>if</u> certain combinations of strategies $A_k$ and B are pursued.

The critical necessary condition determining the possibility of cooperative equilibria is that the discount parameters of the players be greater than the ratio of differences in payoffs resulting from cooperation versus defection, given as:

$$(1) \qquad a_i > \frac{y-x}{y-w} \text{ for player i.}$$

Where this inequality holds cooperative equilibria are possible. The right hand side of this inequality may be termed payer i's <u>temptation</u> to defect (Taylor, p. 43). The quantity (y-x) is the increase in his payoff from defecting unilaterally. Note that as $a_i$ increases (i's discount rate falls) equilibrium solutions become more possible. Where discount rates are high, it pays individuals to "grab" y in the first game even though they get only w in succeeding games. Finally, note that the ratio $\frac{y-x}{y-w}$ must lie between -1 and 1. If an

individual's temptation ratio is 1, then a discount parameter (a)<1 is sufficient to preclude cooperation. For example, if (a) = .9, then (1-a) = .10 and a discount rate of .10 would be sufficient to preclude cooperation. If the temptation ratio is less than 1, say .75, a discount parameter of less than .75, implying a discount rate of .25 or above, is sufficient to preclude cooperation, and so on. In sum, the likelihood of cooperative solutions is a function of the payoffs to defection (temptation ratio) and the discount rate (1-a) being comparatively low for each player.

It is apparent that there is more involved here than time and pure time preference. Pure time preference, given in the left hand side of (1) by the discount parameter (a), is not a sufficient condition for the possibility of cooperation. This possibility rests on the relation between (a) and the right hand side of (1). But the right hand side of (1) is a function of the terms w, x, y, z in the payoff matrix. The magnitude of these terms in any given iteration is in turn clearly a function of choices made by others in previous iterations. Cooperation involving strategies $A_k$ and B in the first t-1 games will determine the temptation to defect in the $t^{th}$ game, since the magnitude of the temptation will not be invarient to past choices.

Hence, the choice of a cooperative strategy by player i is conditional on previous cooperation by the other (N-1) players. This is not simply temporal interdependence: it is interdependence between players. As Taylor notes:

> The Cooperation of all players is thus possible, but precarious: there must be players whose Cooperation is conditional upon the Cooperation of all other players (p. 50).

If each player is assured that $A_k$ or B will be the strategy pursued by others, then each will also pursue that strategy, and a cooperative equilibrium will result. On the other hand, if each player expects others to choose B' or D, the result is mutual defection ($D^\infty$, $D^\infty$) throughout the supergame. These results follow the analytic structure of the assurance game precisely. What Taylor fails to see is the importance of endogenous institutional rules in setting these expectations. In part because his purpose is a defense of anarchy, and largely because of the restrictions imposed by the prisoners' dilemma, institutional rules are treated as exogenous, as in the single prisoners' dilemma.

Hence, although a necessary condition for achieving a cooperative equilibria is satisfaction of (1),

this condition is not sufficient. It depends implicitly on previous outcomes of the game, and therefore on the actions of others, leading to the problem of coordinated expectations. The achievement of cooperative equilibria depends on expectations of the likelihood of cooperation by others. But there is no basis within the analytic structure of the prisoners' dilemma, with its presumed separability of choice, for expectations formation. This is so regardless of the number of iterations.

Indeed, the problem of the rate of time preference (1-a) being sufficiently "low" must itself be considered in relation to the more general issue of separability. For if the strict dominance of individual strategy arising from separable choice characterizes the decisions of the players, the choice of a rate of time preference is itself a prisoners' dilemma (Sen, 1967). An incentive to "grab" implies a low discount parameter (a). This strategy will always dominate where choices are separable so that (1) will never be satisfied. If, on the other hand, the problem is a nonseparable one of assurance, then institutional rules may act to parameterize expectations to promote cooperative equilibria.

The limitations of Taylor's model are thus evident. It may be true that current strategy choices are conditional on past choices; but this does not imply the existence of a mechanism for future choices. The problem of the likely choice of others must be introduced from outside the prisoners' dilemma game, even if it is a supergame. Institutional rules are still modelled as exogenous, despite the introduction of time. The independent decision calculus of a single such game is not overcome by an infinite number of iterations (Nurmi, 1977b, p. 46).

In sum, the role of expectations introduced by Taylor cannot be shown to follow from conditional strategies without explanation of some mechanism describing expectations formation. No such mechanism is possible where each ordinary game is a prisoners' dilemma, since the actions of others in that game do not influence the choices of the players.

The problem of coordinated expectations and cooperative institutional rules thus emerges as of higher order than the explanation of cooperation advanced by Taylor. Although he acknowledges the existence of such problems (pp. 42, 62, 75, 122-124), he treats issues of individuals seeking public goods as repeated prisoners' dilemmas. Yet his entire argument

for the choice of cooperative strategies $A_K$ and B in the prisoners' dilemma supergame depends on the coordination of these expectations.

## 2. Axelrod and Hamilton

The recent work of Axelrod and Hamilton, in which a finite number of iterations is introduced as a modification of the supergame, leads to analogous problems. In these models, the non-cooperative assumptions of the prisoners' dilemma are retained, but an additional parameter, w, is introduced which specifies the probability that after the current iteration of the supergame the players will meet again (Axelrod and Hamilton, p. 1392). With w sufficiently great, the dominant strategy of defection breaks down, and a multiplicity of possible strategies become candidates for equilibrium. It is then shown that a "tit for tat" strategy may emerge as a cooperative equilibrium. This assumes that the individual cooperates in the first iteration, then follows the choice of the other player(s). This is cooperative strategy B as described by Taylor. "Tit for tat" is then argued on empirical grounds to be robust, ultimately dominating other rules.

However, w is an ad hoc, exogenous element, which must be introduced from outside the prisoners' dilemma supergame for cooperative equilibrium to emerge. In a description of simultaneous and sequential iterated prisoners' dilemma, Axelrod and Hamilton (p. 1396, n. 21) note:

> [C]ooperation on a tit-for-tat basis is evolutionarily stable if and only if w is sufficiently high. In the case of sequential moves, suppose there is a fixed chance, p, that a given interactant of the pair will be the next one to need help. The critical value of w can be shown to be the minimum of the two side's values of A/p(A+B) where A is the cost of giving assistance, and B is the benefit of assistance when received.

The necessary conditions for cooperative equilibrium with "tit for tat" are shown to be:

(2) $w > (T-R)/(T-P)$

(3) $w > (T-R)/(R-S)$

in a prisoners' dilemma supergame for player 1 of form:

| | | Player 2 C | Player 2 D |
|---|---|---|---|
| Player 1 | C | R | S |
| | D | T | P |

Here, (C) and (D) are cooperation and defection, as before, and:

R = Reward for mutual cooperation;

S = Sucker's payoff;

T = Temptation to defect;

P = Punishment for mutual defection.

Like inequality (1) above, inequalities (2) and (3) are the restrictions which must be fulfilled if any cooperative solution is to emerge. Again, the right hand sides of (2) and (3) are a function of past games, so that a "high" value of T can be expected with a history of non-cooperation. Hence, as in Taylor's model, cooperation must precede cooperation if a cooperative equilibrium is to emerge.

Finally, w is a way of introducing expectations, this time of future meeting, into the solution of the problem as an exogenous element. Again, no mechanism of expectations formation is provided, nor can one be provided which is consistent with the independent calculus of the prisoners' dilemma, regardless of the number of iterations.

### 3. Berman and Schotter

In a variety of recent contributions, Andrew Schotter and several colleagues have attempted to apply non-cooperative supergames to problems of public goods provision (Schotter; Berman and Schotter, Schotter and Schwodiauer). In a recent survey (1980, p. 41) Schotter and Schwodiauer argue that "it is in the design of institutions and their stabilitity properties that game theory offers a natural tool for analysis." In a subsequent study, Berman and Schotter argue that social institutions can be represented "as the non-cooperative Nash equilibrium of the supergame defined by the infinite iteration of the same simple public goods provision game we will define" (p. 2). The model they propose depicts the process of institutional evolution as a Markov chain defined in the "state space of societal norms," resulting from the iteration of a supergame (p. 2). The supergame, like the cases considered above, is an iterated prisoners' dilemma.

The specific problem considered is the truthful revelation of preference for a public good, in which true revelation acts as the counterpart to the strategy of cooperation in the models considered above. Hence to lie is to defect. The payoff matrix to a particular

player in a single iteration takes the now familiar form below.

| | | Player 2 | |
|---|---|---|---|
| | | Truth | Lie |
| Player 1 | Truth | TT | TL |
| | Lie | LT | LL |

As in the cases above, the choice ordering for player 1 is such that LT > TT > LL > TL. The choice ordering for player 2 is such that TL > TT > LL > LT so that the game is the standard prisoners' dilemma with attendant dominant strategies in each game.

Given the alternative supergame strategies open to the players, Berman and Schotter than set out the possible pairing of strategies to determine which are stable and under what conditions. Unlike Taylor and Axelrod and Hamilton, however, they explicitly identify possible pairings of strategies as candidates for "conventions of behavior" or "social institutions" (Berman and Schotter, p. 8, Schotter). With four alternative strategies available to each player, sixteen possible conventions or institutions are possible, leading to a "supergame of a supergame." Players may then be

absorbed into a state described by one of these conventions through the Markov process.

While extremely similar to the analysis of Chapter I, this approach again faces the inconsistency arising from attempts to explain cooperative behavior inside the structure of a non-cooperative game, albeit iterated an infinite number of times, and raised to another order to describe the evolution of rules. Although it goes beyond the work of Taylor and Axelrod and Hamilton by identifying the critical function of institutions, the possibility of a cooperative equilibrium appears equally fragile. As in the foregoing models, the critical role is played by expectations, implying a nonseparable problem of choice in which the dominant strategies of the prisoners' dilemma are not appropriate. The critical function of coordinated expectations in establishing a cooperative equilibrium emerges to define the function of institutions. Berman and Schotter note the fragility of the resulting equilibrium, however:

> It is also interesting to point out that our equilibrium has all of the properties of a fully rational expectations equilibrium since it depicts a state in which each player expects with probability 1 that the other will adhere to a particular convention of behavior and given these expectations, that is exactly what they indeed do. Hence at the equilibrium all expectations are self-fulfilled while out of equilibrium anything is possible (p. 19).

Despite a recognition of the role of institutional rules in providing information regarding the likely actions of others, this approach fails clearly to account for the evolution of coordinating mechanisms for individual choice. As before, in a non-cooperative prisoners' dilemma the strict dominance of individual strategy in each iteration, regardless of the number of iterations (or iterations of iterations) obviates the problem of expectations respecting the actions of others. Expectations have no place. Hence Berman and Schotter must be describing something other than a prisoners' dilemma game, which I have argued is one of assurance.

A final point concerns the use of Markov chains to describe the evolution of strategy pairs as conventions. In particular, the use of a (first-order) Markov process to describe this evolution suggests the implausible notion that all of the relevant information regarding others' adherence to institutional rules at time t is contained in the set received by the decision-maker at that time (Degroot, p. 63). Everyone always "knows what to expect."

The empirical inadequacy of this model as a plausible description of actual rule-making behavior, despite its mathematical elegance, has been clearly

demonstrated in experimental iterations of prisoners' dilemma games, although more complex models have shown better fit (Alker). Rapoport and Mowshowitz have demonstrated that prisoners' dilemma data, when analyzed in subsets of 50 consecutive iterations, is not a stationary first order Markov process. Its parameters appear to change. Rapoport and Chammah decisively reject the four-state Markov chain because it fails to account for the tendency to "lock in" to strategies of mutual cooperation. The mechanistic and irreversible character of Markov processes fails to capture the evolution of institutional rules. Alker notes:

> Looking at those pairs of responses associated with long CC (mutual cooperation) runs, it is very clear that the probability that a run of CC responses will end at any point is not constant: it increases as the lock-in phenomenon takes hold. . . . Voluntaristically inclined social scientists might say a pattern of non-enforced cooperation--a tacit social contract--had become partly institutionalized or that positive value integration has at least temporarily occurred. And they might be tempted to consider these results a more general methodological indictment of the relevance of simple Markovian structural models to their concerns (p. 213).

Berman and Schotter attempt to explain institutional rules as a result of absorption in conventions arising from of the supergame of supergames. Despite

the difficulties of Markov process models, their model in some ways resembles the more complex efforts of Emshoff (1970). They nonetheless fail to escape from the non-cooperative structure of the prisoners' dilemma and to come to terms with the problem of assurance, in the face of uncertainty respecting the actions of others.

## 4. Conclusion

The foregoing analysis suggests the restrictiveness of the prisoners' dilemma as an approach to strategic interdependence, regardless of its iteration over time. Despite the clear advances of Schotter and colleagues, the absence of a mechanism describing the role of rules providing endogenous coordination of individual expectations suggests that a more general theory is needed, set apart from the separable choice and dominant strategies of the prisoners' dilemma (Faith and Thompson).

The interdependent choice modelled by the assurance problem arises in virtue of the nonseparable nature of the decision making process. Expectations of others' choices enter each individual's decision problem in the course of a single assurance game, or coordination problem. Incentives for cooperation exist in each such

game, so that even at a given point in time, incentives exist to forge institutional rules which will coordinate individual choice and extend the attainable set of possible solutions.

In the more realistic case in which the assurance problem is iterated over many periods, the benefits to cooperation via institutional rules, paramaterizing the expectations of each regarding the actions of all, are even more obvious. Perforce, the gains over time resulting from institutional rules providing a requisite level of assurance suggest that the iterated assurance problem is an even more powerful description of the evolution of cooperative institutional rules.

In the next chapter, the dynamic element of time will be introduced in order to demonstrate the role of institutional rules as mechanisms for the coordination of individual expectations inside the structure of the assurance problem. An explanation of this institutional mechanism will be provided by returning to the problem of overgrazing and common property externalities.

# CHAPTER III

# THE ANALYTICS OF ASSURANCE

## 1. A Rational Decision Framework

This chapter continues the analysis of a group of cattle owners grazing a common range. Each individual is willing to stint on the range as long as he is persuaded that his own efforts to preserve the range are not in vain--that the other grazers will not attempt to free ride on the commons and will stint too.

As argued in Chapters I and II, in each period the nonseparable externalities of the common range tie the welfare and the decision making of each individual to the others. The grazing decision of each is predicated on an expectation of this behavior. This interdependence means that rational, self-interested decisions must include reference to the likely behavior of others. In such a nonseparable choice problem, expectations can be coordinated via a stinting rule specifying a particular "donation" to the public good of range quality.

The simplified analysis of Chapter I presented the assurance problem of the commons as a binary choice between stinting and overexploitative grazing. Yet the decision to stint is not an either/or proposition. It

admits of gradations. As in the supply of any public good, individual contributions may take on a whole range of values. At one extreme, it is possible to imagine a single member of a group carrying the whole burden of maintaining a public good by contributing to the limit while all others ride free. In a common grazing area, this situation might arise if by abstaining from grazing one individual carried the burden of range quality, while all others grazed at maximum capacity. At the other extreme, it is possible that all N-1 members of the group are doing their share, but that one individual seeks to ride free alone.

Just as stinting for one individual can vary hypothetically between full provision of range quality and free rider behavior, so can the expected stinting behavior of others. From the perspective of the individual grazer, the likely aggregate behavior of others admits of varying degree of certainty. As anyone who has been asked to predict behavior knows, such estimates are highly subjective, and incline one to think in terms of a range of possible outcomes.

The range over which the anticipated contribution to a public good is expected to vary, and the weight attached by the observer to the alternative possibilities along it, depend on information. For example, an

individual may be reasonably sure that his neighbor or a kinsman may stint if he does, but less sure about a member of another tribe or village. Hence assurance regarding the net likely behavior of others is due to information conveyed by the existing state of institutional rules which reduce uncertainty. A given individual's subjective probability estimate of the behavior of others is thus a function of institutional rules.

Let $P_i$ be the subjective probability attached by individual j to the possibility that the other grazers on the common range will graze on net at level i. Suppose that it is possible to identify the carrying capacity of the commons in the face of grazing pressures imposed by increasing numbers of cattle in a group of fixed size. Let grazing pressure imposed by others range from a value of 0, which indicates that the range is being completely depleted, to a value of k, which indicates that the precise number of cattle is being grazed which maximizes herd weight without depleting the commons. Individual j faces the same choice as all other grazers. He can graze at a level which makes him a free rider or he can stint. We will call his level of stinting his "donation" to the preservation of the range, or D. The donation by j may take any value from the

overexploitative extreme 0 to some opposite extreme, say n. Note that in contrast to the analytic structure of the property rights school, in which 0 dominates all other strategies, here a range of options is open to j. No single option is given weight a priori, since no strategy is dominant.

This range of possible behavior allows us to develop an operational definition of assurance. In the preceding chapter assurance was defined as the absence of uncertainty respecting the likely behavior of others--as security of expectation. This assurance may be more precisely defined for each individual in terms of a prior subjective probability estimate of contribution to range quality by others. Each individual's donation in the form of stinting on the range (D), is a function of his expectation that the other grazers will also contribute. More formally, consider the following matrix adapted from Frohlich and Oppenheimer.

In this matrix, the costs and benefits to alternative joint actions are expressed in terms of utility units. It is assumed that each individual has a twice differentiable utility function defined over consumption of goods and services derived from cattle production, and therefore range quality donations in terms of grazing pressure. Later, additional content will be given

to this utility function in the form of reputation and other arguments reflecting the interdependence of choice (see Section 5, this chapter).

THE INDIVIDUAL'S DECISION-MAKING MATRIX REGARDING POSSIBLE DONATIONS TO RANGE QUALITY BY "STINTING."

Total Resources Contributed by Others

Range of j's Possible Donations

| | 0 | 1 | ... | i | ... | k |
|---|---|---|---|---|---|---|
| 0 | $U_0$ | $U_1$ | | $U_i$ | | $U_k$ |
| 1 | $U_1-1$ | $U_2-1$ | | $U_{i+1}-1$ | | $U_{k+1}-1$ |
| . . . | | | | | | |
| D | $U_D-D$ | $U_{D+1}-D$ | | $U_{i+D}-D$ | | $U_{k+D}-D$ |
| . . . | | | | | | |
| n | $U_n-n$ | $U_{n+1}-n$ | | $U_{i+n}-n$ | | $U_{k+n}-n$ |
| | $P_0$ | $P_1$ | | $P_i$ | | $P_k$ |

Probability j assigns to the possibilities that the contributions of others will aggregate to the specified sum.

(Adapted from Frohlich and Oppenheimer)

Reading across the top from left to right, the columns 0, 1, ... i, ... k indicate the range of possible contributions to the preservation of the common grazing area which j expects by others. As stated, k represents a level of stinting associated with the maximum common welfare, while 0 represents free rider behavior in which others graze at an overexploitative level. At the bottom of each column in the matrix, $P_0$, $P_1$, $P_i$, ... $P_k$ are the probabilities corresponding to the expected level (by j) of possible contributions by others.

The row entries along the left-hand side of the matrix, reading 0, 1, ... D, ... n represent the range of possible behavior by individual j. Possible contributions cover the range from 0 to n. The entry D is a representative donation by j to range quality.

Therefore, the $i^{th}$ column represents the case where the others donate by stinting at level i, and the $D^{th}$ row represents the case where j donates by stinting at level D. The $D^{th}$ entry in the $i^{th}$ column is the net benefit that accrues to j in utility terms if he grazes at level D when the others graze at level i. Consistent with the assurance problem in grazing, the payoffs to any individual from contributing by stinting on the range are a function of the aggregate grazing behavior of

others. Hence, the $D^{th}$, $i^{th}$ entry in the matrix is the utility j derives from having (i + D) as the overall level of grazing pressure on the common range. Since D is his stinting donation, it may be thought of as a cost of his contributing to range quality. His total payoff in this case is therefore $(U_{i+D} - D)$.

Individual j's estimate of the probability that total grazing pressure by others will amount to level i is given as $P_i$. It is now possible to formulate a rational decision rule for each individual in the group which will allow a discussion of the interdependence, uncertainty, and consequent need for assurance associated with institutional rules. The expected utility to j of each alternative level of grazing by him, given by the rows (0, 1, ..., D, ..., n) is the sum of the payoffs across each row. For example, the expected utility to j of grazing at level D, which we will call $V_D$, is:

$$(1) \quad V_D = (U_0-D)\,P_0 + (U_{D+1}-D)\,P_1 \quad \ldots +$$

$$(U_{i+D}-D)\,P_i \ \ldots + (U_{k+D}-D)\,P_k$$

which we get by adding each entry multiplied times its subjective probability in row D from left to right. This may be simplified to:

$$(2) \quad V_D = \sum_{i=0}^{k} U_{i+D} P_i - D$$

Note that $V_0$, the expected utility of free riding by making no donation is:

$$V_0 = [(U_0 P_0) + \ldots (U_1 P_1) \ldots + (U_i P_i) \ldots + (U_k P_k)]$$

This may be simplifed to:

$$(3) \quad V_0 = \sum_{i=0}^{k} U_i P_i$$

given by the sum of payoffs in row 0. Expressed in terms of the grazing problem, rational self-interested behavior involves choosing the largest of the $V_D$'s (Frohlich and Oppenheimer). This choice is clearly a function of the probabilities attached to the behavior of others, given by the terms $P_0$, $P_1$ ... $P_i$ ... $P_k$ at the bottom of the matrix. Examining his range of choice from 0 to n, individual j should graze at a level such that the expected utility of benefits from grazing on the commons exceeds the cost of stinting, given as D. By choosing the largest of the set ($V_0$, ..., $V_D$, ..., $V_n$) individual j would stint (assuming $P_i$ and D are continuous) so long as:

$$(4) \quad \partial V_D > 0.$$

This behavior would stop when

$$(5) \quad \partial V_D = 0.$$

This assumes second-order conditions for a maximum are satisfied.

Hence, if j stints on the range at all ($D \neq 0$), it must be the case that the expected utility of stinting at some level exceeds that of exploitative overgrazing given as $V_0$. That is:

$$(6) \quad V_{D\neq 0} > V_0.$$

For emphasis, it should again be noted that ($V_0$, ..., $V_D$, ..., $V_n$), the expected utilities of alternative grazing behavior, are all functions of subjective probability estimates of the grazing behavior of others, confirming the nonseparability of choice characterizing the assurance problem in grazing.

Decision rule (6) may be expressed in terms of equation (2). That is:

$$(6) \quad V_D > V_0$$

implies that

$$(7) \quad (V_D - V_0) > 0.$$

From (2) and (3), (7) implies

$$(7a) \quad \sum_{i=0}^{k} U_{i+D}P_i - D > \sum_{i=0}^{k} U_iP_i$$

or

$$(7b) \quad \sum_{i=0}^{k} U_{i+D}P_i - \sum_{i=0}^{k} U_iP_i > D$$

or

$$(8) \quad \left(\sum_{i=0}^{k} \Delta U_iP_i\right) > D$$

Inequality (8) may be given a precise interpretation. The left-hand side is the change in the expected utility of grazing due to improved range quality resulting from individual j's stinting donation. The right-hand side is the cost of this stinting donation: D. Grazer j will stint if benefits exceed costs. As this formulation makes clear, j's decision to stint is rational and self-interested, but also directly conditional on his expectation of the behavior of others at any point in time.

In addition, this nonseparable formulation supports possible donations by j anywhere along the range from 0 (free rider behavior) to n (full contribution). No strategy of contribution to range quality is dominant.

This result is consistent with the notion of multiple equilibria possible in the cooperative context of the assurance problem, in which a variety of solutions to grazing behavior are possible depending on the nature of mutual expectations. It is also consistent with empirical evidence which shows contributions to public goods falling in the interval between 0 and k, rather than being concentrated at 0, as predicted by the dominant strategy of defection in the prisoners' dilemma and the "strong" free rider hypothesis (Brubaker). These empirical results will be discussed in detail in Chapter IV.

In contrast to the prisoners' dilemma and the prisoners' dilemma supergame strategies of Chapter II, this simple formulation provides an analytical foundation for the treatment of the assurance problem facing a group of interdependent individuals at any point in time. It gives more exactitude to the process of decision in the assurance problem. Given fixed utility, if the probability of contribution at a certain level by others is of a certain order, then j will also find it beneficial to contribute at approximately that level. This is similar to what was referred to in Chapter II as a conditional "tit for tat" strategy. Here, however, the motivation for such a strategy arises endogenously

from the rational decision framework of the assurance problem. The role of institutional rules in this framework is to concentrate the probability of certain actions by others around a particular level of stinting.

The way in which institutional rules do this may be shown formally, following an exposition by Brams (1975). Assume that j considers the actions of others in terms of a representative other grazer, z. Assume for simplicity that the options available to each grazer are, as in Chapter I, restricted to two choices: overgrazing and stinting, given as 0 and D and 0 and i respectively. As before, 0 amounts to free rider behavior, while D and i correspond to stinting for j and for z, respectively.

These simplifications amount to a reduction in the decision facing j to a 2x2 matrix. If j and z both stint, following strategies D and i respectively, then the range is preserved. If, on the other hand, both attempt to free ride, following strategies 0 and 0 respectively, the range will be overexploited.

Grazer j contemplates choosing either 0 or D knowing that grazer z can correctly predict his choice with probability p and incorrectly predict his choice with probability (1-p). Similarly grazer z, facing a choice between 0 and i, knows that grazer j can correctly pre-

dict his choice with probability q and incorrectly predict his choice with probability (1-q).

It is now possible to show that by adopting an institutional rule, either player can induce the other to choose his cooperative stinting strategy. This demonstration is based on the expected utility criterion described above. The critical requirement is that the institutional rule must make the subjective probabilities p and q sufficiently large. Note that this probability, unlike the ad hoc notion of "meeting again" or of certain orders of time preference discussed in Chapter II, arises naturally from inside the assurance game.

If grazer j bases his judgment on the information conveyed by an institutional rule which predicts that the others will cooperate and stint, then he will stint too. If he feels a correct prediction of this behavior cannot be made (i.e., p is too small) then he will free ride. The institutional rule acts to parameterize expectations as a group tool of prediction, providing assurance respecting the actions of others.

To see this, consider the 2x2 representation of the matrix facing grazer j.

| | | z's grazing strategy | |
|---|---|---|---|
| | | 0 | i |
| j's grazing strategy | 0 | $U_0$ | $U_i$ |
| | D | $U_D$-D | $U_{i+D}$-D |

With mutual predictability arising from the existence of an institutional stinting rule, any thoughts by j of defecting and choosing strategy 0 would almost surely be detected. The existence of the institutional rule, in Schelling's phrase, leads to the "pain of conspicuousness" if it is broken (Schelling, p. 91).

Assume that grazer z acts in accordance with such an institutional rule. Then if j chooses cooperative stinting strategy D, z will predict this choice with probability p and hence will choose stinting strategy i with probability p and free rider strategy 0 with probability (1-p). Thus, given conditional cooperation on the part of z, j's expected utility from choosing stinting strategy D will be:

$$(9) \quad V_D = (U_{i+D} - D)(p) + (U_D - D)(1-p)$$

On the other hand, if grazer j chooses defection and free rides, following strategy 0, grazer z will <u>incorrectly</u> predict this choice and hence will choose strategy i

with probability (1-p) and free rider strategy 0 with probability p. Hence, j's expected utility from free riding will be:

$$(10) \quad V_0 = U_i(1-p) + U_0(p).$$

Note that the expected utility of stinting is greater than that of free riding when p, the probability of a correct prediction by z, is large. That is:

$V_D > V_0$ when:

$$(11a) \quad (U_{i+D} - D)p + (U_D - D)(1-p) > U_i(1-p) + U_0(p)$$

or

$$(11b) \quad (U_{i+D} - D - U_0)(p) > (U_i - U_D + D)(1-p)$$

or

$$(11c) \quad \frac{p}{1-p} > \frac{U_i - U_D + D}{U_{i+D} - D - U_0}$$

Hence, in order for $V_D$ to be greater than $V_0$, p must be sufficiently large. This will be the case where the conditional cooperation given by the institutional rule correctly predicts the behavior of others. Institutional rules which correctly predict the behavior of others thus offer their own incentive to be kept, since they lead to

Pareto-Superior solutions to the grazing problem. In sum, the grazing strategy of j will be the result of an interdependent or nonseparable choice. This choice may nonetheless be described as the outcome of a rational, self-interested decision process. The choice of a grazing strategy will be a function of j's expectation of the likely grazing behavior of others, as shown in inequality (8). In addition, it will be a function of the accuracy with which institutional rules predict behavior, given by the relative magnitude of p versus 1-p in inequality (11c).

In this precise sense, institutional rules provide assurance respecting the actions of others, by parameterizing the subjective distribution describing the range of expected behavior. Institutions thus lend accuracy to expectations in an uncertain world. It is to the manner in which institutional rules perform such an informational function in a dynamic context to which we now turn.

## 2. Information, Subjective Probability, and Institutions

The strict dominance of individual strategy of the prisoners' dilemma suggests that j will make no donation to the common welfare, so that D = 0 not only for j but

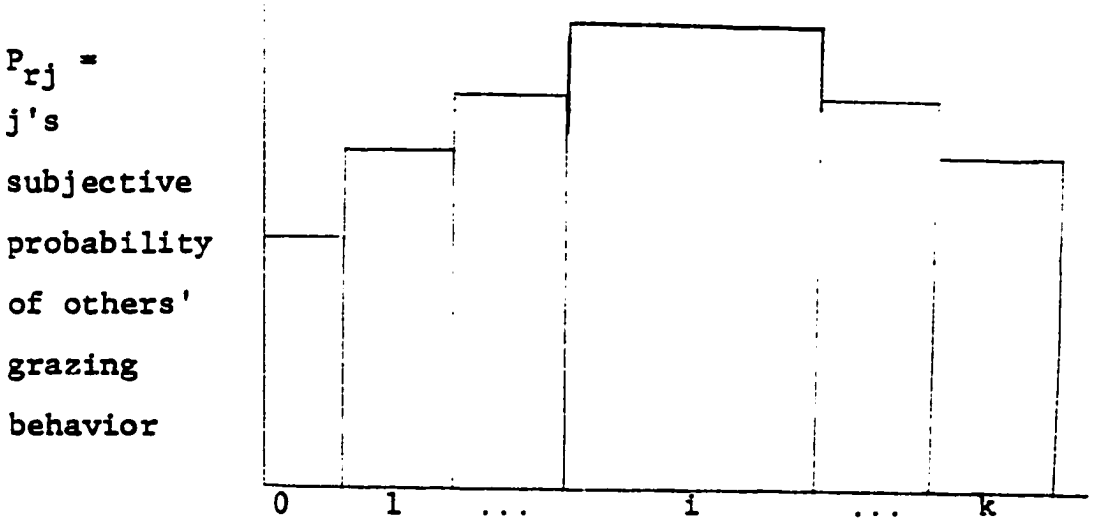
for every individual. All will act as free riders. But if the nature of the grazing problem is one of interdependence, a much richer set of questions and problems arises respecting the prior estimation by j of the set of probabilities ($P_0$, ..., $P_k$) associated with the range of choice of others. It is now possible to examine the nature of these choices, and the influence of institutional rules on them in reducing uncertainty and providing assurance. Recall that our representative individual j faces a problem of coordinating his own behavior with the expected grazing behavior of others so that, in terms of (8):

$$\left(\sum_{i=0}^{k} \Delta U_i P_i\right) > D$$

if stinting is to occur. Satisfaction of this inequality is necessary if j is to behave rationally in this collective context.

Hence, j's problem is to settle on a level of stinting on the commons which does not redound to his disadvantage in terms of the actions of others. This judgment in turn requires that he evaluate his subjective estimate of aggregate grazing behavior by others. If the range of behavior by others were modeled discretely, j

might have a probability density function in mind something like the histogram below.




Range of Possible Grazing Behavior by Others

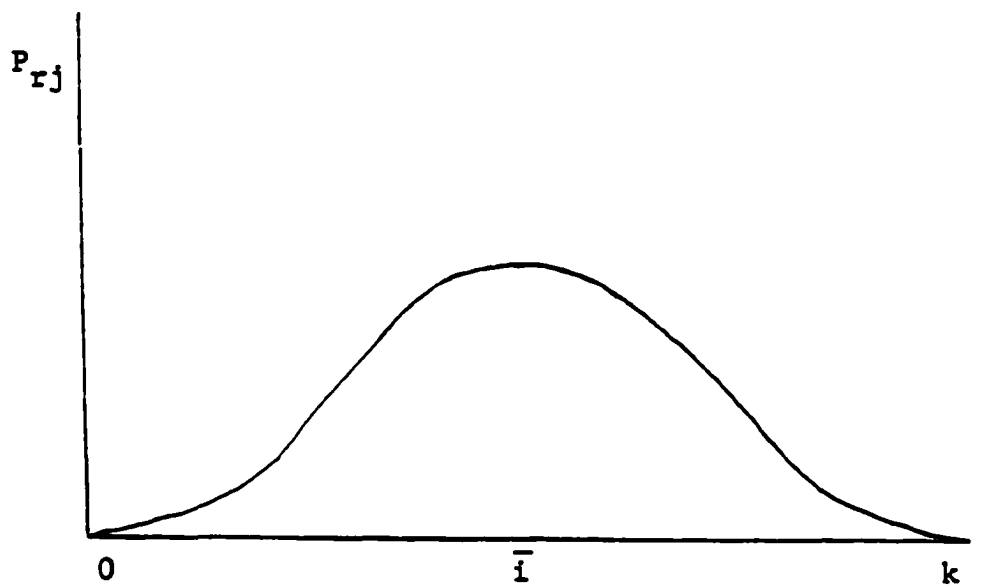
Figure 3.1

This histogram shows the subjective probability that j attaches to each of the discreet possible outcomes of grazing by others. Since the probability of their doing something is certain, the sum of possible outcomes given by the total area under the histogram must have a probability density of one.

The histogram shows that j believes that the other grazers are most likely to graze at level i, somewhere between 0 (complete free rider behavior) and k (maximum stinting behavior). If j responded to what he thought

was the most probable behavior (i in the histogram), he would then graze at whatever level between 0 and n satisfied inequality (8) given this information. But the area under i is less than the total area not under i. In other words, j is still uncertain regarding the likely behavior of others. It is for this reason that the accuracy of his prediction regarding this behavior is so important. The greater the accuracy of his prediction, the less uncertain he is, and the more probability is concentrated in a single column.

The problem is more easily considered in the continuous case, in which the subjective probability density function (PDF) for j appears as below.




Range of Grazing Behavior by Others

Figure 3.2

As is clear, j's problem is uncertainty respecting the probable behavior of others. This uncertainty, in the context of the grazing problem, is a direct function of j's information regarding the expected actions of others (Stigler, Schotter, Wunderlich, Boland, Marschak, 1971, 1974, Hirshleifer & Riley). The more uncertain j is, the more dispersed is the density function in Figure 3.2. This dispersion is a manifestation and a measure of ignorance respecting the probable actions of others. Looking again at the histogram in Figure 3.1, if j's subjective estimate of the probability that others would graze at level i was such that he was certain that they would do so, his own decision would be well defined by (8), since all of his subjective probability for others grazing at level i would be concentrated in one column of the histogram.

As originally demonstrated by Shannon (1948) and subsequently developed in the context of economics, the concepts of information, uncertainty and entropy bear a close relation (Marschak, 1974, Theil, 1965, 1967). One's knowledge about a particular question can be represented by the assignment of a certain probability to a particular outcome in a range of outcomes such as the grazing behavior of others. Complete certainty, or assurance, about a question is the ability to assign zero probability to all conceivable outcomes save one.

A person who (correctly) assigns unit probability to a particular outcome is clearly perfectly assured regarding the question, and is able to make a perfectly accurate prediction given his information. By observing that information can be encoded in a probability distribution, Shannon showed that it is possible to define information as anything that causes an adjustment in a probability assignment. Shannon termed the dispersion of such a distribution "entropy," and showed formally the equivalence between uncertainty and the entropy measure.

More formally, let X represent j's information about the expected grazing actions of others, given as the question Q. This knowledge, X, leads j to assign probabilities to the various possible outcomes. Assigning $P_i = 0$ to any outcome is the same as saying: "that outcome is impossible." Correspondingly, assigning $P_i = 1$ is the same as saying: "that outcome is certain." Shannon's measure may be represented symbolically by S(Q/X) to show that uncertainty or entropy S depends on both the well-defined question Q and the information X. Letting k represent an arbitrary scale factor, Shannon showed that:

$$(12) \quad S(Q/X) = -k\sum_{i=0}^{k} P_i \ell_n P_i.$$

That is, the answer to the well-defined question Q is given by summing over the product of the probability $P_i$ assigned to each outcome times the natural logarithm of that probability.

Shannon went on to define the information in a particular "message" as the difference between two "entropies" or levels of uncertainty: one that is associated with $X_t$ before the message and the other that is associated with $X_{t+1}$ after the message. In our analysis, an institutional rule is a "message," such that the information conveyed by the rule I, is given below.

$$(13) \quad I = S(Q/X_t) - S(Q/X_{t+1}).$$

It can be shown that (13) is formally equivalent to Clausius' classic formula for entropic degradion in a physical system, given below.

$$(14) \quad S' - S = \int_{X_t}^{X_{t+1}} \frac{\partial Qr}{T}$$

where a system again changes from a state described by $X_t$ to one described $X_{t+1}$. Here entropic change is described as (S'-S), equal to the integral arrived at by dividing each increment of heat addition ($\partial Q_r$) by the absolute temperature (T) at which the heat addition

occurs and adding the quotients over the change from state $X_t$ to the state $X_{t+1}$ (Tribus and McIrvine).

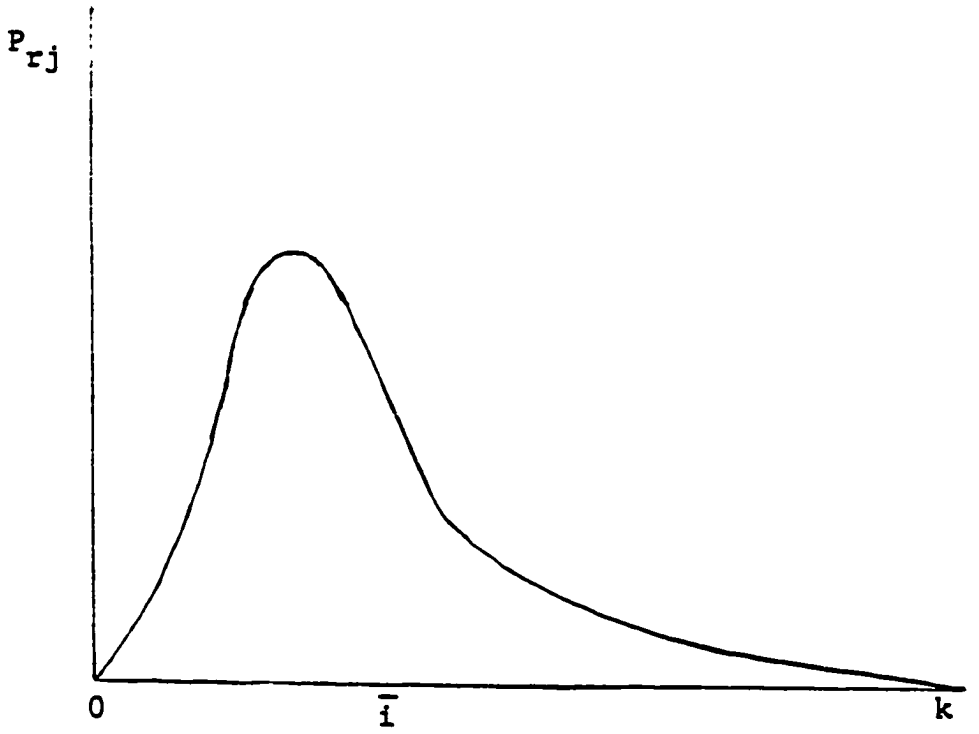
Since Shannon put forward this result, the entropy formula has emerged as the fundamental basis of information theory, the necessary starting point for reasoning about information systems in general. The proof that (12) and (14) are the same function, and not just analogues, has been developed in a series of papers by the theoretical physicist Leon Brillouin (1962). His results suggest a clear scientific basis for the analysis of institutional rules as information systems, or "messages." In this case, the message concerns the likely grazing actions of others, although the applicability of the approach is much broader (Boland).

An additional implication of the equivalence of physical entropy and informational uncertainty merits mention. The informational content of institutions is a purposive creation of individuals innovating these institutional rules. Information preparation, processing and distribution all require energy. "Institution building," as an informational enterprise, carries with it potential work involved in this energy expenditure. This allows a clear statement of the transactions costs of such institution building. These transactions costs

are a function of basic information relations, as recently suggested by Dahlman (1979).

Returning to the problem of overgrazing, the distribution of possible behavior by others around some mean level of stinting $\bar{i}$ suggests that j is uncertain, so that his own behavior is not well defined by (8). One might posit a "rational expectations hypothesis" at this point, arguing that j bases his decision on the mathematical expectation $\bar{i}$ to define inequality (8) (Muth). But to do so is to lose the essence of the role of institutions in providing assurance, which is associated with higher moments of the distribution in Figure 3.2 defining the variance and skewedness of the probability density function.

The less skewed the distribution in Figure 2 toward the left or the right and the less variance in the estimate around a mean estimate of others' behavior, the more accurate the prediction regarding the likely behavior of others. For example, if j's sense of the distribution is as in Figure 3 below, the bias of the distribution toward free rider behavior (0) will lead j to shift his grazing behavior in the direction of 0 too.




Range of Grazing Behavior by Others
Figure 3.3

Alternately, if j expects that the others are more likely to stint, grazing at levels closer to k, he will be more likely to stint himself. These results assume a uniform fixed utility function--an assumption which will be modified below.

The important point is to recognize the significance of the moments of this subjective probability density function. The mean $\bar{i}$ is j's expectation of the likely grazing behavior of others. The variance of the PDF reflects j's relative certainty. Skewedness reflects his "optimism" or "pessimism" regarding the

actions of others (see Keynes, pp. 152-64). The decision to stint is a function of all three moments. Together, these moments define the accuracy with which j can predict the likely behavior of others, much as in a standard forecasting exercise.

Information respecting the probable actions of others may shift the mean, alter the variance, as well as skew j's PDF toward the left or right. Information conveyed by institutional rules reduces the dispersion of the PDF, and the implied reduction in uncertainty increases the accuracy with which the actions of others may be predicted.

Institutional rules thus parameterize the PDF of the expected behavior of others. In this precise sense, they provide information, and therefore assurance, regarding these actions (Boland, Schotter). Whether institutions alter the moments of the PDF toward a distribution concentrated about free rider behavior or about stinting behavior is an empirical question, which I will consider in later chapters. The important point is that institutional rules act to provide information to members of a group which alters the moments of their PDF describing the likely behavior of others thus influencing the donation of each described as a solution to maximization of $V_D$, the expected utility of donating. Institu-

tions coordinate the expectations of each respecting the actions of all, in terms of the "message" conveyed by the institutional rule, given by equation (13).

## 3. Institutional Change: Prior and Posterior

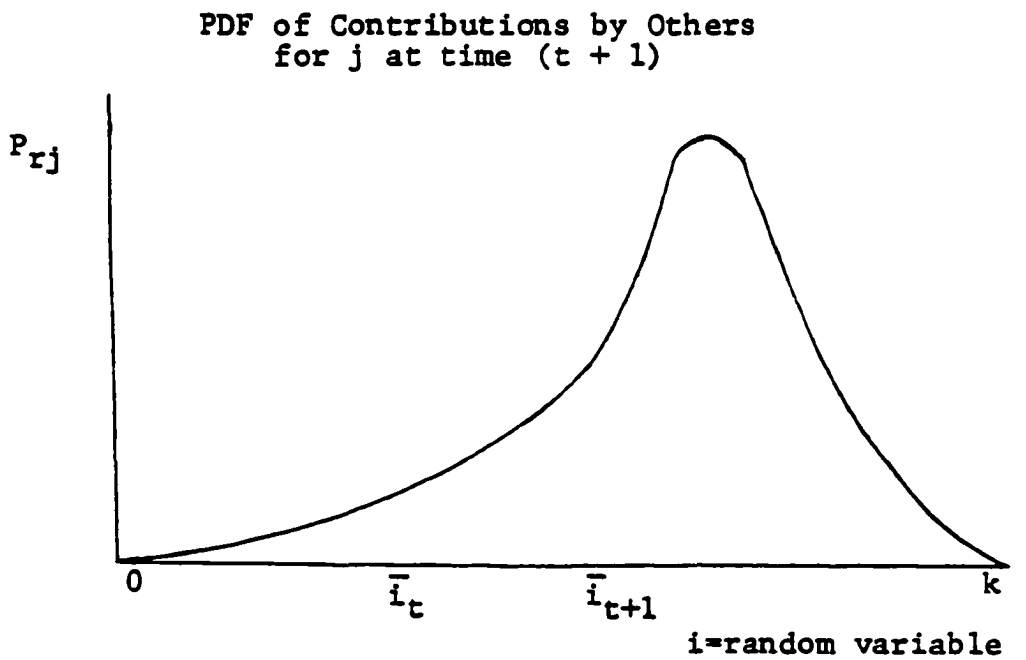
The approach outlined above describes the informational role of institutions in a static context. It is important to make it dynamic. Institutional change may be given formal dynamic expression in terms of Bayesian prior and posterior frequency distributions. These prior and posterior distributions may be thought of as two "periods" relating the behavior of j, our representative grazer, to the expected behavior of others. The "periods" correspond to the before and after notation $X_t$ and $X_{t+1}$ used in equation (13) above. In the first period, we will assume that j faces "diffuse," or "informationless" circumstances (Hays and Winkler, pp. 482-84). The classic example (due to L.J. Savage) of diffuseness concerns the determination of the weight of a potato. Given a potato, and asked to assess a distribution of its weight, one would clearly have some information, but of a rather vague nature. One would specify some limits within which the weight of the potato would surely lie, and one's distribution might have a peak, or

mode, somewhere within these limts. But it is doubtful that the distribution would have a sharp "spike" anywhere.

In the first period of the grazing problem, assume that j faces the same situation. In this "original position" (the logical counterpart to that developed by John Rawls (1971)), he knows that the level of grazing pressure by others will fall somewhere between 0 and k, but he is unsure exactly where it will fall. This is his first period "prior" distribution of the expected level of stinting by others. He requires further information in order to specify the moments of the distribution more precisely, reducing uncertainty respecting others' grazing behavior.

If one were to weigh a potato on a balance of known precision, the posterior distribution resulting from the acquisition of this sample information would be quite different from the prior "informationless" distribution. The posterior distribution is likely to be much less "spread out" or diffuse relative to the informationless prior. Although the sample size in this case is only one, assume that the precision of the balance is very high, so that the prior distribution is much more diffuse than the distribution resulting from the information gained by weighing the potato.

In the second period of the grazing problem our representative grazer j has gained analogous information respecting the likely behavior of others due to the adoption of an institutional grazing rule. The consequence may be to shift the likelihood of a particular level of grazing to some mean level $\bar{i}_{t+1}$. This is shown in Figure 4. Suppose i represents the level of grazing by others, a random variable ranging from 0 to k, and y again represents information regarding this level, analogous to reading the weight of the potato on the balance. Relative to the likelihood function P(y/i), the prior distribution $P(i_t)$ is relatively dispersed and flat.




Range of Grazing Behavior by Others
Figure 3.4

Bayes' Theorem states that the posterior probability, or the result of information gained between the first and second "periods" due to the rule, is equal to the prior probability times the likelihood function over the quantity given as the sum of the prior probabilities times their likelihood. If $P(i_t)$ represents the prior probability of others grazing at level i, and P(y/i) represents the likelihood function, based on the new information, the posterior probability, $P(i_{t+1}/y)$, is given as:

$$(15)\quad P(i_{t+1}/y) = \frac{P(y/i)\ P(i_t)}{P(y/i_0)\ P(i_0) + P(y/i_1)\ P(i_1) + \ldots\ P(y/i_k)P(i_k)}$$

where we assume that $(i_0 \ldots i_k)$ are all of the possible, mutually exclusive levels of grazing or stinting on the commons, ranging from 0 to k. Another way of putting this is to say that the posterior density function is proportional to the product of the prior density and the likelihood functions, where the denominator in (15) is given as a constant of proportionality or "normalizing integral" (Hayes and Winkler, p. 483). That is:

$$(16)\quad P(i_{t+1}/y) \propto P(i_t)P(y/i)$$

where the $\propto$ sign is read "proportional to." The informationless prior in the first period (or "original position") can be approximated by a constant function $P(i_t) = k$, resulting in a posterior density function which depends almost solely on the likelihood function resulting from new information, indicated in (17).

$$(17) \quad P(i_{t+1}/y) \propto kP(y/i)$$

Thus, new information concentrates j's distribution of the expected grazing behavior of others around some value, $\bar{i}_{t+1}$, reducing uncertainty by increasing the accuracy of expectation, or assurance, respecting these actions. One way in which j might obtain this information is to poll all of the other grazers in the group between the first and second periods. The problem with this approach, even assuming that each grazer accurately reveals his intended grazing level, is that it is time-consuming and expensive.

The informational efficiency of institutional rules reduces the costs of such a process. The incentive to innovate self-binding rules, over and above the extension possible in the attainable set of the group, arises from the reduced cost of information given the existence of such rules. It is noteworthy that in certain instances, it is regarded as important to proscribe special rules of

consultation with the group via polling or referenda (Black). But the costs of such devices make institutional rules which act as a "shorthand" for expectations more attractive. One such set of rules in the grazing context is common property (Dahlman, 1980). The transactions costs of maintaining different rule structures will vary. The appeal of alternative institutional arrangements will depend in part on the costs of their maintenance, as will be discussed below.

In an interdependent environment, therefore, a highly efficient way of correlating individual grazing strategies is to formulate cooperative rules respecting joint actions. These institutional rules then become the source, or "measure," providing accurate information respecting the likely actions of others. They are analogous to the balance used to provide information in the mundane example of the potato and convey a precise message in terms of information respecting the actions of others (see Adams and Rosenkrantz). It may not be coincidental that rules of fairness or justice are often personified by an individual engaged in weighing alternatives in a mechanism of balance.

Although the ana
ple two-period case,
many periods. Each p

characterized by a set of rules. This status quo ante will define the prior distribution through which agents apply Bayesian inference to the likely choices of others in subsequent periods. In each period, the existing state of institutional rules will provide prior information respecting the likely behavior of others, which will be conditioned on the sample information gained in the current period.

The examples provided so far suggest that institutional rules can reduce uncertainty by parameterizing expectations over time. Since they convey information, however, institutions are subject to the entropic degradation known to characterize all energy and information systems (Theil, 1974, Shannon & Weaver). In the dynamic context of institutional change, it is to be expected that institutional rules will exhibit negentropic properties, requiring maintenance if they are not to return to an informationless state. As a group "tool," institutions may "decay," posing transactions costs if they are to be maintained at a constant level of informational efficiency.

Indeed, an additional implication of entropic degradation in explaining institutional change relates to the sequential nature of the process, since without the Second Law of Thermodynamics there would be no clear

basis for establishing time in a dynamic context at all (Georgescu-Roegen, 1971). It might also be noted that the irreversible entropic degradation of institutional rules establishes a clear rationale for the existence of pure time preference. This is in contrast to Taylor's supergame of Chapter II, where pure time reference was introduced as an assumption from outside the model.

The historical and comparative cultural observations which these characteristics of institutions make possible will be considered in more detail below. For now, it is sufficient to summarize this section by noting that in each time period, the state of institutional rules may be conceived as a posterior distribution arising from earlier periods' priors and the current period's likelihood of actions by others. Sequential PDF's result from the addition and loss of information as new rules are innovated, and as negentropic degradation of rules occurs over time. The resulting state of institutional rules constitutes a set of information which acts to parameterize expectations. The process of institutional innovation and the development of assurance, as well as the decline of institutional rules, is a rich topic which cannot be fully developed in a single chapter.

One further theoretical issue of major importance requires treatment, however. It is the matter of equilibrium.

## 4. Institutional Equilibrium

Equilibrium in economics is today generally thought of in terms of the Arrow-Debreu formulation (Arrow and Hahn). An Arrow-Debreu equilibrium can be interpreted as a state of affairs where (a) all actions are decided upon at only one instant of time; and (b) actions always contain contingent elements (Hahn, 1973). The result is that a well-defined equilibrium may be shown to exist which is Pareto-efficient, and yields a vector of prices for all goods, present and future. To make sense, this formulation requires markets in all goods and a large number of contingent futures markets.

Hahn (1973) has objected that it is "reasonable to require of our equilibrium notion that it should reflect the sequential character of actual economies," in what he terms an "essential" way. He identifies an "essential" explanation of equilibrium in terms of certain elements characterizing the argument made above, notably time, information, transactions, expectations, and uncertainty. He defines "essential" in stating:

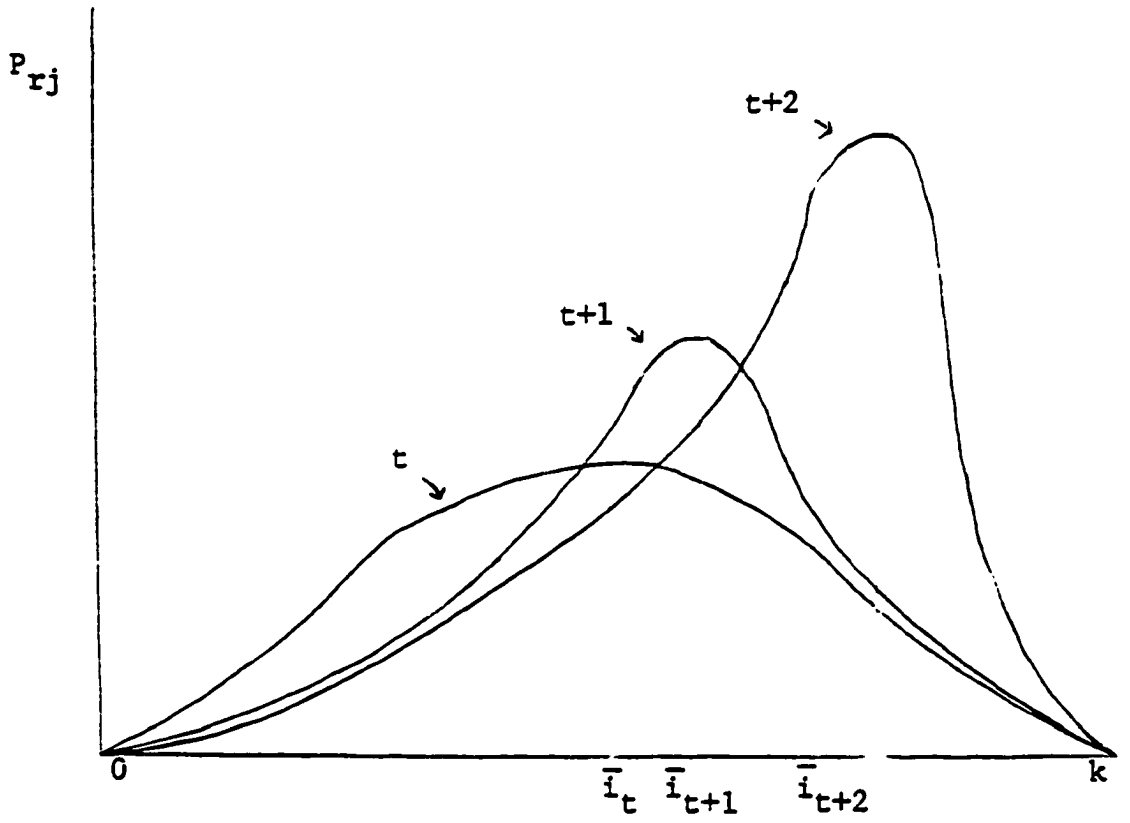
> By this I mean that it should not be possible to reformulate the notion non-sequentially. This in turn requires that information process and costs, transactions and transaction costs and also expectations and uncertainty be explicitly and essentially included in the equilibrium notion. That is what the Arrow-Debreu construction does not do (Hahn, 1973, p. 16).

Since information is not costless, its acquisition becomes a key element in defining an equilibrium state. Radner (1972) has pioneered the study of stochastic equilibrium, in which agents do not differ in their expectations as to price vectors in each state but assign different probabilities to the occurrence of each state. The economy is sequential. A concept of "common expectations" is proposed that requires traders to associate the same future prices to the same future exogenous events, but does not require them to agree on the subjective probabilities associated with those events. An equilibrium is a set of prices at the first date, a set of common expectations for the future, and a consistent set of individual future plans. Agents learn from experience and modify their expectations as Bayesians.

Consider the following description of the formulation of expectations in the grazing problem (see Hahn, 1973). At any date t there is a history of messages received regarding the grazing decision of others. As

outlined above, the sequence of messages up to date t constitutes a prior probability distribution, $P(i_t)$, for each individual j respecting the grazing behavior of others. At date t, individual j assigns a probability to the possibility that the others will graze at some level in the future, based on sample information. This likelihood function, P(y/i), is based on j's posterior distribution, $P(i_{t+1}/y)$, given by existing institutions, as well as on information arising in date t from direct observation of whether the rules are being followed.

Suppose that individual j's distribution of the likely behavior of others at time t is as shown in Figure 3.5. This PDF changes from t to t+1 to t+2 , with the acquisition of new information. As shown, each successive distribution is concentrated around a mean expectation which is shifting toward a level of grazing involving increased stinting by all. The reduction in dispersion around each mean level of grazing also suggests that uncertainty is dropping and assurance in the sense of accurate prediction respecting the actions of others is increasing.




Range of Grazing Behavior by Others
Figure 3.5

Now imagine the underlying institutional change which gives rise to this sequence of expectations. Prior to period t, no institutional rules existed respecting the grazing behavior of others. The time prior to state t describes the informationless "original position." At date t, the parties to the commons agreed, implicitly or explicitly, on a level of stinting which was greater (to the right of) $\bar{i}_t$ in order to promote their common welfare and to reduce the transactions costs of new information.

This agreement, by providing greater information and allowing its rapid apprehension, increased the level of assurance of each respecting the actions of the others (reducing variance) and shifted the mean expected level of grazing to $\bar{i}_{t+1}$. At t+1, the beneficial effects of the agreement due to improved range quality in the prior period promoted a further joint decision to bind behavior. This decision, together with information from the existing rule structure, led to a posterior distribution centered on $\bar{i}_{t+2}$, with further assurance reflected in decreased dispersion.

The process may also occur in reverse. A decline in cooperation and hence assurance might lead to a situation opposite that depicted in Figure 3.5 institutional rules break down, information would be "lost." In a sequential process, this result may be expected from negentropic forces alone (Georgescu-Roegen, 1971; 1975 ).

If the preceding description models the role of institutional rules in binding group behavior and providing security of expectation, then a natural definition of <u>institutional equilibrium</u> emerges. If in moving from t to t+1 to t+2, the moments of some distribution of expectations around mean $\bar{i}_t$ do not change, we may say that the institution is in equilibrium (Hahn,

1973; Radner, 1972; see also, Prescott and Townsend). This suggests that in institutional equilibrium, the prevailing rule structure provides information which has been fully discounted by individuals in formulating their expectations of the likely behavior of others. Prior does not differ from posterior. Rules of long standing, often so deeply embedded in behavior that they go unnoticed, may have this character. They may simply become data. People "know what to expect," and the rules which provide this information may go unnoticed; they provide no new information. Examples abound, such as driving on the right side of the road in most of the world or on the left in Great Britain (D. Lewis).

In the case of grazing, this description implies a multiplicity of possible institutions which may be equilibria, depending on the particular way in which these institutions evolve in different places and times (Akerlof). The things which j takes as given may be consistent with a variety of different sets of actions by others and still lead to maximizing behavior by each individual in the group (see Rothschild, 1973). In addition, the level of assurance, i.e., the relation between p and 1-p in inequality (11c), need not be uniform across agent for an equilibrium to exist (Radner,

1972; Nurmi, 1977b). In contrast, analysis of institutional rules based on dominant strategies, resulting in a single equilibrium of free rider behavior, fail to account for strategic incentives to innovate self-binding rules. In sum, the interdependent character of individual choice suggests that a rich variety of such rules may constitute equilibria across cultural and physical environments.

For a variety of reasons, however, institutions may be subject to forces which give the equilibrium described above an ideal quality. In general, individuals do not always know what to expect from others over time. A characteristic of utopia is that institutions are the equilibrium outcome of a social process. This conception has a timeless quality (Fuz, Hertzler). In John Rawls' discussion of the "reflective equilibrium" of the principles of justice, it is an explicit requirement that the agents be uncertain of their place in time (Rawls, pp. 48-51), and that this place not affect the institutional equilibrium outcome. The negentropic degradation of institutional rules implies that such equilibria are ideal conceptions. "Perfect assurance" amounts to the claim that there is nothing new under the sun, and that nothing new is expected. It is clear that institutional rules must accommodate the informational shocks of new technology, changes in climate, and other

effects that may lead to their inefficacy in an altered environment of choice.

The inability to fully discount such random events suggests that institutional rules adapt to them, reparameterizing expectations in the process. This continual process of adaptation may leave the impression of constant disequilibrium (Riker, but see also, Ordeshook). Yet without such randomness, it is unlikely that the process of institutional change could take place. While negentropic degradation leads to the "loss" of information from institutional rules, randomness leads to "new" sample information from the external environment, feeding the process of change (Ashley, Christiansen and Majumdar, Grandmont).

In institutional change, the random element plays an important role, as institutional rules adapt in the face of shocks to the old rule structure, moving the probability density functions describing the expected choices of others back and forth. This mode of "search" for the institutional rule which provides a requisite level of assurance may be likened to the search for a "reservation wage" in the literature on employment activity (Rothschild, 1974, Jaranovic). The adaptive response to altered environments of choice may also be characterized by the stochastic search seen in biological evolution

(d'Arcy Thomson; J.M. Smith).

It is important to realize that these adaptations are not costless. The changing institutional rule structure of a society reflects the purposive work of its members, involving substantial transactions costs. Naturally, these costs are less where exogenous shocks to the rules structure are few. Some institutional rules may therefore come to resemble the ideal equilibrium described above. Yet even the most deeply embedded rules, because of their informational character, are subject to negentropic degradation.

This notion of institutional equilibrium may be developed more formally in terms of these information theoretic results. The joint processes of information flow and energy flow led to the conclusion that institutional rules convey messages regarding the likely actions of others, but that the maintenance of these rules requires energy, expressable as the transaction costs of maintaining an existing level of assurance.

Information theory clarifies the concepts of institutional equilibrium and transactions costs. As Tribus and McIrvine note, "distinguishable from the environment" and "out of equilibrium" are the same (p. 127). Our ability to recognize an institutional rule depends on the fact that it conveys new information not previously discounted in forming expectations

regarding the likely behavior of others. When it has become data, we "know what to expect" and the rule conveys no newer message at time t+1 than at t.

Thermodynamic information in the form of institutional rules is conceptually the same as "degree of departure from equilibrium." If each of these quantities is measured in such a way as to satisfy the properties of additivity, consistency, and monotonic increase in a system's size, then apart from units of measure each will be the same mathematical expression, since they refer to the same thing (Tribus and McIrvine, Evans). In economic terms, the transactions costs of maintaining an institutional rule are equivalent to the degree of departure from equilibrium in the sense that these costs are necessary if the institution is to continue to convey "new" information. Tribus and McIrvine make the equivalence of these equilibrium concepts clear.

> Thermodynamic information is defined as the difference between two entropies: $I = S_0 - S$. S refers to the entropy of a system of given energy, volume and composition. $S_0$ is the entropy of the same system of energy, volume and composition when it is diffused into (indistinguishable in) a referenced environment. It measures the loss of information in not being able to distinguish the system from its surroundings (as when an iceberg melts in the open sea) (p. 127).

This definition may provide a more formal approach to the problems of transactions recently addressed by O.E. Williamson (1979).

By its nature, this concept of equilibrium captures the "essential" quality cited by F.H. Hahn. The irreversible (or more properly, irrevocable) character of systems subject to entropic degradation means that it is not possible to reformulate the concept of equilibrium nonsequentially (Georgescu-Roegen, 1971). In addition, this concept of equilibrium is explicitly predicated on information process and costs, transactions and transactions costs, expectations, and uncertainty.

The concept of equilibrium provided by a model of institutional rules in which assurance is the chief desideratum is general enough in its application to encompass a wide variety of problems. Common grazing is only one. General issues of public goods and free rider behavior lend themselves to such a treatment. The next section concludes this chapter by presenting a simple model based on the argument to this point.

## 5. A Simple Model

The last several sections have presented the formal structure of the problem of contributions to a public good such as range quality and the role of institutions in providing information solving the problem for a group. In this section, this institutional rule structure will be integrated into the maximization behavior described in the rational decision framework of Section 1. The result will be to provide an approach to the provision of range quality in which individual j's utility ($U_j$) and probability ($P_i$) regarding the actions of others are treated as interdependent, consistent with recent results of Hylland and Zeckhauser.

Recall that the value of "stinting" by a representative grazer j at level D is the sum of the expected values in the $D^{th}$ row of the decision matrix, given in equation (2) as:

$$V_D = \sum_{i=0}^{k} U_{i+D} P_i - D$$

The problem of rational, self-interested agents such as j is to maximize the value of $V_D$. To this point, the utility function described as $U_{i+D}$ was assumed fixed.

We have explored the informational content of the term, $P_i$, describing j's subjective assurance of the likely grazing behavior of others and the influence of institutional rules in parameterizing these expectations over time. In this section, the analysis will be given further richness by dropping the assumption of fixed utility. The result will be a fully articulated model of the role of institutional rules in the provision of range quality.

There are many institutional rules whose disobedience under the right circumstances is of advantage to the person who disobeys (Akerlof). One of the arguments against the notion of institutional rules successfully providing for assurance of range quality is that an individual such as j may decide to free ride by breaking the institutional rule proscribing stinting if he is certain to get his share of range quality anyway.

Hence, even in situations where institutional rules are such that the group is grazing at a level consistent with range preservation, some persons with unusual tastes may be attracted to the gain from breaking the rules. It might be expected that such a failure to observe the rules would undermine the structure of expectations they had provided, provoking further disobedience and a

"breakdown" in institutions. Yet this negative-feedback sequence, which leads to the familiar ineluctability of free rider behavior, abstracts from the opportunity costs which must be considered by the potential rule-breaker. It also neglects the important process of evolutionary rule formation, in which behavior according to the rule generates benefits to further compliance, so that free riders are eliminated as the rule gains force through positive feedback. In the expanded version of the rational decision framework below, an institutional rule, once established as a solution to the assurance problem, will be maintained in the face of these and other negentropic forces provided that the opportunity cost of breaking it is sufficiently high. It should be noted that the costs borne by the rule breaker need not be imposed from outside the group. Indeed, contrary to those claiming the necessity of outside enforcement, as in the prisoners' dilemma scenario, the highest cost of breaking the rule may be a loss of reputation <u>inside</u> the group (Akerlof).

Institutional rules, despite the transactions costs necessary for their maintenance, and the benefits of breaking them, persist. The reasons for this may be

seen in the nature of the utility term in the expected value equation (2), defined for individual j as $U_{i+D}$.

Assume that there exists an institutional rule proscribing grazing at a certain level for each agent j, given as $\bar{D}$. Now assume that only a fraction of the group of N individuals, $\mu$, subscribes to the rule. The fraction may vary from 0 to 1. Individual j, observing the fraction $\mu$ following the "stinting rule," uses this sample data together with the subjective prior distribution of the likelihood of $\bar{D}$ being followed, given by the existing rule, to determine his posterior distribution in the next period. The difference between the contribution satisfying (8), say $D_j$, and the level prescribed by the rule, $\bar{D}$, may be thought of as the opportunity cost to j of following the rule. Deviations of $D_j$ from $\bar{D}$ may be the result of either utility or probability changes. We have examined changes in probability due to institutional rules. What might cause $U_j$ to change, and how might changes in $U_j$ be related to changes in $P_i$, i.e., to changes in institutional rules?

Assume, consistent with the vast weight of anthropological and sociological evidence (Kroeber, Benedict), that people care about their reputation in the group. This is reasonable, since a loss of reputation in one

area such as grazing behavior is likely to spill over into other areas, making the gains possible from cooperation in a variety of circumstances unavailable to the "rule breaker," with whom it is less likely that others will cooperate.

An individual's utility may be represented as a function of four arguments, in addition to own tastes (Akerlof).

$$(18) \quad U_j = U_j \ (G, R, A, d^c, E)$$

where

- $G$ = a vector representing j's consumption of goods and services derived from cattle production
- $R$ = j's reputation in the group
- $A$ = dummy variable representing obedience or disobedience to the rule proscribing "stinting at D"
- $d^c$ = dummy variable representing j's belief or disbelief in the rule
- $E$ = personal tastes.

The question is whether unusual personal tastes (E) will cause there to be some believers in the institutional rule who disobey it. The proportion of those who disobey the rule, $\mu$, would then rise, influencing the inference made by individual j on the basis of his sam-

ple observations of μ. This will lead to a posterior in time t+1 different from his prior at t. Specifically, the information resulting from j's sample will be likely to change the number of people in period t+1 who are believers in rule, compared with believers in period t. Noncompliance undermines belief, given as $d^c$. However, nonbelief may or may not result in j breaking the rule. The benefits of adhering to the rule, even if j does not believe it, may be sufficiently offsetting to lead to strategic compliance. The appearance of reputation R in the utility function will also influence this process of decision, by imposing costs on the breaker of the institutional rule. If net benefits of compliance exceed the opportunity costs of breaking the rule, the rule may be established as part of the longstanding traditions of the group, subject of course to both random shocks and negentropic decline. In the absence of exogenous shocks, this PDF may remain relatively unchanged over time, so that except for differences due to negentropy prior and posterior distributions are congruent. The institutional rule becomes a "convention" (Lewis). Still, negentropy implies that even in this situation, transactions costs of maintaining the rule must be incurred.

To see in more detail how feedback to rule observance may occur, we may break down the reputation function, R, into its component parts (Akerlof). If reputation in the group is a function of obedience to the institutional rule, A, as well as the proportion $\mu$, which follows the rule, we may say that:

$$(19) \quad R = R(A, \mu).$$

Individuals who for reasons associated with personal tastes (E), seek to break the rules and ride free, actually face opportunity costs in the form of a loss of reputation. These costs are less the lower the proportion of the group which obeys the stinting rule (A), and the lower the proportion of believers ($\mu$).

Following the analysis above a negative feedback to rule observance may be sketched. The lower the cost imposed by loss of reputation, the more likely the rule is to be broken; the smaller the proportion which believes the rule, the more people will break the rule, and the lower the cost will be of doing so. If there are fewer persons obeying the stinting rule in time $t+1$ than there are believers, there will be fewer

believers in time t+2, and so on. On the other hand, positive feedback to rule observance may also occur. This overall result may be expressed in terms of equation (20) below.

$$(20) \quad \dot{\mu} = g(\mu, x)$$

Here $\mu$ is again the proportion of the group that believes in the rule, x is the fraction of m that obeys it, and $\dot{\mu}$ is the derivative reflecting believe in the institution over time. Hence,

$\mu > x \Rightarrow$ g is negative;
$\mu < x \Rightarrow$ g is positive.

Where g is negative ($\dot{\mu}$ is negative) we have a case of "erosion of a community's legal (i.e., rule abiding) capital" discussed by Buchanan (1975). Where is positive ($\dot{\mu}$ is positive), it illustrates the positive claim by Rawls (1971, pp. 496-504), in which cooperative behavior by an individual such as j leads to increasing observance of institutional rules by others, resulting in a stable equilibrium structure (Mueller, p. 18).

These results may now be combined into a general model which summarizes the formal process of the evolu-

tion of institutional rules in the representative case of common property externalities in grazing. Substituting (19) into (18), and (18) into (2), we have

$$(21) \quad V_D = \sum_{i=0}^{k} U_{j(i+D)}[G, R(A, \mu), A, d^c, E]P_i - D$$

as the expected value of stinting which the representative self-interested grazer seeks to maximize.

Note that maximization of this complex function may occur at any grazing level and that this level will be influenced by the nature of the institutional rule parameterizing the expectations of the group. As shown in terms of inequality (11c) above, the assurance problem makes it rational to search for rules under which each individual does what he thinks the others expect, given that he expects the others to do the same (Ullman-Margalit, Brubaker, Brams, Schelling). Institutional rules give prior information, allowing this coordinated behavior, by reducing uncertainty and making more accurate predictions possible regarding the actions of others.

It should be noted that the formulation above differs in a variety of respects from received explanations of sequential choice. Its most important characteristic

is that it treats the utility term in j's maximization problem as a function of the probability attached to the actions of others. The probability of certain actions by others influences j's likelihood of following a particular course of action, which leads in turn to altered estimation on the part of others regarding their reputation and utility from following the rule. This is distinctly different from the usual Bayesian assumption that utility and probability are separable.

This follows a recent result of Hylland and Zeckhauser (1979) in which they prove that without the interdependence of utility and probability, a dictatorial scheme of decision making is the only possible outcome. As they note, "(O)ur results can be viewed as arguments against the principle of separate aggregation. The separability assumption in effect rules out one type of log-rolling in the decision process, namely, the possibility that one person gives in on the question of probabilities in return for getting more influence on the social utility scheme, or vice versa" (p. 1322, n. 10).

The interdependence of $U_j$ and $P_i$ arising from their nonseparable character is consistent with the interdependence leading to the absence of dominant strategies.

Assurance via institutional rules is a strategic response to individual interdependence; "log-rolling" is a strategic response to the interdependence of utility and expectations.

## 6. Summary and Conclusions

This concludes the analytic discussion of the role of institutional rules in providing assurance. Consistent with the formulation of Chapter I, a rational decision framework has been developed which allows institutional rule formation to be seen as the outcome of self-interested maximization. The critical distinction between this analysis and more orthodox approaches is that nonseparabilities make institutional rules the outcome of interdependence and consequent uncertainty respecting the actions of others.

The response represented by insitutional rules has been shown to depend on the way in which they increase the accuracy of prediction respecting these actions in such an interdependent environment. This reduced uncertainty has been considered in the formal context of information theory. The informational function of institutional rules in conveying "messages" respecting the actions of others led to a dynamic characterization

of institutional rule formation in terms of Bayesian prior and posterior distributions over time.

Together, information theory and Bayes' Theorem provide a formal basis for consideration of institutional equilibrium, and the measurement of disequilibrium and transactions costs necessary to maintain a given state of institutional rules.

Finally, a simple model combining the elements of institutional rules and their impact on expectations and a utility function incorporating reputation as an argument has been put forward. This model allows content to be given to the utility term in the rational decision process of individual agents facing the problem of providing range quality. In addition, the model treats utility and probability as interdependent, consistent with the interdependence of choice reflected in the larger analysis.

In the next chapter, these results will be extended to the general problem of free rider behavior, and recent empirical results will be adduced which, while inexplicable under current theory, may be straightforwardly explained by the analytics of assurance.

# CHAPTER IV. INSTITUTIONAL RULES AND THE FREE RIDER

## 1. Introduction

Previous chapters have considered alternative approaches to common property externalities in grazing. This chapter considers the general problem of free rider behavior. The analytics of assurance provide an explanation of this behavior which is consistent with recent empirical evidence, as well as with common observations of voluntary contribution where current theory would predict dominant free riding. The key role of strategic misrepresentation of preferences and the implications of strategic choice for some aspects of current theory are explored. Empirical evidence is reported which supports the important influence of institutional rules in problems of free rider behavior. The implications of these results for problems involving the size of the group and the need for outside enforcement are also considered.

## 2. Making Theory Fit Fact

Recent studies in a variety of disciplines have raised questions over the empirical validity of the free rider hypothesis and the consequent impossibility of

decentralized public goods provision (Marwell and Ames, 1979, 1980, 1981; V.L.Smith,1980;Schneider and Pommerehne, 1979; Sweeny, 1973; Brubaker, 1975; Bohm, 1972). Controlled experiments have cast doubt on the claims of Samuelson (1954), Olson and many others that without "excludability," no optimal voluntary mechanisms exist for providing public goods except in small groups.

Although voluntary provision of 100 percent of a public good does not generally occur, neither is it the case that none of the public good is contributed by experimental subjects, as predicted by the "strong" free rider hypothesis. These results conform to casual empirical observations of a wide variety of cases in which some public goods are provided voluntarily, without exclusiveness, consistent with the "weak" free rider hypothesis (Keating et.al.). In the weak free rider case, the average contribution to a public good falls in the intermediate range between zero and full provision. This result seems to be independent of whether a group is large or small (Marwell and Ames, 1979; Smith, 1980).

Prior to these results, a number of explanations of public goods provision were made within the logic of the free rider hypothesis. Vickrey, Clarke, Groves (1969, 1973) and Groves and Ledyard defined situations in which individuals had an incentive to contribute to the public

good an amount equal to their marginal (private) valuation of the good. These attempts accept the logic of free rider behavior, but argue that individually incentive compatible mechanisms may exist which can provide the public good (V.L. Smith, 1980).

These mechanisms have been shown to fail, however, in the face of strategic incentives to misrepresent preferences for public goods by individual agents (Hurwicz; Ledyard and Roberts; Gibbard; Satterthwaite). By acting as if their preferences are other than they may be, individuals can secure an outcome which will be preferred over what would have resulted had they acted sincerely (Sen, 1973). Even in cases not covered by this Gibbard-Satterthwaite impossibility result (viz., Groves, 1973), a dominant strategy of preference revelation for each agent can be obtained only by sacrificing Pareto-Optimality (Walker). In sum, incentive compatible mechanisms with dominant strategies for each actor do not seem capable of providing Pareto-Optimal allocations of public goods.

This chapter presents the claim that the "impossibility" of nonstrategic responses in fact represents the solution to the free rider problem. This solution results from treating public goods provision as a strategically motivated assurance problem, where by

definition no dominant strategies exist. Individuals may agree for strategic reasons to follow institutional rules which do not always reflect their true preference in order to advance their general welfare, consistent with the process outlined in Chapter III. The result is a denial in a wide number of cases of the logic of free rider behavior. This finding is consistent with both experiments and recent theory (Thompson & Faith).

The erroneous assumption of the dominance of free rider behavior pervades the literature on public goods. It leads to policy prescriptions in which enforcement by an outside authority becomes the only basis for insuring contributions to such goods. Such policy leads in turn to expectations which may actually encourage free riding. An illustrative case of such feedback to rule observance, concerning the behavior of a group of economists and economics graduate students, will be considered below.

Although free riding does not appear as the dominant strategy in a wide variety of observable phenomena, including many successful common property rules, there is a tendency where the facts do not fit theory to make them fit (Kuhn). Resistance to evidence disconfirming the free rider hypothesis is explained in part by a tendency to view public goods in terms of the prisoners'

dilemma game considered in Chapter I. Because of the logical equivalence of separable choice and dominant strategies, and the complementarity of separability and exclusive private property, it is difficult to budge the theoretical status quo. An alternative competing hypothesis is needed.

The absence of empirical support for strong free rider behavior may be explained by reconstructing the theory of public goods on the foundation of the assurance problem. The role of institutional rules as endogenous responses to problems of interdependence is then captured. In the more complicated but more realistic world of nonseparable choice, the allocation of resources is not independent of the institutional framework (Marchand and Russell). Institutions may help solve the free rider problem by providing a requisite level of assurance.

## 3. Implications of Assurance Problems for Free Riders

In a prisoners' dilemma situation, the dominant strategy of not contributing to a public good (free riding on the range) made the group worse off. This is consistent with Walker's general proof that there exist no dominant strategies for sincere preference revelation

leading to Pareto-Optimal decisions over public goods. When the implausible assumption of separability is dropped, interdependence and uncertainty alter the structure of the problem. In this situation of assurance, there is no strictly dominant strategy. Each individual must evaluate the likely behavior of others before making his own decision regarding contribution to a public good. If a rule can be developed which will coordinate choices, a Pareto-Inferior result need not occur.

Solutions to the assurance problem are also consistent with the powerful Gibbard-Satterthwaite result respecting the impossibility of nonstrategic mechanisms for preference revelation. In the assurance problem, the absence of dominant strategies extends the attainable set through strategically agreed upon rules or institutions (Elster). These institutions are possible because individuals are willing strategically to subscribe to rules which they may not prefer, but which extend the attainable set of the group. The result may be individually Pareto-Superior (Sen, 1973; Elster). By binding themselves to provide public goods, individuals can extend their attainable sets through strategic collective action.

In the case of common grazing, by acting as if they prefer not to add to another head of cattle, even if they actually feel otherwise, grazers achieve the Pareto-Superior outcome of range preservation. They avoid tragedy by following an institutional rule proscribing greater stinting. Depending on the way in which different rule structures parameterize expectations, compliance may be established at any level of grazing, from zero to full contribution via stinting. The situation is analogous with contributions to public goods of many sorts. Institutional rules allow individuals, acting in concert, to avoid unrestrained free rider behavior and the costs of imposed or dictatorial regimes designed to coerce contributions to public goods. If one expects that others will contribute, clear benefits result from also doing what is proscribed (Akerlof, 1980). Even in cases where one does not believe in the rule, the effect of reputation may be strong. However, no single strategy dictating a certain contribution is dominant. The strategy chosen will depend on the environment of choice, given in terms of available goods and services, reputation, the structure of belief, and the existing state of institutional rules as described in Chapter III.

A variety of implications of the assurance problem are not congenial to current theory stressing the dominance of free rider behavior. The first is that the theoretical exactitude of dominant strategy mechanisms is lost. Since individual strategy depends on the environment of choice, it is no longer possible to argue for the uniqueness of a particular solution. The singular appeal of private property institutions is lost. The suitability of any institution will vary across time and cultures.

While inexact, the impossibility of Pareto-Optimal dominant strategy mechanisms is an optimistic finding. It suggests the possibility of institutional alternatives where current practices based on the dominance of free rider behavior have failed. By contrast, acceptance of the strict dominance of free rider behavior leaves enforcement of private, exclusive use-rights as the only alternative to total anarchy. If private exclusiveness fails, no comparable alternatives exist.

A second implication is that separation of efficiency issues from problems of distribution is more difficult. As the simple model of Chapter III shows, choices over contributions to a public good are a function of expectations of the choices of others. Institutional rules parameterize these expectations.

They enter the maximization process of each individual. These rules involve the distribution of contributions or responsibility for public goods. Hence not only is utility maximization not invariant to distribution; a stronger result holds. The process of utility maximization involves distributional issues since institutional rules enter as arguments. The policy implications of this result will be considered in Chapter VI.

A third implication concerns the impact of strategic misrepresentation on the "theory of revealed preference" (Samuelson, 1938, 1938a, 1948, Green, 1971, pp. 121-128). This theory states that "rational" choice may be derived from the statement: I prefer what I choose because I chose it. More precisely, revealed preference theory holds that if a bundle of goods y could have been bought by a certain individual within his budget when he in fact was observed to buy another bundle x, we may safely presume that he has revealed a preference for x over y. Since this person chose x when y was available, we may infer that they prefer x to y.

Samuelson based this theory on a consistency axiom (the Weak Axiom of Revealed Preference) which requires that given a vector of prices, once one chooses x when y is available, then one will not choose y when x is also available. To do so would be inconsistent, and

therefore "irrational." The theory abstracts entirely from matters which might lead to choices of alternative commodity bundles other than price; it notes simply that preferences are reflected in choices between goods which are feasible in the sense that they are affordable.

The difficulty with revealed preference may be seen in terms of the game theory of previous chapters (Sen, 1973, 1977). Institutional rules result from recognition of interdependence allowing transformation of prisoner's dilemmas into assurance problems. As Sen notes, institutional responses to the prisoner's dilemma may require strategic misrepresentation of preferences, if assurance is to be achieved (1973, p. 12). The importance of institutional rules for revealed preference is that it may benefit people to behave so that they choose to do one thing even if they prefer to do another. If both prisoners cooperate and seek a rule of non-confession by acting as if they were maximizing a different welfare function (given by the rule) from the one they actually have, they will end up better off even in terms of their actual welfare functions. This requires that the strict dominance of individual strategy be dropped, which transforms the prisoner's dilemma into an assurance problem. As Sen notes,

> This is where the revealed-preference approach goes off the rails altogether. The behaviour pattern that will make each better off in terms of their real preferences is not at all the behaviour pattern that will reveal those real preferences. Choices that reveal individual preferences may be quite inefficient for achieving welfare of the group (1973, p. 14).

A notion of rational choice which fails to allow for strategic responses to uncertainty and interdependence grants very little to the intelligence of the allegedly "rational" agents. They become "rational fools" (Sen, 1977). A broader definition of rationality encompassing this interdependence is required. This definition is provided by the rational decision framework of Chapter III.

A final implication of the assurance problem involves recent contributions to the free rider hypothesis by the "theory of clubs" (Buchanan, 1965, 1968; Sandler and Tschirhart, 1980). This work can be traced to the original work on "congested public goods" of A.C. Pigou (1920) and F.H. Knight (1924), concerned with the problem of determining the optimal toll for restricting users of a crowded highway. The toll would restrict users and thereby determine the "membership size" for the highway. This approach has been developed in the context of the grazing problem by Weitzman (1974). As noted in Chapter I, a toll or tax mechanism

requires separability of individual cost functions to be feasible (Davis and Whinston, Baumol). The theory of clubs provides a rationale for this separability.

A related approach involves Tiebout's famous "voting with the feet" hypothesis (1956) concerning the jurisdictional size of local governments, determinable by voluntary mobility or membership decisions. These "local public goods" can be provided at the appropriate level of organization, but when the size of the group becomes too large, free rider behavior takes over. In the classic treatment of this problem, Olson (1965) argued that small groups are necessary to share "impure" public goods where crowding is a problem.

Without attempting to duplicate existing review articles (Sandler and Tschirhart) it is important to consider the impact of this body of theory on the free rider problem. In a series of recent articles, Bryan Ellickson (1973, 1978, 1979) has generalized the theory of clubs and local public goods, arguing that at the optimum, the definition of "local" also defines the appropriate size of the "club" necessary to provide a public good (1979). The point is that within a "club," strategic preference revelation is not a problem, or may be controlled against by appropriate penalties for insincere revelation of preferences. At the "local"

level, all consumers have "voted with their feet" in such a way that provision of public goods may be expected by the remaining club members (see Wooders, 1980).

It follows that a local public good exists where all of the consumers of that good have identical marginal rates of substitution ($MRS_i = MRS_j$ for all i, j) so that Samuelson's (1954) claim regarding the necessary equality of the sum of the MRS's and the MRT becomes superfluous. Local public goods become a class of individual private goods for which a well-defined competitive equilibrium exists (Ellickson, 1979).

In this approach, the problem of strategic incentives to misrepresent preferences is sidestepped by the formation of a "club" of members with identical preferences. By making its members indistinguishable from one another, and excluding outsiders, this formulation obviates the problem of uncertainty by formulating a rationale for separability of choice. Within the "club" or at the "local" level, individuals act as one, while between groups exclusion exists such that the public goods are private, forcibly separating the judgment of the group from other groups. The free rider problem is defined away.

This formulation fails to provide a clear rationale for the existence of alternative institutional rules

which may actually define one locality or club from another, since it exists primarily as a device to generate separability. In the context of the free rider problem, it fails to answer the obvious question (paraphrasing Groucho Marx): "What free rider would join a club that would have him as a member?" It fails to explain the reasons behind the formulation of institutional rules which are successful in preventing (or minimizing) free rider behavior. To do so, a closer look at the dynamics of free rider behavior in a specific empirical setting is required.

## 4. The Marwell Experiments

In a series of recent studies on the provision of public goods (Marwell and Ames, 1979, 1980, 1981), Gerald Marwell and Ruth Ames have tested the free rider hypothesis under a variety of different conditions and assumptions. These tests amount to the first major attempt systematically to explore the empirical validity of claims that group size must be small and that enforcement is necessary to halt defection or free rider behavior.

Previous experiments testing this behavior (V.L. Smith, 1979; Schneider and Pommerehne, 1979; Sweeny, 1973;

Bohm, 1972; Brubaker, 1975) suffer from their restriction to groups of relatively small size, as well as from complex experimental designs which run individuals through multiple trials, each of which involves a somewhat different experimental condition. As a group, these experiments (given their shortcomings) still question the power of the free rider hypothesis as a useful predictor of individual behavior.

The purpose of Marwell and Ames' research is to increase the rigor and scope of experiments in collective action by employing standard social psychological experimental procedures. The Marwell experiments were designed to test the power of the strong free rider hypothesis (Brubaker) which, it was hypothesized, experimental weaknesses in prior research masked. In twelve separate experiments individuals faced a choice of investing in a "group exchange," investing in an "individual exchange," or dividing their investment between the two. The group exchange operationalized a public good, while the individual exchange was a private good. Tokens invested in the individual exchange earned a certain amount, independent of the behavior of the other group members. The return, much like that of a savings bank, was excludable in neither affecting nor being affected by the choices of others. In contrast,

the group exchange paid its cash earnings to all members of the group according to a preset formula. The subject received a share of the return on his own investment in the group exchange, and the same share of the return on the investment of each of the other group members. What made the group exchange a public good was not only non-excludability, but the fact that it was possible to have the group exchange return substantially more than the individual exchange, depending on the number of contributors. This effect captured the interdependence of decision, and extensions possible in the attainable set due to cooperation.

Subjects were carefully checked to insure that they understood the test situation (Marwell and Ames, 1981, p. 4). They were not used in more than one situation in order to eliminate cross-order effects. A large number of experiments was performed with both large and small groups in order to give weight to the conclusions. The fact that subjects were not used in more than one situation is important in light of the analysis of Chapter II, since it suggests that learning over time due to iterated "games" was not possible. Any interdependence or conditional strategies employed were therefore the result of recognition of extensions in the attainable set at a point in time.

The results of these experiments severely damage the empirical case for strong free rider behavior. They confirm the existence of the weak version of the free rider hypothesis, in which voluntary provision of public goods is between zero and 100 percent. The strong version, in which zero contribution results from the dominance of free rider behavior, was flatly controverted. However, voluntary provision of 100% of the public good did not occur, consistent with the weak free rider hypothesis. These results reject the hypothesis that the strict dominance of individual strategy always leads to private gain at the expense of others.

Figure 3.2 in Chapter III is repeated as Figure 4.1 below. It shows a hypothetical PDF of contributions to the public exchange expected by a representative subject in the Marwell experiments, analogous to j's expectation of others' contribution to range quality in Chapter III.

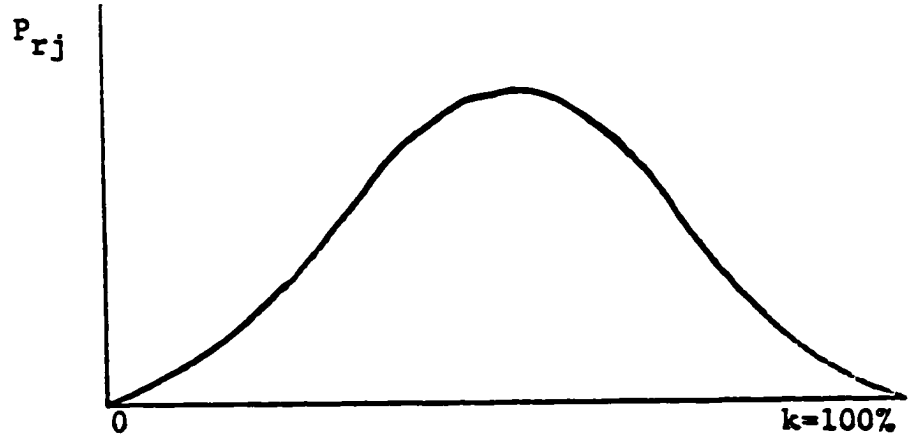



Figure 4.1
% Tokens Contributed to the Public Exchange

Strong free rider behavior implies that each subject will contribute nothing to the public exchange, attempting to ride free at 0 even if others donate at levels higher than 0. If the strong free rider hypothesis holds, each pursues this dominant strategy independent of the actions of others and a "tragedy" results, since no one invests in the public exchange, while everyone invests in the individual exchange, leading to a Pareto-Inferior result. Weak free rider behavior implies that each subject will make some investment in the public exchange, but that these investments will be less than the total amount. In terms of Figure 4.1, let k=100% represent the contribution of the total amount of tokens in the public exchange. The weak free rider hypothesis predicts that the majority of contributions fall somewhere between 0 and k.

This framework allows certain key elements of the assurance problem to be presented. First, the differences between the Marwell experiments and the case of common grazing merit attention. In the case of common grazing, stinting behavior ranges from a strong free rider extreme (0) to a level associated with maximum common welfare due to range preservation (k). In the Marwell experiments, strong free rider behavior is also given as zero contribution to the public exchange. How-

ever, it is somewhat unclear whether 100 percent contribution to the public exchange should be equated with range preservation. Less than 100 percent donation, in the context of grazing, may be sufficient to preserve the range. There may be some k*, such that $0 < k^* < k = 100\%$, which satisfies the requirement of maximum common welfare due to range preservation. This does not affect the analytic representation of the two cases, however, and involves only the appropriate scale by which contribution is measured along the horizontal axis.

The important distinction between contributions to the public exchange and stinting on the range is that in the case of grazing, a failure to contribute at a certain level will lead to overexploitation and the possibility of ecological "tragedy." In Marwell and Ames' case of private and public exchanges, by contrast, a failure to contribute to the public exchange will reduce possible gains, but will not involve net losses. This distinction may be due to the nature of the resources involved. In the case of grazing, a flow resource of rangeland is involved, which may impose net losses on its users if overexploited. In the Marwell experiments, a stock of currency is to be invested, but whether public or private, the investment yields a positive flow over time. The implications of this distinction will be

developed further in Chapter VI. The characteristics of resources, notably their status as stocks or flows, may affect the nature of the "tragedy" if they are over-exploited.

In terms of the maximization framework of Chapter III, the problem for any subject in the Marwell experiments was a problem of uncertainty respecting the actions of others. The interdependent, nonseparable (public) investment decision of each may have been a function of the (public) decisions of all. The relative attractiveness of making a zero contribution to the public good as opposed to contributing some positive amount then depended on the probability attached by each to the likely behavior of others. The more contributions by others, the more attractive the public exchange vis-a-vis the individual exchange. If all contributed to the public exchange, the attainable set of possible solutions was considerably extended, and a Pareto-Superior result was guaranteed for all.

Hence, as in Chapter III, the problem for each subject participating in the experiment may be described in terms of the desire to maximize over a range of possible contributions to the public exchange the simple function:

$$(1) \quad V_D = \sum_{i=0}^{k} U_{i-D} P_i - D$$

to determine the largest of the $V_D$'s. Weak free rider behavior implies that $D > 0$, so that it must be the case that

$$(2) \quad V_{D \neq 0} > V_{D=0}$$

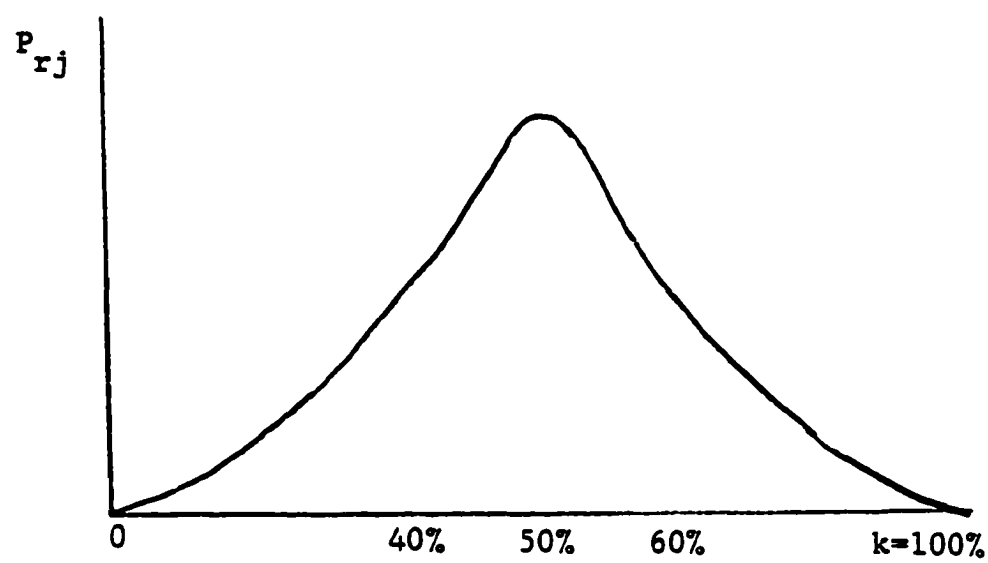
This is the result reported by Marwell and Ames. Summarizing their results, they stated:

> [O]ver and over again, in replication after replication, regardless of changes in a score of situational variables or subject characteristics, the strong version of the free rider hypothesis is contradicted by the evidence. People voluntarily contribute substantial portions of their resourses--usually an average of between 40 and 60 percent--to the provision of a public good. This despite the fact that the conditions of the experiment are expressly designed to maximize the probability of individualized, self-interested behavior. Free riding does exist--subjects do not provide the optimum amount of the public good, and tend to reserve a meaningful fraction of their resources. The "weak" free rider hypothesis is supported. Nevertheless, the amount of contribution to the public good is not easily understood in terms of current theory (Marwell and Ames, 1981, p. 17).

The analytical structure of the assurance problem provides a theoretical explanation of these results. Contributions to the public exchange in the Marwell experiments may be explained as the outcome of the set

of maximization exercises undertaken by the subjects in the group. These contributions are a function of individual expectations of the likely behavior of others, reflected by the PDF in Figure 4.1 and the "$P_i$" term in equation (1) above.

Although the weak free rider is an anomaly in terms of current theory, in the assurance problem contributions falling between 40 and 60 percent suggest the prediction that individuals' expectations of the likely contributions of others were distributed around the 50 percent level, roughly as shown in Figure 4.2. If the subjects expected contributions to fall in the range between 40 and 60 percent, they in turn would be inclined to contribute at approximately this level, assuming the utility maximizing model holds.




% Tokens Contributed to the Public Exchange
Figure 4.2

A question remains over the mechanism parameterizing expectations in Figure 4.2. If the theory of Chapter III is accurate, the parameters of the distribution were given as prior information by the existing state of institutional rules. This assumes the participants in the Marwell experiments behaved somewhat contrary to the experimental design, acting as if the game they were playing was more than a "one shot deal," and involved the repetition of real life experience. In addition, more complex effects may have arisen from the fully articulated interdependent objective function of Chapter III. Utility was defined there as a function of the existing state of institutional rules, the proportion of others which believed in and followed these rules, the reputation function, and other variables, all of which could affect the PDF in Figure 4.2.

The findings of Marwell and Ames cast light on some of these elements of the theory. Two questions were asked of the subjects which concerned "fairness" in this investment situation. The first asked subjects what they thought a "fair" investment in the group exchange would be in terms of a percentage of total resources. The second asked whether the subjects were "concerned with fairness" in making their own investment decision. As

Marwell and Ames note, despite the fact that subjects only participated in one test situation, so that no cross-order feedback could result from the experiment itself, "there was surprising unanimity of thought regarding what was considered fair" (1981, p. 18). This unanimity suggests that the prior information conveyed by a rule of fairness was sufficient to parameterize expectations around some mean level of contribution defined by the rule.

This was in fact the result. With one exception to be considered below, Marwell and Ames note: "we found that more than three out of four thought that 'about half' or more of a person's resources should be contributed, and more than one out of four thought people who were fair would contribute all of their tokens" (1981, p. 18). As the authors note, these rules of fairness implied major investments in the public good, and correlated closely to the levels of investment actually found. They support the prediction of the assurance problem. This suggests that the fairness rule held by the subjects influenced their own choice of strategy.

The manner in which this rule parameterized expectations can be further shown as a function of belief in the rule held by the subjects, providing insight into

the belief term $d^c$ in equation (18) of Chapter III. The two questions posed to subjects respecting "fairness" involved, first, a definition of fairness, and second, a concern with fairness. If "concern with fairness" is a proxy for belief in the rule of fairness, the results of the experiment are very instructive.

Marwell and Ames reported the following results. Table 4.1 (Marwell and Ames, 1981, Table 3) summarizes these results. Two models were tested. In the first definitions of fairness and concern with fairness were treated as independent. In the second they were treated as interdependent. Correlation between investment in the public good and definitions of fairness was not high. Correlation between donations to the public good and whether an individual was concerned with fairness was much higher. Significantly, when account was taken of the interaction of these two terms in a regression on the level of investment in the public good, the interaction term indicate that those who both were concerned with fairness and defined higher levels of contribution as fair were the ones who contributed the most (1981, p. 19).

These results suggest that while concern with the rule led to compliance, an absence of concern did not

Table 4.1

"Fairness" and Percent of Resources Invested in the Group Exchange

| Independent Variables | Regression Coefficients For (Standard Errors in Parentheses) Additive Model | Interactive Model |
|---|---|---|
| Constant | -17.67 (5.69) | 16.56 (11.72) |
| What's Fair? | 6.43* (1.18) | -3.14 (3.10) |
| Concerned with Fairness? | 17.78* (1.54) | 2.45 (4.85) |
| Interaction | -- | 4.27* (1.28) |
| $R^2$ | .516 | .532 |
| F | 83.11 | 60.53 |
| N | 462 | 462 |

*Significant at .001 level.

Source: Marwell and Ames, "Economists Free Ride, Does Anyone Else? Experiments on the Provision of Public Goods, IV," Public Economics, forthcoming (1981).

prohibit compliance. Further research is necessary to determine whether the motivation for such behavior was strategically based on factors such as reputation. Utility derived from contributions to the public exchange was apparently a positive function of concern with a rule of fairness. Since the absence of concern did not preclude such contributions, it may be argued that knowledge of the existence of the rule was sufficient to compel strategic compliance, even in the absence of "belief."

In terms of the analysis of Chapter III, $\bar{D}$ was the percent donation proscribed by a rule of fairness at approximately 50 percent of resources. The rule parameterized expectations of investment behavior in such a way that average individual choices of investment in the public good also fell in the range of 50 percent, presumably because the rules of fairness provided sufficient assurance of contributions by others. The analytics of assurance thus help to explain the choices of subjects in the experiment, indicating the role of institutional rules in the process of individual utility maximization.

Hence, an a priori institutional rule of fairness appeared to significantly condition contributions to the

public good, a posteriori. In addition, it was found that investments in the public good by individuals did covary with their predictions regarding the investments of others (Marwell and Ames, 1979, p. 1356). The higher the expected probability of the public good being contributed by others, the higher the donation by each individual. The lower the expected probability of contribution by others, the lower the donation by each alone, consistent with the analytics of assurance. Just as in the problem of stinting on the commons, the level of contribution to the public exchange may be seen as a problem of coordinated choice. Assurance by each respecting the contribution of others influenced individual donations.

The weak free rider result obtained by Marwell and Ames may be explained in these terms. The aggregate level of contribution proscribed by rules of fairness which yielded an expected level of contribution by others, promoted donations to the public good which, in terms of Figure 4.2, were greater than zero but less than k. The strong free rider result may therefore be seen simply as an extreme outcome in a range of likely alternatives.

The wide range of outcomes possible through individual action, especially where this coordination is imperfect, leads to solutions which generally exhibit

weak free rider characteristics in which $0 < D < k$. The analytics of assurance provide an institutional explanation which is coherent and reasonably simple. They point up the extreme implausability of zero contribution, and therefore why weak free rider behavior is the empirical regularity.

A final point concerns the single exception to these results. This was the case of a subsample of economists and economics graduate students (Marwell and Ames, 1981, p. 19). If the maximization process leading to a particular contribution was a function of expectations set a priori by institutional rules, it follows that different expectations (rules) should have led to different levels of contribution. When a group of economics graduate students was subjected to the same experiment reported above, it presented a problem case.

> More than one-third of the economists either refused to answer the question regarding what is fair, or gave very complex, uncodable responses. It seems that the meaning of 'fairness' in this context was somewhat alien for this group. Those who did respond were much more likely to say that little or no contribution was 'fair.' In addition, the economics grad students were about half as likely as other subjects to indicate that they were 'concerned with fairness' in making their investment decision (1981, p. 19).

The implication of the assurance problem is that the expectations of the economics graduate students were parameterized according to a different rule of fairness, perhaps one laid down by economic theory in the form of the strong free rider hypothesis. The consequence may be hypothesized as a PDF describing the likely contribution to a public good by others for a representative economics graduate student as in Figure 4.3 below, given by adherence to a strict free rider rule.

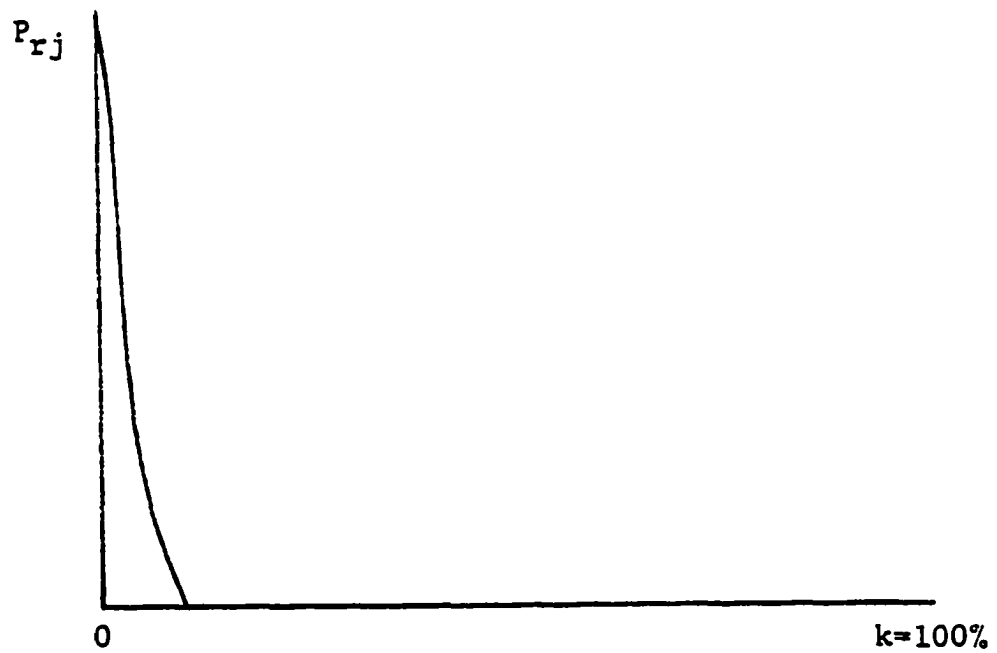



Figure 4.3

In some ways, this PDF is not strictly accurate, since if the strict dominance of individual free rider strategy holds then unit probability should be attached to zero contribution in the left tail of the figure. Figure 4.3 suggests allowance for "irrationality," given the restrictive sense in which this word is used, in the form of small contributions to the public good. Overall, the rule expressing these expectations might be called the "no free lunch rule," given the frequency with which the object lesson of unfairness is repeated by economists.

Although the no free lunch rule may have set the economics graduate students apart, it is consistent with the analytical framework giving rise to free riders, tragedies of the commons, and other consequences of the strict dominance of individual strategy. These results arise from the orthodox economic assumption of the separability of individual choice. Subscription to this assumption is part of the traditional analytic equipment of many economists.

In a complementary survey, Marwell and Ames asked six "famous" economists for predictions regarding the likely outcome of the experiment. Within economics, these are the "rule-makers." Breaking the rules laid down by this group may not be good for one's reputation

as an economist. Five of six "famous" respondents stated that current theory supported the strong free rider hypothesis. Four stated that theory predicted that group members would invest no tokens at all in the public exchange, while the fifth predicted contributions of less than 5%. The sixth said that the typical individual would invest 30% of tokens, but added that this prediction was informed by previous, "vaguely related," empirical research (Marwell and Ames, 1981, p. 6).

As we have seen, the experimental results did not fit the hypothesis held by these famous economists except in the case of economics graduate students. Since the rules taught to economics graduate students as part of their intellectual socialization are not supported by empirical research or casual observation, the explanation for them must lie inside the structure of rules comprising economic theory, notably the assumption of separability discussed in previous chapters. The problems this has caused in the development of reasonable explanations of public choice will be the subject of Chapter V.

A worrisome aspect is that economic theory may actually lead economic policy makers to promote

approaches which stress strict individual dominance where it does not exist, helping to promote it by the creation of rule structures which reward it. People treated like free riders may grow to act like them. This sort of institutional feedback may have important implications for the social costs (rather than the alleged efficiencies) created by the promotion of individualistic decision making (Buchanan, 1978). Among other effects, it may be possible to influence the expectations of noneconomists as a matter of policy, so that the "facts" come more and more to support the strong free rider hypothesis, raising the costs of enforcement which may be necessary as increasing numbers follow free rider behavior due to altered expectations.

Marwell and Ames' problematic results concerning economists and economics graduate students may be described simply in terms of the analytics of assurance. Economists subscribed to rules of fairness which were different from the other subjects in the experiment. These rules proscribed $\bar{D} = 0$. This no free lunch rule conditioned their expectations of others. Economists need not even have believed the rule to subscribe to it. There are strategic reasons (in graduate school, for example), not to reveal one's true preferences

especially if doing so would make one suspect in the eyes of one's peers. Since the no free lunch rule conditioned the choices of the economists, their contributions to the public good fell well below the average, approaching zero. This was a utility maximizing strategy within the rules and conventions of economics, even if it suggested that the rules of economic theory diverge significantly from the expectations of others.

This result gives weight to the claim made in Chapter III that a multiplicity of solutions are possible to problems of allocation, depending on the character of institutional rules. The no free lunch rule or strong free rider hypothesis coordinated expectations very nicely inside economics. As Marwell and Ames noted:

> Economists may be selected for their work by virtue of their preoccupation with the 'rational' allocation of money and goods. Confronted with a situation where others may not behave rationally, they nevertheless behave the way good economic theory predicts. Note as well the very similar responses of our 'famous' economists. Of course, we might also turn the causal order around and gain insight into the deficiencies of the theory of collective action. The basic, or at least common, human concern with fairness and equity, rarely intrudes into economic theorizing. Instead, economists use a set of psychological assumptions about human beings which are fundamentally projections of their own modes of behavior. Since economists are a highly selected sub-

> population, their theories predict their own behavior well, but the behavior of the mass of humanity is poorly understood (1981, pp. 19-20).

In sum, approaching the problem of free rider behavior according to an assurance game based on interdependent decision making leads to more plausible explanations of Marwell and Ames' empirical results. Full confirmation must await further tests. It nonetheless appears that institutional rules (in this case rules of fairness) do parameterize expectations. In so doing they influence individual utility maximization, which feeds back into the formation of institutional rules. The concluding section of this chapter considers the impact of these findings on two problems in public goods provision. These problems arise from restrictions imposed on individual rationality by the free rider hypothesis.

## 5. The Size of the Group and the Need for Enforcement

The size of the group and the need for enforcement have tended to dominate discussion of problems of public goods provision where free riding is identified as the dominant strategy (Olson, Buchanan, 1968, R. Hardin). This section extends the brief discussion of these issues in section 10 of Chapter I. There it was shown

in the context of the assurance problem that complete assurance made outside enforcement unnecessary. Yet it was also noted that perfectly coordinated expectations was an ideal solution, requiring perfect information. In Chapter III, the informational function of institutional rules demonstrated how unlikely is perfect information (i.e., perfect assurance) over time, in light of negentropic decline. The transactions costs of enforcement of rules is therefore an important issue. The critical distinction, generally overlooked by those treating institutions as exogenous to individual utility maximization, is whether enforcement comes from inside or outside the group. This links the issue of enforcement to the size of the group.

Olson's The Logic of Collective Action (1965) argued that increasing group size makes detection of free riders increasingly difficult, leading to the necessity of enforcement of rules from outside the group. Hence ". . .rational, self-interested individuals will not act to achieve their common or group interests," unless the size of the group is small (Olson, p. 2).

This logic accepts the separable nature of choice, since the individual is assumed to make decisions without considering others' actions, and others' actions are

independent of each individual's choice (Olson, pp. 22-23). Hence the problem is often characterized as a prisoners' dilemma in which free riding is the dominant strategy for each individual (R. Hardin). The problem becomes worse as group size increases because detection and enforcement of free riders becomes more difficult.

However, a number of authors have shown that an approach predicated on interdependence of choice in public goods, such as the analytics of assurance, alters the conventional view of the size of the group and the need for enforcement. In particular, it challenges results in which public goods are seen as prisoners' dilemmas, with non-cooperative free rider behavior as the dominant strategy. If free riding is no longer dominant enforcement costs are reduced accordingly. To the extent that cooperative rules provide public goods, enforcement from outside the group is no longer necessary (Frohlich and Oppenheimer). On the other hand, cooperative institutional rules are not free of costs. Although enforcement from outside the group may be reduced, there are important transactions costs which must be met inside the group if cooperative institutional rules are to be maintained.

Individual reputation, to be discussed below, is also an important factor.

With respect to the size of the group, it has been shown that the probability of cooperative collective action designed to provide public goods without enforcement action may increase, decrease, or remain constant as group size increases (Frohlich and Oppenheimer, Frohlich, Hunt, et. al., Chamberlin, Schoefield, Bonacich, Shure, et. al., Marwell and Ames, 1979, 1980, 1981, V.L. Smith, 1980, Taylor, Oliver). If expectations regarding the choices of others are relevant, then coordinated expectations may be sufficient to provide contributions to the public good, as suggested by the results of Marwell and Ames. This is true independent of group size. Summarizing these results, V.L. Smith has concluded from a series of recent experiments that "there appears to be no systematic effect of collective size or experience on the quantity of the public good provided" (1980, p. 592).

These results, however, should not be taken to mean that individual contributions to public goods are totally unrelated to problems of information and transactions associated with group size. The analytics of assurance state that an individual's subjective esti-

mate of the expected actions of others will be determined by institutional rules providing prior information. Where the size of the group is large, the variance of this estimate would be likely to increase. In addition, the transactions costs of finding and maintaining a rule specifying a particular level of contribution would also be expected to rise. On the other hand, the benefits derived from finding and following such a rule due to extensions in the attainable set, the opportunity costs of finding alternative rules, and the losses in reputation from breaking the rule, may all increase with the size of the group. This is true whether the individual believes in the rule or simply conforms out of strategic rationality. The critical point is the institutions may succeed or fail, whether the group is large or small (Taylor, p. 25). Their success or failure turns on the extent to which they coordinate expectations providing assurance.

If institutions provide complete assurance, enforcement from outside the group is not necessary for stable rules insuring contributions to public goods. A cooperative institutional rule providing complete assurance implies that each individual's probability

density function of others' actions is concentrated around a particular contribution over time. This is a limiting case requiring perfect information and the absence of transactions and communications costs (Thompson and Faith, Elster, pp. 20-23). In such situations, depending on the level of contribution specified by the rule, individuals have a sufficient incentive to contribute to the supply of collective goods without any necessity for enforcement from outside the group (Frohlich, Hunt, Oppenheimer and Wagner, p. 328).

But in the absence of enforcement from outside, what prevents someone from seeking to gain from the rule in force at the expense of the others by breaking it and riding free? As Chapter III showed, free riding is not "free" at all. The benefits possible in the short term may be more than mitigated by costs arising within the group from breaking the institutional rule. In the absence of strictly dominant individual strategies, recognized interdependence makes the costs of loss of reputation high (Akerlof). A loss of reputation in one circumstance is likely to lead to a loss of reputation in others, reducing the gains available from cooperation across a wide range of activities, like losing one's credit rating. These costs, plus reduc-

tions in the attainable set if such behavior becomes common, plus the opportunity cost of innovating new rules, may exceed the expense of simply contributing. Again, this is true whether the rule is believed or not. Since defecting or free riding is not a strictly dominant strategy, enforcement is not a logical necessity.

Of course, the reputation of the individual is a function of the proportion of the group which adheres to the rule. If non-observance is common, violations do not carry the "pain of conspicuousness." To be known as a tax evader in some nations is not the same as in the United States, in part because tax evasion approaches a national pastime elsewhere. It follows that the difficulties of rule enforcement from outside the group will rise as the belief in and observance of the rule fall inside the group, since reputation will carry little weight in each individual's calculation of self-interest. These variations in enforcement costs are important policy issues (McKean), which will be considered in more detail in Chapter VI.

Does this mean that the reputation function is simply a negative "selective incentive," or "side payment," designed to induce voluntary contribution by altering the payoff to the individual? This would

imply that reputation is "outside the game," but could be brought in to change the payoffs and alter the outcome (Oliver, p. 1359).

In Chapter III, reputation is treated as part of the utility function maximized by each individual. Loss of reputation inside the group arises in relation to the rule. The rule is innovated by the group to extend its attainable set. Reputation is therefore an endogenous outcome of a rule structure developed inside the assurance game. It is not simply a "side payment."

Is the incentive to contribute to a public good by, say, giving at level $\bar{D}$ only the negative one of approbation and loss of reputation if one rides free? The relationship to the institutional rule is in fact more complex. Although damages may be imposed by the group on individual j for "breaking the rules," if the rule is endogenous the same agents responsible for formulating and adopting the rule are responsible for its interpretation and enforcement. He who is the rule-breaker today may define the rules of tomorrow. In this dynamic context, "leadership" may involve breaking the rules today, establishing new rules for tomorrow. Martin Luther, Lenin and Ghandi exemplify this tradition. The cost of leadership may be approbation, or worse, imposed

on the rule breaker in the short run. This may change if and when the virtue of the new rules is recognized by the group or some subset of it.

By contrast, adherence to rules carries a positive reward. By assisting in the coordination of expectations, one establishes a reputation as someone who helps to extend the attainable set of all. Over time, this may allow significant departures from such rules without loss of reputation if a good individual "track record" has been built. This suggests that positive reputation is an endogenous device which, when established, creates what is in effect a "line of credit" to meet unforeseen emergencies.

Positive reputation may be a protective device against random events which functions inside the structure of institutional rules to protect the individual who obeys them. It is a store of value allowing the rule to be breached, without approbation, when extraordinary circumstances may demand it. The attractions of this positive reputation may be more powerful in promoting adherence to rules than negative incentives inside or outside the group. Experimental evidence supports this explanation of the comparative strength of positive and negative rewards (Oliver).

That there are many factors which act to promote contributions to public goods from inside the group does not deny that in many cases in which strategies are imperfectly coordinated, enforcement from outside the group may help achieve Pareto-Improvements. If should be re-emphasized, however, that enforcement is significantly less when strategic incentives deny the strict dominance of individual strategy. In other words, by allowing groups the opportunity to innovate self-binding rules, enforcement costs may be reduced. It may then be necessary to bind people by recourse to rules imposed from outside the group. But one should not jump to the conclusion that all such rules must be imposed.

The lesson of the assurance game is to let individuals have full freedom to innovate those self-binding rules which best serve their needs, before proceeding to enforce rules from outside the group. Rules will be better suited to the needs of the group (whatever its size), and more likely to succeed, if based on such a premise. Enforcement from outside is a "second-order" solution.

Finally, enforcement from outside the group is not a sufficient condition for preservation of a public good such as range quality (Frohlich and Oppenheimer). The problem is that there is nothing to prevent the

enforcer, such as government, from abusing its authority. Any enforcement mechanism operating from above, designed to provide for provision of a public good, must invoke a higher authority for its own enforcement. Authority is also a public good. The problem will remain until an institutional solution is found which provides assurance inside the group.

## 6. Conclusion

This concludes the general discussion of the implications of the assurance problem for free rider behavior. The theory of interdependent choice presented thus far denies the strict dominance of individual strategy. Strategic choices enlarge the institutional opportunity set. This suggests that approaches which define rationality restrictively in terms of strict dominance must be reconsidered.

This is especially so in the area to be considered in the next chapter: public choice theory. An examination of the development of public choice theory allows a deeper consideration of why such restrictive individualistic postulates have dominated approaches to the provision of public goods.

# CHAPTER V. PUBLIC CHOICE AND INSTITUTIONAL ANALYSIS

## 1. Public Choice and Separable Decision Making

Orthodox economic theory treats externalities and public goods as exceptions to the rule. The ideal of competitive equilibrium requires the absence of externalities and of non-exclusive public goods (Bator, Arrow, 1969a). Where externalities or problems of public goods arise due to interdependence in production or consumption, current theory retains the assumption that individuals make independent choices. This assumption has deep intellectual roots, stretching back to classical economics and beyond. Wicksteed termed such individual independence of choice "non-Tuism" (MacRae, 1976, p. 161).

In Chapter I, this assumption was formally shown to be one of separability. The consequence of the assumption is to abstract from issues involving the interdependence of choice -- notably a variety of alternative institutional responses to externalities and problems of public goods discussed above.

The theory of public choice (also known as collective or social choice) has adopted the assumption of independent actors from the main body of economic theory

(Meuller, p. 3; Plott, 1976). The strict dominance of individual strategy is part and parcel of "rational self-interest." Each individual is assumed to be able to rank the outcomes resulting from actions, and to choose the best outcome (Russell and Nicholson, p. 3). Each individual's choices are not affected by expectations of the choices of others (see MacRae, 1973).

This separability of choice leads to serious problems of translating individually rational decisions into collective actions which remain rational for the group as a whole (Hurwicz; Sen, 1977). The consequence has been to focus attention on problems in which collective goods are argued to be impossible to provide without exclusiveness or outside enforcement.

When rational self-interest is defined in terms of the strict dominance of individual strategy common in public choice theory, it leads to the central paradox of the prisoners' dilemma. Fiorina, a leading public choice theorist, terms the prisoners' dilemma "probably one of the most important discoveries of the twentieth century" (p. 47). A parallel paradox, of equal importance to the formal underpinnings of public choice theory, is expressed in Arrow's famous impossibility theorem (Arrow, 1951; Meuller, pp. 185-201). Arrow's Theorem demonstrates the futility, within certain assumptions, of

building non-dictatorial social choice rules through the aggregation of independent individual preferences. Arrow's Theorem is generally considered as the foundation of "axiomatic" public choice theory (Mueller, p. 185).

The plausibility of both the prisoners' dilemma and Arrow's Theorem as reasonable descriptions of problems of public choice is questioned by individual and historical experience, which indicates the possibility of constructing successful non-dictatorial institutional rules (Shepsle, Friedland and Cimbala). Institutions imposed from outside the group arise in cases of military domination, colonialism, or development assistance, but the majority of institutional rules do not have this exogenous character. Public choice theory has been led by its assumptions into a virtual denial of its name.

Previous chapters have shown that a way out of the paradoxes of modern public choice theory results when collective social decision making is seen as an assurance problem, rather than as a prisoners' dilemma. The distinction between these two types of games is that in the prisoners' dilemma, individual choice orderings are independent, while in the assurance problem, these choices are interdependent. Independent choice in the prisoners' dilemma leads to the strict dominance of

individual strategy. Interdependence, by contrast, extends the feasible set of solutions to problems of economic allocation, and makes institutional rules cooperative adaptive responses arising from inside the group.

The purpose of this chapter is to link the abstract analysis of isolation, assurance, and common property externalities to some issues in the theory of public choice. There is a direct and important relationship between public choice and the theory of common property externalities treated as a prisoners' dilemma. This chapter establishes the link between the two bodies of theory, provided by the postulate of independent choice.

First, the importance of Arrow's Theorem is examined as the foundation of axiomatic public choice theory. Arrow's impossibility result has been shown to depend crucially on the assumption of independent choice. Relaxing this assumption, Arrow and others have opened up an important set of game-theoretic problems, similar to the assurance problem.

Next, to put the problem of independent choice in historical context, the intellectual history of the idea of strictly dominant individual strategy is considered. The purpose is to examine the origins of the idea of

independent economic actors, and to explore the implications of these origins for public choice theory.

The postulate of independent choice or preference independence is argued to be an unnecessary and biasing consequence of our intellectual inheritance. As previous chapters have argued, it is empirically unsupportable on experimental and historical grounds. This chapter argues that because it is the product of only one path of institutional evolution, it leads theorists and planners to overlook the feasible options possible in other cultures. Such oversights can have serious consequences among groups which do not share our individualistic traditions. Finally, it is unnecessary to justify rational utility maximization, and may even be destructive of "methodological individualism" as expressed by Von Hayek.

Hence, the idea of independent choice or preferences is is shown to be an unreasonably limited conception of rational self-interest. Theoretical approaches based on it, such as the prisoners' dilemma and Arrow's Theorem, are too limited to allow for the treatment of institutional rules as rational responses to social and economic needs. A less restricted conception is needed based on a broader interpretation of economic rational-

ity, reflected in the analytic approach to institutional rules put forward in Chapters III and IV.

This broader interpretation is predicated on interdependent choice. This is more attractive on empirical grounds, fits better with the interdependence of externalities and public goods, and is supportive of a more reasonable methodological individualism than in current theory. Perhaps most important, it eliminates the bias of strictly individualistic approaches which treat institutional rules as exogenous, especially where endogenous cooperation is an alternative. Recognition of interdependent choice problems liberates public choice theory from its restrictive assumption of the strict dominance of individual strategy, so that it may actually confront problems of "public" choice.

## 2. Arrow's Theorem

Since the publication in 1951 of Kenneth J. Arrow's Social Choice and Individual Values, axiomatic public choice theory has been dominated by his famous impossibility theorem. The result is both a challenge and a phantom that haunts the work of social scientists. Arrow's Theorem shows that there is no procedure for translating individual preferences into a social

preference ordering, or social welfare function, which obeys a set of seemingly innocuous postulates. The theorem represents a challenge to those concerned with the formulation of social decision rules, but seems to haunt all such attempts by demonstrating the impossibility of such rules within the postulates set by Arrow. These postulates are as follows (Sen, 1970, pp. 37-38).

1. Unrestricted domain: as a method of going from individual preferences to social preference, the social welfare function (SWF) must be wide enough in scope to work from any logically possible set of individual orderings.

2. Weak Pareto principle: if everyone prefers x to y, then society must also prefer x to y.

3. Non-dictatorship: there should be no individual such that whenever he or she prefers x to y, society must prefer x to y, irrespective of the preference of everyone else.

4. Independence of irrelevant alternatives: social choice over a set of alternatives must depend on the orderings of individuals only over those alternatives, and not on anything (or anyone) else, such as rankings of "irrelevant" alternatives not involved in this choice.

Arrow states his result in the following manner.

> If we exclude the possibility of interpersonal comparisons of utility, then the only methods of passing from individual to social preferences which will be defined for a wide range of sets of individual orderings are either imposed or dictatorial (1951, p. 53).

The necessity of imposed or dictatorial social welfare functions in Arrow's Theorem corresponds to the need for enforcement arising from the prisoners' dilemma (Wilson).

The majority of the public choice literature has either chosen to ignore Arrow's Theorem or has attempted to relax one or more of his postulates (Pazner). To public choice theorists, relaxing one or more of the postulates has provided a theoretical basis for showing under what circumstances a social decision rule is "possible." Of these postulates one: the independence of irrelevant alternatives, has been the major point of departure. The reasons this condition has attracted such attention need to be clarified.

Arrow states his independence of irrelevant alternatives condition formally as follows:

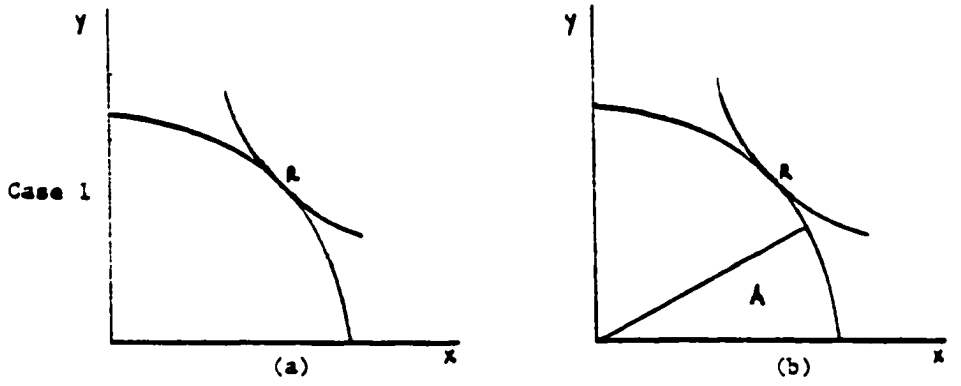
> Let $(R_1 \ldots, R_n)$ and $(R_1' \ldots, R_n')$ be two sets of individual orderings and let $C(S)$ and $C'(S)$ be the corresponding social choice functions. If, for all individuals i and all x and y in a

> given environment S, $xR_iy$ if and only if $xR'_iy$, then C(S) and C'(S) are the same (Blin, p. 96).

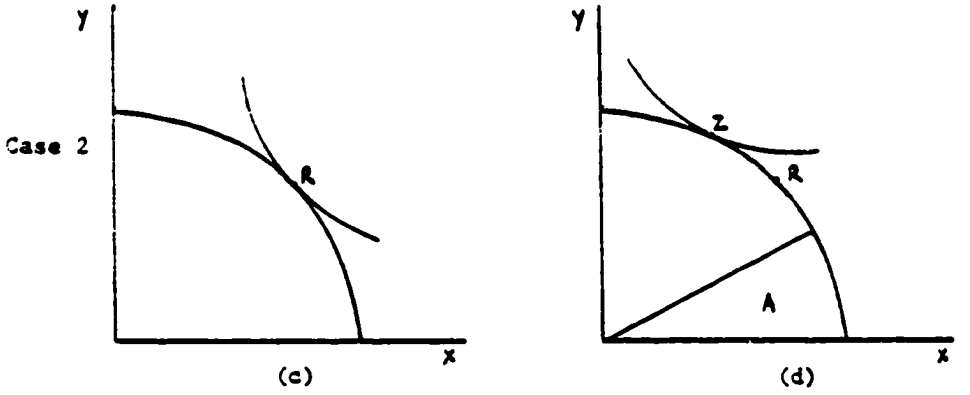
To repeat the basic definition given above, this condition says that social choice over a set of alternatives x and y must depend on the preference orderings of the individuals over those alternatives $R_i$ and $R'_i$, and not on rankings of "irrelevant" alternatives that are not involved in this choice. In a choice between x and y, the introduction of some other choice will not alter the transitive preference relation, and the social choice should remain the same (Sen, 1970, p. 37).

Donald Wittman (1979) has recently suggested a graphical interpretation of this postulate which may assist in its apprehension (see Figure 5.1). Case 1 shows the independence of irrelevant alternatives. In Case 1, graph (a), the preference map for a single individual represented by the indifference curve is tangent to the feasible set of choices of bundles of x and y at point R. Now let the feasible set be reduced by the amount of the area represented as A in graph (b). The point of tangency remains unchanged at R, despite the change in the feasible set. The indifference curve is independent of the feasible set. Note that the set of bundles of x and y given as A are arbitrarily designated as "irrelevant." Eliminating these feasible

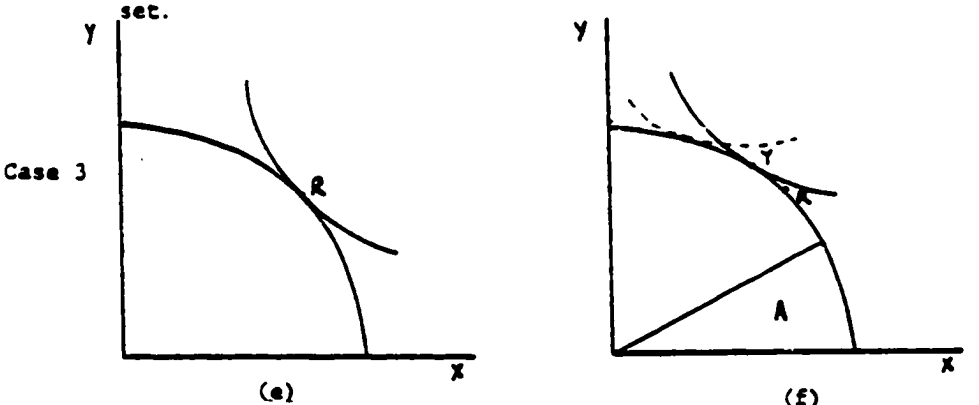
Figure 5.1




Independence of Irrelevant Alternatives
The indifference curve is independant of changes in the feasible set.




No Independence of Irrelevant Alternatives
The indifference curve is dependent on changes in the feasible set.




No Independence of Irrelevant Alternatives. The indifference curve is dependent on changes in the feasible set, and on the expected choices of others resulting from these changes.

points does not alter the fact that the highest indifference curve is reached at point R. This is the independence of irrelevant alternatives.

Now consider Case 2. Here, the initial point of tangency at point R in graph (c) does not remain the same when the feasible set is reduced by the amount A. When this happens, in graph (d), the preference map of the individual is changed, as reflected in the change in the indifference curve, so that a new point of tangency occurs at Z. The indifference surface is dependent on the change in the feasible set. Eliminating these feasible points does alter the highest point of tangency between the indifference surface and the feasible set.

In Case 2, the change in preferences reflected in the changed indifference surface is a function of the changes in the feasible set of (irrelevant) alternatives for goods x and y. There is another, more subtle possibility represented in Case 3. Here, a change in the feasible set has two effects, which are in practice inseparable. First, the change in the feasible set affects the preference map and therefore the indifference surface directly, as in Case 2. In addition, however, the change in preferences leading to the altered choice of goods also leads to a secondary effect,

with a final point of tangency at Y. In Case 3, the dotted indifference curve in (f) is the expected change in the likely choices of other individuals affected by the reduction in the feasible set, projected by the individual onto his or her own indifference map. These others may even be hypothetical constructions ("what would Dad have done?") influencing individual choice. Based on this expected change the individual concerned finds a point of tangency at point Y. In this case, the position of the indifference curve is dependent not only on the change in the feasible set, but also on the changes in the preferences of others which the change in the feasible set is expected to produce.

Although the result has the appearance of simplicity, its interpretation has caused much confusion, due in part to the examples provided by Arrow himself (Blin, p. 96). Hansson has conducted an extremely thorough analysis of these problems. Ray has also clarified the relationship between Arrow's independence postulate and various other similarly named but different conditions in the economics and psychology literature (Blin, Marschak & Radner, Luce).

Without entering into complex analysis, it has been established that a crucial aspect of Arrow's Theorem is a hidden assumption reflected by Case 3 above. The

crucial aspect of Arrow's independence condition, and of the impossibility theorem itself, is not so much the independence of alternatives as the independence of preferences for these alternatives (Blin). Many objections to Arrow's Theorem stem from the implausibility of this postulate.

The postulate is implausible because it rules out the relevance of any information, such as is conveyed via institutional rules, which could be acquired concerning the expected choices of others (Sen, 1979). By leaving out questions of expected actions by others, it abstracts entirely from issues of uncertainty and information respecting these actions. Arrow's independence condition treats individual choice as fixed in relation to a set of conceivable alternatives, so that none of the interdependence suggested under Case 3 above will arise. Not only does it not allow for "irrelevant" alternatives to affect choices, it does not allow individual preference orderings or expectations regarding these orderings to affect one another. Individual orderings are independently constructed and remain unchanged in the face not only of irrelevant alternatives but also the choice orderings of others. This mirrors the strict dominance of individual strategy which characterizes the prisoners' dilemma (see Blin and Satterthwaite, Satterthwaite).

For much the same reasons, the result is untenable. Formally, if $(R_1 \ldots, R_n)$ are sets of individual orderings and S is the set of all conceivable alternatives, it is clearly unrealistic, if not impossible, to imagine a situation where the $R_i$'s are not themselves a function of the set S as well as functions, both directly and indirectly via changes in S, of each other (Blin). Especially in the real world of public choice, it is clear that choices may come to depend on available alternatives which may appear irrelevant, and that these choices may depend critically on expectations of the choices of others. This result has been confirmed in experiments designed to test the actual interactions of individual actors (Plott, 1979).

In later work, Arrow clearly acknowledged the limitations imposed by the strict individualism of the independence condition, although these later comments have received less attention than deserved. In a statement on his impossibility theorem, Arrow noted the crucial problems surrounding the postulate of preference independence.

> A standard liberal point of view in political philosophy, which has also dominated formal welfare economics, asserts that an individual's preferences are or ought to be (a distinction not usually made clear) concerned only with the effects of social action on

> him. But there is no logical way to distinguish a particular class of consequences which pertain to a given individual. If I feel that my satisfaction is reduced by somebody else's poverty (or for that matter, somebody else's wealth) then I am injured in precisely the same sense as if my purchasing power were reduced. . . . I am in effect arguing here that just as we cannot factor social actions so as to make each component pertain to a given individual, so we cannot factor the consequences of social actions in any meaningful way into separable consequences to individual members of society. That is, let me make it clear, we cannot do so as a matter of fact (Arrow, 1969b, p. 231).

Arrow has therefore asserted that, as pictured in Case 3 of Figure 5.1 above, it is not possible as a matter of fact to partition alternative bundles of x and y into "relevant" and "irrelevant" alternatives for each individual. Even more important, Arrow has asserted that the choices of individuals in relation to changing alternatives cannot be treated as independent of one another, at least not as a matter of fact.

These problems have led Arrow (1977) and others (Suppes, Hammond, Strasnick) to the view that the independence postulate must be relaxed to allow for a weak form of interpersonal comparison which involves only ordinally significant comparisons. These theories argue for a form of interdependence known as "extended sympathy." Extended sympathy arises in judgments of the sort in which individuals do not behave according to

independent preference orderings, but instead say "it is better (in my judgment) to be myself under action x than to be you under action y" (Arrow, 1969b, Strasnick). As long as we can meaningfully judge whether we would prefer to be one individual in a particular situation, with all of the attributes or difficulties this entails, or to be another in a different situation, or would be indifferent between the two situations, it is possible to have "extended sympathy."

Introducing interdependence of choice even in the limited form of ordinal extended sympathy comparisons entirely alters the structure of Arrow's decision model. By making individual choices functions of the alternatives available and functions of others' (even only hypothetical) preferences, one introduces the non-separability of choice. The attendant problems of truthful versus strategic misrepresentation of preferences then arise, together with other "game" issues.

In Social Choice and Individual Values (1951) Arrow explicitly recognized, and chose to eschew, game issues such as truthful versus strategic preference revelation. As he noted,

> . . .there remains the problem of devising rules of the game so that individuals will actually express their true tastes even when they are acting rationally. . . . In

> addition to ignoring game aspects of the problem of social choice we will also assume in the present study that individual values are taken as data and are not capable of being altered by the decision process itself (p. 7).

By treating individual values (preferences) as data, Arrow was asserting their independence from each other, ruling out the various forms of interdependence considered in previous chapters. It is important to emphasize Arrow's subsequent observations on the strict individualism of his earlier work. By ruling out interdependent choice, Arrow limited his work to the aggregation of independent individual preferences, thus abstracting at once from game-theoretic problems and the process of institutional choice (Friedland and Cimbala).

Arrow's doubts concerning his original work are worth noting:

> (A)ll non-trivial actions are essentially the property of society as a whole, not of individuals. . .the partition of a social action into individual components, and the corresponding assignment of individual responsibility, is not datum. Rather, the particular factoring in any given context is itself the result of a social policy and therefore already the outcome of earlier and logically more primitive social values (1969b, p. 219).

These issues are those of the coordination norms or institutional rules analyzed above. Social values constitute the basis of public institutions, and account for less visible codes and conventions.

Arrow interprets these coordination norms as possible reactions to market failure. Their function is to provide trust or assurance respecting the actions of others in order to reduce the level of enforcement which would be required if such rules or norms did not exist. He notes, in support of the main point of this study, that institutional rules or coordination norms are a principal response to problems of externalities.

> I suggest as one possible interpretation, that (norms) are reactions of society to compensate individuals for market failures. It is useful for individuals to have some trust in each other's word. In the absence of trust, it would become very costly to arrange for alternative sanctions and guarantees, and many opportunities for mutually beneficial cooperation would have to be foregone (Arrow, 1969a, p. 62 ).

Although he does not use the language of this study, Arrow's remarks amount to an assertion of the informational function of institutional rules discussed in Chapter III, which act to reduce the enforcement costs which would have to be borne in the absence of such norms or rules.

Thus, Arrow's doubts concerning his independence postulate have led to recognition of the critical function of institutional rules, which he argues are of particular importance as responses to market failure.

Arrow amplifies these claims with respect to a particular set of institutional rules also important to this study. He notes:

> In economic transactions the point is clearest when we consider what we call property. Property is clearly a creation of society through its legal structure. The actions of buying and selling through offers of property are only at a superficial level the actions of an individual. They reflect a whole series of social institutions, and with different institutions different people would be having control over any given piece of property. Furthermore, the very notion of control over one's 'own' property, as is apparent upon the most casual inspection, itself acquires its meaning through the regulations of society (1969b, pp. 219-20).

Arrow thus distinguishes between private, exclusive control of one's own property, and the higher order issue of assurance which characterizes institutional rules in general. The nature of control over property, he argues, is a function of the institutional forms prevailing, which may or may not involve private, exclusive use rights to resources.

Despite these important observations (widely scattered in Arrow's work) the implications of "extended sympathy" as a form of interdependent choice for institutional rules such as property remain undeveloped. Approaching these matters from the side of institutional rules will clearly have different implications for public choice than the impossibility result associated with the preference independence of Arrow's Theorem. Wilson (1972) has shown that the exclusion of Arrow's independence condition leads to a view of the social decision process as a game similar to the assurance problem. Thompson and Faith (1981) taking a different approach, argue that the strategic commitment to rules reduces the force of Arrow's claims.

At this point, it is useful to consider preference independence in a larger historical and intellectual framework. This is necessary in order to appreciate the hold which strictly individualistic ideas of rational choice have had on economics and public choice theory.

## 3. Rational Self-interest: An Historical View

The independence of preferences assumed by much of the public choice literature is based on an analytic

tradition in which decision rules for the group are built up by aggregating independent individual choices. Rational economic man confronts choices as a self-interested actor. Exactly what "rational self-interest" means has been the subject of great controversy, not only in the economics literature but in extensions of the idea of "homo economicus" to such fields as anthropology, (LeClair and Schneider), sociology (Lukes), and more recently, sociobiology (Elster, Schotter, Bunge). Simplifying, the polar extremes of the debate involve "individualists" on the one hand and "collectivists" on the other (Bunge).

Both positions have clear ideological overtones which make them earnest competitors for intellectual loyalty, pulling scholars toward one pole or the other. As Von Hayek wrote in his spirited defense of individualism, "whatever else it may have meant at different times. . .the term individualism has the distinction that the word 'socialism' was deliberately coined to express its opposition to individualism" (Von Hayek, p. 3). As he notes, both the term individualism and the term socialism were originally the creation of the Saint-Simonians, who coined individualism "to describe the competitive society to which they were opposed,"

and socialism "to describe the centrally planned society in which all activity was directed on the same principle that applied within a single factory" (p. 3, n. 1).

The ideological resonance of individualism and collectivism, together with the ambiguous nature of the terms, has made dispassionate analysis of their origins and content difficult (Pryor, O'Neill). Yet such analysis is important. By looking, even briefly, into the history of these ideas, insight may be gained into the central role of preference independence in economics and public choice theory.

The economic theory of externalities and public goods has not developed in an historical and social vacuum. It reflects the individualistic assumptions and beliefs of Western intellectual tradition. This tradition, while mainly the product of the last three centuries, also carries vestiges of earlier thought in its approach to problems of scarcity, allocation, and decision making (Schumpeter, Gonce).

The intellectual origins of individualism may be traced at least to the first century writings of the Stoics, including Epictetus, Seneca, and Marcus Aurelius (Gonce, p. 491). Its historical development is also closely linked with the natural law philosophy of

Cicero (Watson), the Sophists, and Heraclitus (Chroust, Rommen).

It is relevant to a study of the role of institutions and public choice that even the early Stoic conception of individual action was part of a science of social and political conduct or praxis. Natural law, according to the Stoic philosophers, could be known through human reason, since reason and nature were regarded as two manifestations of the same truth. By obeying natural law, each individual would act in the interests of others, establishing a rational collective choice rule parallel to the rational choice of the individual actor (Gonce).

Cicero's interpretation of Stoic natural law led to its codification in the jus naturale of Rome, and its reflection in the writings of the early Christian Fathers. Although these ideas fell into desuetude from the fall of Rome to the end of the Dark Ages, they regained currency in the flowering of natural law philosophy after the 14th Century. In this period of regeneration, "atomistic individualism, Epicureanism, and unaided human reason came to replace God and revelation" (Gonce, p. 492).

The methodology resulting from this rebirth reflected the "resolutive-compositive" approach employed

by Galileo (1564-1642) in his studies of planetary motion. It was felt that natural laws could be derived from the speculations of one isolated individual living in a state of nature. Its modern origins in the study of public choice may be traced to the great Dutch rationalist philosopher and founder of international law, Hugo Grotius (1583-1645), who believed it possible to develop an overarching system of social choice (natural law) from postulates of rational individual choice (Rommen, p. 73). The development of the "rule of law," even in wartime, is due to Grotius.

The detailed development of this methodology was carried out by followers of Grotius, including Samuel von Pufendorf (1632-94), Rousseau (1712-78), Thomasius (1655-1728) and Kant (1724-1804) (Krieger, Rommen). Perhaps the most influential of Grotius' followers were Descartes (1596-1650), Hobbes (1588-1679), and Locke (1632-1704). Of these, Hobbes and Locke merit close attention.

a. Hobbes

Hobbes argued that the state of nature was anarchy: a war of "all against all." Nothing short of a monopoly on coercion by a sovereign was sufficient to prevent

each from imposing on others an existence, in Hobbes' famous expression, "solitary, poor, nasty, brutish and short" (Hobbes, 1929, Pt. I, ch. 13).

Hobbes' theory placed absolute primacy on the individual in isolation. From many isolated individuals he proceeded by the resolutive-compositive method to construct a model of society which analyzed the interaction of these individuals (MacPherson, 1964, p. 30). "It is necessary," he wrote, "that we know the things that are to be compounded before we can know the whole compound," for "everything is best understood by its constitutive causes." The causes of social choice resided in individual men, independent of the thoughts and desires of others. Hobbes' device was to treat individuals "as if but now sprung out of the earth, and suddenly, like mushrooms, come to full maturity without all kinds of engagement to each other" (Lukes, p. 119).

Hobbes' conception, reflected in Arrow's condition, asserted not only the independence choices from the environment of alternatives, but the strict independence of individual preferences from one another. Building from the independent designs of men, Hobbes constructed a model of society in which each recognized

it to be in his interest to seek refuge from others through the protective powers of a sovereign state, Leviathan. Leviathan assumed a monopoly on coercive enforcement, becoming a "Mortal God." It policed by common consent the would be chaos of isolated individuals, imposing a dictatorial rule on the otherwise unstable actions of society. In Hobbes, we see the foundation of Garrett Hardin's mutual coercion, and the rudiments of an N-person societal prisoners' dilemma (Taylor), as well as the dictatorial rule of social choice offered by Arrow's Theorem. Imposed or dictatorial rules result from independent individual choice due to the strict dominance of individual strategy.

From this conception also came Hobbes' antagonism to collective organizations such as the guilds. If the strict dominance of individual strategy and its inferior anarchic outcome required a sovereign with a monopoly on force, then cooperative rules at lower levels such as guilds would only act to subvert the power of the sovereign. The result would be to render still more unstable an inherently unstable arrangement. Hence, collectives such as guilds were "like worms in the entrails of a natural man" (Hobbes, 1929, Pt. II, ch. 29). This view is a harbinger of objections to the

role of countervailing institutions of organized labor by the strict individualists of later periods.

In sum, Hobbes' theory held that individuals seek dominance over others without exception. All society "is either for gain, or for glory; that is, not so much for love of our fellows, as for love of ourselves." Since gain and glory "may be better attained by dominion, than by the society of others, I hope no body will doubt but that men would much more greedily be carried by nature, if all fear were removed, to obtain dominion, than to gain society" (Hobbes. 1949, p. 24).

Hobbes provided the prototype for individual choice defined in terms of the strict dominance of individual strategy. Each man is an independent actor--an island unto himself. Without enforcement from outside, all will be worse off. Although his imputations of egoism seem extreme, his logic and perception have implanted themselves deeply in our conception of independent individuals as the basis of "rational self-interest" (Taylor).

b. Locke

Locke rejected Hobbes' glorification of the state as the exclusive source of law. The Scottish philoso-

pher argued for a more benign state of nature, granting more to the wisdom of man. To Locke, the role of natural law was to establish the inalienable rights of the individual, notably to property (Rommen).

The individual rights advanced by Locke appealed to the same strict individualism as did Hobbes', but without such meanness between individuals. Locke's conception was much closer to the abstract self-seeking of modern economic man: others were data. As with Hobbes, Locke's argument was resolutive-compositive: starting with the individual and moving out to society and the state. His confidence in individual reason resulted in a theory in which individual property rights were the necessary precondition to a stable social order. Such exclusive rights both protected and confirmed the sanctity of individual reason.

Despite his fundamental individualism, Locke's dual concern with the larger social order and the crucial role of majority rule in the maintenance of that order has earned him a reputation as a collectivist with some scholars (MacPherson, 1964, p. 195). It has been suggested that his concern with the will of the majority dominated his concern for individual rights (Kendall). In this sense, his subordination of the

individual to the purposes of society is sometimes associated with Rousseau's claim that the will of all individuals must bow to the general will (Runciman and Sen).

MacPherson has provided a resolution of these supposedly contrary strains of individualism and collectivism by concentrating on the institutional prescription offered by Locke. The Treatises make clear that the locus of man's individualism is his right to property, and that the protection of this right is the primary cause of men gathering together to form a sovereign government. As the Second Treatise argued (Sec. 124), "The great and chief end, therefore, of men united into commonwealths, and putting themselves under government is the preservation of their property." This proposition, as MacPherson notes, "clearly requires that man have a natural right to property, a right prior to or independent of the existence of civil society and government" (MacPherson, 1964, p. 198).

Hence for Locke, not only was man in nature independent of civil society; since his person was also his property, he was also independent of every other man. The importance of this assertion for later political and economic theory, notably the property rights paradigm,

cannot be overstated. The separable choice of individuals and its attachment to private property rights finds its modern expression in Locke. With individual persons and private property as one unified conception, Locke argued that men had "perfect freedom to order their actions, and dispose of their possessions, and persons as they see fit, within the bounds of the law of nature, without asking leave, or depending upon the will of any other man" (MacPherson, 1964, p. 199).

The importance of Locke's contribution for this study was his wedding of the strict dominance of individual strategy to private property rights. By linking individual property with the strict dominance of individual strategy, Locke laid the intellectual foundation of the property rights paradigm. The individual right to private, exclusive use was thereby set as part of the law of nature. As Rommen noted in his study of natural law philosophy:

> Locke's philosophy of law does not view the law as an objective order of norms out of which individual rights flow by intrinsic necessity; the rights of individuals are prior, and in them originates whatever order exists. Order is consequently the product of contracts among individuals, who are induced by their rather selfish interests to enter into these contractual relations. . . . The state is the utilitarian product of

> individual self-interest, cloaked in the solemn and venerable language of the traditional philosophy of natural law (p. 89).

Although Locke gestured to the medieval and seventeenth century Puritan notion that God originally gave the earth to mankind in common (which, as argued in Chapter I, reflected no more than the existing dominance of common property), he sought "to show how men might come to have a property in several parts of that which God gave to mankind in common, and that without any express compact of all the commoners" (Locke, Second Treatise, sec. 25). In other words, Locke explained and justified the imposition of private property rights over common property.

This explanation and justification was not without political and economic significance in Locke's time. It was a natural law justification for enclosure of common fields, then at issue across much of England (Dahlman, 1980). It also provided a basis for assertion of private, exclusive rights to common "waste" land, where it was assumed that no property rights existed, such as in the vast tracts of British North America. This argument would later be used by colonial authorities in Africa (see Chapter VI).

Locke's justification for enclosure was in two steps. First, by combining his labor with the land, man "by his labour does, as it were, enclose it from the common" (Second Treatise, section 32). The second and crucial step justifying property acquisition and enclosure was the introduction of money (MacPherson,1964, p. 203). Locke argued that although vast tracts of land lay waste in North America, since no property rights were assigned or defined, it could not be brought into use. By introducing a money economy, a basis for the exchange of use-rights could be established (Second Treatise, section 36).

The appropriation of common where excess supply of lands was in evidence was an accepted right in English law dating to the Statute of Merton in 1235. This statute long preceded the enclosure movement (Dahlman, 1980, pp. 161-2). This right was bolstered in the period of enclosure by Locke's two justifications for imposing private use-rights. The justification extended to the limitless tracts of what were then the "less developed" northern counties of the British Isles and North America.

As MacPherson notes (1964, p.219), the link between private property and individual rights removed the con-

tradiction cited above between Locke's individualism and collectivism. Since, under Locke's thought, individuality could only be fully realized by accumulating property, the chief purpose of the state was to protect the right to such accumulation. Locke's theory demands the enforcement of private property rights in the name of individual property. In the game-theoretic language of Chapter I, independent choice yields the strict dominance of individual strategy, and the need for enforcement from a sovereign authority outside the group. Locke's contribution was a unity between strict individualism and private property rights which survives in the Western intellectual tradition today.

### c. Further Refinements of Rational Self-Interest

The conception of rational self-interest in terms of independent individual choice defined by Hobbes and Locke gave a natural law foundation to the strict dominance of individual strategy. It portended homo economicus: rational economic man. As various economic historians have shown, the political and economic model of a state of nature composed of isolated individuals owed its subsequent popularity in part to the publica-

tion of Defoe's Robinson Crusoe in 1719 (Gonce, p. 492, Rommen, Schumpeter). The grip which this popular work exercised on the English imagination at all social levels was playfully treated over a century later by Wilkie Collin's portrayal of a pipe smoking house steward whose primary reference in times of domestic or social strife was Robinson Crusoe. "I have tried that book for years," he noted, "generally in combination with a pipe of tobacco and I have found it my friend in need in all the necessities of this mortal life" (Collins, p. 12). Many economic theorists continue to refer, with some seriousness, to the isolated Crusoe as the paragon of rational economic man (Von Neumann and Morgenstern, pp. 9-12).

By the end of the eighteenth century, the resolutive-compositive conception of economic relations predicated on individual "atoms" was firmly established. As Adam Smith noted in the Wealth of Nations (1776), the common good is nothing but the sum of the particular goods or interests of individuals. The free pursuit of self-interest on the part of individuals who are restricted only by the like freedom of others will result in social harmony and economic wealth, as if by

the direction of an invisible hand. The acquisition of private reward, underwritten by Locke's natural law in the Treatises, thus found parallel justification in economic markets, where the coordinating role of a sovereign authority was supplanted by the even more adroit capabilities of the invisible hand (Rommen, p. 90).

The conception of rational self-interest was also influenced by the nineteenth century attack on natural law philosophy by skeptics and agnostics such as David Hume (1711-1776) and utilitarians such as Jeremy Bentham (1748-1832). These authors condemmed natural law for putting human reason on a pedestal, from which the passions of unrestrained self-interest might cause it to fall. They thus strengthened the notion of strict, but not necessarily rational, individual choice. As Hume noted in his famous discussion in A Treatise of Human Nature, the problem of draining a meadow models the elementary tendency for man's individual self-interest to dominate his social duty. In one of the first clear statements of the free rider hypothesis, Hume wrote:

> It is very difficult, and indeed impossible, that a thousand persons should agree in any such action; it being difficult for them to concert so complicated a design, and still

> more difficult for them to execute; while each seeks a pretext to free himself of the trouble and expense, and would lay the whole burden on others (Olson, n. 53, pp. 33-34).

In light of the strict dominance of individual strategy, governments must act to supply public goods through outside enforcement. The difficulties of concerting complicated designs because of group size, as well as man's tendency to free ride, are thus overcome. Hume continued:

> Political society easily remedies both these inconveniences. . . . Thus bridges are built, harbors opened, ramparts raised, canals formed, fleets equipped, and armies disciplined, everywhere, by the care of government, which though composed of men subject to all human infirmities, becomes, by one of the finest and most subtile inventions imaginable, a composition which is in some measure exempted from all these infirmities (Olson, n. 53, pp. 33-34).

The free rider hypothesis and the argued need for enforcement from outside the group, especially when the group is large, is thus not a new idea. In the game-theoretic terms of the prisoners' dilemma, Hume may be interpreted as emphasizing the instability of rules or contracts in light of the strict dominance of individual strategy (Taylor). He draws attention to the fact that with such strict dominance, government authority

and control cannot be so light-handed as supposed by natural law theorists.

Taylor has argued that Hume was not unaware of the possibility of coordination and assurance arising from rules developed inside the group, but that he believed that man faced a prisoners' dilemma (Taylor, p. 124). Individual strategy dominates, and without enforcement this self-interest may bring ruin to all. Whereas natural law theorists held that reason and nature were but two reflections of a single idea, Hume found them irrevocably opposed. Lacking reason as a guide, judgments are formed by what pleases (Rommen, p. 112). This provided a basis for the principle of utility outlined by Mill as well as the "felicific calculus" of Bentham.

The result was a critical ambivalence over the capacity for rational self-interest to function in the interest of the common good. Where external effects or problems of public goods arose, self-interest could not lead to optimal outcomes in the absence of enforcement, or unless separability was imposed to allow each individual to cultivate his own garden, or drain his own meadow, through the imposition of private, exclusive property.

This ambivalence arose from the criticism of natural law which held that passions and the pursuit of pleasure ruled. Granting this, the utilitarians (and by inheritance, much of modern economic analysis) did not abandon the idea of independent individual choice and the strict dominance of individual strategy. The primary unit of analysis remained an independent sensor of pain and pleasure, in the tradition of Hobbes (Lukes, p. 119).

In Mathematical Psychics (1881), Edgeworth asserted that "the first principle of Economics is that every agent is actuated only by self-interest" (p. 16). Yet he noted that "the concrete nineteenth century man is for the most part an impure egoist, a mixed utilitarian" (Edgeworth, p. 104, quoted in Sen, 1977, p. 317). As Sen observes, "this raises the interesting question as to why Edgeworth spent so much of his time and talent in developing a line of inquiry the first principle of which he believed to be false" (Sen, 1977, p. 317). The persistence of the assumption of independent actors with strictly dominant strategies had gained ground; Edgeworth interpreted Sidgewick as having destroyed the "illusion" that as a general proposition "the interest of all is the interest of each" (Sen, 1977, p. 318).

Edgeworth set out to relate the interest of each to all in the specific context of the contract, where he was able to show convincingly and diagramatically the existence of a "core" of Pareto-Optimal solutions arising from the exercise of self-interest by two identical, independent, self-seeking individuals (see Telser, Shapley and Shubik, Meunch, Scarf). Edgeworth thus asserted market solutions as the outcome of exclusive contracts. This did not resolve the larger question of free rider behavior, externalities and public goods, but it made these issues exceptions to the rule in general economic theory. Edgeworth did not pause long to explore institutional issues outside of, in his words, the "unsympathetic isolation abstractly assumed in economics" (Sen, 1977, p. 326).

Thus, the strict dominance of individual strategy characterizing the prisoners' dilemma became the basis for the conception of rational economic man. Yet the limitations imposed by the postulate of independent economic actors has remained a serious difficulty. Some "sympathy" or interdependence must be admitted if the theory is to have institutional content. This has been recognized by many contributors to economic analysis, of

whom Arrow is one. Arrow's critique of his own impossibility theorem may be understood in this context. Unfortunately, the main line of public choice theory has tended to follow the earlier and more limited conception of rational self-interest, in which interdependent choice is disallowed, leaving institutions as exogenous forces to be imposed from outside the group.

d. Collective Action and Commitment

The view that institutional rules are a response to individuals' interdependence is also an old one. As Aristotle noted, it is a peculiarity of men that they possess a collective understanding of a set of rules, and that this understanding constitutes a polis (Rawls, p. 243). A medieval maxim held that what touches all concerns all, so that institutions were to be constructed with the interdependence of individuals in mind, rather than promoting the quest for self-mastery (Rawls, p. 233).

The idea that participation in economic and political life is itself evidence that the individual is not entirely master of himself was once a part of conventional wisdom. This interdependence was especially clear in agricultural society, where institutions emphasize collective protection in the face of drought, disease, and

the vagaries of nature. In this traditional environment, giving is the necessary counterpart of taking. "Donations" to a variety of public goods are part of the texture of life. In peasant agriculture from the seventh to the twelfth centuries, Georges Duby noted:

> Society as a whole was shot through with an infinitely varied network for circulating the wealth and services occasioned by what I have called 'necessary generosity' (les generosites necessaries): gifts of dependents to their protectors, of kinfolk to brides, of friends to party-givers, of magnates to kings, of kings to aristocrats, of all the rich to all the poor, and lastly of all mankind to the dead and to God. True, we are dealing with exchanges, and there were plenty of them. But it is not a question of trade (p. 56).

These relationships have been widely noted in traditional agricultural societies in more recent times (Herskovitz, Malinowski, LeClair and Schneider). These cases suggest a common property basis in traditional societies. Motivated in part by this historical sense, explanations of society based on collective action arose with increasing force in the nineteenth century in opposition to the individualism of natural law. The intellectual tradition which identified the c[illegible]ical unit of decision in society as the collectivity reflected an emphasis on commitment, in which institutional rules cause individuals to choose against their own preference

in order to promote the common welfare. This tradition is sometimes opposed by champions of individual freedom, since it is argued that it restricts opportunity in the name of obligation to the collective good (Von Hayek). In its extreme varieties, these theories are associated with idealist justifications of oppression. But there have been a wide variety of approaches to collective action.

In 1854, de Bonald observed that it is "society that constitutes man, that is, it forms him by social education" (Lukes, p. 119). Comte, three years earlier, had denied the efficacy of the resolutive-compositive methods of Hobbes, Locke and their progeny. As he noted, society "was no more decomposable into individuals than a geometric surface is into lines, or a line into points" (Lukes, p. 119). These continental writers were outdone by the German historical school of jurisprudence, which insisted that law is merely the creation of the spirit of the people (Volksgeist), which reveals itself as the product of a collective unconscious through legal conventions and customary law (Rommen, p. 115).

The German historical school intended "to replace the external and unchanging natural law," with a more "positive, historical, national law." Its profound

conservatism, which is sometimes associated today with totalitarianism and Fascism, was reflected in its opposition to "the demands, clothed in natural law dress, of the revolutionary publicists" (Rommen, p. 119).

In North America, collective action became the central thesis of the "institutional economics" of Veblen, Commons, and Mitchell. Although it took a different form from its European antecedents, its demise occurred in part because of its association with the German historical school and European collectivism during the Great Depression and between the world wars. However, the American school of institutional economists stood in a direct line from traditional political economy of Smith, Ricardo, and Mill, except for its rejection of independent individual choice as the basis of analysis (Myrdal).

Heavily influenced by the notion of cumulative causation, described by John Dewey as an unending continuum of ends and means, the institutionalists placed major emphasis on interdependence at every level of the economy, including individual choice (K. Parsons). They saw institutional rules as the expression of rational, self-interested, but interdependent economic agents. Economics was to be freed from strict

individualism through a theory of "negotiational psychology" (Commons, 1934).

"We may define an institution," Commons wrote in 1934, "as Collective Action in control of Individual Action" (Commons, 1934, p. 69). He expressed his general view in the following terms:

> Collective action, as well as individual action, has always been there, but from Smith to the Twentieth Century it has been excluded or ignored, except as attacks on trade unions or postscripts on ethics or public policy. The problem now is not to create a different kind of economics--'institutional economics'--divorced from preceeding schools, but how to give collective action, in all its varieties, its due place throughout economic theory (Commons, 1934, p. 5; Schotter, p. 4).

Until recently the reputation of institutional economics has been in decline. It has emerged as an academic fifth column, divorced from the mainstream of economics in part by its rejection of the postulate of independent choice.

Renewed interest in "negotiational psychology" in the form of game theory has occurred inside of economics and political science, resulting in a new interest in institutions as the basis of public choice (Schotter and Schwodiauer). Institutional rules commit people to certain actions and reduce uncertainty over the actions of others, in such a way that rational self-

interest must be interpreted as a problem of interdependent choice, in the fashion outlined in Chapter III. As Sen notes, "admitting commitment as a part of behavior implies no denial of reasoned assessment as a basis for action" (1977, p. 343). Economic actors may be rationally self-interested yet interdependent, admitting the possibility of strategic commitment to institutional rules. This is a more "globally rational" description of choice, which may distinguish man from other forms of life (Elster).

## 4. Public Choice and Collective Individualism

Consideration of the debate over strict individualism and collective action has provided a sense of the depth and complexity of its origins. The argument has recurred in many guises, not only in economics and politics. Lukes has noted the dispute between "historical" and "abstract" schools of classical economics; the debate in sociology between Durkheim and Tarde, and numerous unsuccessful attempts at resolution.

Although no such resolution is intended in this study, it is possible to organize and clarify the debate by reference to the assurance game. Individuals may

behave rationally and self-interestedly as members of a collectivity, even by acting in a way contrary to their preferences over alternatives due to commitment to an institutional rule. This approach does not resolve the debate, so much as it provides a higher order approximation to observed institutions and problems of public choice.

Whether institutions are characterized by an emphasis on strict individualism or on collective or communal action will depend on the economic and physical environment, and the costs of alternative responses to environmental influences. Assurance provided by institutional rules is not restricted to either alternative, since costs and benefits of each type are likely to vary across environments. The Western intellectual tradition has emphasized the relationship between private property and independent individual rights. The customary land tenure of Africa, the communal Muslim institutions of the Middle East, or Far Eastern principles of filial rights and obligations, all will dictate different costs and benefits to observance of rules of behavior in these societies. These costs and benefits are a function of past history, and the degree of belief in institutional rules in

force at any time, which affect individual reputation in relation to observance of these rules.

Extreme individualism or strict collectivism become, in a formal sense, extrema along a continuum of "collective individualism." A large number of alternatives suited to different conditions exist between these extrema. The imposition of institutions inappropriate to the environment and past history of a group will not provide assurance, nor will they be observed, when poorly suited to the needs of the group. This is true whether the institutions which are imposed are private property or collective farms. To compel observance to rules which are inappropriate will result in high transactions costs to the enforcing authority, as people recognize it as in their long term self-interest to ignore or even subvert the imposed institutional regime (Firey, pp. 87-112).

These conclusions broaden the applicability of public choice theory, interpreted as a theory of institutional analysis. From Arrow's Theorem onward, much of public choice theory has attempted to develop social decision rules based on postulates of rational self-interest which include preference independence and the strict dominance of individual strategy. As long as these postulates are retained, public choice faces the

prisoners' dilemma as a central paradox, resulting in the needed enforcement of institutional rules consistent with independent choice. Wedded to the strict dominance of individual strategy, the institutional opportunity set is restricted to rules such as private property which are consistent with such a postulate. These rules simply restate the independence condition in the form of private property rights which forcibly separate interdependent choice.

There is no reason why public choice theory need find itself in such an untenable position. Arrow and others who have explored the implications of "extended sympathy" have developed numerous rules which are well behaved with respect to postulates closely resembling Arrow's original set (Hammond, Strasnick).

The reasons for the strong hold of assumptions of independent choice become more clear in historical context. Narrow interpretations of rational self-interest are descended from Hobbes and Locke. In addition to asserting the strict dominance of individual strategy, this inheritance links individual rights to private property. Alternative conceptions of collective social decision making are tainted by ideological and historical objections. Although American institutional economists must be set apart from the

continental writers, their work has suffered from associations with collectivism and its abuses. It has also suffered, notably in the case of Commons, from its own lack of clarity and a failure to provide a formal underpinning for its analysis.

The result is the survival of an idea of independent individual preferences which is neither necessary nor sufficient for rational decision making. It is empirically unreasonable prima facie; the existence of cooperative modes of behavior, from the guilds of Hobbes' time to the myriad rules of our own, deny the empirical reasonableness of the postulate.

The strict dominance of individual strategy results in ambivalence regarding appropriate remedies for externalities, and dictates mechanisms which are impossible unless separability is imposed from outside the group. This rules out the possibility of strategic non-revelation of preferences, such as the endogenous formulation of and commitment to institutional rules. As Sen (1973) notes:

> I do not find it difficult to believe that birds and bees and dogs and cats do reveal their preferences by their choice; it is with human beings that the proposition is not particularly persuasive. An act of choice for this social animal is, in a fundamental sense, always a social act. He may be only dimly aware of the immense

> problem of interdependence that characterize a society. . . . But his behavior is something more than a mere translation of his personal preferences (p. 14).

Even the traditions of "methodological individualism" do not require so severe an assumption. Schumpeter distinguished between political, sociological and methodological individualism, arguing with Edgeworth that behavior in the market may be treated as the product of independent choice without implying it as a reasonable description of political or social life (p. 889). But this distinction is not easy to uphold, and is limiting even as a description of market behavior.

Von Hayek, in his justifiably famous brief for individualism in economic theory, regarded the assumption of isolated individuals and the strict dominance of individual strategy as unnecessary. He argued that although "there is no other way toward an understanding of social phenomena but through our understanding of individual actions," these actions must be seen as "directed toward other people and guided by their expected behavior" (Von Hayek, p. 6). He observed:

> Far from being opposed to voluntary association, the case of the individualist rests, on the contrary, on the contention that much of what in the opinion of many can be brought

> about only by conscious direction, can be better achieved by the voluntary and spontaneous collaboration of individuals. The consistent individualist ought therefore to be an enthusiast for voluntary collaboration--wherever and whenever it does not degenerate into coercion of others or lead to the assumption of exclusive powers (p. 16).

A final reason to be cautious of the assumption of independent choice is because of its association with our own unique intellectual traditions. Even in Western Europe and North America, Locke's supposition that individual rights must be connected to private property has been used to justify "land grabs" and the disenfranchisement of the poor and landless (Dasgupta and Heal, p. 77). Promotion of institutions consistent with the assumption of the strict individual dominance, where inappropriate, can have important costs. James Buchanan (while accepting the assumption) states:

> Institutions may have been allowed to develop and persevere that exacerbate rather than mitigate man's ever present temptation to act as if he is an island, with others treated as part of his natural environment. In a properly qualified sense, the latter pattern of behavior is the economists' 'ideal,' but the costs have not been adequately recognized (1978, p. 366).

Individualistic institutions may be particularly inappropriate for traditional societies. The Lockean

presumption that institutional alternatives to private lease holding are inherently inefficient has had a profound influence over advocates of private property rights. It is an ethnocentric view. Private use rights may be wholly inappropriate in many developing countries, just as imposed collective farms may be. The next chapter contains a discussion of the policy relevance of the widened opportunity set of institutional alternatives opened by abandoning the assumption of independent choice.

# CHAPTER VI: DEVELOPMENT THEORY AND NATURAL RESOURCES POLICY: THE RELEVANCE OF INSTITUTIONAL ALTERNATIVES

## 1. The Assurance Problem and Economic Development

Many problems of economic development involve externalities and public goods provision (Heady and Whiting). The analytics of assurance give insights into these problems, of which common grazing is an example, from the point of view of designing viable institutions. Mobilization of groups, large and small, involves the creation of new rules and selective social and economic incentives (Nurmi, 1977b, pp. 94-99, Maass and Anderson, Apter).

This chapter concludes the study by examining the implications of assurance problems for development theory and natural resources policy with reference to pastoral grazing institutions. These institutions, as a public system of rules, set expectations which may play a vital role in policies designed to promote development while conserving scarce natural resources. The chapter begins with observations on the relevance of assurance problems for economic development theory and policy. It then takes up a specific case study illustrating these points.

Previous chapters have shown how rational self-interest, defined in terms of independent individual choice, leads to the impossibility of endogenous institutional responses to problems of externalities and public goods. Current development theory and policy tends to accept the view that new institutions must be exogenously imposed. Institutions are treated as constraints in an individual maximization exercise. This leads to the idea that alternative "modern" institutions must be imposed to loosen the binding constraints of traditional rules.

New institutions, stimulated by new technology, are argued to create new opportunities, touching off the developmental process of technical and institutional innovation (Schultz, 1964, 1978, Hayami and Ruttan). According to the property rights paradigm, the institution most likely to set these entrepreneurial forces in train in the grazing context is exclusive, private property. Property rights to resources must be assigned, defined, and transferable, so that exclusion, strict individual dominance, and outside enforcement will create the incentives necessary for economic growth (O.E.G. Johnson).

Because private property is the institutional complement to the strict dominance of individual strategy,

institutional prescriptions of private exclusive use-rights follow directly from a too restrictive assumption of rational self-interest. This leads to the notion that where externalities or "publicness" of goods is at issue, development must be imposed from outside by government or development experts. Ironically it is argued that private exclusive property, the hallmark of individual freedom in the Lockean tradition, must also be imposed if the constraints of traditional institutions are to be broken.

In a recent criticism of the relevance of this theory to economic development, Oppenheimer (1981) confirms many of the claims of Chapter V. In a policy context, he cites three failures of the restrictive independence of decision in public choice theory. First, it leads to the impossibility of aggregating individual choices into collective decisions except by outside enforcement. Second, it fails to explain the important role in development of informal, endogenous rules. Third, it fails to integrate individual rationality with the critical problem of information acquisition in a developing economy (Oppenheimer, 273-282).

In contrast, the analytics of assurance treat institutions as arising from recognition that commit-

ment to rules makes economic extensions possible for the group. Outside enforcement becomes a "second-order" solution. In the context of policy, the assurance problem meets Oppenheimer's objections, enlarging the focus of public choice theory. The opportunity set of relevant institutional alternatives arising from individual interdependence is as large as the capacity of the group to innovate rules suited to its needs. These rules come in many forms, and private property is only one.

Strategic commitment to institutional rules arises from recognized interdependence and extensions possible in the attainable set of the group. This, as well as incentives such as reputation within the group, imply that the need for and costs of outside enforcement may be much reduced. If policy makers possess a proper recognition of existing institutions, these can be the foundation of new policies. This foundation can include a variety of informal institutions which may be crucial in setting customary expectations. These institutions may act as aids, not just obstacles to economic development (Dorner).

The analytics of assurance describe a rational decision process, in which agents bind themselves by institutional rules because these rules provide crucial prior information which reduces uncertainty. In this sense, the theory integrates individual rationality with information acquisition.

Information, especially in the context of institutions, is a critically scarce commodity in a developing economy. Its scarcity may be even more important than capital supply shortages or other scarce factors of production. Where institutions are treated as exogenous constraints, the informational function they play in economic development is easily overlooked. The mutual expectations which allow coordinated individual action are the foundation of economic activity.

The European experience after World War II is instructive. Despite the destruction of its capital and physical plant, the European "economic miracle" was not only a function of Marshall Plan development assistance. The institutions and rules making economic recovery possible were in the minds of the European people. Mutual expectations of market behavior survived the bombing. Traditional rules, built up over long periods, conveyed critical information in the form of mutual expectations which defined the "human capital"

of European society. Just as this process of change took place inside the structure of European institutions, so must development elsewhere.

Yet institutional rules are also subject to entropic degradation. They "wear out" in relation to a changing environment and information is lost. The rules of traditional society may be less suited to development than those which prevailed in Europe. This raises the issue of the costs of transforming them. If institutional expectations are to be maintained, part of a society's resources must be invested. These transactions costs were defined in Chapter III as the costs of maintaining an existing level of assurance, such that an institution continues to convey information over time. These are costs to society of custom, token and taboo. If institutions are not maintained, they fall into disuse, no longer setting expectations regarding others' actions.

At the same time, a changing "reference environment" means that new institutions must be innovated to fit changing conditions. This process of adaptation may follow a pattern of stochastic search, as institutions are developed which fit with the external pressures of population, technology, and climate (Wilkinson). In addition, institutions may be forced to adapt to new

rules which are imposed from outside. The costs of traditional rules in a rapidly changing reference environment are magnified when new rules are imposed on them from outside. This has been the effect of development assistance.

Development assistance has attempted to break the constraints of traditional rules by encouraging their decline. By shifting scarce resources toward alternative technologies and the adoption of new institutions, the transactions costs of maintaining traditional rules are not met. Traditional institutions' decline is increased by the shock of new technology, which speeds up the search for new institutions suited to the changing reference environment (Hayami and Ruttan, pp. 59-61).

In this rapidly changing environment, new institutions require that a new and different set of expectations be maintained. This implies that the transactions costs of erecting and maintaining a different set of expectations must be met. The greater the degree of departure of the new from traditional rules, the higher the transactions costs of maintaining them over time. To the extent that new rules fail to provide assurance, voluntary compliance will not occur. In this case, costs of outside enforcement may also result.

Focusing on these institutional issues suggests the high costs of promoting rapid economic development. The more rapid the change in the reference environment, the more strain is placed on traditional rules to adapt to such factors as new technology. If traditional rules, treated as constraints to this process, are simultaneously undermined, an institutional lacuna may result in which uncertainty rises as assurance declines. If, in addition, new institutions are imposed or presented as "the" appropriate response, they may require high transactions and enforcement costs to function, if they function at all. These costs may strain the resources of groups originally singled out for such attention because their traditional institutions made them "poor."

In sum, the more rapidly institutions are changed, the more disequilibrium will result in the traditional rule structure (Wilkinson, pp. 18-89). In terms of Chapter III, the information conveyed by new institutions will make posterior expectations (if they can be maintained) very different from prior traditions adapted to the old reference environment. The greater the departure of new institutions from traditional expectations, the more disequilibrium, transactions and enforcement costs. The assurance problem raises

the issue of how far and how fast development may proceed and still maintain institutional cohesion -- and at what cost.

Since many problems of economic development involve new rules proscribing contributions to range quality or other public goods, the issue of free riders arises with particular force (Popkin). Chapters III and IV argued that contributions to public goods are a function of the expectation by each of the likely behavior of all. Since free riding is not a dominant strategy, the proper relationship between expectations set by rules and incentives such as reputation can make donations to public goods rational, utility maximizing behavior. Therefore, careful attention is required to the institutions and related incentives which are most likely to produce contributions in a given context. This is especially true of informal and traditional institutions regulating grazing behavior. Expectations can be structured in terms of existing informal rules, exploiting the costs and benefits which they proscribe (Odell). Outside enforcement costs may be reduced while promoting contributions to public goods such as range quality (McKean).

If declining assurance results from policies designed to break down traditional rules and supplant them with unsuccessful alternatives, free rider behavior may be exacerbated. Traditional rules will lose the ability to define individual reputation. Rational utility maximization, as an interdependent problem of coordinated expectations, will promote less contribution if less is expected.

In grazing, even if new institutional alternatives succeed, it matters what these alternatives are. If they are predicated on the strict dominance of free rider behavior expectations may be promoted which make free riding stronger and stronger. If private exclusive use-rights are advocated over traditional common property institutions, expectations may shift so that free riding is a more rational strategy. In terms of Chapters III and IV, as the proportion of the group that believes in and obeys the new rules increases, belief in the older rules declines. The result is the erosion of information contained in the old rules, and the emergence of strong free rider behavior as the new rule. Exclusive use-rights may therefore create the conditions under which a "tragedy" of overgrazing is more rather than less likely, since they promote the notion that strong free rider behavior is "rational."

This is especially true if strong free rider behavior is promoted, but strict exclusion via outside enforcement is too costly. The result may be overgrazing (in the name of private use-rights) without the actual achievement and enforcement of exclusiveness.

The lesson for policy is that institutions proscribing donations to public goods such as range quality must clearly define an expected level of contribution. If overgrazing of common land is to be avoided, institutions must define a rational contribution via stinting which is sufficient to preserve the range. One institutional alternative is to make all land held in common into private exclusive property. But if the costs of enforcing and maintaining this institutional alternative cannot be met, it may increase overgrazing, especially since it promotes strict dominance of individual strategies. Institutional alternatives which retain common ownership but promote greater levels of stinting, or combinations of common and private institutions in the form of "limited entry," may constitute viable alternatives (see Polinsky). These alternatives will be explored in more detail in the case study below.

The informational difficulty of clear definitions of expected grazing levels makes local level rule making based on existing informal rules attractive as a policy alternative. There is evidence that institutions reducing free rider behavior will be more effective and less costly to maintain and enforce at the local evel (J. Thomson). If alternative rules are imposed by authorities from outside, they may carry less weight in the reputation function defined by local rules. If rules imposed from outside fail to predict the behavior of local actors, they will not be observed without heavy enforcement.

This draws attention to the appropriate level of authority at which maintenance and enforcement of rules may be provided, and the benefits of decentralized administration in which reliance is placed on existing formal and informal institutions. The appropriate level depends largely on the character of information flows. Simply put, the costs of maintaining a set of expectations within a group, or of enforcing actions where cooperative institutions fail, will be lower at more decentralized levels. This is true because less information must flow to fewer people at local levels.

The definition of institutions in terms of information counsels arrangements which maximize its free

flow at all levels. Where enforcement from outside centralized authority is promoted as the appropriate development policy, there is a tendency to restrict the flow of information except from the top down. Such measures fail to exploit the critical information contained in local level rules, and therefore waste an important resource (Firey, pp. 87-115). The analytics of assurance suggest a policy of freedom of information and decentralized authority to reduce costs of development. This approach suggests that local and central authority must be related. The result arises purely from recognition of the informational context of institutional rules, rather than from liberal political ideology.

Instead of the impossibility of public goods provision this study stresses the actual possibilities of public choice in economic development. The basic issues are the contribution to development objectives which can be expected in the absence of enforcement, the transactions costs of promoting and maintaining new institutional rules, the climate of expectations which will contribute to this process, and the minimum necessary level of enforcement which must be undertaken

to secure given objectives. Institutions are no longer simply constraints; they are the recognizable adaptations in a wide variety of circumstances to the exigencies of social and economic life. They allow rational individuals to coordinate their behavior in a wide variety of ways adapted to different environmental circumstances (Vayda, 1966).

Insight may be gained into some current failures in economic development policy by recognizing that in any given case, the existing institutional structure serves purposes which may provide a firmer basis for future development than institutions brought in from outside. Traditional institutions may require modification, but the arrogance may be ended which leads to imposition of institutions in environments where their ratio of costs and benefits is very different from where they were originally developed. An institutional response to environment A may be a disaster in environment B (J. Thomson).

Institutions are adapted to their resource base (see Chapters III and IV). Before promoting a particular policy, careful attention must be given not only to existing institutions but to the relationship between them and the characteristics of the resource

base. The expectations conveyed differ depending on the problem, which in turn is a function of this base (see Ruttan, 1981).

In Chapter IV, for example, reference was made to the distinction between stock and flow resources. The difference between them, and the relationship of their characteristics to economic development, links natural resource policy and development theory (Bromley, 1979). Coal or oil *in situ* is a stock because it can all be used today or spread out over centuries. It is non-renewable. It is like "money in the bank" paying no interest income; it may be spent now or later, but once spent it is gone. By contrast, solar energy is a renewable flow. It is like income which can be "banked" via photosynthesis, but only over very long periods. It may eventually yield stocks such as coal, resulting from millions of years of accumulated plant residues. But for practical purposes, flow resources are convertable into current use on a restricted schedule. They are spending money for now. Their flow rate is beyond our control. One generation may use that part of the flow which is its share in time, but it cannot impinge on future generations' consumption (Georgescu-Roegan, 1975).

Economic development is characterized by techniques of production which rely on capturing and exploiting

low entropy stock resources such as coal and oil (Georgescu-Roegan, 1971). By "borrowing from the future," these concentrated sources of energy allow rapid advances in the wealth of present generations. Traditional societies, by contrast, are characterized by production techniques which exploit flow resources. In each type of society, the choice of technique is a function of the characteristics of production inputs (Lancaster, Stewart). Hunter-gatherers almost by definition subsist on the basis of flow resources. Pastoral grazing involves continued reliance by the tribe on the flow of services provided by the range to cattle and man. Where flow resources are plentiful, subsistence may be "hand to mouth" without being difficult in terms of labor expended; these are the "original affluent societies" (Sahlins, p. 85). But dependence on flow resources also offers no strong incentives to save (Wilkinson, p. 47).

Institutional adaptations in developed and traditional societies reflect the different characteristics of their resource bases. In developed societies technical dependence on <u>in situ</u> stocks may be reflected in institutions which tend to be based on exclusion of others from access to these stocks and on accumulation of stocks for future consumption. In traditional

societies, dependence on flows results in institutions in which common access to such inputs as land resources over time is widely characteristic. "Land belongs to a large family, some of whose members are dead, some are living, and innumerable others are yet to be born," as a Nigerian chief put it (Dumont, p. 126). Accumulation is not at a premium.

Wilkinson, following Boserup (1965), has argued that population growth leading to increased scarcity has driven society from dependence on flows to stocks over time. Rather than a search for efficiency, this "progress" may be seen as a technical imperative to adapt to increasing scarcity (Wilkinson, p. 99). Driven to the edge of subsistence by dependence on flow resources alone, man began borrowing from the future by shifting reliance to stocks, substituting coal and petroleum for firewood and fodder, for example. His choice of techniques reflected these changing inputs: automobiles were substituted for horses. The resource base, and the technology used to exploit it, in turn reflected and influenced the institutions adapted by societies at different stages of economic development.

Since Locke private property rights and their tight relation to strict individualism have increas-

ingly reflected dependence on *in situ* stock resources. Like all institutions, private exclusive use-rights were justified in terms of the needs they fulfilled. The need to appropriate large tracts of "waste" in America, and the desire to consolidate land holdings through the enclosure of common, led to the marriage of private, exclusive use with individual freedom. Today economic development has come to be associated with institutional forms of private, exclusive use-rights, and the use of stock resource inputs.

Yet property rights are mutable. The rights, duties, obligations and encumbrances a given property institution proscribes are not everywhere the same (Bromley, 1978, Hohfeld). In our own time the increasing evidence of depletion of stock resources, even when held under private, exclusive rules of property, leads some to question such a concept of freedom and individualism. Changing production techniques are shifting dependence to flow resources, such as solar energy (Hertzmarck, V.K. Smith, pp. 74-79, 276-290). These attempts to shift techniques to a resource base of flow resources may lead to corresponding changes in the concept of property itself.

MacPherson has argued that the concept of property as individual freedom to exclude others is already obsolete (1973). "A democratic society," he argues, "must broaden the concept again from property as an individual right to exclude others, by adding property as an individual right not to be excluded by others" (1973, p. 122). The spread of a market economy, predicated on technical exploitation of *in situ* stocks may be nearing its conclusion. A concept of common property may again be useful even in "advanced" societies, where growing reliance on flow resources makes the right not to be excluded by others a matter of increasing relevance.

Thus a changing reference environment may lead to a property right not to be excluded from the resource base of the society. This makes common property, typically associated with traditional societies, a matter of importance in advanced ones as well. The rhetoric of environmental protection is not unlike that of the Nigerian chief quoted above. Public wilderness, for example, is argued to belong to the family of man: some of whose members are dead, some are living, and innumerable others yet to be born.

For developing economies, this suggests the possible folly of policies designed to promote private

exclusive use-rights as well as technical changes which shift dependence to stock resources. At the most obvious level, the resources on which these techniques depend may not even be in situ. Coal and oil, for example, are not always located near at hand, and must be imported at great expense. The appropriate institutions associated with techniques which fit with the resource endowment of developing countries may therefore be traditional common property rules. This is not only because of traditional reliance on flow resource inputs. It may reflect the future of productive techniques in currently developed economies as well.

Another implication of the assurance problem for economic development concerns the issues of distribution and efficiency. As noted in Chapter IV, the separation of efficiency issues from problems of distribution is more difficult to sustain with the assurance problem. Rules of fairness, for example, appear to significantly affect utility maximization. Distribution and efficiency are linked in the process of institutional change (see Weisbrod, 1979).

This is consistent with the claims of a number of authors who have asserted the link in problems of economic development (Adelman, Adelman and Morris, Stewart and Streeten). The choice of an institutional basis for economic development cannot be made on efficiency grounds alone. This point will emerge with particular force from the case study to be considered below.

At the highest level of generality, the assurance problem provides insight not only into common property externalities and public goods, but the dynamic process of institutional change which is development itself. It suggests that no single set of institutions constitutes "the" path. Each group or society must build on its own traditions and resources if development is to gain a sure footing (Odell).

The analytic transformation from the independent choice of the prisoners' dilemma to the interdependence of the assurance problem may model the institutional evolution of a society. Assurance in the form of information conveyed by institutional rules provides the foundation of trade and contract. If institutions are imposed which are inappropriate to the traditional

expectations of the group, implying high transactions and enforcement costs, then such policies may founder. If, on the other hand, institutions are developed which increase the overall level of assurance in accord with the existing institutional framework, the resulting security of expectation may be the basis of further gains in the more quantitative senses of income and output (Dahlman, 1980, p. 213).

A certain level of assurance conveyed by cooperative institutional rules may be a precondition of development. Although expectations may be parameterized by outside enforcement as well as by private exclusive use-rights, no society can afford either total non-cooperation, or to constantly police every public action of its citizens. Cooperative rules which provide a stable basis for society without enforcement may be a mark of maturation toward an ideal of self-governance. In such an ideal state, institutions are self-reinforcing and enforcement costs are minimized (Rawls).

It may be argued that "too much assurance" also is possible. Low security of expectation due to a lack of information conveyed by institutional rules may have its opposite in some economies which are institutionally "overdeveloped." In the United States, for example, it

has recently been argued that the New Deal brought many institutions, established and enforced at the Federal level, which provided security of expectation in a large number of areas where expectations had hitherto been uncertain. The Social Security Administration, unemployment insurance, and other programs are now being cited as costly causes of a loss of entrepreneurial activity. Whether these claims have merit is a subject of strenuous policy disagreement. Regardless of one's view on specific policy issues, the discussion suggests the principle that some "optimal" degree of security of expectation may exist at a given time and place. Policy differences would then center on whether more or less assurance is in fact the optimal amount.

The assurance necessary to lift consumer confidence and investor's expectations in the United States in the midst of the Great Depression may not be optimal today. Too much assurance, especially if successfully provided by central governments, may reduce uncertainty but increase both transactions and enforcement costs. The impact of expanding government programs may then be to "crowd out" investment capital which would otherwise find its way into more uncertain but potentially more profitable markets.

The attempt to solve broad problems of economic development involving many externalities and public goods through central authority seems to have succeeded in many cases in the negative cause of breaking down traditional institutions. But a palpable uncertainty in many developing economies suggests that central authority may provide too little assurance to provide the basis for long-term investment and economic growth. The imposition of "modern" institutions (whether the products of Western democracy or Socialist planning) on traditional local rules may end as a poor marriage. The high costs and potentially despotic character of central authority may be incurred without affecting longstanding informal rules and local traditions. Modernity may be only an institutional veneer, or may be restricted to a small subset of the population which subscribes to the new rules. The result, to be considered below, may be the institutional evolution of two sets of rules or customs which exist side by side.

## 2. Institutions, Uncertainty, and Dualism

A theory purporting to describe the role of institutions in economic development which is also useful in policy must answer three questions (Gant, pp. 13-14). First, what function and purpose does an institution serve? Second, what factors lead to acceptance or rejection of particular institutions in different circumstances and locations? Third, how do institutions maintain support and still adapt to changing environments?

Previous chapters established that the property rights paradigm restricts the set of institutional alternatives by a limited conception of individual rationality. Although explaining the function and purpose of private property, it fails to explain why private rights may be rejected except by general, indefinite references to transactions costs (Coase, 1960; Randall, 1974; Dahlman, 1980). It also fails to explain changes in institutions over time, except by reference to individual incentives associated with the strict dominance of individual strategy (Demsetz, 1967; North and Thomas, 1977).

By rejecting the possibility of interdependent choice, approaches based on narrow conceptions of

rational self-interest do not address the issue of uncertainty. As noted in Chapter I, if one has only one's own interest in mind, uncertainty over the actions of others is not a problem. The abstraction from uncertainty, and therefore from institutions' endogenous role in reducing it, has seriously limited the policy relevance of the property rights approach.

In Transforming Traditional Agriculture (1964), Theodore Schultz set forward a major theoretical statement of agricultural development which has guided much subsequent policy. Institutions are taken to be fixed constraints (p. 71). The analysis proceeds in terms of "rational" agents and the supply and demand for income streams (p. 75). The fetters imposed by traditional institutions must be removed as disincentives to agricultural production, so that the supply price of income streams may be sufficiently raised by technical advance to promote expanded economic growth. The supply and demand for income streams is presented in terms of Friedman's permanent income hypothesis (Schultz, 1964, p. 76; Friedman, 1957).

In the writings of both Friedman and Schultz, an emphasis on permanent income and rational independent agents in economic development tends to reduce the importance of uncertainty in agricultural decision

making. This tends to shift policy away from institutional issues toward the high-payoff inputs and technical change which form the basis of agricultural transformation (Hayami and Ruttan). The permanent income hypothesis, for example, states that income (Y) is the sum of a permanent component ($Y_p$) and a transitory component ($Y_t$) expressed in the following identity.

$$(1) \quad Y \equiv Y_p + Y_t$$

The permanent component reflects all factors determining capital value and wealth, analogous to the mean expectation of a subjective probability distribution defined over lifetime income. The transitory component reflects all other factors, interpreted as "chance" occurrences and measurement error. These include such factors as good or bad weather, seasonal or cyclical fluctuations, and whatever other sources of disturbance may arise. To the extent that others' actions affecting income are unpredictable, they must also be included in the set of random events comprising transitory income.

The $Y_t$ term is strictly analogous to the error term in a standard regression exercise (Goldberger, pp. 283-284). Consistent with the classical assumptions of the regression model, the expectation of $Y_t$ is zero.

Further, the permanent and transitory components of income are assumed uncorrelated, so that

$$(2) \quad \rho_{Y_t Y_p} = 0$$

where $\rho$ is the correlation coefficient. This means that the random events associated with environmental conditions, including unpredictable actions by other economic agents, do not influence the expectation of permanent income.

Supply and demand for permanent income, therefore, abstracts from the issue of uncertainty defined by $Y_t$, the transitory component. Yet it is exactly such transitory elements in traditional agriculture which are most likely to affect farmers' decision making (Wiens). The success of technical packages designed to change farming methods may be critically dependent on the variance of $Y_t$ around $Y_p$. Since the theory treats institutions as fixed, it does not account for the way in which this variance, specifically respecting the predictability of others' actions, may be parameterized by institutional rules. Treating traditional farmers' expectations of future income as "rational" in the restrictive sense of the permanent income hypothesis means that only expected mean income "matters." It

therefore understates the critical role of uncertainty in agricultural decisionmaking.

A theory which acknowledges the role in farmers' decisions of random weather patterns, seasonal or cyclical fluctuations, and the predictability of others' actions cannot be based on the mean value of permanent income. Policy must be formulated in relation to farmers' responses to the risks inherent in new techniques of production, and the assurance provided by traditional rules. More generally, the role of institutions in setting expectations by making the behavior of others more predictable will be an important aspect of agricultural transformation. The transitory component matters. Equation (2) no longer holds.

The traditional agriculturalist faces at least two distinct types of uncertain events which have transitory effects on income streams. The first is uncertainty arising from the vagaries of nature ("states of the world") which we will term $Y_{t_N}$. The second is uncertainty arising from the unpredictability of other persons, given as $Y_{t_P}$. The transitory component of income then becomes

$$(3) \quad Y_t = Y_{t_N} + Y_{t_P}$$

and identity (1) may be written as below

$$(4) \quad Y \equiv Y_p + (Y_{t_N} + Y_{t_p})$$

As stated, equation (2) no longer holds. Not only is permanent income correlated with transitory income; transitory income arising from "states of the world" such as changes in weather is also correlated to uncertainties associated with the predicted actions of others, as given by (5) and (6).

$$(5) \quad \rho_{Y_t Y_p} \neq 0$$

$$(6) \quad \rho_{Y_{t_N} Y_{t_p}} \neq 0$$

For example, the predictability of others' actions may not be invariant to the effects of a monsoon, or drought. Glantz has noted that the effect may not be unidirectional. Unpredictable actions by individuals may also affect the state of the world, by inducing desertification and subsequent drought, for example.

The first type of uncertainty ($Y_{t_N}$) is more difficult to control than the second. Technological innovations may allow some of the variance arising from natural sources to be controlled. Irrigation, for example, may allow agricultural production in the

absence of consistent patterns of rainfall (see Maass and Anderson). In terms of the resource base, a shift from flow resources to stocks on hand may also reduce variance arising from states of nature. In more temperate climates, petroleum or coal furnaces even out home temperature over seasonal fluctuations, for example. Stock resources can also provide such energy subsidies to agriculture (Steinhart and Steinhart).

The second type of uncertainty ($Y_{tp}$) may be controlled more readily -- through the innovation of institutions. Parallel to technology in the case of states of nature, institutions reduce uncertainty over the actions of others. Together, technology and institutions act to parameterize the distribution of "chance" given by transitory income.

If transitory effects due to natural causes are correlated to transitory effects due to the actions of others, it is reasonable that the response to these transitory effects by technology and institutions should also be related. New technology as a response to $Y_{tN}$ may upset traditional institutional responses to $Y_{tp}$. If new technology and new institutions are simultaneously imposed on traditional techniques and rules, the interactive effect may be to increase substantially the transitory component of income. Since $Y_t$ and $Y_p$ are

correlated, the impact on the supply price of "permanent" income streams may in turn be significant.

To see this in greater detail, consider common property institutions. The "signal" provided by traditional common property rules conveys critical information regarding the actions of others. With changing conditions in climate and techniques of production, or simply due to the passage of time (negentropy), institutions which were once suitable may become less so. The corresponding transactions costs of maintaining the old rule structure may rise. In this situation, an incentive exists to set new parameters on behavior by innovating new institutional rules. Contrary to the Coasean private property rights analysis, however, it is not clear which rules will provide assurance in the new context. As Randall (1974, pp. 53-54) states:

> The fact that different configurations of property rights have different impacts on both allocation and distribution illustrates the need for understanding the impact of specific configurations of rights. Collective decision making procedures must select appropriate configurations of rights, not only specifying rights in complete and non-attenuated form[52] [n.52: As Cheung. . .would have us believe], but also selecting that particular bundle of rights which will provide the correct incentive structure to achieve the collective goal.

In a later criticism of the property rights public choice (PR-PC) approach, Randall (1978, p. 14) elaborated this position, noting:

> There are numerous possible arrangements, all in the attenuated set and thus ignored by many PR-PC scholars, which are workable and not terribly inefficient. Some of these arrangements, given the societies in which they exist and the resources to which they are applied, are more nearly in accord with social customs, accepted ethical norms, and the need for intergenerational equity in resource conservation than exclusive, private property institutions would be.

In formulating policy, it follows that selecting the appropriate "bundle of rights," cannot be accomplished a priori. Proposed changes in institutions must reflect knowledge of traditional endogenous responses to the environment in both technical and institutional terms.

Exogenously imposed technology and institutions which do not account for traditional rules can end up increasing the level of uncertainty. Rapid technological change, colonial authority, development aid, and imposed governmental plans have combined in recent years to generate a variety of significant "shocks" to traditional property institutions in developing economies. The impact of all of these elements over a relatively short period has created a bimodal distribu-

tion of expectations. New and old rules exist side by side.

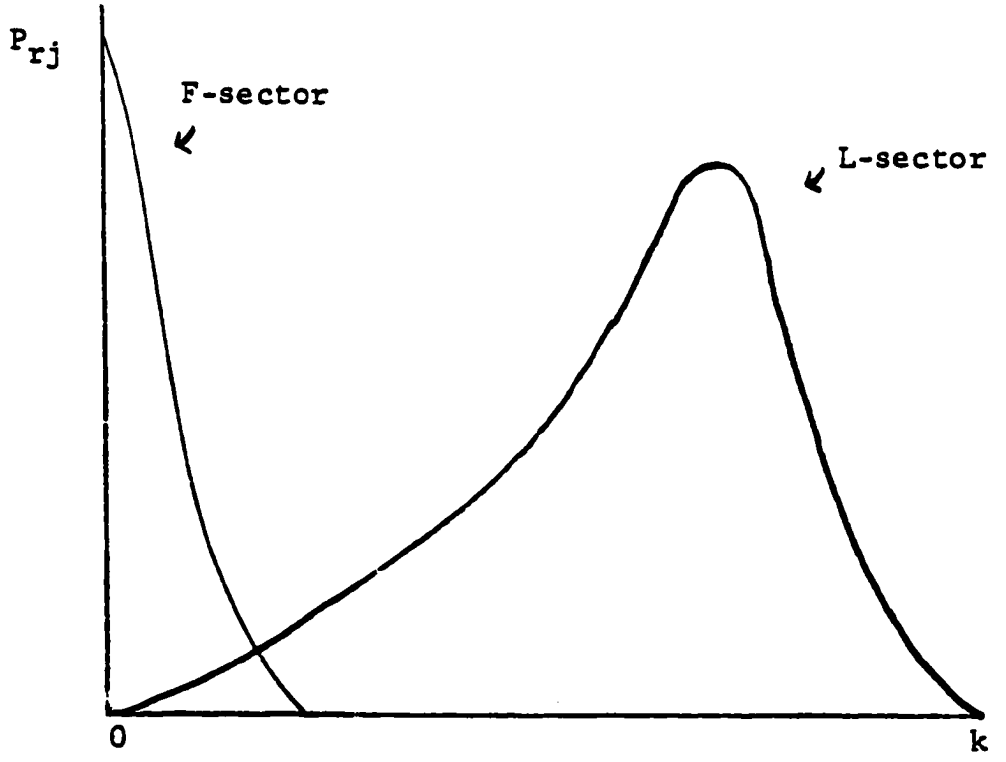
This bimodal distribution of expectations provides a concise institutional explanation of "dual economy" phenomena (Fei and Ranis, W.A. Lewis). With the introduction of foreign technology, capital, or other forms of assistance, two sets of expectations of economic performance and contributions to economic development may exist side by side. The distinction between the agricultural and industrial sectors of developing economies may have more to do with the formal and informal rules which pertain in each than their respective wage rates or marginal productivities.

The rules of the "industrial" sector may be associated with foreign interests and capital, for example. Frances Stewart (1977) calls this the "F-sector." The "agricultural" sector may retain many formal and informal traditional rules which are cast by conventional approaches into what Randall terms the "attenuated set." Stewart terms this structure of traditional rules, associated with labor intensive techniques, the "L-sector."

Debate in development theory and policy has tended to center on the technology appropriate to the factor endowments of the two sectors, and the potential conflicts between them (Stewart). Yet the policy problem

may not be solved unless different institutional rules in force in the two sectors are properly understood.

Consider Figure 6.1, in which the hypothetical bimodal or "dualistic" structure of the developing economy is expressed in terms of the expectations of agent j over the actions of others. The distribution of expectations is expressed in terms of contributions to a representative public good such as common range quality, consistent with the exposition of Chapter III.




Range of Grazing Behavior by Others

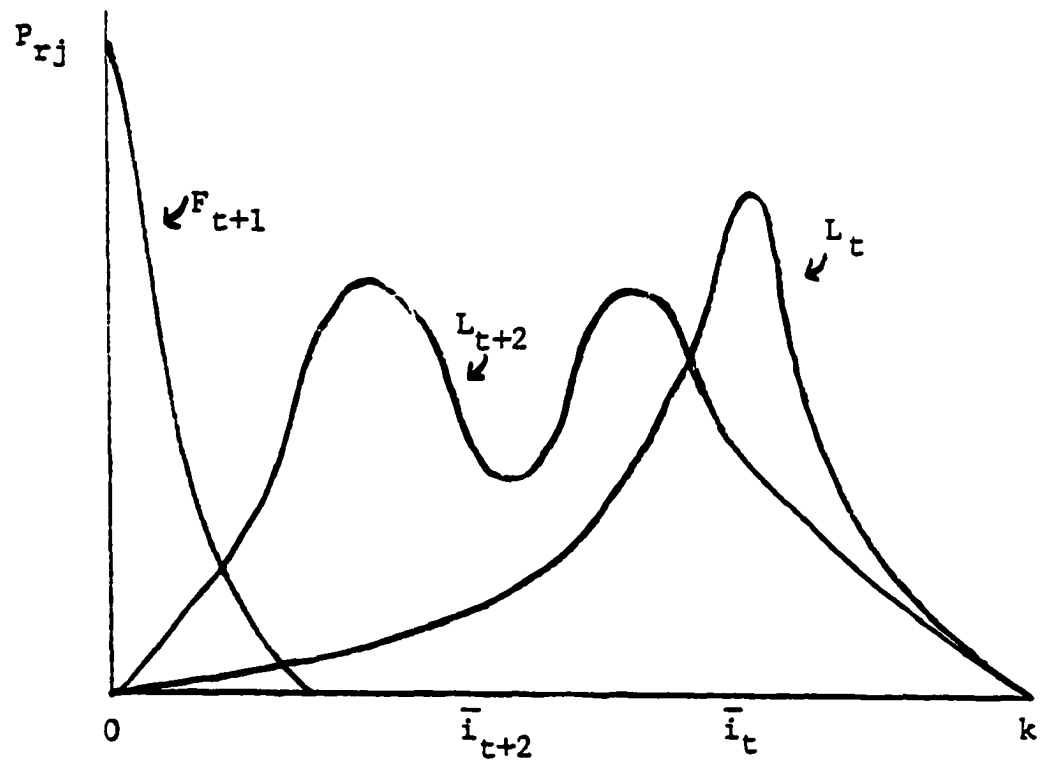
Figure 6.1

The rules of the F-sector are the result of proposals which dictate division of common range by fencing and the development of commercial ranch schemes. The presumption of this policy is that free rider behavior necessitates exclusive use-rights, and the promotion of commercial ranching. Such rights, together with the commercial potential (increases in permanent income) possible from private ranching, are expected to provide the stimulus to rational agents for economic development (Picardi). The rules of the F-sector regarding contributions to common grazing land by stinting reflect the dominance of free riding, promoting this expectation by others.

The rules of the traditional or L-sector, by contrast, are based on common property use-rights. Although some overgrazing occurs under the common property it provides for stinting further out along the horizontal axis. The impact of the F-sector rules, imposed on the L-sector, is to create a bimodal distribution of expectations, which increases the overall level of uncertainty regarding the expected level of grazing.

In Figure 6.2, a sequence describing the impact of the F-sector is shown. At time t, common property institutions provide a reasonably high level of

assurance, concentrated around a mean expected level of grazing at $\bar{i}_t$. This is shown by the distribution $L_t$. The imposition of private exclusive use-rights in time t+1 dictates rules consistent with the strong free rider hypothesis, with some allowance for "backwardness" or "irrationality" in the right tail of the distribution shown as $F_{t+1}$.




Range of Grazing Behavior by Others

Figure 6.2

At time t+2, the imposition of exclusive use-rights reduces assurance provided by traditional common property institutions. Traditional rules are not maintained; negentropic decline and the impact of the F-sector lead to a new set of expectations in the traditional L-sector shown as $L_{t+2}$, with a mean $\bar{i}_{t+2}$. The impact of the F-sector results from the pecuniary rewards of adhering to the new rules, the fact that the old rules have not been maintained, and consequent attempts by members of the traditional sector to gain prestige by establishing a modern reputation by following the new rules. The overall result is a decline in belief in the old rules, observed by a smaller and smaller proportion of the group, and an increase in uncertainty regarding the actions of others, reflected by the increased variance of $L_{t+2}$.

In the disequilibrium induced by this developmental sequence, many people's expectations are defined bimodally, resulting in the dualism shown by $L_{t+2}$. In the African context, Malinowski noted:

> [T]he African in transition finds himself in a no-man's-land, where his old tribal stability, his security as to economic resources, which was safeguarded under the old regime by the solidarity of kinship, have disappeared. The new culture, which has prompted him to give up tribalism, has promised to raise him by education to a

> standard of life worthy of an educated man. But it has not given him suitable and satisfactory equivalents (1961, p. 60).

This "no-man's-land" is reflected in the rule structure shown as $L_{t+2}$, in which the mean expectation is far away from the mean of either the new rules or the old.

Despite attempts to break down traditional common property institutions, these rules are tenacious. As Malinowski observed:

> [W]hile it may seem easy to replace a custom here and there or transform a technical device, such a change of detail very often upsets an institution without reforming it, because. . .beliefs, ideas and practices are welded into bigger systems (1961, p. 52).

The tenacity of traditional grazing institutions cannot be explained simply as the manifestation of "backwardness" or "irrationality." Rational individuals, in the sense defined by previous chapters, are not inclined to relinquish institutional arrangements which have (apparently) acted as survival-promoting strategies. This is true even if survival has not been especially comfortable (De Janvry). The policy lesson is that it will be difficult to promote institutional change to rational agents until alternatives are formulated which are utility maximizing in the sense defined in Chapter III.

In the pastoral grazing context, this implies that the process of development should involve a systematic attempt not only to break down belief in and observance of old rules through new inputs and technology, but to provide technology and institutions which lead to a higher overall level of assurance. In this manner, the uncertainty associated with the transitory component of expected income may be reduced.

In the interval between the old rule structure and the new, institutional dualism is a result of variable rates of adaptation of different segments of the population to new technology and institutions. The issue is whether the new rule structure is capable of providing greater assurance for the entire "target group," or whether the bimodal structure of rules will become a permanent feature of the institutional landscape. This may lead to conflict in a society which has been divided into haves and have-nots.

## 3. Traditional Grazing and Resource Depletion in Botswana: The Assurance Problem Observed

Colonization and development assistance in Botswana promoted European and North American institutions such as private exclusive use-rights (Kloppenburg, 1981). Prior to these exogenous influences, common property institutions based in tribal authority provided use-rights over pastoral grazing. The subsequent superimposition of alternative institutional forms altered the set of responses to natural and social uncertainty. Dualistic hybrid institutions have resulted, with evidence of an increasing gap between rich and poor.

Historical and anthropological evidence suggests that this process is generally representative of grazing patterns in the Sahel and Southern Africa (Brokensha et. al., Shapera, 1940, 1943a, Hitchcock, 1981). Institutional explanations emphasizing the problem of assurance give insight into the failure of exogenous technology and institutions to halt resource depletion. Biases implicit in colonial and development assistance policy, often accepted by the government itself, led policy makers to look at overgrazing in Botswana as a "tragedy of the commons." Common property in tribal grazing and

water rights, from the point of view of European and North American institutions, was mistaken for open access. This led to errors in prescriptive policy, based on the property rights paradigm, which reduced the overall level of assurance. This in turn led to increased overexploitation of common grazing land and the disenfranchisement of traditional holders of use-rights. The result of a failure to recognize and build on traditional rules may end up promoting greater "tragedy" than imagined.

a. Traditional Land Tenure in Botswana

The eastern Kalahari Desert is a major site of current policy measures designed to reduce Botswana's problems of overgrazing. It was explored by David Livingstone and his companions in 1849. Incorporated into the British Protectorate of Bechuanaland in 1895, the Kalahari presented itself to early British explorers as a great trackless expanse. Bryden, writing in 1893, remarked:

> In such a territory as the Kalahari, little explored by natives, and even less known to white men, to allocate boundaries to those various tribal hunting grounds is a matter of absolute impossibility. They are vague and undefined, and even the

> tribesmen themselves and their chiefs have very misty ideas concerning them (p. 139).

To the English, whose own highly articulated sense of property derived from the enclosure movement and Lockean prescriptions of private use, land tenure institutions in Southern Africa fell in the attenuated set. Necessary definition and rights of exclusion were nowhere in evidence. A decade before Bryden, Sir Bartle Frere's scholarly efforts confirmed the general view.

> It would be of little use to inquire regarding the land tenures of the Bushmen. . . . They offer, in fact, an almost unique instance of a people without visible territorial rights, or even a shadow of land tenures (p. 258).

Subsequent investigations by anthropologists, including recent work by a current rural sociologist in Botswana's Ministry of Agriculture, Robert Hitchcock, disprove this view, and show a complex web of tribal property rights. Although tribal institutions have changed substantially over time, they continue as a source of assurance to habitants of the bush. Yet as late as 1979, failure to recognize traditional claims to land resulted not only in conflict, but in the failure of numerous government policies aimed at land and water resource conservation (Hitchcock).

The reason for these and other failures is confusion between open access and common property (see Chapter I). Despite the existence of complex common property arrangements, some contemporary analysts persist in the ethnocentric views of the first English explorers. Today, however, the traditional English view has gained currency in parts of the Government of Botswana itself. In 1978, the Ngwato Land Board was under the impression that the area of the Kalahari commented on by Bryden and others remained undemarcated. As Land Board members stated in a letter to the Central District Council:

> It is accepted that in the furthest part of the Western Sandveld the ward boundaries are not easy to find or that they do not exist at all (Hitchcock, p. 76, emphasis added).

The acceptance of a situation of open access, rather than recognition of the formal and informal common property arrangements actually pertaining, led to calls for privitization of tribal grazing lands. This privitization program interpreted the objective conditions in Botswana as a prisoners' dilemma, and

so failed to recognize the possibility for and crucial role of interdependence and cooperative tribal institutions in generating assurance respecting land and water use.

Traditional land-tenure in Botswana, when considered more objectively, reveals a complex pattern of attenuated use-rights to grazing resources. In his extensive analysis of traditional land tenure patterns in Botswana's Central District, Hitchcock notes the dominant role of the Bamangwato Tribe (pp. 8-9). This tribe incorporated other ethnic groups, and administered the tribal territory (lefatshe) through the structure of tribal institutions. By the middle of the 19th Century, the Bamangwato had established an effective organizational structure under the direction of the chief (Kgosi), who oversaw all tribal activities including the administration of justice and allocation of land. The tribal institutions did not provide for all equally; the tribe was composed of four classes of royal relatives, commoners, refugees, and serfs (pp. 9-11).

The tribe itself was divided into administrative wards (metse), which initially were patrilineal and nonexogenous groupings of families related by blood. Over time, these relationships were loosened, so that single wards came to encompass people of different

ethnic groups, and the ward became the mechanism by which immigrants or conquered peoples were absorbed into the tribe (Shapera, 1940, pp. 56-82).

Land tenure was vested in the chief. Hitchcock notes that although it was sometimes said that the chief "owned" the land, in fact, the chief held the land in trust for the people of the tribe (Shapera, 1943a, p.40). He also notes that "not all the land was allocated to individual wards or ward members. On both the tribal and ward level some land was held in reserve for future dispensation as the need arose." Land was not simply allocated to specific groups, the use to which that land was put was also controlled (Hitchcock, pp. 12-13).

Among the resource conserving practices associated with these common property institutions were tribal restrictions on settlement in grazing areas, since land for arable and grazing purposes was kept strictly segregated. Tribesmen granted land were not required to pay for the land which they had been allocated. However, complaints from neighbors respecting tree cutting or overgrazing could be met by ward-heads or overseers (modisa) with requirements to move. The outright confiscation of land was rare, however.

Although wards were important divisions respecting access to land, they were not exclusive rights of access, any more than they were open access arrangements. It was possible for non-ward members to obtain land within ward areas by approaching the overseer of that area and seeking permission, which was granted if sufficient land was available. Appeals to the chief were also possible, allowing for placement in another ward (Hitchcock, p. 16).

Alternative land-use patterns were possible under this flexible institutional arrangement. The most important of these was the grazing of cattle. Here, special mechanisms provided for the avoidance of land depletion through varieties of stinting. Pasture areas, such as those of the Western Sandveld, were divided into districts (dinaga), each overseen by a modisa. Sometimes a single grazing district was subdivided among different wards. The chief did not allocate all of the grazing areas to modisa, but kept some land for himself and his family (Hitchcock, p. 17).

The Western Sandveld region was divided into at least eight dinaga by the mid-20th Century. The responsibility of the modisa was to ensure proper usage of grazing land. Cattle posts, for example, could be

established only at certain distances from one another. Hitchcock notes:

> I was told by one traditional modisa who oversaw a naga (grazing district) in the Western Sandveld, for example, that he permitted cattle posts to be closer to one another in areas having seloko, black cotton soil, and mopane trees (Colophospermum mopane) than in Kalahari sand areas dominated by thornscrub. It was an accepted principle among Tswana tribes that grazing should be controlled in such a way that the range not be allowed to deteriorate. . . . Tribesmen clearly could not graze unrestricted numbers of livestock anywhere they chose. In addition, land was not merely allocated to wards or overseers, but it was managed, and flagrant violations of sound land management principles resulted in social pressure being brought to bear on the violators (pp. 18-21).

In these social pressures, we see a clear example of the reputation function discussed in Chapter III, leading to the maintenance of stinting through pressures arising inside the group.

The grazing districts established by chief Khama III in the latter part of the 19th and early 20th centuries were essentially a rendering in more concrete form of existing groupings based in part on variations in ethnicity, land use practices, and topography. These districts enhanced the capability of resident overseers to determine appropriate grazing policies, and facilitated the adjudication of disputes. By the

beginning of the 20th Century the administrative system of the Bamangwato had reached its highest level of complexity. As late as 1943, it was reported that the traditional system of land tenure was relatively unaltered (Hitchcock, p. 32; Shapera, 1943b, p. 214). Yet technological and other exogenous impacts would radically alter the nature of these traditional institutions.

In sum, traditional land-tenure institutions provided a common property arrangement with an attenuated bundle of rights, somewhere between private property and open access, which offered assurance in the complex physical and social environment of the Kalahari. They defined, for each individual, his or her right to exclude those outside the group, and individuals' rights to graze or use the resource base generally. In so doing, the traditional institutional structure provided a relatively stable and cooperative basis for resource use and the exchange and trade of basic commodities. These "rules of the game" were sufficient to assure each individual that his rights, duties, liberties and exposures would be respected by others. The arrangement was not ideal -- assurance was not complete or based on anything remotely resembling an equal distribution of wealth and reward. Hence some enforcement

(by the overseer) was required. But the anthropological and historical evidence supports the hypothesis that resource conservation was provided through a cooperative common property arrangement at a much higher level than currently. By providing a requisite level of assurance, traditional rules made it in the interest of all to abide.

b. Water Rights and Technological Change

The traditional institutional structure of the tribe was not static. Once established, it responded to both external pressures such as drought, changes in technology, and feedback internal to the institutions themselves. If a modisa of a grazing area died and had no son to succeed him (modisas were patrilineally inherited titles), the job might shift to an individual with entirely different social ties. The warp and weft of social relations contributed, as much as droughts or other natural events, to negentropic feedback which resulted in less and less land being granted to the original ward members, and the process of ward disintegration was speeded up. This result may be considered in terms of the erosion of the community's rule structure, described by equation (20) of Chap-

ter III. A combination of negentropy and exogenous factors led to this decline. Today, relatively few areas belong solely to individual wards without some nonward members having customary rights there (Hitchcock, p. 33).

On grazing districts, or dinaga, these changes were especially marked. Not only social change but increasing herd sizes led to considerable variations on the original ward system. Data collected by Hitchcock on grazing districts in the Western Sandveld region indicate that virtually all of the traditional dinaga contain cattle posts belonging to people of wards other than those originally included in the allocation (p. 35).

Increasing herd size arose from a complex of forces, some endogenous and some exogenous to tribal authority. The complexity of causes and preponderance of institutional as opposed to strictly market incentives suggest that it was not simply a tragic case of overgrazing of common lands. On the endogenous side, livestock are an important uncertainty-reducing choice of food source in a drought-ridden environment. Despite large losses due to drought, the comparatively low risk in relation to arable crops and the low transactions costs of maintaining herds due to natural reproduction versus yearly

planting of arable makes herd enlargement an attractive survival strategy (Kloppenburg, 1981, p. 7; Haaland, 1977, p. 180). Accordingly, traditional rules reward large herds with positive reputation. Every man aspires to accumulate cattle as a symbol of wealth. However, as noted above, these rules also impose limits to the size of herds (Hitchcock).

On the exogenous side, there is evidence to support the claim that exploitative overgrazing resulted from breakdown of traditional safeguards against overgrazing due to the penetration of British cattle markets. The British Veterinary Department was established under colonial authority in 1905, with expenditures exceeding those for medical services until 1936/37 (Roe, 1980, p. 8). Between 1956 and 1960 British funds for expanded water supplies totaled over 400,000. This water supply expansion, to be considered below, had major impacts on both the flow resource of range quality and the stock of available water. The government continues to treat cattle as the leading sector of agricultural and rural development, despite attractive alternatives arising from extensive mineral reserves (Kloppenburg, 1981, p. 4). A wide variety of government policies now actively subsidize cattle production, notably a ninety percent rebate on tarrifs charged by

the European Economic Community (EEC), the primary importer of Botswana beef (Kloppenburg, 1981, p. 5). As Lipton (1978) notes, while cattle producers receive a heavily subsidized price, arable crop producers face no such advantage. In sum, over and above natural incentives to increase herd size, imposed non-market forces arising from government and colonial authority have actively promoted such increases, while reducing the ability of traditional rules to maintain ecological balance.

Exogenous and endogenous rules become blurred as the government of Botswana takes on the goals and characteristics of its colonial predecessors. The old tribal prestige associated with large cattle holdings is now available to government authorities, who are often in positions to promote their own interests through rezoning of common grazing lands as private, commercial ranches. Kloppenburg cites the ample evidence that large cattle owners and high and middle level government and private sector employees are "to a significant extent coterminous groups" (Kloppenburg, 1981, p. 14; Dixey, 1979, N. Parsons 1977).

In this changing institutional environment, individuals sought technical mechanisms to reduce transitory income effects arising from the continued

threat of drought. One such mechanism was the digging of a well, or later, the sinking of a borehole. By tradition, this act affected institutions by conferring on the person doing the digging or sinking certain exclusive use-rights over the surrounding areas. In contrast, all open surface waters including sand rivers, pans, and springs were considered common property to the ward group. Anyone could use them, provided they fell within the boundaries of the ward allocation.

Digging a well required permission from the overseer of the area, or from the chief if it was not yet allocated. The individual also had to seek consent from the other users of the area where he wished to dig his well. These transactions costs were the natural result of erecting an alternative rule structure founded in water rights. Other users could refuse permission if they considered the area overgrazed already. In this sense, another arrangement existed to conserve resources by common agreement. It should be stressed that the rights conferred by well-digging or borehole drilling were not private property rights: "an individual could gain de facto rights over water, this did not mean he had de jure rights. Water was not 'owned' by individuals, and it could not be sold, at least among the

Bumangwato" (Hitchcock, p. 36). The process cannot, therefore, be explained in terms of the changing market incentives of the property rights paradigm.

By the time David Livingstone crossed the eastern Kalahari to Lake Ngami in 1849, there were wells at a number of locations, including Nkawane and Mmaletswai. With the introduction of wells, cattle could now be kept in a single location year-round. The consequence was that the Western Sandveld, once a rich hunting area, became a grazing area, and allocations of dinaga were made by Khama III to village headmen and senior wardheads.

The implications of the expansion of wells for the ecological balance of the region were not then known. Recent C-14 dating of water extracted from wells indicates that nearly all of it is ancient. Hence, the extraction of undersurface waters amounts to exhaustion of a stock, nonrenewable resource.

As cattle numbers built up in the region due to advances in the control of disease in the 1950's and 1960's, more wells were dug and more cattle posts established. In addition, previous dependence by humans on melons and roots declined as alternative water sources became available. At the time of Hitchcock's 1977-78 survey of the Western Sandveld, many original wells were

still being utilized (pp. 39-40). This number did not, however, include the recent innovation of boreholes, which have had a major impact. A traditional dependence on renewable sources of water in the form of melons and roots is rapidly being replaced by a dependence on stock water resources in the form of wells and boreholes.

The development of borehole technology provides an illustration of the exogenous influence of new technology on institutions and their adaptive response to this technology, as well as the role of technology as a response to natural climatic variables. The first borehole drilling program was suggested by tribal chiefs in 1926-27, and led by 1934 to provision of water supplies by the Bechuanaland Protectorate. The original motivation to undertake borehole drilling was drought. Periodic shortages of rainfall continued to exert pressure on Protectorate authorities to drill boreholes, especially on grazing lands. As Hitchcock notes:

> The technical innovation of borehole drilling was of major significance not only to the cattle industry but also the traditional Tswana land tenure systems. The provision of new and abundant water supplies in grazing districts resulted in further breakdown of traditional patterns of ward segregation, and the larger number of water points facilitated the expansion of livestock numbers. At the same time, the cost

> of drilling was prohibitive, and only richer people could afford the luxury of having their own boreholes (p. 42).

The impact of this technology on the institutional structure was felt at numerous levels. The most important was the relative distribution of wealth in cattle, which accrued unequally to those who had first drilled boreholes. This generated a process which promoted further concentration of cattle wealth.

> Areas such as the Western Sandveld, which up until 1940 had only hand dug wells, were not subject to having the grazing land opened up to large numbers of cattle. Those individuals who had acquired customary rights through the establishment of water points now began to see some of their land usurped by wealthy cattle owners who had the financial means to take advantage of the new technology (Hitchcock, p. 43).

The relationship between the institutional and technological components of this dynamic relationship may be expressed as in Figure 6.3 below.

As livestock industry grew in the 1960's, more trading opportunities sprung up in Bamangwato tribal territory. Although trading establishments had existed in the region as early as the 1870's, the livestock marketing opportunities generated by the innovation of the borehole permitted traders to diversify into ranching. In addition, improved veterinary care, greater

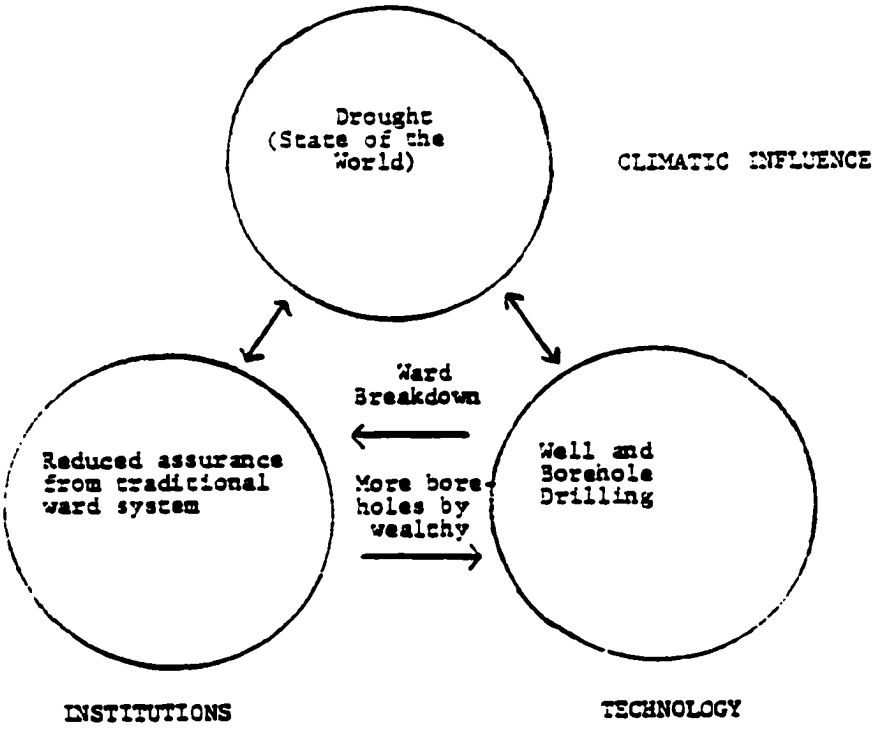



Figure 6.3

numbers of water sources, and an expanding market for livestock resulted in a boom in the cattle industry in Botswana. These factors led in turn to increasing concentration of ownership in private hands (Hitchcock, pp. 42-45).

The consequence of this complex interaction, in light of the nonrenewable nature of water resources, was

serious environmental degradation in the vicinity of boreholes. What may have appeared as a "tragedy of the commons" arose not from the common property characteristics of land and water (which had actually acted to conserve them) but from a combination of declines in assurance provided by traditional common property arrangements, and the impact of technological change resulting in increases in the concentration of wealth. Private property, far from acting as a solution, was actually exacerbating the problem of rangeland degradation, as large individual landholders and absentee traders sought to grab available lands as private resources, excluding others from use-rights over scarce resources.

c. The Development of Modern Land-Use Policy

In 1895 three Tswana chiefs, including Khama III of the Bamangwato, travelled to England to represent the Tswana to the Crown, and to request that the British Government take control of Bechuanaland. They had been induced to do so because of their anxiety over a British plan to transfer administration of Bechuanaland to Cecil Rhodes' British South Africa Company. Lord Chamberlain agreed to the chiefs' requests, and the tribal boundaries of the Bamangwato Batwana, Bakgatla, Bakwena, and Bangwaketse were outlined by Proclamation in 1899.

Subsequent actions of the Crown in 1904 and 1910 brought the area north of the Nata and additional lands under Protectorate status, though not all of this land was declared as tribal territory, some being ceded to private companies. One private area was the Tati Concession; others were the Ghanzi Farms and Tuli Block. Known as "freehold regions," these areas and the tribal Crown Lands were the two types of land holdings recognized by the British Protectorate (Hitchcock, pp. 39-40).

The British system of indirect rule in the Protectorate allowed the tribal chiefs to continue in their role as judges and allocators of tribal land. In 1943, Shapera stated that "the traditional system of land tenure has in the main persisted unaltered since the turn of the century" (Shapera, 1943b, p. 44). However, a complex of forces promoted privitization of land holdings.

The first, discussed above, was the British perception of the land tenure situation as one of open access, or at best as an ill-defined system contrary to the promotion of economic growth as interpreted through the British experience of enclosure. The second, also considered, was the concentration in a relatively few hands of boreholes and the de facto exclusive use-rights that went with them. This, promoted by British development of

livestock and ranching interests, gave even greater impetus to calls for removal of the tribal institutional structure. Additional support for enclosure and privitization resulted from cordon fences constructed in order to prevent the spread of disease in the early part of the 20th Century (Hitchcock, p. 42).

The British institutions superimposed on Botswana's tribal traditions led to a dual structure, in which a balance of power existed between Protectorate interests and tribal authority. As Crowder and Ikime observe:

> Chiefs survived not only because they were the legitimate heirs to institutions that represented the traditions of their people, but also because they still had a power base. In any political struggle the two parties had to use chiefs, and while opposition still existed, the government of the day had to seek their continuing support, the opposition wean it away (p. 27).

The infiltration of English attitudes and ideas, not least respecting land tenure and property rights, led to a decline in belief in traditional tribal mechanisms, including common property. The result was a decline in belief in the "old" rules, and a corresponding fall in the efficacy of tribal authority. Max Gluckman, echoing Malinowski, noted of the colonial period, "the difficulties of the headman's position are enormously aggravated in the modern political system.

In the past he and his followers, with their neighbors and the chief, held a common set of values. They do not accept the values of the dominant modern authorities today" (p. 152). Yet, as Lloyd Fallers commented:

> The situation is not simply one of two radically different social systems colliding head on and, as it were, holding each other at bay. . . . More commonly African and European social systems have interpenetrated with the result that new social systems embodying diverse and conflicting elements have come into being (pp. 294-95).

More formally, the combination of traditional (L-sector) and colonial (F-sector) institutions generated a bimodal distribution of expectations, increasing the variance of the joint distribution of the tribe, with the apparent result that assurance respecting the institutional amalgam actually declined. Vengroff discusses this combination from the viewpoint of the political scientist. His overall conclusion is consistent with the observations cited above, in which a bimodal distribution of expectations resulted with local tribal authorities caught in the middle.

> The population seems to be divided among the rural masses, who still largely adhere to traditional tribal norms, an educated government elite that tries to react in terms of Western bureaucratic norms, and the local level elites, including chiefs and councillors, whose value orientation is in many ways a poorly integrated combination of the other two (pp. 48-49).

In 1966, when the Bechuanaland Protectorate was given its independence and became the Republic of Botswana, the country had experienced an especially severe sequence of droughts. By then herd size had increased to the point that rangelands were severely degraded, and livestock population had been decimated. From one perspective, a tragedy of the commons was at hand. Ironically, the common property arrangements traditionally responsible for resource conservation were being blamed by advocates of privitization for this tragic outcome. Meanwhile, private borehole owners were increasingly exerting pressure on the range (Roe, 1980, p. 10).

In 1970, calls for even greater restrictions on the authority of tribal leaders, and a desire to shift responsibility to representatives appointed by the new parliamentary democracy, led to passage of the Tribal Land Act (Rep. of Botswana, 1970). The purpose of this Act (No. 54 of 1968) was to set up district Land Boards which would have authority in all land matters.

The Act established a system of Land Boards with the power to allocate lands through various Sub-Land Boards. The Sub-Land Boards grant land for residential and arable purposes but not for grazing. Only Land Boards may grant grazing and borehole rights. Typically,

the Land Board is composed of some selected members, as well as representatives of the Tribal Authority. In addition, at least two members are appointed by the Minister of Local Government and Lands (Hitchcock, pp. 47-48).

The Land Boards impose legal procedures designed to conserve land and water resources by appropriating, through the Ministry, authority for customary grazing and water rights in an attempt to convert these customary land tenure use-rights to private, exclusive use-rights. In order for a person to receive a grant of customary land rights, they must state their name, address, and ward affiliation before the Land Board secretary. A letter of no objection from the ward head is also required, allowing a modest contribution by traditional authorities. Water rights are handled in a similar manner through the overseers of areas in which claims are made, which rights are then granted by the Water Apportionment Board in the Ministry of Mineral Resources and Water Affairs.

Although the comparative power of tribal authorities under this system is unclear, various studies and observations suggest that the Land Boards have not established themselves in the eyes of local people. Lack of assurance provided by the new institutional mechanisms

has contributed to the failure of numerous projects which have attempted to supercede traditional tribal demarcations, including a large attempt at "group ranching" by U.S. AID in 1973 (Kloppenburg, 1979).

With concern for the deteriorating rural situation mounting, in 1973 the government launched a wider scale attempt to impose solutions on problems of land and water resource depletion as part of the fourth National Development Plan. The attempt was to further enforce private property rights from above. With the help of foreign consultants, the government decided to establish various categories of land in order to restrain overgrazing and excessive borehole drilling. Between 1973 and 1975 new interministerial committees were formed, and personnel were appointed to the district Land Boards to increase technical capability and collect range and water data. At the same time, a "borehole freeze" was promulgated in an attempt to check the increasing levels of drilling through direct coercion (Hitchcock, pp. 53-54).

These activities culminated in the announcement of the new Tribal Grazing Lands Policy (TGLP) by Botswana's President, Sir Seretse Khama, on July 14, 1975. Linking the need for rangeland and water conservation to the widening gap between rich and poor, the President pro-

posed a new system of land tenure. The system was ostensibly designed both to conserve land and water and ameliorate the increasing concentration of water, and by implication, grazing land, in the hands of a few wealthy Botswana (Rep. of Botswana, 1975).

Curiously, given its stated goals, the TGLP was predicated on the expansion of private property rights. The TGLP White Paper, echoing the theoretical approach of the property rights school, argued that "Unless livestock numbers are somehow tied to specific grazing areas, no one has an incentive to control grazing." The report proposed the expansion of private leasehold rights and increased fencing as the appropriate mechanisms to provide these incentives.

The TGLP currently provides for the division of tribal lands into commercial, communal, and reserve areas. In commercial areas, common law leases are granted to individuals and rents are payable, presumptively generating incentives by defining, assigning, and making transferable the rights of access to land and water. These areas are to be fenced, and the amount of land controlled by a single individual is (as a matter of policy at least) to be controlled. In communal areas, the land tenure system is to remain the same, controlled via the Land Boards. Reserve areas are to be set aside

for future use, with an implied purpose as mechanisms of redistribution to the disenfranchised.

Although few published assessments have appeared outside Botswana, initial examinations by Hitchcock and others (Moody, Kloppenburg, 1981) suggest that the conceptual error of confusing open access with common property arising from the strict dominance of individual strategy is being repeated. It would appear that the institutional responses of British colonial tradition, abetted by biases in favor of private property rights by various economic consultants, are setting the stage for a repetition of failed policy. The private property rights approach has now apparently been adopted by the framers of the TGLP themselves. Whether their confidence in its prescriptions arises from faith in individual rationality and exclusive use-rights or from the opportunities for self-enrichment remains unclear.

When the TGLP was announced in 1975, it was argued that there existed "vast areas" into which commercial ranching could expand. Much like Bryden and Sir Bartle Frere nearly one hundred years before, the maps published in Government Documents, including the 1977 National Development Plan, show large areas to be zoned commercial as "unused." Anthropoligical reports, in contrast, show these areas as filled with hunting and

gathering groups, and demarcated by the common property arrangement examined above. In the manner of the colonist examining traditional property structure from the perspective of English institutions, today's planners confuse open access with common property.

Although the TGLP zoning process is not yet completed, the ostensible division of lands into commercial, communal, and reserve lands has not been accomplished. Despite the fact that commercial zones were originally designated as a residual category, to be allocated only after existing land use patterns had been acknowledged in the form of communal and reserve lands, quite the opposite sequence has occurred. There are virtually no reserved areas planned under the TGLP; in reality "it turned out that designating commercial zones was a major target of the zoning exercise," suggesting feedback to concentrated wealth (Hitchcock, p. 59).

By misdiagnosing the nature of the problem, policymakers have taken action which has reduced the level of assurance provided by the new institutional structure of Land Boards and the TGLP zones, compared with traditional common property institutions. The consequence is an overall reduction in the institutional efficacy of the Government of Botswana, as uncertainty respecting the future afflicts a growing number of citizens. Evidence

of this is provided by the mid-1975 government effort to explain the new policies to the areas to be zoned by establishing over 3,000 "Radio Listening Groups" and conducting follow-up surveys. That grave doubts existed was clear from the responses, which indicated that people were very concerned about the implications of the policy. For now, the central government's desire to privitize land holdings by zoning them commercial is stronger than the objections of affected citizens.

> One of the conclusions which can be drawn from statements made by people who turned in report forms was that few people in the districts felt there to be sufficient land for commercial areas. Nevertheless, where the initial zoning decisions were made, a number of areas were declared commercial, including two in the Central District. . . . The only one of the commercial areas which had had surveys done of the people living within them prior to their being zoned commercial under the TGLP was the Western Sandveld; the balance of the areas did have surveys done, but they were all ex post facto (Hitchcock, p. 61).

By establishing the primacy of the individual right to exclude others through the leasehold rights provision in commercial areas, the TGLP failed to consider the distributional issue of the fate of those with customary rights to the land so enclosed. Nor did it address the rights of access of former group members, who were non-lease holders, who were now excluded by the

private property institutions. In short, an apparent belief in the strict dominance of individual strategy led to a private property solution which failed to consider the interdependence of the individuals living on the land, and the bonds of pre-existing common property arrangements. "There is a real danger," Hitchcock notes, "that under the proposed changes in land tenure, a portion of Botswana's population will be deprived of land." The impact of this approach on people's confidence in the Government is captured by the Ngwato Land Board's comment to the Central District Council in February, 1978: "Asking people to move out of commercial areas has become notoriously known as the government's way of removing the poor from the rich man's land" (Hitchcock, p. 63).

It would appear that the emphasis on privitization has had an effect opposite that laid down by the TGLP White Paper. Zoning lands commercial appears to be leading to increasing concentration of water and cattle wealth, rather than closing the gap between rich and poor. Exclusive private property has led to the disenfranchisement of rural population, and rising mistrust of government institutions.

In this setting, it is also doubtful whether the TGLP can accomplish its primary goal of reducing land

and water resource depletion. If the theory outlined in this study is accurate, and the principal virtue defining the efficacy of institutions is assurance, then the declining confidence in government coupled with the steady erosion of traditional institutions will lead to individual attempts to grab land now, and worry about overexploitation later. As the institutional interdependence implicit in common property institutions is undermined by proclamations of the virtues of private leaseholding, "excess" people will be driven off commercial lands to fend for themselves in South Africa or, more ominously, Zimbabwe.

A harbinger of these results is provided by the World Bank's Livestock I project at the Nojane Ranches. Fences were constructed and individuals were given private leasehold rights over the land. By early 1979 all of the ranches were seriously overgrazed and a number of owners had removed their herds. Some ranchers defaulted on loans. A side effect of the Nojane Ranch scheme was the dispossession of area residents forced to leave when cattle owners were given the land (Hitchcock, p. 66).

Finally, there are major questions respecting the efficiency gains resulting from markets in grazing rights arising from private property regimes. The 1975

TGLP White Paper argued that stocking rates and profit would be "more than doubled" on fenced ranches. Hitchcock reports that figures from the Nojane Ranches show that the productivity indicators are actually lower than on the common property cattle posts. Calving rates, management levels, and other indicators of productivity on traditional cattle posts have been seriously underestimated. While World Bank documents estimated rates of return on traditional posts at 3-3.5%, field studies show profits in many cases as high as 14-18% (Hitchcock, p. 67).

In the case of Botswana, it must be concluded that even on efficiency grounds, the virtues of the strict dominance of individual strategy are not obvious. It appears that an institutional bias in favor of private land use institutions has foreclosed numerous institutional options capable of providing greater efficiency. At the same time, focusing on the issue of assurance suggests the necessity of an alternative structure if resource conservation and long run economic progress are to be achieved.

d. The Challenge of Institutional Alternatives

The case of Botswana demonstrates that policy based on a theory of independent actors may be far from benign. When it dictates private property institutions inappropriate to a communally based culture, the result can be to undermine the institutional efficacy of the state itself, by destroying traditional institutions and leaving an inadequate set of substitutes in their place.

The structure of community, the working rules or institutions of a society, will determine whether individuals act independently or cooperatively. Common property, operating in the traditional tribal context of Tswana society, acted to assure individuals to a degree sufficient largely to prevent resource depleting behavior. Changes in technology, together with the promotion of private property rights, have lowered this level of assurance.

The challenge to the policymaker is to arrive at a set of institutions which will maximize assurance in the institutional domain, while adapting to changes in the technological domain. The opportunity set of institutions is as open as the imaginative ability of the Government of Botswana to generate new alternatives

which provide assurance to its people. Surely these institutional alternatives can include many characteristics of older tribal forms, as well as characteristics drawn from successful contemporary ventures in resource conservation and equitable distribution elsewhere. The alternatives need not be construed in terms of British or North American traditions, which may or may not be appropriate to the physical, social, and economic environment of Botswana.

Suggesting the institutional efficacy of traditional common property does not mean that Botswana must remain chained to its past. But it does suggest the conservative wisdom (akin to the idea of precedent in legal theory) of examining the useful part played by common property in resource conservation, before entering into institutional alternatives which may lower assurance as well as efficiency in the name of misconceived theory or misplaced traditions.

The ultimate lesson of the assurance problem in the context of policy is that institutions must be adapted to their environment. Much discussion has surrounded the idea of "appropriate technology" in the development literature. Our analysis of the vital role of institutions should convince those involved in the

framing of policy that there are appropriate and inappropriate institutions as well.

There is evidence that the Government of Botswana has already shifted its emphasis in response to dissatisfaction with the property rights approach of the TGLP. Odell (1980) reports that institutional innovations based on recognition of common property are currently underway. By acknowledging the traditional role of the modisa and ward system, policy is being devolved to the local level. In communal areas, Odell reports that 550 groups of local farmers have been organized to form cattle dipping and arable crop improvement centers, as well as improved livestock management aids such as bull and weaner camps in the area of their fields (Odell, 1980, p. 11).

Field research shows that while it is important to attach a well defined group to a specific area, in recognition of traditional common property rules this must be accomplished without exclusive individual use-rights. Odell reports:

> [W]hile it was important to attach a defined body of people to a specific area of land, fenced ranching was alien to the majority of the rural population. Farmers in communal areas saw fences as useful for keeping cattle out of their crops rather than for keeping cattle inside a grazing area, and fenced

> ranching was among the lowest of their many development priorities (p. 10).

By shifting emphasis to integration of arable crop production and the use of draft animals for this purpose, programs fostering integrated land use planning (beginning with the separation of fields from grazing areas with drift fences) are gaining more rapid and enthusiastic support than fenced ranches. About 70 communities have begun drift fencing in which traditional common grazing areas are the basis of integrated land use planning (Odell, pp. 10-11).

It is increasingly clear that traditional local institutions must be strengthened and streamlined if they are to succeed. They are seen by the local people as being the most appropriate for managing development efforts. "At the same time," Odell reports, "there is mounting evidence that efforts to ignore or bypass these institutions are not only unsuccessful, but often bring further developments to a halt" (p. 15).

## 4. Conclusions and Directions for Further Research

Reassertion of an institutional approach to problems of economic development comes at a time of increasing doubt over the ability of orthodox economic theory to explain dynamic processes of social and economic change in the developing world. The formulation of economic problems in terms of quantitative efficiency gains, in which distributive and other institutional concerns are held constant, dealt with later, or left out of the analysis altogether is bound to strike policy-makers in nations grappling with development issues as a sterile exercise. Moreover, as I hope I have shown, policies limited to promoting efficiency by advancing the claims of the property rights school can have substantial negative effects on both welfare and efficiency.

The major conclusion in the Botswana case pertains equally well to a variety of policies advanced by Western "experts." It is best stated by Botswana s senior rural sociologist, Malcolm Odell:

> New institutions, not well understood by rural people, must not be allowed to steamroller existing mechanisms that are well known and trusted by the rural population and which provide a base of stability amid rapid change. It has been shown that the changes witnessed in Botswana in the past generation can potentially leave many rural people confused and unable to cope with their social and economic

> environment. As we move toward bringing more and better development down to the level of those in the smaller settlements of rural Botswana we must ask ourselves if we really trust the institutions that have served them so well for centuries. Are we really giving them decisionmaking authority or are we simply using the accepted consultation mechanisms as a means of selling our own ideas? Are we adding bureaucratic procedures for reasons that outweigh simplicity and speedy action? There is ample evidence that, if properly supported, these institutions can serve well through the next century. Their foundations have been severely eroded, however, by good intentions and benign neglect as attention has been focused on the new and different. Once those foundations crumble, the authentic voice of the rural population will lose a crucial and accessible channel of expression, decisionmaking, and action. To build an adequate replacement will take far longer than the demands of development and change will allow in the years to come (Odell, p. 17).

The research necessary to explore adequately the institutional issues of assurance is large. One element is the attempt to identify linkages between institutions and the resource base of the people who have innovated them. Such a study is currently underway by Daniel Bromley and Wayne Miller at the University of Wisconsin-Madison.

A second direction for future research derives from the formal properties of the assurance problem itself. Research into institutions as incentives to voluntary contributions to public goods may give

insights into how weak free rider behavior may be made weaker. This can minimize the costs of enforcement. Depending on the transactions costs involved, erecting new rules (or innovating new variations on existing rules) may be a cost-effective alternative in many public goods situations (see Green and Laffont).

Research must also continue into the comparative informational efficiency of institutions, and the optimal group size for different purposes. This general class of problems is one research focus of both Marschak and Fritz Machlup (1981). Not only the size of the group, but the nature of different groups, is an area to which interdisciplinary research by economists, political scientists, sociologists, psychologists and others may contribute.

Finally, and perhaps most important, is confronting the issue of enforcement. Assurance may be less than optimal due to transactions costs or rapid change. If assurance is less than optimal, there is a need for sufficient enforcement to "close the gap" between the assurance generated endogenously and the level deemed necessary by the group. Heuristically, added enforcement is the analogue in the assurance problem to the level of intervention necessary to correct "market failure" in a perfectly competitive economy. We might

term this enforcement a solution to "institutional failure" (see Wolf). Several research issues are involved. What is the best estimate of the level of assurance which can be generated via endogenous institutional agreement, and how much additional enforcement is necessary to guarantee a minimum level of assurance for stability? Given that endogenous solutions are likely to involve fewer costs than enforcement, how can incentives for such agreements be structured? Since successful institutions are suited to the needs of the group and the group's environment, research programs must also attempt to focus on specific microeconomic environments and well defined groups.

These research needs point to some of the weaknesses of this study. Four major weaknesses stand out. First is the need for a larger empirical base, particularly further and more extensive case studies. By this method, overall results may be subjected to more rigorous testing. Second is the need to specify more precisely the information content of institutions, and how this role can be better extracted from experimental data, such as the Marwell results discussed in Chapter IV. Third, the findings presented here need to be integrated with the political development and comparative politics literature, such as the work of Apter

(1971) and Almond and Verba (1963). Finally, there is a need to develop a more formal taxonomy of institutional types, the result of a synthesis of economic theoretic and political development concepts, to guide and order the work of future researchers and policymakers.

There are undoubtedly many other issues raised at both the theoretical and policy level by an attempt to recast the problems of economic development in these terms. I only hope that this study has provided something of the flavor of this new approach, and has suggested the rather direct link between theory and practical problem solving which it provides.

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