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Alternative Auction Methods for Leasing Oil and Gas Rights on Michigan's Public Lands

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Abstract

Alternative Auction Methods for Leasing Oil and Gas Rights on Michigan's Public Lands

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Michigan's public lands yield significant oil and gas resources. It is characteristic of these resources that their value can not be determined prior to actual development. This uncertainty has led to the use of auctions in many leasing markets. The question addressed in this study is how the performance of Michigan's leasing program may be affected by the choice of a specific auction method.

This research proceeds with a review of the literature on economic decision making under conditions of uncertainty and it's application to the modeling of auction markets. Hypotheses are developed concerning the connection between the leasing situation in Michigan, the choice of auction method and the desired performance of the leasing program.

The purpose of this study is not to provide specific prescriptions concerning the auction structure appropriate in the state. The hypotheses presented here should, however, provide information of use to decision makers in the Department of Natural Resources in designing leasing policy that is consistent with desired objectives.

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Chapter One

Introduction

In the United States government entities do not often engage directly in the exploration for or development of oil and gas resources but establish exclusive rights to these resources for private developers. The manner in which the transfer of rights from public to private hands takes place would be expected to have some effect on the way in which these rights are allocated between interested parties and on the way in which development takes place. Information as to how different institutions governing these transactions affect government objectives and the satisfaction of public preferences will be important to government decision makers. The purpose of this study is to investigate some possible outcomes of different transaction mechanisms in terms of various performance criteria. This information should be helpful in designing policy that is consistent with the management objectives of the government.

This study deals specifically with the transfer of exploration and development rights to oil and gas deposits on public lands under the jurisdiction of the State of Michigan. The study is primarily descriptive in nature although some prescriptions will be made based on specific performance objectives of the state. The focus will be on possible consequences of different mechanisms used to allocate rights to public oil and gas deposits and will provide prescriptions consistent with desired objectives.

These questions are particularly relevant in Michigan for two reasons. In the first place the State of Michigan ranks twelfth in the nation in the production of both oil and gas with over 31 million barrels of oil and over 142 billion cubic feet of gas produced in 1984. Secondly, Michigan has more land under state jurisdiction than most states east of the Rocky Mountains. Revenues from oil and gas development in the state could contribute substantially to the state treasury. This diversification of the economic base is important in a state that is often seen as being too dependent on a single industry. The fluctuations in the automobile industry brought about by periods of recession have severely taxed state resources in the past. In 1984, revenues to the state from bonus and royalty payments on oil and gas developments amounted to over 58 million dollars. Table 1-1 provides a summary of revenues for the years 1927-1984 split out by form of payment.

Aside from revenues from the development of publicly owned oil and gas deposits, the state also gains from the development of privately held deposits through the payment of taxes. In 1982, production from private lands accounted for almost 23 million barrels of oil and almost 110 billion cubic feet of gas. These figures represent approximately 73% of the oil and 77% of the gas produced in the state (Department of Natural Resources, 1982b). Severance tax payments on oil and gas development totaled over $75 million in 1984.[1] It might be expected that the choice of institutions to transfer publicly held resources to private hands will affect the manner in which private landholders bargain with developers.

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[1] "Michigan's Oil Exploration-Production Industry at a Glance", Michigan's Oil and Gas News, May 24, 1985, pp. 24

Table 1-1

Revenues From Oil and Gas Production on State Owned Lands

Years	Royalty ($)	Rental ($)	Bonus ($)	Other* ($)	Total ($)
1927-1931	85,262	43,821	27,707	1,204	157,995
1932-1936	209,125	205,349	87,211	4,506	506,192
1937-1941	1,302,355	724,330	515,705	7,367	2,549,758
1942-1946	1,645,462	2,021,512	601,065	3,759	4,271,799
1947-1951	1,813,632	2,256,913	1,307,470	4,398	5,382,414
1952-1956	2,727,410	1,989,342	256,186	3,028	4,975,967
1957-1961	1,879,927	769,593	475,840	3,702	3,129,063
1962-1966	1,259,162	1,476,949	409,809	4,982	3,150,902
1967-1971	2,160,038	3,258,088	2,168,524	6,009	7,592,661
1972-1976	31,651,761	5,998,726	18,339,720	9,979	56,000,186
1977	13,327,908	1,190,619	357,005	3,069	14,878,602
1978	18,244,756	1,131,238	14,483	1,733	19,392,210
1979	24,269,564	1,100,306	1,414,667	1,047	26,785,584
1980-10/1	24,488,630	1,015,879	-2,982	1,679	25,503,206
10/1/80-10/1/81	44,912,755	1,216,258	32,277,235	1,860	78,408,109
10/1/81-10/1/82	45,802,471	908,025	10,304,780	17,715	57,032,992
10/1/82-10/1/83	49,142,835	790,225	630,029	21,759	50,584,849
10/1/83-10/1/84	49,978,858	1,215,116	7,513,180	33,099	58,740,225
Totals ($)	314,901,920	27,312,297	76,697,639	130,895	419,042,752

* This column is the sum of application and assignment fees

Source: Department of Natural Resources (1982b)

Oil and Gas Leasing in Michigan

The state of Michigan owns 3.8 million acres of surface and mineral rights and an additional 2.1 million acres of mineral rights alone. Although leasing of great lakes bottomland for oil and gas production is currently prohibited, the state also owns 25 million acres of such land that could become available for lease in the future.

The recovery of hydrocarbon resources from state lands in Michigan

takes place under the provisions of Act 17, P.A. 1921, as amended, and Act 280, P.A. 1909 as amended. These acts provide for "... management of land and mineral resources to ensure protection and enhancement of the public trust". In addition, regulations have established the director of the DNR as the supervisor of wells whose duty it is to provide day to day enforcement of "...all matters relating to the prevention of waste...and to the conservation of oil and gas in the state" (Patric and Kakela, 1982a). The policy of the state in leasing oil and gas rights is specifically stated as follows.

> It shall be the policy of the Natural Resources Commission to provide for orderly development of state-owned hydrocarbon resources, to encourage the private sector rather than the state to risk capital in exploration and development, to optimize revenue from state-owned hydrocarbons consistent with other natural resource management objectives, and to provide for regular and systematic review of the oil and gas leasing program.
>
> Oil and gas leasing and development on public lands shall be established in a manner to assure (1) optimum economic return to the state, (2) competition for the acquisition for leases, (3) protection against drainage of hydrocarbons, and (4) protection of the environmental, recreational and other uses of the land, including lakebottoms and connecting bays harbors and waterways. (Department of Natural Resources, 1982a)

The leasing of oil and gas rights on state lands in Michigan falls under the jurisdiction of the Lands Division of the Department of Natural Resources (DNR) with lease sales held two or three times a year depending on demand. Tracts to be leased are nominated by interested parties and these nominations are reviewed by the DNR to determine the desirability of leasing them as well as any restrictions that may apply to the lease. Leases are sold primarily through an auction method although provisions exist for direct sales under certain conditions. The auction used in Michigan specifies a reservation price, the minimum

number of bidders required on a tract, the way in which bids are accepted and the object of the auction. The lease, once purchased by auction, further specifies the term of the lease, the conditions of reimbursement for resources actually recovered under the lease, regulations governing development specifics and lease assignment regulations. Some concern has been expressed within the DNR, however, that the auction method and lease terms currently in use are not well suited to the attainment of leasing objectives. The purpose of this study is to shed some light on the consequences of alternative auction methods and lease terms.

To measure the performance of alternative auction procedures it must be decided how performance is to be measured. The consequences of different auction methods are often stated in terms of revenues to the seller of the lease but other variables are affected and could be considered. Auction methods can affect the distribution of leases between various types of prospective buyers, the manner of development or the distribution of risk and benefits between the parties to the sale. This study will consider a number of performance criteria in addition to returns to the seller. The choice of these criteria is, in part, a function of the concerns expressed by representatives of the DNR in their leasing policy.

Summary

The objective of this study is to explore the possible consequences of alternative auction methods for the leasing objectives of the State of Michigan. Research requires a conceptual framework that will help to

organize ideas about the problem and suggest questions that are likely to lead to resolution of the research objectives. Chapter two introduces the situation-structure-conduct-performance paradigm as conceptualized by the institutional economists and develops it in terms of the subject of the study. Chapter three further develops the conduct portion of the paradigm. In this section current theories of behavior under uncertainty are explored and related to oil and gas markets. Chapter four applies the theories introduced in chapter three to bidding and auction behavior. A number of distinct models of bidding behavior are introduced and related to the sale of mineral deposits. Finally, chapter five applies the theoretical developments of the preceding chapters to the leasing situation in the State of Michigan. The focus of this chapter is on the possible performance outcomes of alternative auction structures under consideration for use in Michigan.

Chapter Two

A Conceptual Framework for Research

Research requires a conceptual framework that will help to organize ideas about the problem under consideration and suggest avenues of inquiry that will lead to resolution of research objectives. This research will make use of the situation-structure-conduct-performance (SSCP) paradigm that was introduced in the field of industrial organization and adopted by the institutional economists. This framework suggests that there is a causal connection between the situation in which a market operates, the structure of the market, the conduct of market participants and subsequent performance.

The purpose of this chapter is to explain in more detail the structure and implications of the SSCP paradigm and to fill out the components of the paradigm in terms of the leasing of oil and gas resources. In the course of fitting the paradigm to this particular problem each of the four components will be defined in terms of the relevant variables of the oil and gas lease market and the nature of the interdependence between them will be explained.

The SSCP Paradigm

The SSCP paradigm has its roots in the field of industrial organization which is concerned with how the organization of production activities affects the satisfaction of society's wants. The paradigm

has been adopted by the institutional economists, with some alterations, for use in research on questions of public policy. While the paradigm used by these two fields in economics is essentially the same, the variables on which the framework focuses are very different because of the difference in the questions that each addresses. Studies in industrial organization have frequently focused on traditional definitions of market structure, behavior and performance (Scherer, 1980) while the institutionalists have defined these variables much more broadly. It is the emphasis of the institutional field that will be used in this research.

Schmid (1978) presents an excellent discussion of the components of the paradigm and the interdependence among them as used by the institutional school. The emphasis of the paradigm as presented here is the development of testable hypotheses about the performance resulting from structural changes in institutions. Situational variables are treated as defining the characteristics of the world within which the institutions work and, as such, must be treated as fixed if the effects of structural change on performance are to be isolated from the effects of changing situational variables.

Externalities are defined as the impacts of the actions of one individual upon another. Externalities are ubiquitous and their presence implies an interdependence among individuals in their actions and uses of goods and services. In the SSCP paradigm the situational variables describe the characteristics of goods and services that create the opportunity for interdependence. The nature of this interdependence can take many forms depending on the characteristics of the good in question and the technology available to affect the pattern of use of

the good. A great deal of energy in institutional economics has been expended in defining a taxonomy of the characteristics of goods that lead to certain types of interdependence. Once situations are classified in terms of their common characteristics that create interdependence similar structural alternatives can be matched to similar situations to create a more predictable performance outcome.

Institutional structure defines the rules of the game or the property rights of the affected individuals within a certain situation or interdependent relationship. Institutions define, explicitly or implicitly, the rights of individuals when conflict arises. The choice of institutional structure is the choice of how rights are allocated and ultimately how conflict is resolved. In the sense that institutions define the rights of individuals in conflict resolution they also define opportunity sets, that is, the opportunities available to the involved parties. The choice of institutional structure must be made in light of the situation creating the interdependence and this is the importance of the taxonomy developed by the institutionalists.

Institutional structure defines the structure of rights; it sets the rules by which the game must be played but does not explicitly state the outcome or specify a decision rule. The structure of institutions sets up rules by which individuals interact and transactions take place; they can structure the pattern of incentives and penalties faced by individuals in their actions. In order to design institutional structure to meet desired outcomes or performance ends the behavior of individuals in response to alternative structural changes must be understood. This is the conduct part of the paradigm and refers to the conduct of actors within the system in response to the rules and

incentives provided by the structure of institutions. A realistic theory of behavior is essential to the determination of performance from a given situation and structure.

The final component of the paradigm is performance, that is the outcome of the behavior of actors in response to the institutions that define their opportunity sets for a given situation. The focus of Schmid's framework is on substantive performance, that is on who gets what in a positive sense, rather than on normative propositions of efficiency that are commonly the performance criteria used in industrial organization. Since performance is the ultimate goal of public policy, the performance objectives of policy, as well as the conduct of economic actors and the situation that creates interdependence, must be kept in mind when designing institutions.

Performance, as the outcome of institutional structure, presents some problems of measurement and documentation (Schmid and Schaffer, 1983). First, categories of performance must be established and related to structural alternatives. Performance may have many aspects and, in order to avoid excessive detail in research, the significant consequences must be addressed while the unimportant ones are ignored. Secondly, performance categories must be aggregated into indices that can accurately account for performance changes. Performance must be measured in meaningful terms, impact indicators that address the real final impact of performance rather than intermediate products. There may also be problems in defining performance. As Schmid and Schaffer point out, some aspects of structure and conduct are valued directly for their own sake and can rightly be considered aspects of performance.

It is important to realize the dynamic nature of the relationship

between the components of the paradigm. While the paradigm implies a causal flow from situation to performance, there can be other interactions as well. Over time, conduct can influence situation and structure. Technological change can affect the situation, or the nature of the opportunity for interdependence. Institutional structure can also ultimately affect the situation. The dynamic character of the entire process becomes evident when it is recognized that performance in one time period can change aspects of situation or structure in subsequent periods.

The SSCP paradigm provides a framework within which to explore how rules, or institutional structure, affect individual choice and how this in turn affects substantive performance. The emphasis is on the formulation of testable hypotheses about how institutional structure affects performance so that institutions can be designed to yield certain desired performance goals. In order to effectively use the framework, the nature of the interdependence between individuals (the situation) as well as human behavior must be well understood. Performance goals must be clearly stated and indices formulated in terms of impact indicators to determine whether institutional structure is effective in reaching these goals.

The Paradigm Applied to Oil and Gas Leasing

This study uses the SSCP paradigm to analyze the leasing of oil and gas resources in Michigan. Stated in terms of the paradigm this study will investigate the effects of alternative institutional structures for leasing, that is alternative auction procedures, on the performance of

the oil and gas leasing market in the State of Michigan. It is hypothesized that variations in the structure of the rules of leasing will affect the substantive performance of the leasing program in terms of the distribution of leases, the allocation of the benefits of hydrocarbon development and other performance variables. In order to proceed with the analysis the oil and gas lease market must be defined in terms of the components of the SSCP paradigm. In the remainder of this chapter the four components of the paradigm will be expanded in the context of Michigan's leasing market.

Market Situation: The situation refers to the characteristics of the good that create interdependence between users. In the oil and gas market this encompasses the current demand and supply conditions for oil and gas resources, certain characteristics of the resource itself and the technology available to develop and use the resource.

Supply and demand conditions for oil and gas resources, or at least the way they are perceived, have changed dramatically since 1970. Energy resources in general and oil and gas in particular have attracted a great deal of attention since the oil embargo of 1973 and the creation of OPEC. These events not only made oil importing countries more aware of their dependence on foreign sources of energy but spurred these countries to seek alternative supplies in both foreign and domestic markets (Landsberg, 1979). In the U.S., this resulted in policy designed to increase the exploration for and the development of domestic resources of oil. Deregulation of oil prices in the U.S. was supposed to stimulate exploration and, in time, increase domestic supply and reduce dependence on imports. The increased prices brought about by

deregulation have focused more attention on the way in which a valuable publicly owned resource is developed.

Government policy has also been aimed at the development of alternatives to oil as an energy source. The U.S. has an abundant supply of coal and production and use of this resource have been on the increase. Special tax treatment has provided incentives for investment in less traditional sources of energy such as solar, wind and oil shale. While these alternatives constitute substitutes for oil the change from one source to another is hampered by technological progress in making these sources economically feasible and the fixed investment in oil dependent technology.

Increased oil prices brought about by OPEC price increases and U.S. deregulation certainly had an effect on both consumption and sources of oil. In the short run high prices have resulted in conservation measures which have reduced the use of some oil products, most notably gasoline, and have increased the interest in alternative energy sources. Deregulation has resulted in greater exploration efforts in the U.S. and a larger known domestic reserve. In the short run substitutes for oil have not played a major part in the market because of investment in oil dependent technology but in the long run oil could become much less important as a source of energy as alternatives become economically and technically feasible.

Probably one of the most important aspects of market situation, from the standpoint of institutional design, results from the characteristics of oil and gas resources. Deposits of oil and gas lie

underground, sometimes at considerable depth, and their fluid nature allows them to migrate through the porous rock in which they occur. The technology of exploration is not developed to the point that the existence of deposits can be detected with any great degree of accuracy before actual drilling takes place. Since drilling is very expensive, and in most cases prohibited before the sale of the lease, the information costs as to the value of a lease are very high. High information costs contribute to a great deal of uncertainty as to lease value for both the buyer and the seller of the lease.

Ramsey (1980) discusses two sources of uncertainty, those of inherent risk and ignorance. When uncertainty results from ignorance the acquisition of information can reduce or eliminate the uncertainty, the cause of uncertainty is insufficient information. While sufficient information can eliminate ignorance as a source of uncertainty it is important to note that some degree of ignorance is almost always economically rational, that is it is not rational to reduce ignorance completely. Information is expensive, even when ultimately knowable, and perfect information is infinitely so. In this situation it would be irrational to purchase information sufficient to eliminate uncertainty resulting from ignorance. Inherent risk refers to uncertainty resulting from the unknowable, no amount of information will reduce this uncertainty. In the oil and gas market the size and value of deposits is a random variable. The gathering of information through seismic tests may be helpful in estimating the distribution of the random variable but does nothing to actually reduce it's randomness. While this uncertainty is caused by ignorance, implying that it is ultimately knowable, current development rules make it essentially inherent in nature.

While some uncertainty in oil and gas markets is caused by the characteristics of the resource, the technology available to discover deposits, and the rules of development, there is also uncertainty caused by the time frame of development. Once a sale is made it may take years (the state allows seven) to develop the lease and begin the recovery of oil or gas. Once production has begun it may take many more years to deplete the deposit. Purchasing decisions are made using some estimate of the value of the resource and this includes the future value of any oil or gas recovered. During the time frame required for development prices may change considerably and this adds to the uncertainty inherent in the purchasing decision.

Another important situational characteristic of oil and gas resources is the the fluid nature of the deposits. The uncertainty involved in the location of deposits from the surface creates problems in the mapping of rights to underground deposits to the surface rights in which leases are sold. If a deposit is found to lie under surface areas for which the development rights are held by two or more parties, the fluid nature of the resource can lead to problems in development. A party who pumps at a faster rate than others can draw oil from under adjacent claims. From an engineering standpoint, there is an optimal rate at which oil or gas can be extracted from a well in order to maximize total recovery. Too great an extraction rate will significantly reduce the total resource recoverable. The fluid nature of the resource, in effect, creates non-exclusive rights to the deposits and, coupled with the engineering realities, can lead to a form of the tragedy of the commons discussed by Hardin (1977). The maximizing actions of each developer on the field will result in a substantially

reduced total recovery from the deposit.

The situational variables define the environment within which structural alternatives must perform. The most important consideration from the standpoint of this study will be the degree of uncertainty faced by both parties to the transaction. Most states, as sellers of rights to publicly held oil and gas resources, do not engage in any activities to estimate the value of leases prior to sale, Louisiana is the only exception. The seller, therefore, faces more uncertainty than the buyer as to the value of the lease and relies on the method of sale, that is institutional structure, to ensure a fair price.

Institutional Structure: Given the interdependence described by the situation, the institutional structure defines the property rights of individuals. It imposes some order on the interdependence. In the oil and gas lease market, the structure of leasing institutions, the rules that govern the leasing of rights to oil and gas resources, define the property rights, either explicitly or implicitly, accruing to the interested parties.

The most common institutional arrangement for the allocation of property rights to oil and gas resources is the auction. An auction is essentially a price discovery mechanism used by the seller of an object of unknown value and mineral lease sales, having the characteristic of uncertain value, are often structured as such for this reason. Auctions, however, can take many forms and these structural alternatives may affect the outcome of the auction process. Auction forms are distinguished by the way in which bids are solicited, the manner in which bids are accepted, the object of the bidding, and the relationship

of the winning bid to the selling price. Besides the actual structure of the auction there are terms specified in the lease, once purchased, that further define the rights and responsibilities of the parties to the agreement.

Ramsey (1980) makes a distinction between a competitive and a discriminatory auction. A competitive auction is one in which the high bid wins but pays the amount of the second highest bid. In a discriminatory auction, on the other hand, the high bidder wins and pays the amount of his bid. In some more recent studies (Milgrom and Weber, 1982) these auction types are described as first and second price auctions which is the terminology that will be adopted in this study. Besides the first and second price concepts auctions can be distinguished by the method of bidding, either oral or sealed. In a sealed bid auction all prospective buyers submit sealed bids which are then opened simultaneously and the winner announced. In this case either the first or second price auction can be employed to determine the amount paid by the winner. In an oral auction, on the other hand, bids are accepted orally and bidders have the opportunity to alter bidding behavior in response to the actions of others. If second price auctions are used in this case a bidder could win simply by bidding a very large amount, consequently only the first price auction is appropriate in this context. It should be noted, however, that the first price concept used in an oral situation is similar to the second price sealed bid auction. The high bidder in an oral auction knows the second highest bid and his bid will only be slightly higher, there will be no reason to bid as high as his real valuation if this is much higher than the second highest bid and he will essentially win the lease at close to the second price. In a

sealed bid auction, however, the second highest bid is not known and a bidder will bid his valuation of the object.

Another common distinction is between the English and the Dutch auction methods. Bidding with the English method is progressive, starting at a low level and gradually increasing the asking price until only one bidder remains. English auctions are also referred to as oral, ascending, progressive or open auctions. In a Dutch auction, also called a descending auction, the selling price is first announced at a high level and is progressively reduced until a bidder accepts the stated price.[1] The English auction is essentially an oral auction in that bidders must be able to respond to the bids of their competitors, there are, however, variations that protect the anonymity of the bidder (Milgrom and Weber, 1982). Dutch auctions are oral in nature but do not result in any interaction between the bidders as in the English auction.

It would be expected that the choice of auction method (structure) would be motivated by a belief that the desired performance outcome will result. A number of articles have addressed the question of the relationship between auction method and some performance measures, most notable perhaps being the work of Milgrom and Weber (1982) and Mead (1967). This study will focus on three of the auction methods discussed in these studies that are also under consideration for use in Michigan. A distinction will be made between first and second price sealed bid auctions and the English auction, hereafter referred to as the oral auction method.

Auctions of oil and gas rights are also differentiated by the

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[1] A more complete discussion of the Dutch auction method can be found in Milgrom and Weber (1982)

object of bidding, the most common being the bonus, royalty, profit share and full share. These variables specify how the seller is to be reimbursed for the object that is auctioned and, while only one is usually the object of bidding, a combination can be used for actual payment.

The bonus is an up front payment, made at the time of sale, for the right to develop a specified surface area and is usually defined in terms of a price per surface acre. The bonus payment bears no relation to the actual amount of oil or gas that may be discovered under the surface leased. The royalty is specified as a percentage of the wellhead value of resources recovered under the lease and as such the total payment will depend on the amount of the resource recovered as well as its price. The royalty may be used as the object of bidding in which case the bid is in terms of the percentage of wellhead value of the resource that the buyer will pay to the seller upon recovery. Although the bonus and royalty are often used separately, it is also common in oil and gas leasing to charge both a bonus and a royalty with the bonus being the object of the auction and the royalty set at a specified level. Since the bonus and the royalty are used as partial payment for the same object it would be expected that their ultimate magnitudes would be inversely related. The higher the royalty rate specified in the lease the lower the expected bonus bid, other factors held equal.

The primary difference between the bonus and the royalty as objects of the bidding are in the timing of payments and the sharing of risk. Payments under a bonus scheme are made in full at the time of sale. Royalty payments, on the other hand, are made only when and if actual

recovery takes place.

When the bonus is the exclusive method of payment, the buyer assumes the risk of finding no recoverable deposits. Under this scheme the seller is paid the same amount regardless of whether oil or gas are discovered. The buyer, on the other hand, may pay the bonus and find no recoverable deposits, The buyer, under a royalty payment, bears less "dry hole" risk. If deposits are not discovered the buyer has still lost the cost of exploration but has paid nothing for the lease. A royalty is often seen as a way to shift the dry hole risk to the seller but seller risk is defined differently than buyer risk. The risk to the seller with a royalty is that no payment will be received on an unproductive lease where a bonus payment would yield revenues. The most common case is a bonus bid with a specified royalty which, in effect, shares the risk between the two parties, the actual share borne by each determined by the relative size of the two payments.

The concepts of risk and the timing of payments would be expected to be important determinants of auction behavior because of the risk aversion and time preference of the parties to a lease agreement. This will be discussed in greater detail in chapter four.

Two other methods of payment or objects of bidding are based on profits and known as profit-share and full-share. In a profit share agreement a bidder decides on a share of any positive profits made as a result of development of the resource that will be relinquished to the seller. The profit share can be the object of the bidding or a method of payment in addition to a bonus when the bonus is the object of bidding. A full-share payment scheme, on the other hand, does not restrict the sellers liability for losses in development. In a full-share

agreement the seller is liable for a share of the losses if a tract proves not to contain mineral deposits. In the profit-share case, the seller bears none of the risk of dry holes.

As with the choice of auction method, the choice of payment may also be expected to influence some aspects of performance. Robinson (1984), Reece (1978b) and Leland (1978) explore the effects of alternative payment structures on such measures of performance as revenues to the seller and expected price.

Besides the method and object of bidding there are several other factors that can distinguish one auction process from another. In some auction markets a minimum number of bidders may be specified; that is, an object will not be sold unless a certain number of bids is entered. The seller may also specify a minimum acceptable price for the object to be auctioned. This is referred to as a reservation price and represents the value of the object to the seller. Robinson (1984) investigates the effect of the choice of a reservation price on some aspects of auction performance.

In addition to the actual auction process, the institutional structure of the sale is further defined by specific terms set forth in the lease. These terms may specify regulations applying to development of a lease or additional payments that must be made to the seller. Many leases require an annual rental payment in addition to the bonus or royalty, this is usually a charge per surface acre per year over the specified term. The term, or the amount of time for which the lease is in effect, is also specified as part of the conditions of sale. In addition provisions are usually made for the assignment of a lease to another party and for extensions of the initial term under certain

conditions. Finally a lease will specify the activities that can take place during the exploration and development process on the site. Differences in specific terms may also affect the performance of the auction system in terms of how the resource is developed, who obtains the rights and how the proceeds are distributed between the buyers and the seller.

Participant Conduct: Individual and group behavior provide the link between institutional structure and market performance. Knowledge of how economic actors will behave when confronted with the incentives and penalties dictated by institutional structure is essential to the accurate prediction of performance. The behavioral models of economics generally assume that individual behavior is both purposive and rational, that is that individuals act with some purpose and that they do so in a rational manner. These assumptions imply that the economically rational man chooses so as to maximize an objective function such as profit or utility. Furthermore these models assume perfect information and the cognitive abilities to determine the maximizing, or rational, course of action.[2]

Markets in oil and gas leases are characterized by uncertainty which makes rational behavior, in the sense described above, impossible. If accurate predictions of performance in these markets are to be made, an understanding of behavior with less than perfect information and limited cognitive resources must be considered. The expected utility

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[2] For a discussion of the neoclassical theory of economic behavior see a good text in microeconomic theory such as Deaton and Muellbauer (1980).

hypothesis (EUH) has been used to create a model of rational decision making under uncertainty that has gained wide acceptance in economics and has been applied frequently to oil and gas markets. Simon (1978) and others have proposed models of the decision making process when faced with uncertainty and limited cognitive abilities. Both of these types of models will be considered in this study.

Besides the uncertainty faced by participants in the oil and gas market there is another violation of the assumptions of the perfectly competitive model that bears consideration in this study. It is generally assumed that markets are competitive in nature and that the actions of one player do not affect those of another. Because of the limited number of participants in the market for oil and gas leases and the heterogeneity of the leases these markets are often seen as oligopsonys, that is a market with a small number of buyers. In this case the behavior of other bidders must be accounted for when deciding on a course of action, decisions are not independent. Game theoretic models have been developed for such situations and have been widely applied to oil and gas markets.

Theories that describe both bidding and development behavior will be important to the determination of performance in oil and gas leasing markets. Because of the importance and the complexity of the behavioral component of the SSCP paradigm for this study it has only been introduced here and will be developed in more detail in chapter three.

Leasing Performance: The ultimate goal in the design of leasing institutions is the attainment of program objectives, the performance of the program. Performance has many aspects, however, and it must be decided

how it is to be measured so that real changes can be observed and hypotheses tested. Performance can be measured in terms of normative concepts such as economic efficiency or in the more substantive terms of who gets what. The focus of this study will be on substantive performance. Efficiency in the context of the economics of production and consumption implies equality between marginal conditions and price ratios for input allocation, product mix and consumption.[3] Efficiency so defined depends on the status quo and says little about substantive performance.

The substantial literature on auction theory deals with performance primarily from the standpoint of revenue to the seller and the capture of economic rent. The distribution of leases among buyers, however, has generally received very little attention in this literature. Questions of distribution do not address final impacts but are related to larger issues of performance that may arise from different distributional patterns. It is conceivable, for instance, that the way in which leases are allocated among different types of buyers will affect such variables as the development of the lease or employment in the region of development. Furthermore the fact that these are public rights being transferred may lend added importance to the distributional issues. Public ownership may be used to justify certain distributional goals, for instance ensuring that Michigan based developers receive a specified share of the offered leases.

From the seller's perspective a relevant measure of the performance of auction alternatives is the capture of the economic rent associated

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[3] For a good discussion of the conditions of efficiency applied to resource economics see Randall (1981), Chapter 6.

with the oil and gas resource. Economic rent is defined as the surplus paid to a factor of production exceeding the minimum amount necessary to call forth its services. This surplus results from supply inelasticity. If supply were elastic surpluses would bring about increases in supply until demand and supply were equated. Land, or exhaustable natural resources, are prime examples of perfectly inelastic goods. In the literature, economic rent is often discussed in terms of land rents.

The concept of economic rent can also be applied to oil and gas resources and would consist of any revenues from the lease that exceeded the amount necessary to produce and market the oil. Costs of exploration, development, risk bearing and a return to the developer on invested capital would be subtracted from revenues to determine rent.

Howe (1979) explains economic rent in oil and gas markets as arising from differences in recovery costs of deposits. Demand may be sufficient to support the development of deposits with varying quality or recovery costs. With certainty, the least expensive deposits will be the first to be developed with more expensive ones following. In this model the price of oil is the cost of recovery from the marginal deposit, that is the one with the highest recovery cost. Developers of intra-marginal deposits earn economic rent because development costs are below price.

Perhaps a more significant source of rents in oil and gas markets arises from uncertainty. When deposit existance, size, quality and recovery costs are unknown a developer may pay less for a lease than it is ultimately worth and hence earn positive economic rent. If lease value were known, competition among buyers would eliminate rent on each lease. The problem in institutional design for leasing under conditions

of uncertainty is to extract the economic rent in spite of the uncertainty as to its magnitude.

The emphasis of this study is on performance in terms of the capture of economic rent by the seller and the possible effects of the distribution of leases among different types of buyers on other objectives of the state leasing program. Some attention will also be directed to the impacts on development of various leasing institutions.

Specifics of the Leasing Procedure in Michigan

The SSCP paradigm has been described in terms of the oil and gas lease market in general but the issues discussed are relevant to the more specific problem of the leasing of Michigan state lands for hydrocarbon development. The market in the State of Michigan is unique in a number of ways and these specifics need to be understood in the context of the paradigm used in this study.

Oil and gas in Michigan are found in relatively small deposits, effectively increasing the difficulty of locating and developing the resource. The size of a deposit will, to a large degree, determine the revenues generated from a producing well. Smaller deposits generally increase the risk faced by developers and imply that successful wells will yield a smaller profit than would be the case when deposit size is larger.

Oil and gas have been produced in Michigan for almost 100 years and have been part of a significant industry in the state since 1925, (Patric and Kakela, 1982b). The information in Table 2-1 illustrates the historic development of the oil and gas industry in the state for

Table 2-1

Oil and Gas Production on State Lands

Years	Oil Production (barrels)	Gas Production (1,000) cubic ft.	Acreage Under Lease
1927-1931	555,101	----------	----------
1932-1936	1,665,578	220,620	27,120
1937-1941	9,810,671	732,423	160,473
1942-1946	8,270,928	2,315,755	291,644
1947-1951	5,277,096	5,085,920	446,021
1952-1956	7,272,536	5,161,244	933,531
1957-1961	4,543,205	8,354,698	264,725
1962-1966	3,146,716	6,974,406	438,539
1967-1971	5,337,231	6,497,155	284,651
1972-1976	21,324,223	91,132,019	1,563,465
1977	8,980,542	33,329,183	1,643,488
1978	7,936,277	41,310,258	1,535,088
1979	9,228,560	37,898,681	1,666,320
1980-10/1	1,185,380	29,786,521	1,584,850
10/1/80-10/1/81	8,229,847	39,188,686	1,707,986
10/1/81-10/1/82	8,450,258	32,296,848	1,888,286
10/1/82-10/1/83	8,901,078	18,298,733	1,841,761
10/1/83-10/1/84	8,488,415	39,343,217	1,693,189
Totals	128,674,097	397,926,372	

Source: Unpublished figures collected by
Michigan Department of Natural Resources

state lands. Referring to the map of Figure 2-2, the first phase of development was primarily in the Michigan Basin which covers the center of the lower peninsula but in recent years the primary producing area has become the Salina Niagaran trend which in 1980 yielded 73% of the state's oil and 85% of the natural gas. The Salina Niagaran trend, which runs northeast across the northern lower peninsula, is thought to have reached its production peak and some interest has shifted to the application of new extraction technologies in previously abandoned

fields. In 1980, however, a large natural gas find was located in what is known as the Mid-Michigan Gravity High which is a formation at almost the 11,000 foot depth that runs from south of Detroit to the Traverse City area. This find generated a great deal of interest and prompted speculation about a major resurgence in the industry as the "deep play" was explored. Drilling wells to this depth, the current average is around 5,000 feet, is very costly an d if this signals a new stage in exploration and development the cost of discovery and extraction in the state could rise significantly. Figure 2-3 illustrates the location of oil and gas fields relative to land under state jurisdiction.

There are currently approximately 491 companies or individuals that are active producers of oil or gas in Michigan although an average lease sale draws thirty to fifty participants. Developers range from private individuals and small local firms to representatives of the major oil companies. In a recent sale held in December of 1984, for instance, there were 75 registered bidders 55 of which were from Michigan. Also among the bidders were representatives of major out of state oil companies such as Shell, Amoco and Atlantic Richfield. It might be expected that the ability to obtain a lease would differ among these various types of bidders and leasing institutions will need to account for this if allocation is important to the performance of the leasing program.

The Auction System in Michigan: The State of Michigan currently conducts two or three sales of oil and gas leases annually with the tracts offered chosen from lands nominated by the industry. At the present there exists a large backlog of nominations that were not offered at the time they were nominated. Some of these backlogged tracts may be so old that

Figure 2-1

Oil and Gas Producing Areas in Michigan

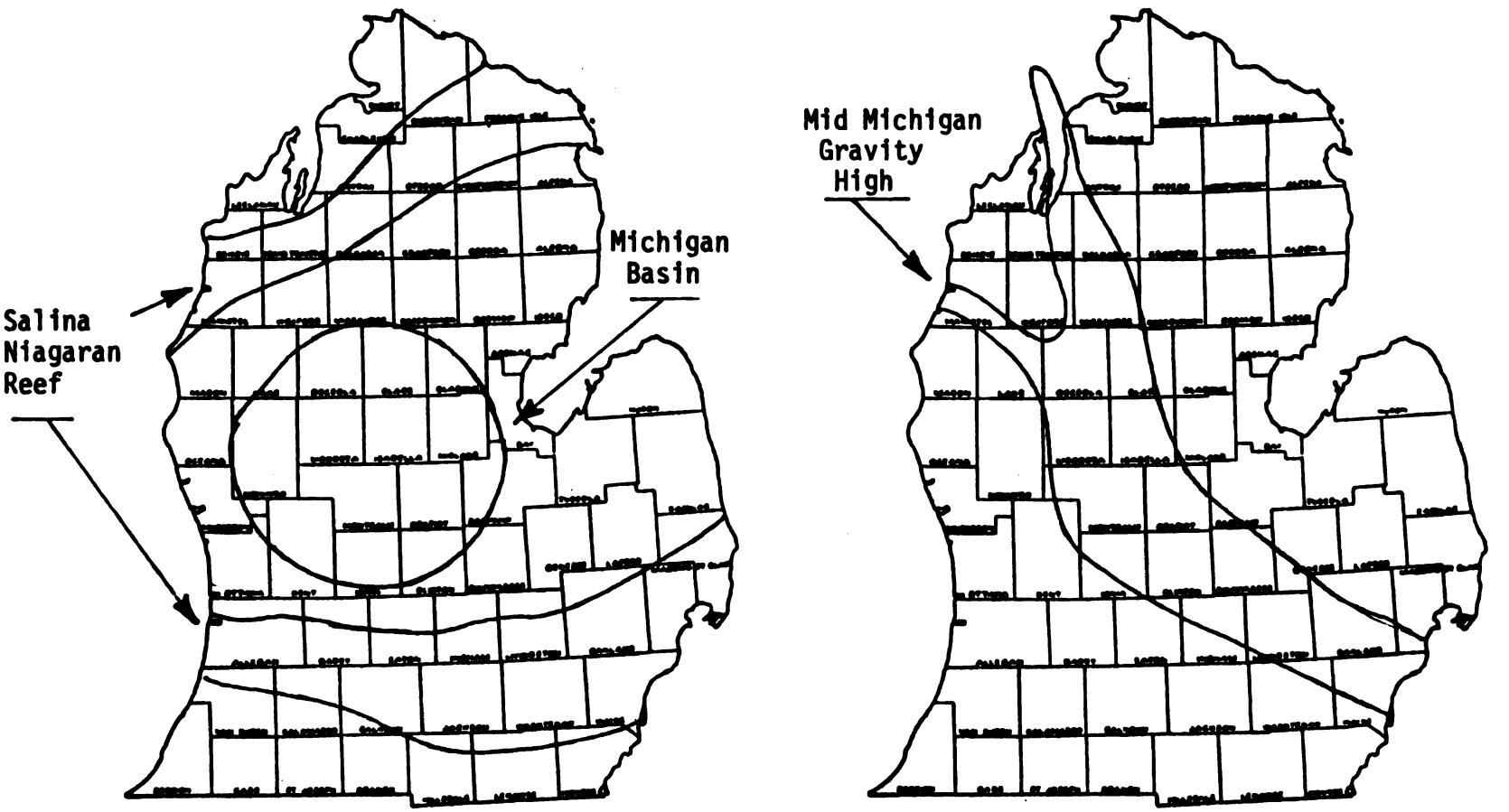

Figure 2-2

State Lands and Oil and Gas Fields --
Michigan's Lower Peninsula

there is no longer development interest in them and the previously interested parties may have nominated additional land. The offering of leases for which there is no longer interest increases the number of leases offered at a sale and results in many tracts receiving no bids. When the backlog is worked through, it would be expected that the number of acres offered would be reduced and the percentage of tracts receiving bids in a sale will increase.

In order to avoid, or at least decrease, the problem of several developers drilling the same structure and the attendent common property related problems the state requires that drilling take place only on drilling units of specified size. Drilling units are usually 40 or 80 acres but may be as large as 640 acres (Patric and Kakela, 1982c). The size of drilling unit required depends on the geological conditions in the area leased.

Lands nominated by the oil and gas industry are reviewed by the DNR in order to determine whether they will be offered for sale and if so under what conditions. The state distinguishes between development and non-development leases, the former are those that allow exploration and development activities on the surface of the land area covered by the lease. Non-development leases, on the other hand, restrict these activities because of environmental or other concerns. Leases are classified as non-development if they fall within parks, state forest campgrounds, natural or wilderness areas or areas with unusual natural or recreational values where these would be disturbed by oil and gas development. Non-development leases are often purchased to fill out a drilling unit or because they can be developed by drilling at an angle from adjacent lands. The Commission can be petitioned to change the classification of a non-development lease and, based on a field review

and information provided by the applicant, may reclassify the lease if it is determined that the non-development classification is no longer applicable.

Once the DNR has determined which lands will be offered for lease, the proposals are published and interested parties will be allowed to contest leases and classifications before the Natural Resources Commission. The Commission reviews any contentions of the proposed classifications and may require that they be changed. A list of the tracts finally determined to be leasable is then published prior to the sale so that parties interested in acquiring a lease are aware of the offering at the sale.

Lease sales in Michigan are held by oral English auction. That is, bids are elicited orally in an ascending fashion and the winning bidder pays the amount of his bid. The object of the bidding is a bonus with the royalty specified in the terms of the lease. Professional auctioneers are hired by the state and, starting at the reservation price of ten dollars per acre, they elicit progressively higher bids until only one bidder remains. If there are no bidders willing to offer the reservation price the tract is not sold.

The ten dollar reservation price represents a recent change in leasing policy. Until 1983 the state had a reservation price of two dollars per acre with a minimum of three bidders required in order for a lease to be sold. It was found that bidders would immediately offer two and then three dollars leaving a third bidder to decide, at a price of four dollars, whether to continue the bidding. This amounted, in practice, to a reservation price of four dollars and no restriction on the minimum number of bidders. The minimum was instituted because it was thought that it would ensure competition for the lease but in practice

it did nothing to affect competitive behavior. Because of the ineffectiveness of this policy, it was changed to the current reservation price with no minimum bidder requirement.

The Commission reserves the right to refuse any bid and states a number of reasons for doing so. Bids may be refused because a bidder has failed to maintain good credit by failing to pay the total amount of the bid at the time of sale, is in violation of rules or terms on a previously purchased lease or for any other stated reason. The Commission also has the power to authorize alternative auction methods.

In addition to auctions, the Commission is authorized to enter into directly negotiated sales under certain conditions and for certain lands. Direct sales are the result of negotiation between the state and a buyer and do not require the presence of other prospective buyers. Direct sales are authorized in order to complete a drilling unit, on lands previously offered but not leased at two previous lease sales within a one year period, or on lands on which it is suspected that drainage is occurring. Direct leases may not provide for less than the standard royalty or rental rates and may not have a term longer than those offered at public sales.

The lease specifies further conditions of the sale and reimbursement to the state for oil and gas recovered. The lease currently in use in Michigan specifies a term of seven years during which oil and gas must be found if the lease is not to revert to the state. If oil and gas are found within the seven year period the lease extends for as long as oil or gas are recovered in paying quantities. The lease specifies a royalty rate of 16.66% (1/6) of the wellhead value of oil or gas produced. Beginning in the third year of the lease term a rental of two dollars per acre will be required. Once a producing well of oil or gas

is established the rental is no longer required.

In order to ensure compliance with these terms the state requires a performance bond of each leasee, the amount of which is determined by a schedule. Subject to the approval of the Commission, any lease may be assigned to another person.

The term of the lease may be extended beyond the initial seven year period provided that the extension is determined by the Commission to be in the best interests of the state. Extensions may be for a period of one year only and if additional extension is requested it must be on an annual basis. Rental rates on extensions will be three dollars for the first year and increase by one dollar for every additional year.

Michigan Leasing Objectives: The specific objectives of the leasing program are stated as being, (1) optimum economic return to the state, (2) competition for the acquisition for leases, (3) protection against drainage of hydrocarbons, and (4) protection of the environmental, recreational and other uses of the land. These stated objectives are too vague to be meaningful measures of performance and, it seems, confuse intermediate objectives with ultimate goals in some cases. Discussions with managers of the state leasing program have refined these objectives and turned up other concerns that will be reflected in the measures of performance used in this study.

The concern with an optimum economic return to the state is primarily aimed at the concept of economic rent or a "fair" price for the lease. Auction models generally imply that competition is a necessary condition for the capture of the full economic rent and the concerns of the DNR in this area again seem motivated by the concept of a fair price. One component of performance that will be used in this

study will be the capture of economic rent. Due to difficulty in the measurement of economic rent, the analysis of this component of performance will rely on theoretical models in describing the link between institutional structure and rent capture given the situation in Michigan.

The orderly development of hydrocarbon resources is also listed as a concern in the design of leasing policy in Michigan and, coupled with a stated mission of stewardship of public resources, this seems to imply a concern for non-wasteful development practices. Another area of focus for this study is on the effects of alternative institutional structures on the pattern of development of publicly owned oil resources.

Michigan relies very heavily on the automobile industry and during the recent recession high unemployment in the state caused financial hardship for the state and fostered concern for a broader industrial base that would be less vulnerable to fluctuations in a single industry. With the total value of oil and gas recovered in the state in 1980 listed at 1.5 billion and the level of drilling activity rising, oil and gas development is big business in Michigan and is an important aspect of the state economy (Patric and Kakela, 1982b). Oil and gas activities brought around $494 million to the state in 1984 in the form of bonus payments, royalties and severance taxes. Besides the revenue to the state generated by oil and gas activity there are also employment opportunities to be considered. It is estimated that approximately 21,000 individuals in Michigan depend on the oil and gas industry for their livelihood.[4] It is conceivable that the allocation of leases between

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[4] "Michigan's Oil Exploration-Production Industry at a Glance", Michigan's Oil and Gas News, May 24, 1985, pp. 24

different types of firms, local as opposed to national or international, may affect the employment of Michigan residents in the industry and the tax revenue and other benefits to the state. While this study will not directly estimate the impacts of various ownership patterns on employment, state income or other factors it will describe some of the possible allocative consequences of alternative leasing institutions in the event that these factors are found to contribute to state performance objectives.

Summary

The SSCP paradigm provides a framework within which to explore how rules, or institutional structure, affect individual choice and how this, in turn, affects substantive performance. The choice of institutional structure is the choice of how property rights are to be assigned given the interdependence between individuals dictated by the characteristics of the good and existing technology. Individual behavior in response to the property rights, incentives and penalties imposed by the structure of institutions dictates the performance of the system in terms of who gets what.

Oil and gas lease markets are characterized by uncertainty as to the value of resources. Because of this uncertainty rights to these resources are allocated using an auction method. This study will investigate how various auction alternatives allocate property rights and what sort of substantive performance results. Measures of performance will be linked to state objectives in leasing oil and gas resources and will focus on rent capture and distributional issues. Although the allocation of leases among bidders is not a direct measure of

performance, it is possible that this distribution may be important to some objectives of the state in leasing or may be politically desirable.

Chapter Three

Theories of Behavior Under Uncertainty

In economics assumptions are made in order to simplify analysis and yield tractable mathematical models that economists often rely upon for prediction.[1] Assumptions, by necessity, abstract from reality and it must be determined in each case whether the usual assumptions can be applied without seriously affecting predictions. One of the common assumptions in economic models is that economic actors possess perfect knowledge. In some cases, however, the very fact that economic agents do not know all suggests very different behavior from that implied by the general model. If meaningful predictions are to be made in such situations we must be able to describe how the presence of uncertainty affects the behavior of the economic decision maker and how, in turn, this affects the performance of the system.

The development of oil and gas resources is inherently a very risky venture. The uncertainty involved is greater than in many other economic activities and has been instrumental in shaping the institutions that deal with oil and gas development. The objective of this study is to describe the consequences of alternative auctioning institutions and lease terms in a situation characterized by uncertainty. Because of this uncertainty we can not rely on theories based on the

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[1] A more complete coverage of assumptions in economics can be found in a microeconomic text such as Leftwich (1976).

assumption of perfect knowledge and must explore alternatives that can explain behavior under conditions of uncertainty. The purpose of this chapter is to present two theories of behavior under uncertainty that will be useful in evaluating the performance of alternative structural forms for the allocation of oil and gas resources.

There are two primary theories of behavior in the face of uncertainty that merit discussion in the context of this study, the Expected Utility Hypothesis (EUH) and what will be referred to as the Behavioralist Approach. These two theories make very different assumptions about the rationality or the cognitive abilities of economic actors but they can both contribute to an understanding of how decisions are made when uncertainty exists.

Risk and Uncertainty

Decision making under uncertainty is often seen as a problem of deciding on a course of action when the consequences of the action are unknown. The payoff, or consequence, of a particular course of action will depend on the value of a random variable which is unknown at the time of the decision. This random variable is known as the state of the world and is defined to include all variables that will affect the value of the payoff. Since this value depends on the value of a random variable the payoff is itself a random variable. Formally stated, the problem for the decision maker is to choose a course of action when the payoff is an unknown random variable depending on the state of the world. Of course the decision maker may have knowledge of the

probabilities of occurrence of the random variable and this fact can be used to define two distinct cases.

Knight (1921) makes a distinction between the concepts of risk and uncertainty, defining the latter as the case where the decision maker has no knowledge of the probabilities of occurrence of the random variable. In the case of risk, however, this knowledge is assumed. Knowledge of the probability distribution for the state of the world implies knowledge of the probability distribution of payoffs as long as the state of the world is defined as above to include all elements of uncertainty. The amount or type of knowledge possessed by the decision maker would be expected to influence his behavior when faced with a situation involving uncertain outcomes.

Ramsey (1980) dismisses the distinction made by Knight as one that is irrelevant in most practical problems with the justification that neither case is likely to occur. The most common case, according to Ramsey, is one in which the decision maker has some knowledge of the form of the probability distribution and can use this, along with information from sampling, to estimate its unknown parameters. This view emphasizes the importance of gathering information for the purpose of estimation. A decision maker would also be expected to revise his estimates over time as he learned more about the importance of various sources of information and the suspected form of the probability distribution. In light of this discussion Ramsey proposes to use the terms risk and uncertainty interchangeably which is how they will be used in the remainder of this paper.

The Expected Utility Hypothesis

More is needed to determine behavior under uncertain conditions than what is given above. The general model of uncertainty puts the economic decision maker in the position of choosing a course of action when the payoff is a random variable. Predicting behavior requires that the decision rule be known. In standard economic theory, assuming certainty, the rational decision maker is a maximizer. That is, he makes decisions so as to maximize an objective function such as profit or utility. The decision rule is to make decisions consistent with this objective. In the case of uncertainty, maximization of utility or profit is no longer a feasible decision rule as it is not known what action will produce the maximizing outcome. The problem facing economists is to determine a decision rule for the case of uncertainty that yields results consistent with observed behavior.

Historically economic actors were thought to maximize expected income when faced with uncertainty as to the outcomes of their actions, this expectation being the mathematical expectation over all possible values of the random variable, the state of the world. This sort of decision rule, however, led to predictions of human behavior that were at odds with empirical observation. Perhaps the most famous contradiction was the St. Petersburg paradox addressed by Bernoulli (1738). In this example an individual is unwilling to pay a large sum to play a game with an infinite expectation. In an attempt to explain this paradox Bernoulli introduces the concept of utility and hypothesizes that individuals make decisions based not on money but on the utility that they can obtain from it.

> "...in their theory mathematicians evaluate money in proportion to its quantity while, in practice, people with common sense evaluate money in proportion to the utility they can obtain from it." (Bernoulli, 1738, pp. 33)

Bernoulli goes on to propose a decision rule stating that individuals act so as to maximize the expectation of utility rather than income or profit. Although Bernoulli recognizes that individuals will exhibit different reactions towards risky prospects he falls back on a belief in the diminishing marginal utility of money to support his claim. According to Bernoulli the reaction to a risky prospect will depend on the initial wealth of the individual although no rational individual will ever accept a fair gamble, this latter point being a consequence of a belief in the concept of the diminishing marginal utility of money.

While Bernoulli's theory seemed to be a start towards an understanding of human behavior in risky situations it was not accepted by many economists because it was not able to explain riskless choices. If the concept of diminishing marginal utility of money is accepted, then a decision rule of expected utility maximization restricts rational individuals to never accepting a fair game, an obvious contradiction to observed behavior such as gambling. Von Neumann and Morgenstern (1947) and Friedman and Savage (1948) among others have pointed out that the concept of a cardinal utility measure such as that of diminishing marginal utility is not necessary to explain riskless choices. With an ordinal concept of utility, a decision rule of expected utility maximization can be consistent with behavior in riskless, as well as risky, situations.

With diminishing marginal utility no longer necessary it is not required to restrict study to the class of utility curves that Bernoulli discussed, namely concave utility functions. Without this restriction

there are three cases that can be explored -- risk aversion, risk neutrality and risk loving behavior. Individual reactions to risk can be explained in terms of the shape of the individual utility curve rather than initial wealth. Concave utility functions correspond to the case discussed by Bernoulli and would indicate a risk averse individual, one who would not accept a fair gamble. A risk averse individual would have to be paid in order to accept a fair gamble, the amount determined by the degree of risk aversion. To this person there is a cost associated with bearing risk. A risk loving individual, on the other hand, gains some utility from risk and will accept an unfair gamble without payment, again the gambles that he will accept are restricted by the degree of risk loving. The third type of individual will accept a fair gamble, and any that are better than fair. In other words, gambles are evaluated on their mathematical expectation. The last two cases describe convex and linear utility functions respectively. Arrow (1971) and Pratt (1964) developed a measure of risk aversion, that is essentially a measure of the concavity of the utility function, that can be used to measure the cost of risk to an individual with a given utility function.

Very simply the Expected Utility Hypothesis can be stated as a decision rule that has individuals making decisions so as to maximize expected utility. Each person's behavior, given this theory, will depend on the shape of their personal utility function. Bearing risk imposes a cost on some individuals and increases utility for others depending again on their personal utility function.

The Behavioralist Approach

The Expected Utility Hypothesis described above is one way that economists deal with decision making under uncertainty but there are some who would disagree with the basic behavioral assumptions implied by this theory. Specifically the EUH assumes that individuals exhibit "rational" behavior, that is that people will always choose correctly, from all possible courses of action, the action that is best in accordance with their objectives. One of the advantages of a decision rule of rationality is that it serves to narrow the range of behavioral alternatives that must be considered and yields tractable solutions to problems of predicting behavior. If rationality is assumed, then behavior, given the individuals' objectives, is determined entirely by the environment in which an individual finds himself. There may, however, be other factors that influence behavior that are ignored under a theory that assumes rationality and the predictions of such a theory under such conditions could be incorrect.

The behavioralist viewpoint is that individuals do not always act rationally, in the sense implied by economic theory, because of cognitive and informational limitations. Rational behavior requires that the individual be able to use all the relevant information at his disposal and to accurately evaluate, and be aware of, all possible courses of action. The proponents of the behavioralist theory would state that this is next to impossible in all but the simplest of situations. The complexity of the environment in which we make decisions is such that we can not evaluate our actions in a manner consistent with rational behavior. Simon (1957) proposes a theory of satisficing rather than

optimizing behavior as a decision rule that is more consistent with the actual decision making process. Individuals act not in a rational manner but in accordance with "bounded rationality", or what Simon refers to as subjective, as opposed to objective, rationality. Subjective rationality is rational behavior given the cognitive and perceptual limitations of the individual whereas objective rationality is rational behavior as described in the standard economic theory.

The basic tenet of Simon's satisficing theory is that the complexity of the environment necessitates methods of simplification for the purpose of decision making. To better predict human behavior we must have a better understanding of the manner in which individuals make these simplifications. It might be expected that the simplification mechanisms employed by the individual will depend on the persons' objectives, their cognitive abilities and on their perceptions of the environment. The view of the satisficing theory is that behavior is related to the concepts of perception and cognition rather than to a universal decision rule of rationality.

Simon (1979) develops an outline of individual satisficing behavior as follows. An individual faced with making a decision engages first in a process of search for a course of action consistent with his objectives. The first step in the simplification process is the use of Standard Operating Procedures (SOP's) by which the individual limits the portion of the problem space in which alternative courses of action are sought. SOP's are developed over time through a learning process as different areas of the problem space are found to yield more profitable actions in certain situations. In this sense, SOP's are a product of past experience and are subject to alteration as the individual more

clearly defines the situations in which different SOP's seem to result in satisfactory outcomes. SOP's can also become obsolete as the environment in which they are used changes.

As stated above, SOP's serve to narrow the area of search for alternative courses of action but rarely will this result in but one choice. After reducing the set of alternatives the individual must still search for a course of action. Search is not a costless process, however, and the individual must decide when to terminate the search process and proceed with a chosen course of action. The theory of satisficing suggests that search proceeds until a course of action is found that yields a satisfactory outcome, an optimal outcome being unknown in the face of uncertainty and cognitive limitations. The decision to terminate search is made not on the basis of a comparison of marginal costs and benefits of continuation but on the discovery of a choice that is satisfactory in the view of the decision maker.

While this presents a general model of choice it leaves many questions unanswered as to how SOP's are arrived at and what sort of simplifications are employed by individuals in an attempt to reduce a decision problem to manageable decision proportions. Tversky and Kahneman (1974) provide some interesting insights on how people may arrive at systematically biased perceptions of probabilities. This paper hypothesizes that individuals employ heuristics to estimate the probabilities of occurrence of an event. Heuristics serve to reduce the complexity of calculating estimates but the type of heuristic used can lead to systematic bias in the estimates. The authors tested the hypothesis in a laboratory setting and found that people did seem to ignore some important information and rely on heuristics when

formulating probability estimates. This finding would seem to support a belief that people do not act rationally because of the complexities involved in such behavior.

The decision of whether to buy insurance is a well used example of decision making under uncertainty. A person must decide whether to insure against a loss before it has occurred with no assurance that it ever will. The assumptions of the expected utility hypothesis have been used to derive many predictions of how the rational person would act when considering the purchase of insurance. Kunreuther and Slovic (1978) argue that the empirical evidence of behavior is not consistent with the predictions of utility analysis and we must look instead at the psychological, economic and environmental factors that influence the purchase of insurance. The authors make a study of the market for flood insurance and reach some interesting conclusions concerning the perception of probabilities. They conclude from the study that people ignore low probability events because of a "finite reservoir of concern". If people concern themselves with all possibilities they would have too much to worry about. It was also found that the way in which a probability was stated would make a difference in the way in which people reacted to it. The bottom line of this study is that people do not act rationally because of limited abilities to correctly perceive probabilities or to be aware of all possible threats or even of the conditions of insurance. Generally people do not make decisions from a position of perfect knowledge nor do they act "rationally" in the objective sense because they perceive probabilities incorrectly.

The Modeling of Auction Markets

Auctions are often used when the value of the object for sale is unknown and hence the calculation of a bid involves making a decision with incomplete information. Attempts to model the behavior of auction participants have drawn from both utility analysis and from game theory models to explain decision making under these conditions. Whether an auction market is modeled using a game theoretic or a decision theoretic utility analysis approach will depend on the nature of the interaction between market participants and the structure of the market. Gilley and Karels (1981) claim that the two methods, if correctly specified, yield generally the same qualitative predictions of bidding behavior.

The decision theoretic approach assumes that bidders act so as to maximize the expected value of utility defined over net worth. Pre-sale utility for a bidder will be U(w) where U(.) is the bidder's utility index and w is net worth. If a bidder wins a lease with value v and pays a price of p then the level of utility after winning the lease will be U(w+v-p). If a non-winning bid is entered the level of utility will be the same as before the sale if it is assumed that there are no bid preparation costs. The bidder chooses p, the bid price, so as to maximize the objective function, the expected value of the utility function defined over net worth. The expectation of utility is taken with respect to lease values, given the distribution of these values conditional on the bidders information about the lease and the distribution of maximum losing bids by competitors, which is a function of the number of bidders. Information about lease values is assumed to be obtained through independent random sampling. Each bidder is usually assumed to

have access to the same information and each bidder's valuation is assumed drawn from the same distribution of lease values.

The game theoretic approach searches for a Nash equilibrium bidding strategy in which a firm's bidding strategy maximizes expected profit given the bidding strategies of other firms. It is characteristic of a Nash equilibrium that no firm can increase profits by changing its strategy unless at least one other firm does the same. Strategies in this formulation of the problem are bid amounts.

As Ramsey (1980) points out, the game theoretic approach yields not only the optimal decisions for each player but also the outcome of the game. The decision theoretic approach, on the other hand, while it derives optimal decisions for each player, says nothing about market outcomes. The decision theoretic approach yields the form of the market supply and demand curves to which a traditional equilibrium analysis can then be applied.

The choice of a theoretical approach to modeling bidding behavior will depend on the structure of the market and the interactions among participants as well as the ease of application of the model. In oil lease markets, and particularly offshore markets, the supply side is dominated by the government as the sole supplier of leases while the demand side is seen as a competitive market. For onshore leases in Michigan a substantial number of leases are offered by the private sector and there is probably more competition for leases than in the offshore markets. If it can be reasonably assumed that the demand side of the market is competitive, the actions of one actor do not affect others and a decision theoretic approach is appropriate. If, on the other hand, the interaction between actors is thought to be important a

game theoretic approach may be easier to apply.

Applications to Decision Making in Oil and Gas Leasing

Two very different theories of decision making under uncertain conditions have been presented in this chapter, as well as an application to a specific decision setting, auction markets. The following chapter will contain a much more in depth review of current models of auction behavior and will use these models to compare alternative institutional structures for the leasing of oil and gas rights.

While the two theories of behavior presented in this chapter are very different in their assumptions about cognitive abilities and actual decision processes, they both contain ideas that can be helpful in understanding the effects of uncertainty on oil and gas lease sales. When participating in a sale a prospective buyer must decide how much to offer for a lease of unknown value. Decisions are made subject to the information available at the time and the ability to process that information. The type of information that a prospective buyer possesses may be used to divide the decision making process into two distinct parts in which different decision processes may be used.

Before the sale, interested parties nominate tracts that they are interested in purchasing. This interest implies some level of information concerning the relative value of the tract. At this stage tract value information can be obtained from seismic tests that detect certain geological structures beneath the surface or through observation of adjacent tracts that may already have been leased and developed.

Exploration by seismic testing is far from an exact science but these tests do provide some information about the prospects on a tract. With experience firms have developed probability distributions for the existence of oil or gas given certain types of geological formations found by seismic means. If a firm can determine, before the sale, the probability of finding oil or gas then some sort of expectation of oil or gas deposits can be formed. In preparation for the sale, a prospective buyer would use this information along with other expectations, prices, the firms attitude towards risk, etc., to arrive at a bid.[2] It seems reasonable to assume that decision making before the sale is "rational" given the knowledge and cognitive limitations of the individuals.

Before the sale there is time to collect and interpret information relevant to the purchasing decision and make the decision in as "rational" a manner as possible. There will always be limitations to the knowledge available, however, and to the ability to assimilate all the relevant information. Once the sale is underway the actual method used to make the sale may serve to transmit information. In an oral sale situation, for instance, a bidder will gain information about the number and identity of competitors for a lease and their valuations of the tract. This new information may lead to different assessments of certain leases and may alter the predetermined bidding behavior of some bidders. Since this information is gained in the process of bidding on a tract there is not time for careful calculation as to how this information alters bidding strategies and it would be expected that decisions made at this time would rely on SOP's and would not be as "rational" as

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[2] Capen, Clapp and Campbell (1971) claim that the distribution of tract value is approximately log-normal.

those made before the sale. While a decision made before the sale may be more "rational", a split second decision made in the course of bidding may be based on more information and may be a better decision despite its spontaneity. A decision maker in this situation must decide quickly on the value of information gained during bidding and how it will affect his behavior in the sale. Such spontaneous decisions may well be based on SOP's rather than being the result of the usual economic rationality.

Summary

Two quite different theories of behavior in the face of uncertainty are discussed in this chapter. The main difference between the two theories is in the degree of rationality assumed in individual behavior. While the expected utility hypothesis assumes rational behavior, the satisficing approach regards objectively rational behavior as impossible because of cognitive and informational limitations. Because of this difference in assumptions the two theories focus on different factors as the determinants of behavior. A utility analysis will be concerned with how characteristics of the environment affect behavior, which is assumed to be rational, while a satisficing analysis will focus more on the actual process by which information is perceived and used to arrive at a decision given limited cognitive abilities.

While Simon's theory that no decision making takes place under the rationality assumptions of the EUH seems very reasonable there are certain concepts from the traditional theory that will be useful in determining bidding behavior and in evaluating performance. In

particular the concepts of the cost associated with bearing risk and the dependence of this upon the level of risk aversion will be important.

Chapter Four

Bidding and Auction Theory

Starting with a seminal paper by Vickery (1961) a number of models of auctions and bidding behavior have been presented in the literature. For the most part these models have focused on describing bidder behavior in order to define an optimal auction structure from the seller's point of view, usually in terms of maximizing expected revenues (Meyerson, 1983). These models vary considerably in their assumptions concerning bidder behavior, knowledge and the interaction between participants. Some of the models are quite simple while others incorporate a variety of the complex variables that can influence auction outcomes. The purpose of this chapter will is to review the current development of the theory of auction markets so that it can later be applied to the oil and gas leasing situation in the State of Michigan.

The writers on auction theory have yet to adopt a standard terminology to describe alternative auction structures so in order to avoid confusion the definitions employed in this paper will be presented here. Ramsey (1980) makes a distinction between the competitive and discriminatory auctions based on the relationship of the winning bid to the selling price. In a competitive auction the high bid wins but pays the amount of the second highest bid while in a discriminatory auction the high bid determines the price paid by the high or winning bidder.

The definitions used by Ramsey cut across the traditional distinction between oral and sealed bid auctions, a division which he dismisses

as not theoretically useful. An oral auction is essentially a competitive auction as the winner need not bid more than a small increment above the second highest bid to win the object. A sealed bid auction, on the other hand, may be either competitive or discriminatory depending on the auction rules. The Dutch auction, used in The Netherlands for the wholesale auction of flowers, uses a descending price counter until the registered price is accepted by one bidder. While this is a discriminatory auction, it is also referred to as an oral auction as is the standard English auction which is competitive in nature. The distinction between oral and sealed bid auctions in this context is the "real time" element of the oral variety. During the course of an oral auction a bidder has the opportunity to observe the bidding behavior of other bidders and react to their bids while this is not possible in a sealed bid auction.

While Ramsey dismisses the distinction between oral and sealed bid auctions, it can be a useful distinction when some of the more complex models are considered. Some more recent work, most notably Robinson (1984) and Milgrom and Weber (1982), distinguishes between an oral, or English, auction, which is necessarily a competitive auction; a Dutch auction; and two forms of sealed bid auctions, the first and second price types corresponding to discriminatory and competitive auctions respectively. This study will follow the lead of the more recent work and distinguish between English auctions, Dutch auctions, first-price sealed-bid and second-price sealed-bid auctions with the following definitions.

An English auction is a progressive auction in which bids are openly solicited at increasing amounts until only one bidder remains who

is willing to pay the announced price. The English auction is competitive in that the winning bidder pays the amount of the second highest bid, or a small increment more. The Dutch auction is a descending auction in which the seller announces a high price that is lowered until a bidder claims the object at the stated price. The Dutch auction is discriminatory in that the winner pays the amount of his bid, that being the high, and only, bid. The first-price sealed-bid auction is one in which sealed bids are collected and opened simultaneously with the highest bidder winning and paying the amount of his bid. In the second-price sealed-bid auction the highest bidder wins the object but pays the amount of the second highest bid. The Dutch and first-price auctions have been shown to be strategically equivalent while the English and second-price auctions are also equivalent but not as strongly so (Milgrom and Weber, 1982).

A Review of the Literature

There is a considerable literature on auctions and bidding theory, the Stark and Rothkopf (1979) bibliography includes almost 500 articles and many more have been published since. The current theory has been developed for a wide variety of applications including the sale of treasury bills, the letting of procurement contracts and the leasing of mineral rights. The range of applications of the theory has led to a number of distinct models that employ different assumptions and seek to answer a variety of questions concerning auction markets. While these models differ in a number of ways perhaps the most important is in their assumptions concerning the knowledge each bidder possesses and the way

in which it is related to that of other bidders.

Much of the literature on auction theory has focused on the revenues to the seller under alternative auction methods. The usual procedure is to establish the model in terms of the characteristics of the object being sold and the assumptions concerning the bidder's knowledge and interaction. Bidders are then assumed to act rationally within the confines of the model towards the end of maximizing expected profits. In the game theoretic approach, the auction game is usually modeled as a non-cooperative game in which a Nash equilibrium is sought. Under this formulation, bidders choose strategies so that it is not possible for any bidder to gain by changing strategies given the strategies of the other players. A strategy so chosen is termed a dominant strategy. Given the equilibrium strategies resulting from rational bidder behavior, the revenues to the seller can then be calculated and compared across auction types.

Under the decision theoretic approach the profit maximizing bid of the one strategic bidder can be calculated and the expected revenue to the seller derived. The difference between this and the game theoretic approach is that a market equilibrium is not found using decision theoretic methods.

Engelbrecht-Wiggans (1980) describes a very general auction model that is essentially a game with incomplete information. In this model there is an underlying true state of nature that is defined by the characteristics of the object for sale, the number of objects being auctioned, the utility functions of the players, the number of strategic players and the behavior of the non-strategic players. A strategic player is one whose bidding strategy is not specified by the model while

the behavior of the non-strategic players is endogenous. The decision theoretic approach to auction modeling corresponds to the case of one strategic player where the bidding behavior of the non-strategic bidders is incorporated into the true state of nature through the reservation price. In the game theoretic approach, on the other hand, the number of strategic players can be any number larger than one and is occasionally modeled as random.

It is assumed that all players know the true states of nature that are possible and the probability distribution over the states but do not know which state will apply in any given situation. Each player may receive information regarding the state of nature through the observation of some random variable. In the case of oil and gas leasing this information may be the result of seismic tests or other sources of knowledge about probable tract value.

Each player chooses a bidding strategy that defines how the observed information will be used to formulate an actual bid. Strategies are assumed to be chosen before any information is actually observed, therefore the choice of strategy is independent of information. The choice of a bid, using the strategy, will depend on the strategy assumed to be employed by the other bidders. A common strategy of many models is to determine the fraction of an objects value to enter as a bid.

Finally the model contains a payoff function, known to each player, that determines to whom the object is sold and the price paid. The payoff function will depend on the player's bids, the true value of the object, the auction mechanism employed, the payment scheme and the reservation price. There may be other factors involved in the payoff function as well, including costs associated with bid preparation or

participation in the auction. Although the payoff function is assumed to be known the actual payoff may remain uncertain if the true value of the object is unknown.

The four components of the general theory presented here, players, objects, payoff functions and strategies, are further broken down into their component parts by Englebrecht-Wiggans (1980). The classification of these components serves to define a taxonomy of auction models that will be useful in the discussion of the various theories to follow. Some of the variables that will be important to this study are as follows.

1) Players:
   a.Number of strategic participants
   b.Utility functions, Linear (known), Non-linear (known), Random
2) Objects:
   a.Number of objects, known or random
   b.Information on object's value
   c.Physical characteristics of objects
   d.Type, divisible or indivisible
3) Payoff Function
   a.Award Mechanism, first-price, second-price, other
   b.Payment scheme, bonus, royalty, profit share, etc.
   c.Reservation price
   d.Other Transfers, participation costs, bid preparation costs, etc.

The Independent Private Values Model

Much of the literature on the theory of auctions analyzes the sale of a single object using the independent private values model. In this model, it is assumed that a single indivisible object is to be sold to one of a number of bidders. Each bidder is assumed to be risk neutral and knows the value of the object to himself but not to the other

bidders, hence the term private values. The values placed on the object by the bidders are assumed to be independently drawn from some continuous distribution. Furthermore bidders are assumed to behave competitively, without collusion.

In terms of the independent private values model, the Dutch and first-price auctions are strategically equivalent (Milgrom and Weber, 1982). This is intuitive in that in each auction the bidder must choose at what level to make a bid without knowledge of the actions of other bidders. In each case the bidder does not know at what level other bidders will enter bids and must make his decision in a static environment. This strategic equivalence means that the strategies chosen in the two models will be the same as will the expected revenue to the seller.

Also in the context of the independent private values model the English and second-price sealed-bid auctions are equivalent. In the setting of the English auction, the bidder must choose a price at which to stop bidding if the auction is still in progress. If the bidder knows the value of the object to himself, he will bid until the price reaches his valuation, a dominant strategy (Milgrom and Weber, 1982). This strategy is independent of the valuations of the other bidders. In the second-price sealed-bid auction, when the value of the object is known, the dominant strategy is to submit a sealed bid equal to the bidder's valuation of the object (Meyerson, 1983). In both auctions, the winning bidder will be the one who values the object most highly and he will pay the amount of the second highest bid. It is important to note that this result requires that the bidders know the valuation of the object to themselves, an assumption which is not necessary for the

equivalence of the Dutch and first-price sealed-bid auctions.

The dominant strategy in the independent private values model is for the bidder to bid his valuation of the object. In this case the bidder who places the highest value on the object will win it. The result is that the allocation of prizes in the English and second-price auctions is Pareto optimal. This result carries over to the Dutch and first-price auctions as well if the model is symmetric. Another important result of the independent private values model is that the expected revenue to the seller of the object of the auction is the same regardless of which of the four auction methods is used (Milgrom and Weber, 1982).

The Common Values Model

The assumption of the independent private values model, that bidders know their own valuation of the object of the auction, is not very realistic in the context of the auction of such objects as mineral rights. In such cases the value of the rights will depend on the actual quantity of minerals found, quality, ease of recovery and prices prevailing at the time of extraction and sale. Since these variables are unknown at the time of the sale, the value of the rights is not known with certainty. Given these uncertainties it is impossible for a bidder to know the true value of the rights at the time of the sale. The common values model assumes that the object of the auction has a common, although unknown, value to all bidders where each bidder may have a different estimate of this value. It is, of course, unlikely that an object such as mineral rights will have the same value to all bidders.

The actual value of the rights to a bidder will depend on costs that may vary among bidders as well as the possibly different utility functions of the participants. The common value assumption is, however, useful as a first approximation.

This model usually assumes that bidders make independent and unbiased estimates of the value of the object of the auction. This means that the valuation of one bidder is not related to the valuation of others and the expected value of a bid is equal to the true value of the object. Rothkopf (1969) shows that in a symmetric common values model, that is one in which all bidders have equal costs and can be considered identical, the winning bidder will be the one with the highest value estimate. The actual amount bid by this bidder will depend on the bidding strategy he chooses which is a function of the number of bidders. In this case the bidding strategy is to bid a fraction of the estimated value of the object. Wilson (1977) obtains the same strategies with the additional result that the expected selling price converges to the true value of the object as the number of bidders becomes large. The results of these two papers are valid for the first-price or Dutch auctions only.

When bidders are uncertain of their valuation of the object of the auction information becomes an important consideration. Early models made the assumption that each bidder's value estimate was based on a sample independently drawn from a common distribution that was known to all bidders. The resulting valuations were unbiased estimates of the true value of the object, implying that some estimates were higher than the actual value and some lower. In the symmetric common value model the bidder with the highest valuation will make the highest bid and win

the object (Milgrom and Weber, 1982). This formulation led to bidding strategies in which the winner was the bidder who had most overestimated the value of the object and consequently paid too much, a problem referred to as the "winner's curse" by Capen, Clapp and Campbell (1971) who find that winning bidders often pay too much for mineral rights.

Wilson (1977) points out, however, that winning an auction is, in itself, an informative event and failure to account for this source of information yields the winner's curse result with bidders making negative expected profits. Reece (1978), in the context of a first-price bonus bidding model, demonstrates that when this source of information is accounted for bidders will revise their bidding strategies and eliminate the winner's curse. Both Reece and Smith (1981) found that the winner's curse phenomenon led to non-aggressive bidding behavior where optimal bids fell as the number of bidders increased. Intuitively, if a bid wins against a large number of competitors it is more likely that the object has been overvalued. These results were further corroborated by an empirical test of offshore lease sales by Gilley and Karels (1981). In contrast to the winner's curse predictions Reece found bidders to make positive, and often large, profits over a wide range of conditions.

While the Dutch and first-price auctions are strategically equivalent in the common values model, as they were in the private values case, the English and second-price auctions are no longer so. In the common values case the English auction generally leads to higher prices (Milgrom and Weber, 1982). This result stems from the information about other bidder's valuations that a bidder can gain in the course of an oral auction. The extra information weakens the winner's curse and

leads to more aggressive bidding in the English auction. The structure of the auction can enhance or impede the transmission of information among bidders and this is the major reason why the distinction between oral and sealed bidding is a useful one.

The common values model, unlike the private values model, allows for statistical dependence among value estimates but does not provide for different valuations due to different tastes or costs. When value estimates are statistically dependent the second-price auction generates a higher average price than does the first-price auction. Milgrom and Weber (1982) rank the four auction methods in terms of expected prices with the English auction first followed by the second-price and then the Dutch and first-price auctions.

The above ordering of auction methods in terms of expected prices depends on the assumption of competitive behavior among bidders. Mead (1966) discovered evidence of collusive behavior in federal timber auctions and analyzes the effects of collusion on auction choice (Mead, 1967). Game theory would indicate that collusive behavior needs to be enforced, if a party to the collusive agreement can cheat and not be punished it will be in his best interests to do so. Collusion in auction markets will tend to lower selling prices as bidders agree not to bid against each other. The choice of auction method can facilitate the policing of collusive behavior by the bidders and, if collusion is present, can affect the level of prices received by the seller. In an oral auction bidders can observe who is bidding and can identify, and later punish, cheaters on a collusive agreement. In a sealed bid auction, on the other hand, the identity of bidders is not known and

collusive agreements will be more difficult to police.[1] Given these considerations a ranking of auction methods in terms of expected prices can be very different than that found by Milgrom and Weber (1982). Mead (1977) states that in the presence of collusion the auctions can be ranked in the reverse order, that is first-price sealed-bid followed by second-price and English auctions.

Alternative Auction Objects

The theory of auctions presented so far has been in terms of the choice of auction method but there are other factors, as well, that can influence auction outcomes. There are many methods by which payment for the object of the auction can be made and these are usually associated with the object of the auction. Some common auction objects and payment schemes used in the auction of mineral leases are the bonus, royalty, profit share and full share. There is a small, but growing, body of theory dealing with the consequences of alternative auction objects and payment schemes, most notable among the recent articles are Robinson (1984), Reece (1979) and Leland (1978).

Reece (1979) analyzes the bonus, royalty and profit-share as bidding objects, and as payment methods, in terms of a symmetric common values model. The comparison is made on the basis of expected prices. Using a decision theoretic approach he shows that the amount of rent captured by the seller is, in part, a function of the uncertainty

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[1] This result assumes a single sale, with repeated sales including the same bidders a cheater on a collusive agreement can be identified once sale results are announced and can be "punished" at a later date.

associated with the value information of the bidders. Regardless of the level of uncertainty, however, he finds that the profit-share dominates the royalty which, in turn is better than the bonus in terms of rent capture. The comparative advantage of the profit-share and royalty is found to be greater when the number of bidders is low and the uncertainty high.

Leland (1978) addresses the choice of payment form in terms of the "optimal" sharing of risk between the buyer and the seller of mineral rights and the effects on production decisions. Excessive risk aversion by development firms, when higher than the applicable social level, imposes social costs as it affects firm decision making with respect to a publicly owned resource. The optimal sharing of risk will depend on the risk aversion of both the buyer and the seller of the rights, the seller in this case being the government. The optimal sharing of risk between the buyer and the seller depends on the relationship between the measures of risk aversion of both parties. The choice of payment method can be used to adjust the share of risk borne by either party towards an optimal level. Oil and gas lease sales, however, typically involve a number of potential buyers who most likely exhibit varying degrees of risk aversion. Because of differences among buyers in their attitudes towards risk an auction that is optimal from the point of risk sharing for one buyer may provide an advantage or disadvantage in the sale for other buyers. The choice of payment method therefore is likely to benefit some buyers relative to others.

The payment forms dealt with in Leland's paper are the profit-share and the royalty. The analysis concludes that uncertain costs can not be adequately insured under a royalty payment. The firm must bear this

cost uncertainty. This non-optimal sharing of risk leads to prices that are lower than optimal. Furthermore the royalty payment leads to a host of inefficient production decisions by the firm.

The physical characteristics of oil and gas wells dictate that production costs rise as the age of the well increases. In the context of the discussion of economic rent as presented by Howe (1979), as production costs rise the amount of rent falls. At the point that rent becomes negative, that is when marginal extraction costs exceed marginal revenues, the rational developer will cease production. A roylaty payment acts as a tax, a deduction from marginal revenue. The larger the amount of the royalty the greater will be the deduction from marginal revenue and the earlier abandonment will occur. A lower royalty, or a form of payment that does not affect marginal revenues, will result in greater recovery from each well.

The profit-share payment, on the other hand, tends to share risk more effectively, leading to higher expected prices and more efficient outcomes if the bidders are more risk averse than the sellers. Furthermore, the profit-share scheme does not distort production decisions as a royalty does. The primary disadvantage of profit-share payments is the relative difficulty of effectively and accurately monitoring them. Profits are much more difficult to monitor and define than is the physical production of oil or gas that is necessary for a royalty payment determination.

Robinson (1984) notes that the most common current practice in the leasing of oil and gas rights is a bonus bid with a fixed royalty, a practice which clearly contradicts the ordering of payment methods found by Reece and Leland. To explain the use of the bonus and royalty in the

face of the current theory he introduces the concepts of monitoring costs, offer comparability and landowner risk aversion.

As Leland mentions, but dismisses as relatively unimportant given the magnitude of possible benefits, the cost of monitoring profit-share or full-share arrangements may present problems. These plans require that the seller keep track of output, prices, capital costs, operating costs and overhead. As Robinson points out under a profit-share system the developer has an incentive to shift as much cost as possible from dry holes to producing wells since he is not reimbursed for losses on dry holes. Furthermore the developer has less incentive to control costs than would be the case with either a bonus or a royalty. These problems are further exacerbated by a full-share arrangement. The problem of monitoring the developer may be greater for a private landholder than for a government body as the government could audit a firm's financial records.

Another problem is that of comparing offers if bids differ in more than one dimension. In the profit-share and full-share arrangements the costs faced by the firm will affect the ultimate rent recovered by the landowner. If firm's costs differ, perhaps because one is more efficient than another, then it will be difficult to compare bids in terms of profit shares. A high bid by an inefficient firm could result in less revenue than a lower bid from a more efficient one. Operating costs can also affect production decisions which, in turn, affect the amount recovered under a royalty system of payment. If these costs differ greatly among firms a bonus payment may be more desirable than a royalty.

Finally the risk aversion of the landowner and the bidders may

influence the choice of payment. Leland's results depend, in part, on the assumption that bidders are more risk averse than sellers. Robinson disagrees with this assumption and finds it more likely that the bidder is less risk averse. Bidders are able, through diversification and stock offerings, to spread risk among many prospects and may be less risk averse than small landowners who do not have these opportunities. This argument loses some of its validity when the seller is a government offering a large number of leases.

The analysis of Robinson, while it is not developed in a model, suggests a ranking that is the reverse of that obtained in the earlier results of Reece and Leland, that is bonus, royalty, profit-share and full-share. While Robinson admits that these results are not conclusive they do present some important variables for consideration in auction theory and help to explain the current practice in mineral rights auctions.

While the literature addresses the bonus versus royalty question in terms of the optimal sharing of risk between the two parties to a lease the concept of time preference is not introduced. Time preference refers to the preference of an individual for consumption (money) in the present as opposed to the future. The time preference of an individual may depend on a number of factors such as current wealth or expectations. The higher a persons time preference the higher current consumption is valued relative to the future. The choice between a bonus or a royalty affects the time of payment, either in the present or in the future. A buyer of leases with a high time preference may prefer to delay payment through a royalty bid relative to a buyer with a lower time preference. Similarly, the time prefernce of the seller will affect

his preference for payment forms.

It seems clear from this discussion that the choice of an "optimal" auction should consider the relative time preference of the parties involved. As with risk aversion the choice of a payment method will benefit some relative to others because of differences in time preference.

Multiple Object Auctions

Most auction models consider the auction of one object while the common practice in many auction situations, including oil and gas leases is to auction a number of objects at a single sale. Very little work has been done on the theory of multiple-object auctions but some results are available.

Weber (1983) distinguishes among three types of multiple-object auctions, the simultaneous-dependent auction, the simultaneous-independent auction and the sequential auction. In the simultaneous-dependent auction each bidder must take a single action after which the objects are distributed and payments made. An example of this sort of auction is the sale of U.S. treasury bills. A simultaneous-independent auction, on the other hand, describes the case where the bidders must act simultaneously in a number of auctions where the outcome of each sale is independent of the outcomes of the others. The sealed bid auctions of mineral rights are a good example of this sort of auction. Finally the sequential auction is one in which the multiple objects are sold sequentially with each sale concluded before another is begun. The sale of mineral leases by English, oral, auction is an example of the

sequential type of auction.

Multiple-object auctions, like the single object type, can be either discriminatory or competitive in nature. In the context of a model in which each bidder wants only one of the items offered, the discriminatory auction would award an object to each one of the highest bidders, up to the number of items offered, and these bidders would pay the amount of their bid. In a competitive setting each high bidder would pay the amount of the highest rejected bid, this is also called a uniform price auction.

As in the single object case for the independent private values model Weber (1983) finds that the total expected revenue to the seller is the same under either the discriminatory or the competitive auctions. It must be remembered that this theory deals with the sale of identical objects, a uniform price auction with non-identical objects, oil and gas leases for instance, would not be expected to yield the same results.

The simultaneous-independent auction is the one that most closely corresponds to the typical sealed-bid oil and gas rights auction. An important consideration in this type of auction market is that bidders risk winning more objects than they desire. Since the sales are simultaneous a bidder does not have the choice of submitting contingent bids, that is bids with the condition that if a particular object is won then other bids are withdrawn. This is a major complaint about sealed-bid auctions of multiple objects and particularly in the presence of budget constraints for the bidders. Rothkopf (1977) derives optimal bidding strategies in this case where bidders have a constraint on exposure.

The off-shore auctions of oil and gas rights conducted by the federal government have often exhibited substantial differences between

the winning bid and the second highest bid, this difference is referred to as money left on the table. For example Capen, Clapp and Campbell (1971) analyze the bids offered in a number of offshore sales and show that the ratio of high to low bids is sometimes as high as 100 and is often in the range of five to ten. An explanation for this has always been the uncertainty involved in tract value estimation. Differences in value estimates may result from bidders having access to different information or from different interpretation of the same information. Differences in valuation resulting from interpretation can be attributed to inherent uncertainty. It is this uncertainty that accounts for the log-normal distribution of estimated tract values cited by Capen, Clapp and Campbell. By definition inherent uncertainty can not be reduced. Differences in value estimates based on different data is, on the other hand, the result of ignorance. Additional information gathering could reduce this source of uncertainty.

While second-price auctions eliminate the problem of money left on the table and weaken the winner's curse phenomenon there may be other causes of the large differences in bids. Mead (1966) points out that in the timber industry a firm may bid very aggressively in order to gain at least one sale in an area that is necessary to the firm's survival. Oil and gas developers must also obtain leases if they are to remain in business. In a sequential auction it would be expected that firms would enter a few high bids to ensure winning something and a number of smaller "fishing" bids. Sequential auctions should be expected to increase the variance of bids.

The sequential auction has the same properties as the other multi-object auctions in the context of the independent private values model.

In these models a bidder did not have to consider how his actions might affect the strategies of other bidders since their strategies were independent of their perceptions of him. In the oil and gas lease markets, however, it is realistic to assume that bidders have dependent value estimates and the situation becomes much more complex. Bidders can bid strategically by altering bids in one round in the hopes of influencing the bids of competitors in subsequent rounds.

The complex situation that would occur in a common values model with dependent value estimates and non-identical objects has yet to be modeled and would provide a rich area for further research.

Asymmetric Information

A common assumption in many bidding models is that all bidders have access to the same information concerning the value of the object of the auction. Different valuations and bids, in such a case, are a result of differences in interpretation of the available information. It seems reasonable to assume that in most cases bidders do not have access to the same information about lease values because of the cost of such information or because of information monopolies discussed by Reece (1978). Gathering information on oil and gas leases is expensive and it would be expected that some firms would face fewer constraints in its purchase than others. Furthermore, the results of seismic tests are very sensitive to the actual procedure. Two firms could carry out tests on the same tract and obtain very different results. Information monopolies may occur when a firm developes tracts already under lease. The information gathered from these leases may yield significant information

regarding adjacent tracts that may be offered at a later sale. Since this information is proprietary to the firm it may result in an informational advantage in the future sale.

Milgrom and Weber (1982) claim that a bidder's expected profits may depend more on the privacy of his information than on its accuracy. In the equilibrium of the first-price auction two bidders with the same information will receive zero expected profits while a bidder with private, although inferior, information may have positive expected profits. For a first-price sealed-bid auction Hughart (1975) demonstrates that a bidder with better information on tract value can restrict the profits of a less informed bidder to zero while maintaining positive profits for himself.

Both of these results depend on a first-price sealed-bid auction that offers no possibility of a less informed bidder learning from the bids of a more informed one. If the auction structure is changed to one in which a bidder is able to revise his bids upward in response to the bids of others then very different results are obtained. Assuming that the less informed bidder knows the strategy of the more informed bidder and that the less informed bidder is risk neutral Hughart (1975) demonstrates that there is no strategy available to the informed bidder by which he can profit from his superior information in an English or second-price auction. The two assumptions of the model are crucial to the result, if either are violated the more informed bidder is able to make positive expected profits although they would probably not be as high as in the case of the first-price auction.

The importance of information in bidding strategies and rent

capture by bidders raises questions about access to such information and its effect on auction markets from the seller's point of view. Analysis by Hughart (1975) and Reece (1978) suggests that in some cases, depending on the promise of the region in which the leases are located, it may be in the best interests of the seller to explore the region and make the information available to all bidders. Milgrom and Weber (1982) further demonstrate that in an English or second-price auction the seller benefits from complete disclosure of information.

Reservation Price

In many auction situations the seller will specify a reservation price, that is a price below which the object will not be sold. The seller sets a reservation price to assure that the object does not sell for less than that amount, usually the seller's valuation of the object. Clearly the seller suffers a loss if the price is set too low and the object sells for less than his personal valuation. While the use of the reservation price protects the seller from loss some recent studies indicate that the choice of a reservation price may affect not only the minimum price but the maximum as well.

The reservation price represents the lower bound on bids and, in an oral auction, is the level at which the auctioneer begins the bidding. With a reservation price set higher than the seller's valuation there is a chance that the seller will retain an object that a bidder values more highly. While this represents a risk of loss to the seller, studies by Meyerson (1983), Robinson (1984) and Riley and Samuelson (1981) indicate that it may be optimal, under certain conditions, to bear this risk.

Riley and Samuelson (1981) demonstrate that when bidder's valuations of the object are independent the optimal reservation price should be higher than the seller's valuation. While the seller risks some loss of revenue by setting a high reservation price, he will be compensated by higher revenue extracted in the case of a lone high bidder. Also in the independent private values model the choice of optimal reservation price does not depend on the number of potential bidders or the type of auction.

In the common values model the expected value of the object to a bidder will depend on the number of bidders and their value estimates since the "winner's curse" must be considered. Robinson (1984) shows that, in this model, the optimal reservation price depends on the expected value of the object to the winning bidder given the information available to him. Since some auction methods convey more information than others, the optimal reservation price depends on both the number of bidders and the auction type. As the number of bidders increases the expected high bid also increases and the potential gains from a high reservation price are reduced while the potential losses are unaffected. The optimal reservation price, therefore, depends negatively on the number of bidders.

The results given so far depend on the assumptions of symmetry and non-cooperative bidder behavior. Robinson (1984) demonstrates that in both the independent and common values models the optimal reservation price increases with an increase in the probability of a stable bidder cartel. The logic behind this result is that collusion reduces effective competition and decreases the expected level of a lone high bid. In the extreme case of perfect collusion, there is only one bidder and the

reservation price should be set quite high. Similar results would be expected to apply in other cases of reduced effective competition such as the case of informational asymmetry. In an auction where one bidder is thought to have better information than others the optimal reservation price is higher than in the symmetric case (Robinson, 1984).

Risk Aversion

Most auction models consider only the case of risk neutral bidders, a condition that is often implicitly met in a model with the assumption of expected profit maximizing behavior. Remember that risk neutrality implies a linear utility function. If utility is defined over wealth, then maximization of profits is equivalent to utility maximization. If an individual is risk averse, however, the utility function is not linear and expected profits are discounted for the level of risk. In this case the maximization of expected utility and expected profits do not correspond.

Very few models consider the implications of risk aversion of either bidders or sellers. It would be expected that a risk averse bidder who faces uncertainty as to the value of an object, in an auction would discount his bid as the uncertainty increased. If two bidders placed the same value on the object the less risk averse bidder would make the highest bid. To the extent that the choice of auction structure can affect the uncertainty associated with the value of the object it could also influence the bidding behavior of bidders who are not risk neutral.

Milgrom and Weber (1982) demonstrate that the first-price auction

leads to higher prices than the second price auction when bidders exhibit risk aversion in the independent private values model. When risk averse bidders are uncertain of the value of the object of the auction, as in the common values model, additional information may affect their bid. Unless some restrictions are placed on the form of the utility function, however, it is not possible to determine whether expected prices will rise or fall when additional information about the value of the object is made available.

Milgrom and Weber show that if information is perfect, so that uncertainty is completely resolved, or bidders exhibit constant absolute risk aversion, expected prices will rise with the disclosure of information. When the resolution of uncertainty is only partial expected prices may either rise or fall. Reductions in expected prices would only be possible when the range of possible wealth outcomes of the auction is large[2] or when unresolved uncertainty is great. In addition, under the assumption of constant absolute risk aversion the expected price under the English auction is at least as large as under the second-price sealed-bid auction.

Holt (1980) uses an independent private values model of bidding for contracts to show that the English and first-price sealed-bid auctions yield the same prices. An important assumption of this model is the risk neutrality of the the bidders. If bidders are assumed to be risk

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[2] Absolute risk aversion is defined by Arrow (1971) as -u"(.)/u'(.) where u(.) is the utility function. A measure of absolute risk aversion that is constant implies that an individual will have the same risk premium regardless of assets. In other words the amount by which the individual discounts a particular risk will not depend on his assets. In the above case a bidder with non-constant absolute risk aversion may still increase bid amounts if the wealth outcomes of the auction are not too large.

averse then the first-price sealed-bid auction is shown to yield the higher price. At first glance this result seems counterintuitive since bidders may be able to reduce value uncertainty in the English auction by observing the behavior of other bidders, a source of information that is not available with the sealed-bid auction. When value uncertainty is reduced the bids of risk averse bidders would be expected to rise. Holt, however, does not seem to consider the value information that bidders acquire but only information as to the number of competitors. The uncertainty as to competition inherent in the sealed-bid auction induces more aggressive bidding from risk averse bidders and increases the expected prices of the sealed-bid auction.

Leland (1978) addresses the optimal degree of risk sharing between the buyer and the seller of an uncertain prospect, in this case a mineral lease, from the standpoint of social welfare. He shows that the optimal sharing of risk will depend on the relative risk aversion of both parties. The greater the degree of risk aversion of the lease buyer relative to the seller, the more risk the seller should bear. As mentioned previously the choice of a bonus, royalty, profit or full share as a method of payment will affect the share of risk borne by the buyer and the seller. Leland goes on to discuss payment schemes in terms of risk sharing. Robinson (1984) uses these results to help explain the common use of the bonus as a form of payment. If sellers of mineral leases are more risk averse than buyers, as Robinson suspects, then sellers will specify payment schemes that will shift the risk to the buyer.

Summary

There is a great deal of diversity in models of auction markets but the one that most closely fits the mineral rights leasing situation seems to be the common values model. This model, in its simplest form, assumes that the object of the auction has a common, but unknown, value to all prospective buyers. Each bidder has an independent estimate of the true value of the object drawn from a common continuous distribution which implies that all bidders have access to the same information about the value of the object. It is generally assumed that there is only one object to be sold to a number of bidders who are risk neutral and behave non-cooperatively.

When the value of the object of the auction is unknown the role of information becomes an important consideration. In the private values model information about value was unimportant since each bidder knew with certainty his valuation and it was independent of that of other bidders. In the common values model, however, information becomes more important and, since valuations can be dependent, the valuations of other bidders can yield useful information. When the value estimates of other bidders were not accounted for in bidding strategies, winning bidders often paid too much for leases and suffered the winner's curse. The possibility of the winner's curse leads to non-aggressive bidding and lower expected prices.

In the common values model, as in the private values case, the first-price and Dutch auctions were shown to be strategically equivalent. The second-price and English auctions no longer yield the same expected prices, however, because of the possibility of information

exchange. An oral auction structure allows bidders to revise bidding behavior in response to the bids of others. This provides for better information and weakens the winner's curse leading to more aggressive bidding and higher expected prices in the English auction. Judged in terms of expected prices, the English auction is preferable to the other forms in the common values model.

When bidders have access to different information, the choice of auction method can also affect the outcome. It was shown that a bidder with superior information could restrict a less informed bidder to zero profits while gaining positive profits for himself. This advantage breaks down, however, when an auction method is used that allows response to the bids of others such as an English auction.

The advantages of the English auction method depend, in part, on the assumption of non-cooperative behavior. In the presence of a stable cartel among the bidders the English auction may lead to lower prices than the first or second-price sealed-bid auctions. The availability of information about bidders and bids in an oral auction facilitates the policing of a collusive agreement and, in the presence of such behavior, reduces effective competition and lowers the expected price.

While much of the literature has addressed the question of auction type there has been some attention given to the method of payment. The payment method, either bonus, royalty, profit share or full share, serves to share risk between the buyer and the seller of the lease. In terms of expected prices the profit share payment dominates the royalty method which, in turn, is better than the bonus. The comparative advantage of the profit share and royalty is greatest when the number of bidders is low or the uncertainty high. The choice of payment method

can also affect production decisions and this must be accounted for as well.

The ranking of payment methods given above contradicts the empirical dominance of the bonus with a fixed royalty. This inconsistency is explained by introducing the concepts of landowner risk aversion, offer comparability and monitoring costs. The inclusion of these factors suggests that the ranking could be reversed with the bonus being the preferred choice.

Although few results are available when either buyers or sellers are assumed to exhibit aversion to risk, it is expected that this will influence the choice of auction and payment method. Alternative auction and payment methods subject the parties to the sale to different types and shares of risk and, given aversion to risk, this would affect behavior and possibly auction outcome. Optimal risk sharing is found to depend on the level of risk aversion of the two parties but no clear linkage to payment schemes or auction methods is made.

It is also suggested that a reservation price above the seller's valuation may, in most circumstances, result in higher expected prices. The optimal reservation price is shown to depend on the number of bidders as well as the auction method in the common values model. As the number of bidders increases the optimal reservation price falls while an increase in the probability of a bidder cartel will increase the optimal price. A high reservation price serves to protect the seller in the case of inadequate competition.

The common case in mineral lease auctions is for a number of items to be offered at the sale. While some work has been done with multiple-object auctions the assumptions of such models are very restrictive.

These models generally assume that items are identical and value estimates are independent which does not correspond well to the mineral rights leasing case. An important consideration in the choice of auction method in multiple-object sales is the effect of a budget constraint in simultaneous sales.

In using the results of these models to prescribe actions in actual auction situations it is important to bear in mind the assumptions that have been made. Actual auction markets will never conform fully to the requirements of a particular model and the results of such a model should not be expected to apply exactly to a real situation. While most assumptions of these models are made explicitly the assumption of rational behavior by bidders is often overlooked. As seen in the work of Simon, economically rational behavior may be impossible because of cognitive limitations. Despite the restrictions of the models, however, they can serve as a useful starting point for applied work. Where actual conditions deviate from model assumptions it is often possible to estimate the probable affect of these differences on theoretical predictions and hence to provide some guide to actual market outcomes.

Chapter Five

Oil and Gas Leasing in Michigan

Chapter two of this paper introduced the SSCP paradigm and expanded it in terms of the oil and gas leasing market in the State of Michigan. The situation was presented both in terms of general characteristics of mineral leasing markets and those specific to Michigan. Also in that chapter structural alternatives in auction markets were discussed along with some possible performance measures. Chapter three developed more fully the conduct portion of the paradigm by presenting two very different theories of behavior under uncertainty, one based on an assumption of rationality and the other on bounded rationality. Chapter four provided a review of the literature on the theory of auctions with special attention to oil and gas leasing markets.

Most of the literature is oriented towards an analysis of the performance consequences of alternative auction structures. These theoretical models, however, define performance quite narrowly, almost exclusively in terms of expected revenues to the seller of the lease. Likewise, bidder behavior was considered only in terms of rational economic models, that is in terms of expected utility or profit maximization. While these simplifications are understandable in the development of theory it is necessary to go beyond these models in applied work. The purpose of this chapter is to adapt the results of these models to the concerns of the DNR with the oil and gas leasing program in the State of Michigan.

The analysis in the present chapter will expand on the theoretical models by considering a wider range of performance measures and by relaxing some of the assumptions to more closely coincide with the actual leasing market in the state. The analysis will focus an specific questions of auction structure that have been raised as concerns by the Department of Natural Resources. Measures of performance used in this chapter will also be defined in a somewhat broader context that includes such variables as the distribution of leases among bidders and the development consequences of structural alternatives. These performance measures are also dictated to some extent by the concerns of the DNR with the state's leasing program. This adaptation of auction theories to the market in Michigan and the performance concerns of the DNR will permit some conclusions to be drawn concerning the auction structure appropriate for use in the state.

Auction Method

The State of Michigan currently uses an oral, English auction for the sale of rights to publicly owned oil and gas resources. Some concern has been raised within the DNR, however, that the oral auction method does not capture the economic rent associated with a lease and that a sealed bid auction should be adopted. The alternative to the oral auction considered for use in the state has been the first-price sealed-bid auction and several bidding experiments have been conducted using this method.

Milgrom and Weber (1982) demonstrated, in the context of the common values model, that the auction methods could be ranked in terms of

expected revenue with the English auction first followed by the second-price and first-price or Dutch auction. The model used to derive these results has an attractive feature when oil and gas lease auctions are considered. One of the important assumptions of the model is that bidder's valuations of the object are dependent, or "affiliated" in the terminology of the model. In terms of oil and gas leasing models the assumption of dependent value estimates is appealing from an intuitive standpoint. Information concerning possible tract value comes from many sources and it is reasonable to assume that different bidders will have similar information sets. Valuations will not be identical because of differences in information and interpretation.

The ranking of the English auction above other, sealed-bid methods, in the Milgrom and Weber study was a direct result of the oral nature of the sale. When bidders are uncertain of the value of the object they can gain useful information by observing the bidding behavior of others during the course of an oral auction. Extra information weakens the winner's curse and leads to more aggressive bidding in the English auction. More aggressive bidding leads, in turn, to higher expected prices. The added information also implies a decrease in value uncertainty which would lead risk averse bidders to enter higher bids.

While information about valuation can lead to more aggressive bidding and higher prices it also introduces the possibility that some bidders will act as "free riders". Mead (1967) discusses the possibility that some bidders will not invest in information but will enter bids based entirely on others bidding behavior. The money saved on geophysical tests and other information gathering techniques could be used to outbid the competition. This would be expected to be more of a

problem in situations where exploration costs were very high such as in the offshore markets.

The primary argument against oral auction methods also stems from the resulting accessibility of information. Bidders gain not only information about other's valuation of the lease but also discover who is bidding and the amount of their bid. When this sort of information is easily available collusive practices become more easily policed. Collusion would tend to decrease effective competition and lower expected prices. In addition to outright collusion, where agreements are made before the sale, the oral auction method allows the possibility of implicit signaling during the sale. A bidder may signal, by his bidding behavior, his determination to gain a particular lease and other bidders may not compete on the implicit condition that they will receive similar treatment on "their" lease. Discussions with both bidders and auctioneers at Michigan's lease sales would indicate that there is no perceived problem of collusive behavior in lease sales in this state.

Mead (1967) presents an excellent discussion of how industry characteristics can influence auction preferences. Resource and industry characteristics may dictate that a firm have access to a reliable source of specific raw materials if it is to remain in business. Timber, for instance, can not be economically transported over great distances, furthermore mills represent large fixed investments that require a steady supply of logs. The timber industry, states Mead, prefers the oral auction method because they can more easily ensure frequent access to sales within a specific geographical area. The opportunity to react to the bidding behavior of competitors gives the bidder greater control over auction outcomes for specific sales and provides a means to protect

investments in production facilities. In the sealed bid setting it is difficult to guarantee that an object will be won and this causes planning problems for bidders who must obtain the resource.

Oil and gas, unlike timber, is easily transportable over long distances and, argues Mead, the major investment in drilling rigs and other equipment usually takes place after the sale. It is not as important in the oil and gas industry to acquire a specific lease and Mead concludes that the arguments for an oral auction will not be as strong. It is important to note that oil and gas development firms have capital invested in drilling equipment and, in order to remain in business, must discover new resources. While leases in specific geographical locations are not often required it is still important to obtain some leases in order to utilize capital investments and ensure a future supply of the resource. This will be particularly true for small firms that do not have a large number of tracts under development. There are also cases where, in order to fill out a drilling unit, a firm must purchase a specific lease. It seems that many of the arguments for an oral auction preference apply to the oil and gas industry, and particularly a market with a number of small firms.

The preference for oral auctions may be weakened somewhat by the presence of alternative sources for the resource. Acquisition of the resource in an auction will not be as critical if the opportunity exists to purchase from private landowners or from other sources. In this case a buyer will not be as dependent on the outcome of the auction for resource supplies. In Michigan there is a large market in oil and gas leases on private lands and this provides an alternative source of resources for the oil and gas industry in the state.

In certain types of markets the sealed bid auction could reduce the number of bidders competing for a given lease and reduce the selling price arrived at in the auction. In an oral auction bidders have the ability to respond immediately to bids offered by competitors and to know at any given time during the auction how much money has been spent and which leases acquired. If a desired lease is not acquired the bidder can reallocate money to the purchase of another lease and be more certain of winning a lease even if not the most desired. Since most bidders do not win every lease that they bid on, bidders will participate in the auction on more tracts than they actually purchase. In a sealed bid auction, on the other hand, once bids are submitted there is no chance to change bidding strategy in response to the number of leases won or the behavior of others.

In a sealed bid situation a prospective buyer will be able to submit bids on a limited number of tracts, limited by his budget. He will not know until the sale is concluded which leases were won and how much of the budget was actually spent. In an oral bid situation, however, if a lease is not won the bidder can immediately use the unspent money to submit a bid on another tract. The effect of this characteristic of sealed bid auctions will depend on the capital limitations faced by the bidder. A small firm would be more constrained in bidding than a larger one with a larger budget and would submit fewer bids. If the number of leases won depends in part on the number of bids submitted on different tracts, which is a reasonable assumption, then limiting the number of different leases on which a buyer can submit a bid reduces his chances of winning a lease. A buyer could, of course, bid on any number of leases in a sealed bid auction, regardless of a

budget constraint and simply default an any unwanted leases so obtained. The DNR would, however, take such behavior into account in evaluating the buyers bids in future sales so such a strategy may not be in the buyers best interest in the long run.

This analysis suggests that if a market exhibits a disparity in size and capital levels among bidders then a sealed bid auction would tend to yield an allocation of leases that was biased in favor of the wealthier bidders who could submit a larger number of bids. The market in Michigan consists of large national firms, smaller local firms, speculators and some individuals or private investment clubs. There is wide disparity among bidders in capital available for the purchase of leases. In terms of an "equitable" allocation of available leases among the prospective buyers in this market it would appear that an oral auction would be preferred. Furthermore an oral auction will allow more bids to be submitted and would be expected to raise the overall level of competition and the level of the winning bids.

While the allocation of leases among bidders is not listed as a specific performance measure by the state, it may be that this allocation will affect other measures of performance. It may be found that some types of firms are more likely to develop a lease in accordance with the state's leasing objectives than others. Some firms may provide more employment for state residents than others or it may be politically desirable to favor certain firms. If the allocation of leases among different types of bidders is important to the performance of the leasing program then the choice of auction method given the market in the State of Michigan could have significant consequences.

It should be noted that the problems faced by bidders who are

subject to a budget constraint are caused less by the sealed bid method than by the simultaneous nature of the multiple-object auction. It is possible, although not common in practice, to conduct a sequential sealed-bid auction in which sealed bids are accepted for each object and opened before bids are accepted on the next item.

A final consideration in the choice of auction method is the ease of application. An oral auction requires the physical assembly of all prospective buyers and can take a substantial period of time. The oil and gas lease sales in Michigan typically take between two and three days to conduct. Simultaneous sealed bid auctions, on the other hand, do not require the presence of the bidders and the opening of bids and awarding of leases can be accomplished in much less time and at much less expense.

In summary the English, or oral, auction method is shown theoretically to yield higher expected prices than the sealed bid auction when bidder's valuations are dependent on each other. This result depends on the reduction in value uncertainty in the oral auction as information is gained from the bidding behavior of others. If bidders are risk averse, which seems reasonable, the reduction in uncertainty will also lead to higher bids because of lower risk discounting. The ease with which information is transferred in the oral auction also leads to concerns about free riders and collusive behavior. The free rider problem will be most severe when the cost of exploration is high, as in offshore leasing, and would not be expected to be as much of a concern in Michigan. Collusive behavior is not thought to be much of a problem in Michigan's lease sales but it is often difficult to detect and should be watched for. Finally the sealed bid method, as most commonly used

for multiple-object auctions, can lead to a biased distribution of leases among bidders subject to different budget constraints. To the extent that this affects other leasing objectives it is an important consideration in the design of auction structure. The large disparity between the size and budgets of bidders in the state's lease sales would indicate that this could be a significant factor in Michigan's leasing program. When budget constraints are binding in sealed bid auctions an, oral auction may result in increased competition and higher expected prices as bidders are able to enter bids on a greater number of leases.

Bidding Objects and Payment Method

Michigan currently utilizes a bonus as the object of bidding with an additional royalty payment of 16 2/3 percent specified in the lease. There has been some discussion of adopting the royalty as a bidding object in cases where a drainage lease is to be sold. Remember that a drainage lease is one in which it is thought that hydrocarbon resources are being drained from under state lands. In the case of a drainage sale the uncertainty to the buyer is considerably reduced because resources are being recovered on lands adjacent to the lease.

The choice of payment method determines, in part, the shares of risk borne by the buyer and by the seller of a lease. When buyers and sellers are risk averse their attitudes towards bearing risk will affect the relative outcomes of the use of alternative payment forms. Payment methods can also affect development of a lease and this may have consequences for the performance of a particular auction market.

The theoretical results of Reece (1978) rank payment methods in

terms of expected revenue for the common values model with profit-share first followed by the royalty and bonus methods. The ranking of Reece is in inverse order of the value estimate to the bidder. This result is intuitive for a risk averse bidder since he will pay more when risk is reduced. The ranking given by Reece is in decreasing order of the amount of risk borne by the buyer. Under a profit share arrangement the landowner shares dry hole risks and cost uncertainty with the developer. With a royalty payment the landowner shares only the dry hole risk and with a bonus he bears neither.

Leland (1978), approaching the problem from the standpoint of the optimal sharing of risk, obtains the same ranking as Reece under the assumption that bidders are more risk averse than landowners. In Leland's model the optimal share of risk to be borne by the landowner increases as his level of risk aversion falls relative to the bidder. The choice of an optimal payment method will depend on the relative risk aversion of both parties to the lease.

Robinson (1984) introduces three explanations to account for the empirical preference for the bonus payment over either a royalty or profit share. These are landowner risk aversion, offer comparability and monitoring costs. The profit share payment requires that sellers keep track of costs, output, prices and overhead which may be very difficult. Furthermore the buyer has an incentive to shift costs from dry holes to producing wells and this may be difficult to detect. The costs of accurately determining a profit share payment may make it unattractive for most landowners despite the possibility of greater revenue. While monitoring may not be as difficult for a state government as for a private landowner it may still entail considerable cost. A

royalty determination requires only a knowledge of output and prices which will be more easily obtained than the information to determine a profit share and this may account for the greater popularity of the royalty, often in conjunction with a bonus.

When firm costs differ because of differences in efficiency or production processes it may be difficult to compare offers from competing firms when a profit share or royalty is the object of the bidding. The problem is greater with a profit share than a royalty since development costs as well as production costs must be accounted for in payment determination. With the royalty payment only costs of production, which determine production rates and influence the abandonment decision, need be considered.

Finally, if the landowner, in this case the State of Michigan, is more risk averse than the bidder it may be optimal from the standpoint of the state to shift as much of the risk as possible to the bidder through the use of a bonus payment. Robinson argues that it is likely that landowners are more risk averse than bidders since development firms can diversify their risk over a large number of leases. This argument loses some of its validity when the seller is a government body that sells thousands of leases and diversifies more in this respect than most of the bidders. Government bodies, however, may reflect the risk attitude of the public in decision making and may have other, internal reasons for being risk averse.

Michigan specifically states as a criterion for the choice of auction method that the development risk be borne by the buyer. While this supports the current use of a bonus as the object of the bid it contradicts the inclusion of the royalty as an additional payment. The

use of both a bonus and a royalty achieves a level of risk sharing that is intermediate between either one used alone and the adjustment of the royalty rate can further fine tune the risk sharing. The expected amounts of the two forms of payment, when used together, will be inversely related.

In addition to risk aversion the relative time preference of the buyer and the seller must be considered when deciding on a payment method. If the seller has a higher time preference than the buyer, that is has a greater preference for current consumption, a bonus may be the prefered payment method from the sellers point of view. In a manner analogous to the sharing of risk an "optimal" auction should consider the relative time preference of the two parties.

In addition to affecting the sharing of risk between the two parties to a lease sale the choice of payment method may affect some aspects of lease development. The royalty payment acts as a tax on production and will influence the abandonment decision, the higher the royalty rate the earlier the well will be abandoned. The affect of the royalty payment on the abandonment decision can be ameliorated through the use of a sliding scale royalty. With this scheme the royalty rate is tied to the amount produced. As a well ages and production drops the royalty rate also falls and premature abandonment is avoided. The time of abandonment will also affect the total revenue ultimately recovered from a lease through royalty payments as it affects the physical output from the well.

The expected price to the seller of a lease would be expected to increase as the share of risk borne by the buyer falls if buyers are risk averse. The seller, in choosing a payment method, must decide on

his own level of risk aversion, that is what amount of risk he is willing to bear. Other considerations include the cost of monitoring any payment method to insure that the proper payments are being made and the ability to meaningfully compare bids when the payment method is the object of bidding.

Discounting for risk involves applying a discount rate to the expected revenue from a lease. When only a few leases are being developed a firm may not be able to afford to play the averages and may be risk averse. A government body, however, that sells thousands of leases can diversify very effectively and would probably increase expected, and actual, revenues by increasing the amount of risk borne. Given the difficulty in monitoring profit share payment methods, increasing the royalty seems an effective way to accomplish this. When using a royalty, however, a sliding scale should be considered in order to avoid the negative effects on well abandonment and subsequent royalty revenue.

In the case of drainage leases the uncertainty concerning tract value is considerably reduced because of the presence of an adjacent producing well. The same argument used above could be used to justify a higher royalty rate on drainage leases. Furthermore the reduced level of risk for such leases implies that the seller may benefit from specifying a higher royalty rate on these tracts in order to bear the same amount of risk as on non-drainage leases.

Reservation Prices

In many auction situations the seller will specify a reservation price, a minimum price below which the object will not be sold. The reservation price is generally thought to represent the seller's valuation of the object although there may be strategic reasons for setting it at other levels. The State of Michigan recently changed their reservation price for oil and gas leases from two dollars with a minimum of three bidders required to ten dollars with no requirement on bidder numbers. The reservation price in this state is based on the belief that competition was not sufficient to ensure a fair price rather than any knowledge of possible opportunity costs of development.

The work of Robinson (1984) demonstrates, in the common values model, that the seller's revenue will be increased if the reservation price is set higher than the seller's valuation. In this model the optimum reservation price will depend on the bidder's valuation of the object. Since this valuation is a function of information and some auction methods convey more information than others the reservation price will depend, in part, on the auction type as well. Bidder's valuations will also be affected by the number of bidders so this, as well, enters the function that determines the optimal reservation price.

In setting a reservation price that is higher than his valuation the seller risks not selling an object that a prospective buyer values more highly. While this represents a loss to the seller it may be recovered when a lone bidder places a value on the object that is higher than the reservation price. When several bidders place a value on the object that is greater than the reservation price competition among them

will result in a price higher than the minimum. When only one bidder places a value at least as high as the reservation price on the object, however, the seller must rely on the reservation price to increase the bid.

As the number of bidders increases so does the expected level of the high bid and the potential gains from a high reservation price are reduced while the potential losses are unaffected. The optimal reservation price, therefore, is negatively related to the number of bidders. In Michigan's lease sales many leases are sold with only a few, and in many cases only one, bidder active. Few bidders on many sales would indicate that a reservation price should be set that is substantially higher than the state's valuation. While the level should be set higher than the valuation, however, the theory does not indicate at what level.

Since bidder's valuations will be affected by auction type and the optimal reservation price is a function of bidder's valuations, the choice of a reservation price will depend on the type of auction. The English, or oral, auction conveys more value information than other auction types, weakens the winner's curse and leads to more aggressive bidding and higher expected prices. The optimal reservation price in the English auction would be expected to be lower than with the other auction methods.

In summary a reservation price set higher than the seller's valuation of the object would be expected to yield the greatest results when the number of bidders is small. For many of the leases sold in Michigan's sales there are few bidders and a high reservation price would be expected to increase revenues to the state. The actual level for the reservation price would have to be determined by when losses

from a high price begin to exceed gains. Because of the effects of auction method on bidder's valuations the optimal reservation price should be higher under a sealed bid auction than with the English method. The reservation price is seen to be effective in increasing expected prices when bidder numbers are low and there is little effective competition. The use of the reservation price should also be considered when effective competition is reduced by other means such as collusive behavior.

Summary

The purpose of this chapter has been to suggest some performance outcomes of alternative institutional structures in Michigan's oil and gas leasing program. The analysis has applied the results of the theoretical models of auctions and bidding behavior with special attention to the situational characteristics of the State of Michigan. It is hoped that the results of this study will assist the DNR in designing the state's auction market so that the desired performance can be obtained.

Given the nature of the market for oil and gas leases in Michigan the English auction has some advantages over the sealed bid methods. First, the expected revenue from the English auction exceeds that from the sealed bid auction when bidder's valuations are dependent, which is a reasonable assumption in mineral lease markets. This is a result of the additional value information provided in the English auction and the comparative advantage will be even greater when bidders are risk averse. Secondly, in a market characterized by a disparity in firm size and

bidding budgets, which is the case in Michigan, the English auction eliminates much of the advantage of the larger, wealthier firms in winning leases. The allocation of leases among bidders may not be a performance end in itself but may have consequences for other performance measures. The primary disadvantage of the English auction is that collusive behavior, which can result in reduced revenue to the seller, is difficult to control. Collusion is not seen as a problem in Michigan's sales but is often difficult to detect and the possibility should not be ignored. The English auction can also encourage free riders but this would be a greater problem when exploration costs are high or where the object of bidding makes up a large share of the total payment, neither being the case in Michigan.

The choice of payment method determines the shares of risk borne by the two parties to a lease. The optimal sharing of risk will depend on the relative risk aversion of the buyer and seller. When the buyer is more risk averse than the seller the largest expected revenues will result from those payment methods that shift risk to the landowner, that is the profit share and royalty as opposed to the bonus. It seems reasonable to assume, when the seller is a government agency that sells many leases, that the risk aversion of the buyer exceeds that of the seller.

The profit share payment has the disadvantage of being difficult to monitor and while the royalty shares these problems they are not as severe. When used as the object of bidding the profit share and royalty methods suffer from a difficulty in comparing bids that is not a problem with the bonus. Finally the royalty payment can affect development of a lease through the abandonment decision and this may affect other

performance measures used by the state. In Michigan the bonus is the object of bidding, avoiding the problem of offer comparability, while the royalty, on a producing lease, makes up the majority of the actual payment. Furthermore, when uncertainty is reduced, as in the case of drainage sales, the royalty is increased. This behavior is consistent with the goal of increasing revenue when the seller is less risk averse than the buyer.

Finally the choice of an appropriate reservation price is important to market performance in terms of expected revenue. The setting of a reservation price above the seller's valuation in a mineral leasing model would be expected to increase revenue to the seller. The optimal reservation price will depend both on the number of bidders and the auction type. The advantages of a high reservation price are most pronounced when competition is least effective, this may be the result of few bidders, different levels of information or collusive behavior. In any of these cases a relatively high reservation price would be expected to increase revenue. The optimal reservation price would be expected to be smaller in the English auction than the sealed bid auctions but is still greater than the seller's valuation. While the theory states that reservation prices should be greater than the seller's valuation the optimal level must be empirically determined. Results of past sales in the state could be used to determine whether the change in the reservation price has affected revenues.

In conclusion it seems as though the auction structure currently in use in the State of Michigan is well tailored to the market situation to obtain the desired performance. The English auction is expected to generate a greater revenue than the sealed bid methods and yield a less

biased allocation of leases. These results are especially relevant in a market, such as that in Michigan, where there is a large difference in bidder size and wealth. A question that needs more attention in this context is the possible performance consequences of the distribution of leases among different types of firms. The bonus as the object of bidding eliminates the problems of offer comparability encountered with a profit share or royalty while the royalty as an additional payment shifts some of the risk to the state. Since it seems that the state should be less risk averse than most of the buyers this is consistent with theory. It may be desirable to explore the use of a sliding scale royalty to avoid the impact of the payment method on lease development. Finally the choice of a reservation price can affect revenue and some effort in the empirical determination of an appropriate level could pay off.

A Note on Empirical Work

The State of Michigan's lease sales and bidding experiments with sealed bids have resulted in a considerable quantity of data. As initialy conceived this study would have used these data to draw some inferences about Michigan's leasing program. The data were, however, found to be inadequate for this purpose. It may prove helpful for future research to explore the deficiencies of the available data and to discuss some possible methods of testing the hypotheses presented in this paper.

The results of this study suggest that small firms may face constraints in sealed bidding relative to larger firms. In a market where

large and small firms compete with each other for leases these constraints would imply (1) greater competition for leases under the oral bidding structure, (2) higher prices with oral bids and, (3) a different distribution of leases among bidders under the two bidding structures. Given the proper data these should be testable hypotheses concerning the difference between oral and sealed bidding.

Empirical testing of the differences between oral and sealed bidding may encounter several problems. First, because the oil and gas market, and hence the situation under which leases are sold, can change considerably from one sale to the next it would be desirable to collect data on both oral and sealed bids at the same sale. Secondly, the buyers should be familiar with both methods.

The DNR conducted sealed bid experiments in five lease sales. In these experiments fifty leases were sold through sealed bids which were opened at the start of the regular oral sale. Several attempts were made to compare the results of the oral and sealed bids. First an attempt was made to compare the mean prices of the sealed bid group with the leases sold by oral bidding. Bid prices in both groups, however, exhibited considerable variation and it was not possible to draw any statistically significant conclusions from the data. Casual observation suggests that tracts that are geographically close to each other have similar sale prices. The second test compared the selling prices of tracts sold by oral bids with adjacent tracts sold through sealed bids. Again significant results were not obtained.

One possible solution to the difficulty in comparing oral and sealed bidding in terms of the capture of rent may be to examine the historical record of leases that have been sold and developed. Given

the selling price of a lease that has already been developed it may be possible to determine whether the state has captured the economic rent associated with the lease. This could be accomplished by comparing the selling price with the eventual revenues. This method would be limited to deteriming whether the state had captured the economic rent associated with a particular lease conditioned on the method of sale. Unless different auction methods were used in the initial sale the comparison of auction structures in terms of rent capture would not be possible. The historical comparison method described above could also be used to compare the bonus and royalty as methods of payment. To yield useful results, however, there would have to be some variation in actual methods of payment.

While this method may hold some promise it too has limitations. Probably the greatest obstacle to implementation will be the data requirements. In addition to original selling price, historical data on development costs, production, and firm revenues will be required. Since the development takes place over time it will also be necessary to discount revenues and expenditures and the question of an appropriate discount rate will have to be addressed. Finally, the calculation of rent must account for the cost of risk bearing to the developer and a normal return to his investment. These may be difficult to determine and some simplifying assumptions may be needed.

Given the proper data it may also be possible to test the hypotheses concerning competition and lease distribution. In the sealed bid setting the collection of information on the number and identity of bidders on each lease is straightforward. If similar information could be generated from the oral auctions it may be possible to determine

whether there is a difference between the two methods. The nature of the oral auction, however, makes it difficult to count and identify bidders.

While there are difficult problems associated with empirical tests of these hypotheses, the information gained from such tests could be very useful. Feasible empirical tests of auction markets may provide a fruitful area for future research.

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