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Transaction costs and choice of petroleum contract

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TRANSACTION COSTS

AND

CHOICE OF PETROLEUM CONTRACT

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF
THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN AGRICULTURAL AND RESOURCE ECONOMICS

DECEMBER 1989

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ABSTRACT

Petroleum contracts are very complicated in their share structure. This makes it difficult to generalize explanations on choice of petroleum contract. Current contracts are classified into four major types: concession, production-sharing, joint-venture, and service contracts. Two existing explanations on choice of contract--fisical regime and risk sharing--explain in terms of physical risk. They are inadequate for the purpose because the industry is also inherent with behavioral risk as shown by the existence of various mitigating terms in every type of contract. Behavioral risk here refers to the opportunity of the contracting parties to deviate from the original promise.

This study proposes that a contract is selected not only to moderate physical risk but also to minimize ex-post opportunism. The theories of agency and self-enforcing contract are used in constructing a contractual choice model. It shows that types of contracts are distinguished by incentive payment terms, which are designed to minimize opportunism. When the country has little information on petroleum reserve, a high incentive payment contract will be selected, and vice versa. Also, if the circumstance changes ex post, new terms or a new type of contract are adopted to maximize the contracting parties' mutual benefits. The available evidence supports this hypothesis. The high incentive contract--concession contract--is always granted in newly oil exploration countries. Other three lower incentive contracts are drawn in countries which have high commercial quantity of petroleum reserve. A one-way analysis of variance test shows that means of oil-field size among the three groups of countries that adopted different types of contracts at a particular time

differ significantly at the level of 90%. The Less Significant Difference (LSD) test confirms that means for the group of countries employing the production-sharing or the joint-venture differs significantly from the group of countries that employs the service contract. When oil prices change, new terms or a new type of contract are adopted without interventions from the third party.

In conclusion, empirical evidence is consistence with the model for choice of petroleum contract developed in this study. The model can be more vigorously tested if additional data and information are available.

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CHAPTER I

INTRODUCTION

Petroleum exploration and development involve with a high level of risk, large capital requirements, a need for continuity of operations, and a complex environment of government regulations. As a result, petroleum contracts have become very complicated because of the inclusion of terms designed to allocate risks and minimize expected losses associate with the above factors. There is also a considerable variation among existing petroleum contracts. The earlier classifications of petroleum contracts were often based on the writer's objective or argument. One writer divides petroleum contracts into 20 types and notes that it is the minimum possible classification (Van Meurs 1981: 551). The current literature has reduced the number of classification to four. However, within the four classifications there exists considerable variations.

The complications in contractual terms and the large variation in contractual formats make it difficult to explain why each type of contract is selected. Existing explanations suggest that the choice of petroleum contract is associated with the nature of the high level of geological risks involved in the industry. While this is critical factor this explanation is inadequate for the problem at hand. The purpose of this study is, therefore, to propose a more consistent explanation for choice of petroleum contracts.

The contents of this chapter are organized into 5 sections. Section 1.1 describes the four existing types of petroleum contracts. Section 1.2 describes the contractual terms in petroleum contracts. Section 1.3 describes the existing explanations for choice of petroleum contract and discusses why they are

inadequate for the purpose. Section 1.4 states the objective and the hypothesis of the study. Section 1.5 provides an outline of the following chapters.

1.1 Types of Petroleum Contracts

Petroleum contracts have been divided into four major categories: concession, production-sharing, joint-venture, and service contracts (Mikesell 1984: 26). Some disagreements regarding details of each type of contract do exist. For example, service contracts are subdivided into purerisk service and nonrisk service contracts (Broadman 1985: 228). Concession and joint-venture contracts are sometimes not considered as distinct types (Barrows 1983: 1). Nevertheless, the above classifications of petroleum contracts appear to be increasingly used in recent literature to describe petroleum contracts. The features of the four major types of petroleum contracts are described below.

(1) Concession Contract

Under the concession contract, the host country does not exercise any control over the contractor. The host country grants to the contractor exclusive rights to explore, obtain, develop, render suitable for trade, carry away, export and sell petroleum and its related substances within the concession area for a fixed period of time. Most significant of all, once oil is found, the host country gives the contractor the power to determine how much of the resource should be produced and at what price it should be sold, and the host country's share is a function of the contractor's revenue.

(2) Production-Sharing Contract

In the production-sharing contract, the host country has some participation in the exploitation activities. If oil is discovered in any portion of the

contracted area during the exploration period, decisions concerning development are made by the contractor after consultation with the host country. Each phase of the operation is planned and carried out by the contractor, but subject to approval by the host country. There are also requirements for periodic reporting and submission of information by the contractor. The degree of the host country's control over the contractor under this type of contract is relatively higher than concession contracts but still less than join.-venture and service contracts. The main principle of the pattern of share payment in this type of contract is that the contractor is allowed to reimburse production costs at a certain percentage from the amount or value of oil produced. The remainder will be shared between the host country and the contractor.

(3) Joint-Venture Contract

Under the joint-venture contract, the host country takes part in the development and production of the petroleum field as a joint operator when a discovery of commercial quantity is made. In this type of contract, the commercial quantity of oil discovery is better defined than the above two types of contracts. For example, the contract between Libya and Auxirap drawn in 1968 specifies that the contractor is obligated to develop that oil field if the oil production is expected to be greater than 90,000 barrels per day (Hossain 1979: 133). In the 1967 joint-venture contract between Saudi-Arabia and Azienda Generale Italiana Petroli (AGIP), the discovery of an oil field in commercial quantities is specified as an oil field that can produce a minimum of 25,000 barrels of 42 US gallons at 60 Fahrenheit per day for a period of 30 consecutive days. In some arrangement, a clause is incorporated to permit either the host country or the contractor to undertake the development of an oil

discovery if there is a difference of opinion between the contracting parties regarding the level of oil discovery in commercial quantity.

If both parties agree to develop the discovered oil reservoir, the host country agrees to share the exploration costs with the contractor by paying directly or through a portion of the host country's share of revenues. When a field is in the process of being developed, the host country takes a direct part in running the joint enterprise through its own managerial, administrative and technical staff and in sharing expense. Finally, the net profit is equally shared between the contractor and the host country. Therefore, the degree of the host country's control is higher in joint-venture contracts relative to the concession and production sharing contracts.

(4) Service Contract

The main feature of the service contract is that the host country takes full control over the production operation at a certain period after the oil is found. The host country also owns all petroleum deposits and any oil and gas produced at the wellhead. Once oil is found, the contractor is obligated to develop the oil field. The definition of discovery of an oil well may be clearly defined in the contract, the same as in the joint-venture contract. For example, the contract between Iran and the Enterprise de Recherches et d' Activite Petrolieres (ERAP) in 1968 defines the discovery oil well as a well of which a production capacity of not less than 2,000,000 barrels per day of crude oil for horizons not exceeding 2,500 meters in depth or 3,000,000 barrels per day for deeper horizon (Hossain 1979: 166). Sometimes, the decision of developing the discovered field may be left to the host country. For example, the Brazilian

case stipulates that the host country will make such a decision if the oil discovery was made (Hossain 1979: 169).

During the production stage, exploration and development costs are repaid in the form of crude oil. Also during this stage, the contractor acts as an agent for the host country and markets its oil abroad, if the latter so wishes, in return for a nominal commission. Unlike the other three types of contracts, management is assumed by the host country. The host country also takes over the whole operation about five years after the start of commercial production. The contractor is usually given the right to purchase a portion of the crude oil from each of the exploited areas for the entire production period. The fee for this portion of oil is determined by a specific formula which affords the contractor a substantial discount (Hossain 1979). Service contracts are, therefore, the most closely monitored type of contract, compared with the other three types of petroleum contracts.

1.2 Contractual Terms in Petroleum Contracts

Based on the above descriptions of the four types of petroleum contracts, every petroleum contract contains of five essential provisions: (1) duration of contract, (2) relinquishment, (3) exploration obligations, (4) the host country's control or monitoring of operations, and (5) payment system. Terms (1) through (3) are applicable to the exploration phase, and terms (4) and (5) apply to the exploitation phase. The five contractual terms are briefly described below. Details are provided in Appendix A through various actual petroleum contracts. The contents of the four types of petroleum contracts are also concluded in Table 1.1.

Table 1.1

Comparison of the Four Types of Petroleum Contracts

Term	Concession	Production Sharing	Joint-Venture	Service
Exploration Phase				
Duration	10 years with periodical renewal	10 years with periodical renewal	12 years with periodical renewal	12 years with periodical renewal
Relinquish-ment	25% at 2th year 50% at 5th year 25% at 10th year	30% at 3th year 30% at 6th year 40% at 8th year	25% at 5th year 25% at 9th year 50% at 12th year	50% at 3th year 25% at 5th year 25% at 6th year
Exploration Obligations	minimum investment within specific time	minimum investment within specific time	minimum investment within specific time	minimum investment within specific time
Production Phase				
Host-Country's Control	none	program & budget approval,	joint operation, 50% of net profit	owner, hires the contractor as agent (takes over after 5 years), 100% of net profit
Payment-System	Royalty: 12.5% Income tax: 50%	65/35 of the 60% output in favor of the host country	Royalty: 12.5% Income tax: 50%	Income tax: 50% (can purchase 30% of output at special price)

Source: For the concession contract is taken from U.N. 1983: 6. Information on the production sharing is taken from Mikesell 1984: 61. Information for the joint-venture contract is taken from Hossain 1979: 121. Information for the service contract is taken from U.N. 1983: 12. See Appendix A for detailed contents of additional petroleum contracts.

(1) Duration of Contract

Duration of contract indicates the contracted period that the contractor will work for the host country. The granted periods are separated into exploration and exploitation periods. The exploration period is divided into subperiods. If oil is not discovered by the end of each subperiod, the contract may be renewed. Renewal is conditional, however, and is based upon past performance of the contractor. If oil is still not found after the whole exploration period, the rights of the contractor to explore will be terminated. In the event that oil in a commercial quantity is found, the contractor has the right to proceed into the production period. In general, every type of contract stipulates that the contractor retains exploration rights for 5 to 7 years. If oil is discovered in large enough quantities, exploitation rights would be granted for another period of 20 to 25 years.

(2) Relinquishment

Relinquishment terms are terms that force the contractor to progressively surrender a stipulated percentage of the initially granted area to the host country if oil is not found at the termination of each subperiod of exploration.

(3) Exploration Obligations

The most common exploration obligations of the contractor in petroleum contracts are that the contractor (1) bears all exploration risks and (2) is responsible for financial and technical resources in the exploration phrase. The contractor will not be reimbursed for any of the expenses he incurs if the search is unsuccessful. Minimum work requirements and expenditure obligations to be discharged by the contractor during each subperiod of exploration are normally stipulated. The minimum work program specifies in some detail the nature of

the exploration work to be carried out. For example, the provisions stipulate the minimum number of wells to be drilled, the minimum drilling depths of each drilling well, and the minimum expenditure obligations with an escalation clause. Further, the host country may require the contractor to submit all acquired geological and geophysical data during the course of exploration, and may require the contractor to furnish those geological information for the host country.

(4) Host Country's Control or Monitoring

In all of the types of petroleum contracts, contractors come under an obligation to develop the oil reservoir, if the geological data acquired from the exploration indicates the potential oil deposit in commercial quantities. Criteria for determining whether the oil discovery should be regarded as "commercial quantity" or not vary from one type of contract to another. Some types leave contractors with greater discretion, while others introduce more objective criteria; others give the host country power to require the contractor to develop if the host country deems that the discovery is commercial. After the oil well is developed, terms of the rights over management and marketing the oil production are stipulated differently among the four types of contracts.

(5) Payment System

In every type of petroleum contract, the agreed upon rewards of contract are functions of the rate of oil production from the discovered reservoir. The chosen patterns of payments take various forms: revenue sharing for the concession contract, and the different forms of profit sharing for the other three types. However, every type of petroleum contract is formulated under a share structure associated with expected future outcomes.

In brief, the role of the petroleum contract is to permit the oil contractor to participate in the exploration, development, and production of any discovered resources, in return for an agreed share of the actual production. Petroleum contracts contain contractual terms for both exploration and development, and exploitation phases. The development and the exploitation contract is, of course, subject to the success of the exploration stage. During the exploration stage, all types of contracts stipulate that contractors are subjected to all exploration risks associated with random output or value of outputs. During the exploitation stage, rights over oil production and payment sharing differ among four types of contracts. The pertinent characteristic of the petroleum contract is, therefore, a contingent contract, i.e., an agreement to share an outcome if and only if the agreed amount of oil has been found.

1.3 Explanations for Choice of Petroleum Contract

There are two conventional explanations on why there are many types of petroleum contracts and how each type is selected: (1) fiscal regime or taxation system; and (2) risk sharing. These two explanations are briefly described below with discussions on why they are unsatisfactory for the purpose.

(1) Fiscal Regime Explanation

The term "fiscal regime" is defined as a set of rules about how the cash flow of the project is distributed between the host country and the contractor (Blitzer et al. 1983: III.3). Therefore, fiscal regime is simply the taxation system stipulated in each type of petroleum contract. There are three main types of tax instruments being used in the petroleum contract: (1) bonuses, (2) profit taxes, and (3) production-base taxes. Under bonuses, the contractor pays a lump sum

to the host country when an exploration or production contract is drawn up. The other two tax systems are functions of profits and output respectively.

In the fiscal regime analysis, only tax systems are used to distinguish types of contracts, i.e., the alternative cash-flow projects are distinguished by the different tax system. Therefore, the project's expected net present value profit (ENPV) is a direct function of the chosen tax system. All other thing being equal, each party will select the alternative project having the highest positive ENPV. However, there is a question of how both parties can arrive at an agreed contractual arrangement. Since their cash-flow maximization are separately derived, each party's best choices are unlikely to be identical. Some writers explain that both parties can arrive at the agreed upon rate of return or the type of contract because of the difference in their bargaining power (Smith and Well 1975, Hossain 1979, Blitzer et al. 1985).

There are at least two difficulties in using fiscal regimes to explain choice of petroleum contract. First, the argument that an agreed contract results from the difference in the contracting parties' bargaining powers lacks empirical evidence. The fact that a host country employs many different types of contracts at the same time contradicts the concept of this argument. It also suggests that the market for petroleum contracts is fairly competitive. Second, the argument that types of petroleum contract are distinguished by different tax rates is invalid. To be able to distinguish types of contracts by tax rates, one must observe that there is a fixed set of tax rates associated with each type of contract. But in reality, the set of tax rates or the fiscal regimes of a contract within the same type and among different types of contracts are different. There are no standard rates or any particular rule for setting the types and rates of tax for any individual contract or type of contract. As illustrated in Appendix A, all types of contracts

can be made fiscally equal by adjusting terms of fiscal regimes, i.e., tax rate, royalty or profit sharing rates, in different types of contracts. Therefore, fiscal regimes or a tax system can not be used to explain choice among the four classifications of petroleum contracts.

(2) Risk Sharing Explanation

The risk sharing explanation postulates that contracts are determined by risk allocation patterns. Each type of petroleum contract is selected according to the respective risk preferences of host country and the contractor. Under this framework, the inherent risks, which are shared between the contracting parties, are generally specified as: exploration risk, development risk, and oil price risk. It is then argued that the differences among contractual terms, involving the ownership of assets and discovered reserves, reflect the desire of the parties to use the contract as a risk allocation institution. It is further argued that in each type of contract, the divisions of costs, revenues, and profits between the contracting parties can be inferred from the type of legal ownership and the corresponding degree of risk bearing.

Most of the literature on the risk-sharing explanation postulates that most or all of the risks are borne by the contractor in the concession contract. At the other end, all risks are borne by the host country in the service contract. Risks are allocated in different degrees between both parties for the production-sharing and joint-venture contracts. This explanation can be seen, for example, in the works of Blitzer et al. (1985) and Broadman (1983, 1985). Both authors use the risk sharing concept to distinguish types of petroleum contracts, but their interpretations in risk allocation patterns for each type of contract are somewhat different.

Blitzer et al. (1985) divides petroleum contracts into four main types: (1) service, (2) toll or fee per barrel, (3) production sharing, and (4) royalty. He explains that under the service contract, all risks are borne by the host country. Under the toll or fee per barrel contract, most of the risks are assumed by the host country, but the contractor shares the oil price risk. Note that the toll or fee per barrel contract is the same as the service contract, since the contractor is the one who provides exploration and development services for the host country and is then compensated in terms of a (flat) fee per barrel of oil produced. Under the production-sharing contract Blitzer et al. considers that all risks are equally shared between the host country and the contractor. In the royalty contract all risks are borne by the contractor.

Broadman (1983, 1985) interprets the degree of the host country's and the contractor's risk burdens in each type of contract differently from Blitzer. Types of contracts are distinguished into: (1) royalty, (2) production sharing, (3) nonrisk service, (4) service, and (5) joint-venture contracts. Under the service contract, all exploration risks are borne by the contractor, but the host country assumes risks associated with the development stage. In a nonrisk service contract, all risks are borne by the host country. Under the production sharing contract, the contractor bears all exploration risks, and the host country shares the development risk with the contractor. Under the joint-venture contract, the host country participates as an equity partner with the contractor in the development stage. Both parties, thus, share in proportion to their equity interest, the risks and rewards of a combined exploration and development project. In the royalty contract, all risks are borne by the contractor, but the host country indirectly assumes the oil price risk with the contractor.

The implication of the risk-sharing explanation is that petroleum contracts are arrangements that shift some or all risks in oil searching from the host country to the contractor. In other words, the contract is an institution to insure the host country against the uncertainty associated with oil exploration. This explanation is similar to that for the emergence of an insurance company. That is, it is profitable for all concerned that risks are shifted to the agency best able to bear them. An example of a contract 's use as insurance is the cost-plus contract for military procurement. The contract stipulates that the government will reimburse the contractor for all his costs, whatever they may be, plus an agreed fixed profit. This type of contract usually is drawn up between the government and the manufacturer in purchasing very large and expensive items which have not been produced in large quantities previously, for example, air planes. The reason to select this alternative mode of payment is that the contractor finds himself very uncertain about costs and is unwilling to bear the risks. The cost-plus contract can be interpreted as an insurance contract by which the government agrees to reimburse or to mitigate the contractor for his unexpected loss.

In the petroleum industry, contracts may be viewed as a mechanism to shift risk and to insure the host country against expected capital losses in the event that oil is not found. The contract permits the host country to engage in risky activities in oil exploration--a search for an unknown outcome--which it would, in general, not otherwise undertake with its own resources. The contractor can bear all exploration risks because he has a better ability to spread risk relative to the host country. In general, only uncertainty in the amount of the oil discovery is allocated between the host country and the contractor.

Although the risk-shifting explanation seems reasonable, it is an incomplete explanation of the choice of petroleum contract. The risk-sharing explanation assumes symmetric information both ex ante and ex post. Thus, there is no ex-post contractual enforcement problem. In other words, the risk sharing contract implies that the first-best contract can always be realized. This assumption is invalid. In the petroleum industry, asymmetric information may occur ex post or after the contract is agreed upon. Because the contractor solely conducts the oil exploration, only he can acquire the additional geological information. With asymmetric information, the problem of ex-post opportunism may occur. In this study, opportunism is defined as the incomplete or distorted disclosure of information, especially calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse (Williamson 1985). Opportunism can therefore refer to: (1) behavior that involves the appropriation of wealth of one party by the other; and (2) behavior that does not maximize joint profits when particular contingencies arise. Opportunistic behavior may be, in other words, defined as the uncertainty which arises from the unpredictability of human behavior, i.e., the quality of attention and efforts in working for others. The term opportunistic behavior will be interchangeable used with the term behavioral risk.

If risk allocation is the only concern of the contracting parties, one should not observe complicated provision terms in petroleum contracts. The provision terms in petroleum contracts described in section 1.2 reflect the anticipation of the ex-post opportunistic problem by both parties. They also reflect the intention of both contracting parties to prevent the deviation from the original promise in order to increase the other party's utility. All types of contracts contain obligation terms for the contractor to put his full efforts in oil searching such as a

minimum requirement in exploration works, minimum expenditure for exploration. Criteria for resolving the conflict in determining whether a discovery should be regarded as commercial or not is another example. These terms are needed because the host country's interest is specific to the contractor's performance, and the above provisions are mechanisms to detect the contractor's efforts. Therefore, behavioral risks should be one of the major concern of the contracting parties when the contract is drawn.

1.4 Objective and Hypothesis of the Study

As concluded in the previous section, existing explanations for choice of petroleum contract are inadequate. This study hypothesizes that the petroleum contract is designed not only to allocate geological risks between contracting parties, but also to minimize the possible loss from ex-post opportunistic behavior. In other words, this study assumes positive transaction costs in enforcing contractual promises. These transaction costs are the result of ex-post opportunistic behavior or behavioral risks.

By asserting the ex-post opportunism, the agency theory will be used as a framework in explaining the choice of petroleum contract. The agency theory is useful for this study because it closely approximates the character of the petroleum industry. In the agency theory, the share contract is adopted to reduce the incentive problem. This problem is presumed to arise whenever the problem of asymmetric information exists between contracting parties. It takes the form of a principal-agent relationship under conditions of uncertain future outcomes. An agent performs some service in which he has to make a decision on behalf of a principal on productivity as well as to bear the consequences of the random outcome dependent upon nature. In brief, the features of the

existing petroleum contracts are similar to that of the agency theory, i.e., the share contractual structure, the presence of the ex-post opportunistic behavior, and the principal-agent relationship. Therefore, this theory will be applied to explain the choice of petroleum contract.

This study also focuses on the ex-post opportunistic behavior that caused by the host country. Since the contractor is obligated to invest in all exploration activities; if an oil is found in the host country's territory, the host country may deviate from the original promise by expropriating the discovered oil field or the developed oil well. This kind of behavioral risk can be explained as the problem of specificity. Specificity is defined as an input, in which the value belonging to the coordination is higher than elsewhere (Alchian 1984). In the petroleum industry, the oil exploration and development are both specific investments since their capital input is specific and dispensable to a collaboration when the production starts taking off. It is the sunk investment as soon as the contractor starts his activity.

The example of the asset specificity that causes the ex-post opportunism is that if one invests in a machine whose value depends on services rendered by some particular person, and if the services by that person are withdrawn, then the machine losses its specific quasi-rent. This quasi-rent is the excess above the return necessary to maintain a resources current service flow, a sort of recovery of sunk cost (Klein et al. 1978). The investment in specific assets is said to be a potential source to create an opportunism of specific quasi-rent expropriation. The potential ex post opportunism of specific quasi-rent expropriation can be explained as the problem of incomplete information. The incomplete information arises when both concerned contracting parties encounter uncertain outcomes. Hence, they are limited in the ability to specify

response to the future outcomes. In the postinvestment period, if the circumstance changes, each party may deviate from the original promise. As the specific assets after installment are too expensive to remove or so specialized to the particular user that there no market closure to their next best use, then the opportunistic behavior may lead to an appropriation in the investor's specific quasi-rent from the specific asset ex post.

In the petroleum industry, the investments of the contractor in searching for oil or in pipelines, oil fields, etc., once in place, are hostage or specialized to the host country. Thus, the inherent host country's ex post opportunism of specific quasi-rent expropriation in this industry is real. For instance, once the oil is discovered or begins to flow out of the ground, the host country might violate the contract by expropriating that oil field or paying the contractor as low as the marginal cost of extracting oil and might not even generate a return to the contractor sufficient to recoup the initial investment of exploration and drilling. Fearing appropriability, the contractor will therefore seek protection against reneging by the host country.

There are two potential solutions for solving the problem of expropriating specific quasi rent according to the ex post opportunism: common ownership (vertical integration) and some form of long-term contractual relationship (Klein et al. 1978). In petroleum industry, the long-term contract is constructed as a mechanism to prevent this future hazard.

According to the economic theory, there are two major patterns of the long-term relationship to assist in avoiding future hazards of ex post appropriation which are discussed in the existing literature. First, the ideal long-term contract to solve this problem is mentioned as a complete long-term contract: i.e., the contract must clearly specify ex ante the process for the

amount of exchange and the transfer of ex post surplus. In practice, however, unforeseeable contingencies prevent the possibility of specifying all the contingencies at the time the ex ante contract is drawn. Most of the existing long-term contracts in the real world are, therefore, usually in the second type of long-term contract, i.e., the incomplete form.

The incomplete contract emphasizes that contingencies are unforeseeable because there are too many uncertain events to specify in writing. In order to minimize the negotiating cost, it requires the original contract to define only the broad lines of the relationship. If any ex post disputes arise, they will quickly effect a settlement by themselves or through a third party. The incomplete contracts are in two forms. The first is an explicit contract by which the two concerned parties resort to a third party when the unspecified contingencies occur in ex post. Any ex post conflict between them can be solved by the judgment of the third party (e.g., legal centralism). The underlying idea in the explicit contract is that the courts are well suited for administering justice whenever contract disputes arise. In practice, however, the relation between contracting parties tended to be more informal (MaCaulay 1963). Instead, efficiency is usually sustained by the contracting parties' reputation. Hence, this assumption leads to the second form: an implicit contract in which the guarantee is enforced by the market mechanism of withdrawing future business if opportunistic behavior occurs (Klein et al. 1978). This idea of how business can successfully sustain contracting relationships, with relatively so little attention to detailed planning, is found, for example, in Telser (1980) and in Klein and Leffer (1981). Telser and Klein and Leffer assume that coadaptation or behavior in conforming to this implicit contract preserves and reflects reputability for not exploiting the trust of others. Conveying a similar idea,

Williamson (1985) uses his hostage model in discussing the market force to assure that the exploitation of the specific quasi rent will not occur in ex post. These models make the same major assumption that the continuity of the contract is possible whenever each party believes that they will both better off than ending it. In addition, if one party does violate the contract, then the only recourse of the other party is to terminate the contract after he discovers the violation. All ex post problems in the implicit contract are settled without third-party intervention. The self-enforcing contract theory is therefore employed to explain why the renegotiation for a new term or type of contract is observed in the petroleum industry.

1.5 Organization of the Dissertation

This dissertation consists of four chapters. Chapter II discusses the concept of the agency theory and its application to the petroleum contractual choice. Chapter III formulates a theoretical framework to analyze petroleum contractual choice in the context of the agency theory. The discussion on the continuity in the contractual relationships and general solution to the ex-post problem are also presented in order to explain how the contractor mitigate the host country's ex-post opportunistic behavior. This chapter will lead to a series of statements about conditions under which one should observe different types of contracts if the explanation is correct. Empirical evidence and hypothesis testing are presented in Chapter IV. Chapter V summarizes and concludes the study.

CHAPTER II

AGENCY THEORY AND CHOICE OF PETROLEUM CONTRACT

The purpose of this chapter is to review agency theory and to assess its application to the contractual choice problem in the petroleum industry with respect to ex-post opportunistic behavior. Section 2.1 provides a review of the agency theory and its application to the problem of choice of petroleum contract. Section 2.2 discusses the asymmetric information problem and the ex-post opportunistic behavior in the petroleum industry. Section 2.3 discusses the geological information differential in host countries. Section 2.4 summarizes the main points of the chapter.

2.1 The Agency Theory

The essence of the agency theory is to scrutinize the efficiency of alternative types of share contracts and conditions for attenuated or "second best" solutions advanced under the incentive problem. According to the agency theory, it is the incentive problem that prevents the arrangement by the contracting parties for the first-best contract. The incentive problem may arise in a contractual relationship because of the fact that one party's action can affect uncertain outcomes and that party has better access to information about causes of observed outcomes ex post. In other words, there is a problem of asymmetric information between the contractual parties after a contract has been drawn. This kind of situation is usually found between a principal and his agent. The agent performs some service in which he has to make decisions about productivity on behalf of the principal as well as bear the consequences

of the random outcomes of the state of nature. In other words, the principal must rely upon the agent's choices about uncertain outcomes.

The problem of contractual choice in the agency theory context can be better understand when we compare it with the symmetric information situation (entailing optimal risk sharing). In the situation of symmetric information, a first-best solution can be achieved by employing a forcing contract. Any misbehavior can be detected and penalized because all information necessary for identifying each party's specific contributions (in terms of productivity) to the outcome is available. Therefore each party will be rewarded according to his contributions. That is, the more effort one contributes, the more residual values one can collect.

In the case of asymmetric information, the contracting parties are still assumed to be making their decisions optimally in view of their constraints. But the agent's constraint differs from the principal's in that the agent has some observation that the principal does not have. The agent uses this observation in making their decisions, and the principal cannot check whether the agent is using this information to promote the principal's interests. Since the future outcome and the agent's action can not be observed by the principal at the time he has to set the fee schedule, the principal will pay the agent in proportion to the the future output that will be generated by the agent. The underling concept is that the generated outcome is a function of the agent's performance. Therefore, a fee schedule associated with the future outcome will serve as the index of the agent's performance and the agent's incentive to work will be compatible with the principal's interests. In other words, the establishment of a fee schedule which relates to the agent's effort, trades off some of the risk-sharing benefits for provision of incentives in the situation of asymmetric

information. The agency theory further predicts that if additional information related to the future outcome is available, there will be gains in observing the agent's action since the information and the agent's action are functions of each other. This additional information is useful in detecting the agent's action and in improving the accuracy of the fee schedule which corresponds to the agent's contribution. That is, the principal will provide the agent with a reduced incentive fee schedule when additional information becomes available. The more information the principal can obtain, the more accurately he can set up the fee schedule which corresponds to the agent's performance. Therefore, in the case of an incentive problem, the normative agency theory predicts that various payment patterns of share contractual structure are selected according to the principal's information level at the time the contract is drawn.

The normative agency theory described above can be applied to explain the problem of petroleum contractual choice for four reasons. First, both the agency theory and petroleum contractual choice model primarily deal with the problem of risk-sharing contractual choice. As concluded in Chapter I, petroleum contracts serve as a risk-sharing institution. Therefore, the agency theory is applicable to choice of petroleum contract. Second, one of the objectives of the agency theory is to explain the choice of various types of share contracts. Share contracts, in the context of the agency theory, are distinguished by the payment patterns adopted by the principal. By the same token, share contract with different patterns of payment are observed in petroleum contracts as demonstrated in section 1.2, Chapter I. Third, the relationship between the host country and the contractor can be characterized as a principal-agent relationship. Fourth, the purpose of the normative agency theory is to explain the choice of share contracts in the presence of the incentive

problem. Since the purpose of this study is to explain the choice of petroleum contracts under the condition of ex-post opportunistic behavior, the agency theory is applicable to the problem because ex-post opportunism may be manifested as the incentive problem.

Before formulating a model of the choice of a petroleum contract in the context of the agency theory, the problems of ex-post opportunistic behavior and the nature of information differential among host countries will be discussed. These are two main factors in contractual choice in the context of the agency theory.

2.2 Ex-post Opportunism in Petroleum Exploration Industry

Ex-post opportunistic behavior in petroleum exploration industry may arise when the contractor can solely acquire additional basic geological information as exploration proceeds, and he uses it to serve his interests which may not be compatible with the host country's interests. The conditions that may lead to information differentials or asymmetric information in the petroleum industry and how the problem of asymmetric information may lead to the problem of ex-post opportunistic behavior are described below.

(1) Asymmetric Information

Asymmetric information in the petroleum industry occurs during the post-investment period. This problem arises because the contractor is obligated to conduct all the exploration activities and to bear any losses that might occur. Since the ability to determine whether oil exists in commercial quantity is a function of the basic geological data collected during exploration of a site, only the contractor can acquire such information.

The accumulation of geological data at each exploration stage is as follows: (1) The oil exploration begins with a geological survey using a geophysical prospecting method, such as gravimetry and magnetometry, associated with mapping techniques. The operations at this stage can not be specific to the presence of petroleum because it normally forms only part of the general inventory of natural resources at a particular area. If the geological survey shows the possible presence of hydrocarbons, further exploration will be taken. (2) Next, seismic survey, a type of geophysical survey, is conducted. It attempts to locate the depths within the basin where structures may have captured and preserved hydrocarbons by using data taken from surface measurements. Although a geophysical survey shows the presence of hydrocarbon traps, none of the available techniques can show whether an oil deposit in commercial quantities lies beneath. There is no other way but to drill a hole in a ground. (3) Drilling or development is a method of trial and error to specify exactly whether there is any commercial oil at that site. Therefore, the final result of the oil discovery is determined by the geological data accumulated from succeeding exploration processes. Since the contractor solely conducts all stages of the oil exploration, the occurrence of asymmetric information ex post is obvious.

(2) Ex-post Opportunistic Behavior

With the presence of the asymmetric information, it is likely that the contractor will pursue courses of action inconsistent with the interest of the host country, especially in the decision to develop the oil reservoir. That is the problem of ex-post opportunistic behavior. According to the original promise, the contractor is obligated to search and to develop oil that is discovered.

However, there is a possibility that the contractor will not want to keep this promise. The contractor can estimate the amount of oil or gas in the area using the geological information from an exploratory well. This information is, of course, only known to the contractor. If this estimated amount of oil discovery is equally known by both parties, the parties may have different opinions about whether the discovered reservoir should be developed. This is because each of the parties' maximized net profits can differ for a certain quantity or quality of oil discovery. The host country is interested in developing any reservoir which will ensure maximum ultimate recovery and yield maximum benefits to its economy. The host country may only aim to maximize its revenue from the oil reservoir discovery because it does not have any obligation in capital investment in exploration and development. At the same time, the contractor's maximization function may differ from the host country given the same quantity and quality of oil discovery because he may rather maximize his long-run net return on his overall global operation.

Due to the costs of oil reservoir development are substantially high compared to costs in other stages of petroleum operations, they may prevent the contractor from continuing the operation in some discovered oil field despite a certain amount of capital he has already invested in the exploration stage. Hossain (1979: 77) approximates that 5 to 10 percent of the total cost is on geological survey, 15 to 30 percent on the geophysical prospecting, and 60 to 75 percent on the exploratory and development well drilling. Furthermore, drilling or development is a very expensive method of trial and error. It is estimated that there is a chance of about 85 percent that results in either not finding oil or finding oil in an non-commercial quantity in drilling exploratory well (Welker 1985: 35). Costs and length of time in drilling are also unpredictable.

Drilling costs per day can vary from $ 3,000-$ 50,000, and the time required to drill can range from a few days to several years (Welker 1985: 41). Therefore, it is not unusual that the contractor's discount rate may be different from that of the host country, and that conflicts in opinion over oil reservoir development between the host country and the contractor can arise in the development stage.

If the contractor finds it unprofitable to further develop the oil reservoir, but suspects that the host country may want him to develop it at the amount of the estimated oil discovery, the contractor will certainly not reveal the actual amount oil discoveries to the host country. This is characterized as the ex-post opportunistic behavior in the petroleum exploration business. Evidence to support this argument can be seen from the case between Iraq Petroleum Company (IPC) and the Iraqi government.

> The files...proved that IPC had drilled and found wildcat wells that would have produced 50,000 barrels of oil per day....The firm plugged these wells and did not classify them at all because the availability of such information would have made the company's bargaining position with Iraq more troublesome.
> (Hossain 1979: 47)

2.3 Geological Information Differential in Host Countries

According to the agency theory, the principal's possession of information about the future outcome is another major determining factor in the choice of contract. In principle, this information differential determines the patterns of the payment schedule or types of contract. Therefore, there should be an information differential across the host countries at the time the contract is drawn if the agency theory is applicable to the problem of the petroleum

contractual choice. The information differential in the petroleum industry is described below in terms of the geological risk differential across countries.

By its very nature, petroleum exploration involves a high risk since there is no known scientific method of determining whether a commercial deposit lies beneath a given spot before drilling. In addition, before drilling, there is no kind of model to use as an analog in searching for oil since the basic process which controlled the origin, accumulation, migration, and entrapment of petroleum reserves is not known from the outset. Even in previously drilled areas, the prospect of oil discovery still cannot be predicted with any certainty (Adelmen 1972).

However, the probability estimation of possible outcomes of exploration can be applied to a particular area if many fields have been discovered in that area (Van Meurs 1981: 65). Therefore, at the time a contract is drawn, each party can rely on the past experience in oil discovery of commercial fields in a similar condition in the granted area. This information is then transformed into the form of subjective probability to find oil in a particular area. The probability estimated will then be used as the fundamental factor in making the choice of contract. This past information is therefore essential to decision making in a petroleum contract.

The discussions above point out that the possible outcome in oil exploration can be predicted from oil field discoveries in that area. The close correlation between a high probability of finding oil in a commercial quantity and a large amount of oil discovered in that country is widely recognized in the petroleum business (Welker 1985: 35). According to the existing oil discovery process models, the proxies of geological information which are indicators for possible oil discoveries are generally presented in the form of the amount of

past oil discovery at that site. Although structures and data requirement by these models are different, the central assumption is that the larger the field, the more likely oil will be discovered (Attanasi, Drew, and Root 1981: 9). For example, Fisher (1964) predicts a new reserve discovery by using the past record of (1) the success ratio (proportion of wildcat wells that resulted in a dry well and that resulted in a commercial discovery), and (2) the average size of oil fields discovered. MacAvoy and Pindyck (1975) use Fisher's basic approach in their petroleum industry econometric model in forecasting the reserves from new discoveries. Arps and Roberts (1958) propose that the probability of discovery is directly proportional to the number of fields remaining to be found and their areas. Barouch and Kaufman (1977) assume the size of distribution of fields to be lognormal and the probability of discovery is proportional to the size of the oil field.

Since the information relating to the future oil discovery is determined by past oil discoveries, the level of this information varies from area to area, i.e., the more development wells are drilled, the more geological information is available and the better the estimates are that oil will probably be produced from that area. Hence, it is a general rule that the degree of accuracy of the subjective probability estimation in an explored area is higher than in an unexplored area. The level of information can be roughly divided into two groups. The first group is the group where the probability distribution of oil discovery can only be estimated with a wide range of confidence. This situation can be applied to the case of an initial investment in searching for oil in an area where very limited geological data is available. The probability distribution in this area is still uncertain, even after the area has been explored and one or two successful wells have been drilled because there are only a few degrees of

freedom in existence at that site. The second group is the group where the probability distribution of the possibility to find oil is known with more certainty because an area has been explored and a high volume and distribution of reserves in that area is experienced. In this case, knowledge of the geological structure will provide a basis for determining the probability of a petroleum reserve discovery in that area. Further, the previous exploration and production in a given region provides the basic information for estimating the size/frequency distribution of reserves in a given field, i.e., the probability of the existence of reserves of different amounts of oil.

In conclusion, the above discussion relates the subjective probability for success of finding oil to geological information possession. This degree of information varies from area to area and can be revised over time. In this study, the proxy for information is the probability density function of oil to be discovered at any time in a particular country; it is a proportion between the proved reserves to date and the number of oil fields or oil wells in operation of that country. The larger the size of this random variable, the higher the chance to discover oil in that area. The proven reserve of crude oil is defined as the quantity of crude oil demonstrated with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. The term "field" is used to refer to a single accumulation or a set of closely related accumulations of petroleum.

2.4 Summary

In this chapter, it is shown that the condition of asymmetric information can arise in the petroleum industry. Therefore, apart from the geological risk, potential ex-post opportunistic behavior may also be present in the petroleum

industry. The potential ex-post opportunistic behavior arises from the incomplete or distorted disclosure of information which may take place ex post. In this respect, the nature of the agency theory approximates the character of the petroleum industry. Therefore, the agency theory may be applicable to the problem of choice of petroleum contract. In the subsequent chapter, the relation between these two factors will be incorporated into a choice model using the concept of the agency theory.

CHAPTER III

A PETROLEUM CONTRACTUAL CHOICE MODEL

The purpose of this chapter is to formulate factors determining choice of petroleum contract discussed in the previous chapter into a contractual choice model. The model is based on the premise that a host country and a contractor cooperate in various contractual forms in order to minimize expected production and transaction costs. The expected production and transaction costs are derived from both event and behavior uncertainty. The assumption of agency theory has been shown to be applicable to the problem of petroleum contractual choice and thus agency theory will provide the theoretical structure for formulation of the model. Since the renegotiation of a new term and type of contract is usually observed in the petroleum industry, the assumption of the self-enforcing contract will also be used to explain such phenomenon.

The contents of this chapter are organized as follows. Section 3.1 discusses the choice of contract under symmetric information. This section provides a base case for the model formulation which will be modified in subsequent sections. Section 3.2 incorporates the ex-post opportunistic behavior into the model; the choice of petroleum contract in the situations of little known information and additions to known information will be analyzed, respectively. Section 3.3 discusses the economic of continuity in contractual relationships and analyzes the general solutions to the ex-post problem. Section 3.4 summarizes the main findings of the chapter.

3.1 Contractual Choice Under Symmetric Information

In constructing a contract, if the presence of the geological risk and symmetric information are assumed, it can be shown by a mathematical proof that choice of contract depends on each party's risk preference. The mathematical model presented here is based on the following assumptions:

(1) A set of possible outcomes, {x}, depends on a given set of state of the world, {S}.

(2) Before and after the time a contract is drawn, both the host country and the contractor can acquire the same information about future outcomes of oil discovery.

(3) The generated outcomes {x} are produced through the actions of the contractor, and the oil discoveries generate utility to both parties.

Based on the above assumptions, the contractor therefore receives y_i as his share of producing x_i in state S_i. Thus, the host country receives x_i-y_i. These shares are set before the oil productivity is known. Since both contracting parties are dealing with decision making under an uncertain outcome, their utility functions are represented by the Neuman-Morgenstern (N-M) utility function. Both parties are assumed to be utility maximizers and can be either risk neutral ($U'' = 0$) or risk averse ($U'' < 0$).

The host country's problem is portrayed by the following Lagrangian function:

$$L = P_1 * U(x_i - y_i(x_i)) + \varnothing (P_2 * V(y_i) - V^0) \qquad (3.1)$$

where U(.) and V(.) are the host country's and the contractor's utility functions, respectively. P_1 and P_2 denotes the probability of success of finding oil in the

opinion of the host country and the contractor, respectively. The above function is set up in expected functional form because the analysis involves risk.

The solution of the optimal payment y^*, in order to share geological risk, can be characterized by the first order condition of equation (3.1):

$$\frac{U'(x_i - y_i^*)}{V'(y_i)} = \phi * \frac{P_1}{P_2} \tag{3.2}$$

The optimal contractual choice under pure risk-sharing model can be obtained by differentiating equation (3.2) with production x_i. Then,

$$- P_1 * U'' \left(1 - \frac{\partial y^*}{\partial x}\right) + \phi * P_2 * V'(y_i) \frac{\partial y^*}{\partial x} = 0$$

$$\frac{\partial y^*}{\partial x} = \frac{P_1 * U''}{P_1 * U'' + \phi * P_2 * V''(y_i)} \tag{3.3}$$

The indexes of absolute risk aversion of the host country and the contractor are respectively defined as:

$$r_p = \frac{-U''}{U'} \qquad r_a = \frac{-V''}{V'}$$

Given risk aversion $r_p, r_a > 0$, substituting for ϕ in equation (3.3) and rearranging gives

$$\frac{\partial y^*}{\partial x} = \frac{r_p}{r_p + r_a} \tag{3.4}$$

Equation (3.4) implies that the choice of contractual form under the efficient geological risk-sharing problem only depends on the contracting parties' behavior toward risk. Whereas, the difference in the opinion of probability of fining oil is canceled out. In the case where the fee payment is in a linear payment schedule of the stochastic outcome, the schedule is in the form of:

$$Y = aX + b$$

Then, $$Y^* = \frac{r_p}{r_p + r_a} X + b$$

This implies that if the host country is risk neutral, $r_p = 0$, then $Y^* = b$; the optimal contract is in the wage contractual form since for any change in oil production, the contractor's reward is constant. In another extreme, the contractor is risk neutral, $r_a = 0$, then $Y^* = x+b$; the optimal contract is the fixed-rent contract since for any change in oil production, the contractor's reward will change by the full amount. If both parties are risk averse, an optimal contract is in a share contractual form since for any change in oil production, the contractor's reward will also change by a same proportion to the change in oil production. Therefore, if symmetric information prevails, both in ex ante and in ex post, the first-best optimal contract can be arrived at with any type of contract, which is sometimes called forcing contracts.

3.2 Contractual Choice Under Asymmetric Information

In this study, it is assumed that the behavioral risk is inherent in the contractual arrangement and determines the type of petroleum contract. Behavioral risk will be incorporate into the choice model in this section. As shown in Chapter I, many contractual terms contained in petroleum contracts are to mitigate the effects of behavior risk. However, it will show in this section that not only the mitigating terms have been adopted, but also different patterns of incentive payment have been provided to the contractor in accordance with the host country's level of information about future oil discovery. These patterns of incentive payments provided by the host country determine the type of petroleum contract.

With uncertainty in future outcomes and behavior risk, the fee schedule will apportion the contractor's rewards to generated output. There are two purposes in this assignment: (1) the use as a means to reveal the contractor's marginal productivity, and (2) the use as a means to induce the contractor to allocate his full effort to produce the common product in a way compatible with the host country's interest. Therefore, the reward to the contractor is a sign of incentive payment, i.e., the more the contractor works, the higher reward he will obtain.

Since the uncertainty of outcome is a function of geological information, the incentive payment is related to the geological information. The following model will show that under the condition of asymmetric information, the host country will provide different incentive payments in accordance with the available geological information he acquires at the time contract is drawn. Therefore, the share contractual form is determined by the different incentive payment associated with the geological information acquisition.

Since the information differential across countries can be distinguished into two levels, the model will present the optimal incentive fee under these two conditions.

(1) The first condition assumes that the host country and the contractor encounter the condition of limited geological information, i.e. there has been little or no exploration in that country , at the time a contract is drawn. Given the problem of the ex-post opportunistic behavior, the contractor's effort is allowed to vary. He will not want to continue his works, if the net return is not high as he expects, $G'>0$, and his effort aversion will increase at an increasing rate, $G''> 0$. The host country's maximization problem is therefore constrained by the contractor's reservation utility function, that is $\{V(y(x_i))-G(a)\}$. In this case, the

host country's lack of ability to observe the contractor's effort means that the host country cannot directly police the contractor's incentive to cheat directly. So, a constraint called "the incentive constraint" is added to the host country's maximization function in order to make the contractor put his full efforts into the operation. Since this incentive constraint can affect the contractor's actions and mitigate the ex-post opportunistic loss, then the host country's maximization problem is to select an appropriate incentive constraint which is reflected by his choice of payment schedule or the optimal contractual form. The maximization condition can then be written as:

$$\underset{y,a}{\text{Max}} \quad P(a)^{*} U(x_i - y_i(x_i))$$

$$\text{S.T.} \quad P(a) * V(y_i) - G(a) = V0$$

$$P'(a) * V(y_i) - G'(a) = 0$$

The incentive constraint is the function by which the contractor chooses action "a" to maximize his reservation expected utility function. Thus, the new Lagrangian form is written as:

$$L = P * U[x_i - y_i(x_i)] + \varnothing [P * V(y_i) - G(a) - V^0] + \mu[P'(a) * V(y_i) - G'(a)]$$

Under the assumption of an interior rule, the optimal sharing rule will satisfy:

$$\frac{U'(x_i - y_i^{*})}{V'(y_i)} = \varnothing + \mu \frac{P'(a)}{P(a)} \qquad (3.5)$$

The result in equation (3.5) shows that the risk-sharing rule with the presence of the incentive problem will not be Pareto-efficient. Because the ratio $\frac{P'(a)}{P(a)}$ is a monotonic likelihood ratio, the more effort the contractor puts in, the

higher is the chance to find oil, $\frac{\partial P}{\partial a} > 0$. Therefore, the distortion $\mu > 0$ accounts for the incentive effects of the contractor and his choice of action "a".

Under the condition of the limited geological information, the optimal contractual form with the presence of tne asymmetric information problem can be gained by differentiating equation (3.5) with respect to production x_i. This is sharing rule in the presence of the incentive problem. Given the incentive problem, the optimal type of contract is:

$$\frac{\partial y^*}{\partial x} = \frac{r_p}{r_p + r_a} \frac{U'}{V'} + \frac{\mu}{r_p + r_a}\left[\frac{P_{ax}}{P} - \frac{P_a P_x}{P^2}\right] \qquad (3.6)$$

The choice of payment or type of contract, given the outcome, depends on the contractor's choice of effort and hence the effect on the probability of getting x. It can be seen that the simplicity of the earlier results on the form of the efficient risk-sharing contract, as shown in equation (3.2), is lost, but the optimal choice of contract or payment can still be interpreted from the way the probabilities P and $\frac{\partial P}{\partial a}$ vary with x--i.e., the degree of beliefs of chance to find oil plays a direct role in choice of payment or of contractual form.

The interpretation of choice of optimal payment schedule for this model has to be somewhat redefined following Holstrom (1979), who explained this problem by an alternative in payment schedule resulting from an added incentive constraint. He interpreted ø not as a multiplier associated with the reservation utility constraint but simply as a fixed weight. ø is now constant and non-zero.

Since $\mu > 0$, $1 \leq p \geq 0$, and ø is constant. The sign of $\frac{U'}{V'}$ will therefore depend upon the sign of $\frac{\partial P}{\partial a}$. That is, the more effort the contractor puts in, the greater the chance that he will find oil. Therefore, the host country must choose an optimal incentive payment to induce the contractor to work hard for him.

Under the condition of limited geological information, the high incentive type of contract is therefore selected by the host country in order to encourage the contractor to work harder.

(2) Next, the consideration will shift to the selection of type of contract under the condition of less uncertainty of geological risk. Since the host country can use the realized oil production to reveal the contractor's marginal productivity under the share contractual structure, then the more geological information about the realized production the host country can obtain, the more accurately the host country can determine the contractor's reward. This will lead to an alternative incentive compensation payment in the contract. Therefore, the condition of the additional information of future realized oil production and the new contractual choice will be considered as follows.

Suppose a set of messages {m}, i.e. oil is discovered in a particular country, is available to both parties. According to the statistical principle, "information" means any observation that effectively changes probabilities according to the principles of conditional probability. The receipt of this new information enables the contracting parties to revise their initial probability estimates using the statistical method called Baysian Analysis.[1] The acquisition of additional information results in a reduction of uncertainty and, in turn, allows an alternative type of optimal contract.

The revised probability deriving from additional information can be expressed in the following computation.[2] Suppose $s_1, \ldots, s_n$ are N mutually and exhaustive states of nature, and let "m" be an event for which one knows the conditional probabilities $P(m|s_i)$, given s_i and the absolute probabilities $P(s_i)$. The conditional probability $P(s_i|m)$ or $P_{s.m}$ of any one of the states of nature s_i, given m, can be computed from the following equation:

$$P(s_i|m) = P_{s.m} = \frac{P(m|s_i)P(s_i)}{\Sigma\,[P(m|s_i)P(s_i)]} \qquad i = 1, \ldots, n$$

$P(s_i)$ represents the original probabilities, sometimes referred to as a priori probabilities. When "m," some new bit of information, is used to calculate a new value of $P(s_i)$, we get the conditional probability $P(s_i|m)$. This revised probability is called posterior probability.

The payment schedule and the probability terms are now changed from the above discussion, since additional information is incorporated. The posterior probabilities give a joint probability of outcome "x" and information "m." New payment schedules, {Z}, are used under the new arrangements. So, the host country's maximization problem becomes:

$$\underset{z,a}{\text{Max}} \qquad P_{s.m}{}^{*}\, U(x_i - z_i(x_i))$$

$$\text{S.T.} \qquad Ps.m(a)^{*}\, V(Zi) - G(a) = V0$$

$$P'\, s.m(a)\, {}^{*}\, V(Zi) - G'(a) = 0$$

where "$P_{s.m}$" is a function of the contractor's efforts, as in the previous case.

Expectations in the new equation depend on the joint distribution of the random variables--the outcome and event "m." Then, the Lagrangian function becomes:

$$\frac{U'(x_i - y_i^{*})}{V'(y_i)} = \varnothing + \mu \frac{P'_{s.m}}{P_{s.m}}$$

This equation implies that the acquisition of additional information will lead to a higher predictability of the oil discovery events for both concerned contracting parties and for any other oil contractor who comes to explore in that area, since the revised probability results in greater accuracy in the prediction.

The effect of additional information on outcomes is illustrated by Figure 3.1. Suppose the possibility of oil discovery is a continuum of values from zero to some upper limit S, depicted horizontally. In the prior probability pictured, the bulk of the initial probability is weighted toward the low end. When a message (evidence) is received, the chance of finding oil assumes a larger rather than smaller value, as the likelihood function indicates. The posterior probability distribution is a compromise or average of the other two curves.

The acquisition of additional geological information in any particular area is a direct function to past explorations in that area. The longer that area has been explored, the more geological knowledge is available in that area. On the other hand, the more efforts the contractor has put in, the more geological knowledge will be obtained and the higher chance to find oil can be expected. The effect of the joint distribution of the contractor's effort and the acquisition of the additional geological information on raising the chance to find oil can be seen from the incentive constraint function. According to this function, the contractor is supposed to choose action "a" to maximize his expected utility in order to be rewarded with the additional payment of:

$$\frac{\partial P}{\partial a}\frac{\partial m}{\partial a}V(Zi) - G'(a) = 0$$

$$\frac{\partial P}{\partial a}\frac{\partial m}{\partial a} = \frac{G'(a)}{V(Zi)}$$

Both G'(a) and V(Zi) are positive, therefore the joint distribution $\frac{\partial P}{\partial a}\frac{\partial m}{\partial a}$ is also positive. The higher contractor's efforts, the more geological information will be available and this will increase the probability accuracy of finding oil, $\frac{\partial P}{\partial a} > 0$ and $\frac{\partial m}{\partial a} > 0$.

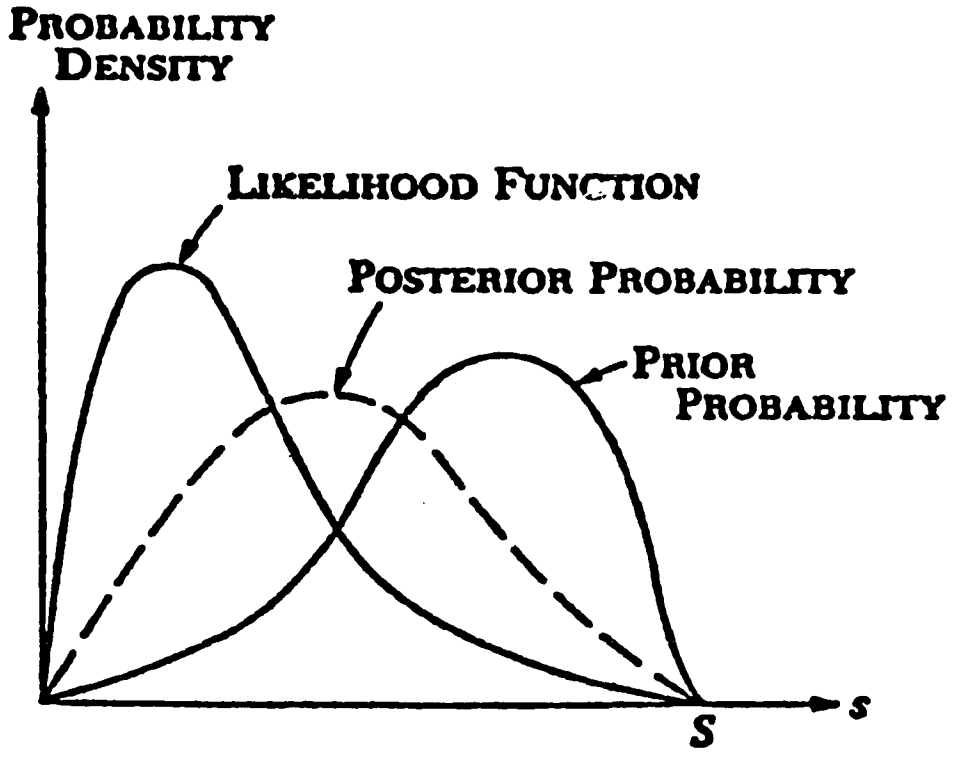

Figure 3.1 Bayesian Recalculation

The more certain the host country is in predicting the probability of finding oil , the more likely he is to modify his payment to the contractor in the light of an observed message. Therefore, there is increased likelihood of setting up the right kind of incentive for the contractor. The form of payment function is similar to the previous case; only the probability of success of the future outcome is different. As more geological information becomes available, if $\frac{\partial P}{\partial a} > 0$, which is the result of $\frac{\partial m}{\partial a} > 0$, the payment made by the host country for a given outcome will be lower. The value of additional information is not the information gain on the likely value of the contractor's effort, but the host country's cost reduction in providing the right incentive to the contractor. If some variable "m" is observed, whose value also increases with "a" and "s", it becomes less likely that high values of both "x" and "m" would be observed when "a" is in fact low, and less likely that low values of both "x" and "m" would be observed when "a" is in fact high. Thus, incorporating "m" into the function reduces the chance of wrongly rewarding a low "a" and wrongly penalized a high "a". Therefore, the alternative optimal contract will be reached under the correct payment constraint. In brief, the hypothesis on the choice of petroleum contract can be stated as follows: the optimal share contractual forms are dependent on the contracting parties' subjective probabilities of realized oil production, i.e. the more information they have about the realized production, the more likely the contract will be characterized by a lesser incentive compensation system.

3.3 Economics of Continuity of Contractual Relationship

The following analysis will concentrate on the assumption that the reputation is a factor of restraining a host country's ex-post opportunism in any contractual arrangement. Suppose that the concerned specific assets begin to

generate common products in period t=1, and this production is expected to continue until period t = n. Therefore, the contractor's specific quasi-rents prevail during period t = 1, 2,...,n of the contract's life. For simplicity, it will be assumed that the host country expects to receive the same amount of the revenue, R, in every period "t", from t=1 until t=n. It also pays the same production costs, C, during the entire period t=1...,n. If $\beta = 1/(1+r)$ denotes the discount factor and r is the market interest rate, the host country's intertemporal profit is equal to:

$$(R-C)\,(1+\beta+\beta^2+\ldots+\beta^n) = \frac{(R-C)}{1-\beta}$$

$$= \frac{1+r}{r}\,(R-C)$$

In other words, if the host country is honest, it can expect to obtain the intertemporal or long-term revenue of $\frac{1+r}{r}$ (R-C) from the collaboration. However, the host country also has the option to choose short-term profit. That is, if it decides to take over the specific assets or to appropriate the contractor's specific quasi-rent, the host country gains additional intertemporal profits from such opportunistic behavior without paying additional resource costs. However, such opportunistic behavior on the part of the host country also creates some costs to it. Its short-term benefit or one-time theft is the trade-off between the one-time profit and the loss of all future business with its contractor and maybe with all other contractors. This loss of future business can therefore be interpreted as the host country's reputation cost, denoted by C_0. Therefore, a necessary condition of honesty imposed on the host country can be written as:

$$\frac{1+r}{r}\,(R-C) \geq R - C_0$$

This equation can be interpreted as the function of the market value of the host country's reputation for contract reliability. According to the equation, the left-hand side is the host country's intertemporal profit from the honesty as already mentioned. On the right-hand side is one-time theft or short-run profit that he can earn, if he cheats. In terms of the self-enforcing contract, this means that the host country will be honest as long as its long-term profits from the ongoing contractual relationship are equal to or greater than its one-time theft or short-run profits.

The equation expressing the host country's reputation for reliability of contract can be rearranged as follow:

$$R + rR - C - rC \geq rR - rC_0$$

$$rC_0 \geq C + rC - R$$

$$rC_0 \geq (1 + r)C - R$$

$$C_0 \geq \left(\frac{1+r}{r}\right) C - \frac{1}{r} R$$

This new equation implies that the host country will not cheat if it expects that its reputation costs are equal to or greater than the difference between its intertemporal production cost and present value of its income stream. The terms on the right-hand side can be interpreted as intertemporal loss (negative net present value of revenue). On the other hand, it can be said that the host country will not cheat if it expects that its reputation cost will be higher than the intertemporal loss (see Table 3.1).

On the contrary, the above equation can deviate from the equilibrium under two conditions: (1) The host country does not care about its reputation. This implies that its reputation cost has become lower than its intertemporal loss

Table 3.1

Potentiality of Opportunistic Behavior when Circumstances Change

Change in Variable	Left-hand Side	Right-hand Side	Result
None	C_0	$\{(\frac{1+r}{r})\,C - \frac{1}{r}R\}$	LH=RH
$C_0\downarrow$	$C_0\downarrow$	$\{(\frac{1+r}{r})\,C - \frac{1}{r}R\}$	LH < RH
$r\uparrow$	C_0	$\{(\frac{1+r}{r})\,C - \frac{1}{r}R\}\uparrow$	LH < RH
$C\uparrow$	C_0	$\{(\frac{1+r}{r})\,C - \frac{1}{r}R\}\uparrow$	LH < RH
$p\uparrow$	C_0	$\{(\frac{1+r}{r})\,C - \frac{1}{r}R\}\uparrow$	LH < RH

or its negative net present value of revenue. The host country will therefore deviate from the honest position by expropriating the contractor's assets installed in the country. (2) There is a change in the expectation in the intertemporal rates of costs, production, prices, or any other factors relating to the net present value of revenues. Furthermore, the effects of changing terms on the right-hand side can take two forms: (1) First is the change of any factor that leads to a change in the expectation relating to the net present value of revenues from operation. For example, the steep increases in oil price may effect in the higher expectation in the intertemporal revenues. (2) Second is the change of any factor that leads to a change of control in variation of prices, output and other conditions affecting the level of the net present value of revenues. Under the sel-enforcing contract, a conflict arising from the change in circumstance, as in case(1), could be resolved by renegotiation the terms of the contract or by a solution within the existing ex ante contractual structure. Case (2) requires considerable rearrangement in the degree of the ownership rights between the concerned contracting parties. On the other hand, the conflict has to be resolved by a switch to a new contractual form.

Now suppose some circumstances change, i.e., the expectation of the net intertemporal revenue or of the reputation costs changes. These changes result in a potential violation either in the case that the host country becomes a potential one-time cheater or that the host country expropriates the contractor's specific assets. As we assume that the contractual choice has incorporated a reputational factor as a constraint, this condition can be true if one observes that, when ex-post conflict arises, there will be some mechanism to solve the problem in order to preserve the ongoing contractual relationship. The underlying concept of this hypothesis is associated with the presumption of the

self-enforcing contract, which predicts that if the reputational assumption is correct, one should observe that both concerned contracting parties will avoid conduct that might interfere with their continuing successfully in business.

First, consider the change in the terms of the right-hand side of the equation. In the case where the change leads to the change of the net present value of revenues, and if the hypothesis of the implicit long-term relationship is correct, then one should observe that the adjusted mechanism or renegotiation will be adopted by the concerned contracting parties to preserve the ongoing relationship. One type of mechanism which may be used to prevent the one-time theft dispossession by the host country is to pay the latter a future premium. That is a price sufficiently greater than the average variable cost to assure a quasi-rent return that will exceed the potential gain from cheating (Klein et al. 1978: 304). In this case the host country's future premium stream might be increased through an adjustment of contractual terms, e.g., contractual renegotiation. So, the host country will receive a higher portion of the generated outcome than was provided in the original agreement. Thus, the value of its expectation on the right-hand side will be equal to the term on the left-hand side again.

Taking another case, a change may occur in the right-hand side of the equation if the control over the variation in the value of the outcome switches from the contractor to the host country ex post. The adjustment to resolve their ex-post problem can lead to the formulation of a new type of contract. Under this new circumstance, a rearrangement in the ownership rights is necessary since the contractor is not only specific to the host country on specific assets, but also because of the ex-post opportunistic behavior. In order to reduce the opportunistic behavior, the contractor will therefore be willing to rearrange the

ownership by allowing the host country to claim higher residual rights. Hence, one will observe that the contractual form alters from the initial arrangement in this case.

Second, if dispossession did occur according to the change in the terms on the left-hand side, under the reputational assumption, the contractor is still able to solve the ex-post problem without third party intervention. To solve this problem, the self-enforcing contract theory relies on the mechanism of effective market sanctions. It is hypothesized that this sanction mechanism can help to enforce the contract effectively since the host country has considerable interests tied up in the contractor's performance in associated with human-capital specificity. Therefore, if the condition holds that the host country is specific to the contractor's performance, the contractor can effectively enforce the contract by withdrawing his services partly or entirely until the host country has performed in the contractor's satisfaction. The more the host country's interest has to depend on the contractor's performance, the better the sanction mechanism can enforce the contract. This sanction mechanism may be enforced directly by only one contracting party or by all the contractors in the industry. If the good cooperation among the group of the contractors exists, any misbehavior by the contractor will easily lead to the loss of his future business in that industry and result in better enforcement of the contract mechanism.

3.4 Summary

In this chapter, the model of petroleum contractual choice is formulated. With the presence of geological and behavioral risks, the model predicts that each type of petroleum contract is selected to minimize the expected production and transaction costs. The host country and the contractor enter into a contract

to share risk related to each party's ability to bear risk. The type of contract is determined by the incentive payment. A different incentive payment is selected in association with the risk situation in that country which in turn relates to the past geological record. Countries that encounter high risks will select a high incentive type of contract. In addition, when additional geological information is available, a lower incentive payment contract will be adopted. Since, the renegotiation for a new term or type of contract is observed in the petroleum industry, an additional explanation in the model of petroleum contractual choice is required. In this chapter, the following explanations about such behavior are also provided: (1) when circumstances change and lead to a change in net present value of revenues, there will be a contractual renegotiation for new award terms, (2) when circumstances change and lead to a change in the control over the variation of the value of outcome, a new contractual form may be chosen and, (3) when circumstances change and lead to expropriation,a sanction by the contractor will take place. Empirical evidence and statistical tests regarding the theoretical constructs in the chapter will be provided in the next chapter.

Notes to Chapter III

1. The purpose of using the Bayes' Theorem is to identify the state of nature from new information. For useful literature on this theorem, see DeGroot (1970). For an applied version, see Newdrop (1976: Chapter 6).

2. The posterior probability can be computed as follows. Suppose that, based on what little information about the state of the world is available, the initial risk estimation on the prior probabilities is $P(s_1) = 0.33$ and $P(s_2) = 0.67$. When the messages {m} are available, the conditional probabilities that the evidence, m, could have occurred (given the state of nature) are supposedly $P(m|s_1) = 0.58$ and $P(m|s_2) = 0.75$. The revised likelihood of the posterior probabilities is:

$$P(s1|m) = \frac{(.58)(.33)}{(.58)(.33)+(.75)(.67)} = 0.28$$

$$P(s2|m) = \frac{(.75)(.67)}{(.58)(.33)+(.75)(.67)} = 0.72$$

CHAPTER IV

CHOICE OF PETROLEUM CONTRACT: EMPIRICAL EVIDENCE

The objective of this chapter is to examine the empirical evidence for the hypotheses that : (1) incentive payments are set according to information acquisition and this is the determining factor for types of contracts, and (2) when a circumstance changes ex post, a new term or type of contract will be renegotiated between the contracting parties without the third party intervention. Four types of empirical evidence are provided in this chapter. Section 4.1 discusses the problem of distinguishing the types of petroleum contracts by different schedules of incentive payments. Section 4.2 discusses the choice of concession contract (a high incentive payment contract) for newly explored countries which are represented by high uncertainty or little geological knowledge of exploration areas. Section 4.3 presents evidence on the correlation between changes in contracts from higher incentive payment types to the lower ones when additional information about future outcomes are available. Statistical tests for this correlation are also provided. Section 4.4 presents evidence on the contractual choice in association with the ex-post specific quasi-rent expropriation. Section 4.5 summarizes the main findings of the chapter.

4.1 Incentive Payments in Petroleum Contracts

As shown in Chapter I, the features of contractual terms in petroleum contracts reflect the contracting parties' anticipation of the ex-post behavior problem. Furthermore, the payment system in the four types of contracts differ in

terms of the exclusive rights granted to the contractor. The concession contract is the most extreme compared to the other three types of contracts. The concession contract grants the contractor the exclusive rights to explore, produce, and sell all the oil discovery, while the other three types allow the host country to participate in production and marketing in varying degrees. In the production-sharing contract, the host country has some participation in the exploitation activities. If oil is discovered in any portion of the contracted area during the exploration period, decisions concerning development are made by the contractor. Each phase of the operation is planned and carried out by the contractor. Although there are requirements for periodic reporting and submission of information by the contractor, this type of contract clearly grants lower ownership rights to the contractor relative to the concession contract. In the joint-venture contract, if both parties agree to develop the discovered oil reservoir, the host country agrees to share the exploration costs with the contractor by paying directly or through a portion of the host country's share of revenues. The host country also takes a direct part in running the joint enterprise through its own managerial, administrative and technical staff and in sharing expense. Likewise, the net profit is equally shared between the contractor and the host country. Therefore, the degree of the host country's control is higher in joint-venture contracts relative to the concession and production sharing contracts. For the service contract, management is assumed by the host country. The contractor is usually given the right to purchase a portion of the crude oil from each of the exploited areas for the entire production period. The fee for this portion of oil is determined by a specific formula which affords the contractor a substantial discount (Hossain 1979). The host country takes full control over the production operation at a certain period after the oil is

found. The host country also owns all petroleum deposits and any oil and gas produced at the wellhead. Service contracts are, therefore, granted the lowest degree of incentive to the contractor compared with the other three types of petroleum contracts.

Since the four types of petroleum contracts differ in their degree of ownership rights, it follows that incentive for the contractor to work among these four types of contracts also differs. Ownership rights obviously affect one's additional revenues from his contribution in any contractual relationship. If one is a residual claimant, one will obtain his additional profit for every additional contribution. In the petroleum contract, if the contractor obtains all the exclusive rights in managing all the production and marketing of any oil discovery, he will fully receive additional revenues from his additional efforts. Therefore, the concession contract represents the highest incentive type of contract. At the other extreme, the service contract allows the host country to take over the oil well and to market the product at a certain time after the oil field is developed. Therefore, the service contract is a type of contract that provide the contractor with the lesser incentive relative to the concession contract.

The incentive differentiation between the concession and the service contract can be explained in term of an additional revenue from the oil well for an additional efforts as follows. Oil well developments require long-term investment which generates a future stream of income. Under the concession contract, the contractor will have a higher incentive to invest because he can earn the additional future revenue for the lifetime of the oil field. Under the service contract, the contractor's additional investment now will yield an additional future revenue for the host country. Therefore, the incentive to make long-term investment under the service contract is lower than that under the

concession contract. Therefore, the concession and the service contract represent two extreme cases of investment incentive as a result of the degree of ownership rights granted. The production-sharing and the joint-venture provide a degree of incentive to the contractor which is somewhere between the concession and service contract. In other words, these two types of contracts provide a higher degree of incentive than the concession contract, but less than the service contract. The production-sharing contract appears to provide a higher incentive to the contractor relative to the joint-venture contract. This is because the host country is allowed a lower participation in the production and marketing stage under production-sharing contract. However, the difference in their degree of incentive is difficult to be distinguished using this interpretation method. One needs data of expected net return per unit from particular area at the time each type of contract is drawn, to compare whether net return of the contractor are different among these two types of contracts.

The logic of this argument can be easily seen in the type of contract employed by an author and a publisher. In the case of a revenue sharing contract between an author and a publisher, the contract will stipulate that the author will receive a given share of the revenue from the sale of the book. Since the success of the book and the total revenue its sale will generate are not known when the contract is drawn, the publisher will tend to advertise less than the lump-sum payment contract because he does not share added revenue with the author. If the author had been paid a lump-sum payment, the publisher will receive every additional revenue from the advertisement. Therefore, he tends to have incentive to advertise the book. The publisher can claim all the residual rights in the lump-sum arrangement, so, it is a more attractive to him to put in his additional effort in relative to the others.

The level of geological information acquisition of the host countries will be compared among the four groups of the countries who employ different types of contracts, in 1982. The purpose is to show the relationship between the level of the information and the degree of incentive. Types of petroleum contracts in 1982 are grouped under country names and each country's level of geological information acquisition. The country's level of geological information acquisition is represented by the amount of oil discoveries. These are presented in Table 4.1 (see also Table C-1 in Appendix C). The cumulative oil discovery for the four groups of countries for the period, 1950-1982 are in terms of indices of: (1) the oil discovery per exploratory well, and (2) the oil discovery per wildcat well. Due to the large variation in the amount of oil discovery per well, medians are used as measures of the central tendency of the cumulative oil discovery per exploratory and per wildcat well.

The medians show that geological information is lowest in the concession contract group, highest in the service contract group, and in between for production sharing and joint venture. These results show that at the time each type of contract was employed, the host countries had different information levels. The information level in the country which employs the concession contract is the lowest. Therefore, the highest incentive payment was offered. The arithmetic means of these measures are also presented. They show similar results but with much larger magnitude, especially in the group of the service contract. These results support the argument that given the ex-post opportunism problem, the type of petroleum contract is determined by the incentive payment, which is set according to the level of information acquisition at the time the contract is drawn.

4.2 Choice of Concession Contract in Newly Explored Countries

Evidence shows that the choice of the concession contract is always observed to be granted by a country which is new in petroleum exploration and in turn can be assumed to have little geological information and little experience in the oil business. The concession contract has been adopted in the petroleum industry since the beginning of the modern oil exploration industry. This type of contract was first used shortly after the modern oil industry began in the United States in 1859, when oil companies started to explore for oil by drilling for it, instead of hunting for it by looking for oil seepages from the ground (Frankle 1969). When American and European oil companies began to extend their oil exploration business internationally at the turn of this century, the concession contract became the sole basic feature of the petroleum contract for the first half of this century. The concession contract in the early period is known as the traditional concession contract. Its main features were simple and characterized as a high incentive system. Three implications of high incentive provisions in this type of contract can be inferred from: (1) the royalty (the revenue-sharing payment) which was fixed according to the amount of crude oil produced, and the contractor was left with exclusive rights in deciding the level of production, (2) the long contract duration (60-90 years), and (3) the larger concession area relative to that at present.

The above provisions of the incentive systems could be observed, for example, from the traditional concession contract of the Middle Eastern countries employed during the 1900s to the 1950s. The royalty payment of this contract was fixed at four shillings of gold or three rupee per ton of crude oil produced. A similar character of the concession contract can be observed from concession contracts in Indonesia during the same period. The contractor paid

a fixed price per acre and a percentage of the value of any oil produced. The long duration of concession was widely known. For example, the concession contract between the Iraq Petroleum Company (IPC) and the Iraqi Government in 1925 covered 75 years. Amoco's original concession in Saudi Arabia was granted for 60 years and was subsequently extended to 66 years. The concession granted to Kuwait Oil Company (KOC) in Kuwait in 1934 was for 75 years, and was subsequently extended to 92 years. Regarding the size of the exploration area, under the traditional concession contract, the host country always granted a very large portion of the country (sometimes the whole country) to the contractor for exploration. The D'Arcy concession covered the whole of the Persian Empire, except for five provinces. It extended cover an area of about 480,000 square miles. The IPC's concession of 1925 was for the whole of Iraq east of the Tigris River. The concession granted to KOC covered all of Kuwait (Cattan 1967).

The reason why the concession contract was the only type of contract employed during the early day of the international petroleum exploration business can be simply explained by the model in Chapter III. Being new in exploration, the host country lacked experience of the oil business and the geological information in those areas were still little available at that time. This explanation can be confirmed by the event of the changes in terms of the incentive provision of the traditional concession contract in the 1950s.

The evolution of countries in terms of type of contract occurred with the emergence as major oil producers of those countries. The results of the renegotiation in the terms of the traditional concession contract led to a significant reduction in incentive features of the traditional concession contract. The terms of the traditional concession contract have significantly altered, but

the mean of the apportionment in the future outcome still does not change. This implies that the evolution is not in term of the contractual form, since only the terms of contract had evolved. However, there are new features incorporated into the "modern" concession contract. The modern concession contract consists of the following changes: (1) the conditional payment has been changed from a fixed price per ton to a proportionate share of revenues, (2) relinquishment has been imposed, (3) there is a shorter contractual duration of exploration and exploitation, and (4) minimum exploration expenditures are required. After the 1950s, the "traditional" concession contract disappeared, although the modern concession contract is still employed by many countries in which there is only a slight chance of finding oil.

Geological information changes which cause changes in terms of incentive provisions of the 1950s can primarily be considered the result of the change in relationship between the concession contract and the possession of the proven reserves of those host countries. Venezuela was an early leader in changing the incentive terms of the traditional concession contract, because it was a leading oil producer outside the United States. In 1940 Venezuela produced as much oil as Indonesia and all of the oil producing Middle Eastern countries combined. It produced more oil than the Soviet Union in 1950 and more than any single country outside the United States until 1960 (Danielsen 1982). In November 1948, Venezuela led the way in formulating legislation to put the royalty in the form of a proportionate share of revenues and establishing an income tax law that secured a fifty-fifty profit distribution between the host country and the contractor. In 1950 Saudi Arabia made a comparable concession to Pacific Western Oil Company (which later became Getty Oil) in the Neutral Zone and revised the existing concession contract with Aramco

following Venezuela's contract pattern. This principle also found its way into concession contracts with Kuwait in 1951, Qatar and Bahrain in 1952, and Iran in 1954.

The evolution in terms of incentive provisions of the Middle Eastern countries were associated with the acceleration of oil output in those countries. For example, the oil output of Kuwait and Saudi Arabia rose from 16,000 and 160,000 barrels a day, respectively, in 1945 to 345,000 and 548,000 barrels a day in 1950. Iraq's production increased from 99,000 to 137,000 barrels a day in the same period (Penrose 1976: 63).

In addition, the observability in realized outcomes also led to the rejection of the traditional concession contract in the 1950s. This observability grew from the realization of the host countries that the home countries of the contractors (the United States, the United Kingdom, the Netherlands, and France) received a relatively larger share from the contractor's profits than they did (Danielsen 1982). Hence, the evolution in the concession contract in the 1950s primarily provides evidence of the relationship among the incentive system, the ability to monitor, and geological information change or the reduction of the degree of the asymmetric information in the petroleum industry.

Moreover, the selection of the concession contract by a newly explored country as an incentive contractual type is a general rule that can be observed even in a subsequent period. When Libya first granted concessions to foreign oil companies in 1955, the Libyan government was eager to see the country's petroleum resources explored and developed and was therefore eager to attract as much foreign investment as possible. Libya's newly promulgated Petroleum Law contained numerous tax incentives; e.g., royalties and taxes were paid on the basis of realized sale prices rather than posted prices. Also all

exclusive rights in making decisions affecting exploration, development, and production were fully granted to the contractor in a way typical of the concession contract. This Libyan concession contract reflects a high incentive contractual type, as can be seen by comparing the changes imposed in 1961 by Libya in the terms of payment provision. Libya altered many of the terms of the previous concession contract because the first commercial oil deposit was discovered in the Zeltan field in 1959. In 1961 the terms of newly granted concession contracts to other contractors were less attractive that the earlier contract. Surface rents were greatly increased, and the timetable for forced relinquishment of underdeveloped land was accelerated. The depletion allowance was eliminated, and other tax provisions were considerably tightened (D.O.E. 1984: 184). The development of the petroleum contract in Libya during these ten years reflected the changing knowledge of the petroleum resources of the country. In the face of promising, although almost completely untested prospects at first, inducements were offered to the contractors in order to persuade them to take the requisite risks, as the theory expects. As prospects improved with the growing information of the oil resources, the degree of the asymmetric information became lesser, the host country attained a better position for demanding a higher price from the contractor.

This modern concession contract is still granted in many countries where the geological risks and the asymmetric information problem are considerably high. In the 1970s this type of contract was still predominant in 121 countries, both in countries that had newly granted concessions and in countries where the life of old contracts had not yet ended (Barrow 1980). Evidence in Table C-1, in Appendix C, also shows that fifty-five countries still employed only the concession contract at the end of the year 1982. Available data of geological

information possessed by selected countries that employed the concession contract in 1982 have shown that the mean value of the oil discovery index of this group of countries is relatively low in comparison with the same index of other groups of countries that employ other types of contracts (see Table C-2 and Table 4.1). This evidence supports the prediction of the contractual choice model that when little geological information is known the type of contract with the pattern of high incentive payment will be selected.

4.3 Evidence of Choice of Production-sharing, Joint-venture, and Service Contracts

Evidence in this section supports the hypothesis that the host country will be more likely to opt, in order of increasing preference, for a production-sharing, joint-venture, or service contract when geological information is available. On the other hand, the host country will choose to subsequently grant a new type of contract that is characterized by a lower incentive payment than the previous contract. The more geological information makes it possible for the host country to distinguish the contractor's behavior from the undesirable future outcome, therefore, the pattern of lower incentive payment can be stipulated. Evidence on the contractual choice of new types of contracts in association with a higher geological information is presented below.

The evidence on the correlation between the changes in levels of proven oil reserves in various countries and the emergence of the production-sharing, joint-venture, and service contracts of those countries will be first presented. These three types of contracts originated during 1957-66 in the countries that later became OPEC members. The joint-venture contract was initiated by Iran in 1957 in its agreement with AGIP. This type of contract was also concluded

Table 4.1

Comparison of Cumulative Geological Information Acqusition of Host Countries Who Employ Different Type of Contract, 1982

	Concession	Production-sharing	Joint-venture	Service
Oil discoveries per exploratory well (million barrel per well)				
Median	0	2.51	5.86	43.58
Mean	0.67	6.31	9.27	297.51
Oil discoveries per wildcat well (million barrel per well)				
Median	0	3.18	5.42	52.93
Mean	0.59	4.95	9.46	445.41

Source: Calculated from the data in Table C-2, Appendix C.

between Saudi Arabia and the Japan Petroleum Company (1957) and between Kuwait and the Arabian Oil Company (1958). The first production sharing contract was signed between IIAPC and Pertamina, the state oil company, in August 1966. The service contract was introduced for the first time in Iran and Iraq in 1968.

The emergence of these three types of contracts is closely related to the amount of proven reserves of the countries. The joint venture and the service contract originated in the Middle Eastern countries where the chance to find oil is considered to be higher than other areas. Table 4.2 shows that in 1962 the proven reserves of the countries where these two types of contracts originated--i.e, Iran, Iraq, Saudi Arabia, and Kuwait--constituted more than half of the proven world reserves. The emergence of the production sharing contract was developed in Indonesia, which had proven reserves that were relatively smaller than those of the Middle Eastern countries (see Table 4.2). In nature, the Indonesian oil fields are small but are easy to exploit (Mikesell 1984: 67).

The conclusion that the type of contract is associated with geological information is supported by the evidence from Gabon. Gabon's first oil discoveries in 1957 resulted in an initial production at the rate of 3.5 thousand barrels per day. The discoveries in offshore areas during the 1960s and early 1970s led to an oil production peak of 225 thousand barrels per day in 1976. Even though Gabon became an associate member in OPEC in 1973, the country renegotiated its petroleum exploration concession contracts to require government equity participation of 12.5 percent in any oil discoveries. The amendment in contractual form came in March 1977, after the oil exploitation rate peak in 1976, to require production-sharing in all future contracts. These contracts stipulated that the contractors can recover up to 40 percent of their

Table 4.2

World Crude Oil Proven Reserves, By Principal Producing Countries, 1948, 1962, And1972 (Million Barrels)

Countries	1948 Amount	1948 % of Total	1962 Amount	1962 % of Total	1972 Amount	1972 % of Total
United States & Canada	21,470	45.3	39,900	14.3	47,023	7.6
Argentina	200	0.4	2,400	0.9	4,900	0.8
Mexico	1,200	2.5	2,500	0.9	2,800	0.5
Venezuela	8,500	18.0	18,487	6.6	13,700	2.2
Other Latin America	950	2.0	2,326	0.8	11,200	1.8
Western Europe	50	0.1	1,891	0.7	12,632	2.0
Africa	100	0.2	12,420	4.4	106,402	17.2
Iran	9,500	20.1	38,200	13.6	65,000	10.5
Kuwait	5,000	10.6	63,000	22.5	64,000	10.5
Iraq	7,500	15.8	26,000	9.3	29,000	4.6
Neutral Zone			11,000	3.9	16,000	2.6
Saudi Arabia	6,000	12.7	52,000	18.6	138,000	22.0
Other	550	1.2	8,375	3.0	42,402	6.8
Indonesia	800	1.7	10,000	3.6	10,005	1.6
Other Far East	500	1.1	1,330	0.5	4,917	0.8
Non-Communist World	40,850	86.3	249,929	89.3	521,860	84.2
Communist Bloc	6,500	13.7	29,976	10.7	98,000	15.8
Total	47,350	100.0	279,905	100.0	619,860	100.0

Source: Jacoby (1979).

exploration costs in eventual production, with the remaining 60 percent to be shared on a sliding scale (D.O.E. 1981: 179).

As shown in section 4.1., evidence on the gain in geological information associated with the selection of production-sharing, joint-venture, and service contracts increases sequential; this relation will be statistical tested. Table 4.3 compares the mean value of size of oil-field discoveries in (1) the year before (2) two years before, (3) three years before, and (4) the three-year average before among three groups of countries that grant a lower incentive type of contract relative to the existing one in different years during 1970-82. The names of the countries and years of granting new contracts with respect to the type of contract are presented in Table C-3, Appendix C. Data for items (1) to (4) are the results of proven reserves divided by the oil fields operating in each country, presented in Table C-4, Appendix C. Evidence in Table 4.3 shows that the decision of selecting a new type of higher incentive contract depends upon the level of geological information as expected. The value of means in different groups increases from the group of country that employed production-sharing, joint-venture, and service contracts.

However, the descriptive statistical comparison of the mean values in Table 4.3 may not effectively determine the differences of the group means. They might have some other factors that would contribute to bring about differentials in geological information. Therefore, the choice of a lower incentive payment type of contract in relation to the level of geological information is tested. One-way analysis of variance is used to compare the mean value of the independent size of the oil fields among three groups of countries that employ production-sharing, joint-venture, and service contracts. The purpose of conducting this statistical test is to see whether the differences between group

Table 4.3

Comparison of Mean Values of Oil-field.Size Among Three Groups of Countries Who Alter to a Lower Contractual Form, 1970-1982

Type of contract	Production-sharing contract	Joint-venture contract	Service contract
Data on Year t-1	13.93	179.92	1,949.50
Data on Year t-2	27.09	139.15	1,752.70
Data on Year t-3	16.39	145.44	1,839.40
Data of Previous Three-Years Avg	19.14	154.84	1,847.20

Source: Calculated from the data in Table C-4, Appendix C.

means are large enough to assume that corresponding population means are significantly different from each other. If the null hypothesis asserting that there are no differences among the three sample means is rejected, the prediction that a choice of a higher incentive type of contract depending on the higher degree of geological information is correct.

Although the analysis of variance (ANOVA) is a test of differences in means, it is based upon the comparison of variances. It is designed to measure in terms of random sampling errors, regardless of any variations between groups that are due to individual differences. The basic rationale of this method is that the total sum of squares (or total variation) of a data-set in this study is composed of (1) a within sum of squares or within three groups variation and (2) a between sum of squares or between three groups variation.

The within sum of squares can be obtained by subtracting the group mean from each score in that given group, squaring the differences and then summing these squared differences. The between sums of squares can be obtained by subtracting the grand mean from each group mean, squaring these differences and summing these squared differences. These within sum of squares and between sum of squares are divided by their respective degree of freedom to obtain a within and between group's variance estimate. These variance estimates are commonly called "mean square."

The ANOVA test has a sampling distribution know as "F." The F sampling distribution is a function of the degree of freedom for the between and within sums of square. The computation F value is obtained by:

$$F = \frac{\text{mean square between class}}{\text{mean square within class}}$$

The mean value of F should be around 1 when the null hypothesis holds and should become large when the group means differ substantially.

The results of the ANOVA test of the differences in the group mean value of size of oil field discoveries in Table 4.4 show that the group means differ significantly at the 0.1 level in all categories. Moreover, the F value of means in the category of one year before the contractual form changes gives the largest magnitude. Therefore, the choice of new type of contract should be effected by oil discoveries in the period one year before.

The results of the follow-up analyses, the least significant difference (LSD) are presented in Table 4.5. This technique has been introduced to find out exactly where the significant differences lie, after a significant F ratio has been obtained in Table 4.4. For this purpose, this statistical procedure analyzes each possible pair of means to determine if the two means are significantly different from one another. The LSD in each category, calculated from the standard error of the difference between two means multiplied by the 10% value of t with 27 degrees of freedom, is 1.703. The value of the standard error is equal to $(2S^2/df)^{-2}$, where S^2 is the mean square within the class. The difference between a specific pair of means is significant at the 10% level if it exceeds the value of LSD in its respective category.

Table 4.5 reports the multiple comparisons of LSD by the underlining method. A line is drawn beneath the pairs that do not differ significantly from one another. The results demonstrate that the mean group of the size of the oil field of the production-sharing and the joint-venture contract do not differ significantly from one another in every category.

The results reported in Table 4.4 show only a 90% confidence level to reject the null hypothesis. Moreover, Table 4.5 demonstrates that the pair of

Table 4.4

ANOVA Results for Geological Information Comparison Among Different Contractual Arrangements

Source	SS	df	MS	F
Geological Data of Year t-1				
Between SS	23017000	2	11509000	3.1857
Within SS	97542000	27	3612700	
Geological Data of Year t-2				
Between SS	18646000	2	9322900	2.6955
Within SS	93385000	27	3458700	
Geological Data of Year t-3				
Between SS	20698000	2	10349000	2.8007
Within SS	99769000	27	3695200	
Geological Data of the Past Three-year average				
Between SS	20747000	2	10373000	2.9939
Within SS	93551000	27	3464900	

Note: All F value is significant at the .10 level

Source: Calculated from the data in Table C-4, Appendix C.

Table 4.5

Results of the Multiple Range Test for the Geological Effects of Each Type of Petroleum Contract

	PS	JV	SC	LSD
Geological Data of Year t-1				
Mean	13.93	179.92	1949.5	1447.58
Geological Data of Year t-2				
Mean	27.09	139.15	1752.7	1416.40
Geological Data of Year t-3				
Mean	16.39	145.44	1839.5	1464.02
Geological Data of the Past Three-year Average				
Mean	19.14	154.84	1847.2	1417.67

PS- Production-sharing Contract
JV- Joint-venture Contract
SC- Service Contract

means does not differ significantly between the group of countries that employ production-sharing and joint-venture contracts. Therefore, it may conclude that choice of concession contract which implies a high incentive contract is determined by the low level of geological information acquisition in that host country. When the more geological information is available in any host country, the host country will switch to a lower incentive type of contract, as the petroleum contractual choice predicted. However, the available data do not allow the hypothesis testing on the choice of production-sharing, joint-venture, and service contract against the level of geological information acquisition.

4-4 Evidence on Contractual Choice in Association with the Ex post Specific Quasi-rent Expropriation

The evidence provided in the last three sections have already shown the host country's maximization problem on the choice of various types of contracts in association with its fear of the problem of the contractor's ex-post opportunism. This section deals with evidence supporting the hypothesis of the contractual choice from the perspective of the contractor's fear of appropriable specific quasi-rent during the post-investment period.

As mentioned, if circumstances change and effect the total net revenue, the appropriation of the contractor's quasi-rent or the expropriation of the contractor's specific assets might occur. With regard to the maximization problem, the contractor deals with the ex-post opportunity by an implicit long-term contract, as explained in Chapter III. If the hypothesis of the petroleum contractual choice model is correct, one will observe that whenever the ex-post problem occurs, there will be a mechanism to resolve such a problem without third party intervention. The premise is that the ex-post problem resolution can

taken two forms: (1) renegotiation or (2) boycott or sanction. Furthermore, there is also evidence to show that renegotiation can lead to either a change in terms of the division of net revenue or a change in contractual form. The change in type of contract implies the change in the mean of the net revenue apportionment. The outcome of the renegotiation will depend on whether the changes in that circumstance are effected by changes in the pattern of the control on the variation of the net revenue. If the pattern of control in the variation of the outcome changes, one should observe the change in the contractual form in ex post. The ex-post problem resolution in this study is analyzed in three forms: (1) an adjustment in terms of contract, (2) an adjustment in type of contract, and (3) sanction or boycott.

The analysis of the ex-post problem resolution is divided into two distinctive periods: before and after the 1970s. There is a difference in the resolution mechanism of the ex-post conflict that took place between these two periods, especially due to the change in the pattern in controlling the variation of the net revenue in the major oil producing countries. As Kobrian (1984) points out, the earlier conflicts were not motivated attempts by the host country to gain ownership rights over oil production via a transformation of the contractual structure. On the contrary, after the 1970s most Middle Eastern OPEC countries--including Saudi Arabia, Kuwait, Iraq, and Iran--converted all their contracts into service contracts. Under this type of contract, the former contractors continued to provide technical services, henceforth for a fee, and purchased a substantial volume of crude oil from the host country (Mikesell 1984: 24). Since the OPEC member countries have gained control over the variation of the net revenue since 1973, this implies that the conflict resolution between those OPEC member countries and the oil contractors, involving the

alternation in terms of ownership rights, led to the change in contractual form as the efficient contract model expected.

In the international petroleum industry, although long-term contracts are formal legal arrangements, expropriation does occur, contracts are renegotiated, and changes are made. Before the 1970s, the ex post problem resolution in the petroleum industry ended up in two forms: (1) boycott or sanction in association with the condition of expropriation and (2) changes in terms of payment in association with the conditions of renegotiation in the original contract. These two conditions will be analyzed in order to support the argument that ex-post conflict will be resolved without third party intervention.

In 1938 Mexico's policy of opposing foreign investment was a significant factor leading to the nationalization of foreign oil companies' assets. The international oil companies immediately began an embargo of Mexican oil, which led to the virtual elimination of exports. By 1947 the necessary arrangements were concluded dealing with the expropriation between Mexico and all oil companies. About this event, Sampson (1976) pointed out that the oil contractors' boycott in the Mexican case was noted and remembered by the other producing countries. It is likely that its effect served to demonstrate the futility of expropriation.

Early in 1948 there was a conflict between the Anglo-Iranian Oil Company (AIOC), which is an affiliate of the British Petroleum Company, and the Iranian government on the issue of new supplemental terms of revenue sharing. The company had accepted an increase in the royalty from 22 to 33 cents a barrel, but it refused to accept the fifty-fifty profit-sharing terms conceded by American firms to the governments of Venezuela and Saudi Arabia. This conflict led to the expropriation of AIOC's assets without compensation by the

Iranian government in 1951. Following the nationalization, Iranian oil was boycotted by the international oil companies, and production in Iran declined from 660 million barrels per day in 1951 to 60 million barrels per day shortly thereafter (D.O.E. 1981: 129). Finally, in 1954 Iran and a consortium of foreign oil companies reached an agreement in allowing the consortium to exploit the great oil field of southern Iran--from which almost 90 percent of Iran's oil production is derived. This arrangement is further evidence to show that the contractor can resolve specific quasi-rent expropriating opportunistic behavior without the intervention of a third party.

The forgoing analysis has shown that the contractors can effectively resolve a problem by cooperating among themselves to boycott when expropriations occur. However, renegotiation is generally the first attempt to settle a conflict, as for example when the Iraqi government expropriated approximately 99 percent of the concession area of the Iraq Petroleum Company (IPC) in 1961. The original concession area held by the IPC covered the entire territory of Iraq except for a small area around Khanaqin on the Iranian frontier. In the beginning, there were four main issues that the Iraqi government wanted to revolve: (1) the relinquishment of some of the concession area of the original agreement; (2) the terms of sharing; (3) the rights to natural gas; and (4) equity participation by the government. Renegotiations continued for three years before the expropriation really happened in 1961, showing that the oil company was willing to go a long way to meet the Iraqi government's demands (Penrose 1976: 72). After the expropriation, in 1965 an new arrangement between the Iraqi government and the oil company was negotiated. The company accepted most of the new terms, since the company believed that more might be gained by accepting

unpalatable terms than by resisting the expropriation. But when IPC was unsuccessful in its demand to get back the north Rumaila field in southern Iraq, IPC threatened legal action against any firm or country that helped Iraq develop this oil field (D.O.E. 1981: 134). This was because the oil contractor could not accept further losses of its interests under the new arrangement. The contention over the status of north Rumaila continued until both finally reached a settlement by themselves in 1973. Under the new settlement, IPC accepted the nationalization of 1961 by withdrawing its claims against the sale of north Rumaila oil. In return, the government waived all further monetary claims against IPC and agreed to pay compensation for nationalization.

In fact, expropriation of a foreign oil company's assets is not a common practice in the international oil industry. Even if expropriation does occur, the first response will be to renegotiate. Evidence this is provided by both Iranian and Iraqi cases. Mexico is an exceptional, in which the expropriation can be attributed to nationalism. This behavior can be explained by the efficient contractual choice model and the host country's concern about its international reputation. Evidence for the argument that renegotiation to resolve the ex-post conflict is commonly practiced by the concerned contracting parties can be seen in the event of the 1950s, as discussed in the section 4.2. Much pertinent evidence supporting this argument can also be found the newly agreed terms and types of contracts between host countries and contractors during 1970s. This evidence is consistent with the hypothesis that under changed circumstances the concerned contracting parties will try to preserve their ongoing relationship by resolving the conflict by themselves rather than through a third party. In addition, evidence of the conflict resolution in the major producer countries during 1970s supports the argument that the revision of the

forms of contracts is observed when the host country subsequently gains the power to control the variation of the net revenue.

It can be seen from the forgoing analyses that, prior to the 1970s period, conflict only revolved around the terms of revenue sharing. By the 1960s some producing countries realized that they could reduce their costs of negotiating prices if they could control oil pricing and production. This crude oil prices came to play an important role in revenue sharing after the traditional concession contract evolved into the modern concession contract in the 1950s, since the calculation system of the payment to the host country also changed. Under the traditional concession contract system prior to the 1950s, crude oil prices did not have any relationship to revenues. Since royalties were based on quantities exported, income taxes were not generally employed until the 1950s. Crude oil produced in eastern hemisphere before World War II was priced to meet the prices on U.S. crude oil exported to foreign markets. This was because during this period the U.S. gulf coast and the Caribbean were the world's primary sources of crude oil. This pricing structure, known as "gulf-plus" or the "single basing-point" system, was the price of oil in the U.S. gulf plus tanker rates from there to the point of delivery, irrespective of the actual point of origin. During the war, this system of posted price came under the pressure from the Allies to reduce the cost of oil. Hence, the oil companies finally replaced the existing single basing-point pricing system by a double basing-point. This involved establishing a second basing point in the Middle East to match the first basing point in the Gulf of Mexico. In other words, the price of the Middle East oil and that of the United States oil was equalized at the export terminal. A centrally located area at Naples, Italy, was selected. By shifting this hypothetical competitive equalization point westwards to London, the price of

Middle East oil was reduced by an amount equivalent to the transportation costs from Nepals to London. As this system of posted price was initiated at the time that the Middle Eastern countries instituted their sharing system, this posted price system was therefore used in calculating the payment system for the new concession contracts. Under the modern concession contract, the profit from oil operations in the producing countries came to be defined as the difference between the posted price at a sea terminal and the cost of producing the oil and getting it to that terminal. The contractor's income tax was defined as half of the difference, in addition to the percentage royalty payment.

As mentioned that the new posted prices were the major determinant over the sharing system of the modern concession contract, the host producing countries realized that their revenue depended on price set by the interlocking group of international oil companies. According to the concession contracts, it was the oil companies that solely decided how much oil to produce once it was found and that set the price at which it would be sold. Although the companies operating in each country were legally distinct, in reality there was a pattern of interlocking ownership at that time: BP, Shell, Mobil, and Exxon jointly owned IPC, which operated in Iraq; Exxon, Taxaco, Standard Oil of California, and Mobil jointly owned Aramco, which operated in Saudi Arabia; Exxon, Shell, and Gulf, through affiliates, operated separately in Venezuela; Gulf and BP jointly held the concession in Kuwait. Later, all seven of them held shares in the Iranian consortium that replaced BP after the crisis of 1951, as discussed. Such an integrated structure implied that the price charged for crude oil loaded at ports on the Persian Gulf or the Caribbean Sea represented little more than bookkeeping transaction between one company and its partners. The

discounts could be easily adjusted so as to increase the ultimate income of the companies and to reduce the tax and royalty income of the country.

When Middle Eastern posted prices were first introduced, the system went well in the beginning. Crude oil prices rose moderately due to the strong growth in consumption, which outran new production capacity. Thereafter, prices declined up to 1959 (Jacoby 1974). These lower prices led to the unilateral reduction in posted prices by the oil companies in 1960. However, when the oil companies decided on a general price increase following an oil shortage, the increase in price of the Middle East oil was less in proportion in relative to the western hemisphere and, by the same token, when the companies decided on a general price cut in 1959, the cuts on Middle Eastern oil were heavier than those applied to the western hemisphere (Al-Chalabi 1980). In response to this, in September 1960 Venezuela, Iran, Iraq, Kuwait, and Saudi Arabia founded the Organization of Petroleum Exporting Countries (OPEC). In 1962 OPEC began to negotiate with the oil companies over the accounting details on which the host countries' revenue per barrel depended. Finally, an agreement was reached to bring the posted price to the August 1960 level and hold it steady for the entire decade.

The first modest achievement encouraged OPEC, at its sixteenth meeting in June 1968, to adopt a Declaratory Statement of Petroleum Policy. The principles of this declaration reflect their concept of the new arrangement for petroleum exploration in their countries. Some points of the Declaratory Statement included:

> Member Governments.shall endeavor, as far as feasible, to explore for and develop their hydrocarbon resource directly....However, when a Member Government is not capable of developing its hydrocarbon

> resources directly, it may enter into contracts of various types, to be defined in its legislation but subject to the present principles.... Under such arrangements, the Government shall seek to retain the greatest measure possible of participation in and control over operations. (Hossain 1979: 19)

Such a statement supports the argument that the major producing countries began to seek coordinated measures for controlling ownership rights in coordination, according to the premise.

The real attempt to coordinate the OPEC member countries' claims to residual rights began with Libya's crisis in 1969. In December 1968 the Libyan government became the first country to implement the new OPEC guidelines on seeking control over operation as stated in 1968 Declaratory Statement. A state oil company, LIPETCO, was formed in a move by the government to assert greater control over its hydrocarbon resources. Also the government proposed to negotiate a new posted prices rate with the oil contractors. On September 1, 1969, just before negotiations with the contractors on posted prices were scheduled to commence, King Idris was overthrown by Colonel Muammar Al-Qaddafi. The new government declared that the ten-cent increase in posted price sought by its predecessor was inadequate. A new demand was made for an increase of 30 cents per barrel plus an increase in the tax rate from 50% to 55%. The oil contractors resisted the government's demand. Qaddafi ordered production cuts which aggravated the developing shortage, and he used mandated production cuts and the threat of a shutdown effectively against individual contractors. The government put a great deal of pressure first on the smaller oil companies. Occidental agreed to the government's demand in September 1970 and was quickly followed by most the other oil contractors. This settlement of 1970 is well known as the Tripoli Settlement. In addition,

Qaddafi transformed of LIPETCO into the Libyan National Oil Company (LINOCO) in 1970. LINOCO was made responsible for joint ventures and service contracts envisioned by the new regime, a move that signalled the new regime's determination to achieve greater control over its resource through intervention and active participation. Venezuela at once raised its tax rates to 60%, and henceforth claimed the right to set tax-reference price unilaterally. The Persian Gulf countries, such as Iran and Kuwait, immediately joined in the demands for higher prices and 55% tax in the Tehran negotiations of 1971.

The next target of OPEC countries was an increase in control over oil operations. By Resolution No. XXIV. 135, adopted in July 1971, OPEC urged member countries to take immediate steps towards the actual implementation of the principle of participation in existing contracts (Hossain 1979, 20). In 1972, Saudi Arabia, Kuwait, Qatar and Abu Dhabi pursued the plan of participation by gradual transfer of the oil companies' equity to governments. In October negotiations were concluded, with participation to begin at 25% in 1973 and to reach 51% in 1982. In September 1973 Kuwait began to negotiate with the oil contractors, rejected the 25% to 51% participation plan in 1973 and instead insisted on an immediate 60%. The Middle East war in October 1973 led to an unilateral decision by OPEC to raise crude oil prices, to cut back production, and to impose embargoes. As a result of this event, control over pricing and production was shifted from the contractors to the major producer host countries. After the end of the embargo in the spring of 1974, the major producers of the OPEC member countries concentrated once again on expanding their control over ownership rights. Thus, an acceleration of the participation process, disregarding the timetable earlier agreed upon, went on. In November 1974 Saudi Arabia demanded a 100% takeover--a move that led

to negotiations between the government and Aramco and, by December 6 in the same year, Aramco agreed in principal to yield 100% control to the government. These moves were soon duplicated by other major OPEC producers, including Iran, Iraq, Kuwait, Venezuela, etc. Compensation to the contractors for the host country take over was calculated based on the net value of assets.

By 1976, most major producer OPEC member countries had fully transformed their contractual arrangements with the oil contractors into the form of service contracts. Under the service contract, the former contractors continued to provide technical services for a fee and arranged to purchase substantial volumes of crude oil from the host countries. The amounts of these purchases often depend, however, upon the prices charged by the host countries. The implication of the success in transforming the contractual form of OPEC countries after 1973 is not only evidence that the self-enforcing hypothesis is correct but also implicitly supports the differentiation in various degree of residual claimant within four type of petroleum contracts, which are assumed in Section 4.1 in this chapter, is correct. With the change in circumstances after 1973, there was another group of countries negotiating for a higher payments from the oil contractor. This group of countries lacked the power to control the variation of the net revenue. Under the efficient contractual arrangement, if a country is able to control the variation of future outcome, it will obtain the residual claimant or ownership rights under the collaboration. Therefore, the transformation to higher ownership rights by the major OPEC member countries provides evidence that this assumption is correct, since it has been shown in the forgoing analysis that this group of countries has been able to control prices and production in place of their contractors.

Evidence to support the argument of the self-enforcing contract in association with the lack of controlling power, which eventually leads to a change in the terms of a contract, is provided by the experience of Indonesia, which altered certain terms in its existing production-sharing contracts in 1974. Even though Indonesia is an OPEC member country, Indonesia's power of control over the variation in product was not as high as that of the Middle Eastern OPEC countries. The prominent difference was that Indonesian oil fields were smaller and exploitation cost was considered higher than in the Middle East. Following the sharp rise in crude oil prices in 1973-74, the Indonesian government demanded that the contracts be renegotiated to increase the host country's share of the output. In the existing contracts, the split of production was usually 65 to 35, but this basic profit spilt was applied only to the first $5 per barrel. Beginning in 1973, this $5 per barrel price was adjusted with the rise in the UN commodity index . On profits in excess of the base price, the contractor received a 15 percent share on the first 150 thousand barrels per day of production, 10 percent on production ranging from 150 to 250 thousand barrels per day, and 5 percent above 250 thousand barrels per day. Mikesell (1984, 61) indicates that this government's demand was resented by the contractors but it apparently did not reduce their profits to the point at which they were unwilling to continue the relationship.

There is no doubt that most of the host countries responded to the 1973 price rise by renegotiating for better contractual terms as predicted by the contractual choice model. It should also be noted that a new flexible fiscal regime was introduced in various contractual forms to enable the host country to appropriate a substantial part of the "excess" or "windfall" profit accruing to the contractor. An adjustment clause has subsequently become a common feature

in the new fiscal regimes of every type of contract (see the example given in Appendix A). This can be simply explained in terms of transaction cost--i.e., that both parties want a flexibility formula in the contract in order to minimize the cost of negotiating price since oil prices regularly increase during 1970s.

The adjustment-clause provisions in the petroleum contracts may taken any of four forms: (1) The sliding scale of royalty rates and host country production shares are adjusted cumulatively or daily. Some examples include the contracts employed by Indonesia, the United Kingdom, Egypt, and India. (2) Price caps and profits taxes are levied on revenues in excess of some base price, in anticipation of a predictable relation between price and profitability, as in the contracts employed by Argentina and Peru. (3) Cost recovery is allowed so that some multiple costs incurred and rapid write-offs of capital costs can be reduced, as in the contracts employed by Indonesia, Malaysia, and the Philippines. (4) Variations in the host country's rate depended on such factors as the location of exploration or production (onshore vs. offshore), as in the contract employed by India, and Thailand.

4.5 Summary

In this Chapter, the evidence which has been provided supports the prediction of the model of petroleum contractual choice. Incentive provisions of petroleum contracts and the associated level of information by country implies that the concession contract has an inherent higher incentive endowment in relative to the other three types of contract. The evidence on choice of the concession contract and the relationship of information gain to the choice of the other three types of petroleum contracts is also discussed. The evidence provided in this chapter supports the argument that under conditions of little

geological knowledge, the type of contract with a high incentive system attribution--concession contract--will be selected. This is further supported by the evidence that the traditional concession contract was the sole type of contract granted in the international petroleum industry during the first half of this century. Evidence for the premise that the incentive provision is correlated with geological risk is provided by the events of the 1950s, when contractual terms changed simultaneously with the emergence of the major Middle Eastern producer countries. This relationship is also shown by the cumulative oil discovery by type of contract employed in 1982, as shown in Table 4.1. Evidence also supports the hypothesis of a new type of contract, with less incentive payment, which is selected once the geological knowledge is acquired. A statistical test by using one-way analysis of variance method results in a 90% level of significant, which is quite high for the available data used. Although the conclusion can not be individually drawn against the selection of the production-sharing, joint-venture, and service contracts, it may be concluded that the choice of concession contract and the selection of the other three types of contracts when the information gains are likely to be determined by the incentive payment.

The hypothesis of the reputational constraint is also investigated from the resolution of ex-post conflict between the host country and the oil contractor in the past. Prior to the 1970s, when the ex-post problem occurred, renegotiation was the first mechanism employed by the two sides to resolve the conflict. Evidence from the evolution of concession contract in the 1950s supports the argument that the concerned contracting parties could resolve their problems without third-party intervention. In cases where negotiations were not successful, such as in Iran, Mexico, the contractor still could rely on the sanction

or boycott. Since the 1970s condition have changed, and the same group of countries that negotiated for better contractual terms in the 1950s gain the power to control the variation of outcome. Therefore, they could negotiate for a new contractual form which gave them a higher residual claim. Meanwhile, the other group of countries that do not gain such controlling power negotiated for better contractual terms. There are two implications from this analysis: (1) Ex-post conflict can be resolved without third-party intervention, as the theory expected, and therefore the host country's reputation is a constraining factor in efficient contractual choice, as the model predicted. (2) Residual rights are inherently different among different types of petroleum contracts. Moreover, the enactment of the adjustment clause in petroleum contracts to cope with an unpredicted increase in oil prices during the 1970s is also evidence of the prevalence of the transaction cost--the cost of negotiating prices--in the petroleum contract.

CHAPTER V

SUMMARY

5.1 Restatement of the Problem

There is a large variety in the type petroleum contracts that exist between host countries and contractors in the international petroleum industry. Complicated contractual terms make the classification of types of contract difficult. Moreover, the confusion in identifying types of contracts also increases when: (1) different terms are applied to denote similar fiscal regimes, or a single term is used for two or more different fiscal regimes, and (2) the name of contract does not really represent the main characteristics of the contract.

There are two existing explanations for why so many types of petroleum contracts exist and how each type of contract is selected : fiscal regime and risk-sharing.

The fiscal regime is simply a taxation system stipulated in a petroleum contract. Under the fiscal regime explanation, it is argued that types of petroleum contracts are distinguished by the taxation system imposed by the host country. This explanation is invalid because terms of fiscal regime in different types of petroleum contracts can be adjusted to make the expected net present value equal. In addition, the explanation lacks empirical evidence to support the postulation that different bargaining powers of the contracting parties lead to the type of agreed upon contractual arrangement.

The risk sharing explanation distinguishes types of petroleum contracts according to the pattern of risk allocation between the host country and the contractor. Different patterns of risk allocation are specified in terms of the degree of ownership of oil discoveries. Hence, the divisions of costs and profits

between the contracting parties arise with different definitions of legal ownership and, in turn, the degree of risk sharing associated with that type of contract. In comparison to the fiscal-regime explanation, the risk-sharing explanation provides a more possible explanation for the problem at hand. The existence of high geological risk in the petroleum industry makes the explanation reasonable. However, the risk-sharing explanation still leaves some puzzle unexplained. It is observed that existing contractual terms in all types of petroleum contracts reflect the contracting parties' anticipation of ex-post opportunistic behavior. This ex-post opportunism manifested from the asymmetric information problem in the petroleum industry.

The existing explanations on choice of petroleum contracts are inadequate for the purpose at hand. In addition, most contractual terms in every type of petroleum contract reflect the problem of opportunistic behavior between the contracting parties. Therefore, it appears that an explanation that focuses on the role of behavior risk in contractual arrangements would be a more consistent explanation. This study proposes to explain choice of petroleum contract using the concept of the agency theory. The effect of opportunistic behavior on choice of petroleum contracts will be the focus of the analysis.

5.2 Justification of the Study

While the existing literature has been directed toward the effects of geological risks on the choice of petroleum contracts, this study regards terms of payment imposed as the reflection of the desire to moderate the ex-post opportunistic behavior of the concerned contracting parties as an additional factor in explaining the choice of petroleum contract. Hence, terms of payment are suppose to reflect the opportunistic problem in terms of the incentive

compensation system. The geological information and the incentive system are postulated to be inter-related in a decision making process of the choice of petroleum contract.

By introducing the ex post opportunistic behavioral into the petroleum contractual choice model, it is expected that an improved understanding of why many types of petroleum contractual forms exist and how each of them is selected would be obtained.

5.3 Main Findings From the Study

The common feature in every type of petroleum contract is that the host country entitles the contractor to bear all the exploration risk. If an oil field in commercial quantity is found, the revenue of profit from the discovered oil will be shared in different forms according to types of contracts. Petroleum contracts are classified into four types: (1) concession contract, (2) production-sharing contract, (3) joint-venture contract, and (4) service contracts. This study asserts that these four types of petroleum contracts differ in term of the incentive payment.

One difficulty in testing the hypothesis in this study is that the data required for testing the degree of the incentive inherent in the four types of contracts are unavailable. However, the degree of incentive in each type of petroleum contract can be inferred from payment terms in each type of contract. The petroleum contracts are divided according to the incentive system into two groups--the concession and the other three types of contract. This makes it possible to explain the petroleum contractual differentiation by the level of the geological information acquired by the host country. The selection of a contractual form is inversely related between the geological information

acquisition and the incentive system. The higher geological risk in any particular tract, the higher incentive system will be granted. The concession contract reflects a higher incentive type of contract than the other three types of contracts. Evidence shows that under the condition of little geological information, the concession contract will be selected. If more geological information is available, the expected geological risk becomes less and less, and the production-sharing, joint-venture, and service contract will be selected, in order. The median of the magnitude of the accumulative amount of oil discoveries in different countries in 1982 supports such an argument. The medians increase progressively from the groups of countries that employed concession, production-sharing, joint-venture, and service contracts.

Evidence also supports the argument that, when more geological information can be acquired in any particular area, the host country will tend to choose the production-sharing, joint-venture, or service contracts. One-way analysis of variance is employed to compare the mean value of the size of the oil-field discoveries among the three groups of host countries that correspond to one of these contractual forms at a particular time. The results from the statistical test show that the difference among the value of means are significant at the level of 90%. The Less Significant Difference (LSD) is also employed to find out exactly where the significant difference lies. The results demonstrate that the mean value of the group of countries employing the production-sharing, the joint-venture, or the service contract significantly differs from the group of countries that employ the concession contracts. These results can be interpreted as that the choice of concession contract and the other three types are determined by the incentive payment in associated with the geological information in each country. In addition, a test for the difference in the mean

value among the three types of contracts is also conducted. The results reveal that the mean value of the group of countries employing the service contract significantly differs from the group of countries that employ the two other types of contracts. The difference between the mean value of the two groups of countries that employ the production-sharing and the joint-venture contract is not significantly different.

This study also finds that when the circumstances change and a problem is created ex post, the concerned contracting parties will be able to settle their own problems without the intervention of a third party. There are three possible mechanisms for ex-post problem resolution used in the international petroleum industry. They are: (1) sanction or boycott; (2) renegotiation for new terms of contract; and (3) renegotiation for a new contractual form. The descriptive evidence shows that the negotiations for a new term of contract were very common during the period prior to the 1970s. However, if expropriation did occur, the contractor was still able to resolve the problem without third party intervention by using a boycott or sanctions to settle the hold up opportunistic behavior of the host country. Comparing the ex post conflict resolution, it is found that the negotiation for a new contractual form was very common among the major producing OPEC member countries. This can be explained by the efficient contract model in which the control over the variation of future outcome has changed hands in favor of these OPEC member countries. The consistency of this argument is supported by evidence from another group of host countries, without the ability to exercise control over the variation of the oil prices, which also negotiated for a change with oil contractors when the oil price increased during the same period, but only for a change in the terms of contract. Moreover, an adjustment clause introduced in the new terms of every type of

petroleum contract. This is a very common practice in the efficient contracting collaboration in order to reduce the costs of negotiating prices.

In short, the evidence provided here supports the hypothesis that the petroleum contractual choice that the high incentive type of contract, concession type, is selected because there is limited geological information available at the time a contract is drawn. The limitation in geological information makes it difficult for the host country to measure the contractor' s efforts, therefore, higher incentives are granted to mitigate the problem. In addition, the evidence also supports the hypothesis that the lower incentive types of contract are drawn when additional geological information is gained by the host country. It is anticipated that if the necessary information in testing hypothesis is available, the prediction of the petroleum contractual choice model can be more vigorously tested. Consequently, the hypothesis that types of petroleum contracts are determined by the incentive payment can be confirmed with a higher degree of confidence. In addition, all types of petroleum contracts are observed to be constructed in the form of implicit long-term contracts; i.e. both concerned contracting parties want to preserve a long-term relationship with each other. Hence, when the circumstance change, they will try their best to resolve the ex-post conflict rather to end the relationship and will try to do so without the intervention of a third party. Therefore, the choice of new contractual form is sometime renegotiated to resolve the ex-post problem.

APPENDIX A

PETROLEUM CONTRACTUAL ARRANGEMENTS IN SELECTED COUNTRIES

The purpose of Appendix A is to provide examples of four types of petroleum contractual arrangements being used in the international petroleum industry. The materials in this Appendix have been obtained from the "Worldwide Concession Contracts and Petroleum Legislation" by Barrows (1983). The content of the petroleum contract provided in this Appendix, as indicated by Barrows, is somewhat extensive since the actual petroleum contract does not appear in the general. The contents of the petroleum contracts in selected countries are presented below.

(1) Concession Contract

1.1 Honduras

Petroleum Legislation: Decree No.4 of 25 October 1962, as amended by Decree No. 65 of 28 March 1963, and regulations promulgated pursuant thereto authorize nonexclusive reconnaissance permits, exploration concessions, and exploitation concessions to private persons. Decree 457 of 11 May 1977 and Bidding Decree 589 apply.

Duration: Exploration concession duration is six years for the initial term. May be renewed twice for the periods for two years each time. Exploration concession holders are entitled to an exploitation concession upon discovery of petroleum. The duration of exploitation is 40 years with a possibility of one 20-

year renewal. Exploitation concessions may not exceed 50% of the area originally covered by the exploration concession.

Investment Obligation: The concessionaire is to commence exploratory operations within 180 days of the grant and must make an annual investment ranging from 0.5 lempira/hectare in the ninth and tenth years of the concession.

Royalty and Tax: Royalty is 12.5% onshore. Offshore production royalty rate is 10.5%. Exploration concession surface tax ranges from 0.25 lempira/hectare to 0.75 lempira/hectare, although to varying degrees the amount invested on exploration may be deducted from the surface tax. Exploitation concession initial tax is 2000 lempira in addition to a surface tax, which ranges from 3 to 9 lempira/hectare, although royalties and a percentage of its investment may be deducted from the amount due. Concessionaires pay the normal income tax plus an additional taxes if the total of surface taxes, royalties, and normal income taxes paid to the government does not equal 50% of the net profits.

1.2 France

Petroleum Legislation: At present, exploration operations are governed by Law 77-485 of 11 May, 1977.

Duration: Maximum initial term of an exploration permit covering onshore areas is five years; it may be extended twice for a maximum of five years each time. A continental shelf exploration permit has a maximum term of 18 years, inclusive of all applicable extensions. The French government has an option to reduce the area included within the permit (except producing areas) upon the granting of each extension. Exploration permits have a maximum term of five years, subject to a maximum of two five-year extensions. Concession may be granted for a period of up to 50 years.

Investment Obligation: Minimum sums for exploratory operations are not specified in law but are set out in a permit grant. Minimum exploration expenditure is 1000 to 3000 francs/sq. km.

Royalty and Tax: On a continental shelf exploitation permit, holders pay a specific royalty per ton of production. Onshore, concessionaires only pay royalties.

Decree 81-372 of 15 April 1981 changed royalties effective 1 January 1981. New oil is that produced from wells that came onstream after 1 January 1980. Old oil is that from wells onstream before the date.

Crude Oil	Percent Value at Well head	
Production Level	Production	Production
(Annual Metric Tons)	Old Oil	New Oil
0- 50,000	8	0
50,000-100,000	14	6
100,000-300,000	17	9
Over 300,000	20	12

(2) Production-sharing Contract

2.1 Ivory Coast

Petroleum Legislation: Under the 1970 law the State can undertake petroleum operations itself or can grant exploration permits and concessions to private firms through concessions awarded on a negotiated basis. In 1982 the government has adopted a policy of any granting new rights on a production sharing basis in partnership with its State Oil Company. This review is focused on 1982 concession grants and the model contract.

Duration: Exclusive exploration permits are granted for not more than three years. These may be renewed twice by decree, the first time for not more than two years and the second time for not more than three years. Exploration concessions have a term of 25 years but may be extended on conditions to be defined by decree or in the award itself.

Investment Obligation: Geological and geophysical work is to commence within three months of the contract's effective date. Two wells are to be drilled in the first two years; three wells are to be drilled in the third year.

Cost Recovery and Production Sharing: The contractor is to bear all exploratory, development, production, and transportation costs (petroleum costs) as well as current operating expenses, defined as "annual expenditures necessary to assure and maintain the regular production of hydrocarbons". The contractor is to recover its petroleum costs and current operating expenses out of a 40% share of production. If in any year the total of current operating expenses and recoupable petroleum costs exceeds the value of the 40% share, the surplus may be carried forward until full recovered.

After cost recovery, the remainder of annual production is shared as follows:

(1) If water depth is less than 1,000 meters, the government is to receive 70% and the contractor is to receive 30%. However, if production is greater than 200,000 barrels per day, the government is to receive 75% and the contractor is to receive 25%.

(2) If water depth is more than 1,000 meters, the government is to receive 65% and the contractor is to receive 35%. However, if production is greater than 200,000 barrel per day, the government is to receive 70% and the contractor is to receive 30%.

2.2 Thailand

Petroleum Legislation: The Petroleum Act B.E. 2514 of 1971 provides for concessions to private companies on a negotiated basis. On February 5, 1982, Thailand invited investors to bid for onshore exploration under production-sharing contract.

Duration: Exploration period of a concession is eight years. This may be renewed for an additional four years. The production period of a concession is 30 years from the time the exploration period expires. It may be renewed for for an additional term not exceeding ten years.

Cost Recovery and Production Sharing: (1) Limitation of costs in calculation of net profit to 20% of petroleum sold. (2) production sharing of 27.5% of petroleum sold at the average of 10, 000 barrels per day but not more than 20,000 barrels per day; 37.5% of 20,000 barrels per day but not more than 30,000 barrels per day; and 43.5% of petroleum sold in excess of the average of 30,000 barrels per day.

(3) Joint-venture Contract

3.1 India

Petroleum Legislation: At present, the exploration contract of India is based on the 1981 model contract.

Duration: Total duration is 22 years. Exploration period is four years divided into Phase I of two years and Phase II of two years (Offshore Phase II is expected to be one year).

Investment Obligation: The model contract leaves obligations to be negotiated. For example, the contract between chevron and Indian government calls for $29

million and three wells drilled in Phase I, two more wells and $18 million minimum in Phase II.

Host Country Participation: Oil and Natural Gas Commission (ONGC), the official government agency for petroleum, carried interest of 50% will be exercised after a commercial discovery, with payment for its share but not to include payment of its share of the exploration costs.

3.2 Colombia

Petroleum Legislation: Decree 2310 of 1974 as regulated by Decree 743 of 1975 provides that, except for rights granted under concessions still in force, the National Petroleum Company (Ecopetrol) has sole authority to explore for and recover hydrocarbons in Colombia. Ecopetrol can undertake such activity directly or through contracts of association.

Duration: Maximum duration is 28 years.

Investment Obligations: If at the end of seismic programme the contractor elects to continue operations under the agreement, it must commence drilling at least one exploratory well within one and a half years after the agreement's effective date. Within two years after the effective date, the Contractor must drill such well to its producing objective or spend a minimum of US$800,000 on exploratory drilling work within the contract area.

Joint Venture: The contractor is to advance all exploratory and development costs. Upon discovering a commercial petroleum field, the contractor must report the discovery and thereafter deliver to Ecopetrol a royalty of 20% of the hydrocarbons produced. Remaining production is allocated 50% to the contractor and 50% to Ecopetrol. The contractor has the right to take all of Ecopetrol's working interest share of production until the Contractor has

recovered 50% of its exploratory and development costs, or Ecopetrol may pay cash.

(4) Service Contract

4.1 Qatar

Petroleum Legislation: In 1974 the Government of Qatar acquired 60% of Qatar Petroleum Company Limited (QPC) rights and assets in Qatar, and under an agreement dated 16 December 1976 agreed to pay for the remaining 40%. QPC's rights and assets were then transferred by the State to Qatar Petroleum Company.

Duration: Thirty years. The Government may, at its discretion, extend a contract for 10 years on terms to be negotiated.

Investment Obligation: The contractor is to begin to explore within six months and, within 15 months after the effective date, complete initial geophysical operations. Within eight years from the effective date, the aggregate depth of wells shall not be less than 40,000 ft. at least one exploratory well will go 300 ft. into the Khuff Formation. The contractor must spend US$18 million during the first eight years.

Management Committee: On discovery, a management committee of six members is to be established. The host country and the contractor shall each appoint three members, one of the member appointed by the government to be Chairman. Decisions will be made by majority of votes. The Chairman will have the casting vote after the contractor has recovered all petroleum costs.

Recovery Costs and Production Sharing: The contractor will recover costs out of 40^% of the net production of crude oil. The value of cost recovery crude oil

that exceeds actual costs recoverable in any year taken by parties is in the following proportions: host country --90%, contractor--10%.

The contractor will have a preferential right to purchase all or portion of the host country's share of such excess cost recovery crude oil. Of the remaining 60% of crude oil, the host country and the contractor are entitled to the following:

Average Net Production Barrels/day	Host Country's Share, %	Contractor's Share, %
1- 25,000	80	20
25,001- 50,000	82.5	17.5
50,001- 75,000	85	15
75,001-100,000	87.5	12.5
Over 100,000	90	10

4.2 Argentina

Petroleum Legislation: Permits and concession are awarded by bidding under Law 21.778 of 1978, which allows risk contracts between State and private companies. Yacimientos Petroliferos Fiscales (YPF) is the State oil company. While the specified geographical areas are reserved for development by YPF, the remainder of the country is open to private enterprise pursuant to exploration permits and exploitation concessions and risk contracts.

Duration: Exploration term is five years, which will consist of two periods. First period--three years. Second period--two years. The term may be extended for two years for evaluation of any discovery. Development and production term is twenty years. The term may be extended up to five years more.

Investment Obligation: In the first exploration stage, the contractor assumes the following minimum work commitment:

(1) One hundred kilometers of seismic lines.

(2) Five exploration wells with a total of not less than 16,000 meter drilled.

The contractor is to pay YPF the amount of the unfulfilled committed investments as well as uncompleted wells committed if surrender occurs. The cost of each undrilled exploration well shall be US$ 1 million.

Management: Under these contracts, the contractor must incur all risks inherent in petroleum exploration and exploitation. Contractors are paid in cash for production until current domestic needs are satisfied and an adequate margin of reserves has been established, after which time they may export and receive compensation in kind.

Payment to Contractor: YPF shall pay for each cubic meter of net production of crude oil a price based on production levels. The price should accord with international levels with an inflation adjustor.

APPENDIX B

EFFECTS OF ALTERNATIVE FISCAL ARRANGEMENT ON CONTRACTOR'S RETURN

The purpose of Appendix B is to show that the same net revenue-terms from different types of contracts can be derived by varying the terms of the fiscal regimes or the host country takes. The reason of comparing revenue-terms on different ventures is to show that revenue derived from different contracts are due to differences in terms of the contracts and not due to types of contracts used. these financial results are presented using cash-flow of the different ventures.

A cash flow of a venture gives a year-by-year forecast of cash surplus for a particular year, the anticipated cash outflow (the sum of the payments made on behalf of the venture) will be subtracted from the anticipated cash inflow (the anticipated gross proceeds of sales as a result of the venture).

The main cash-inflow item is the company's share of gross revenues, being the proceeds of sales of crude oil or gas. The cash-outflow items can be subdivided into two groups: (1) the technical costs and, (2) the fiscal regimes or the host country takes.

1. Technical Costs

Technical costs are either capital expenditures (CAPEX), expenditures for goods with a lifetime of more than one year, and operating expenses (OPEX) for goods with a lifetime of less than one year. Typical capital expenditures are exploration and development costs, such as the costs of geological surveys, oil platforms, production facilities, pipelines, and drilling. Typical operating

expenditures are the costs of well repairs and work-overs, lifting costs, maintenance costs, insurance premiums, tanker rentals, etc.

2. The Fiscal Regimes or the Host Country's Take

The fiscal regimes or the host country's take depends on contract terms and the fiscal system in the host country. For example, in the case of the concession contract, the contractor has to pay a royalty, based on the value of the recovered mineral resources, and one or more taxes, based on "taxable income".

The following cash-flow model is constructed to show that the variation in the host country takes will effect the net revenue term in the cash flow. The concession system is used as an example to illustrate the model below.

The cash-surplus (CASSUR) is defined as:

CASSUR = REVENUES-CAPEX-OPEX-ROYALTY-TAX (1)

The royalty is a percentage of the gross revenues of the sales of hydrocarbons and it can be either in cash or in kind. The royalty will be deductible item and its therefore fiscally considered as an operating expense.

The tax is generally a percentage of taxable income. The taxable income is calculated by subtracting the fiscal acceptable costs from the revenue of sales:

TAXABLE INCOME = REVENUES - FISCAL COSTS (2)

The definition of the fiscal cost is laid down by legislation of the host country. The royalties and operating expenses are normally in fiscal costs of the fiscal year in which these expenses have been incurred. The depreciation (DEP) -- a compensation for the "wear and tear" of the capitalized assets, is also included in the fiscal costs. Therefore, the fiscal costs are defined as:

FISCAL COSTS = ROYALTY + OPEX + DEP (3)

Next, the tax term in the royalty/tax system is defined as:

TAX = TAX RATE * TAXABLE INCOME

or, TAX = TAX RATE * (REVENUE - ROYALTY - OPEX - DEP) (4)

If the relation in (4) is substituted into the expression (1) for the cash surplus, the new expression will become:

CASSUR = (1 - TAX RATE) * (REVENUES - ROYALTY - OPEX)
- CAPEX + (TAX RATE * DEP)

Since the royalty is the product of revenues and the revenues in turn are the product of production and price, the following simple expression is obtained:

CASSUR = NET REVENUES - NET CAPEX -NET OPEX (5)

In the expression (5), the net revenues are the part of revenues that remains after the royalty and the tax have been paid; in formula it can be defined as:

NET REVENUES = (1 - ROYALTY RATE) * (1 - TAX RATE)
* PRICE * PRODUCTION (5A)

The expression (5A) can be simplified by the following two expression:

ROYALTY = ROYALTY RATE * REVENUE

Then, the expression (5A) can be written as:

NET REVENUES = (1 - TAX RATE) * (REVENUE - ROYALTY)

The net CAPEX is the actual capital expenditures minus the tax relief of this expenditure that accrues to the company:

NET CAPEX = CAPEX - (TAX RATE * DEP) (5B)

The net OPEX is likewise the actual operating expenses minus the related tax relief:

NET OPEX = (1 - TAX RATE) * OPEX (5C)

From the relation in (5A), it will be clear that the variations in the host country take or the fiscal regimes (royalty and tax income in the concession case), oil prices, or production profile will only effect the net revenue term. Moreover, from the relation in (5B), a variation of the capital expenditures and depreciation rules will only effect the net CAPEX term. From the relation in (5C), a variation of the operating expenditures will only affect the net OPEX term.

To study the effect of contractual terms on revenue, technical and fiscal cost data are presented in Table B-1. They are used to calculate cash-flow under the different types of contracts.

Since the effects of contractual terms to the revenue derived are the interest of this study; the assumption of the hypothetical data of revenue, technical costs, and fiscal costs (the government take) are made in Table B-1. These data will be used to calculate the cash-flow projects of different type of contracts which are used in the petroleum exploration industry.

The hypothetical data of the fiscal regimes are allowed to vary in order to demonstrate that revenue derived from different types of contract are the same. Therefore, the difference in types of contracts are due to different in terms of each contract, rather than the fiscal regimes. The price of oil is also allowed to vary in order to represent another type of contract: a progressive-rate concession or production-sharing contract. This type of contract introduces the progressive fiscal regime to capture windfall profit.

Using the hypothetical data in Table B-1, Table B-2 to Table B-7 show the cash-flow projections of the contractor by different types of contracts. Table B-8 summarizes the results of Table B-2 to B-7 in order to facilitate the comparison. Each cash-flow projections in Table B-8 is separated into three

parts: (1) net revenues, (2) net capital expenditures, and (3) net operating expenditures in accordant with the expression in (5A), (5B), and (5C).

With the same technical costs and levels of production, Table B-8 has shown that the same net present value of the cash surplus in different types of contracts are obtained as expected. The only different variation among the different types of contracts are the difference in the combinations of the rate of the fiscal regimes. Therefore, it should be clear that the four different types of petroleum contracts do not exist due to different fiscal regimes.

Since the petroleum exploration business is a risky one, risks in oil exploration will be incorporated into the model in order to show that the revenue derived are also due to the probability of finding oil in the following section. Given all other being equal, it is expected that the same net present value of the cash surplus can be arisen when the different contracts are drawn under the different combination of risks.

The combination of risks in this study are assumed to be composed of three different outcomes: (1) the probability of undiscovered (dry hole), (2) the probability of discovering a production level of 5 million barrels of oil per year, and (3) the probability of discovering a production level of 10 million barrels of oil per year. Hypothetical data in Table B-1 are again used in the cash-flow computation. Since the calculation of the net present values cash surpluses to find a 5-million-barrels of oil production annually for the different contracts have already been calculated in Table B-2 to B-7; only the different net present values of cash surplus of the chance to find a 10-million-barrels of oil production annually are calculated and shown in Table B-9 to Table B-13. This computation are based on the sane fiscal-regime rate that used in the previous case.

With the different combination of probability of outcomes, the same expected money value of the different contracts are obtained as expected and are presented in Table B-13. Therefore, the conclusion can be drawn here that the difference in types of contracts are not due to the fiscal-regime rates and the combination of probability of outcomes, it is the content of contract that matter.

Table B-1

Hypothetical Data for Calculation of Net Present Value

	Concession		Production-sharing		Joint-Venture	Service
	Flat-rate	Pro-rate	Flat-rate	Pro-rate		
Revenue data						
Production (million barrels/year)	5	5	5	5	5	5
Price (US $/barrel)	20	30	20	30	20	20
Revenue (million US$/year)	100	150	100	150	100	100
Discount rate (percent)	15	15	15	15	15	15
Technical costs						
Capital expenditure(million US$)	60	60	60	60	60	60
Operating expenditure (million US $/Year)	20	20	20	20	20	20
Fiscal costs						
Royalty rate (percent)	10	30	-	-	15	-
Tax rate (percent)	46.6	64.3	-	-	-	-
Term of sharing(Gov:Co.)	-	-	64:36	84.5:15.5	50:50	67.5:32.5
Cost recovery (percent)	-	-	40	30	-	-
Straight line depreciation (million US $/year)	20	20	-	-	-	-

Table B-2

Calculation of Net Present Value of the Concession Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	100	100	100	100	100	100	100	100	100	100
Royalty (10 percent)	-	-	-	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
Operating expenditure	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Allowable depreciation	-	-	-	20	20	20	-	-	-	-	-	-	-
Taxable income	-	-	-	50	50	50	70	68	68	68	68	68	68
Tax (46.6percent)	-	-	-	(23)	(23)	(23)	(33)	(33)	(33)	(33)	(33)	(33)	(33)
Cash in	-	-	-	100	100	100	100	100	100	100	100	100	100
Cash out	(10)	(10)	(40)	(53)	(53)	(53)	(63)	(63)	(63)	(63)	(63)	(63)	(63)
Cash surplus	(10)	(10)	(40)	47	47	47	37	37	37	37	37	37	37

Net present value at 15% = 94.7

Table B-3

Calculation of Net Present Value of the Prduction-sharing Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	100	100	100	100	100	100	100	100	100	100
Operating expenditure	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Cost oil (40%)	-	-	-	40	40	40	40	40	40	40	40	40	40
Profit oil	-	-	-	60	60	60	60	60	60	60	60	60	60
Company's share (35.96%)	-	-	-	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
Cash in	-	-	-	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6
Cash out	(10)	(10)	(40)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Cash surplus	(10)	(10)	(40)	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6

Net present value at 15% = 94.7

Table B-4

Calculation of Net Present Value of the Progressive-rate Concession Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	150	150	150	150	150	150	150	150	150	150
Royalty (15 percent)	-	-	-	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)
Operating expenditure	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Allowable depreciation	-	-	-	20	20	20	-	-	-	-	-	-	-
Taxable income	-	-	-	80	80	80	100	100	100	100	100	100	100
Tax (46.6percent)	-	-	-	(51)	(51)	(51)	(62)	(55)	(55)	(55)	(55)	(55)	(55)
Cash in	-	-	-	100	100	100	100	100	100	100	100	100	100
Cash out	(10)	(10)	(40)	(101)	(101)	(101)	(114)	(63)	(63)	(63)	(63)	(62)	(62)
Cash surplus	(10)	(10)	(40)	47	47	47	37	37	37	37	37	37	37

Net present value at 15% = 94.7

Table B-5

Calculation of Net Present Value of the Progressive-rate Production-sharing Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	150	150	150	150	150	150	150	150	150	150
Operating expenditure	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Cost oil (30%)	-	-	-	45	45	45	45	45	45	45	45	45	45
Profit oil	-	-	-	105	105	105	105	105	105	105	105	105	105
Company's share (15.79%)	-	-	-	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Cash in	-	-	-	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6	61.6
Cash out	(10)	(10)	(40)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Cash surplus	(10)	(10)	(40)	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6

Net present value at 15% = 94.7

Table B-6

Calculation of Net Present Value of the Joint Venture Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	100	100	100	100	100	100	100	100	100	100
Company's share	-	-	-	42	42	42	42	42	42	42	42	42	42
Cost oil recovery	-	-	-	20	20	20	-	-	-	-	-	-	-
Operating expenditure	-	-	-	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
Royalty (15%)	-	-	-	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
Cash in	-	-	-	62	62	62	62	62	42	42	42	42	42
Cash out	(10)	(10)	(40)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(20)
Cash surplus	(10)	(10)	(40)	52	52	52	32	32	32	32	32	32	32

Net present value at 15% = 94.7

Table B-7

Calculation of Net Present Value of the Service Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	100	100	100	100	100	100	100	100	100	100
Cost recovery	-	-	-	20	20	20	-	-	-	-	-	-	-
Company's share (32%)	-	-	-	32	32	32	32	32	32	32	32	32	32
Cash in	-	-	-	52	52	52	32	32	32	32	32	32	32
Cash out	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Cash surplus	(10)	(10)	(40)	52	52	52	32	32	32	32	32	32	32

Net Present Value at 15% = 94.7

Table B-8

Calculation of Net Present Value for the Different Types of Contracts

	Concession		Production-sharing		Joint-venture	Service
	Flat-rate	Pro-rate	Flat-rate	Pro-rate		
NPV of revenue	330.0	495.0	330.0	495.0	330.0	330.0
Company's share rate	0.5	0.3	0.4	0.2	0.4	0.3
(a) Net revenue	158.5	141.6	118.8	78.2	140.3	107.3
NPV of CAPEX	42.6	42.6	42.6	42.6	42.6	42.6
NPV of cost discovery or depreciation	30.0	30.0	132.0	148.5	30.0	30.0
Tax rate	0.5	0.6	0.6	0.8	0.0	0.0
(b) Net CAPEX	28.6	23.3	-41.9	-82.5	12.6	12.6
NPV of OPEX	66.0	66.0	66.0	66.0	33.0	0.0
Company's share rate	0.5	0.4	0.0	0.0	0.0	0.0
(c) Net OPEX	35.2	23.6	66.0	66.0	33.0	0.0
(a)- (b) - (c) NPV of cash surplus =	94.7	94.7	94.7	94.7	94.7	94.7

Table B-9

Calculation of Net Present Value of the Concession Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	200	200	200	200	200	200	200	200	200	200
Royalty (10 percent)	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Operating expenditure	-	-	-	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)
Allowable depreciation	-	-	-	20	20	20	-	-	-	-	-	-	-
Taxable income	-	-	-	120	120	120	140	140	140	140	140	140	140
Tax (46.6percent)	-	-	-	(56)	(56)	(56)	(65)	(65)	(65)	(65)	(65)	(65)	(65)
Cash in	-	-	-	200	200	200	200	200	200	200	100	100	100
Cash out	(10)	(10)	(40)	(116)	(116)	(116)	(125)	(125)	(125)	(125)	(125)	(125)	(125)
Cash surplus	(10)	(10)	(40)	84	84	84	75	75	75	75	75	75	75

Net present value at 15% = 218

Table B-10

Calculation of Net Present Value of the Production-sharing Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	200	200	200	200	200	200	200	200	200	200
Operating expenditure	-	-	-	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)
Cost oil (40%)	-	-	-	80	80	80	80	80	80	80	80	80	80
Profit oil	-	-	-	120	120	120	120	120	120	120	120	120	120
Company's share	-	-	-	43	43	43	43	43	43	43	43	43	43
Cash in	-	-	-	123	123	123	123	123	123	123	123	123	123
Cash out	(10)	(10)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)
Cash surplus	(10)	(10)	(40)	83	83	83	83	83	83	83	83	83	83

Net present value at 15% = 231.8

Table B-11

Calculation of Net Present Value of the Joint Venture Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	200	200	200	200	200	200	200	200	200	200
Company's share	-	-	-	85	85	85	85	85	85	85	85	85	85
Cost oil recovery	-	-	-	20	20	20	-	-	-	-	-	-	-
Operating expenditure	-	-	-	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Royalty (15%)	-	-	-	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)	(30)
Cash in	-	-	-	105	105	105	85	85	85	85	85	85	85
Cash out	(10)	(10)	(40)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Cash surplus	(10)	(10)	(40)	85	85	85	65	65	65	65	65	65	65

Net present value at 15% = 202

Table B-12

Calculation of Net Present Value of the Service Contract
(million of dollars); ( ) = cash deficit

	1	2	3	4	5	6	7	8	9	10	11	12	13
Capital expenditure	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Revenue	-	-	-	200	200	200	200	200	200	200	200	200	200
Cost recovery	-	-	-	20	20	20	-	-	-	-	-	-	-
Company's share (32.5%)	-	-	-	65	65	65	65	65	65	65	65	65	65
Cash in	-	-	-	85	85	85	65	65	65	65	65	65	65
Cash out	(10)	(10)	(40)	-	-	-	-	-	-	-	-	-	-
Cash surplus	(10)	(10)	(40)	85	85	85	65	65	65	65	65	65	65

Net present value at 15% = 202

Table B-13

Expected Money Value of the Different Types of Contracts

	Concession			Production-sharing			Joint -venture			Service		
	CMX	P(X)	EMP	CMX	P(X)	EMP	CMX	P(X)	EMP	CMX	P(X)	EMP
Dry hole	-42.6	0.5	-21.3	-42.6	0.5	-20.4	-42.6	0.4	-19.2	-42.6	0.5	-19.2
5 million barrel/year	94.7	0.3	28.4	94.7	0.4	34.1	94.7	0.4	36.4	94.7	0.4	36.3
10 million barrel/yr	218.1	0.2	43.6	231.8	0.2	37.1	202.0	0.2	33.5	202.0	0.2	33.5
Expected money Value			50.8			50.8			50.8			50.8

Note: CMP = Conditioned Monetary Profits
P(x) = Probability of outcomes
EMV = Expected Monetary Value

APPENDIX C

SUPPLEMENTARY TABLES TO CHAPTER IV

Table C-1

Contractual Arrangements Governing International Petroleum Industry at the End of 1982.

Type of contract	Countries
Concession	Australia, Austria, Bahama, Barbados,Belgium, Belize, Benin, Botswana, Brunei, Chad, Costa Rica, Cyprus, Dubai, El Salvador, Ethiopia, Fiji, France, France Guiana, Gambia, Germany, Martinique, Guyana, Hondurus, Hong Kong, Italy, Japan, Kenya, South Korea, Lebanon, Malawi, Mali, Malta, Mauritius, Nicaragua, Niger, Palau, Paraguay, Puerto Rico, Senegal, Seychells, Sharjah, Sierra Leon, Somali , Republic, Surinam, Switzerland, Sweden, Tongo, Tunisia, United Kingdom, Canada, the United States, Yeman, Zaire, Zimbabwe, Uruguay.
Production -sharing	Bangladesh, Bolivia, Burma, Denmark, Guatemala, Dominican Republic, Equatoria Guinea, Gabon, Greece, Guinea, Haiti, Ireland, Israel, Ivory Coast, Jamaica, Jordon, Lesotho, Liberia, Mauritania, Morocco, Mozambique, Pakistan, Panama, Philippines, Sri Lanka, Sudan, Tanzania, Thailand, Togo, Trinidad, Tabago, Veitnam, Egypt, Chile, Cameroon, Congo.
Joint-venture	Algeria, Angola, Colombia, Greenland, Guinea , Bissau, India, Indonesia, Madagascar, Norway, Papua New Guinea, Portugal, Spain, Turkey, Zambia, Peru, Netherland, Abu Dabi, Ras Al-Khaimah, Malaysia, Spain, Nigeria.
Service contract	Argentina, Brazil, Ecudor, Iran, Kuwait, Libya, Mexico, Qatar, Saudi Arabia, Iraq, Venezuela, Syria, Baharain, Oman.

Source: The types of contract are distinguished in according to the definition of this study in Chapter I. For the contents of the contract to make distingushment relies on Barrow (1983).

Table C-2

Geological Information of the Four Types of Petroleum Contracts Across Countries, 1982

Countries	Oil Discoveries (mil barrel) (A)	Number of Exploratory Well (B)	Number of Wildcat well (C)	(A/B)	(A/C)	(C/B)
Concession Contract						
Austria	667	495	372	1.4	0.6	0.7
Barbados	neg	17	45	neg	neg	2.6
Belize	0*	31	37	0	0	1.2
Benin	0*	11	16	0	0	0.5
Chad	100	21	19	4.8	5.3	0.9
French	713	1399	1292	0.5	0.5	0.9
Ethiopia	0*	28	32	0	0	1.1
Dominican	0*	8	29	0	0	1.6
Hondurus	0*	14	25	0	0	1.8
Nicaragua	0*	31	36	0	0	1.2
Guyana	0*	19	12	0	0	0.8
Suriname	0*	35	39	0	0	1.1
Italy	455	1349	1739	0.3	0.3	1.3
Greece	160	77	81	2.1	2.0	1.1
Senegal	0*	56	71	0	0	1.3
Liberia	0*	4	4	0	0	1.0
Ghana	9*	32	31	0.3	0.3	1.0
Somalia	0*	36	48	0	0	1.3
Kenya	0*	19	14	0	0	0.7
Mozambique	0*	51	53	0	0	1.0
Zaire	186	29	37	6.4	5.0	1.3
Mauritania	0*	11	12	0	0	1.0
South Korea	0*	10	10	0	0	1.0
Germany	1334	1200	1487	1.1	0.9	1.2
Paraguay	0*	29	37	0	0	1.3

Table C-2 (Continued)

Countries	Oil Discoveries (mil barrel) (A)	Number of Exploratory Well (B)	Number of Wildcat well (C)	(A/B)	(A/C)	(C/B)
Production-sharing						
Guatemala	56	32	48	1.8	1.8	1.5
Bolivia	400	308	249	1.3	1.6	0.8
Syria	2324	21	50	110.0	46.5	2.4
Ireland	114	64	72	1.8	1.6	1.1
Denmark	732	74	89	9.9	8.2	1.2
Ivory Coast	394	32	35	12.3	11.2	1.1
Togo	0*	3	1	0	0	0.3
Camaroon	417	166	131	2.5	3.2	0.8
Gabon	1592	324	385	4.9	4.1	1.2
Congo	698	66	80	10.6	8.7	1.2
Sudan	400	28	41	14.3	9.7	1.5
Pakistan	311	131	105	2.4	3.0	0.8
Taiwan	21	260	216	0.1	0.1	0.8
Philippines	49	236	261	0.2	0.2	1.1
Trinidad &Tobago	2598	598	186	4.3	13.9	0.3
Morocco	100	413	210	0.2	0.5	0.5
Burma	528	70	49	7.5	10.8	0.7
Thailand	350	88	75	4.0	4.7	0.8
Egypt	7000	431	651	16.2	10.7	1.5
Chile	400	498	412	0.8	0.6	0.8

Table C-2 (Continued)

Countries	Oil Discoveries (mil barrel) (A)	Number of Exploratory Well (B)	Number of Wildcat well (C)	(A/B)	(A/C)	(C/B)
Joint-venture						
Malaysia	1599	376	361	4.2	4.4	0.1
Netherland	400	550	556	0.7	0.7	1.0
Norway	9682	226	249	42.8	38.9	1.1
Turkey	644	628	586	1.0	1.1	0.9
Algeria	18493	816	797	22.6	23.2	1.0
India	3529	241	211	14.6	14.9	0.9
Angola	2000	341	369	5.9	5.4	1.1
Nigeria	17200	867	885	19.8	19.4	1.0
Indonesia	19600	1872	1560	10.4	12.5	0.8
Colombia	3100	782	919	3.9	3.4	1.2
Service						
Peru	2100	910	264	2.3	7.9	0.3
Argentina	3407	2447	1271	1.4	2.7	0.5
Venezuela	61451	2546	1161	24.1	52.9	0.5
Libya	36225	1656	1323	21.9	27.4	0.8
Ecudor	2900	345	164	8.4	17.7	0.5
Brazil	3100	2265	1009	1.4	3.1	0.5
Suadi Arabia	211345	252	93	838.7	2273.0	0.4
Kuwait	108889	66	43	1650.0	2532.0	0.7
Neutral zone	15230	40	32	380.8	475.9	0.8
Qatar	7695	48	51	160.3	150.9	1.1
Iran	93600	329	287	284.5	326.1	0.9
Iraq	69300	76	107	911.8	647.7	1.4
Baharain	1025	43	11	23.8	93.2	0.3
Oman	5012	115	206	43.5	24.3	1.8

Source: This Table corresponds to Table 4.1. For types of contracts see Table C-1.Data marked with an asterik * are taken from Broadman (1985). The rests of data are taken from Root, et. al. (1982).

Table C-3

Year at Contractual Form Change of Selected Countries

Country	Year	Sources
Production-sharing Contract		
Trinidad & Tobago	1974	Hossain 1979: 150
Burma	1973	Hossain 1979: 167
Gutamala	1978	Mikesell 1984: 78
Gabon	1978	D.O.E. 1981: 179
Pakistan	1976	Barrows 1983: 206
Thailand	1982	Barrows 1983: 260
Bolivia	1972	Barrows 1983: 62
Camaroon	1978	Barrows 1983: 73
Chile	1975	Barrows 1983: 79
Israel	1976	Barrows 1983: 149
Joint-venture Contract		
Malaysia	1982	Barrows 1983: 177
Norway	1973	Hossain 1979: 134
Indonesia	1977	Mikesell 1984: 65
Peru	1978	Mikesell 1984: 72
Colombia	1975	Mikesell 1984:108
Algeria	1973	D.O.E. 1981: 164
Negeria	1972	D.O.E. 1981: 192
Angola	1978	Barrows 1983: 43
Spain	1974	Barrows 1983: 242
India	1974	Barrows 1983: 135
Service Contract		
Brazil	1976	Mikesell 1984: 100
Argentina	1980	Mikesell 1984: 195
Syria	1977	Barrows 1983: 253
Ecudor	1982	Barrows 1983: 98
Baharain	1982	Barrows 1983: 62
Oman	1975	Barrows 1983: 205
Venezuela	1975	D.O.E. 1981: 52
Qatar	1976	D.O.E. 1981: 144
Kuwait	1975	D.O.E. 1981: 140
Saudi Arabia	1977	D.O.E. 1981: 150

Table C-4

Size of Oil Field Discoveries in Selected Countries

Country	t-3			t-2			t-1			Average
	P	F	S	P	F	S	P	F	S	S
Production-sharing Contract										
Trinidad & Tobago (1974)	1053	21	50.1	560	23	24.3	500	25	20.0	31.5
Burma (1973)	50	2	25	39	3	13.2	40	5	8.0	15.4
Gutamala (1974)	14	2	7.3	20	2	9.8	14	2	7.2	8.1
Gabon (1978)	579	39	14.9	587	50	11.7	543	35	15.5	14.0
Pakistan (1976)	32	5	6.5	30	5	6.0	26	5	5.2	5.9
Thailand (1982)	1	2	0.2	1	2	0.2	1	2	0.2	0.2
Bolivia (1973)	300	7	42.8	262	8	32.7	220	8	27.5	34.4
Camaroon (1979)	0	0	0	15	1	147.6	143	4	35.8	91.9
Chile (1975)	144	9	16.0	220	9	24.4	210	11	19.1	19.8
Israel (1976)	2	2	1.2	2	2	1.0	2	2	0.8	1.0
Joint-venture Contract										
Malaysia (1982)	1400	14	100.0	1800	15	120.0	2500	15	166.7	128.8
Norway (1973)	2000	3	666.7	1467	3	489.0	2300	3	766.7	640.8
Indonesia (1977)	12000	85	141.2	12000	94	127.7	11500	100	115.0	127.9
Peru (1978)	747	17	44.0	728	13	55.9	750	21	35.7	45.2
Colombia (1975)	1598	22	72.6	688	21	32.8	627	29	21.6	42.3
Algeria (1972)	8089	49	165.3	9839	47	209.4	9750	27	361.1	245.2
Negeria (1972)	5600	50	112.0	11500	51	225.5	12600	69	182.6	173.4
Angola(1978)	1358	24	56.6	1322	24	55.1	1414	27	52.4	54.7

Table C-4 (Continued)

Country	t-3			t-2			t-1			Average
	P	F	S	P	F	S	P	F	S	S
Spain (1974)	55	1	55.0	65	2	32.5	90	2	45.0	44.2
India (1974)	739	18	41.1	787	18	43.7	891	17	52.4	45.7
Service Contract										
Brazil (1976)	774	16	48.4	779	16	48.7	783	19	41.2	46.1
Argentina (1980)	2515	10	251.5	2317	10	231.7	2900	10	290.0	257.7
Syria (1977)	2776	5	555.2	2707	4	676.9	2638	14	659.5	630.5
Ecudor (1982)	1200	13	92.3	1050	13	80.8	1100	16	68.7	80.6
Baharain (1982)	230	1	230.5	223	1	223.1	206	1	206.2	219.9
Oman (1975)	3027	4	756.7	3321	4	830.2	3294	7	470.5	685.8
Venezuela (1975)	13872	80	173.4	13812	80	172.6	18567	80	232.1	192.7
Qatar (1976)	5624	4	1406.0	5438	4	1359.4	5277	4	1319.4	1361.6
Kuwait (1975)	73974	7	10567.7	72969	7	10424.1	70890	8	8861.3	9951.1
Saudi Arabia (1977)	103480	24	4311.7	107875	31	3479.3	110187	15	7345.8	5045.6

Source: Data on proven crude oil reserves and total producing fields come from Blitzer et. al. (1983).

Notes: (1) Figures in parenthesis are the year at contractual form changes in that country;
(2) "t" denotes the year at contractual form changes;
(3) "P" denotes proven crude oil reserves;
(4) "F" denotes total producing fields;
(5) "S" denotes average size of the oil-field discoveries.

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