A QUANTITATIVE MODEL OF COMPETITIVE STRATEGY

by

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ABSTRACT

A quantitative model of competitive strategy is developed here based on the resource-based view of the firm. In this view firms are defined as heterogeneous sets of resources. It is assumed that heterogeneity in resource sets allows some firms to enjoy positive surplus purchases in strategic factor markets. A series of such transactions is considered required for firms to improve their resource sets. This in turn yields an increase in firm performance and persistence in competitive advantage.

The resource-based view is developed primarily in qualitative form in the strategy literature and econometric models are derived directly from it. However, to facilitate the "conciseness and preciseness of statement" in reasoning with the resource-based view, while forcing the analysis to have "assumptions explicit at every stage of reasoning," a quantitative form is derived here (Chiang 1984).

An econometric model is then derived to test the implications of the model in the exploration and production segment of the petroleum industry. Two strategic dimensions are defined: internal organization of complex inputs and acquisition of complex inputs. Proxies are developed for detecting strategic intent in each dimension. Hypotheses regarding the effect of strategic intent on firm performance are then tested. The results suggest that strategic intent in either or both of the dimensions can yield a performance gain. There is an apparent negative synergy effect in combined strategy pursuit in this industry.

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Chapter 1

INTRODUCTION

Casual observation of performance across firms often reveals heterogeneity within a given industry. The notion that some firms are able to maintain superior resources that enhance their profitability for nontrivial periods of time may explain this phenomenon. The investigation of how firms augment their resources and in turn increase and sustain their competitive advantage is the focus of this research. A model incorporating concepts from the resource-based view of the firm is formed to draw hypotheses regarding the effects of strategic expenditure, competitor expenditure, and simultaneous expenditure in more than one strategic dimension on firm performance.

Many of the concepts and theories from the economic literature, especially industrial organization, are useful in the investigation of strategic action: i) the objective of profit maximization, ii) the nature of information imperfections and their influence on competitor interaction, and iii) generalizations regarding price, production, and cost, among others. The economic literature has pulled these concepts together to form models of strategic interaction in the field of industrial organization, especially with the incorporation of game theory. This is concisely stated by Tirole (1997) for the case of oligopolists:

> Oligopolists are affected by many variables they cannot observe or estimate precisely: their own cost function, the cost functions of their rivals, the state of demand or the potential of the market, and their rivals' strategic decisions. To the extent that some pieces of information are private (for instance, a firm may have a good estimate of its own cost but no good estimate of its rivals' costs), we must envision market interaction as a game with asymmetric information.

Game theoretic models as well as others from industrial organization have evolved as methods for handling the relaxation of the assumptions of the primary economic theory of the firm and firm interaction - homogeneous firms in a market structure characterized by perfect competition. Although these methods handle many aspects of strategic behavior, an alternative theory of the firm and firm interaction, the resource-based view of the firm, is employed for the derivation of quantitative model derived here. This theory directly approaches the nature of the firm and firm performance from a set of assumptions that may more closely map to the heterogeneity of reality identified above by Tirole (1997).

The resource-based view of the firm in the strategy literature provides a framework for analyzing how firms generate and sustain a competitive advantage. This view defines the firm as a set of resources, along with the essential assumption that these resources are heterogeneous across firms. Incompleteness in the markets for these resources is used to explain the persistence of heterogeneity in resources across firms.

A quantitative model of competitive strategy is derived from the resource-based view of the firm. The model is couched within general dimensions of competitive strategy. Separate resources are associated with each dimension. The degree of resources under a give firm's control in each dimension serves as an identification of a given firm's location in the strategic dimensions. The positions are then associated with levels of performance.

Three hypotheses about strategic investment are drawn from this model. The first hypothesis suggests that firm expenditures on strategic resources can have a positive effect on rent. The second hypothesis suggests that competitor expenditures on resource addition yield a negative affect on firm performance. The third hypothesis suggests that there is a positive synergy in resource addition in pursuing additions to more than one resource at a time.

An empirical testing of the hypotheses is then performed in the exploration and production segment of the petroleum industry. Two dimensions for cost competition in a commodity industry are developed from economic principles: internal organization and acquisition. Proxies are developed for using public data to detect strategic intent in each dimension. The results are consistent with the first two hypotheses, but not the third hypothesis.

The following chapters are organized as follows. The development of the resource-based view and its relation to two previously established paradigms in the strategic literature is reviewed in Chapter 2. A quantitative model is developed in Chapter 3 to outline the process of creating and sustaining competitive advantage within the framework provided by the resource-based view. The hypotheses are then drawn in this chapter. A specification for empirically testing the hypotheses is presented in Chapter 4. The data set formation and estimation results are presented in Chapter 5. Implications for firm management in the petroleum industry, and firm managers in general, are drawn from the results. Finally, in Chapter 6 general conclusions are presented along with avenues for further research.

Chapter 2

COMPETITIVE STRATEGY

The focus of the analysis here is on competitive strategy as opposed to corporate strategy. Competitive strategy refers to how firms compete in a given product market, whereas corporate strategy refers to selecting which markets to compete in.

A complete theory relating competitive strategy to competitive advantage, must address three primary concerns: i) how firms identify an opportunity to generate a competitive advantage, ii) how firms achieve the competitive advantage, and iii) how firms sustain a competitive advantage. Three related paradigms in the strategic literature that address one or more of these concerns include i) the analysis of strategic position, ii) strategic group theory, and iii) the resource-based view of the firm.

The first two paradigms focus on the process of identifying dimensions of competitive advantage (low cost, product differentiation, or their sub-dimensions) and then analyzing the value of alternative positions within those dimensions. Strategic group theory provides an analysis of how firms sustain a position. The resource-based view is a model encapsulating the identification, achievement, and sustainability of a position in the dimensions of competitive advantage. Each paradigm is discussed in the following sections.

Strategy: Positioning and Strategic Groups

The analysis of strategic position is a natural initial framework for general modeling in strategic research. The analysis begins with the identification of a set of general strategic dimensions. This provides a map for the goal of strategic management. The dimensions are selected according to principles borrowed from economic theory, or some other discipline. Then, locations within the strategic dimensions are conceptually related to a degree of competitive advantage. This form of analysis is an attempt to formulate cross-sectional relationships between strategy and performance.

In economic strategy research, the strategic dimensions are based on the principle elements of economic profit: price and cost. Porter (1980) refines these elements into the strategic dimensions of i) cost reduction in production and distribution, ii) increasing market power through product differentiation, and iii) market focus. Each of these dimensions is closely tied to, and has a separate influence on, profitability. Porter (1980) suggests that firms should only focus on one of these dimensions. However, subsequent research suggests that intermediate positions may be optimal (see Karnani 1984 and Dess et al 1995).

Depending on the industry under study, differing positions within these dimensions may yield differing degrees of competitive advantage. For example, in commodity industries, where output is largely homogeneous, it is probably more profitable to focus on a position that is more intensive in cost reduction than product differentiation. On the other hand, in the clothing industry a mixture of the differentiation and cost reduction strategies may be the most profitable position.

Regardless of where a firm positions itself profitability will depend on the number of firms in the position - generally, the fewer the firms the better. This declaration is similar to an established principle in microeconomics: there is negative relationship between the number of firms in an industry (decreasing concentration) and firm profits. Here the contingency is between the number of firms in a resource position and profits. For example, if all firms attempt to be low cost producers, a price war may occur, driving the price downward, along with the degree of competitive advantage associated with a low cost structure. If all firms attempt to differentiate their product, market demand may become very fragmented eroding total revenue and thus absolute profit.

On a side note, the declaration that a given position yields greater performance when fewer firms are in it requires one qualification. In some instances, when there are significant positive externalities associated with a given firm's arrival, the change in performance associated with the position may be nonnegative.

The value of the analysis of strategic position in isolation is questioned in strategy research. Cross-sectional analysis of strategic position does not provide a trail of causation to describe how a firm gained a position. Amit and Schoemaker (1993) note that key success factors alone (analogous to strategic dimensions) cannot provide a thorough explanation of how firms maintain competitive advantage. They point out that if all firms exploit the key success factors (or the same position in the strategic dimensions), no firm will enjoy a competitive advantage.

The cross-sectional problem in the analysis of strategic position is partially alleviated in strategic group theory. This body of research, originally developed in the 1970's (see for example Newman (1978), and Porter (1979)), enriches the analysis of strategic position with additional insight regarding the identification and sustainability of competitive advantage. According to this theory, firms can be grouped according to homogeneous positions within the dimensions of competitive advantage, such that each group holds a different position. The groups are then analyzed for performance differences.

For example, consider Oster's (1982) study of strategic groups in consumer product industries. Oster (1982) examines coarse groupings based on advertising expenditures. Advertising expenditures are essentially a proxy for location in the dimension of product differentiation. The soft drink industry is separated into high advertisers (Coca Cola, Seven-up, and Seagrams) and low advertisers (Cott, Glenmore, and National Distillers). Oster (1982) finds a significant profit difference between these groups.

Within strategic group theory, the foundation for sustainability of competitive advantage is formed by the concept of mobility barriers. Mobility barriers provide the basis for determining the ability of firms to move between groups within an industry. They are derived from the concept of barriers to entry in industrial organization economics.

Barriers to entry limit the onset of competition, and the resulting erosion of market power, from outside an industry. Mobility barriers limit the movement of firms from one strategic group to another within an industry, for example, from a low market share position to a high market share position. Groups with strong mobility barriers, enjoying a relatively higher degree of performance, will have some ability to sustain a competitive advantage. Note that a mobility barrier may or may not serve as a barrier to entry, depending on whether the entrant attempts to enter a group or an unoccupied position.

In order to improve their competitive advantage, firms will first search the strategic group structure in their industry for groups with superior performance. Then firms will determine whether or not the mobility barriers surrounding the superior group can be subverted efficiently, such that the benefits are not eclipsed by the costs. In order to maintain a competitive advantage, firms within a group will attempt to efficiently maintain the group specific mobility barriers.

Although strategic group theory addresses the identification and sustainability of competitive advantage, it does not offer a causal process for the generation of competitive advantage. That is, the process of how firms identify profitable strategies in the first place is not detailed. In addition, strategic group theory constrains strategic analysis to a course level that does not facilitate the analysis of per firm variability in strategy.

An alternative theory, the resource-based view of the firm, does not rely on the existence of a strategic group structure. However, it maintains the notion of positioning in strategic dimensions in the product market. In the resource-based view it is assumed that firm managers analyze their competitive environment to identify their own position and superior positions, much like strategic group theory. Then firm managers examine their firm's internal resources to generate information and formulate strategy in enhancing their resources in the pursuit of competitive advantage.

The Resource-Based View of the Firm

In the resource-based view of the firm, the firm is defined as a set of resources (see Wernerfelt (1984), Barney (1986), (1991), Dierickx and Cool (1989a), and Peteraf (1993)). An additional assumption that resources are heterogeneous across firms opens up the analysis of how firms act strategically and why some firms outperform others. In general, some resources are considered i) valuable in production and distribution, ii) scarce, and iii) do not trade in perfect markets. Firms with favorable resources may therefore enjoy a competitive advantage.

A firm's resource base is associated with its position in the dimensions of competitive advantage defined in the product market. A strategy under the resource-based view is therefore a plan to alter one's resource base to achieve a position in a product market associated with a higher degree of competitive advantage.

Forming a view of the firm around firm resources provides a more complete incorporation of economic principles than the preceding strategy literature. Specifically, economic principles of markets, information, expectations, and marginalism are incorporated into the modeling of strategic management. Assumptions of information imperfections and incomplete resource markets are used to explain the identification, generation and sustainability of competitive advantage (Barney 1986, and Dierickx and Cool 1989a).

Strategic Factor Markets

Barney (1986) introduces the concept of strategic factor markets to examine a strong necessary condition for the ability of firms to enjoy a rent from achieving a product market position. Strategic factor markets are defined as the markets in which firms make expenditures necessary for the implementation of a strategy (Barney 1986). For example, advertising expenditures for product differentiation or research & development expenditures for achieving a low cost position are made in strategic factor markets. The economic cost of these factors must be taken into account before a firm can claim to earn a rent from the implementation of a strategy (Barney 1986).

Barney (1986) notes that when all firms in a strategic factor market (buyers and sellers) have the same "perfectly accurate" expectations regarding the value of strategic factors, the price of the factors will reflect their full value. No firm will be able to earn a rent from their purchase.

Barney (1986) then considers the case where some firms are "better informed" and have more accurate expectations regarding the value of a particular factor relative to other firms. In this case, firms with more accurate expectations more often correctly recognize when factors are overvalued (overpriced) and under-valued (under-priced). These firms will on average avoid more losses from purchasing overvalued factors and secure more gains from purchasing under-valued factors, relative to firms with less accurate expectations. Barney (1986) then prescribes that firms should analyze their own resources to generate information to in turn increase the accuracy of their expectations.

Barney (1986) notes that some less accurate firms may occasionally enter a strategic factor market when the factor is under-valued. These firms will enjoy a rent form purchasing that factor through luck rather than an advantage in the accuracy of their expectations. This implies that firms do not need a special ability in deploying the factor. If no firm has a special ability this further implies that firms have the same resources. Therefore, Barney's (1986) model is not necessarily a model of the resource-based view. However, the concept of strategic factor markets is very useful and has been employed in the literature on the resource-based view.

Conner (1991) provides an application of strategic factor markets under the condition of heterogeneous firm resources. Conner (1991) uses the concept of asset specificity to demonstrate how firms can achieve a rent when the firms (buyers) in a strategic factor market have heterogeneous abilities to use the factor. If firms have heterogeneous abilities to use a factor some firms can derive more value from combining the factor with their own existing resources when deploying the factor. These firms find the factor to be relatively specific to their assets (resources). In relation to the case in Barney (1986), firms now have heterogeneous values for the factor rather than heterogeneous expectations regarding its value.

Conner (1991) considers several cases where firms can earn a rent when they find a strategic factor to be more specific to their assets than other firms in the strategic factor market. In one case, the number of firms that find the factor to be specific to their asset base is set equal to the number of factors available for purchase. Conner (1991) demonstrates that as long as a given firm finds the factor to be specific to its assets, and more specific to its assets than the next "marginal purchaser" of the factor, the firm will earn a rent from its purchase and deployment.

In a second case, the number of factors available for purchase is set greater than the number of firms that find the factor specific. Conner (1991) notes in this case that the necessary condition for earning a rent is that a firm finds the factor to be specific. In both cases, the seller(s) must not be able to price discriminate, whereby the buyer is charged exactly what the factor is worth to them.

Resource Accumulation

In response to Barney's (1986) concept of strategic factor markets, Dierickx and Cool (1989a) offer a stock and flow paradigm for strategic resources. Dierickx and Cool (1989a) claim that strategic resources are not simply purchased in strategic factor markets, rather, they are internal stocks that do not trade easily in markets. Due to severe strategic factor market incompleteness, Dierickx and Cool (1989a) suggest that the internal stocks must be built up over time with a consistent set of investment flows.

Dierickx and Cool (1989a) offer the example of a reputation for quality as a resource that does not trade easily in a resource market. A reputation for quality takes years of investing in consistent production processes and policies focused on quality; it cannot be purchased easily in a market. If competitor firms eventually develop information and positive expectations about achieving a reputation for quality, it will still take them time to achieve the position. Therefore, firms that pursue a particular reputation for quality first will enjoy some sustainability to their strategic position.

In a comment following this research, Barney (1989) points out that Dierickx and Cools (1989a) stock and flow framework is complimentary to the concept of strategic factor markets. Although the final resource that allows for the implementation of a strategy is not simply purchased in a strategic factor market, the investment flows are expenditures in strategic factor markets. In a reply, Dierickx and Cool (1989b) agree.

Given the establishment of that the frameworks complimentary, it is worth further investigating Dierickx and Cool's (1989a) concepts regarding the resource accumulation process. The amount of time it takes for competitors to imitate the position will determine the degree of sustainability. Dierickx and Cool (1989a) offer four reasons why the process of imitating strategic resources may be impeded: i) time compression diseconomies, ii) asset mass efficiencies, iii) interconnectedness of asset stocks, and iv) causal ambiguity.

The notion of time compression diseconomies refers to the diminishing returns from increasing the inputs used in producing a resource while time is held constant (Dierickx and Cool (1989) note the connection between this concept and the concept of convex "adjustment costs" in the economic literature). The concept of asset mass efficiencies suggests that the process of accumulating a strategic resource internally becomes easier as the stock of the resource grows larger. The concept of interconnectedness of resource stocks augmenting the stock of a resource may require the presence of other resources.

These concepts incorporate the notion of first mover advantage, from industrial organization, into the resource-based view (see Wernerfelt 1984 and Conner 1991). Those firms that move first in developing a resource may be able to continuously outpace their rivals in adding to or maintaining a given resource.

A resource characterized with the fourth trait, causal ambiguity, is hard to duplicate due to uncertainty in the process of generating the resource. Taken further, the concept may even be applied in the case where firms do not know themselves how they came about some operational advantage. In this case, the advantage would be serendipitous rather than strategic.

A Summary and Interpretation

The concept of strategic factor markets is an essential component to the analysis of competitive advantage under the resource-based view. For if firms cannot somehow secure the factors necessary for a strategy for an economic cost that is less than the value of the strategy when implemented the goal of competitive advantage is confounded. An important building block for any model of competitive strategy under the resource-based view is thus an analysis of strategic factor markets. A provision of logic demonstrating how the characteristics of the strategic factor market allow a firm to make expenditures for factors such that the expenditures are less than the value of the factors once deployed is necessary.

The characteristics of information and firm resources will determine the ability of firms to earn a rent through transactions in a strategic factor market. Information may be perfect or imperfect, while resources may be homogeneous across firms or heterogeneous across firms. A short digression on the definitions of information in the industrial organization literature is provided below. This is followed with a table for organizing four primary scenarios for the characteristics of strategic factor markets.

In the case of perfect information all firms have the same information. Conditions alternative to perfect information and their effect on the competitive environment are modeled in industrial organization economics. Two closely related forms of information defined in the literature: imperfect information and incomplete information.

Information is considered imperfect when one firm does not know the complete history of another firm's actions (Tirole 1997). Therefore, when one firm does not know the evolution of a competing firm, for example how it developed a specific production process, information is imperfect.

Information is considered incomplete when one firm does not know another's characteristics (Tirole 1997). For example, one firm may not know how productive another firm is in performing a given task. According to Harsanyi (1967), incomplete information can be considered a form of imperfect information after passing it through a theoretical transformation. Thus, incomplete information can be considered a subset of imperfect information. Tirole (1997) describes the distinction as essentially "semantic."

Given two alternative forms of information, perfect and imperfect, and the notion that firm resources can be homogeneous or heterogeneous, a table can be formed depicting four scenarios for strategic factor markets. Table 2.1 displays the four scenarios, itemized by the number in brackets. The domain of the resource-based view where firm resources are assumed to be, or at least allowed to be, heterogeneous is represented by the shaded column containing scenarios [3] and [4].

The analysis of strategic factor markets by both Barney (1986) and Conner (1991) can be placed within the context of this table. Scenario [1] is akin to perfect competition in the economics literature where no firm can earn a rent from transactions in a strategic factor market,

Table 2.1 Four Scenarios for Strategic Factor Markets

	Homogeneous Resources/Abilities	Heterogeneous Resources/Abilities
Perfect Information	[1] No potential for rent.	[3] Firms with better resources can earn a rent.
Imperfect Information	[2] Firms with better information can earn a rent.	[4] Firms with better resources can earn a rent.

as noted by Barney (1986). Barney (1986) then assumes imperfect information and implies homogeneous resources to demonstrate the possibility of earning a rent, as in scenario [2].

Conner (1991) assumes that firms have different abilities to use a strategic factor and thus implies that firms have heterogeneous resources in her analysis. She then demonstrates cases where firms can earn a rent from purchasing and deploying the factor without explicitly assuming any information imperfections. This is associated with scenario [3]. The possibility of firms earning rent under scenario [4] is explored in the last section of the next chapter.

On a final note, one may question the core assumption of the resource-based view - heterogeneous resources across firms. This assumption is supported by the concept in industrial organization of creative destruction. The strategic literature often cites Schumpeter's (1942) concept of creative destruction in an evolutionary market as a framework for ongoing heterogeneous investment (see Besanko et al 1996 and Conner 1991).

Creative destruction is a process of dynamic market conditions based on external forces such as significant discrete changes in consumer tastes, technology, and public policy (Besanko et al 1996). The competitive environment is considered inherently unstable. The value of a given product market position likely changes over time due to the external forces. In this environment, the existence of heterogeneous resources across firms is expected as firms chase moving targets (resource positions) rather than settling on a stable optimum.

Chapter 3

A QUANTITATIVE MODEL OF COMPETITIVE STRATEGY

The resource-based view is presented above as a set of logical principles that can be used to explain the identification, generation, and sustainability of competitive advantage. It is applied in empirical studies in its qualitative form (see, for example, Barney 1991). In addition, principles from the resource-based view are estimated in quantitative form at the level of corporate strategy (see Montgomery and Wernerfelt 1988). However, its use in quantitative analysis at the level of competitive strategy is limited. A quantitative model is developed here to provide precise description of its principles and to facilitate the construction of an econometric model for statistically testing the resource-based view at the level of competitive strategy.

The model rests on primary assumptions regarding strategic factor markets. It is assumed that firms can make expenditures in strategic factor markets such that the value of the strategy once implemented is greater in magnitude than the expenditures. That is, some firms are able to enjoy a positive surplus from their transactions in strategic factor markets. Conner (1991) demonstrates this ability under conditions of heterogeneous resources, perfect information, and whereby sellers cannot price discriminate. The ability of firms to enjoy a positive surplus also under conditions of heterogeneous resources and imperfect information is provided in a section following the model.

A Model of Rent and Resource Accumulation

The model construction begins with some basic model definitions. Strategy is defined here as the optimization of the nature and magnitude of a firm's resource base in the planned pursuit of a product market position that yields competitive advantage. Rent serves as a measure of competitive advantage. The term rent is borrowed from the economic literature, denoting economic profits that persist beyond the short run. Firm resources encompass firm specific assets that are developed through positive surplus expenditures made in strategic factor markets.

Throughout the model development below, the index 'i' denotes a specific strategic dimension, while the index 'j' denotes a specific firm. Let the symbol 'e_{ij}' denote firm j's expenditures in a strategic factor market for the intention of adding to its resources in strategic dimension i. The symbol R_{ij} represents firm j's resources associated with dimension i. Given N firms in an industry, the sum of firm j's competitors' resources is given by

$$\widetilde{R}_{ij} = \sum_{k=1}^{N-1} R_{ik} \tag{3.1}$$

In the resource-based view, a given firm's rent is a function of its own resources, its competitors resources and exogenous changes over time. A given firm j's rent is thus given by the following general function:

$$r_j = g(R_{ij}, \widetilde{R}_{ij}, t) \tag{3.2}$$

A similar function is defined by Solow (1956) where aggregate production is defined as a function of capital, labor, and time. If the strategic space where a firm can build resources is restricted to two dimensions, firm j's rent becomes

$$r_j = g(R_{1j}, R_{2j}, \widetilde{R}_{1j}, \widetilde{R}_{2j}, t) \tag{3.3}$$

To analyze how a firm's rent changes with resource changes over time, the total derivative of equation [3.3] is taken with respect to time:

$$\frac{dr_j}{dt} = \frac{\partial g}{\partial R_{1j}}\frac{dR_{1j}}{dt} + \frac{\partial g}{\partial R_{2j}}\frac{dR_{2j}}{dt} + \frac{\partial g}{\partial \widetilde{R}_{1j}}\frac{d\widetilde{R}_{1j}}{dt} + \frac{\partial g}{\partial \widetilde{R}_{2j}}\frac{d\widetilde{R}_{2j}}{dt} + \frac{\partial g}{\partial t}\frac{dt}{dt} \tag{3.4}$$

Each of the components in the terms in equation [3.4] can be characterized by assumptions from the resource-based view.

First consider the partial derivatives of the rent function with respect to own firm and competitor resources. A primary assumption of the resource-based view is that an increase in a given firm j's resources leads to an increase in firm j's rent, ceteris paribus. This is expressed in the model with the following two conditions:

$$\frac{\partial g}{\partial R_{1j}} > 0, \; \frac{\partial g}{\partial R_{2j}} > 0 \tag{3.5}$$

Another primary assumption of the resource-based view is that an increase in given firm j's competitors' resources leads to a decrease in firm j's rent, ceteris paribus. This is expressed in the model with the following two conditions:

$$\frac{\partial g}{\partial \tilde{R}_{1j}} < 0\,, \quad \frac{\partial g}{\partial \tilde{R}_{2j}} < 0 \tag{3.6}$$

Next consider the derivatives associated with the change in own firm and competitor resources with respect to time. In the resource-based view changes in firm resources over time are effected through firm expenditure in strategic factor markets and affected by initial levels of resource stocks. Let the symbol $R_{ij}(0)$ denote firm j's initial stock of resource i, the derivatives of own firm resources with respect to time are then expressed with the general functions

$$\frac{dR_{1j}}{dt} = f^{1}(e_{1j}, e_{2j}, R_{1j}(0), R_{2j}(0)) \tag{3.7}$$

$$\frac{dR_{2j}}{dt} = f^{2}(e_{1j}, e_{2j}, R_{1j}(0), R_{2j}(0)) \tag{3.8}$$

The effect of expenditures and initial resource stocks on the rate of change of firm resources with respect to time can be further characterized with assumptions from the resource-based view.

The positive effect of strategic expenditure on firm performance is modeled with the positive first partial derivatives

$$f^{1}_{e_{1j}} > 0, f^{2}_{e_{2j}} > 0 \tag{3.9}$$

Dierickx and Cool's (1989) concept of time compression diseconomies (or convex adjustment costs) is then modeled with the negative second partial derivatives

$$f^{1}_{e_{1j}e_{1j}} < 0, \; f^{2}_{e_{2j}e_{2j}} < 0 \tag{3.10}$$

This reflects the notion that a firm's ability to attempt to secure increasing levels of resources in a given time period diminishes in a given time period.

Cross partial derivatives can incorporate Dierickx and Cool's (1989) concepts of asset mass efficiencies and the interconnectedness of resource stocks. The presence of asset mass efficiencies is modeled with the positive cross partial derivatives

$$f^{1}_{e_{1j}R_{1j}(0)} > 0, f^{2}_{e_{2j}R_{2j}(0)} > 0 \tag{3.11}$$

This shows the condition where the rate of change of a given firm resource through expenditures on the resource, in a given time period, is positively affected by the initial stock of that resource.

The presence of interconnected resource stocks is modeled with the positive cross partial derivatives

$$f^{1}_{e_{1j}R_{2j}(0)} > 0, f^{2}_{e_{2j}R_{1j}(0)} > 0 \tag{3.12}$$

This shows the condition where the rate of change of a given firm resource through expenditures on the resource, in a given time period, is positively affected by the initial stock of the firm's other resource (other resource or resources in a model with more than two dimensions).

One final set of cross partial derivatives can be employed to address an additional assumption regarding resource addition. It is assumed here that simultaneous expenditure on more than one resource addition may yield positive synergistic effects in resource additions. This is referred to here as interconnected resource expenditure. The assumption is conceptually related to interconnected asset stocks. Interconnectedness to resource stocks relates the initial stock of a resource to the expenditure on another resource. As one resource begins to realize additions during the simultaneous expenditure period, the new additions to the resource should facilitate the effect of expenditure on the other resource in the same way the initial stock of the resource does. This is modeled with the positive cross partial derivatives

$$f^1_{e_{1j}e_{2j}} > 0 \, , \, f^2_{e_{2j}e_{1j}} > 0 \tag{3.13}$$

The derivatives of competitor firm resources with respect to time are expressed in a similar fashion with the general functions

$$\frac{d\tilde{R}_{1j}}{dt} = m^1(\tilde{e}_{1j}, \tilde{e}_{2j}, \tilde{R}_{1j}(0), \tilde{R}_{2j}(0)) \tag{3.14}$$

$$\frac{d\tilde{R}_{2j}}{dt} = m^2(\tilde{e}_{1j}, \tilde{e}_{2j}, \tilde{R}_{1j}(0), \tilde{R}_{2j}(0)) \tag{3.15}$$

The first partial derivatives of [3.14] and [3.15] with respect to expenditure are assumed to have the same sign as given in equation [3.9]:

$$m^{1}_{e_{1j}} > 0\,, m^{2}_{e_{2j}} > 0 \tag{3.16}$$

Likewise, the second partial derivatives are assumed to have the same sign as given in equation [3.10]:

$$m^{1}_{e_{1j}e_{1j}} < 0\,, m^{2}_{e_{2j}e_{2j}} < 0 \tag{3.17}$$

This represents a symmetry condition, whereby it is assumed that there are no special effects in aggregating competitor expenditures and the effect of expenditure on their resources.

The last term in equation [3.4] represents exogenous changes in rent over time. This term reduces to

$$\frac{\partial g}{\partial t}\frac{dt}{dt} = \frac{\partial g}{\partial t} \tag{3.18}$$

This term captures the changes in a firm's rent over time that are not attributed to changes in firm's resources or its competitors' resources.

General Hypotheses

Three general hypotheses are drawn from the assumptions in the above model for empirical investigation. The first hypothesis addresses the effect of own firm strategic expenditure. The second hypothesis focuses on the assumption that competitor expenditures have an effect on a given firm's rent. The third hypothesis addresses the assumption regarding interconnected strategic expenditure.

The effect of a given firm j's expenditure on a given resource i can be traced through the model above according to the following causality (throughout the discussion of the hypotheses, the arrows denote the directional effect of the associated term on rent):

$$\uparrow e_{ij} \Rightarrow \uparrow \frac{dR_{ij}}{dt} \Rightarrow \uparrow \left(\frac{\partial g}{\partial R_{ij}} \frac{dR_{ij}}{dt} \right) \Rightarrow \uparrow r_j$$

In accordance with equations [3.5] and [3.9], rational expenditures on a given resource lead to a positive change in firm resources in a given time period which in turn has a positive effect on firm rent. This leads to the following hypothesis:

<u>Hypothesis 1</u> A strategic effort represented by expenditures on a given strategic resource over a given time period will have a positive effect on firm performance.

The effect of competitor expenditure on strategic resources on a given firm j's rent can be traced through the model above according to the following chain of causality:

$$\uparrow \tilde{e}_{ij} \Rightarrow \uparrow \frac{d\tilde{R}_{ij}}{dt} \Rightarrow \downarrow \left(\frac{\partial g}{\partial \tilde{R}_{ij}} \frac{d\tilde{R}_{ij}}{dt} \right) \Rightarrow \downarrow r_j$$

In accordance with equations [3.6] and [3.16], rational expenditures by competitors on a given resource lead to a negative change in firm resources in a given time period which in turn has a negative effect on firm rent. This leads to the following hypothesis:

<u>Hypothesis 2</u> There is an inverse relationship between the intensity of competitor investment in a given

strategy and the performance of a given firm pursuing that strategy.

The prescriptive implications from hypothesis 2 deserve careful interpretation. It may be the case in some industries, that one position or direction has been revealed as the most valuable over time, and thus many firms have grouped into that position. This hypothesis does not suggest that firms in such an industry should immediately move away from that position. Rather, it suggests that if two moves of equal magnitude are possible, and one is in a more intensely populated region than the other, the move in the less populated region will generate a relatively stronger competitive advantage.

The effect that firm j's expenditure on a given resource has on the same firm's ability to add to another resource can be traced through the model above according to the following causality (the specific effect of expenditure on resource 1 on expenditures on resource 2 is shown here):

$$\uparrow e_{1j} \Rightarrow \uparrow \frac{dR_{2j}}{dt} \Rightarrow \uparrow \left(\frac{\partial g}{\partial R_{2j}} \frac{dR_{2j}}{dt} \right) \Rightarrow \uparrow r_j$$

In accordance with equations [3.5] and [3.13], rational expenditures on a given resource lead to a positive change in firm resources in a given time period which in turn has a positive effect on firm rent. This leads to the following hypothesis:

> Hypothesis 3 A combined strategic effort, represented by multi-period expenditures in more than one strategic dimension, yields positive synergies in resource investment, further enhancing firm performance.

The third hypothesis addresses the degree of competitive advantage associated with exploiting one dimension relatively more intensely than the other or exploiting a combined position. This hypothesis is conditional upon the nature of the industry under study. Focusing on either of the broad dimensions of low cost or product differentiation may be more favorable than pursuing a combined position in some industries, while in other industries a balanced pursuit may be superior. These conditions will affect the nature of equation [3.13].

It is worth considering a short discussion regarding the distinction between hypothesis three and Porter's (1980) notion of "caught in the middle." In a two-dimensional analysis of low cost and product differentiation, Porter (1980) suggests that firms should pursue either one of these strategies in isolation rather than attempting to implement both. This prescription is rational under two assumptions: i) firms have budget constraints for strategic expenditure in a given time period, and ii) strategies have investment hurdles, greater in magnitude than any one firm's budget, that must be overcome to realize the benefits of a strategy. In this case, the benefits of a strategy can only be realized in isolated implementation.

If either one of these two assumptions is relaxed, the issue addressed in hypotheses 3 arises. Given that a firm can choose to pursue more than one strategy in a given time period, are there any positive synergies to simultaneous pursuit?

Imperfect Information and Strategic Behavior

The above model can be extended for analysis of the case where firms have both heterogeneous resources and imperfect information. Four scenarios for the characteristics of information and resources in strategic factor markets are presented in table 2.1 in the previous chapter. In scenario [4], firms have both heterogeneous resources and imperfect information about their competitors' resources. In the analysis of rent potential in this scenario it is particularly important to distinguish between whether the transaction in the strategic factor market takes place through a pre-disclosed price determined by the equilibrium of market supply and demand or a sealed bidding process. The analysis under a sealed bidding process is more complicated.

First, a note is provided on why the transaction distinction is not necessary for scenario [1] and [3], a discussion on scenario [4] then follows. Under a sealed bidding process in scenario [2] firms with better information can simply make more accurate bids on average (rarely making overvalued purchases and sometimes capturing under-valued factors). In scenario [3], the firm (A) with the best resources knows the maximum rational bid of thè next best endowed firm (B) since firm A knows firm B's resources & abilities. This leaves a window for firm A to earn a rent.

Now consider scenario [4], first under the case of a market price transaction. Two market equilibrium transactions are depicted in Figure 3.1 below. In graph on the left, market supply and demand for the factor determine a market equilibrium price (P_F). A firm that values the factor at exactly P_F, pays exactly what the factor is worth

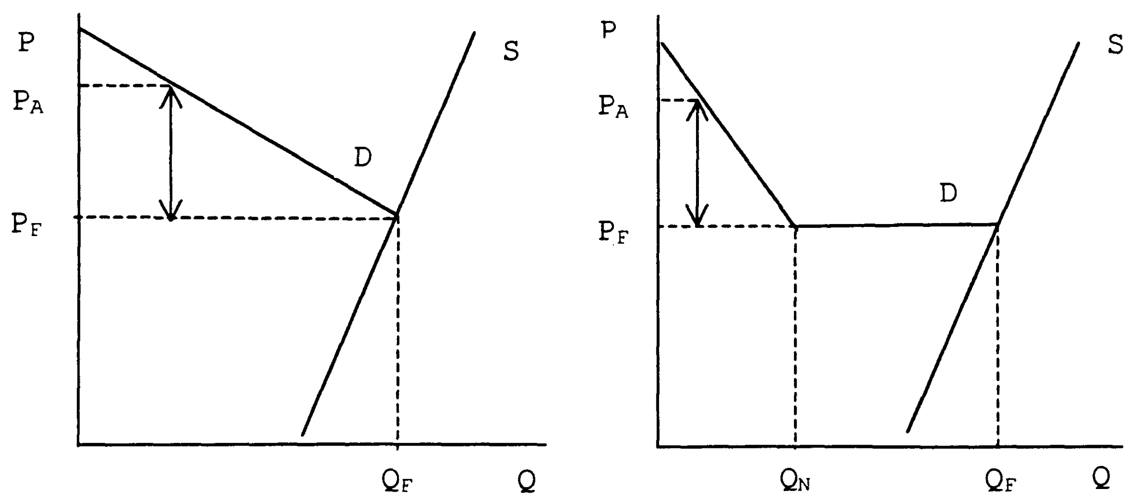

Figure 3.1 Market Price Transactions

when the firm deploys it. The firms that value the factor above P_F can purchase the factor at P_F enjoy a surplus and can earn a rent from deploying it.

For example, firm A can earn a rent depicted by the double arrow. In this case, the fact that there is imperfect information does not matter. The market price is all the information firm A needs (relate this to consumer theory, a consumer may get a surplus from buying a soda for $1 that they value at $2 - they do not need to know other buyers' utility functions to do so).

Next consider the very similar case in the graph on the right (nothing much new happens here, but it may make the bidding analysis in the next paragraph more clear). In this case the number of factors sold at equilibrium is greater than the number of firms that can use the factor to generate a rent. Firms on the sloping part of the demand curve earn a rent, while firms on the flat part, between Q_N and Q_F, do not.

Now consider scenario [4] under the condition that the SFM transaction occurs through sealed bidding. Here a firm cannot first observe a market price and then check to see if it can earn a rent with that price. Additionally, a firm does not know the other firm's bids. The problem here is that firms have to deal with the tradeoff between bidding low to try to capture rent and risk losing the bid, or bidding high, which in turn erodes the rent potential. In the extreme all rent potential is captured in the bid price.

One assumption can be made to resolve this problem. Assume that the number of factors available is greater than the number of firms who have a special ability to use the factor (Conner (1991) assumes this in one of her cases). The graph on the right in Figure 3.1 displays the situation where several firms do not have a special ability to use the asset in a market S&D situation. The quantity of the factor available (Q_F) is greater than the quantity of firms that have a special ability to use it (Q_N).

Now consider a bidding environment where several sequential bids are made on separate units of the factor in a given time period. Firm's with special abilities will be able to secure the factor and earn a rent, even with imperfect information according to the following logic.

Firm A can pick a bid between P_A and P_F, and repeatedly place that bid past the point where all the other firms with special abilities have won bids and left the market (in a given time period). In the next bid, Firm A will win the bid since all the remaining firms will bid no more than P_F. The only other possibility is that Firm A wins an earlier bid that still provides room for a rent. This demonstrates the ability of firms to enjoy a positive surplus in strategic factor markets with imperfect information, under the assumption regarding the factor market quantity.

Now it is possible to analyze strategic behavior under the assumption of imperfect information in the context of the quantitative model developed in the previous section. In the above model, a firm's competitors' resources, and therefore an increase in competitor resources, have a negative effect on firm performance. Thus it is necessary for profit maximizing firms to make an expectation about their competitors resources and planned expenditures. This is expressed by taking the expectation of equation [3.4]:

$$E\left(\frac{dr_j}{dt}\right) = \frac{\partial g}{\partial R_{1j}}\frac{dR_{1j}}{dt} + \frac{\partial g}{\partial R_{2j}}\frac{dR_{2j}}{dt} + \frac{\partial g}{\partial \tilde{R}_{1j}}E\left(\frac{d\tilde{R}_{1j}}{dt}\right) + \frac{\partial g}{\partial \tilde{R}_{2j}}E\left(\frac{d\tilde{R}_{2j}}{dt}\right) + E\left(\frac{\partial g}{\partial t}\right) \quad (3.19)$$

Here an expectation is also placed around the last term to imply that a given firm j does not know exogenous changes in rent over time with certainty.

Equation [3.19] demonstrates that a firm needs to make an expectation about its competitors' resources over the time period in which it is making an addition to its own resources to properly value the strategic action. That is, the expectation is still necessary, even though a firm does not need to know other firms' resources in order to enjoy a positive surplus in a strategic factor market. The firm's constrained maximization problem under these conditions can be depicted graphically, see appendix A.

Chapter 4

MODEL APPLICATION IN THE PETROLEUM INDUSTRY

This chapter outlines the application of the model developed in Chapter 3, to the exploration and production segment of the petroleum industry. Strategic dimensions are outlined for the industry, followed by the development of proxies for measuring intent in these dimensions, and finally, specification for testing the hypotheses within these dimensions is covered. First, an explanation for selecting the petroleum industry for analysis is offered.

There are two advantages to testing the hypotheses in the petroleum exploration and production industry. First, the industry's output is commodity-like, which limits the breadth of strategic options available for exploitation. Specifically, firms in the industry cannot easily exploit the generic strategy of product differentiation. Therefore, they must focus on the cost dimension.

Testing the model is simplified in an industry with such narrow strategic latitude, since fewer strategic dimensions are incorporated into the model. This alleviates, though it does not necessarily eliminate, the problem of omitted variable bias in the econometric analysis. Upon successful testing of the model, further research could include testing the hypotheses in industries with more complicated strategic spaces.

The second advantage is that the petroleum industry is subject to relatively stringent reporting requirements by the Securities Exchange Commission. These requirements provide more latitude in identifying proxies for the strategic dimensions in the model estimation.

Strategic Dimensions and Proxies for Intent

Given that firms in the industry under study are restrained to the cost dimension, strategic sub-dimensions are defined for that dimension. Two strategies are defined in association with two alternative means of approaching the production process. The strategic intent in each dimension is to generate firm specific resources defined by expertise in either of the approaches to the production process.

The two approaches defined as sub-dimensions of the cost dimension are i) the internal organization (generation) of complex inputs, and ii) the acquisition of complex inputs. In any multi-stage production process, firms can either organize each subset of the process necessary to generate a complex input or acquire the complex input. The intent to gain expertise in the organization of subsets of the production process is defined as an internal organization strategy. The intent to gain expertise in the acquisition of collective subsets is defined as an acquisition strategy.

Separate proxies are developed to measure intent in each of the strategic sub-dimensions outlined above. In the exploration and production segment of the petroleum industry going concerns must maintain a petroleum reserve base. The exercise of strategic intent in the alternative dimensions in the model is measurable through observation of alternative methods employed to maintain the petroleum reserve base.

Before examining the alternative methods, consider some reserve definitions outlined in the Financial Accounting Standards Board's (FASB) Statement of Financial Accounting Standards No.19 (these definitions are based on those given by the Securities and Exchange Commission). Proved reserves are:

> ...limited to those quantities of oil and gas which can be expected, with little doubt, to be recoverable commercially at current prices and costs, under existing conventional equipment and operating methods (Statement of Financial Accounting Standards No.19, 1977).

Proved developed reserves "can be expected to be recovered through existing wells with existing equipment and operating methods" (Statement of Financial Accounting Standards No.19, 1977). Finally, proved undeveloped reserves "are expected to be recovered from new wells on undrilled acreage, or from existing wells where a relatively major expenditure is required for recompletion" (Statement of Financial Accounting Standards No.19, 1977).

There are two alternative approaches by which firms can maintain their proved-developed petroleum reserve base: i) explore for or acquire undeveloped reserves and develop them, and ii) acquire proved-developed reserves. When firms specialize in the former process they are implementing an internal generation strategy, while firms specializing in latter process are implementing an acquisition strategy.

As noted above the two strategies are based on the process of gaining expertise. The expertise is gained through unique experience. In the internal organization strategy, firms develop skills in exploring for and developing reserves. In the acquisition strategy, firms develop skills in securing proved-developed reserves through acquisition experience. These firms garner expertise in identifying and valuing proved developed reservoirs. They understand how to translate observable proved developed reservoir characteristics into relatively more accurate expectations for ease of production maintenance and potential for reservoir extensions.

Note that the concept of gaining knowledge through experience is in some ways a refinement of the learning curve concept. Typically, a learning curve model focuses on production efficiencies manifested through cumulative production. The strategies here focus on alternative approaches to production followed over time.

The process by which firms are maintaining their reserve base could be observed through physical measures, such as proved to total reserve ratios, or financial measures, such as costs incurred for exploration or property acquisition. The use of financial information or a mixture of financial and physical information for the formulation of proxies is considered preferable to using physical information alone. FASB Statement 19 suggests that physical information tends to reflect accomplishment, while financial information more closely reflects managerial intent. For example, a firm may attempt to increase its reserve base, but the actual physical increase is a function of many more variables than management intent. On the other hand, when funds are deployed the amount closely matches (if not exactly) management intent.

Rizzuto et al (1996) implicitly concur using financial information to indicate strategy and physical information for measures of success. Specifically, Rizzuto et al (1996) use plow-back ratios to determine a firm's exploration strategy. The plow-back ratio is defined as the ratio of acquisitions, exploration, and/or development expenditures to oil & gas revenues less operating costs. Rizzuto et al (1996) suggest that a high plow-back ratio including acquisitions relative to a plow-back ratio excluding acquisitions, indicates when a firm is an "acquirer" as opposed to a "driller."

Similar plow-back ratio definitions are developed here to form the proxies for measuring intent in the internal organization and acquisition strategies. The denominator is the same as that used by Rizzuto et al (1996) for all plow-back definitions: oil & gas revenues less operating costs. This serves as a basis for the magnitude of funds a firm has available from E&P operations for strategic expenditure. However, note that firms may spend more than this amount, financed by other business segments or through capital markets.

Two separate numerators are defined, one for each dimension of strategic intent. The numerator for the internal organization strategy is the summation of exploration and development expenditures, which yields the following formula:

$$S_1 = \text{(exploration costs + development costs)} \\ /\text{(revenues - operating costs)}$$

The numerator for the acquisition dimension is proved developed property acquisition costs, which leads to the following formula:

$$S_2 = \text{(proved developed reserve acquisition)} \\ /\text{(revenues - operating costs)}$$

Note that with these definitions, the plow-back ratios are defined to be mutually exclusive, to reflect separate strategic intents.

Proxies are also formed to measure the intensity by which competitors are pursuing each of the strategies. The competitor intensity proxy incorporates the plow-back formulas used for the strategic intent proxies to capture the degree to which other firms are attempting to implement the strategy. Instead of inserting the information from a single firm into the formulas, modified industry averages are taken and placed into the formulas. The averages are exclusive and unique to each firm. In a given observation, the industry intensity is measured using the averages from all the other firms, without including the firm under consideration.

Since the study will cover the exploration and production segments of the petroleum industry, and some firms are integrated into other segments, a performance measure specific to exploration and production operations must be chosen. Fortunately, a traditional performance measure can be constructed. Return on assets (net income/exploration and production assets), can be calculated at the exploration and production level, since most firms report their exploration and production assets and income separately, if they are integrated.

Specification

The hypotheses are tested in specific econometric equations based on the general functional form containing the per firm performance proxy (π_j), proxies for strategic intent (S_{1j}: internal organization, S_{2j}: acquisition), and proxies for competitor intensity (I_{1j}: internal organization, I_{2j}: acquisition):

$$\pi_j = f(S_{1j}, S_{2j}, I_{1j}, I_{2j}) \tag{4.1}$$

Three primary specification issues must be addressed: i) the lag structure between strategic expenditure and performance, ii) filtering strategic noise, and iii) the functional form in addition to the lag structure.

First consider the need for a lag structure. A key concept in the theoretical model is the notion that competitive advantage is developed over time through a committed investment in a strategy. Revisiting Dierickx and Cool's (1989a) concept of asset accumulation, a valuable resource position can not be achieved instantaneously with a single expenditure. Rather, a firm must make a commitment via a series of multi-period expenditures. Otherwise, there would be no capacity for sustainability of competitive advantage in the model, since any favorable strategy would be instantly replicated by competitors.

In this sense, a single expenditure without contiguous expenditures in neighboring time periods is not considered strategic. Strategic intent is realized only when a set of expenditures is made over a given number of time periods necessary to generate a competitive advantage. This captures firm management's strategic decision and a consistent strategic intent from the decision forward to completely implement the strategy (up to the time period of performance measurement).

It is only under these circumstances that a positive relationship between performance and the strategic proxies is expected. Estimation therefore requires a lag structure, reflecting consistent investment, in the econometric model.

The lag structure also helps to ensure that the proper direction of causality is measured. That is, with the estimation performance on lagged expenditures, the results will apply to causality running from the expenditures to the performance variable, not potentially the other way around.

Lag Structure

A graphical presentation of the lag structure incorporating a contiguous set of expenditures is presented in Figure 4.1. Here, five contiguous expenditures have

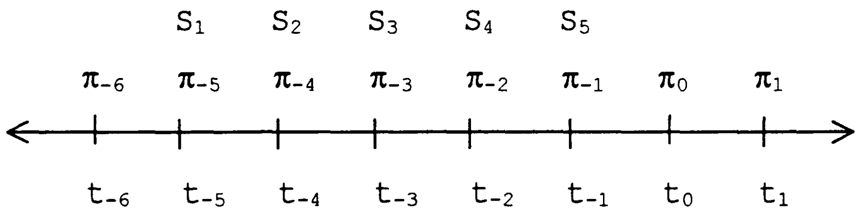

Figure 4.1 Lag Structure

been made (S_1 through S_5), from time period t_{-5} to t_{-1}. Under an assumption that a five-year commitment of expenditures is necessary and sufficient to realize a competitive advantage, a performance increase observed in π_0 would be expected in time period t_0. The use of five years is arbitrary here, a justification for the number of years used in the estimation is provided later in the specification.

There are alternative ways to estimate the lag structure under the primary assumption of contiguous expenditures. The selection of a structure depends on the degree of detail incorporated in the assumptions regarding the effect of strategic expenditure on performance.

Simply regressing the performance variable on the five expenditures is problematic. The estimation will likely suffer from multicollinearity since the independent variables are really the same variable measured from different time periods, and in the theoretical model it is expected that these variables will be moving in the same direction at the same time. The multicollinearity will in turn yield low t statistics since the method will not be able to attribute a significant amount of variation to any one variable (even though the variables may be significant in explaining performance movements).

This problem can be mitigated through the use of polynomial restrictions on the coefficients (see Almon (1965)). This involves introducing non-sample information in the form of exact restrictions, which in turn increases the precision of the estimation (Griffiths et al 1993). This method requires a detailed assumption regarding the shape of the effect of the strategic expenditures on performance. For example, a second order polynomial restriction could be used with the assumption that the effect of expenditures for a given strategic intent may increase over time and then begin to diminish. However, it is more likely that such a level of detail is inappropriate given that the actual shape of the effect of strategic expenditure is possibly variable. Less detailed structures are therefore considered.

Another alternative method is to take the average of the five expenditures, whenever five contiguous expenditures are made, and place that observation along with the next period's performance observation in the estimation data set. In a sense, this is the other extreme in making an assumption about the expected shape of strategic expenditures under a given strategy implementation - no shape is imposed at all. The average takes no account of where large or small expenditures are made in the series, or whether there is an inclining, declining, linear, or curved pattern.

There is a problem with this method regarding Dierickx and Cool's (1989a) stock and flow concept for building strategic resources over time before a performance gain is realized. According to the theoretical model, the expenditures reveal strategic intent to make resource additions. However, the actual resource additions involve both the expenditure and the passage of time for development and interpretation of new information generated by the expenditure. Given this notion, without considering the specifics of the exact shape of the expenditures, the general location of the magnitude of the expenditures in the series is an important issue.

Even though there are, by definition, expenditures in each of the five periods, the magnitude of the average could be driven by a very large expenditure in the first, last or middle time periods before the performance measurement. For example, consider the expenditure patterns in the two panels of Figure 4.2.

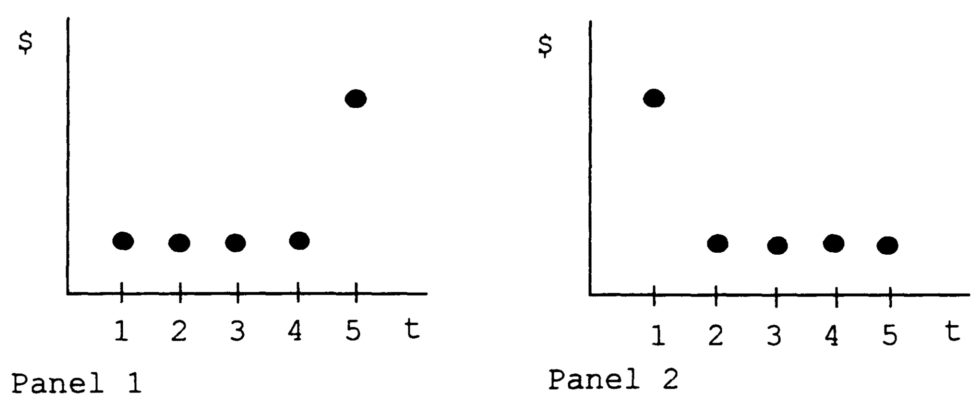

Figure 4.2 Strategic Expenditure Patterns

In both cases, the average of the expenditures could be the same. However, the magnitudes of each series of expenditures are skewed to opposite ends of each series. The theory suggests that the effect of the series in panel 2 would be stronger in terms of resource addition since there is more time for processing information generated in the implementation of the strategy after the magnitude of the expenditures have been deployed. A simple average would not capture this.

A fourth method, serving as a compromise between the detail of reality and model simplicity, is considered. The requirement that a certain number of contiguous expenditures are necessary for strategic intent to be realized is retained in this method. However, the measurement of strategic magnitude is taken exclusively at the initial expenditure. That is, whenever a given expenditure (S_1) is succeeded by a certain number of consecutive expenditures (here, four), that expenditure (S_1) along with the performance value at the end of the expenditures (π_0), are included as an observation in the data set.

The magnitude of large expenditures is incorporated in the estimation only when an appropriate amount of time for processing by the firm has been allowed to pass. In this case, large expenditures made toward the middle or end of the lag structure are not allowed to inflate the effect of strategic expenditure on performance.

This is further detailed as follows. First, note that for a given set of expenditures as presented in Figure 4.1, the magnitude of the succeeding expenditures, S_2 through S_5, is not directly included in the estimation. Rather, they serve as necessary components to signal a commitment to follow through with the implementation of the strategy. However, if these expenditures have their own sufficient set of succeeding expenditures, then they are included in the data set, representing a new strategic decision, or a decision to extend the original strategy.

This method models the relationship between the initial decision to pursue the strategy and performance, while incorporating the magnitude of the initial expenditure. Effectively, an additional assumption is implied. The magnitude of strategic intent is measured according to the magnitude of the initial investment in the strategy, rather than the magnitude of the whole set of expenditures. This method adheres to the concept that it takes time for expenditures to transform into a resource. This is the chosen method for incorporating the concepts of commitment and a lag structure in the estimation.

The determination of the length of the lag structure for estimation is an empirical issue. It is directly related to the assumption regarding the necessary commitment, in terms of consecutive expenditures, for the realization of competitive advantage.

Recall that the proxies are designed to reflect strategic intent by a firm in a given dimension: during a sequence of expenditures a firm is building resources in a strategic dimension(s) for generating competitive advantage. The length of the lag structure must therefore accommodate at least the minimum amount of sequential expenditures that it takes to generate a competitive advantage in a given dimension.

If the selected length is too short, then non-strategic expenditures are included as observations in the estimation. On the other hand, if the lag length is too long, some strategic expenditures will not be included as observations. These are the opposing issues in selecting the appropriate lag length. In reality, the necessary commitment is likely variable depending on the particular strategy and current conditions, suggesting a variable lag length. A compromise is made here between reality and the necessity of model simplicity to avoid over-specification. A separate length for each dimension is developed below according to differing assumptions about the generation of competitive advantage under each strategy. This length remains constant for each dimension throughout the specification.

To select the lag length, assumptions are made based on the physical and technical nature of each strategic dimension. Broadly, one would expect the lag length to be longer in the internal organization dimension than in the acquisition dimension. An internal organization strategy has two potential components, the generation of expertise in productive processes and the physical reengineering of productive processes to exploit the expertise. On the other hand, an acquisition strategy likely involves only the former component. In an acquisition strategy, expertise is generated through significant intentional experience, which is useful in and of itself, likely without the need for extensive physical reengineering.

Focusing on the internal organization dimension, recall that the proxy is the exploration and development plow-back. There are two phases in deploying funds in this strategy related to the generation of expertise: exploring for reserves and fully developing them. An exploration effort and the following complete development effort can each take two years. As a firm makes a significant effort in this dimension it may at first be generating expertise, but eventually it may simultaneously begin reengineering as it acquires new knowledge. A lag setting of five years should be sufficient to capture the semi-simultaneous generation of expertise and reengineering.

The acquisition proxy is a proved acquisition plow-back. As noted above, the only necessary component of this strategy is the generation of expertise. Firm management must value and purchase reserves, then operate them to determine where there may have been discrepancies in initial valuations. Then firm managers can improve future reserve valuations based on new information. Given the singular component nature of the acquisition strategy, a shorter lag is set at three years.

When examining the combined pursuit of both strategies a compromise can be made in formation of the lag structure. The requirement of five contiguous expenditures is retained, since this is the greater of the two necessary commitments in the strategies analyzed here. The question then becomes where to take the measurement of strategic magnitude. Noting that the three and five year lags were selected as the assumed average time periods for the strategic commitment in each of their own dimensions, a four year lag serves as an assumed average for pursuing a combined strategy. The measurement is therefore taken between lags three and five, at lag four.

Strategic Noise

Next, consider the issue of handling "strategic noise." In most years, for each firm there are expenditures in both acquisitions and exploration & development. That is, firms are almost always maintaining their petroleum reserve base through some mixture of the two methods of securing proved reserves. However, not all expenditures are considered strategic. That is, simply making a one-dollar expenditure on reserve maintenance each year for several years in a row is not considered a sufficient commitment to generate expertise in either of the processes.

To handle this noise in strategic expenditure, an empirically based filter must be developed to indicate when expenditure is considered strategic. The simplest method is to consider a set of contiguous expenditures strategic whenever each expenditure in the set exceeds the industry average for that year. A slightly more complicated, though more flexible, method is to consider a set of expenditures strategic whenever each expenditure is greater than a given percentile (50^{th}, 75^{th}, 90^{th}, etc.) in the industry for that year.

An even more flexible method is to consider a set of expenditures strategic, when the average of the set is greater than a percentile of the industry average over the years in the set. This is done as follows: a data set containing averages over the years in the group of contiguous expenditures for each firm is formed, then a percentile value across the industry is calculated in each year. A set of expenditures is then defined as strategic whenever the average of a firm's expenditures in a strategic dimension over a given number of years is greater than a percentile of the industry's expenditures over the same time period.

The additional flexibility of this method comes from the fact that it does not require each expenditure to meet a hurdle for the given year (although some expenditure is required). Rather, the set of expenditures together must pass a hurdle. This allows for more forms of contiguous strategic expenditure, while still filtering noise. This method is selected for estimation.

A final point is made regarding the combined use of the selected lag structure and the selected strategic filter. The selected lag structure is formed to restrict large expenditures made in the middle or late in the series from increasing the measured magnitude of the strategy. The selected strategic filter, on the other hand, allows large expenditures anywhere in the series to signal the presence of strategic intent.

Functional Forms

The final issue in the specification is the functional form of the estimation equations (in addition to the lag structure). The first and second hypotheses address the causality between expenditure in a specific strategic dimension, the degree of competitor intensity in that dimension, and the response of firm performance. Both of these hypotheses are tested simultaneously in a single equation. However, each strategy is tested in a separate equation for model simplicity. A third equation is formed to test the third hypothesis, regarding the pursuit of both strategies simultaneously.

According to the conceptual framework, there may be diminishing marginal returns to strategic effort and a diminishing marginal effect of competitor intensity (see equations [3.10] and [3.17]). This suggests a specification that allows strategic intent to have a positive effect on performance, increasing at a decreasing rate. Similarly, competitor intensity should have a negative effect on performance that lessons with increasing magnitude. Two basic specifications can accommodate these mechanics.

The simplest one is a semi-log specification:

$$\pi_j = \beta_0 + \beta_1 LN\ (S_{ij}) + \beta_2 LN\ (I_{S_{ij}}) + \varepsilon \qquad (4.2)$$

The expected sign on β_1 is positive, while the expected sign on β_2 is negative. The marginal impact of strategic intent is

$$\frac{\partial \pi}{\partial S} = \beta_1 \frac{1}{S} \qquad (4.3)$$

From this equation, it is easy to see that as strategic intent increases in the semi-log functional form, the positive effect on performance decreases. Similar comparative statics hold for the competitor intensity proxy.

The second specification uses a second degree polynomial for both the strategy and competitor variables:

$$\pi_j = \beta_0 + \beta_1(S_{ij}) + \beta_2(S_{ij}^2) + \beta_3(I_{ij}) + \beta_4(I_{ij}^2) + \varepsilon \quad (4.4)$$

This specification erodes 2 more degrees of freedom, however, it can fit a wider range of relationships (it has more model degrees of freedom).

Here the expected sign on β_1 is positive while the expected sign on β_2 is negative, to capture the increasing at a decreasing rate concept. The expected signs on the intensity coefficients are reversed (negative for β_3, and positive for β_4). The marginal impact of strategic intent in this specification is

$$\frac{\partial \pi}{\partial S_{ij}} = \beta_1 + \beta_2 S_{ij} \quad (4.5)$$

From this equation, it is evident that the expected signs will achieve the desired effect. As strategic intent increases, the positive effect decreases. A similar effect holds for the competitor intensity proxy.

Mixtures of the semi-log and the polynomial functions could also be used. In the following case, the polynomial is applied to the strategy variable, and the competitor intensity variable is logged:

$$\pi_j = \beta_0 + \beta_1(S_{ij}) + \beta_2(S_{ij}^2) + \beta_3 LN\,(I_{ij}) + \varepsilon \qquad (4.6)$$

This specification represents a compromise between the specifications in equations [4.2] and [4.4], and is initially chosen as the specification for estimation.

The third hypothesis addresses the issue of whether or not there is a positive synergy between the strategies, in other words, is there more than an additive effect to pursuing the strategies simultaneously. This requires a specification that captures the effects of both strategies at once, unlike the separated strategy approach described above. The simplest way to test for synergies is to use an interaction variable in a single equation incorporating both strategies:

$$\pi_j = \beta_0 + \beta_1 S_{1j} + \beta_2 S_{2j} + \beta_3 S_{1j} S_{2j} + \varepsilon \qquad (4.7)$$

The expected sign on β_3 is positive (while the expected signs on β_1 and β_2 remain positive as well). The expected sign would demonstrate that there is a positive effect of strategic intent in both dimensions over and above their additive effect.

Chapter 5

ESTIMATION, RESULTS, AND IMPLICATIONS

Using the proxies and specification developed in Chapter 4, the hypotheses developed in Chapter 3 are tested. A discussion regarding the construction of the data sets is presented, followed by the results and implications for firm management.

Data

The data for the estimation are gathered from the Pennwell Oil & Gas Journal database. The data in this database are collected from company 10K reports. The database includes both a time-series and cross-sectional component: 15 years of data from 1981 to 1995 on more than 50 petroleum companies. The model estimation includes 29 firms (listed in appendix C).

The firms are selected based on the amount and type of data available for each firm. Business segment data is not provided for some firms, which precludes return on asset measurement for their exploration and production segment. These firms are excluded. Some firms do not have enough years of data to accommodate a lag structure, and are also excluded.

A separate data set is formed for estimating each strategy equation. By estimating each strategy in isolation, the equation specifications are kept as simple as possible. However, the estimation process must address the potential for omitted variable bias. When there is an observed increase in performance, it should be attributable to the strategy under observation, not the other strategy or synergy effects across strategies, which are not under observation. That is, the estimation process should avoid attributing an increase in performance to one strategy, when the performance increase may have been caused by the other strategy alone, or the combination of strategies.

Figure 5.1 shows an algorithm for creating the data sets in a way that completely eliminates the omitted variable bias identified above. First, a set of

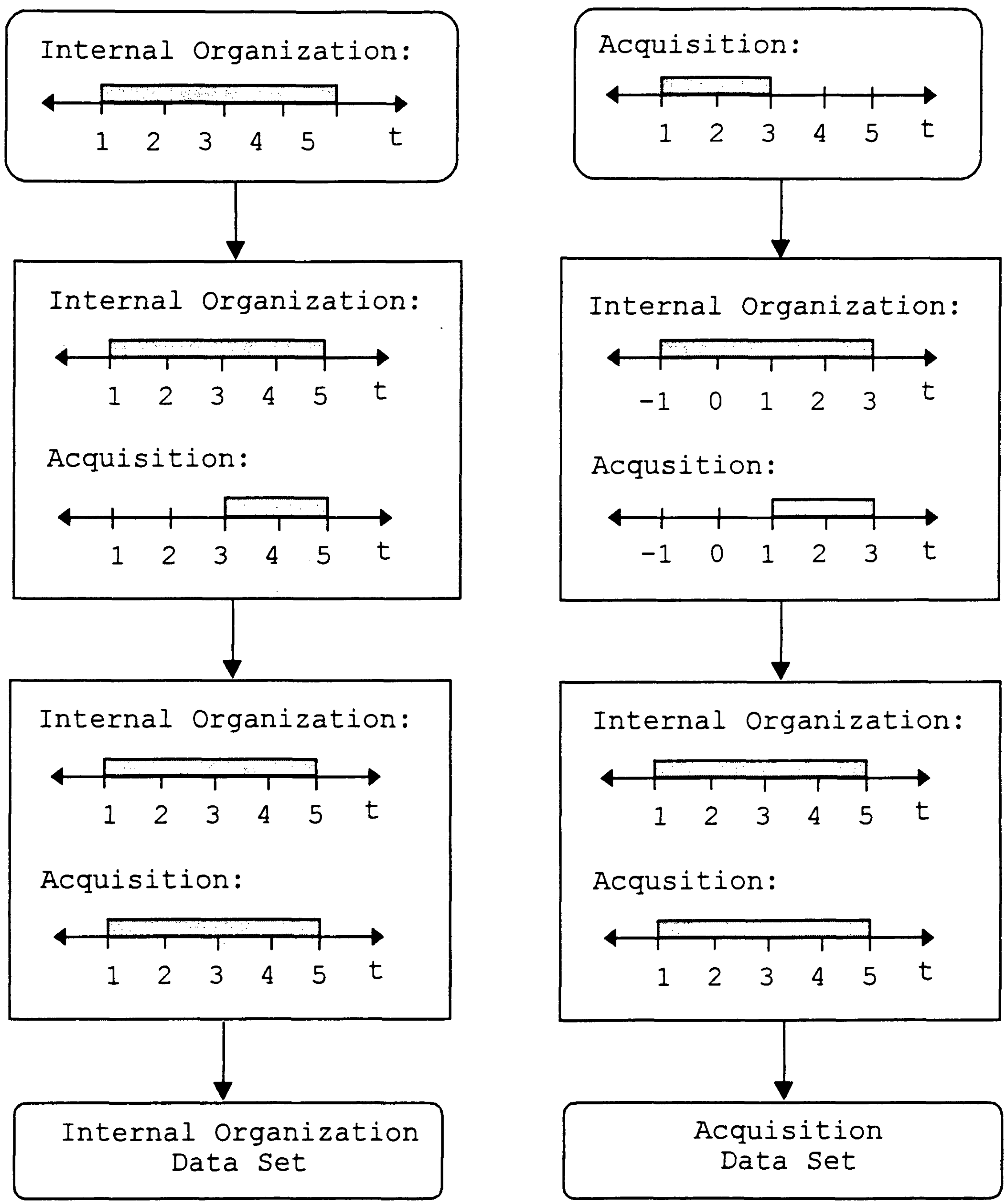

Figure 5.1 First Algorithm for Data Set Formation

expenditures is checked to see if it passes through the percentile filter. Next, it is checked against expenditures in the other strategic dimension. If a set of expenditures has been completed in the other dimension at the same time as the dimension under observation, the observation is not included in the data set. This alleviates the problem of attributing an increase in performance to one strategy when in fact it is caused completely by the other strategy.

Next the set of expenditures is checked to see if it is in fact part of a combined strategy, rather than an isolated strategy implementation. If so, then the observation is not included in the particular strategy data set. This alleviates the problem of attributing an increase in performance to an isolated strategy, when in fact the combined strategy is causing the performance increase.

This algorithm dramatically reduces the size of the strategy data sets with respect to forming data sets solely based on the percentile filters. This in turn dramatically reduces the degrees of freedom in the estimation and may therefore reduce the precision of the estimates. A second algorithm for data set formation, which erodes fewer degrees of freedom, is considered.

Figure 5.2 outlines the second, less complicated, algorithm. First, as before, a set of expenditures is analyzed for whether or not it passes through the percentile filter. Next, the set of expenditures in the same time period in the other dimension is analyzed for whether or not it passes through the percentile filter. If the expenditures in the other dimension pass through the filter, the observation under consideration is not included in the data set.

The second algorithm eliminates much of the potential for omitted variable bias while increasing the degrees of freedom. In a small number of cases this method will not eliminate observations that are attributed to more than one strategy (internal organization, acquisition, or combined). Essentially a small tradeoff is made between precision and the potential for bias. This is similar to the tradeoff made between precision and bias when specifying what

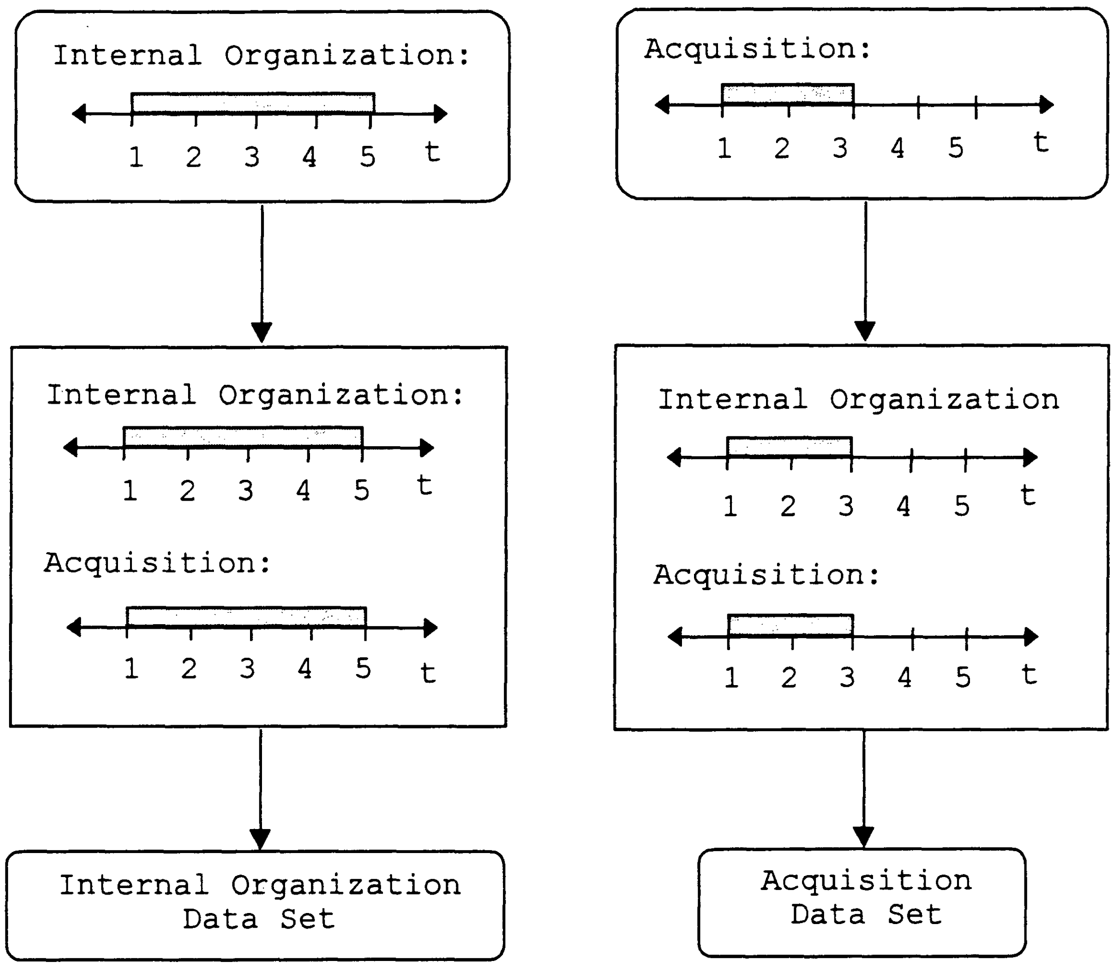

Figure 5.2 Second Algorithm for Data Set Formation

variables to include in an econometric model (see Griffiths et al 1993). This algorithm is chosen for its simplicity and precision effects.

There is one final data treatment issue. The data on property acquisitions is not broken down into developed and undeveloped reserves. A modification is made to account for this problem. The numerator in the acquisition proxy includes the total acquisition costs multiplied by the ratio of a firm's proved developed reserves to total reserves for a firm in a given year. Although this is not an exact replication of the original formulation, the approximation should be sufficiently accurate.

Results

First, the results for testing hypotheses one and two in the internal organization dimension are discussed followed by the results for the acquisition dimension. Finally, the results for the third hypothesis are presented. In the next section, these results are translated into implications for firm managers and further research directly related to the results.

Five years of lagged values and the 50th percentile strategic investment filter are used for estimation in the internal organization dimension (see the specification section in the previous chapter for a discussion of these initial settings). The mixed quadratic polynomial and logarithmic functional form is employed. The strategy proxy and its square are included, while the competitor intensity variable is logged (see equation [4.6]). In this estimation, each of the coefficients is significant with the correct sign, as shown in table 5.1.

Table 5.1 Internal Organization Strategy Results

Parameters*	Intercept (β_0)	Internal Organization Strategy	Competitor Intensity (β_3)	R^2
Estimate (53 d.f.)	-0.4195 (-2.99)	β_1: 0.3939 (1.77)	-0.5022 (-3.14)	17%
		β_2: -0.2684 (-1.70)		

*Specification: $\pi_j = \beta_0 + \beta_1(S_{ij}) + \beta_2(S_{ij}^2) + \beta_3 LN(I_{ij}) + \varepsilon$

Based on these results, the null hypothesis that strategic expenditure has no effect or a negative effect on performance is rejected for the internal organization strategy (critical t, 53 degrees of freedom, $\alpha = 0.05$, one sided = 1.674). Similarly, the null hypothesis that the intensity of competitor expenditure in a strategic dimension has no effect or a positive effect on performance can be rejected in the internal organization strategy dimension.

The R^2 for this estimation is relatively small. The low R^2 implies that the model does not explain a great deal of the behavior of firm performance in this industry. However, this is not the primary goal of the model. The intention of the model is to test whether or not strategy has an effect on firm performance, rather than to test whether or not strategy explains most or all of firm performance. The results imply that other influences affect performance in addition to firm strategy.

The simple semi-log specification is also estimated for this strategy. Although all of the coefficients have the correct signs, the strategy coefficient is insignificant.

Next, the first two hypotheses are tested in the acquisition dimension. Neither the mixed quadratic semi-log specification nor the semi-log specifications yield complete significance in the coefficients.

An analysis of firm plow-backs in the context of the industry averages suggests that a higher percentile filter may be more appropriate for testing this strategy. Many firms demonstrate massive "acquisition spikes" in their proxies for this strategy (see appendix D). It may be that a more intense level of expenditure (greater than a percentile higher than the 50^{th}) is necessary in this dimension for the expenditure to be considered strategic.

Alternative percentile hurdles (60^{th} and 70^{th}) are then tested with the semi-log functional form. At the 70^{th} percentile hurdle, complete significance and the correct signs across all coefficients are exhibited, as shown in table 5.2.

Based on these results, the null hypothesis that strategic expenditure has no effect or a negative effect on

Table 5.2 Acquisition Strategy Results

Parameter *	Intercept (β_0)	Acquisition Strategy (β_1)	Competitor Intensity (β_2)	R^2
Estimate (59 d.f.)	-0.1855 (-2.58)	0.0124 (1.69)	-0.1560 (-3.59)	18%

*Specification: $\pi_j = \beta_0 + \beta_1 LN\ (S_{ij}) + \beta_2 LN\ (I_{S_{ij}}) + \varepsilon$

performance can be rejected for the acquisition strategy (critical t, 47 degrees of freedom, $\alpha = 0.05$, one sided: 1.678). Similarly, the null hypothesis that the intensity of competitor expenditure in a strategic dimension has no effect or a positive effect on performance can be rejected in the acquisition strategic dimension.

The results from testing the hypotheses regarding each strategy serve as empirical support for the assumptions made and hypotheses developed for the quantitative model in Chapter 3. Specifically, the assumption that strategic expenditure has a positive effect on firm performance, outlined in equations 3.5 and 3.9, is supported empirically. There is also empirical support for the assumption that competitor expenditures have a negative effect on firm performance, outlined in equations 3.6 and 3.16.

Finally, the combined strategy equation is estimated and the third hypothesis is tested. To ensure strict measurement of strategic expenditure rather than noise the longer requirement for strategic expenditures, 5 years, and the higher percentile filter, 70^{th}, are used. As noted in the specification, lag-four is selected for its location between the lags for the individual strategies.

The estimated equation exhibits signs consistent with the earlier findings for the internal organization and acquisition strategies, as shown in table 5.3. The coefficient for the interaction variable for both strategies is significantly different from zero, but it has a sign contrary to the original hypothesis. Based on these results, the null hypothesis that the interaction effect from pursuing a combined strategy is less than or equal to zero can not be rejected.

Table 5.3 Combined Strategy Results

Parameter *	Intercept (β_0)	Internal Org. (β_1)	Acq. (β_2)	Internal Org.*Acq. (β_3)	R^2
70th Perc. Estimate (43 d.f.)	-0.0098 (-0.452)	0.0564 (2.10)	0.1182 (2.24)	-0.1330 (-2.10)	12%

*Specification: $\pi_j = \beta_0 + \beta_1 S_{1j} + \beta_2 S_{2j} + \beta_3 S_{1j} S_{2j} + \varepsilon$

This equation is also estimated with the 60th and 50th percentile strategic filters. In these results the t statistics increase as the percentile filter decreases. This demonstrates that the combined strategy results for the hypothesis tests do not change over the range of percentile filters used in the isolated strategy cases.

The results from testing the third hypothesis offer two points concerning the assumptions made in constructing the model in Chapter 3. First, the results do not provide empirical support for the assumption made in equation [3.13]. However, the results do further support the notion that strategic expenditure has a positive effect on firm performance.

Implications

Firm managers in the petroleum industry can use these results, combined with an understanding of the theoretical model, in forming strategic plans and making strategic decisions. First, firm management should use all available information in their environment to form an industry perspective. In this process, firms will develop an understanding of their own resource position. In addition, firm management will make expectations about the location of other firms within the strategic dimensions.

After firm management creates the industry perspective, it can determine two initial conditions. First, the firm will see in which dimension it has built relatively more resources, or perhaps it will find that it has a balanced position. Second, the firm will observe the nature of its position relative to other firms. Combining the observations will provide a perspective on the magnitude of the firm's resources relative to the industry, alert the firm as to how crowded its position is, and reveal whether or not there are any relatively open positions with few firms occupying them.

Three specific implications can then be drawn from the testing of each hypothesis. First, firm management should consider the lag structure and percentile filters used to estimate the strategy equations and test the first hypothesis. Based on the results, the acquisition strategy requires a more intense commitment of funds relative to the industry's expenditure level when compared to the internal organization strategy. However, the internal organization strategy appears to require a greater commitment in terms of years of consecutive expenditure.

Note, however, that the time it takes for a firm to successfully implement a strategy depends on its current position in the strategic dimensions. According to the resource base view, a firm will have an easier time increasing its competitive advantage in strategies associated with the dimension where it has developed relatively more resources, ceteris paribus. If a firm is in a balanced position, the results imply that management should consider its tolerance for making intense expenditures and its tolerance for waiting for performance gains. When firm management is relatively more tolerant of intense expenditure, the acquisition strategy should be pursued, ceteris paribus. On the other hand, when firm management is relatively more tolerant of waiting for performance gains, the internal organization strategy should be pursued, ceteris paribus.

The second hypothesis implies that crowding erodes performance in strategic space. If a firm is in a crowded position, the management may want to consider any opportunity it has to increase its resources in another dimension. Likewise, if a firm is considering a new strategic position, it should consider the expected future crowding of the position. That is, not much value may be added from a strategy if a significant number of firms act simultaneously upon the strategy.

The third issue relates to the simultaneous pursuit of both strategies. The estimation results indicate a negative effect on the interaction of both strategies. That is, after sweeping out the positive effects of each strategy, there appears to be a partially offsetting negative effect attributed to simultaneous pursuit. This does not simply mean that firms should never pursue both strategies at once. It is possible that at some point, the majority of firms are specializing in either strategy (such that there are groups of firms along each axis in strategic space). In this case, pursuing both strategies at once may be justified to escape a crowded position.

On the other hand, these results do imply that firms should never make the decision to pursue a combined strategy with the expectation of positive synergies eventually enhancing performance. The results suggest a negative synergy in a combined strategy. Overall, there appears to be some support for the old idea of specialization over diversification, in the context of this industry study.

In addition to the above implications associated directly with each hypothesis test, three broad implications for valuation can be drawn from the results. Perhaps all reserve maintenance decisions involve some sort of traditional financial capital budgeting analysis. If, however, firms do not include some sort of strategic analysis along with the traditional capital budgeting analysis, there may be some negative implications for performance. For example, if a firm's traditional capital budgeting analysis does not lead to a consistent intense expenditure in either dimension, the firm may suffer from a stasis in its resource base. This translates into an irrational foregoing of the added value that could have been generated by competitive advantage.

The model and estimation results may also explain some reserve transactions that appear to be overvalued under traditional valuation techniques (such as net present value). If a firm anticipates learning from a set of reserve purchases or a set of exploration and development expenditures in a particular region, it may be willing to pay more than what traditional valuation techniques suggest. That is, the strategy model developed here provides an explanation of the overvaluation by considering the value of initiating a strategic intent to develop a competitive advantage inherent in the investment. This could explain comments often overheard in the petroleum industry, such as "firm A paid too much for reserve (or property) X."

This notion is related to the development of modern valuation techniques, which also account for what appear to be overpayments from the perspective of traditional capital budgeting methods. In modern valuation techniques, overpayment is accounted for through the incorporation of option values (see Trigeorgis (1996) for a review). Option values account for the value of managerial flexibility in altering the course of an investment in succeeding time periods. The value of these options is not explicitly included in a traditional capital budgeting analysis.

A subset of this literature addresses the notion of compound or strategic options. Compound options arise when an investment, in a given time period, includes acquiring an option to make sequentially optional expenditures for added value in the future. Compound option pricing models focus on determining a specific value for such sequentially optional expenditures in the context of current, historical, and expected values of financial variables. There are two complications involved in the valuation of such compound options: i) identifying which options a given firm should acquire for value maximization, and ii) identifying the potential for competitor action that may result in the erosion of compound option values (see Trigeorgis (1996), Chapters 8 and 9).

The strategy model developed and estimated here provides insight for handling the two complications in compound option valuation. First, a given firm's resource base serves as a general diagnostic tool for identifying which types of compound options are appropriate. For example, a firm's resource base can guide a firm in deciding whether to secure options in a internal organization or acquisition dimension. Second, expectations drawn from the perspective of the resource-based view can aid in determining the potential for competitor erosion of option values. For example, if firms are currently crowded in the acquisition dimension, the successful arrival of competitors in the internal organization dimension will likely take a relatively longer period of time (due to the stock and flow concept for resource generation).

Finally, Barney (1986) notes that the markets for firms are an example of strategic factor markets. This research may therefore have implications for both valuing and making decisions regarding horizontal mergers & acquisitions (M&A) as well as joint ventures (JV's). In M&A, the issue is the combination of resources from different firms while in a JV the issue is the temporary association of resources from different firms. M&A and JV's may involve firms with resources in the same strategic dimension or resources in different strategic dimensions.

Before examining the separate cases, consider what it means for two firms to have resources in the same dimension. Two firms may have an equal magnitude of resources in the internal organization dimension, and enjoy a similar degree of competitive advantage. However, that does not necessarily mean that they have the exact same resources. For example, they may have developed different internal organization techniques with equal cost reducing magnitude. The following discussion is facilitated with two new definitions to accommodate this issue. The situation of two firms having the same resources in the same dimension is referred to as intra-dimensional homogeneity, while the situation of firms having different resources in the same dimension is referred to as intra-dimensional heterogeneity.

First, consider a merger between two firms with resources in the same dimension, under the case of intra-dimensional homogeneity. With the exact same resources, the merger would result in no expected net change in the strategic position and hence overall performance. There would simply be a single larger firm in the same position, ceteris paribus.

Under a case of intra-dimensional heterogeneity, there could be an additive change in strategic position from combining different resources. There may even be a multiplicative change due to synergies in combining the resources (note that we are not dealing with synergies across strategic dimensions here, rather, synergies across resources in the same dimension).

The same issues arise in acquisitions regarding the intra-dimensional heterogeneity or homogeneity of resources. However, there is one additional concern. When one firm acquires another, the price will likely embed the expected value of the competitive advantage of the acquired firm (this is similar to the notion of having to pay for expected monopoly rents when acquiring a monopoly firm, in the economics literature). Here the multiplicative effect from potential synergies across the resources (in the same dimension) is the only potential source of value.

Next, consider the case of M&A where the firms in question have resources in different strategic dimensions. A net change of strategic position is possible. However, note that in the results in table 5.3, the sign on the interaction variable for combined strategies is negative. This should be incorporated in analyzing the value of the merger or acquisition. As in the single firm combined strategy case, this move should be taken when a firm is trying to escape a crowded region, not to gain expected positive synergies from combining strategies (the results do not support the existence of such synergies).

The issues of intra-dimensional heterogeneity and homogeneity, as well as the combining of resources across dimensions, also arise in the analysis of joint ventures from the strategic perspective. It is assumed here that the goal of a joint venture is to add value to a specific project, and hence the firm, that would not be available if either firm pursued the project in isolation. Under this assumption, two firms with intra-dimensionally homogeneous resources engaging in a joint venture would realize no expected added value over pursuit of the project in isolation.

In the case of intra-dimensional heterogeneity, added value from a joint venture is possible. This would be similar to the case of a merger under these conditions. It may also be the case that the project is simply not profitable with only one firm's resources, and that without the added value, the project yields a loss.

Firms with resources in different dimensions may be in even a better position to enjoy added value through a joint venture. However, there is one clarification in order, in light of the econometric results. The results that imply negative synergies are generated from firm level combinations of resources. Although this point is relegated to further research, there is reason to believe that there would be positive synergies. The suggestion of negative synergies from combining strategies in the results may be a function of confounded managerial oversight within a single firm. In a joint venture, the management of the strategies remains in separate firms and therefore, combining strategies may provide added value and possibly positive synergies.

There is a final point to consider regarding joint ventures where resources are heterogeneous across firms, whether intra-dimensional or not. Firms must keep in mind that there will likely be information sharing during the joint venture. This means that the added value from the project will be at least partially offset by a decrease in the degree to which each firm's strategic information remains private.

Before proceeding to the concluding chapter, the reader is reminded about a caveat inherent in interpreting results generated through econometric methods. Take the internal organization dimension for example. The results show that over the years in the study when firms made five consecutive expenditures, whereby the average was greater than the 50^{th} percentile of the industry's expenditures, the firms generally enjoyed a positive gain in performance.

This does not mean that in the future every firm that makes similar expenditures will enjoy an increase in performance. One must return to the theoretical model of causality before drawing prescriptions from the econometric results.

Chapter 6

CONCLUSIONS AND FURTHER RESEARCH

This research investigates the nature of firm performance with a combination of principles from the strategy and economic literatures. The resource-based view of the firm is incorporated for its combined use of such principles. This view provides an integrated explanation for the identification, achievement, and sustainability of competitive advantage. A quantitative model is developed here based on the resource-based view to facilitate the formation and empirical testing of hypotheses regarding the effect of strategic expenditure on firm performance. The results lead to implications for firm management within the context of the model.

The alternative specification methods and the potential for future data availability are areas for further research. In addition, many of the implications drawn from the results suggest rich avenues for further investigation. These issues are addressed below, following a discussion of the general conclusions of this research.

General Conclusions

Currently, there is a lack of significant research in statistically testing the principles of the resource-based view at the level of competitive strategy. Quantitative and econometric models for the resource-based view are formed here for drawing hypotheses based on the tenets of the view. An econometric specification is then offered and implemented for testing in the petroleum industry.

The evidence empirically supports the assumptions and hypotheses regarding the value of strategic expenditure and the effect of competitor intensity. Specifically, the assumption that strategic expenditure can have a positive effect on firm performance is supported. The assumption that competitor strategic expenditure can have a negative effect on firm performance is also supported empirically.

On the other hand, the results for the hypothesis of a positive synergy effect in combined strategic expenditure run contrary to the original hypothesis (a negative effect is measured). However, the results for combining strategies do concur with an alternative hypothesis in the strategy literature. Porter (1980) suggests that firms should choose one dimension to focus on from the two broad strategies of cost reduction or product differentiation. In this research the cost dimension is broken down into two sub-dimensions of internal organization and acquisition of complex inputs. It appears that Porter's suggestion of pursuing strategies in isolation holds in the sub-dimensional analysis - there appears to be a negative synergy realized when pursuing combined strategies rather than a single strategy.

The model and results provide several implications for firm managers in the petroleum industry. The results imply that strategy in reserve maintenance does matter. When firms specialize in either the exploration and development or acquisition forms of reserve maintenance, a positive effect is measured in their succeeding performance. Note that the term specialize here is used to indicate when a firm pursues one method significantly and relatively more intensely, not exclusively.

The actions and reactions of competitors in strategy maintenance will also ultimately influence a given firm's performance. As competitors increasingly pursue intensity in investment in the same form of reserve maintenance as a given firm, that firm's performance will decline as competitive advantage is eroded away, ceteris paribus.

Firm managers should combine these two results along with the principles of the model in making reserve maintenance decisions. First, firms should analyze their own resources to determine which strategy is appropriate for them. Simultaneously, firms should consider the degree to which competitors are pursuing each strategy along with the expected degree to which competitors will pursue each strategy in the future.

Some broader implications are general enough for application in any industry. Firms should take into account their own resource bases as well as other firms when considering a merger, acquisition, or joint venture. In many cases the resource base analysis could be an explicit or implicit motivation for the transaction. Firms can use the resource base analysis to identify if or when such a transaction is profitable. In addition, firms may want to consider how much information is shared, and therefore compromised, in a joint venture. When the information sharing yields a net benefit, the joint venture is rational. However, it is feasible that in some joint venture one firm could realize a handsome information gain, while the other firm gains little or no new information.

On a final concluding note, models and results such as those developed here could be tied to notions of risk, risk tolerance, and specifically, risk aversion. Do the internal organization strategy, acquisition strategy and the lack of a strategy all have the same risk? Firm managers may want to consider the expected risk of alternative strategies and their own risk tolerance when making strategic investments. Further, risk aversion to strategic investment may be tied to sub-optimal firm performance. This could be an area for further research.

Further Research

The suggestions for further research are broken down into two areas: econometric specification and expanded strategic analysis. Alternative specifications, facilitating the testing of more hypotheses, could be employed in the estimation, contingent upon greater data availability. More refined hypotheses regarding the nature of strategic expenditure could also be developed and tested.

The estimation in Chapter 5 is performed on a single equation for each strategy. If a much larger data set were available, the estimation equations could be written at the firm level, whereby one equation is attributed to each firm. This yields a system of n equations for n firms, for example (the subscripts on the parameters identify the firm, and the parameter):

$$y_1 = \beta_{10} + \beta_{11} x_{11} + \beta_{12} x_{12} + \ldots + \beta_{1k} x_{1k} + \varepsilon_1$$

$$y_2 = \beta_{20} + \beta_{21} x_{21} + \beta_{22} x_{22} + \ldots + \beta_{2k} x_{2k} + \varepsilon_2$$

$$\vdots$$

$$y_n = \beta_{n0} + \beta_{n1} x_{n1} + \beta_{n2} x_{n2} + \ldots + \beta_{nk} x_{nk} + \varepsilon_n$$

Each equation could be estimated separately in addition to an industry wide equation. A statistical test could then be performed on the results to identify the correct specification.

Under some conditions, estimating the equations together as a system could improve the properties of the estimation results. Other variables that are not included in this model may influence the performance for some or all of the companies in the data set, given that they are all in the same industry. In addition to industry effects, economy wide fluctuations may influence each firm's performance in a similar manner.

The influence of the omitted variables and the economy wide fluctuations, unaccounted for in the deterministic portion of the model, will be captured in the error terms of each firm's equation. It can then be assumed that the error terms of these equations are likely contemporaneously correlated (correlated in the same time period). For example, if a change in the economy generates a higher performance in a given time period (unexplained by the strategy variables), each firm's equation will have a positive shift upward in its error term for that period's observation.

The information in the correlated error terms can be incorporated into the estimation procedure with a process developed by Zellner (1962) called seemingly unrelated regressions (SUR). This process incorporates the cross firm correlation in the error terms in the estimation. A given firm's performance level may be higher than another's across all observations due to uniform unmeasured influences. The intercept, varying across firms, will capture these effects.

Research extensions for enhancing the strategic analysis include expanding the scope of the analysis developed here to corporate strategy, exploring more complicated dimensions in strategic space, and exploring the nature of strategic risk (these extensions are in addition to those suggested in the implications section of Chapter 5). Instead of focusing on expenditures in alternative dimensions, an analysis could be framed around expenditures in alternative business units or markets. There is already some research in the area of specialization versus diversification, and the nature of diversification, at the corporate level. The quantitative form of the resource-based view developed here could be modified for statistically testing hypotheses in this area.

Recall that this research is built around analyzing two sub-dimensions of the internal organization strategy. Further research could involve testing the hypotheses in the product differentiation dimension. An even more general model would simultaneously encapsulate both the cost reduction and product differentiation strategies.

The issue of strategic risk may also be an area for further research. Managers may want to develop expectations regarding the risk of alternative strategies. Then firms can match the expected risk with their own risk tolerance. Alternatively, to achieve the goal of profit maximization, firm managers must act as if they are risk neutral and not hedge to protect the investment of their own human capital. Further research could explore to what degree risk aversion in strategic investment is eroding firm value. An initial point can be drawn from the results here. The synergy effect of pursuing both strategies is found to be negative. If firm managers pursue two strategies at once to diversify the risk of a single strategy, there may be a negative synergy effect on performance.

Finally, suppose that over time unique implementations of the model developed here are discovered by firm managers to consistently map to reality. This research then becomes a component of strategic resources.

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APPENDIX A

RESOURCE CONSTRAINTS AND ISO-PERFORMANCE CURVES

Figures A.1 and A.2 graphically depict the firm's constrained maximization problem in strategic expenditure. The curves are based on functions derived from the model. The concave curve represents the resource addition constraint. The resource addition constraint is represented by the following implicit general function formed from equations 3.7 and 3.8 (the bar represents a constant):

$$\overline{R}_j = h\left(\frac{dR_{1j}}{dt}, \frac{dR_{2j}}{dt}\right)$$

As drawn in Figures A.1 and A.2 the constraint allows for the case whereby a firm may actually move to a position representing fewer resources in a given dimension (for example, the intercept with either axis). This could happen due to resource erosion over time (Dierickx and Cool (1989)). Therefore, the curves incorporate the assumption that the equation above contains a resource erosion or depreciation parameter, which is not included in the original model.

The following function represents an iso-performance curve constructed from an expectation of equation 3.3:

$$\bar{r}_j = g\left(R_{1j}, R_{2j}, E\left(\overline{\tilde{R}_{1j}}\right), E\left(\overline{\tilde{R}_{2j}}\right), \bar{t} \right)$$

The iso-performance curve represents the set of alternative resources a firm can have that yield the same level of performance. This function is represented by the convex curves in Figures A.1 and A.2.

Profit maximizing firms will want to use all possible information in making their expectations. Barney (1986) suggests that firms can analyze their existing resources to generate information for making expectations. This suggests the following information function:

$$v_j = q\left(R_{1j}^{t_0}, R_{2j}^{t_0}\right)$$

The model would then have to incorporate the information function in a way that allows for improving expectations. This is yet another area for further research.

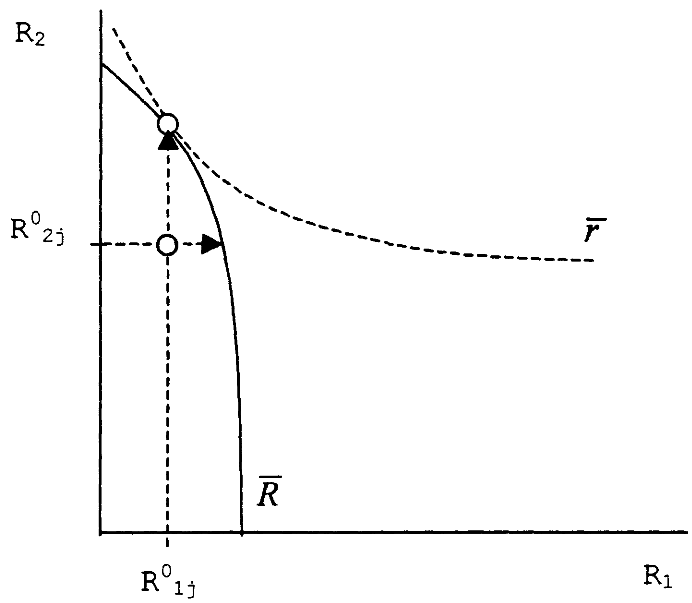


Figure A.1 Isolated Resource Expenditure

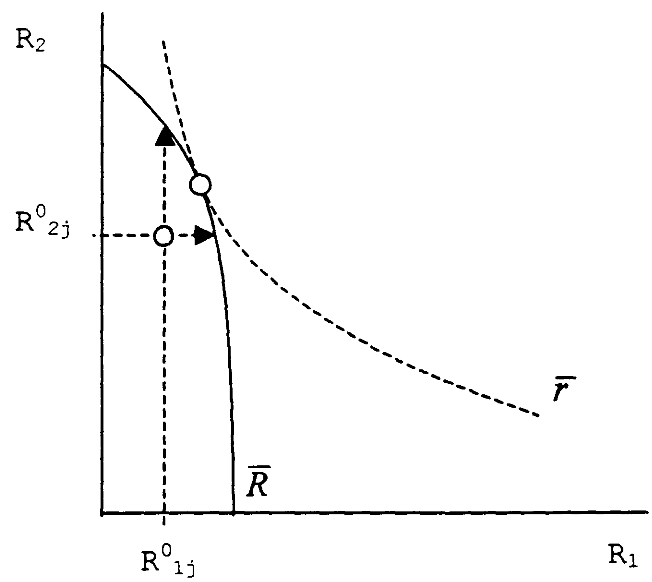


Figure A.2 Simultaneous Resource Expenditure

APPENDIX B

STRATEGIC NOISE FILTER ALGORITHM

Table B.1: Moving Average and Percentile Calculations for Proxy 1.

Proxy 1	Raw Data			Moving Average (2 year)			Industry Percentile
	Company			Company			
Year	A	B	C	A	B	C	
1	X_{1A}	X_{1B}	X_{1C}				
2	X_{2A}	X_{2B}	X_{2C}				
3	X_{3A}	X_{3B}	X_{3C}	Y_{1A}	Y_{1B}	Y_{1C}	Z_1
4	X_{4A}	X_{4B}	X_{4C}	Y_{2A}	Y_{2B}	Y_{2C}	Z_2
5	X_{5A}	X_{5B}	X_{5C}	Y_{3A}	Y_{3B}	Y_{3C}	Z_3

Table B.2: Moving Average and Percentile Calculations for Proxy 2.

Proxy 2	Raw Data			Moving Average (2 year)			Industry Percentile
	Company			Company			
Year	A	B	C	A	B	C	
1	I_{1A}	I_{1B}	I_{1C}				
2	I_{2A}	I_{2B}	I_{2C}				
3	I_{3A}	I_{3B}	I_{3C}	J_{1A}	J_{1B}	J_{1C}	K_1
4	I_{4A}	I_{4B}	I_{4C}	J_{2A}	J_{2B}	J_{2C}	K_2
5	I_{5A}	I_{5B}	I_{5C}	J_{3A}	J_{3B}	J_{3C}	K_3

Table B.3: Single and Combined Strategy Observation Identification

Company	Proxy I Moving Average (2 year)	Proxy I MA > Industry Percentile [Proxy I]	Proxy II Moving Average (2 year)	Proxy II MA > Industry Percentile [Proxy II]	Each Proxy > Proxy Industry Percentile
A					
	Y_{1A}	•	J_{1A}		
	Y_{2A}	•	J_{2A}		
	Y_{3A}		J_{3A}		
B					
	Y_{1B}		J_{1B}		•
	Y_{2B}		J_{2B}		•
	Y_{3B}	•	J_{3B}		
C					
	Y_{1C}	•	J_{1C}		
	Y_{2C}		J_{2C}		
	Y_{3C}		J_{3C}	•	

Example calculations are provided on the following page.

Example Calculations and Observation Identification

Table B.1

$Y_{1A} = (X_{1A} + X_{2A}) / 2$
$Z_1 = P^{th}$ Percentile (Y_{1A}, Y_{1B}, Y_{1C})

Table B.3

Lightly Shaded Cell: $Y_{1A} > Z_1$
(3rd column)

Darkly Shaded Cell: $(Y_{1B} > Z_1)$ AND $(K_1 > J_{1B})$
(6th column)

Observation: $\{X_{1A}$, (Company A Year 3 Performance)$\}$

Note that three and five-year moving averages are used for the proxies in the actual data set formation. Two-year moving averages are used here for brevity.

APPENDIX C

FIRMS INCLUDED IN MODEL ESTIMATION

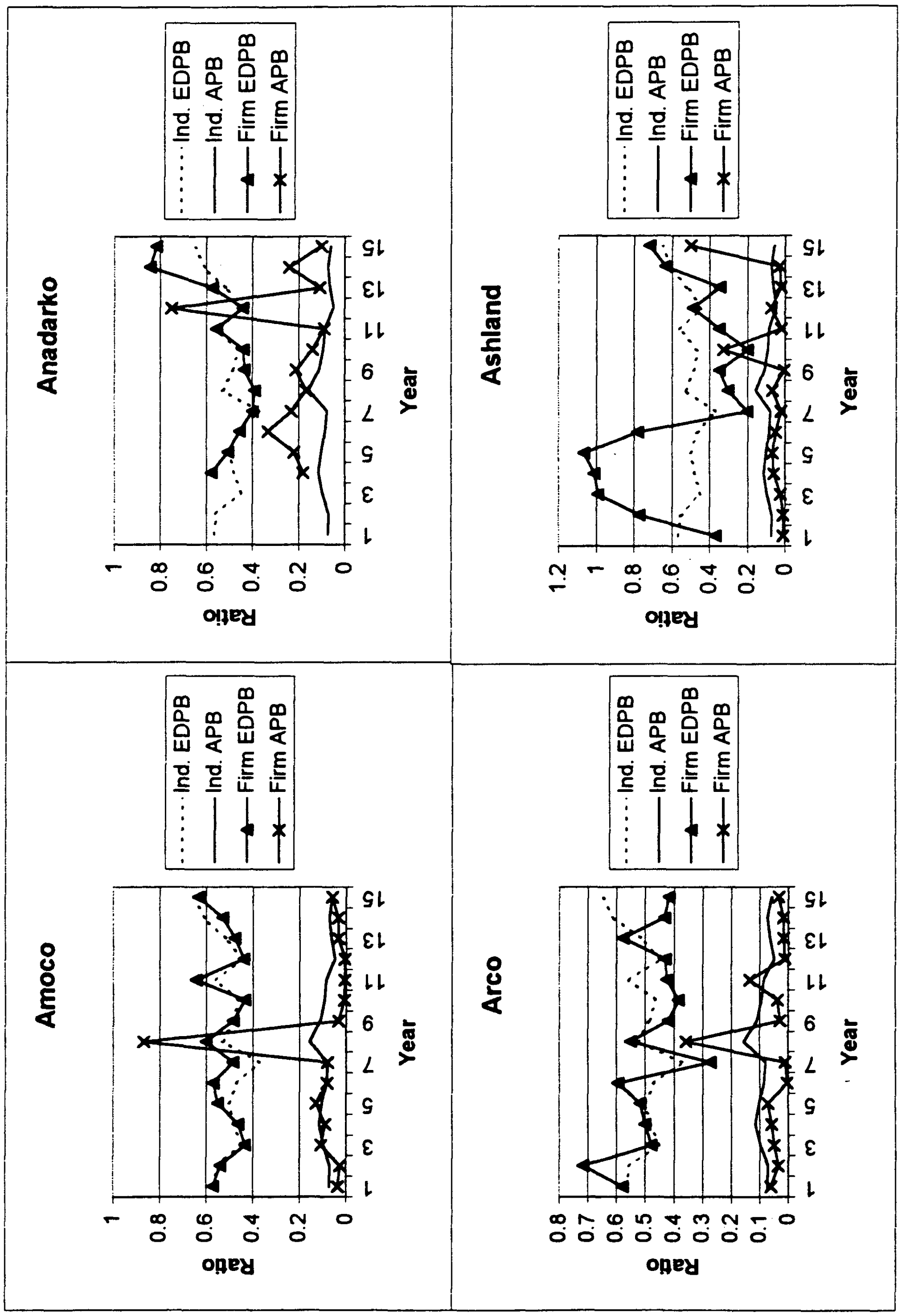
Table C.1 Firms Included in the Model Estimation.

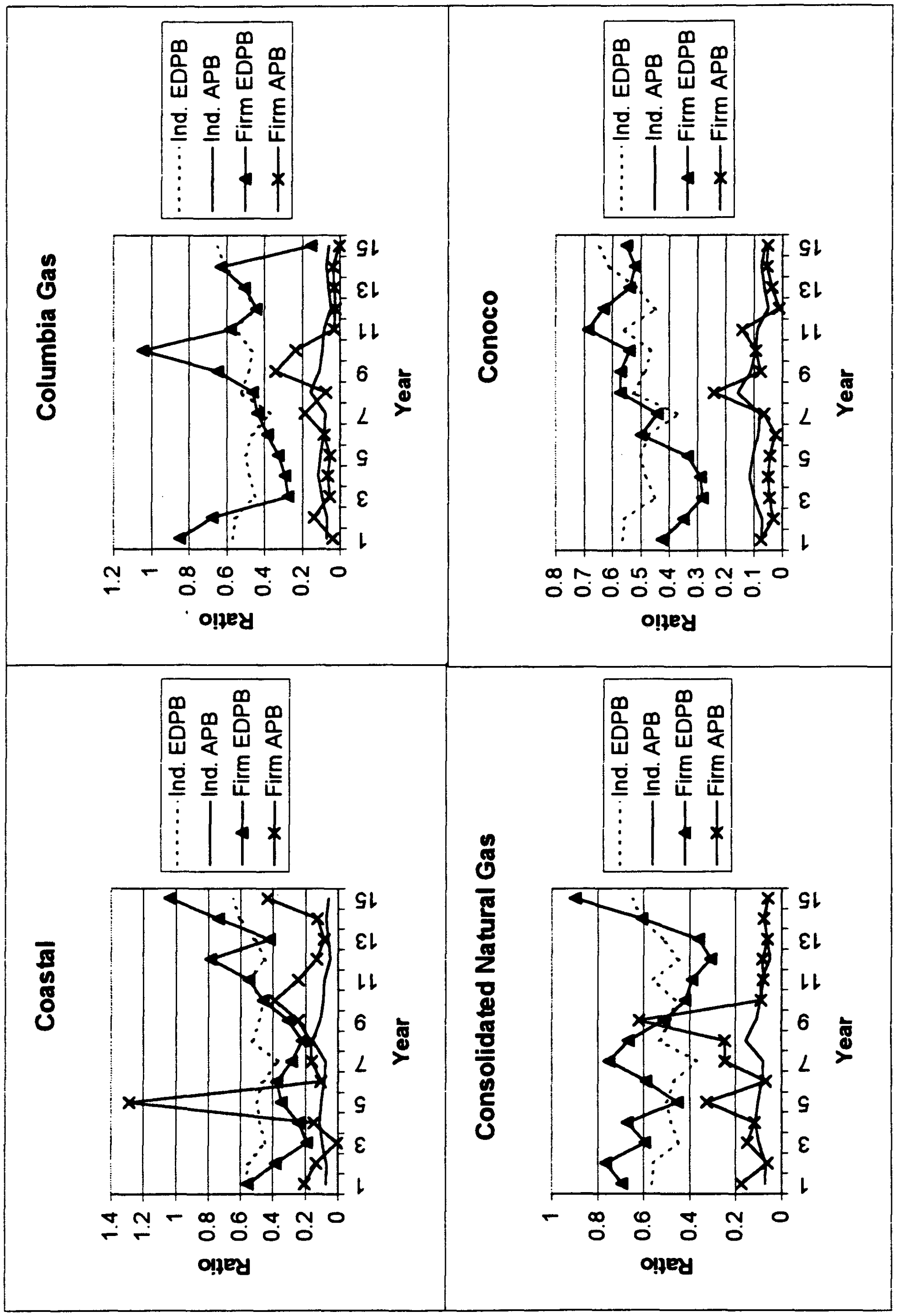
Amoco	Montana Power
Anadarko	Murphy Oil
Arco	National Fuel Gas
Ashland	Noble
Consolidated Natural Gas	Occident
Coastal	Pennzoil
Columbia Natural Gas	Phillips
Conoco	Questar
Enron	Sante Fe
Enserch	Shell
Fina	Sun
Kerr-McGee	Southwest Energy
LL&E	Union Texas
Mitchell	Unocal
Mobil	

APPENDIX D

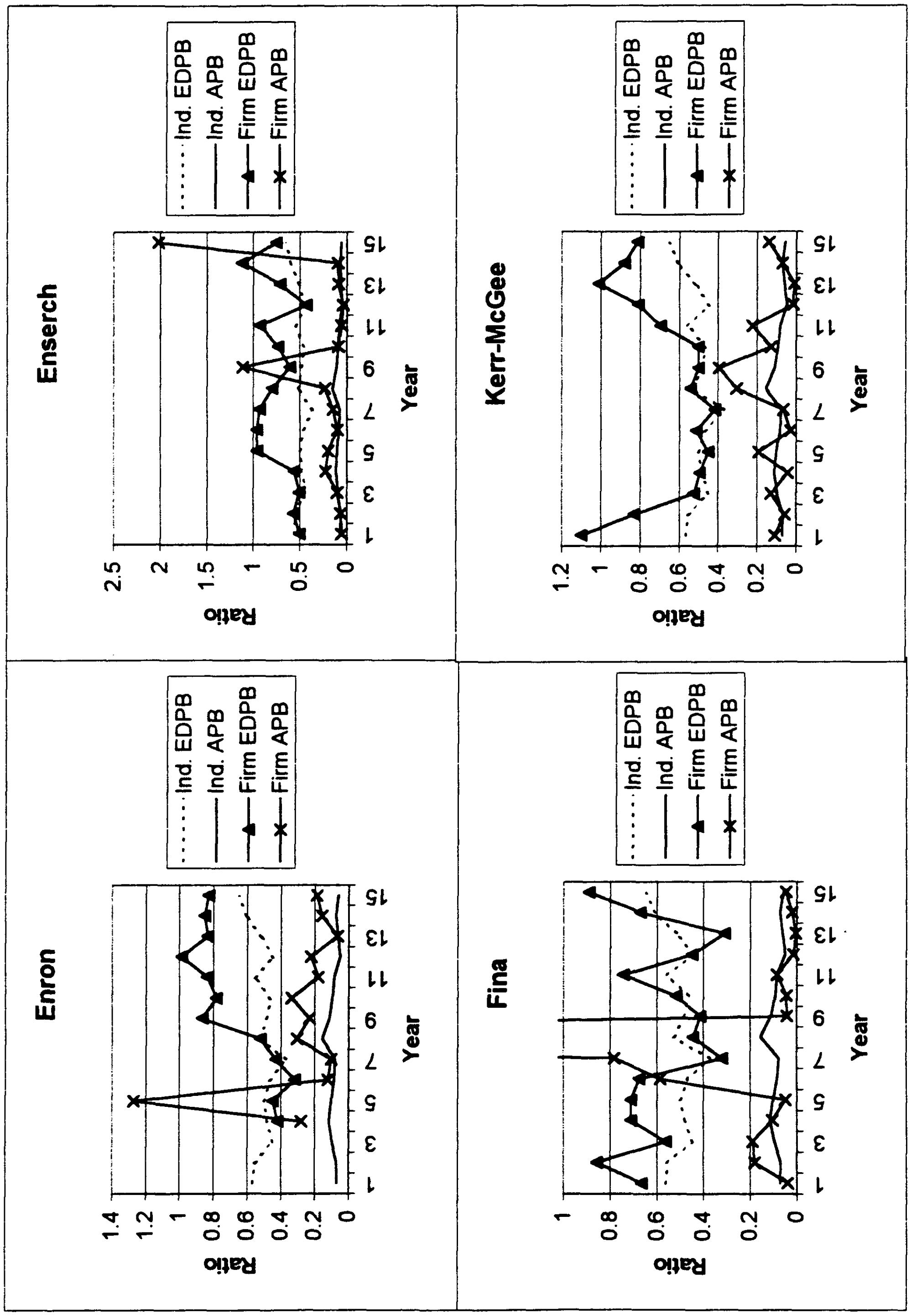
INDIVIDUAL FIRM PLOW-BACK GRAPHS

This appendix contains each firm's plow-back proxy for each strategy, presented in per firm graphs. In addition, each graph contains the industry average for each proxy. The industry averages appear to vary across graphs due to scale differences from graph to graph. The internal organization strategy proxy is associated with the exploration and development (EDPB) plow-back, while the acquisition strategy is associated with the acquisition plow-back (APB).

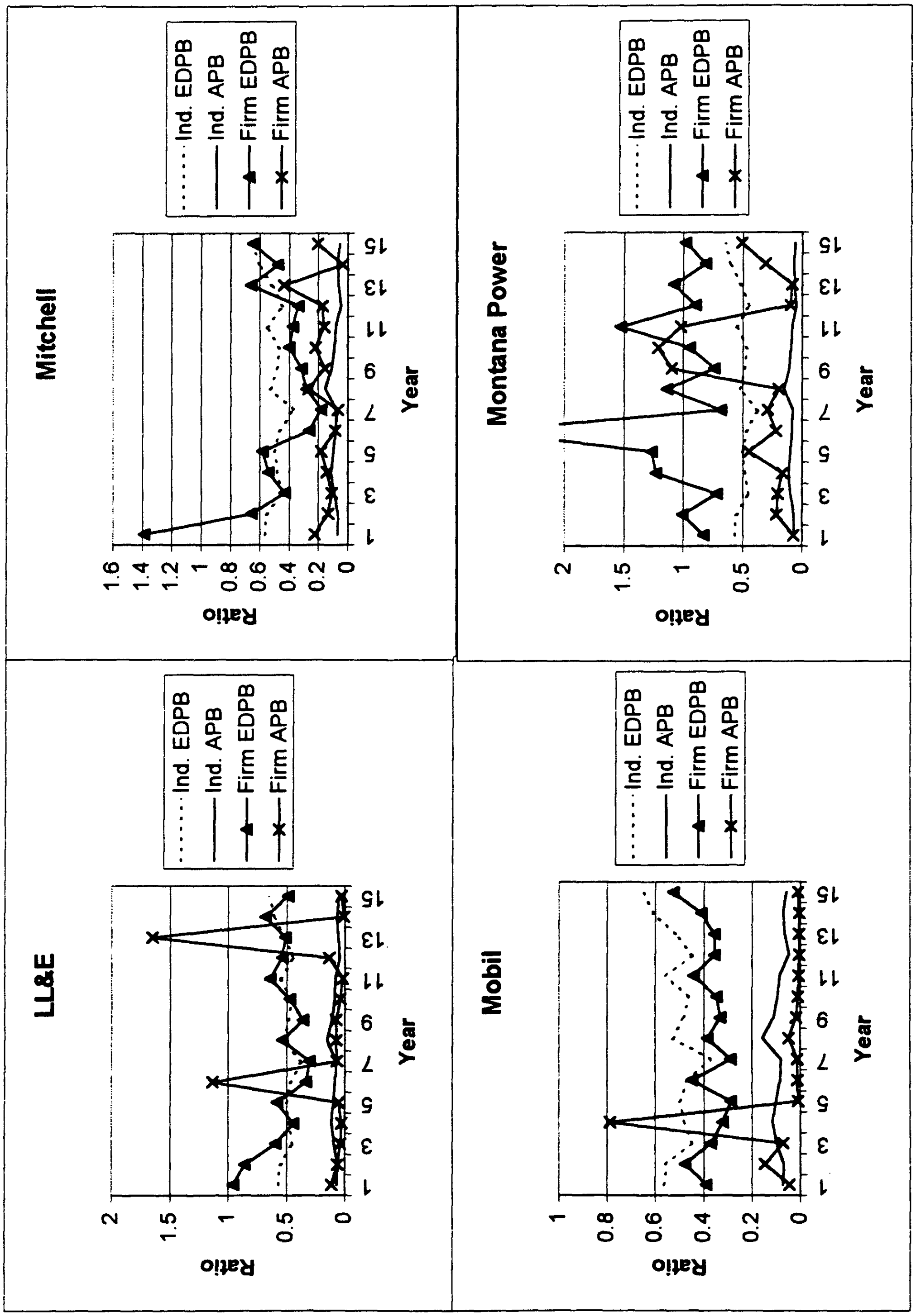

Amoco
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Anadarko
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Arco
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Ashland
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB

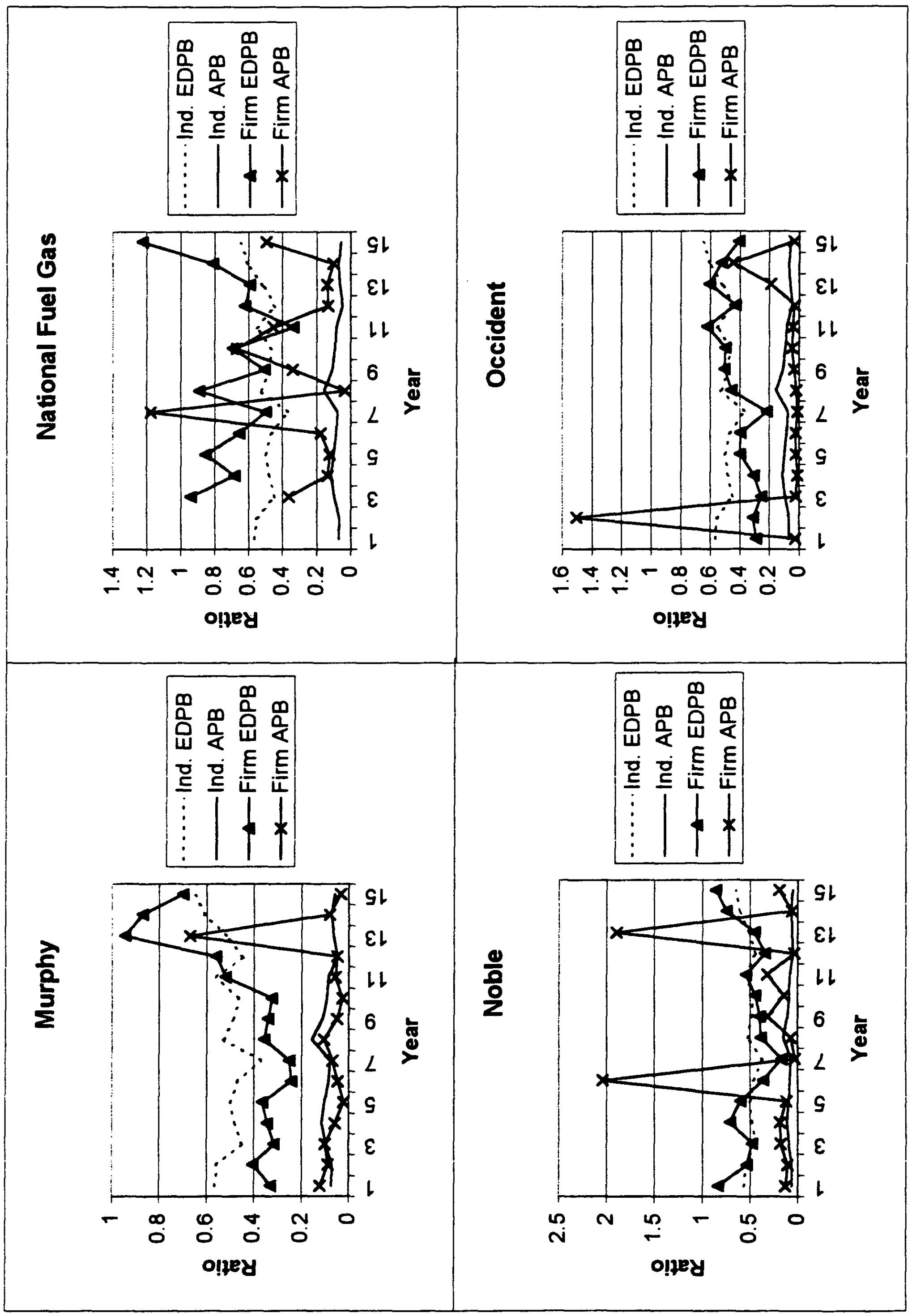


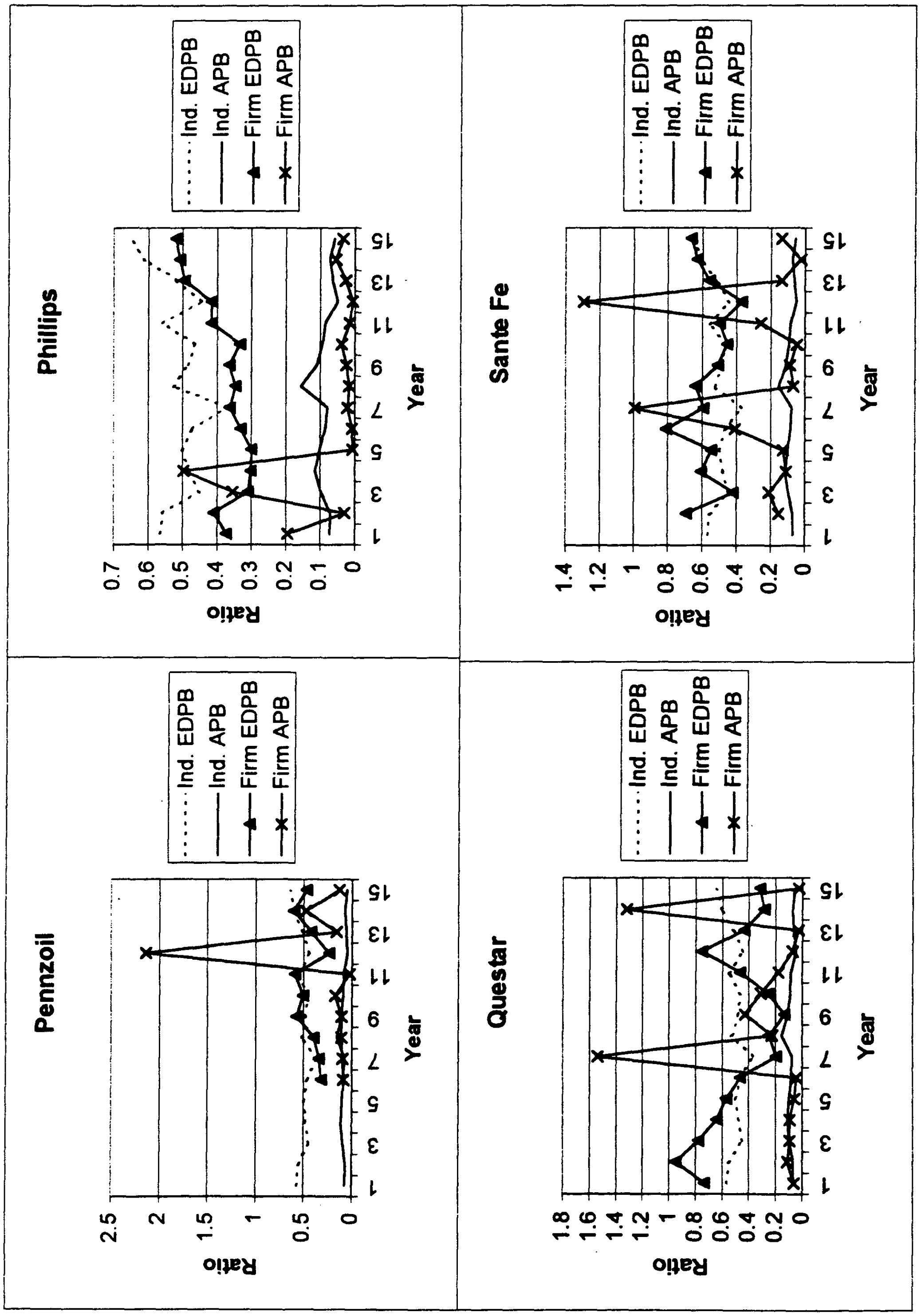
Coastal
Columbia Gas
Consolidated Natural Gas
Conoco
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB

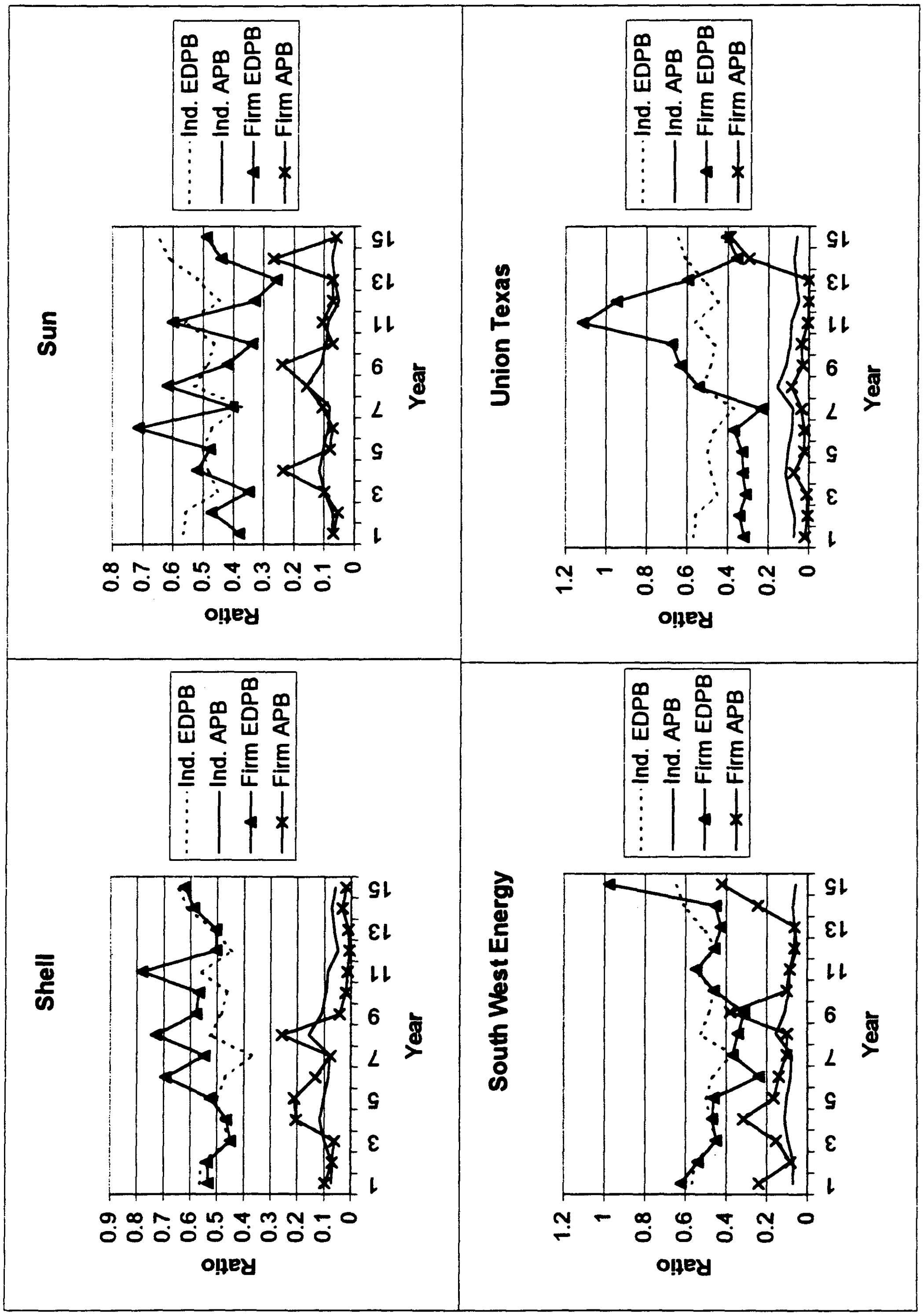


Enron
Enserch
Fina
Kerr-McGee
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB

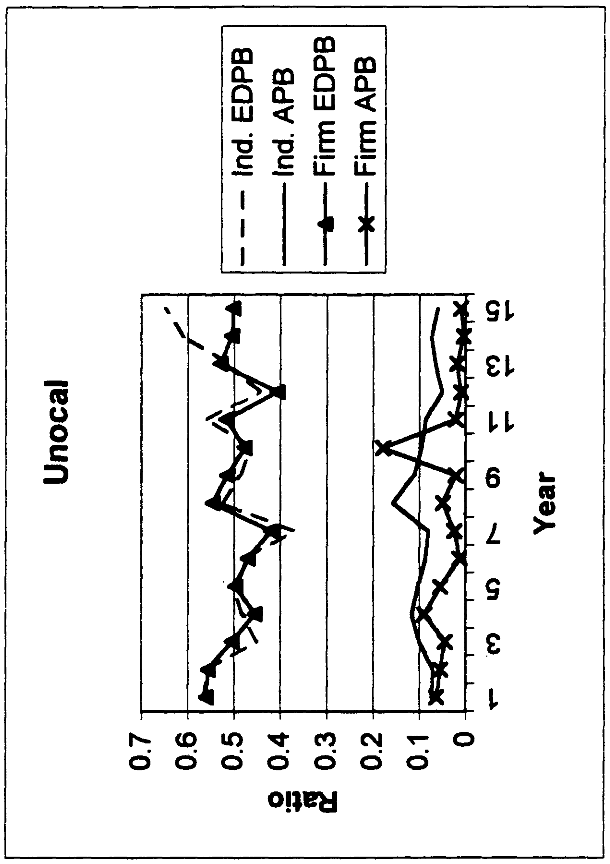

LL&E
Mitchell
Mobil
Montana Power
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB


Murphy
National Fuel Gas
Noble
Occident
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Ratio
Year


Pennzoil
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Phillips
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Questar
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB
Sante Fe
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB



Shell
Sun
South West Energy
Union Texas
Ratio
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB


Unocal
Ratio
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
3
5
7
9
11
13
15
Year
Ind. EDPB
Ind. APB
Firm EDPB
Firm APB