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INDUSTRY, STRATEGY, AND THE MANAGEMENT OF CAPACITY

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INDUSTRY, STRATEGY, AND THE MANAGEMENT OF CAPACITY

by
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MICROFILMED DISSERTATIONS

For Sandy In Gratitude Of Her

Immeasurable Support Over The Years

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To any doctoral candidate the sacrifice, trials, and tribulations of preparing a dissertation are practically beyond description. In my particular case I acquired a good deal of knowledge about a narrow subject area, but the true worth of the experience to me was in gaining a much deeper understanding of life itself. I wish to thank all the people who aided me in this journey. To my parents, thanks for the continual encouragement and support - I never requested your help, but it was always unselfishly there. To Sandy Anderson, who has proven time and again the meaning of true and lasting friendship. I only hope that some day I can repay you. To Dave Snyder, who helped alleviate the tedium with his companionship, humor, and thoughtfulness. Of course, thanks to my committee - Birger Wernerfelt, Brian Talbot, Kan Chen - and especially my chairperson, Cynthia Montgomery. I respect your academic abilities, but even more so your genuine concern about me as a friend. Last but not least to Mary Cook. May you some day develop a true appreciation of what I endured.

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CHAPTER I

INTRODUCTION

This dissertation primarily reports on an empirical analysis of the aggregate capacity decision for a business. The analysis is organized into four distinct "parts." First, a series of cross-sectional regression models are specified in which capacity utilization is in turn a function of technological and industry (e.g. competition) characteristics. Capacity utilization is used as the proxy for the firm's aggregate capacity decision, since it most closely represents the relationship between demand and choice of capacity. The approach to the model building is that past key works will initially be replicated, and then additional variables will be selectively included to enhance the explanatory power of the "base models." The second "part" of the analysis looks at the effect of capacity utilization on business performance. Of particular interest here are varying combinations of technological and industry characteristics which will influence the overall capacity utilization - performance relationship.

The third and fourth parts in a sense expand the analysis beyond simply capacity to look at the overall relationship between business strategy and manufacturing. The expanded variable set is necessary since many of these manufacturing decisions are interrelated with capacity. For the third part a series of business strategy types will be identified and then compared across a series of manufacturing variables. The last "part" uses regression analysis to examine the influence of these same manufacturing variables on business performance. The objective is to ascertain if manufacturing policies are in fact equally critical to the performance of the various business strategy types. For all four parts the PIMS data base will be used for the hypothesis testing.

1.1 Purpose Of The Research

One of the major decisions a business must make is the selection of an appropriate aggregate capacity policy. In many instances, the long-run success or failure of a business can hinge on this aggregate capacity decision. Numerous examples of problems created by too much or too little capacity abound in the business press. ITT Rayonier (cellulose pulp) and Cities Service (polyethylene) recently closed plants and each incurred write-offs of approximately $300 million. Both businesses expanded capacity in the face of signs of excess capacity in the industry (Schmenner, 1983). Oxirane's venture into the production of ethylene glycol failed due to insurmountable technical problems caused by the premature scale-up to an 800 million pound per year plant, and had to be eventually closed.[1] Expanding capacity too slowly, however, can be equally problematic. DuPont's failed experience with Corfam was partially attributed to insufficient capacity during the early years of production. More recently, Coleco Industries experienced problems of insufficient capacity for the Cabbage Patch doll. An "opportunity cost" of lost sales was incurred, and also enabled competitors to make inroads by offering imitative products.

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[1]See "Strategic Management of Technology," Chemical Week, November

The competitive significance of aggregate capacity is apparently particularly acute in capital intensive industries which produce standardized products. In their study of the corn wet milling industry, Porter and Spence (1978) noted some of the consequences of this decision:

> If the firm fails to add capacity at the appropriate time, it not only loses immediate sales and market share but may also diminish its long-run competitive position . . . if the firm adds too much capacity, it can be burdened with unmet fixed charges for long periods of time. . . additions to capacity can pose major problems since the matching of capacity to demand is often a major determinant of industry rivalry and profits (p. 1).

For a business "aggregate capacity policy" falls under the general heading of "capacity and facilities planning" (Marshall *et al.*, 1975, p. 215; Wheelwright, 1979, p. 1; Schmenner, 1981, p. 297). Wheelwright (1979, p. 5) has identified five key decisions in "capacity and facilities planning." In order, these decisions are: 1) how much capacity to provide, 2) when to add or drop capacity, 3) what kind of capacity (facilities) to provide, 4) where to locate the capacity, and 5) how to accomplish the desired facilities plan. The rationale for including these particular decisions can most easily be illustrated by example. Dow Chemical in 1977 faced a need for additional capacity to produce methocel (an inert thickening agent which is used to improve the properties of a wide variety of products). It was not clear, however, how much capacity should be built, when the new capacity should come on-stream, what process should be used, or at which facility the modifications should be made. Significant economies existed in the capital cost per pound of capacity, as well as the variable cost of production (both costs were also influenced by the choice of batch or continuous process-

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11, 1981, pp. 32-6.

ing) (Hosmer, 1982, p. 137).

Two points must be made from this example and list of decisions. For this research, "aggregate capacity policy" is defined to encompass Wheelwright's first two decisions (how much and when). This grouping is logical, since the issue of "how much" capacity is a dynamic one as requirements change over time. Second, however, the example illustrates that these "capacity and facilities planning" decisions are far from independent. The choice of aggregate capacity may in fact be intimately intertwined, for example, with the choice of production process, or the nature of the plant system (i.e. the number of plants and their organization - the what kind and where decisions).

Despite the apparent strategic and financial implications of aggregate capacity policy, a paucity of research in the academic literature concerning this topic has been undertaken to date. The nature of the research has tended to fall into one of four classes: 1) prescriptive work which tends to emphasize that decisions made in the manufacturing realm must be linked to and consistent with business strategy (Skinner, 1969; Wheelwright, 1978); 2) a conceptual description of the linkage between business strategy types and the manufacturing system (Rothschild, 1979; Stobaugh and Telesio, 1983); 3) a description of the underlying factors which influenced the capacity decisions of the various competitors in a specific industry (Porter and Spence, 1978); and 4) a description of industry characteristics which influence phenomena related to aggregate capacity, such as investment or market share stability (Scherer, 1969; Caves and Porter, 1978; Smith, 1981). Only two examples of empirical investigations (Hambrick, 1983a; Woo and Cool, 1983) which compared the manufacturing characteristics of different business strategy types have been found, although aggregate capacity was not the primary focus of the research.

In summary, proposing and empirically testing a model of aggregate capacity policy would appear to be a significant and timely endeavor. The timeliness of general research concerning manufacturing also cannot be overstated. Much of the Japanese success, such as in the steel and automobile industries, has been attributed to their manufacturing prowess. Concern with "productivity" has become one of the foremost management challenges of the 1980's. Closely linked to this productivity concern is rapid technological change on the factory floor, particularly in the areas of robotics and CAD/CAM. The focus on productivity, however, has tended to overlook the strategic implications of manufacturing.

1.2 Research Questions

The most widely documented aggregate capacity policy has been described in the context of how a business achieves market leadership within a high-growth industry. As espoused by the Boston Consulting Group (1972), capacity should be added not as growth actually materializes ("matching of demand"), but instead in anticipation of growth. The rationale behind the building of capacity as quickly as possible during the rapid growth period of an industry is so that "economy of scale" and "experience curve" effects can occur (the more capacity the competitor has, the faster volume will double). Volume growth is thus used to establish a wide cost differential over the competition. A similar notion is that this "preemptive" capacity addition serves to discourage entry into the industry. Excess capacity thus permits existing firms to expand output and reduce price when entry is threatened, thereby reducing the prospective profits of the new entrant (Spence, 1977).

The example illustrates that aggregate capacity policy is based upon elements such as technology ("economy of scale"), demand ("volume growth"), and competition ("discourage entry"). The first two research questions focus on developing an understanding of these elements. The first research question mainly addresses issues of technology and demand:

- What is the influence of technology and demand on aggregate capacity policy?

For the most part the technology - capacity relationship has been well documented in models of monopolistic industries and is included for "completeness" of an overall model.

The second research question relates to issues of competition. For example, the willingness of the business to pursue a capacity policy of "preemption" has been hypothesized to be a function of "uncertainty":

> Uncertainty represents a significant qualification to the strategy of preemptive capacity expansion and growth. . . Depending on the known demand, the firm will either do nothing or build to the limit. . . With no uncertainty, preemptive investment limited only by the financial resources available to the firm, becomes the appropriate strategy because it clearly maximizes discounted cash flow (Porter and Spence, 1978).

Such "uncertainty" can be loosely interpreted as an "unpredictability" in the rate of industry growth, but may also be construed as "uncertainty" of competitive moves. The second question, then, mainly encompasses understanding the factors which contribute to "uncertainty" as it influences aggregate capacity policy. The appropriate focus for the analysis is the industry level. Simply stated:

- What is the influence of industry characteristics on aggregate capacity policy?

The nature and extent of these factors must thus be explicitly recognized and tested. For this research, "industry characteristics" encompasses more than the notion of "uncertainty," however. A major focus will be on the effect of the oligopolistic bargain on capacity utilization.

While these two questions both deal with modeling of capacity utilization, the third question considers the importance of capacity utilization to business performance. This "importance" is expected to vary by combinations of key characteristics posed in the preceding two questions (e.g. technology, growth, industry structure):

- What characteristics influence the capacity utilization - performance relationship?

The influence of strategy will be specifically excluded in this particular analysis.

The fourth research question simply relates to the influence of business strategy:

- Can it be demonstrated that different business strategy types adopt different aggregate capacity policies?

A business may theoretically pursue any of a number of "competitive postures" within a given industry. Porter (1980), for example, has defined these strategies as cost leadership, differentiation, and focus. The notion explored here is that aggregate capacity policy must be consistent with business strategy, and that different strategies will indeed make different demands on the manufacturing systems (Schendel and Hofer, 1978; Wheelwright, 1978).[2] Such differences, however, can only be understood in the context of technology and the industry. The analysis

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[2]The notion of "consistency" and of a "manufacturing strategy will be further explored in 1.31.

must therefore use the preceding "models" (research questions one and two) as a means of "control." To illustrate the need for "control," the "cost leader" in an industry with volatile demand will likely exhibit different capacity attributes than the "cost leader" in an industry with more stable demand characteristics (Hambrick, 1983c).[3]

The fifth research question deals with the linkage between strategy, aggregate capacity policy and performance:

- Does the capacity policy - strategy match serve to explain differences in business performance?

This question examines where capacity policy can effectively explain differences in performance after controlling for industry and technology differences. The basis for this question is the concept of "distinctive competence." To illustrate, a business pursuing a strategy of differentiation would likely focus its resources on differentiation-related functions - for example, advertising and promotion, product development, customer service, etc. To perform well, the business would have to excel at these functions vis-a-vis the competition. This portion of the research, however, deals with whether the "differentiator's" performance would also hinge on its manufacturing prowess (again in comparison to other "differentiators").

The last research question is intended to amplify upon the analysis of strategy posed in the fourth question. The objective of the question can best be illustrated by example. Assume that business strategy is found to not impact capacity policy. The reason for a lack of dif-

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[3]Strategies also may not "appear" with equal frequency in all industries (Porter, 1980; Snow and Hambrick, 1980). A strategy of differentiation, for example, would be relatively difficult to achieve in a commodity product industry. This point will only be of secondary interest in this research.

ference, however, may simply be that other manufacturing policy decisions (such as choice of process) may be "relatively more important." The notion, then, is that such differences in other policy decisions should also systematically exist between strategy types:

- To what extent do differences in other manufacturing policy decisions exist between business strategy types?

This analysis can be easily incorporated, since a number of these policy decisions will also impact aggregate capacity policy. This question in a sense touches on the concept of "manufacturing trade-offs," which is further discussed and developed in 3.31.

In summary, these research questions progressively build upon each other. For example, understanding the effect of capacity policy on performance is impossible without first incorporating the effect of technology, industry, and strategy.

1.3 Discussion Of Key Concepts

Two concepts are at the essence of this research - that any manufacturing business (either implicitly or explicitly) adopts a "manufacturing strategy," and that "aggregate capacity policy" is a part of this strategy. The following two subsections will discuss "manufacturing strategy" and existing models of the aggregate capacity decision process. Much of the intent of these subsections is to reinforce the linkages among the research questions, and to further illustrate how this research serves to advance the understanding of aggregate capacity policy.

1.31 Manufacturing Strategy

Strategy in its broadest sense was defined by Andrews (1971) as:

> . . . the pattern of major objectives, purposes, or goals and essential policies and plans for achieving those goals, stated in such a way as to define what business the company is in or is to be in and the kind of company it is or is to be (p. 28).

Strategy thus serves as a guide for decision-making such that the overall pattern of decision making is internally consistent and interrelated.

A significant refinement in this definition was made when it was recognized that strategy in the diversified corporation is hierarchical in nature - different strategies exist at three different levels of the organization (Hofer and Schendel, 1978). Corporate strategy focuses on the determination of what set of businesses to be in, and how resources should be allocated among businesses. Business strategy relates to the competitive actions that the firm adopts in a given product-market.

Last, functional area strategy is defined by Hofer and Schendel (1978, p. 29) as "maximization of resource productivity." "Productivity", however, implies the relationship between resource inputs and outputs - an efficiency measure. In general, organizations depend much more for their long-run success and survival on effectiveness (how well the firm relates to its environment, or alternatively the degree to which actual outputs correspond to desired outputs) than efficiency. A more comprehensive definition of functional area strategy, therefore, would be "maximization of resource effectiveness and efficiency."

Hofer and Schendel recognized that a fundamental characteristic of this hierarchy is that while each type of strategy is distinct, the three levels should "fit" together coherently and consistently. Furthermore, functional area strategy is constrained by business strategy, which in turn is constrained by corporate strategy.

This dissertation broadly focuses on strategy in one functional area - manufacturing. Wheelwright (1978) proposed a conceptual framework for manufacturing strategy which links strategy, manufacturing performance criteria, and policies which pertain to the design of the manufacturing system (Figure 1.1). The framework offered a major contribution in two respects. First, the explicit identification of multiple manufacturing performance criteria was made. Wheelwright noted that manufacturing executives have too frequently based policy decisions solely on minimizing production cost per unit - the "efficiency" criterion. Other criteria can be as important as the achievement of efficiency.[4] For example, TRW learned in one division that poor delivery lead times were hurting market share more than high costs. The company restructured manufacturing policies to focus on becoming not the low cost producer, but the low lead time producer (Skinner, 1983). Second, the manufacturing decisions which have strategic significance were also identified by Wheelwright. Aggregate capacity is one of these five strategic manufacturing decisions. However, as was noted previously, these decisions are by no means totally independent. For example, process choice, facilities choice, and vertical integration choice will all be interrelated with the aggregate capacity decision.

The manufacturing strategy framework in Figure 1.1 is incomplete, however, in two respects. First, the aforementioned hierarchical nature of strategy is not recognized by incorporating both corporate strategy <u>and</u> business strategy into the framework. In a sense, corporate strategy can have a direct influence on business-level manufacturing strategy if the corporation is trying to achieve a high degree of

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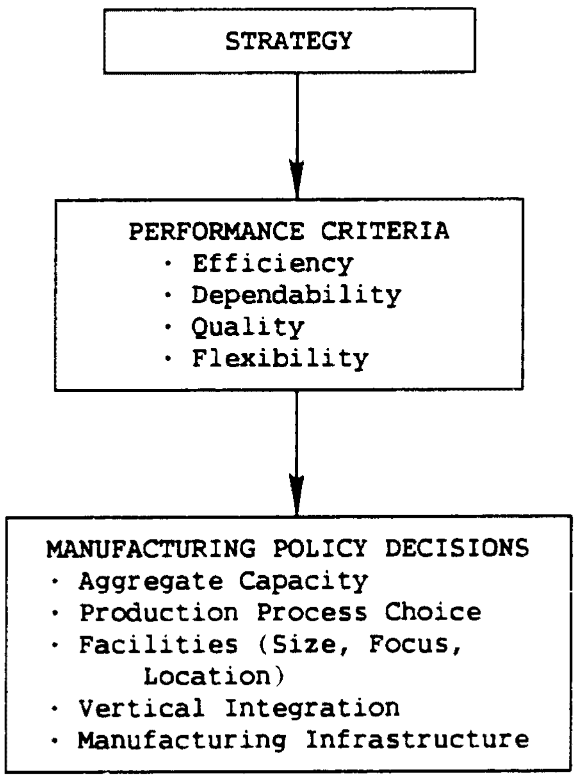
[4]Ironically, Hofer and Schendel make the same mistake in their definition of functional area strategy - they proclaim that the objective is to maximize efficiency.

Figure 1.1

Wheelwright's Manufacturing Strategy Framework



"relatedness" among its businesses. The notion is that businesses may thus be more likely to share manufacturing facilities, particularly if there is a commonality of production processes for the products of the respective businesses. The consequence of shared facilities is that no single business may be able to make manufacturing decisions unilaterally.

The second deficiency is that the influence of the industry on manufacturing strategy is not well defined. A fundamental notion of strategy is that the organization must deal with a set of non-controllable variables (economic, technological, social, political) which will impact its strategic decision-making (Hofer and Schendel, 1978). These industry characteristics - especially the economic and technological dimensions - need to be precisely recognized.

In summary, then, the "manufacturing strategy" framework has recognized that the aggregate capacity decision is an instrumental component of strategy. This "component" is in turn influenced by a series of factors - the industry, corporate and business strategy, and other manufacturing decisions.

1.32 The Aggregate Capacity Decision

This subsection will first briefly summarize the steps which the aggregate capacity decision entails. After this description a discussion will be presented which summarizes how various fields have tended to emphasize (or de-emphasize) elements of this process.

Wheelwright (1979, p. 2) and Schmenner (1981, pp. 297-315) have described primarily a five-step process for capacity expansion (or contraction) decisions. The first two steps involve the identification of a capacity "need," and the formulation of alternatives to meet the need. Broadly speaking, this need can be the result of an expected change in demand (increase or decrease) or a change in competitive position and/or performance. The precise "need" is simply derived by comparing available capacity with an estimate of required capacity. Required capacity is usually calculated through some type of forecasting methodology, and can be further split into short-term and long-term requirements (Monks, 1982, p. 516). Short-range need (usually up to twelve months ahead) implies the control of capacity to ensure utilization according to plan, since obtaining additional capacity by adding new facilities is usually out of the question. Typical short-run responses to adjust the capacity/demand balance would be to increase backlog levels, stockpile finished goods to meet later demand, change the employment level, subcontract production, or defer maintenance. Over the longer term, management is of course still interested in maintaining a planned level of system capacity vis-a-vis demand. The number of alternatives, however, can expand and may involve major investment in facilities, equipment, land, and/or human resources.

The third and fourth steps are to simply quantitatively and qualitatively evaluate the proposed alternatives. The quantitative aspect can be accomplished with a variety of tools, such as financial analysis techniques and/or mathematical programming. Usually no single technique will provide all of the information needed to choose among several alternatives. Qualitative considerations would include those factors for which no data can be obtained, or which cannot be easily measured, such as ease of implementation. The last step is to develop a recommended course of action.

Since the crux of this research is to focus on the output of this decision process, a worthwhile endeavor is to summarize the importance which different fields of research have tended to attach to the steps described. The fields of strategic management, industrial organization economics, operations management, and operations research have all made some contributions to understanding this issue. Figure 1.2 characterizes the perspectives of these fields. These contrasts can be drawn with regard to the time frame of the decision and assumptions about the environment (stable technology, known demand, and no competitive effects versus the case where any of all of the three elements are uncertain).

Operations management (OM) has tended to focus on the "short-range need" problem. Schmenner (1981, p. 259) gives an example situation where a sporting goods company must develop a plan for the production of baseball gloves and hockey gloves - obviously two seasonal products. Decisions have to be made concerning inventory levels, workforce levels, and the production mix. In examples of this type, demand forecasts are usually taken as a "given," or represent the output from any of a number of different statistical techniques (e.g. moving averages, exponential smoothing) (Schmenner, 1981, p. 310). Past research has primarily dealt with the application of quantitative methods (such as linear programming) to the development of least-cost production schedules. The relevant costs here largely consist of inventory carrying charges, wage premiums, and changing the employment level. The research focus, therefore, can be characterized as primarily better demand forecasting methodologies or more sophisticated evaluation of the economics of short-range capacity alternatives.

Operations research (OR), in contrast to OM, <u>has</u> tended to focus on

Figure 1.2

Aggregate Capacity Perspectives

TIME FRAME	ENVIRONMENT: Certain	ENVIRONMENT: Uncertain
Short Range	Operations Management	
Long Range	Operations Research	Strategy, Economics

the long-range expansion problem.[5] The crux of the analysis usually consists of determining the sizes of facilities and the associated times at which these facilities should be added. Two "wrinkles" can be added to this basic problem. First, in applications like the cement industry, transportation cost can be substantial in relation to product cost. Thus, in addition to sizing and timing decisions, the appropriate location becomes an important part of the planning process. Second, capacity investment cost may exhibit substantial economies of scale; i.e. the average cost per capacity unit decreases with the expansion size. The expansion decision must therefore consider the trade-off between the economy of scale savings of large expansion sizes versus the cost of installing capacity before it is needed. These relationships are formulated such that the objective function is to minimize the discounted costs associated with the expansion process. Applications for the models are usually large, capital-intensive systems in monopolistic settings with a long planning horizon (twenty years is not unusual), such as communication networks or electrical power systems.[6]

To make the analysis tractable, numerous simplifying assumptions are usually made, such as stable product/ process technology and known future demand. Much like OM, OR has focused on improving the sophistication of analytical techniques. However, due to the long-range focus, the primary "costs" considered here relate to "economy of scale"

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[5]The long-range capacity issue is frequently addressed by OM researchers in the Harvard Business Review, however, as Chase (1980) notes, these pieces are written for the executive rather than for the researcher. For examples, see Leone and Meyer (1980), Hayes and Wheelwright (1979*a*, 1979*b*), and Schmenner (1976).

[6]For some representative examples of the formulation and solution of these problems, see Freidenfelds (1981) and Erlenkotter (1973).

savings attributable to different capacities, transportation costs, and the discount rate.

The fields of strategic management and industrial organization economics have focused on vastly different aspects of this problem. Porter (1980, p. 325) summarizes this perspective:

> The mechanics of making a capacity expansion decision in the traditional capital budgeting sense are quite straightforward - any finance textbook will supply the details. Future cash flows resulting from the new capacity are forecasted and discounted to weigh them against the cash outflows required for the investment. . . However, the simplicity masks an extremely subtle decision-making problem. . . To determine future cash flow from the new capacity the firm must predict future profits. These will depend crucially on the size and timing of capacity decisions by each and every one of its competitors, as well as on any number of other factors. There is also usually uncertainty about future trends in technology, as well as about what future demand will be. The essence of the capacity decison, then, is not the discounted cash flow calculation but the numbers that go into it . . . Estimating these is in turn a subtle problem in industry and competitor analysis (not financial analysis).

Two types of expectations, then, are crucial to the aggregate capacity decision - those about future demand and those about competitors' behavior. Porter notes that the aggregate capacity decision can consequently involve all the classic problems of oligopoly. Luss (1982) concurs with Porter's conclusions in that the influence of rapid changes in technology, technology-dependent operating costs (e.g. if a choice exists between a capital-intensive and non-capital-intensive process), capacity deterioration, and capacity utilization policies should be necessary components of any capacity "models." An assessment of the pertinent demand, technological, and competitive factors which underlie forecasts of needed capacity are at the crux of the long-range capacity decision.

In summary, the major thrust of this paper will be on the long-range aggregate capacity decision. The operations management literature offers limited insights into this decision because of the aforementioned gravitation towards the short-range models. Similarly, the rigorous treatment accorded long-range decisions by OR is embodied in highly simplified models of very special circumstances - broad applicability is thus problematic. The primary emphasis will consequently be on the strategic management/economics perspective. Nonetheless, OM/OR results will also be incorporated where appropriate.

1.4 Organization Of The Dissertation

Chapter II summarizes pertinent literature which is germane to understanding aggregate capacity policy. The chapter is organized into major subsections which define capacity and how it is measured, elements of technology which influence the firm-level capacity decision, industry characteristics (mostly demand and competition) which contribute to "uncertainty," and the relationship of capacity to business and corporate strategy.

Chapter III first proposes five successive models which define how aggregate capacity should vary as a function of 1) technology and 2) industry and competitive characteristics. The influence of these factors on the capacity - performance relationship is then assessed. These models are then extended to include business strategy. Detailed discussions of the capacity implications of various business strategy types are found in this chapter. The last portion of the chapter concerns performance testing at the business level. The relevant hypotheses are explicity stated in each section.

Chapter IV defines the variables to be used and the statistical tests to be made. Included at this point is the methodology used to identify business strategy types within PIMS (the data base used for hypothesis testing). The chapter concludes by describing the characteristics of the various data samples to provide the reader with an assessment of the range of business types and industry settings included.

The bulk of Chapters V and VI are devoted to presenting the results of the hypothesis testing. Both quantitative results and a qualitative assessment of the outcomes are included.

Finally, Chapter VII includes conclusions of the research, implications for management, and directions for possible future research.

CHAPTER II

SURVEY OF RELATED LITERATURE

As defined in Chapter I, the major "tasks" of the dissertation are to attain a better understanding of 1) the effect of technology and competition on capacity policy, 2) the strategy - capacity policy relationship, and 3) the relationship between capacity policy and performance. Unfortunately, the existing literature either is sparse or cannot be compartmentalized quite so neatly. The content of the four major sections diverges slightly from these "tasks," and can be summarized as follows:

- Section 2.1 briefly defines "capacity." An added consideration here is that the terms "aggregate capacity policy," "excess capacity," and "capacity utilization" will generally be used interchangeably in this research. The rationale is that all three are meant to address the same phenomenon - namely the size of installed capacity in relation to the demand placed upon such facilities.

- Section 2.2 looks at aspects of technology which influence capacity policy. The broad assumption in this section is that the decision described takes place in an industry with no uncertainty with respect to demand or competition.

- Section 2.3 broadly introduces the effects of competition and uncertainty on capacity policy. The broad assumption here is that the factors described will influence all competitors in the industry equally. Virtually no works have directly examined the degree to which industry characteristics effect excess capacity. Much of the review therefore focuses on research which has dealt with somewhat comparable phenomena (such as market share instability and investment instability).

- Section 2.4 describes the influence of strategy (both corporate and business) on capacity policy. In comparison to section 2.3, this summary investigates the intraindustry aspects of how the firm can use capacity to gain competitive advantage.

- Section 2.5 briefly summarizes the literature regarding the capacity utilization - performance relationship.

The assumption made in writing sections 2.1, 2.2, and 2.3 is that the "typical" reader is relatively unfamiliar with the literature cited. These sections are consequently quite detailed and descriptive. As an alternative, the reader can refer to Tables 2.1 and 2.2 (which summarize sections 2.2 and 2.3), and then skip to section 3.1. Section 3.1 presents summary arguments for a series of hypotheses concerning technology, demand, and competition.

Sections 2.2 and 2.3 are both organized in basically the same manner. A number of key research pieces will first be reviewed in each section, and then additional evidence to support the key pieces will be cited where appropriate. To reiterate a problem with this organization, little of the literature deals exclusively with firm-level, industry-level, or intraindustry influences on aggregate capacity. For example, the Caves and Porter (1978) study of market share instability examines all three influences. The organization chosen, therefore, will be to review each major piece in the category which it most appropriately fits, but also cite additional results from these pieces as "supporting evidence" in the other sections if necessary. As noted above, chapter III will then initially summarize and organize these arguments in hypothesis format.

2.1 Definition Of "Capacity"

The first task of this review is to develop an understanding of the meaning of "capacity." Despite "common knowledge" about the meaning of this term, precise definition is rather difficult. This difficulty can be attributed to the characterics of different production processes and to the capacity measurement method used.

"Capacity" can be loosely defined as the maximum output a firm can readily produce during a given period of time from its existing plant and equipment, with normal workshifts and normal down time for maintenance.[1] As a substitute, capacity can also be expressed in terms of inputs, such as available labor hours or machine hours per time period (Adam and Ebert, 1978, p. 119).

This notion of "maximum output" is highly dependent on both the type of process technology that exists and on the product mix being produced. In the case of the most "rigid" process with respect to product mix - the continuous flow process - capacity is explicit and can be measured in terms of physical output per unit of time (tons/day for a paper machine, for instance).[2] Likewise, "capacity utilization" is simply actual output in relation to measured capacity. However, as process flows become less well defined and constantly changing (as would be the case for production of customized, low volume products), capacity as measured by physical output becomes much more vague. The capacity of a job shop - the most flexibile of production processes - can change radically depending on the complexity of the orders worked on and the skill of management in production scheduling.[3] Between the two ex-

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[1]See "The Capacity Ceiling: How Far is Up?" First National City Bank Monthly Economic Letter, July 1975, pp. 5-9.

[2]Continuous flow processes are characterized by fixed routings of bulk products through their process steps, specialized equipment, little in-process inventory, and low labor content. Examples of continuous flow processes can be found in paper mills and oil refineries.

[3]Job shops are characterized by the production of low quantities (often one-of-a-kind) of specialized products. The products are often technologically complex. Examples of job shop "products" include tooling (molds, fixtures, die sets), custom machinery (heat exchangers, large electrical apparatus, printing presses, mining equipment), product

tremes of the continuous flow process and the job shop (on the basis of characteristics such as flexibility, capital intensity, etc.) exists mass production of discrete products and batch production.[4]

The point of the preceding discussion is twofold. First, for the more flexible production process types, the concepts of "capacity" and "capacity utilization" are likely to be highly inaccurate and quite indistinct (particularly if output measures are used). Second, this variability will also tend to be larger for businesses with large, complex product lines. "Capacity" and "capacity utilization" may thus be a function of management's skill in production scheduling.

Irrespective of this process type/product mix issue, capacity can be measured using any of a number of different methods. Wheelwright (1979, p. 3) reports four different possible measures - rated, standard, actual, or peak - which can be used for managerial control.[5] Despite

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prototypes, machine tools, and aircraft. For a summary of job shop planning methods, see Adam and Surkis (1977).

[4]Mass production is typified by the dedicated production of large quantities of one discrete product (with perhaps limited model variation). The assembly line generally falls into this category. Product types include automobiles and appliances. Batch production involves medium lot sizes of the same product which may be produced once or repeated periodically. Examples include books and clothing.

[5]"Rated capacity" is the output per unit of time that the facility is theoretically capable of producing. "Standard capacity" is the output per unit of time set as an operating goal for management and can form the basis for budgets. The differences between "rated" and "standard" can be primarily attributed to changes in standard product mix, run length, maintenace requirements, or scrap allowances. A paper machine, for example, produces thin and high-quality papers at slower speeds than commodity grades, which will tend to lower capacity. Run length is a factor in that the more frequent a change in machine set-up for different products, the more the reduction in attainable capacity. Capital-intensive facilities are usually designed to shut down only for maintenance. A typical steel mill will schedule twenty production shifts (or "turns") and one maintenance "turn" per week. "Actual capacity" is simply the average output per unit of time over the immediate past periods. This is standard capacity adjusted for actual

the diverse number of capacity measures available, the crux of the definitional problem is simply to identify the difference between "full capacity" and "excess capacity." Winston (1974) defines "full capacity" as:

> . . . a firm's planned, intended level of utilization; the level that reflects satisfied expectations is built into the capital stock and is embodied in the "normal" working schedule. Higher utilization than this will induce new investment.

"Excess capacity," then, is the failure to attain the intended level of utilization.

Figure 2.1 illustrates the fundamental difference between "full" and "excess" capacity. The figure compares the operation of two different plants for a typical year. Winston (1974) defines "M" as the maximum allowable time for production after an allowance for maintenance. The planned level of utilization (such as might be built into the plant and reflected in the normal operating schedule) is represented by "P." In the first case, maximum and planned utilization are approximately the same. The second case, however, shows that maximum utilization is much greater than planned. In both cases, the actual level of utilization achieved ("A") is less than the planned ("P"). "P," then, is "full capacity," "P - A" is "excess capacity," and "A/P" is capacity utilization (usually expressed as a percentage). The point of the illustration is that an explanation of desired idleness (the difference between maximum (M) and planned (P) levels of utilization) is the primary focus of this research. None of the empirical research

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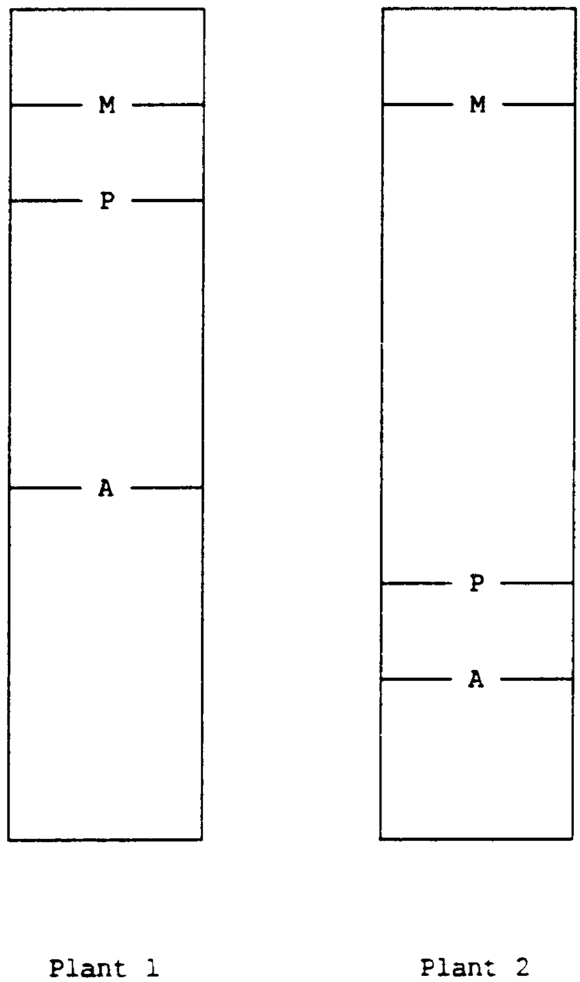
scrap, product mix, downtime, etc. "Peak capacity" is the level at which the plant can run for short periods of time, and is usually achieved through delayed maintenance and extended workforce overtime. Peak capacity is usually less than "rated" capacity, but more than "standard." The likelihood that all four capacity measures for a given production system would be identical is slight.

Figure 2.1

Full and Excess Capacity



which will be cited in this chapter recognizes these innuendos and qualifications with respect to the measurement of capacity. Such research must be viewed in the context that this variable (capacity) may be quite imprecise.

2.2 The Influence Of Technology And Plant Structure

To reiterate from the introduction, the primary assumption at this juncture is that the firm operates in an environment with no or inconsequential competitive effects. The aggregate capacity decision then largely revolves around characteristics of technology, the plant system, and demand.

The section is organized into two major subsections. The first subsection deals with the static capacity model (in the sense that the capacity decision is not time dependent). The key works reviewed here deal with capital utilization. The next subsection does recognize the dynamism involved in the capacity decision. Table 2.1 presents the "framework" which was used to organize the review, and recognizes the key author(s) which have cited the major influences listed.

2.21 The Static Capacity Model

The Marris (1964) study of British industry significantly changed the prevailing understanding of capital utilization. The idea which the author emphasized was that idleness of capital was in fact an *ex ante* economic variable. An optimal amount of idleness exists and depends on economic costs.

The relevant issues explored by Marris can be simply stated. First consider a business which operates a single plant under a single-shift

Table 2.1

The Influence of Technology and Plant Structure

	Factor	Key Author(s)
"Static"	"Rhythmic" Production Inputs	Marris (1964), Betancourt and Clague (1981)
	"Economies of Scale"	Betancourt and Clague (1981), Manne (1967), Gold (1982), Schmenner (1976), DeVany (1976)
	Capital Intensity	Marris (1964), Betancourt and Clague (1981)
"Dynamic"	"Lumpiness of Investment"	Scherer (1969), Esposito and Esposito (1974), Smith (1981)
	Process "Continuity"	Smith (1981)
	Multiple Plants	Manne (1967), Scherer *et al.* (1975), Smith (1981)
	Discount Rate	Manne (1967)

system. For a given level of output, a given level of capital input and labor can be specified. Assume, however, that the existing machines "wear out" and new ones must be purchased. The possibility of a two-shift operation is one of the alternatives that can be considered by the production manager. Instead of producing the entire output on a single shift, the same daily output can be produced with half on the first shift and half on the second shift.

The economic advantage involved here is relatively clear. Obviously, only half the amount of capital investment would be required for the two-shift operation.[6] The machinery is simply worked twice as long each day. This higher planned utilization means that a smaller capital stock is needed to produce a given output per unit time so that capital costs per unit of output fall with increasing utilization.

Marris explored reasons why the firm would not attempt to maximize utilization in this manner. His argument largely revolved around characteristics of the inputs to the production process. He focused on the fact that the price of labor, unlike capital, varies rhythmically (i.e. in a regular, predictable pattern). Labor prices are usually higher at nights and on weekends and holidays. These wage differentials are not insignificant. In the U.S., Saturday work usually receives a 50 percent premium, and a 100 percent premium is likewise accorded for Sundays. Night shift differentials are particularly large outside the U.S. Colombia, for example, has a legislated night premium of 50 percent (Winston, 1974). The impact of these differentials is straightforward. Since it is known that the price of the input will change predictably,

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[6]The assumption is also made that the rate of depreciation is not affected even though the machinery is worked twice as long each day.

the firm will produce its desired output with a "large" plant in order to take advantage of low input costs and then remain idle during periods of high input cost. In summary, even though higher utilization will lower average capital costs per unit, higher utilization will raise the average cost of the rhythmic input.[7]

Given this rhythmic quality of labor, Marris posited that three parameters would then determine the optimal utilization level. First and most obvious is the magnitude of the price "rhythms." The larger the relative cost of operating at different times, the greater the penalty resulting from high utilization *ceteris paribus*. The second determinant is the relative price of capital and labor. Simply, expensive capital will be economized by high utilization levels. Conversely, cheap capital enables the purchase of a larger capital stock. Third is the choice of production process - more specifically, the capital intensity of the process. Marris noted that these factors interact to determine the optimal policy. For example, a capital-intensive plant may optimally be used for only one shift if the price of capital is low.

To test these theories, the author collected data on the shift work

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[7]In his analysis, Marris concentrated on the rhythmic nature of labor prices due to weekend and night premiums. His observations can be generalized to other production inputs as well. For example, electricity is cheaper during off-peak periods (Winston, 1974). A more pervasive influence, however, is the rhythmic nature of some raw material inputs. Processes that use agricultural products will usually face prices that vary seasonally - that is, if the agricultural product is available at all. For example, many products in the canning industry have a season of approximately forty operating days or less. Ullman (1980, p. 100) notes that in 1964, peas had a canning season of 42 days, pears 39 days, peaches 29 days, and boysenberries 11 days. The seasons may have a different influence on industries such as lumbering or iron ore mining. In this case winter weather (specifically snow and cold weather) is likely to lower productivity and raise operating costs. The precise effect on "capacity" and "capacity utilization" in this case, however, is nebulous at best.

characteristics of British manufacturing industry as a part of the 1951 government Census of Production. The sample encompassed roughly 54,000 businesses with employment levels of more than ten persons. This data was supplemented with a series of case studies.

The sample was split into businesses which indicated that more than 35% of their total production employees were on shift work, and businesses with shift work employees with less than 35%. Averages and simple regressions using these two subsamples were then calculated and compared for a series of independent variables (e.g. earnings per employee). Marris concluded that the data tended to support his theory:

> Shift work will tend to be profitable, given the elasticity of utilisation, where the elasticity of mechanisation is high, where money wages are relatively low, or the price of the product relatively high (p.204).[8]

This framework offered by Marris should be particularly noted with respect to the treatment of production process. Production process is not a "given" - in numerous cases a ranges of choices are available with varying degrees of labor and capital intensity. Production process choice does in fact, however, appear to be substantially influenced by relative factor prices. If capital is cheap relative to labor, then capital intensive technologies are likely to be chosen (Hughes, 1983). The converse - that inexpensive labor will influence the adoption of labor intensive methods - appears to be sometimes true. Scherer *et al.* (1975, p. 134), for example, found that the tendency in low labor

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[8]Marris defines the elasticity of utilization as "the proportionate increase in the number of hours a unit of equipment is operated divided by the proportionate increase in the hourly labor cost per unit of output, in a given activity with a given technique." The elasticity of mechanization is "the proportionate increase in output per man-hour divided by the corresponding increase in capital per man when changing from a technique of lower mechanisation to a technique of higher mechanisation."

cost countries was for more people to tend machines (to decrease machine idle time and thus improve utilization) or less inclination to automate material handling, rather than a radical change in the core processes. Labor- and capital-intensive technologies may also simply not be interchangeable or substitutable - the product can only be made with a certain process. Here the production of light bulb jackets (the exterior glass shell) would serve as an example. This latter characteristic is probably most true for continuous processes (Hughes, 1983).

Factor substitution was explicity dealt with by Betancourt and Clague (1981). Of particular interest is this notion of "interchangeability" mentioned above - or, more formally, the "elasticity of substitution." For a high elasticity of factor substitution, the influence of the relative prices of capital and labor diminish until prices have virtually no effect at all. Consider the case of a plant which consists of two machines and two operators. Due to an increase in demand, management is considering either purchasing two additional machines, or operating the existing machines on two shifts. Because of a high expected shift differential, the economics of the two alternatives appear to be equivalent. In addition to these two basic alternatives, technology exists which would enable total automation of each machine through replacement of the operator (an elasticity of substitution of one). The implementation of the automation case can be economically justified for a single machine. Given this substitution alternative, now consider the initial attractiveness of a single shift versus two shifts. Two shifts make this capital-labor substitution all the more attractive. Capital is conserved since additional machines are not needed plus the shift differential is saved.

The authors noted an important implication of this point. Marris noted that high capital intensity will lead to shift work and high utilization. The example shows, however, that because of the phenomenon of substitution, the reverse causality may be true - that high utilization can lead to high capital intensity.

Betancourt and Clague also explicitly introduced the effect of "economies of scale" into the example. The notion is that some diseconomies may be associated with smaller-scale production (in this case, the two-machine, two-shift configuration). The "traditional" concept of economies of scale is that as the capacity of a plant or machine is increased, its total cost rises more slowly than its capacity. The mathematical form of this relation is $C=aK^b$, where C is total cost, K the capacity in units of output per unit of time, and a and b are constants. When economies of scale are present, b has to be less than one (typically ranging from .6 to .9) (Ullman, 1980, p. 5). In this case, increases in scale are considered as synonymous with increases in capacity.

In the example described previously, even though the <u>total</u> capacity of the two alternatives is equivalent, the single-shift case has a higher output per unit time. The supposed existence of such "economies," however, does not create any further understanding as to their source. A starting point for understanding these "sources" is Gold's (1955) definition of scale:

> . . . the scale of production may be defined as relating to the level of planned productive capacity which has determined the extent to which specialization has been applied in the subdivision of the component tasks of a unified operation (p. 115).

This definition means that while scale may be a function of capacity, scale may also be a function of degree of specialization of equipment, required labor tasks and skills, and the specification of purchased materials and components. The two sets of factors may tend to act in concert, but must be recognized as distinct. Progressively larger plants will thus become increasingly differentiated from small plants in product mix, factor proportions, capital cost structure, and operating flexibility - not just capacity (Gold, 1982). Boylan (1975, p. 2) notes that scale can also be impacted by concentrating more heavily on a reduced variety of products. Conversely, increases in plant capacity need not insure an increase in the scale of production.

Returning to the one shift-two shift example, an overhead structure can be added for illustration. Assume that a material handler is needed to receive shipments of purchased goods, move the items to the machines, and then retrieve the finished product to be shipped out. A material handler can service a maximum of four machines. For the one shift case, the material handler staffing meshes well with the design of the plant. The handler is neither over- or underutilized. However, two handlers are needed for the two-shift case. Furthermore, the handlers are both underutilized. The two-shift case thus incurs some significant diseconomies. The same argument can be used for maintenance or supervision. Schmenner (1976) terms this difference "economies of capacity" - the existence of overhead functions which result in proportionately lower unit cost performance for the larger plant.

Schmenner also identifies "process technology" as a source of economies. For example, assume that an alternative for the four-machine, one-shift case would exist in the form of a single large machine. Even if the machine required an equivalent number of operators, operating savings could be derived from probable lower power needs and less floor space requirements (and attendant occupancy costs such as heating, lighting, etc.). Quality control would be simplified, since one machine is now the focus, instead of four. Quality improvements would result in less scrap and rework, thus lowering product cost. Again, this alternative is not likely to be viable in the two-shift case, unless the factors described earlier in this section point to one shift as being the optimal utilization. This example is obviously related to the prior discussion of a "range of process choice." Even though labor and capital prices (the inputs) may influence process choice, the outputs of the different process choices and the overhead costs incurred may not be comparable. For some production operations, adequate manual methods may not exist to permit satisfactory control over quality and consistency. An example would be the automatic electronic testing of computer circuitry. Apple Computer's new Macintosh factory is reported to be one of the most automated factories in the industry. The primary reason for automation, however, is for quality control - not labor savings (Morrison, 1984).

DeVany (1976) developed a different argument for the advantage of capacity "economies of scale," however the advantage relates to customer waiting time, not cost. He argued that a rational consumer adopts a "stopping rule" in his search for a low waiting time. The consumer will only join those queues whose length is less than or equal to some "critical value," which in turn is dependent upon the "distribution of queue lengths, the value of time, the cost of search, and the availability of alternative suppliers."

Because customers will "balk" at long queues, the firm thus finds that its capacity will influence the effective demand for its product. DeVany suggested that economies of scale exist in the "production of waiting time" because any queue is more rapidly served for a given ratio of demand to capacity by a bigger plant. He provided a physical analogy to this relationship:

> One might consider a stream flowing into a pond. If we double the mean inflow and outflow of the pond, the average level of the pond will be unaffected, but the average time a unit of water is in the pond will be halved.

This means, then, that a large firm has a lower waiting time than a small firm when both utilize their capacity at equal intensity (the "economies of scale" notion).

DeVany cited the impact of these "economies" in the context of a hospital. He reasoned that the number of patients waiting for a hospital room will reach the "balking value" less frequently in the large hospital than in the small hospital. For this reason, the large hospital has a higher ratio of effective arrivals to beds than has the smaller hospital. The most important consequence, therefore, is that the occupancy rate of the larger facility is greater, and its share of the market will thus be greater than its share of beds. The author suggested that this result is quite general, and may be a reason why the share of the market captured by large airlines is <u>greater</u> than their share of flights (Douglas and Miller, 1973). A formal queueing model of this theory was developed, however the model was not tested empirically.

A similar notion was illustrated by Duesenberry (1958):

> Most oligopolistic industries tend to follow a long-run price policy and do not raise prices in periods when there is a sudden increase in utilization. It can sometimes happen, then, that some or all of the firms in an industry do not have enough physical capacity to meet demand. They can build up order books to a certain extent without fear of losing customers, but if the waiting period becomes very long, construction of new capacity becomes a competitive matter. If any one firm is willing to build additional capacity, other firms must do so also. Otherwise, the firm with the new capacity will serve some of their customers, so that they cannot get them back (p.131).

DeVany and Duesenberry thus both suggest that excess capacity can enable the firm to gain competitive advantage due to the enhanced service capability, less waiting time, etc. Two additional points concerning this theory, however, must be mentioned. First, DeVany's waiting time examples compare a large firm to a small firm, with both apparently selling a homogeneous product or service. It is unclear whether the excess capacity notion can be generalized to other situations, such as heterogeneous products or equal-sized firms. Second, the problem can be dynamic one in the sense that if the firm with excess capacity is able to attract a disproportionate share of demand, the excess capacity will soon disappear unless a compensating capacity increase appears at some point.

2.22 The Dynamic Capacity Model

Two implicit assumptions were made in the "static" capacity situation discussed in the previous section. First, demand is constant over the life of the plant, which means that capacity choice is a one-time decision. Second, total capacity for the firm is embodied in a single plant. This section will thus explore the impact of growth in demand over time and of multiple facilities.[9]

2.221 The Single Plant Firm

Manne (1967) modeled the planning of manufacturing investment in a series of heavy process industries in India. The modeling was undertaken with the assumption that future demand was known with certainty. Furthermore, unlike U.S. private enterprise, the industry studies were

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[9]Growth instability/uncertainty will be discussed in later sections.

part and parcel of an economy-wide planning process. Competitive interaction thus was not a part of the model.

The dynamic capacity problem can most easily be illustrated by reference to Figure 2.2. The figure shows a time path of demand and installed capacity. The sequence depicted is that capacity follows a "stair step" pattern. Furthermore, capacity never fails to satisfy demand (i.e. the installed capacity line never drops below the demand line). Therefore, new capacity is timed to come "on-stream" exactly as needed.

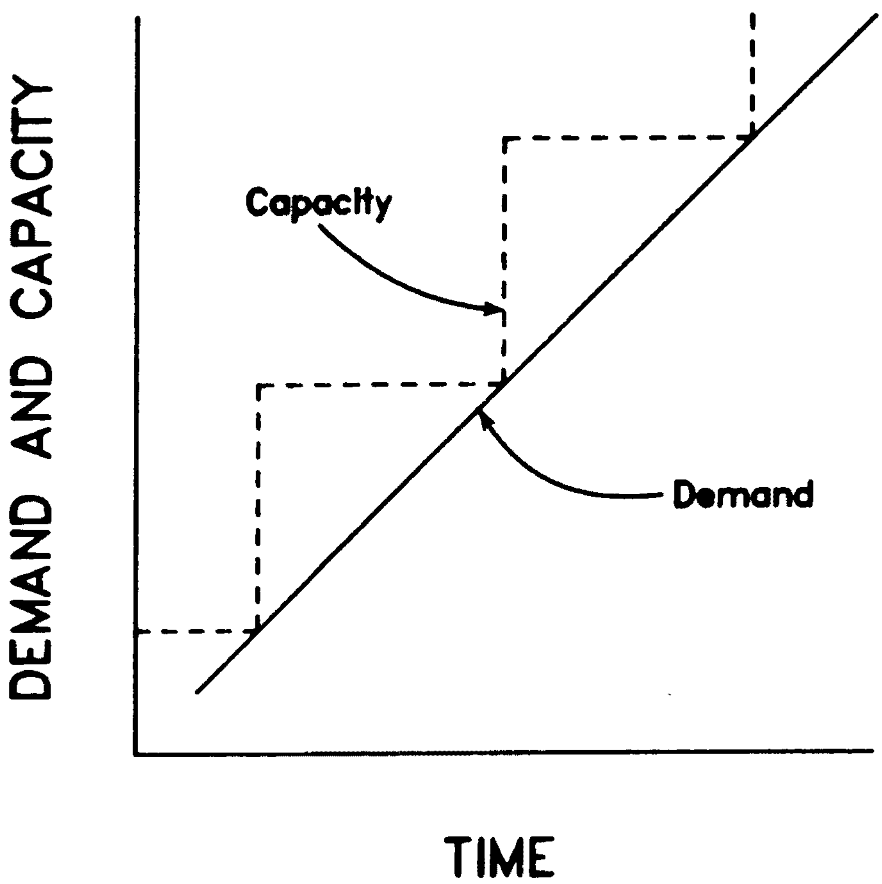
Of primary interest in the figure is excess capacity, which is represented by the vertical distance between the capacity and demand lines. Several observations can be readily made concerning this "vertical distance." First, excess capacity is a partial function of the size of the vertical "jumps" in capacity. Second, the amount of excess capacity at any point in time is also related to the slope of the demand line - the absolute growth rate. Even though large capacity increases may be made, the average excess capacity would be small if the growth rate is high.

The key, then, to understanding Manne's capacity/demand scenario is to explain how the size of the capacity increases is determined. In broad terms, the calculation involves a discounted cash flow which balances operating savings due to "economies of scale" against capital investment made in advance of its actual need:

> . . . time plays an essential role. The costs incurred at one point in time have an influence upon the costs incurred at other points. Under conditions of growing demand and economies of scale in plant construction, there will typically be a choice between several time streams of expenditure. If a single large plant is built, advantage can be taken of economies of scale in construction. Alternatively, if several smaller plants are built at different point of time, there is the advantage of delaying a portion of the total investment

Figure 2.2

Time Path of Demand and Capacity



outlays.

To summarize Manne's argument, the amount of excess capacity to add (for instance, at time 1 of Figure 2.2) is a function of the discount rate and an "economy of scale" factor. The lower the discount rate and the more significant the economies of scale, the more it will pay to build capacity ahead of demand. To reiterate the previous discussion, the "economy of scale" factor alluded to by Manne can be construed as a function of both the absolute size of capacity and the process technology. The discount rate and "scale factor" will interact with the demand growth rate to determine the optimal expansion policy.

Manne did not undertake any hypothesis testing. Instead, capacity expansion models were developed for four process industries (aluminum, caustic soda, cement, and nitrogeneous fertilizer). The model output consisted of the optimal size and timing of plant capacity expansion and, where appropriate, the location of such an expansion. The results were then compared with the proposals submitted for the Fourth Plan (the Indian five-year planning exercise). In general, the results suggested that the government planned to build <u>larger</u> plants than would be optimal.

A few empirical results can be cited to lend additional support for the importance of these factors. The size of the capacity increase "steps" in Figure 2.2 has been termed "lumpiness of investment" by several authors (Scherer, 1969; Esposito and Esposito, 1974; Smith, 1981). Such "lumpiness" has been described as both capital intensity and process "continuity":

> Since investment is likely to be "lumpier" in capital intensive industries, capital stock may be increased by an amount greater than that required by a permanent increase in demand. It may also be more difficult to reduce capital stock quickly, or by the ap-

> propriate amount, when demand declines (Esposito and Esposito, p. 191).
>
> Continuity of the production process is another indication of lumpiness and inflexibility of expansion decisions. Contrast the difficulty of increasing the capacity of an existing oil refinery to that of expanding a pharmaceutical plant (Smith, p. 10).

Both authors hypothesized that a positive relationship would exist between the investment characteristics of the process and excess capacity. Again, by inspection of Figure 2.2, this statement is logical.[10] The problem of "lumpiness" of investment can also be compounded when planning and construction lead times are lengthy. Paper mills, for example, take five to seven years to build (Rothschild, 1979, p. 105). Long lead times thus increase the penalty to the firm that is left behind without capacity. Smith also hypothesized that the value of investment in excess capacity would increase as the construction lead time for a plant increased (a positive relationship).

Smith obtained positive and significant coefficients for both the "process continuity" and "construction lead time" independent variables. Esposito and Esposito, however, obtained a significant <u>negative</u> result. This discrepancy can be resolved if <u>investment</u> properties are distinguished from <u>operating</u> characteristics. Once the "large chunk" of investment is made, a great deal of excess capacity is generated. The cost structure of the firm (the ratio of fixed to variable costs) is likely to increase. The net result is that a tremendous incentive exists to utilize the excess capacity, even to the extent that manufacturers may cut prices to increase demand rather than incur excess

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[10]The Smith and Esposito and Esposito assertions are consistent if continuous process plants are more capital intensive than other process technology types, however this relationship has not been explicitly tested.

capacity, or even choose to live with insufficient capacity:

> In capital intensive industries the cost of excess capacity may be very large and the unit contribution margin fairly small. . . the firm might choose to err on the side of insufficient capacity. . .(Wheelwright, 1979, p. 3)

The experience of McLouth Steel, which went into Chapter 11 in 1981, is indicative of this dilemma (Chavez, 1981):

> . . . Analysts said McLouth was caught with an automated and efficient process of steelmaking that became expensive to operate when its mills were not running at full capacity. . . the equipment was not efficient running at half speed, and could not be scaled down easily. . . the equipment made McLouth less flexible and its operating costs spiraled as its orders ebbed (p. D1).

In summary, while the "lumpiness" notion may create wide variance in capacity investment, countervailing pressures exist for that capacity to be fully utilized once it is installed.[11]

2.222 The Multiple-Plant Firm

Manne extended the single plant model discussed above to incorporate the multiple plant situation. The tendency for firms to develop and manage a system of plants appears to be quite strong. Miller (1978) reports that of 450 industries surveyed (at the four-digit SIC level) the top four companies in 364 cases averaged two or more plants per firm. In only two industries (fur goods and wood kitchen cabinets) did all firms choose to concentrate all of their manufacturing at a single location.

The notion can be posed that if a business consolidated all of its manufacturing facilities at a single location, some substantial

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[11]To support this summary, Scherer (1969) found a positive relationship between capital intensity and investment instability (the "lumpiness" idea), while Caves and Porter (1978) found a negative relationship between capital intensity and share instability.

economies would result. First, existing real estate could be used (assuming sufficient space was available); the support staffs and overhead would be proportionately less; the consolidation of production (and thus higher volume) might allow the use of more cost- and capital-efficient production processes; and training of a new workforce might be largely avoided along with other start-up costs. The "centralization" of production would also allow the business to avoid costs - such as the search for new plant sites, and the coordination of plant operations (e.g. the establishment of a managerial information and control system).

The previously-stated preference for businesses to operate a multi-plant system portends that some significant offsetting influences must be at work. The most obvious factor is transportation cost (Scherer *et al.*, 1975, p. 235). Spatial characteristics of an industry come into play as the unit transport costs per dollar of product value increase. The classic case is cement, which is produced with a highly capital intensive process. Substantial economy of scale benefits accrue from operating a large cement plant. Typical industries impacted other than cement are petroleum refining and glass bottles.

Given multiple market areas, Manne proposed two different scenarios for serving this demand (Tables 2.2 and 2.3). The base case consists of two market areas which each have current demand of 10,000 units per year which is growing at an annual rate of 10,000 units. Assume a minimum efficient plant size of 40,000 annual output.

The first scenario (Table 2.2) consists of putting one plant in each of the two market areas. A large amount of excess capacity is initially created in both areas simultaneously. The excess capacity is gradually decreased until a second plant is needed in both areas in year

Table 2.2

Multiple Market Area Expansion - Scenario 1

Time	Area 1				Area 2		
	Capacity	Demand	Shipments	Excess Capacity	Capacity	Demand	Excess Capacity
0	40	10	--	30	40	10	30
1	40	20	--	20	40	20	20
2	40	30	--	10	40	30	10
3	40	40	--	--	40	40	--
4	80	50	--	30	80	50	30

4. Despite the large amounts of excess capacity created, it is possible to eliminate any shipment of product between the two areas.

The second scenario (Table 2.3) differs from the first in that shipment of the product between the areas is allowed. Only one plant is initially built which then serves both market areas. A second plant is not built until year 2, and at this point no shipment is required. The "cycle" repeats starting in year 4, with the third plant being built and shipments again being made to the second market area. Scherer *et al.* (1975, p. 44) term this investment pattern the "whipsaw" effect of multiple plants.

A comparison of Manne's two scenarios indicates that the first case incurs significantly more excess capacity. Implicitly, this scenario would be preferred if transportation cost savings outweigh the cost of carrying the excess capacity.[12]

Smith (1981) investigated the effect of multiple plants on excess capacity. From Table 2.3, the "whipsawing" of expansion between plants can result in lower excess capacity - through the ability to finely adjust the overall capacity of the plant system. For example, in the case of a downturn in demand, "blocks" of capacity (the individual plants) can be closed. This practice is common in the recreational vehicle industry, where most of the competitors operate a large number of small

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[12]In reality, however, it appears that neither scenario may be followed, such as in the cement industry. Two factors contribute to this difference. First, growth may not be as rapid as is illustrated. The effect of slower growth would be a tendency to minimize the excess capacity carried. The second factor is that plants smaller than the minimum efficient scale are feasible, however a cost penalty will be incurred. Rather than sizing a plant at minimum efficient scale, the cement plant will instead be built in direct relation to the size of local demand, and thus the likelihood of plants at less than MES (Norman, 1979).

Table 2.3

Multiple Market Area Expansion - Scenario 2

Time	Area 1				Area 2		
	Capacity	Demand	Shipments	Excess Capacity	Capacity	Demand	Excess Capacity
0	40	10	10	20	--	10	--
1	40	20	20	--	--	20	--
2	40	30	--	10	40	30	10
3	40	40	--	--	40	40	--
4	80	50	10	20	40	50	--

plants (Lovdal, 1974). Smith found a significant confirming result to this hypothesis, which is consistent with the findings of Scherer *et al.* (1975, p. 281).

2.23 Summary

The capacity decision at this point can be related to characteristics of the inputs to the production process (the "rhythmic" nature of prices and availability, relative prices), the range of choice in selecting a production process (e.g. the elasticity of factor substitution), economies associated with the choice of a given capacity, spatial considerations (transportation cost), and demand (to be dealt with more explicitly in the following section). The relationship among these elements is complex, particularly in the choice of process. The capacity "solution," however, is not static - meeting future growth may necessitate building such capacity ahead of demand.

2.3 Industry Influences On Capacity

The assumptions of the prior section are discarded here. The broad influences of demand, innovation, and the oligopolistic tendencies of the industry on capacity will be reviewed. The bulk of the review will focus on four different works - Esposito and Esposito (1974), Smith (1981), Caves and Porter (1978), and Scherer (1969). None of these references deals explicitly with causes of excess capacity. The first citation examines chronic excess capacity, which is slightly different than excess capacity. The latter three references address the relationship between market structure and strategic investment, market share instability, and investment instability. Parallels, however, exist in the phenomena which these authors have argued.

The first subsection will review these four works. The following four subsections will briefly examine demand uncertainty, cost reduction, excess capacity as an entry barrier, and the influence of the product life cycle. Table 2.4 summarizes the key industry effects cited in this review. No attempt has been made in the table to "sort out" or represent the interdependencies between these factors (e.g. industry type and demand characteristics, or the effect of the product life cycle). This task is deferred to Chapter III.

2.31 Review Of Key Research

2.311 Esposito And Esposito

The only research which has explicitly investigated the industry effect on capacity was conducted by Esposito and Esposito (1974). The authors studied the degree to which industries experience chronic excess capacity. Chronic excess capacity is defined by Bain (1956, p. 190) as a tendency toward redundant capacity at times of maximum or peak demand. The primary industry variables which the authors used to explain excess capacity are industry concentration, growth, and the industry type (producer or consumer goods).

Esposito and Esposito hypothesized that industry concentration would influence aggregate capacity. The authors cite separate arguments for tight oligopolies, partial oligopolies, and atomistic industries:

> High seller concentration, high barriers to entry and an insignificant competitive fringe characterize tight oligopolistic markets. Under these conditions the probability of collective action is very high. If cartel-like behavior is followed, one expects a rather smooth adjustment toward the new long-run equilibrium capacity level given a permanent increase in demand. Capital is fully utilized much in the same manner as in monopolies. . .

Table 2.4

Industry Capacity Influences

	Factor	Author				
		Esposito & Esposito	Smith	Caves & Porter	Scherer	Others
"Competition"	Seller Concentration	X	X	X	X	
	Entry/Exit			X		
	- Entry Barriers					Spence (1977) and others
	Imports			X		
"Demand"	Long-Term Growth	X	X	X		
	Variability/Stability		X	X	X	
	Exports			X		
	Industry Type	X			X	
	Uncertainty					
	- Innovation		X	X		
	- Number of Customers					Porter and Spence (1978)

Industry Capacity Influences
(continued)

Factor	Author				
	Esposito & Esposito	Smith	Caves & Porter	Scherer	Others
- Substitution					Porter and Spence (1978), Harrigan (1980)
<u>"Cost Reduction"</u>					Nabseth and Ray (1974) and others
<u>"Product Life Cycle"</u>			X		Smallwood (1973), Anderson and Zeithaml (1984)

> . . . Excess capacity may result in partial oligopolies because of the behavior of either the largest firms or the competitive fringe. Given a permanent increase in demand, excess capacity may arise if the largest firms fail to act collectively and attempts by ambitious oligopolists to increase their market share are unsuccessful. Given the lower seller concentration, this outcome is more likely in partial rather than tight oligopolies. . .
>
> . . . (in atomistic industries) increases in industry demand are likely to be reflected in disproportionate increases in sales for all firms. One expects some firms to expand their capacity significantly, some very little, and some not at all. In such cases, actual aggregate increases in industry capacity may approximate the correct adjustment to the increase in industry demand.

In summary, partial oligopolies were expected to generate significantly more excess capacity than either tight oligopolies or atomistic industries. Tight oligopolies are expected to act "collectively;" atomistic industries will adjust capacity in proportion to changes in their own sales. In both cases industry market shares will tend to be preserved, thus tending to lend an element of "stability" to the capacity decision.

Second, the authors expected market growth to exhibit a negative influence on excess capacity. No supporting explanation was given for this expectation. However, inspection of Figure 2.2 would again argue that the higher demand (the steeper the slope of the demand line), leads to less average excess capacity *ceteris paribus*.

The authors also hypothesized that a systematic difference in aggregate capacity policy exists between producer goods and consumer goods industries, with producer goods industries tending to incur excess capacity. The major reason offered for this distinction is:

> . . . consumers tend to be loyal to their usual brands and either postpone consumption until their preferred brand is available or switch back easily once their preferred brand reappears on the market. Producer goods firms on the other hand, may permanently lose customers should they be unable to supply them because of increases in demand (p. 191).

The fundamental reasons for any difference which exists between producer and consumer goods industries are suspected to be frequency of purchase coupled with the cyclical nature of demand for many goods. Manufacturers may be more likely to maintain excess capacity if purchases by customers are made infrequently, as is the case for numerous capital goods (machine tools or construction equipment) or consumer durables (automobiles). Typically what occurs in such industries is that demand experiences large cyclical swings. The tendency for competitors would be to maintain capacity in excess of average demand to enable the holding or gaining of market share in peak periods. Second, customers might be unwilling to live with long delivery times, and may seek manufacturers with more available capacity - and hence shorter delivery. This phenomenon has occurred several times with the introduction of new IBM mainframes. Backlogs have become so lengthy that customers are often persuaded to buy elsewhere.[13]

Multiple regression was used to analyze the stated relationships. The measure of excess capacity was derived from McGraw-Hill data on preferred and average operating rates for 35 three-digit SIC industries during the period 1962-66. A trichotomous dummy variable was used for seller concentration. Tight oligopolies were considered to have a four-firm concentration ratio of 70 or greater, partial oligopolies a four-firm ratio of 40 to 69, and atomistic industries a four-firm ratio of less than 40. A dummy variable was also used to distinguish between producer and consumer industries.

The authors found that partial oligopolies experienced significantly more chronic excess capacity than do tight oligopolies or atomistic

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[13]This argument was also developed in 2.221.

industries, and thus "tend to misallocate resources to a greater extent." No significant difference was found between the tight oligopolies and atomistic industries.[14] As expected, high growth resulted in less excess capacity, and the producer goods industries experienced significantly more excess capacity than consumer goods industries.

Although this research provides some broad insights into utilization influences, a few reservations are raised about the research design. The identification of chronic excess capacity can probably only be accomplished by a careful analysis of the dynamics between utilization and the occurrence of peak demand (rather than using aggregated data). A much longer time frame would probably also be needed, such as 10-15 years. As a consequence, what was most likely examined was simply market influences on capacity utilization, instead of on chronic excess capacity. Second, McGraw-Hill data assumes that within each industry the definition of capacity is similar. The likelihood is high, however, that this definition will vary from industry to industry.

2.312 Smith

Smith's (1981) research is derived from the notion that many aspects of industry behavior appear to be inconsistent with short-run profit maximization - for example, firms may operate well below capacity for extended periods. Capital investment is thus made far in advance of actual need, and such investment can be construed as strategic in na-

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[14]The ability of tight oligopolies to make more orderly capacity adjustment than partial oligopolies was corroborated by Mann, Meehan, and Ramsey (1979), although their research found no difference between partial oligopolies and atomistic industries.

ture. The author attempted to identify factors which should contribute to predicting whether such an investment will be made. A key notion introduced was supply coordination failure. Supply coordination failure is simply that planned aggregate supply is wrong due to forecast errors of competitors' capacity investments. Smith observed that the greater the expected loss in the event of supply coordination failure, the greater should be the degree of concern about competitors' investments and the greater should be the value of strategic investment for supply coordination. In other words, "high concern" would translate into a willingness to invest in excess capacity; "low concern" would have the opposite effect.[15]

Smith identified five industry-level variables which would affect the degree of concern a firm would have about the investments of its competitors. The first variable was industry concentration:

> Clearly, as the number of firms in the industry declines the potential number of simultaneous investors also falls. In addition, the cost of learning about competitors' investments is less since there are fewer competitors to keep track of. Thus concentration should reduce the expected cost of coordination failure.

Concentration is therefore hypothesized to lead to less need for strategic investment, i.e. less need for excess capacity. The notion of "learning about competitors' investments" is an important one. A central focus of the research of Porter and Spence (1978) was the importance of competitor analysis in predicting a pattern of industry expansion. Making such an analysis is a formidable task - even in a stable industry such as corn wet milling which consists of approximately a dozen firms. The ability to gather such information and make implica-

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[15]Smith (1981) also examined non-capacity investments, such as for innovation.

tions about competitive behavior becomes more difficult, if not impossible, in a more fragmented industry.

Second, high industry growth was hypothesized to result in a higher likelihood of incurring excess capacity (i.e. strategic investment):

> . . . the cost of coordination failure will tend to be higher for industries that are growing relatively slowly as compared to those growing rapidly. If growth is slow a coordination failure resulting in excess capacity could depress industry profitability for several years instead of several months, as might be the case if growth were more rapid (p. 8).

The cost of "overshooting" is thus low during high demand periods. Porter (1980) provides similar reasoning for preemptive capacity addition:

> With known future demand, firms will race to get capacity on stream to supply that demand. . . The rationale is that the firm will lose more by being caught with insufficient capacity in a growth market than it will by having built too much (p. 324).

Smith's third industry-level influence was demand stability. He reasoned that the likelihood of coordination failure is lessened if firms adopt simple rules for investment, such as trying to maintain a stable market share:

> Such rules are more plausible if the rate of industry growth is stable. Hence, concern should decline as the stability of the growth rate rises.

The fourth and fifth influences related to industry characteristics which would contribute to such growth instability. Smith specifically identified innovation ("the prevalence of product and process innovations") as contributing to such instability. Concern with competitors' actions would therefore be higher the more the pattern of actual growth depends on successful product or process innovations; i.e. excess capacity is more likely.

The data to test Smith's hypotheses was gathered through a survey of 167 corporate planning directors in 45 four-digit SIC industries in the United States. Information collected in the survey included descriptive industry data as well as information related to concern with expansion and innovation activities of competitors. The survey responses were used to construct an "index of concern" which was intended to reflect the magnitude of the supply coordination problem. The index was constructed by summing the numerical responses to twelve individual "concern factors" from the survey. The "concern factors" were developed by presenting each respondent with statements which required an indication of agreement on a five-point scale ("Strongly Agree" to "Strongly Disagree"). An example of such a statement is:

> Competitors' expansion plans are very important for major capacity expansion plans of firms in this industry.

OLS regression of the index of concern on industry descriptive data was then performed.

Four of the five industry-level variables described here were all correctly signed and significant at the .05 level (the exception was market growth rate). While the results are intuitively appealing, the nature of the methodology used (albeit unique and innovative in its own right) raises numerous questions. Surveying corporate planning directors, for instance, is not as desirable as directly contacting a division general manager. Furthermore, it would be difficult to tell if the response of a corporate manager was given with a particular business or product in mind, or was merely an espousal of "corporate philosophy." While the "index of concern" might indicate elements which will tend to influence decision making, a corroborating objective measure of the dependent variable would have been beneficial (such as actual investment or capacity expansion which has occurred).

2.313 Caves And Porter

The third study deals with the relationship between market structure and market share instability (Caves and Porter, 1978). The linkage between share instability and excess capacity is a simple one. Capacity share and market share are strongly and positively associated; in fact, capacity share practically limits attainable market share.[14] The numerical association between the two measures is capacity utilization. If all competitors are assumed to have the same capacity utilization, then capacity share will equal market share. Capacity share, however, entails "fixed factors" and "irreversible investment" (at least in the short term). As the authors noted, share instability will thus likely reduce capacity utilization. To summarize, the reason behind citing this research is that factors which influence share instability should also lead to excess capacity, *ceteris paribus*.

The authors identified three "families" of structural influences on share instability. The first source is exogeneous disturbances that upset share equilibrium. Such disturbances can be largely attributed to demand or cost shifts (e.g. cyclical demand variation, cost inflation, entry of new competitors, or innovation). The second category is related to technological elements which curb market share instability (e.g. the speed with which capacity can be adjusted). Last, the extent to which any disturbance affects market behavior in turn depends on the stability of the oligopolistic consensus. The authors expected instability to increase as collusion becomes less effective. The follow-

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[14]Market share could conceivably exceed capacity share in two cases - where capacity utilization is greater than 100%, or where the firm supplements its own capacity with a significant amount of purchases of finished product.

ing factors thus can be related to one of these three categories.[17]

The first exogeneous "disturbance" is variation in overall demand:

> Instability of demand puts an incomplete oligopolistic consensus to the test by changing the joint profit-maximizing values of price and other variables. These changes require adjustment of the consensus and create incentives for defection during the adjustment process.

The authors represented demand variation as the average absolute value of percentage deviations from a regression of annual industry shipments on time.

The long-term growth rate of the industry was the second factor considered. The authors regarded the effect of growth as indeterminate. The reasoning was that rapid growth could "destabilize an established consensus by promoting competitive capacity additions" - thus a positive relationship to instability. Conversely, high growth could remove all "practical recognition of mutual dependence where concentration is not too high and market opportunities tend to run ahead of firms' abilities to keep up with them."

Third, a "disturbance" could be created by the entry or exit of a major competitor. In this case share will obviously change if for no other reason than an arithmetic one - combined shares of ongoing competitors will be adjusted by the share of the entering or exiting firm. Caves and Porter also noted that the oligopolistic consensus is likely to be disturbed by entry and exit.

A similar notion is the effect of imports. Imports "inject into the domestic market a set of competitors not counted in conventional measures of seller concentration." The competitiveness of the market is likely increased, as imports tend to reduce the completeness of collu-

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[17]The factors concerning technology were mostly discussed in 2.2.

sion among the domestic firms.

Last among the exogeneous disturbances is innovation. Innovation creates share instability in the sense that cost or output can be improved (as a result of process innovation), or the preferences of consumers may be shifted among the various product offerings (product innovation). The authors used process R & D and product R & D (both as a percentage of net sales) as the "innovation" independent variables.

The first of the variables which indicate the likelihood of oligopolistic behavior is seller concentration. Caves and Porter suggested a non-linear effect of concentration on share instability comparable to the effect posited by Esposito and Esposito (1974):

> Concentration high enough to achieve essentially complete joint-maximizing collusion should reduce instability from the level prevailing with incomplete collusion or collusive agreements subject to breakdown. On the other hand, shares cannot be destabilized by weak agreements, where no agreements exist, or where agreements are incomplete and dc not coverall variables affecting shares. Therefore we expect a non-linear relation with instability rising and then falling as concentration increases from very low to very high levels.

Last, the ability of the firm to export output should also provide a measure of stability. The rationale is that interdependence with foreign producers is less likely to be recognized than among domestic producers. The net effect is that the oligopoly may have an incentive to attenuate disturbances to the domestic market by varying foreign sales.

Caves and Porter used the PIMS project data base for the analysis. Since the data base will be used for this research, a discussion of its strengths and weaknesses will be deferred until Chapter IV. Two different dependent variables were employed - relative share instability (the absolute value of the annual percentage point change of share for each of the four largest competitors) and absolute share instability (absolute changes are summed without division by the initial share). The time period for the data was 1970-73. Observations were excluded in which the market contained four or fewer competitors; a total of 470 manufacturing businesses were left.

Ordinary least squares regression was the analytical method used. The two different dependent variables yielded approximately the same statistical conclusions. Regressions were run for the entire sample, and then for various subsamples (e.g. low, medium, and high concentration). For the sake of brevity, the results reported here will mostly be for the entire sample.

In general, all of the influences on share instability noted in this section were significant and of the expected sign. The exceptions were the dummy variable used for exits from the industry (expected sign, but insignificant) and process R & D (incorrect sign and insignificant). For the entire sample, the concentration variable was negative and highly significant (i.e. high concentration reduces share instability). However, upon examination of the low, medium, and high concentration subsamples, the authors concluded that the true relation swings from positive to negative as concentration increases. The hypothesized nonlinearity was thus confirmed. The growth variable was positive and significant at the 10% level for the absolute measure of share instability. Opposing signs for growth, however, were obtained for the medium (negative) and high (positive) concentration subsamples, which was consistent with the authors' suspicions.

Use of the PIMS data base obviously assisted this research through the scope of variables collected. One major assumption is made concerning the use of this data for industry analysis. A number of the variables pertain only to the reporting business (e.g. the R & D variables), where ideally variables which characterize all competitors in the industry are desired. Reporting businesses are therefore assumed to be "typical" of or comparable to the competition. At least for some variables, then, the industry is assumed to be homogeneous.

2.314 Scherer

The last work to be reviewed in this section is Scherer's (1969) empirical analysis of the relationship between market structure and investment instability. Again, a linkage between investment and capacity can be drawn - manufacturing assets are likely to be the most frequent recipient of investment dollars. Of course, it must be recognized that significant investment can occur for non-manufacturing assets (e.g. a new headquarters, diversifying investments, etc.). Furthermore, investment can be intended for new capacity or to simply replace outmoded high cost capacity. Investment thus may not result in an overall change in capacity. Conversely, capacity change, such as through "debottlenecking" of the production process, can be made at minimal investment.[18] Despite these differences, Scherer's results are nonetheless instructive.

Scherer focused on whether investment was more stable in con-

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[18]To illustrate "debottlenecking," consider a simple three station production process, each being a stand-alone machine. Station 1 is capable of 60 units per day, Station 2 50 units per day, and Station 3 75 units per day. Assuming that all three machines work at equal number of hours per day, the capacity of the total process is 50 units per day - the capacity of the "bottleneck," Station 2. However, if Station 2 is increased to 65 units per day through replacement by a new, larger machine, total capacity is now increased to 60 units per day.

centrated or in atomistically structured manufacturing industries, *ceteris paribus*. The author offered arguments on both sides of the issue. The rationale behind the oligopolist being less prone to overreacting to demand shifts has been discussed previously in this section, and will not be repeated here.

The case for overinvesting in an oligopoly, however, is of primary interest. Scherer first posited that the oligopolist may fear losing market share and future profits to more aggressive competitors when demand is growing. The tendency would be to invest heavily and then cut back sharply when serious excess capacity appeared. Second, Scherer noted that concentrated industries would generally have higher profits and cash flow, and are consequently better able to finance an investment program. Increases in demand would therefore be met with a sharper acceleration of investment.

Because of this indeterminacy, the sign of the expected effect on investment stability was not specified. Unlike the other research described here, Scherer did not use dummy variables or subsamples to develop a better understanding of the effect of seller concentration. Instead, a simple unadjusted four-firm concentration ratio was used.

The author also introduced several additional independent variables which were expected to impact investment variability. First, Scherer expected investment to vary positively as a function of demand variability. The factor was measured using the standard error derived after regressing the logarithm of annual production worker man-hours on a time trend. Sales was not used because it was reasoned that this measure would be more strongly impacted by "differences in pricing behavior associated with market structure."

Second, a complementary approach to incorporating demand variability was introduced using dichotomous dummy variables to reflect the demand characteristics of different products. Durable goods industries (as contrasted to nondurable goods) were expected to exhibit a positive relationship with investment variability, primarily because the demand for durable goods is "notoriously unstable." Consumer goods industries were expected to be more stable than commodity industries. Last, the effect of intermediate goods (e.g. steel, flour, cement) (as contrasted to commodities sold as end items) was "not obvious on *a priori* grounds."

To test these relationships, a sample of 80 four-digit maufacturing industries was gathered. The source for the data was the Biennial Census and Annual Survey of Manufactures. The time period used to derive the stability variables (investment, man-hours) was 1954 to 1963. Other continuous variables used for the most part a simple average over the same time period (e.g. seller concentration).

The results generated by the OLS regression generally supported the hypotheses. Concentration was positive and significant at the 10% level. The variable for demand variability was positive and significant. The dummy variables for durable, consumer, and intermediate goods were all positive, and, with the exception of consumer goods, were also significant. Scherer tested for nonlinearity by introducing a squared concentration term, however this change resulted in only a small and statistically insignificant incremental increase in R^2.

With the exception of concentration, Scherer's results are consistent with the other three empirical studies reviewed in this section. Whether this sole difference can be attributed to the sample, the properties of the measure, or misspecification of the model due to omitted variables cannot be ascertained.

2.32 Uncertainty

Variability and/or uncertainty impact aggregate capacity policy in the sense that management obviously will have more confidence in committing to manufacturing assets if forecasts of demand can be made with confidence. The distinction between variability and uncertainty is subtle, yet important. Variability can be viewed in this research as an anticipated variance from a long-term growth trend. In this sense, variability can be loosely equated to seasonality and cyclicality.

Uncertainty, however, can be likened to highly unknown long-term industry growth and/or competitive actions. Curiously, Porter and Spence (1978) have treated uncertainty as a "stabilizing and leveling force in the capacity expansion process." High uncertainty will likely cause even the more risk averse firms to limit investment (if an investment is made at all), irrespective of the expected return:

> Unless firms are lacking aversion to risk and can bear significant drains on cash, uncertainty will cause them to prefer and to choose lower levels of investment in the market. (p. 33)

However, under conditions involving lower uncertainty, the authors posited that preemptive investment (limited only by the financial resources available to the firm) is the most desirable action.

The crux of the problem here is to understand the determinants of "uncertainty." Few clues exist. To reiterate a finding of Smith (1981), a significant relationship was found between a willingness to make a strategic investment and innovation. A possible interpretation of this result is that if investment is not made, potential returns may be sacrificed entirely. The consequence is that "he who hesitates misses the market," which can be heightened as the product life cycle shortens. This phenomenon, for example, is evident in the microcomputer market (Fraker, 1984):

> The microcomputer was almost unheard of seven years ago. The first commercially successful machine could process only eight bits of information at a time - a bit being a one or a zero in binary code. But no sooner did the eight-bit micro come to market in 1977 than the 16-bit micro was on its way in 1981, followed by the 32-bit in 1983 (p. 62).

A second way of viewing uncertainty is through the ability of management to forecast how much demand would be anticipated. Accurate forecasting obviously eases the capacity decision. Demand uncertainty should be lessened the fewer the number of customers (Porter and Spence, 1978). The simplest case would be the business which has only one customer - for the sake of example, a can manufacturer which has one plant located next to its only customer (a brewery). "Demand forecasting" simply consists of obtaining a copy of the brewery production schedule. Of course, uncertainty will also exist in the brewery schedule, however the can manufacturer would usually achieve some protection through contractual mechanisms.

Forecasting may also be somewhat easier for substitute products. Harrigan (1980, p. 373) found that declining demand which resulted from technological substitutes (such as receiving tubes) was relatively easier to forecast than declining demand due to demographic (baby food) or cultural changes (cigars). The converse is expected to be true - that forecasting is also simplified for the manufacturer of the new substitute product (in this case, transistors). The reasoning is that at the minimum a benchmark for the overall size of the market may have already been established by the older product. The forecasting task then becomes one of projecting substitution rates of the new product for the old and market shares of the key competitors. Porter and Spence (1978) found this to be the case in the introduction of high fructose corn syrup (a sugar substitute) by the corn wet milling industry. Although in the relative sense the forecasting task may be simpler for substitutes, it still must be recognized that in the absolute sense any technological change is still highly uncertain.

2.33 Cost Reduction

The implicit "driving force" which has stimulated capacity investment in the discussion to this point is demand (i.e. the "accelerator principle"). Capacity investment and expansion, however, can be motivated by a need to reduce cost. This phenomenon is summarized by the vintage growth model of investment:

> New technology is assumed to be embodied in new capital equipment and so gross investment is the vehicle of diffusion. Old equipment is only replaced or scrapped when its operating costs exceed the rents it earns. It is usually assumed, for analytical convenience, that plant is indivisible and that new technology cannot be introduced on old equipment. . . The appearance of a cost-saving process innovation, within this framework, will have the following consequences. It will become profitable to immediately replace some proportion of existing equipment because the total costs of the new equipment are lower than the operating costs of some old equipment. . . Some of the more efficient old technology equipment will still remain, its operating costs being lower than total costs of the new innovation. This equipment will gradually be replaced over the years, given a favorable movement in factor prices and improvements in later vintages of the new innovation (Davies, 1979, p. 29).

Such investment can result in capacity expansion at either the plant or the plant system level. At the plant level, process change can serve a dual purpose of cost reduction and capacity addition. Nabseth and Ray (1974) summarized the results from their study on the diffusion of new industrial processes:

> One major conclusion from the case studies is that introducing new processes very often increases capacity. . . in contrast with the accelerator principle, whereby the investment in new plant is decided by an actual or expected change in demand, here new investment entails additional capacity, and the question is whether, by price reduction or other means, the firm can dispose profitably of the extra output (p. 306).

Capacity increase can thus result as a by-product of newer, more efficient processes.[19] The net effect is largely consistent with the previous analysis. The change has in all likelihood changed the scale of the process, which could justify the carrying of excess capacity. The causality in this case, though, is obviously different.

The plant system will also undergo changes which are motivated by opportunities to reduce cost. As the plant system evolves, new plants are added and older, less efficient capacity is closed or maintained as a "spare." In his study of the tire industry, Dick (1980) found that the tire companies tended to build new automated tire plants outside the Akron area as a result of the increase of labor relative to capital. For example, in 1969 Goodyear announced investments for new plant capacity at Gadsden, Alabama; Fayetteville, N.C.; Union City, Tenn.; and Lawton, Okla. Once the new plants were built, older plants in Akron, Los Angeles, and Mansfield, Ohio were closed. This pattern of replacement - one of expansion of a multi-plant system, then closing of higher cost facilities - can be observed in other firms. For example, Clark Equipment is phasing out three of its eleven North American plants,

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[19]For other examples, see Davies (1979); Gold, Pierce, and Rosegger (1970); Hollander (1965); and Lynn (1982). Gold *et al.* (1970) provide a particularly interesting illustration from the steel industry. Between the years 1950 and 1960, 39.6 million tons of open hearth capacity were added industry-wide. Of the total, 29.9 million tons were derived from the upgrading of existing furnaces through the addition of a new process (oxygen lancing).

while shifting the capacity to new facilities.[20]

This pattern of plant and capacity evolution is consistent with models developed by Abernathy (1978) and Hjalmarsson (1974). The Abernathy model, which is conceptual in nature, indicates that capacity is increased in the earlier stages of a business by simply adding plants ("paralleling of plants"). However, later capacity change occurs not only by a changing configuration and consolidation of the plant system, but also by making changes at the plant level ("breaking bottlenecks"). The "plant consolidation" phenomenon is consistent with Hjalmarsson's results. The smallest plants in the plant system continuously disappear and a size distribution results with fewer and somewhat larger plants.

The implication of this pattern is the relationship between capacity, capacity utilization, and cost. Capacity may increase in a "stepped" function as new plants are added, and an accompanying decrease in utilization will result. However, as old plants are then closed, total capacity will drop, but utilization will increase (the assumption is made that demand is constant). Unit costs will improve, however this improvement will be a function not only of better utilization, but closing of higher cost plants. Thus, as in the plant level example, cost reduction needs have resulted in a short-term change in capacity utilization.

The propensity of the business to pursue major change (new plants) or incremental improvements at the plant level is likely to be a function of overall costs trends and inflation. Leone and Meyer (1980) have noted that if the industry is in a declining cost situation (for ex-

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[20]See "A Survival Effort that Depends on Streamlining," Business Week, December 6, 1982, p. 93.

ample, semiconductors in the 1970's), the newest plant brought on stream with the latest process technology should have unit costs that will be the lowest for its industry. Large "preemptive" blocks of capacity are thus likely to be added. Conversely, in the rising cost situation new capacity may not be sufficient to create unit costs lower than those achieved by facilities already in place. A historical or imbedded capital cost advantage can offset high inflation.[21] Smaller increments of capacity (through debottlenecking or process change) undertaken more frequently in these existing facilities is thus preferable.

Older plants thus may not conclusively handcuff the business into accepting high unit costs. A number of firms, such as Heilemann Breweries and White Consolidated, have grown through the acquisition of production facilities for this very reason. In the case of Heilemann, the resulting per-barrel capacity cost was far lower than construction of new plants. These circumstances especially arise when the industry matured in an earlier technological era, and plant and equipment are highly durable (e.g. the steel industry).

2.34 The Entry Barrier Effect

The use of excess capacity as an entry barrier has been discussed by a number of authors (Wenders, 1971; Spence, 1977; Dixit, 1980; Spulber, 1981; Bulow *et al.*, 1983). The notion is that an existing firm in an industry can intentionally carry excess capacity in the pre-entry period. Under the assumption that the firm can freely vary its output, this excess capacity will then permit an expansion of its output and a reduction in price when entry is threatened. The prospective profits of

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[21]See Galbraith and Kaufman (1978) for a similar argument.

the new entrant are thereby reduced.

For excess capacity to be used in this manner, it must be a credible threat; i.e. it will be profitable for the existing firm to behave in this fashion. The "irreversible" nature of the capacity investment is important for this credibility in two aspects:

> One is that it is a way for the existing industry to commit itself in advance. . . Secondly, there is no need suboptimally to set a relatively flexible instrument like the price, since that can be adjusted within the time horizon required for entry to take place (Spence, 1977).

This type of capacity strategy is clearly most applicable to industries with homogeneous products and significant economies of scale (Spence, 1977). The existence of significant economies is important in that the incumbent firm with the large installed capacity base will likely operate at a much lower cost level in the short run and in response to entry.

2.35 The Product Life Cycle

The product life cycle (PLC) has been suggested as an alternative framework to systematically explaining capacity behavior. Smallwood (1973) predicted that the product life cycle would impact the relationship of industry capacity to demand in the following manner:

Introductory - Overcapacity

Growth - Undercapacity

Maturity - Optimum capacity

Decline - Substantial overcapacity

Levitt (1965) slightly modified Smallwood's scenario in that he considered maturity to lead to some overcapacity. The exact reasons for this capacity pattern are unclear. Neither author provided any theoretical or empirical justification. Anderson and Zeithaml (1984) examined trends in a number of strategic variables over the course of the PLC. Using the PIMS data base, the authors found that capacity utilization showed a trend of steady increase from the growth stage to decline. Again, the theoretical justification for this result was nil.

Why this utilization trend should be the case can perhaps be reasoned as a function of a number of underlying factors. Caves and Porter (1978) rationalized that the newness of the market or the "youth" of its key competitors would exert a positive influence on share instability. This effect is expected because the "oligopolistic bargain and its methods of adjusting to disturbances should be more settled in industries with older companies and products." Simply put, competitive "personalities" and likely actions would not be as well understood. The authors represented this phenomenon by dummy variables, one of which represented the stage of the product life cycle and the second the age of the reporting business. The result for both variables was in the expected direction (positive) and significant.

Second, one of the key differences between the stages of the life cycle is growth rate. PIMS, in fact, uses growth rate as one of the distinguishing features in classifying an industry as "growth" or "mature." Growth was established in section 2.31 as exhibiting a potential "destabilizing" influence, which would be consistent with the trend found by Anderson and Zeithaml (1984).

Last, the production process may evolve as the industry matures. Hayes and Wheelwright (1979a) have presented the notion of process evolution in the form of a product-process matrix. The notion underlying the matrix is that a consistent relationship must exist between the product life cycle and the production process. The product life cycle will progress from low volume and low standardization of product in the introductory stages, to high volume, high standardization of product at maturity. This transition fits with a natural progression of process from a low volume, high cost system (the job shop) to one of higher volume and lower unit costs (the assembly line or continuous flow process). One of the trends which occurs as the process "evolves" is that capital intensity increases, which would then tend to encourage higher utilization (Schmenner, 1981, p. 117).

Whether the concept of the "product life cycle" would provide additional explanatory power over and above these "underlying" factors is unclear. However, substantial general criticism has been levied against the product life cycle concept which would cast in doubt its usefulness (Porter, 1980, p. 158; Dhalla and Yuspeh, 1976; Rink and Swan, 1979). The authors have questioned the applicability of the product life cycle to a broad variety of industry settings. For example, the duration of the stages varies widely from industry to industry - particularly if comparing industries such as apparel and glass containers. Growth does not necessarily go through the characteristic "S-shaped" pattern. The life cycle will sometimes skip maturity and go directly to decline.

2.4 The Strategic Use Of Capacity

This section of the review examines how capacity can be employed by the firm to gain competitive advantage. Five subsections will follow.

The first and second subsections deal directly with business strategy. Porter (1980) has hypothesized that businesses attempt to establish competitive advantage through "differentiation" or "cost leadership." The first subsection examines how capacity can be used to <u>support</u> a differentiation strategy. The second subsection will largely examine preemptive capacity expansion, which has been described as a means of achieving cost advantage (as explained by the experience curve).

The third subsection briefly reviews various business strategy typologies and the conceptualized implications for aggregate capacity policy. Following this subsection is a summary of the influence of <u>corporate</u> strategy on capacity policy at the <u>business</u> level. The final subsection will briefly summarize the major issues presented in this section.

2.41 Differentiation

DeVany's (1976) theory of customer waiting time is one means of using capacity to establish a non-price advantage over the competition. Scherer (1980, p. 468) recognized, for example, that travellers may likely patronize airlines with the most flights and seats available, or industrial buyers may favor suppliers who are able to meet their demands in unusually tight markets.

This phenomenon as it is stated, of course, applies principally to a firm which holds no inventories. Orders are filled only through production. If a customer desires one of the finished products, it then becomes a question of whether or not to join the customer queue (i.e. the order backlog). The most typical example of this type of business would be a manufacturer of industrial durable goods. However, excess capacity does appear to have some "service" value in other types of situations as well. Excess capacity can be viewed not only as a means of attracting <u>new</u> demand, but also as a means of enhancing the dependability of servicing current demand, as can be seen in the semiconductor industry (Flaherty, 1983):

> Promptness of delivery is an important consideration for many customers. . . Several of the larger component maufacturers like Motorola maintain two fabrication lines for each product. One is typically a high volume line. . . and the other simply maintains the capability to produce the product in case the main line goes down (p. 81).

The notion, then, is that excess capacity enhances the probability of uninterrupted service. This concept has been termed "economies of massed reserves" (Scherer *et al.*, 1975, p. 274; Wahlroos, 1981), and has usually been applied to the operation of multiple facilities to minimize exposure in case of wildcat strikes, fire, natural disasters, etc. The multi-plant business decreases the risk of total production interruption as the number of plants increases - the firm will be able to still manufacture finished product, albeit at a lower rate. The same rationale can be applied to the value of excess capacity, irrespective of whether it resides in single or multiple facilities. The authors note that the highest need for uninterrupted production occurs in those industries where brand loyalty is important, and the product purchase frequency is high. The reasoning is that the consumer may be persuaded to switch to another brand (and establish new loyalties) if the preferred brand is simply not available.

The prior explanation approached excess capacity as a means of establishing a non-price advantage. In the remainder of this subsection, however, a slightly different view is taken. The objective is to understand how aggregate capacity policy supports a given strategy of differentiation. The research of Esposito and Esposito (1974), Caves and Porter (1978), and Smith (1981) will again be referenced here.

All of the authors incorporated "product differentiation" as an independent variable in their models. Esposito and Esposito did not specify an expected relationship between differentiation and excess capacity. Opposing arguments were offered because of the measure used (advertising/sales ratio). If the ratio is primarily measuring the barrier to entry due to product differentiation, the authors expected an inverse relationship with excess capacity. Conversely, product differentiation "may enable the firm to set prices which exceed the cost of production at less than full capacity." In this case a positive relationship would be anticipated.

A dichotomous dummy variable was eventually used which distinguished between industries with a "high degree of product differentiation" (an advertising/sales ratio of 2% or greater) and a "low degree" (less than 2% of sales). Various other cutpoints for the dummy variable were tried as well as the continuous ratio, however they proved to be less satisfactory. The relationship was negative but insignificant.

Some additional comments are in order with respect to the authors' reasoning of a positive relationship. The implication is that the "differentiator" will build plants of the same scale as the competition, but will use them less intensively since a price premium can be charged. A different explanation, though, is that the firm will simply build smaller-scale plants which would then be used with equal (or possibly higher) intensity. For example, Scherer *et al.* (1975) noted that if scale economy sacrifices could not be avoided at entry, the firm was likely to pursue a strategy of differentiation:

> . . . most new entries were at less than minimum efficient scale, thus incurring some scale economy sacrifices. Smaller-scale entry was likely if the entrant found a strategy to minimize these sacrifices, such as through differentiation (p. 147).

Caves and Porter (1978) also used the advertising/sales ratio as an indicator of differentiation. Like Esposito and Esposito, these authors cited an ambiguous relationship to the dependent variable:

> By indicating differentiation, it may signify a source of structural damping of market share movements following any exogeneous disturbance. But it also represents a form of competition ill-suited to effective collusion, and can provide a source of disruptive behavior. The former consideration represents a negative sign, the latter ones a positive sign.

Unfortunately, as in the Esposito and Esposito research, the result was insignificant (the sign, however, was positive).

Caves and Porter also developed a measure for "competitive homogeneity." One of the notions is that differentiation may be realized through means other than advertising. The existence of competition on the basis of differentiation portends that it will be "harder to reach agreement on the terms of an oligopolistic bargain due to different objectives" of the firms and to maintain any type of "agreement" in the face of "disturbances." In this sense, then, "competitive dissimilarity" would be positively related to instability. A composite variable was formulated for which the observations were scored on each of a number of different "dimensions" (a "1" if dissimilar, a "0" otherwise), and then the scores added. The dimensions of "similarity/dissimilarity" were served market; breadth of product line; marketing expense, service quality, and product image; vertical integration; product quality; product price; and direct production cost.

The authors also included a measure of <u>product</u> dissimilarity. Nonstandardized products would thus "expand the number of factors on which consensus must be reached and reduce the chances for a stable consensus." A dummy variable was used to indicate if the product was custom designed or produced to order for individual customers.

For both measures of dissimilarity a significant positive result was attained. Again it must be emphasized that the authors intended for these variables to measure industry-level phenomena by assuming that each observation was also representative of other firms in the industry. If the assumption is not true for all observations, the intended effect of the variables on instability certainly becomes less clear.

Last, Smith (1981) considered differentiation as a means of reducing interdependence among firms:

> . . . each firm becomes relatively more concerned with the demand for its own product than with aggregate industry demand. The firm is then more able to expand capacity to meet the demand for its own product without concern for the actions of others in the industry (p. 9).

Conversely, lack of product differentiation, such as in commodity industries like corn wet milling, increase the penalties associated with overbuilding - the need to recognize interdependence is thus magnified (Porter, 1980, p. 324). Smith measured differentiation using a survey question which asked the respondent to rank his product on a five point scale from "Undifferentiated" to "Unique." The result was appropriately signed but insignificant.

In summary the precise effect of a strategy of differentiation on aggregate capacity policy cannot be easily ascertained from these results. The concept is difficult to understand theoretically (what constitutes "differentiation") and to operationalize. Attempts to further address this problem will be deferred until the next chapter.

2.42 Cost Leadership

One of the paths to achieving cost leadership in an industry is through the preemptive addition of capacity. The reasons behind why such a strategy is logical are numerous. The following subsection will mainly discuss the concept that the firm will be able to establish a unit cost advantage as a result of "experience."[22]

The experience curve by definition is simply a scatter plot of historic costs (in real terms) versus cumulative production quantity (Lloyd, 1979). Theoretically, each time cumulative production doubles, unit costs will decrease by some fixed amount (the slope of the experience curve). The firm which adds capacity most rapidly will therefore be able to more quickly double its cumulative output and lower its unit costs. A lasting cost advantage is thus established over the competition. This effect is more significant the more rapid the growth rate (Boston Consulting Group, 1972).[23]

Explaining why the experience curve effect exists is difficult, although it undoubtedly acts to summarize a series of influences on cost. A major component of experience is likely to be the effect of changing scale. Porter (1980, p. 336) notes, for example, that the preempting firm may be able to achieve economies of scale not available to the competition. There simply is not enough "residual demand" to permit the competitors to be efficient. The competition will be forced to either invest on a smaller scale or invest on the larger scale and incur substantial excess capacity.

Agreement on the relationship between experience and scale, however, is far from universal. Gold (1982) hypothesized that there is little connection between the two concepts:

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[22]A related effect is that the firm may discourage the competition (or potential competition) from also investing in capacity (see 2.34).

[23]Advantages can sometimes also accure to the first mover in that the shortest lead times can be obtained in the ordering of equipment (Porter, 1980, p. 331).

> . . . in the overwhelming proportion of cases, therefore, improvements reflected by the progress function or the learning curve are likely to have little or no relationship to changes in scale (p. 24).

Sahal (1981, p.110) partially concurs that experience should be viewed as a model of improvement in the productivity of any system embodying a given technology. The author cites two examples to support his contention. For a period of 15 years after its construction, no further investments were made in the Swedish steelworks at Horndal. Thus, there was no change in the production technology employed. The output per man-hour, however, continued to grow at an average annual rate of about 2% over the same period of time. Lawrence Cotton Textile Company of Lowell, Massachusetts provides a similar illustration. For a period of 22 years, except for maintenance and repair work there was neither new investment for expansion of its production capacity nor significant replacement of the machinery employed. Productivity increased at an annual rate of 2.25% over the period. Lloyd (1979) and Tsuji (1982), however, hypothesize that experience is indeed a function of scale, although the authors do not offer any supporting evidence.

Resolving this association is particularly difficult, since experience curve studies do not identify the relative contributions to cost reduction of the numerous factors involved, such as changes in product mix or product technology, process technology, facilities, planning and control systems, or materials quality. A confounding factor may be industry type. Tsuji(1982) notes that in some industries, scale may be the determining factor in cost reduction presumed by the experience curve, whereas in other situations scale may not be a factor. The author did not specify the variable(s) which would influence the occurrence of scale effects.

Irrespective of the truth of these arguments, cost decreases will result from scale effects due to relative size of capacity and/or process technology (see 2.21) to which experience may be related. The findings of Sahal would tend to indicate that experience does indeed measure some type of "learning," but that its impact might be small in relation to the scale effects cited. Of course, a final source of difference in relative manufacturing cost would be simply "economies of volume" (Schmenner, 1976). The term refers to spreading fixed costs over a greater number of units. In comparing the performance of two plants with equivalent capacity and comparable process technology, the plant producing at the higher capacity utilization will achieve the lower unit cost.

An important secondary implication of preemptive capacity expansion is the capital investment which is required to simply maintain (let alone increase) capacity in a growth market. Not only is such a financial commitment likely to be expensive, but returns are not likely to be immediately forthcoming - particularly if cost declines are coupled with price declines (Boston Consulting Group, 1972, p. 32). The financial resources of the competitor are thus extremely important in being able to make the required investments and carry any resulting excess capacity.[24]

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[24]A similar need for financial strength can be seen when a company strives to maintain utilization (and cover overhead costs) during a downturn in demand by cutting prices and/or building inventories. Scherer (1980, p. 214) notes that if such a slump persists, the firms which would be driven into bankruptcy would not necessarily be the least efficient producers, but those that were the weakest financially.

2.43 Business Strategy Typologies

The relationship of business strategy to manufacturing capacity has been conceptualized in a number of different strategy classification systems. This section will review various classification systems which have been proposed, and in particular examine the capacity implications. A discussion of the strengths and weaknesses of typologies as a research tool will be found in Chapter III.

There has not been agreement about the precise content of a business strategy classification system. Table 2.5 summarizes four strategy classification systems - Porter (1980), Rothschild (1979), Miles and Snow (1978), and Stobaugh and Telesio (1983) - which have made explicit inferences about the significance of the business strategy for manufacturing. The context of the typologies shown, however, is somewhat different. Porter's system is squarely oriented in the field of industrial organization economics. Rothschild is a practitioner, and the system shown is a subset of a larger model which included "investment" strategies and "implementation" strategies. The Miles and Snow typology was developed to describe how the business adapts and responds to environmental change and uncertainty. Consequently, the system cannot be absolutely equated to the other systems. The authors, however, did indicate that one of the firm's problems was choice of technologies for production and distribution (the "engineering" problem). Last, the Stobaugh and Telesio framework was principally oriented towards examining a multinational manufacturing system. Some features of the model, such as the <u>country</u> locational choices, are beyond the scope of this research.

A number of commonalities can be identified from examination of

Table 2.5

Business Strategy Typologies

Author	Strategy Type	Capacity Implications
Porter (1980)	Cost Leadership*	Aggressive construction of efficient-scale facilities, state-of-the-art equipment, scale economies.
	Diffferentiation	Unique process technology, customer service (reliability).
	Focus	Either of the above.
Rothschild (1979)	Marketing-based	Small leased specialized facilities, constant high capacity utilization, moderate to low flexibility, ability to achieve "low cost" for contingency response.
	Innovation-based	Small self-owned facilities, as much capacity as possible without sacrificing innovation and quality, high flexibility, enough efficiency to permit response, no backward integration.
	Manufacturing-based	Capacity in advance of demand, high capacity utilization, process innovation, automation to reduce costs, large generalized facilities.
Miles and Snow (1978)	Defender**	Single highly efficient core technology, high vertical integration, continuous improvements in process technology to maintain efficiency.

Business Strategy Typologies
(continued)

Author	Strategy Type	Capacity Implications
	Prospector	Avoid long-term commitments to single type of process technology, low degree of routinization and mechanization, inability to develop maximum efficiency.
	Analyzer	Efficient in stable portions of domain and flexible in changing, technology never completely effective or efficient, adaptation of product to fit stable technological core.
Stobaugh and Telesio (1983)	Technology-driven	Volume flexibility important, flexibility to change products and processes quickly, small scale at first - then larger as markets grow, assembly - then simple fabrication - finally full scale manufacture, manufacturing cost not of prime importance.
	Marketing-intensive	Prompt delivery, heterogeneous mix of plant sizes depending on local market, from contract manufacturing to fully integrated production.
	Low cost (scale economies)	Large scale plants to keep costs at a minimum, specialized facilities.
	Low cost (low-cost labor)	Small scale plants, technology adapted to use low-cost labor.
	Low cost (other inputs)	Energy, raw materials.

*Cost leadership - low unit cost relative to the competition; Differentiation - industry-wide perceived uniqueness; Focus - cost leadership or differentiation for a specific buyer group, product line segment, or geographic market.

**Defender - Little/no product/market development, competing primarily on the basis of internal efficiency; Prospector - pioneer in product/market development; Analyzer - intermediate between defender and prospector.

Table 2.5. Three broad strategy types appear to have been identified by the authors. The first broad strategy is Product Innovation, which is drawn from "innovation based" (Rothschild) and "technology driven" (Stobaugh and Telesio). Porter recognizes technology as an approach to differentiation, but does not establish it as a separate type. The Miles and Snow "prospector" could be introducing either high technology or low technology products. The business pursuing technological innovation attempts to offer a steady flow of new high performance products. Example firms which have distinguished themselves through this strategy are Polaroid (instant photography), Hewlett Packard (calculators and scientific instrumentation), and Apple (personal computers).

The second broad strategy type can be termed Marketing Intensive, which equates to "marketing based" (Rothschild) and obviously "marketing intensive" (Stobaugh and Telesio). Again, the Porter "differentiation" and Miles and Snow "prospector" could be likened to this type. This type relies on heavy marketing expenditures to distinguish its products from those of its competitors through brand identification. Coca-Cola (soft drinks) and Procter and Gamble (various consumer products) are the epitome of this group.

The third strategy type - Low Cost - is similar to "cost leadership" (Porter), "manufacturing based" (Rothschild), "defenders" (Miles and Snow), and, of course, the "low cost" of Stobaugh and Telesio. The obvious implication of this strategy is that the business is able to compete by offering the lowest-price product as a result of a highly efficient manufacturing system.

The Stobaugh and Telesio distinction between three different "Low Cost" strategies is an important one. The "path" to low cost depends on the factor characteristics of the industry, which is consistent with Gold's (1982) notion of factor dominance (particularly the manner in which scale is increased and costs are therefore lowered). For example, businesses with "capital-dominated" manufacturing systems tend to lower cost by increasing the size and degree of specialization of individual facilities and equipment units, by more effectively integrating successive operations, and by progressively reducing the roles of human production efforts. The benefits which would presumably result would be higher productivity of fixed capital (as measured by the ratio of capacity to fixed investment) and gains in output per man-hour (Gold, 1982). Haldi and Whitcomb (1967) found similar results in their analysis of operating costs in several capital-dominated industries:

> . . . increasing returns to scale on construction cost . . . no great scale economies in the consumption of raw materials . . . unit costs decline slightly with size increases, since larger furnaces, motors, etc. are more efficient . . . large economies of scale in labor costs are possible for a process-type plant, including indirect labor such as supervision . . . substantial economies of scale in maintenance (e.g. repair/janitorial, spare parts inventories) . . .(p. 381)[25]

By contrast, "labor-dominated" production operations tend to focus on reducing the degree of labor dominance by increasing the role of capital goods and by increased standardization of products. Gold (1982) indicates that gains in output per man-hour are thus likely to be overshadowed by gains from increases in the role of capital goods. Haldi and Whitcomb (1967) also found that capital/labor substitution and longer production runs were of more importance in job shops or assembly

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[25]The types of plants surveyed were cement, chemicals, aluminum, pulp and paper. The authors also recognized that observed cost variation between two plants in an industry can also result from unstable demand, age differences in plants (new plants embody different technology), and different locations.

line plants than capital-intensive plants. Evidence of cost improvement for a labor-dominated business with constant sales might be higher capital intensity (the result of capital/labor substitution) and higher capacity utilization (caused by longer production runs).

Scale increase in "materials-dominated" processes tends toward joint factor dominance.[26] The joint dominance arises through a sequence of subdivision of labor, replacement of labor with machinery, and finally larger and more highly specialized equipment and facilities.

Low cost will therefore be achieved in different manners depending upon whether the business is capital-, labor-, or raw materials-dominated. "Low Cost-Capital Dominated," "Low Cost-Labor Dominated," and "Low Cost-Materials Dominated" thus need to be considered as subsets of the low cost strategy type.

The typologies described in this section - Product Innovation, Marketing Intensive, and the three Low Cost types - are in essence an extension of the Porter "differentiation/cost leadership" dichotomy. Technology and marketing are simply different means of allocating resources to achieve differentiation, while the "cost leadership" types recognize the influence of factor dominance. Again, particular note should be made that the particular route to achieve "low cost" may vary depending on the dominant factor. Economies of scale, for example, may not be as significant if the business is labor-dominated (versus capital-dominated).

Empirical research which examines the difference in the manufactur-

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[26]Gold (1982) indicates that materials dominated processes can be defined as having constraints on output which relate to the richness of the natural resources being utilized or processed. For example, a mine with high-grade ore would be more productive with respect to output per unit of input than a mine with lower grade ore.

ing attributes of strategy types is, to say the least, extremely limited. Hambrick (1983a) compared the "engineering attributes" of "prospectors" and "defenders" (the Miles and Snow typology) using the PIMS data base. "Defenders" were hypothesized to use their resources much more efficiently than the "prospectors." Such efficiency was proposed to be evident by measures of fixed asset intensity (gross fixed assets/employee), relative backward vertical integration, employee productivity (value added per employee), capacity utilization, and process R & D expenditures in relation to total R & D. In comparison to the "prospectors," the "defenders" were found to have higher productivity and greater fixed asset intensity.[27] No difference was found in the level of backward integration, capacity utilization, or process R & D.

Woo and Cool (1983) studied the functional attributes of Porter's generic strategies of cost leadership and differentiation. The purpose of the study was to simply examine the differences in attributes - no statements were made as to what differences should be expected. The authors found that the "cost leadership" strategy exhibited higher capacity utilization, lower finished goods inventory, and a higher propensity towards mass production (all in relation to "differentiation"). No difference was found in capital intensity, backward integration, or process R & D.

2.44 The Corporate Strategy - Capacity Linkage

This section summarizes one factor - financial resources - which in

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[27]A "defender" was defined by new product sales below 1 percent for each of four years. A "prospector" was defined as a business with new product sales above 10 percent for each of four years.

essence provides a corporate influence on capacity policy at the business level.

As mentioned in 2.42, any type of plan for the manufacturing system will be difficult to implement if sufficient financial resources are not readily available. In the diversified firm, resource availability is a two-part proposition. One, resources would have to be available at the corporate level. This implies that the corporation as a whole has funds to invest, which in turn is a function of current profitability and cash flow, dividend policy, debt capacity, or the willingness to issue new equity.

Second, the corporation must also be willing to fund the capacity request of the business, as opposed to investing in other businesses. MacMillan and Meshulach (1983) examined influences which would dictate whether a business would tend to invest for capacity expansion ("expansion") or cost reduction ("replacement"). Their findings are of interest because of the notions of "pressures" to invest and confidence in the business at the corporate level:

> In summary, management was inclined to expand capacity primarily because demand for the products grew and a shortage of capacity became a threat. On the other hand, no incentive to expand was found when cost competitiveness was declining and margins on sales were shrinking. . . Management decisions can be visualized as being driven by two sets of factors, reflecting pressure and confidence. Pressure was seen in the form of distress signals (decline in cost competitiveness, decline in capacity utilization, and decline in real growth of sales). Variables affecting management's confidence (market share of imports, changes in current asset intensity, changes in return on sales) also were significant (p. 724).

Such "pressures" to invest can thus be either "positive," such as growing demand coupled with capacity shortage, or "negative."[28] "Nega-

[28]The notion of "positive" or "negative" pressures is similar to the prior discussion of either growth or inflation/rising costs leading to manufacturing investment.

tive" pressure can be the result of a weakening competitive situation and/or "cost push."[29] Some cost pressures, such as pollution control requirements or shortages of inexpensive energy, will accelerate the obsolescence of existing capacity or add to the capital stock, but not add capacity (Rost, 1982). However, as the authors noted, management confidence in the business at the corporate level is necessary for any investment decision to be made.

2.45 Summary

The role of business strategy in determining capacity policy is far from "crystal clear." This section has attempted to broadly represent business strategy as being oriented toward "differentiation" or "cost leadership." Capacity appears to promote a non-price advantage through "service" ("economies" in customer waiting time, or enhanced delivery reliability through the holding of excess capacity). The role of capacity in achieving product-oriented differentiation is less clear. The business typologies which have been summarized here, however, hint that the precise source of differentiation (e.g. technology, marketing) may play a role in determining capacity policy.

"Cost leadership" represents the "classic" notion of where manufacturing plays an integral role. Rapid additions of capacity to attain "experience" effects are key to establishing cost differentials over the competition. The exact "path" to achieve such a differential, however, appears to be further related to growth rates and "factor dominance." Last, corporate strategy is suspected to impact capacity policy largely

[29] An increase in foreign competition presents the "worst case" scenario, particularly if this competition operates with substantially different factor prices.

through corporate vertical integration policies and the availability of financial resources to the business.

2.5 The Capacity Utilization - Performance Relationship

Capacity utilization is generally recognized as having a positive influence on performance. A number of cross-sectional models of profitability have found such association (Schoeffler *et al.*, 1974; Schoeffler, 1977; Hatten and Schendel, 1977; Schendel and Patton, 1978; Lubatkin and Pitts, 1983). The objective of this section is to summarize a limited number of works that report "contingencies" ("industry" and "strategy") which impact this performance relationship.

2.51 Industry Effect

Anderson and Zeithaml (1984) found that the effect of capacity utilization on performance (as measured by ROI) in industrial goods industries varied across the product life cycle. Capacity utilization was not significantly correlated with ROI during the growth stage. By contrast, utilization did have a significant positive effect on performance during both the mature and decline stages. The effect of capacity utilization on relative market share was also tested, however was not significant in any of the life cycle stages.

MacMillan *et al.* (1982) corroborated this finding in that capacity utilization was important to the profitability of "cash cows" and "dogs" (also in industrial products industries). No effect, however, was found for the "wildcats" or "stars." This finding is consistent with Anderson and Zeithaml in that the difference in categorizing "wildcats"/"stars" versus "cash cows"/"dogs" is simply industry growth rate.

The rationale for this effect supplied by the authors is that efficiency of operation is less important than satisfying high demand. High growth brings to bear extreme pressures on resources, and profits are more likely to be made from increasing revenues rather than reducing cost.

The only other "industry" factor which has been empirically examined is innovation. MacMillan and Hambrick (1983) found that businesses in "innovative" industries experienced no effect of capacity utilization on ROI.[30] By contrast, a more general sample of mature industrial products businesses (of which "innovative" industries are apparently a subset) showed a positive and consistent relationship of capacity utilization to ROI. No specific explanation for this effect was provided by the authors.

2.52 Business Strategy Effect

A difference in capacity utilization has been found between "high performers" and "low performers" for a number of different business strategy types. In general, however, such differences were not explicitly predicted by the authors and fell under the guise of broad "profiles" of strategic attributes (such as might be developed through cluster analysis).

Hatten and Schendel (1977) and Schendel and Patton (1978) both developed regression models of the beer industry which linked a series of environmental and strategic variables to profitability (the Hatten and Schendel paper), market share, and production efficiency (all three

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[30]An "innovative" industry is defined as one whose top three competitors derived over 10% of their sales from new products.

performance goals in the latter paper). In both studies an "overall" model was formulated and then tested against first the data set for the entire industry, and then a series of "homogeneous" subsets of firms. These subsets could thus be interpreted as strategic groups. Both papers reported widely varying relationships of capacity utilization to ROI - positive, negative, or insignificant, depending upon the strategic group. Neither paper stated any hypotheses concerning differences that should have been expected.

Hambrick (1983c) examined high- and low-profit strategies in two different samples of industrial goods "environments" (clusters of industries with comparable characteristics, such as frequency of product purchase or share stability). The high- and low-profit strategies were also developed through cluster analysis. Hambrick established "characterizations" for each of the strategy clusters which were contended to be loose approximations of Porter's (1980) three strategy types. The two high performing "low cost" types ("cost leadership" and "asset conscious followers") in the "Disciplined Capital Goods" sample both showed higher capacity utilization than the mean utilization of the entire sample (all "Disciplined Capital Goods" firms). Conversely, the high performing "differentiator" ("high quality gendarme") experienced much lower capacity utilization. Direct comparisons with the "low performing" strategy types are difficult, however, since clusters quite dissimilar to the "high performers" were constructed. The same type of analysis in a second industry cluster ("Aggressive Makers of Complex Capital Goods") yielded the same result - that high capacity utilization is not consistently associated with high ROI.

Woo and Cool (1983) extended their analysis of Porter's strategies by examining the influence of the functional attributes of each strategy on ROI. Of primary interest for this research is that capacity utilization had a common impact (+) on the profitability of both generic strategies. No attempt was made in this study to specifically look at high- or low-performers, or to control for technology or industry effects.

Last, MacMillan and Hambrick (1983) examined the attributes of two clusters of high ROI businesses which were also highly capital intensive.[31] The two clusters could again be loosely labeled as competing via differentiation and price. The results were comparable to the work by Hambrick cited earlier. Despite the high capital intensity, the "differentiator" exhibited capacity utilization which was not significantly different from all mature industrial businesses; the "cost leader" showed significantly higher capacity utilization.

In summary, business strategy does appear to influence the capacity utilization - performance relationship in some fashion. Previous research, however, has failed to develop theory as to why these observed differences should occur. Until such theory is presented, these differences could be interpreted as little more than statistical artifacts.

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[31]Once again, all of the businesses analyzed were mature industrial goods producers.

CHAPTER III

CONCEPTUAL FRAMEWORK AND HYPOTHESES

The hypotheses for this study are presented in the next four sections. The first group of hypotheses (3.1) largely relates to "technology and demand" variables which influence capacity utilization. These hypotheses will serve to first replicate the "Manne"-type models described in section 2.2, and then selectively extend this model. The second group of hypotheses (3.2) serves the same purpose for "industry" variables impacting capacity utilization. The Esposito and Esposito model described in 2.3 will be replicated and then extended. After each of the above models is tested separately, a combined model which incorporates both "technology and demand" and "industry" variables will be formulated. The third section (3.3) completes the capacity utilization modeling by examining "environments" which influence the capacity utilization - performance relationship.

Section 3.4 extends the above work by incorporating business strategy and stating appropriate hypotheses. A hypothesis is also presented which compares the capacity properties of high and low performing businesses. The last section (3.5) briefly summarizes the chapter.

3.1 Technology And Demand Hypotheses

This section is intended to correspond largely to the presentation of sections 2.2 and 2.3. The theoretical and empirical support for the bulk of the statements to follow has been discussed in the literature survey. Only a brief summary of the argument with appropriate references will therefore be presented with each statement. The first subsection (3.11) states hypotheses which in essence will replicate the "Manne"-type models summarized in 2.2. Subsection 3.12 cites a number of additional variables which serve to extend the "base" model of 3.11.

Some of the variables discussed in Chapter II are difficult to operationalize due to the nature of the data base used for this research. Those variables which cannot be satisfactorily treated will be mentioned at the appropriate point in the discussion.

3.11 Replication Of The Manne Model

In short, the Manne model of capacity expansion considers investment decisions to be a function of investment economies of scale and the demand growth rate. Three hypotheses are offered to capture these relationships:

H_{1a}: "Lumpiness of investment" is negatively correlated with capacity utilization.

The first hypothesis states that "lumpiness" essentially limits the firm to making large incremental increases in capacity. Economies of scale in investment are hence large. Such large increases are thus more likely to lead to lower capacity utilization (Scherer, 1969; Smith, 1981).

Two additional points about investment "lumpiness" should be noted. First, an interaction will likely exist between capacity utilization, "lumpiness," and demand growth. For example, investment which is very "lumpy" will not necessarily saddle the firm with excess capacity if the growth rate is high *ceteris paribus*; conversely, even capacity which can be increased in small increments may be detrimental in a low- or no-growth environment. Second, investment will likely be "lumpier" the younger and/or the smaller the firm. Consider the example of a one-machine plant. Capacity can only be added in increments of "one machine." The one-machine plant can therefore only increment capacity by a minimum of 100%. The next addition of a machine, however, will constitute only 50% of the current installed capacity. This same downward trend is thus related to increase in firm size. The underlying concept is simply that while total capacity increases, the unit of capacity increment (which is technology-based) remains constant. To summarize, the interaction between "lumpiness" and growth must thus be explicitly dealt with in the analysis.

H_{1b}: Industry demand growth is positively correlated with capacity utilization.

A positive relationship for demand growth can be argued simply from inspection of Figure 2.2. As the slope of demand increases, capacity utilization also increases *ceteris paribus*. The relationship, however, may be contingent upon the relative growth rate. A negative correlation could be expected following the reasoning of Porter (1980) and Smith (1981) that the firm will "lose more by being caught with insufficient capacity in a growth market than it will by having built too much."

The suggested negative correlation is likely to be more prevalent when the cost of overshooting is low (i.e. when fixed costs and/or capital intensity is low). The influence of demand growth may thus also be a function of the type of production process. The effect of demand growth may also be impacted by seller concentration. The reasoning is that demand growth could "augment the incentives for the individual seller (or sellers) to upset the oligopolistic consensus by investing in an enlarged market share" (Caves and Porter, 1978). The tightness of the consensus and the extent to which it can be upset is in turn a function of concentration.

H_{1c}: Industry demand instability is negatively correlated with capacity utilization.

This expectation is easily rationalized. First, when an industry demand downturn occurs, the firm is likely to be saddled with excess capacity. The firm, however, may have "reservations" about shedding the excess capacity, particularly if customers may be permanently lost if supply shortages are the case when demand reappears. Furthermore, stability in the industry in terms of simply trying to maintain a constant share of industry capacity is much more difficult to achieve (Smith, 1981; Caves and Porter, 1974; Scherer, 1969).

This effect is also considered to be a function of production process type. The reasoning is that capacity in job shops or assembly lines is much easier to adjust than a continuous process. Capacity utilization may thus be subject to less variance. In the assembly line case, capacity can be changed to some degree by changing the number of shifts and/or rebalancing the line. This degree of flexibility is usually not possible for the continuous process - the process operates at either designed capacity, or not at all.

The last two hypotheses of this section are included to deal with the cases of order backlogs and multi-plant investment:

H_{1d}: The order backlog level is positively correlated with capacity utilization.

The effect of order backlogs is to "store" demand, thus effectively raising average capacity utilization over time. The ability to backlog indicates that capacity need not precisely match demand. The precise relationship of this variable to capacity utilization is also likely to interact with growth and the production process type. For example, a flexible process may result in relatively stable backlogs as demand changes. Similarly, very high growth could consistently create high backlogs.

H_{1e}: Regional businesses are negatively correlated with capacity utilization.

The notion explored here is that a firm which operates on a regional basis is likely to operate with more excess capacity than the national competitor. The underlying assumption is that the national competitor is apt to have a more extensive system of plants than the regional firm. The higher the number of plants, the easier for the firm to "whipsaw" investment between plants (Manne, 1967; Scherer *et al.*, 1975; Smith, 1981). A second explanation is that the regional firm may exist because of high transport costs in relation to product value. If transshipment of product among market areas is not feasible, the firm is thus more likely to be forced to invest in excess capacity.

In summary, then, the replication of the Manne work is represented by the following model:

CAP UTIL = f(CAP INCR, GROW, INSTAB, BACKLOG, REGIONAL) (I)

where:

CAP UTIL = Capacity Utilization

CAP INCR = Lumpiness of investment

GROW = Industry demand growth

INSTAB = Industry demand instability

BACKLOG = Order backlog level

REGIONAL = Regional businesses

The following section describes the extensions to this model which are proposed.

3.12 Extensions To The Manne Model

The first three hypotheses mostly deal with the <u>operating</u> characteristics of the technology (as opposed to its <u>investment</u> properties). This distinction is made because two plants in which equivalent investment has been made can have vastly different operating (or variable) costs based on the production technology selected:

H_{1f}: <u>The "continuity" of the production process is positively correlated with capacity utilization</u>.

H_{1g}: <u>Capital intensity is positively correlated with capacity utilization</u>.

H_{1h}: <u>Fixed costs are positively correlated with capacity utilization</u>.

These three hypotheses simply indicate that the business will be more inclined to utilize capacity if a substantial financial penalty is incurred for idleness (Marris, 1964; Betancourt and Clague, 1981; Wheelwright, 1979). In this case, the type of process, capital intensity and the cost ratio are likely to be positively correlated. For example, continuous processes are apt to be more capital-intensive than other process types (e.g. a job shop or assembly line). A redundancy between these two variables may logically exist, and therefore one may be eliminated in the final model. A difference in the latter two phenomena could exist, though, if the firm's manufacturing assets have been largely depreciated.

H_{1i}: "Economies of capacity" is positively correlated with capacity utilization.

A positive correlation between capacity utilization and "economy of capacity" would be expected based on DeVany's (1976) notion of "economy of waiting time." "Economy of capacity" is defined here as relative size of capacity. Due to "balking" at long queues for the product, customers will be disproportionately drawn to firms with the higher relative capacity (and thus the least waiting in the queue). The larger capacity results in higher utilization *ceteris paribus*. Second, as discussed earlier in this subsection, the larger capacity would enable capacity to be changed in smaller relative increments (in relation to the absolute size of capacity).

Given a constant discount rate, the correlation of "economies of capacity" and capacity utilization is also a likely function of the growth rate and the type of process. The reasoning parallels the "preemption" argument, which is the rational course to follow if economies of scale are significant (such as would be the case for a continuous process) and growth is rapid. The firm generates excess capacity in anticipation of future demand, which can preempt possible future investment by the competition and also permit lower relative unit costs.

H_{1j}: The finished goods inventory level is negatively correlated with capacity utilization.

In contrast to order backlogs, the building of finished goods inventories can be used to "prop up" capacity utilization in the short term (in a sense, to "store" capacity). Over the longer term, however, if demand remains at reduced levels, capacity utilization must by necessity drop to subnormal levels. At this point output must be below demand levels to dispose of excess inventories. A more detailed explanation of these effects is found in 3.423.

In summary, the extensions to the Manne replication described here are represented by the following model:

CAP UTIL = f(CAP INCR, GROW, INSTAB, BACKLOG, REGIONAL, PROCESS, CAP INT, FIXED, ECON CAP, FIN GOODS) (II)

The first five independent variables represent Model I described in 3.11. The remaining independent variables are thus:

PROCESS = Production process type

CAP INT = Capital intensity

FIXED = Fixed costs

ECON CAP = Economy of capacity

FIN GOODS = Finished goods inventory

3.13 Summary

Table 3.1 summarizes the hypotheses of this subsection. The table describes the independent variable involved in each hypothesis, the expected correlation with capacity utilization, and contingent variables which are expected to interact with the independent variable and capacity utilization. To reiterate, the sign and/or significance of a number of the independent variables is expected to vary based on several contingencies. Contingencies will be treated through subsamples of the data base.

These two models are intended to replicate and extend the "technology-oriented" models discussed in section 2.2 (e.g. Manne

(1967), Marris (1981), Betancourt and Clague (1981), DeVany (1976)). Demand characteristics are also explicitly treated, as is the ability to "store" demand and/or capacity (backlogs, finished goods).

The existence of "rhythmic" inputs to the production process (e.g. seasonal agricultural products, shift premiums for a labor-intensive business) is expected to be negatively correlated with capacity utilization. No formal hypothesis testing will be attempted here, however, because of a lack of relevant variables in the PIMS data base.

Similarly, the discount rate would be expected to be positively correlated with capacity utilization. PIMS does report the discount rate which will be used to evaluate future investment. To use this variable, the assumption would have to be made that the same discount rate has been used for past investment. This assumption is deemed to not be reasonable, since the economic and/or corporate "situations" are likely to have changed since the initial capacity investment. No hypothesis testing will thus be attempted.

3.2 Industry Hypotheses

Like the previous section, the statement of industry hypotheses is organized into two subsections. The replication of the Esposito and Esposito model is contained in 3.21; extensions to this model are then described in 3.22. Some overlap between the Manne and Esposito and Esposito models does exist, however a consistent relationship to capacity utilization is expected for these variables.

3.21 Replication Of The Esposito And Esposito Model

H_{2a}: Seller concentration is significantly correlated with capacity utilization.

Table 3.1

Technology- and Demand-Related Hypotheses

Hypothesis	Independent Variable	Sign	Contingent Variable(s)
Model I			
1_a	"Lumpiness of Investment"	-	Growth
1_b	Demand Growth	+	Absolute Growth, Process Type, Concentration
1_c	Demand Instability	-	Process Type
1_d	Order Backlog	+	Growth, Process Type
1_e	Regional Businesses	-	
Model I Extensions (Model II)			
1_f	Production Process Type	+	Growth
1_g	Capital Intensity	+	
1_h	Fixed Costs	+	
1_i	"Economy of Capacity"	+	Growth
1_j	Finished Goods Inventory	-	Process Type

H_{2a1}: <u>"Atomistic industries" are positively correlated with capacity utilization</u>.

H_{2a2}: <u>"Partial oligopolies" are negatively correlated with capacity utilization</u>.

H_{2a3}: <u>"Tight oligopolies" are positively correlated with capacity utilization</u>.

The effect of seller concentration is expected to be significant, yet depend on the <u>level</u> of concentration. For example, tight oligopolies (high concentration) will tend to promote minimal excess capacity since the competitors will tend to act collectively. Acting "collectively" is manifested in few simultaneous investors - the ability to learn about (or forecast) these other investments is thus enhanced. A "smooth" adjustment of capacity to meet increased demand is consequently expected. Conversely, no collusive "agreement" would exist in the atomistic industry (low concentration). Rather than be concerned about the investments of the competition, the firm would simply tend to adjust its capacity in proportion to changes in its own sales. On average, then, the industry would tend to minimize excess capacity (Esposito and Esposito, 1974; Smith, 1981; Caves and Porter, 1978; Scherer, 1969).

Excess capacity is therefore likely to result if the competitors do <u>not</u> act collectively. This situation could result if the mutual interdependence among the largest firms is <u>not</u> recognized, or if a significant competitive fringe tries to increase its market share. This type of outcome is more likely for the partial oligopoly (moderate concentration). Although the <u>overall</u> influence of seller concentration is expected to be significant, the exact effect depends on whether the the industry has low, moderate, or high concentration.

H_{2b}: Product differentiation is negatively correlated with capacity utilization.

An inverse relationship is expected in this case, since firms in industries where product differentiation is important may be able to "set prices which exceed their costs of production at less than full capacity" (Esposito and Esposito, 1974). Alternatively, product differentiation reduces interdependence among firms. As a consequence, each firm becomes relatively more concerned with the demand for its own product than with aggregate industry demand. This "dissimilarity" makes it more difficult for firms to reach an oligopolistic bargain or to maintain it in the face of industry "disturbances" (Caves and Porter, 1978). For this case, a negative relationship to capacity utilization would also be expected.

Esposito and Esposito expected capacity utilization to be lower in industrial goods firms than in consumer goods firms. The reasoning which the authors provided for this expectation can be more broadly stated as two separate hypotheses:

H_{2c}: Irregularity of product change is negatively correlated with capacity utilization.

H_{2d}: Purchase frequency is positively correlated with capacity utilization.

The notion behind Hypothesis 2_c is simply that under conditions of uncertainty the firm is more likely to deal with such uncertainty by carrying excess capacity (Caves and Porter, 1978).[1] If demand "takes

[1]Frequent product change has been previously used by Caves, Gale, and Porter (1977) to represent situations with a "high expected variance of luck" - i.e. high uncertainty.

off" and/or competitive moves are minimal, the excess capacity can then be used to maximum advantage.[2] The notion of "irregularity" is important in that some firms expect regular product change (such as a toy or clothing manufacturer), and are unlikely to build excess capacity which might be underutilized if variations in product demand occur. In other words, regularity of change should be easier to plan for and manage. Conversely, "irregularity" connotes a higher likelihood of not dealing with the change effectively.

The propensity of the firm to take this course of action again is predicated on the choice of production process. Carrying excess capacity makes sense if a very flexible process with low fixed costs can be selected; if a high fixed cost process represents the sole alternative, the firm would be motivated to minimize its investment and operate at a higher utilization level.

The hypothesis concerning purchase frequency is based on the notion that if products with a high purchase frequency are not available (for example, as a result of insufficient capacity), the customer will either postpone the purchase or switch back to the preferred product (or brand) when their preference is once again available. Conversely, if purchase frequency is low, customers may be permanently lost if they cannot be supplied. The propensity, then, would be for firms which produce infrequently purchased products to carry excess capacity.[3]

The last two variables included in the Esposito and Esposito (1974) model are demand growth and capital intensity. Hypotheses have already

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[2]To follow the argument of 2.34, such excess capacity may also serve as a barrier tc entry.

[3]Esposito and Esposito implicitly contended that consumer products have higher purchase frequencies than industrial products.

been stated in 3.1 for the relationship of these variables to capacity utilization and will not be repeated here. Such variables will thus be tested as a part of replicating both the Manne and Esposito and Esposito models.

In summary, the replication of the Esposito and Esposito work is represented by the following model:

CAP UTIL = f(CONCEN, PROD DIFF, PROD CHG, PUR FREQ, GROW, CAP INT) (III)

where:

CONCEN = Industry concentration

PROD DIFF = Product differentiation

PROD CHG = Irregularity of product change

PUR FREQ = Purchase frequency

The following section describes the extensions to this model.

3.22 Extensions To The Esposito And Esposito Model

H_{2e}: Significant entry into the industry is negatively correlated with capacity utilization.

H_{2f}: Significant exit from the industry is negatively correlated with capacity utilization.

H_{2g}: The excess of exports over imports is positively correlated with capacity utilization.

The general idea which is transmitted by these three hypotheses is that a "disturbance" to the industry (either in the form of entry, exit, or imports) is likely to unbalance the collective behavior of the competitors (Caves and Porter, 1978). Irrespective of this "collective behavior" aspect, significant entry could be expected to automatically reduce the utilization of existing capacity. The case of exit, however, would likely prompt capacity addition by the remaining competitors. The notion is that capacity additions made with the intention of "fighting" over the vacated share are not likely to occur in a "smooth" fashion.

Industry imports and exports should have opposing effects on capacity utilization. Since an industry can be simultaneously an "importer" and "exporter," it is important to look at whether a net export or import situation exists. A "net import" situation tends to practically "reduce" the seller concentration of the industry - thus making a tight oligopoly "act" more like a partial oligopoly. Conversely, competitors may be able to "vent disturbances to the domestic market by varying their foreign sales" (Caves and Porter, 1978). In other words, demand variance in the domestic market can be attentuated by either emphasizing (or de-emphasizing) exports. A positive relationship would thus be expected for the "net export" situation.

These hypothesized effects should in turn be a function of demand growth and industry concentration. For example, the occasion of entry into a high-growth industry should not be as damaging if the incumbents are already struggling to keep pace with rapid demand growth. Likewise, a "disturbance" which upsets the oligopolistic consensus is less apt to occur if such a consensus is not "tight." The impact of entry/exit or imports is thus less likely to be felt in the atomistic industry or partial oligopoly than the tight oligopoly.

The next two hypotheses deal with "uncertainty:"

H_{2h}: The "youth" of the product is negatively correlated with capacity utilization.

H_{2i}: Industry technological change is negatively correlated with capacity utilization.

The rationale for Hypothesis 2_h is simply that the "oligopolistic consensus and its methods of adjusting to disturbances should be more settled in industries which have older companies and products" (Caves and Porter, 1978). The incumbents in "older" industries simply should have a much better perspective on what to expect from the competition.

Second, significant technological change in the industry (either product or process) is likely to create differing effects on each competitor. Some capacity may be totally obseleted or substantial change to the process may be required - in either case, excess capacity will likely result. Technological change thus has much the same impact as a "disturbance" related to entry and demand variability (Smith, 1981; Caves and Porter, 1978).

H_{2j}: <u>The number of customers is negatively correlated with capacity utilization</u>.

The number of customers which a firm possesses (alternatively, buyer concentration) is an indicator of the bargaining power which can be exerted on the seller. The existence of many customers minimizes the ability of the sellers to reach and maintain any oligopolistic bargains among themselves. The net result thus is the expected positive correlation with capacity utilization.

H_{2k}: <u>Inflationary pressures are significantly correlated with capacity utilization</u>.

Pressures on the firm to reduce cost are expected to have an indeterminate relationship with capacity utilization. The firm may simply attempt to utilize existing facilities more efficiently, such as through better production scheduling, fewer product varieties, etc. Conversely, a negative relationship can be anticipated if the firm is "pressured" into making a significant investment in either new, more cost-efficient processes or new plant facilities. The net result of either move is a likely short-term increase in total firm capacity - thus lower utilization.

This capacity influence should also interact with the growth rate. Consider the firm which adds 10% to its capacity base by virtue of a new plant constructed in a low labor cost region. Although the primary purpose of the plant may be to reduce cost, the plant will secondarily aid in serving demand growth. The net effect of the capacity addition will be more apparent the lower the rate of demand growth.

To summarize, the extensions to the Esposito and Esposito replication described in this section are represented by the following model:

CAP UTIL = f(CONCEN, PROD DIFF, PROD CHG, PUR FREQ, GROW, CAP INT, ENTRY, EXIT, NET EXPORT, PROD AGE, TECH AGE, CUST CONCEN, P-C SQZE) (IV)

Once again, the first six independent variables essentially represent Model III described in 3.21. The remaining independent variables are identified as:

ENTRY = Entry into the industry

EXIT = Exit from the industry

NET EXPORT = The "net" export position of the industry

PROD AGE = The age of the product type

TECH CHG = Technological change

CUST CONCEN = Number of customers

P-C SQZE = Inflationary squeezes on margins

3.23 Summary

Table 3.2 summarizes the hypotheses which have been presented in

Table 3.2

Industry-Related Hypotheses

Hypothesis	Independent Variable	Sign	Contingent Variable(s)
Model III			
2_a	Seller Concentration	+ or -	
2_{a1}	- Atomistic	+	
2_{a2}	- Partial Oligopoly	-	
2_{a3}	- Tight Oligopoly	+	
2_b	Product Differentiation	-	
2_c	Irregular Product Change	-	Process Type
2_d	Purchase Frequency	-	
Model III Extensions (Model IV)			
2_e	Entry	-	Concentration,Growth
2_f	Exit	-	Concentration,Growth
2_g	Net Exports	+	Concentration,Growth
2_h	Product "Youth"	-	Process Type
2_i	Technological Change	-	
2_j	Customer Concentration	+	
2_k	Inflationary Pressures	+ or -	Concentration, Growth

this subsection. The format of this summary exhibit is consistent with the previous summary of "technology" hypotheses. Indeterminate relationships are indicated as "+" or "-". The sum total of the "sub-model" hypotheses listed in Tables 3.1 and 3.2 thus represent a "complete" model of capacity utilization.

An implication of Tables 3.1 and 3.2 is that concentration, growth, and the type of production process are expected to have a contingent effect on the relationship between capacity utilization and a number of the independent variables. Two additional contingent variables which have been used in business strategy research - the product life cycle (Anderson and Zeithaml, 1984) and industry type (Hambrick, 1983*b*) - are not expected to add any explanatory power to the model. Stated in hypothesis form:

H_{3a}: Use of the product life cycle as a contingent variable will not significantly impact the models of capacity utilization.

H_{3b}: Use of industry type as a contingent variable will not significantly impact the models of capacity utilization.

As summarized in 2.35, the product life cycle representation is expected to be inferior to the more explicit specification of underlying factors. A comparable lack of effect is expected for industry type (i.e. consumer, industrial). These hypotheses will be tested using models II and IV.

3.3 Capacity Utilization - Performance Hypotheses

The intent of this section is to offer hypotheses concerning industry "settings" in which capacity utilization varies as a determinant of performance. In essence, then, several "contingent" factors which should effect this relationship will be specified and discussed. The form of the hypotheses will generally follow a two-part format. First, the expected relationship of a primary variable to profitability will be stated (e.g. "growth is positively correlated with profitability"). Next, the relationship of an interaction between each primary variable and capacity utilization will be stated. For example, capacity utilization is expected to detract from profitability if growth is high. Last, some three-way interactions will be considered.

H_{4a}: Capacity utilization is positively correlated with profitability.

The simple notion here is that at high operating levels, fixed costs will be spread over a larger volume of output and thus reduce unit costs. As a consequence high capacity utilization will tend to boost profit margins, which will in turn increase ROI (Schmenner,1976; Gale, 1980).

H_{4b}: Capital intensity is negatively correlated with profitability.

H_{4c}: The interaction of capacity utilization and capital intensity is positively correlated with profitability.

The negative association of capital intensity and profitability has been well documented by other authors (Schoeffler, 1977; Schoeffler *et al.*, 1974; Zeithaml *et al.*, 1981; Gale, 1980). Such an association is obvious if for no other reason than the arithmetic relationship between capital intensity and ROI. However, capital intensity also promotes severe price competition during periods of weak demand, acts as a barrier to exit, and potentially hurts the firm in its bargaining position with customers, suppliers, and unions (Hambrick and MacMillan, 1983).

Hypothesis 4_c suggests that capacity utilization is especially important to profitability as capital intensity rises (i.e. the effect on profitability becomes increasingly non-linear) (Schoeffler, 1977).

H_{4d}: Industry growth is positively correlated with profitability.

H_{4e}: The interaction of capacity utilization and industry growth is negatively correlated with profitability.

H_{4f}: The interaction of capacity utilization, industry growth, and capital intensity is positively correlated with profitability.

Industry growth is expected to have a positive effect on profitability (Schoeffler, 1977). While this association is expected to be true, it is not expected to be highly significant. Various scenarios can be posed for a negative or no correlation. For example, profitability in a high growth environment may be lower if start-up problems occur and substantial investment to gain market share is made. While the case for the indicated association is admittedly weak, it is nonetheless included for completeness of the model.

Capacity utilization, however, is not expected to boost profitability during growth periods; in fact, a negative association is expected. The rationale is that the achievement of efficiency by intensively using fixed assets in growth industries will not lead to superior returns. Growth in volume is more important to profitability, and can be more easily attained if capacity growth is rapid and the firm is willing to "live" with short-term excess capacity. Various studies have found that capacity utilization does not impact ROI in high growth environments (MacMillan *et al.*, 1982; Anderson and Zeithaml, 1984).

Hypothesis 4_f, however, suggests that if the industry in question is capital intensive, capacity utilization is essential to profitability irrespective of the growth rate. Such a relationship should therefore be consistent with Hypothesis 4_c.

H_{4g}: Concentration is positively correlated with profitability.

H_{4h}: The interaction of capacity utilization and concentration is positively correlated with profitability.

H_{4i}: The interaction of capacity utilization, concentration, and capital intensity is negatively correlated with profitability.

The association between seller concentration and profitability has been well established in the literature (e.g. Bain, 1956; Mann, 1966; Weiss, 1974; Shepherd, 1972; Gale, 1972). High capacity utilization in a concentrated industry is expected to provide even more of a boost to profitability. The reasoning is that high capacity utilization will trigger a tendency towards a boost in selling prices. Such a price boost will be easier to achieve when the number of sellers is low (high concentration). Hypothesis 4_i, however, suggests a slightly different relationship when the effect of capital intensity is introduced. In this case, high capacity utilization may in fact be an indicator that producers may be "competing away" profit margins more vigorously in hopes of keeping plants operating at high levels. The effect may be less for high seller concentration, nonetheless complete success in the curbing of price cutting would not be expected.

The model of the capacity utilization efect on performance can thus be expressed as follows:

ROI = f(CU, CI, CU*CI, GROW, CU*GROW, CU*GROW*CI, CONCEN, CU*CONCEN, CU*CONCEN*CI) (V)

where:

ROI = Return on investment

CU = Capacity utilization

CI = Capital intensity

GROW = Industry demand growth

CONCEN = Industry concentration

The regression model of profitability used to make the tests will also include several additional independent variables from the capacity utilization model (e.g. customer concentration, price-cost squeeze, product age). The intent is to reduce problems of misspecification, since the purpose is not to build a comprehensive model of profitability. Table 3.3 summarizes these respective hypotheses.

3.4 Business Strategy Concepts And Hypotheses

The discussion of the business strategy-capacity utilization relationship is organized into three subsections. First, to reiterate one of the primary observations summarized in Chapter 1, Skinner and Wheelwright contend that strategy should influence the capacity policy of any business. The effect of strategy on excess capacity, however, is not expected to be straightforward. The reasoning is that the design of the manufacturing system encompasses a myriad of quite significant trade-offs and multiple objectives. Focusing on one element of manufacturng system design (such as excess capacity) can be quite misleading without recognizing these trade-offs. The first subsection further explains the concept of "capacity trade-offs" and why it is important to introduce them in this analysis of capacity utilization.

The second subsection is a bit of a digression, however a necessary one. The hypotheses concerning business strategy are generated in terms of typologies. It is important to understand the strengths and weaknesses of using typologies as a research "tool," since other alternatives do exist. This second subsection can be skipped without loss of con-

Table 3.3

Capacity Utilization - Performance Hypotheses

Hypothesis	Independent Variable	Sign
4_a	Capacity Utilization (CU)	+
4_b	Capital Intensity (CI)	-
4_c	CU * CI	+
4_d	Industry Growth (GROW)	+
4_e	CU * GROW	-
4_f	CU * GROW * CI	+
4_g	Concentration (CON)	+
4_h	CU * CON	+
4_i	CU * CON * CI	-

tinuity.

Third, arguments are presented to address the difference in capacity utilization (i.e aggregate capacity policy) between several different strategy types. An expanded group of typologies to represent "differentiation" and "cost leadership" are used which are expected to be more revealing of the subtleties in the business strategy-manufacturing linkage than the simple "differentiation/cost leadership" dichotomy. The "capacity trade-offs" which the different strategy types are expected to make are also examined as a part of this third subsection, along with the impact of capacity policy on performance.

3.41 Capacity Trade-Offs

"Capacity trade-offs" involve explicit choices made in the operations performance criteria of a business which are in turn reflective of the objectives the business emphasizes. Wheelwright (1978) contends that any business must make some explicit choices among the operations performance criteria shown in Figure 1.1 - efficiency, dependability, quality, and flexibility. These choices are needed because Wheelwright posits that a manufacturing system cannot perform equally well on all measures. For example, efficiency and flexibility cannot be achieved to an equal degree simultaneously, particularly in relation to the competition. A brief description of these performance criteria is in order.

First, efficiency is comprised of both cost and capital efficiency. Cost efficiency relates to unit cost performance; capital efficiency relates to "fewness" of assets (both plant investment and inventory) per unit of capacity.

Dependability is also "multidimensional." This performance criterion in essence broadly implies the ability to adequately serve existing demand. For example, dependability is particularly important when the business is competing in a rapidly growing industry. Capacity must be added at a rate which is equal to or greater than the industry growth rate in order to hold or increase market share. A secondary aspect is that the business must be able to serve demand in a timely, reliable manner, irrespective of the growth rate. The notion is to provide an adequate level of service to customers such that they will not be forced to deal with the competition. No measures for this criterion are known to have been proposed or used by other authors.

Quality can be simply viewed as the ability of the manufacturing system to produce a consistent product (in a sense, an internal view). However, the external view must also be recognized in how the product "stacks up" against competitive offerings.

Last, flexibility can be defined in terms of both volume and product. Flexibility appears to be linked to the choice of production process, and the capital intensity of that process. To illustrate, a business which chooses to remain highly flexible with respect to both product and volume would invest very little in manufacturing assets and make use of outside suppliers where possible. Flexibility is therefore achieved by adding, deleting, or changing suppliers. Conversely, the relatively inflexible firm would have a very product-specific, capital-intensive production process (such as a petroleum refinery).

The essence of the capacity trade-off problem, then, is to recognize the operations performance criteria which will be most critical to the achievement of the chosen business strategy. This primary criterion will then be used as a "screen" for decision making. Wheelwright (1978) provides the example of the business which needed to expand capacity for its rapidly growing branded household product. The higher volume would allow the use of a new production process which was much more efficient with respect to both unit production cost and investment cost. The new process, however, was untried. Management concluded that if the business was unable to meet all of the demand for its product, the penalty would be a loss in market share and a waste of advertising dollars. Furthermore, the cost of excess capacity was minimal compared with the product's gross margin. Management opted for the importance of dependability and chose to expand using the existing process.

As related to this research, not incorporating the notion of trade-offs into the analysis of capacity can lead to some erroneous conclusions. For the moment, assume that higher utilization will lead to higher cost efficiency (within a relevant range).[4] The business with higher utilization would then be regarded as "relatively more cost efficient." However, two cases can be easily cited where lower utilization may not have any effect on relative cost efficiency. First, a different process technology may allow improved cost performance even at lower (or equivalent) utilization levels (e.g. continuous casting vs. conventional ingot casting in a steel mill). Second, the "low utilizaton" business may be able to achieve lower costs simply through more extensive backward integration. Obviously, these two cases do not exhaust the possible explanations. However, the two examples illustrate "trade-offs" in the sense that higher cost efficiency (despite the lower utilization) may have been exacted at a "price" of lower investment efficiency and/or

[4]Beyond the relevant range (particularly higher), cost efficiency would logically drop, due to deferred maintenance or the rhythmic nature of inputs.

lower flexibility.

The proper approach, then, to understanding the effect of strategy on capacity is to understand 1) how the broad objectives of a strategy translate into a specific emphasis on particular operations performance criteria, and 2) how the capacity decision supports these criteria in light of its interaction with other manufacturing policy decisions (e.g. process technology, vertical integration). Aggregate capacity (as is measured by capacity utilization) is only one piece of the puzzle which cannot be properly evaluated in isolation. Figure 3.1 shows the predominant view which is unfortunately taken in most empirical strategy research which examines the functional attributes of a business. Hambrick (1983a), for example, states a hypothesis that "Defenders have greater capacity utilization than do prospectors." The implied assumption is that a "one-to-one" relationship between strategy and aggregate capacity should exist. The point is that this "tunnelvision" is patently incorrect. What is indicated by the "realistic view" in Figure 3.2 is that the pattern and interaction of policy decisions is more revealing than any single decision. The pattern should also be predictably consistent with strategy.

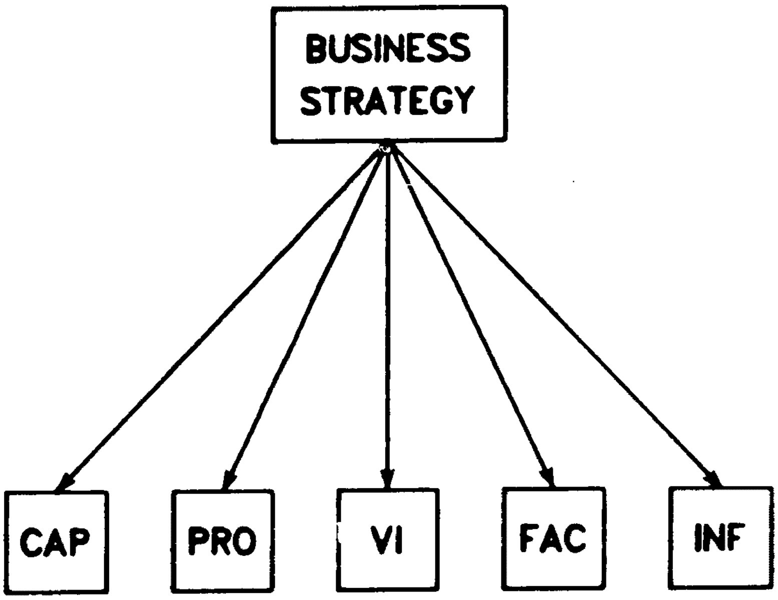
Some of these interactions have already been represented in the hypothesized model described in section 3.1 - for example, the influence of process technology on excess capacity. The introduction of "business strategy" complicates the analysis, yet increases the need to explicitly recognize such interactions and trade-offs.

3.42 Typology Descriptions And Hypotheses

First, it should be recognized that the strategy typology concept

Figure 3.1

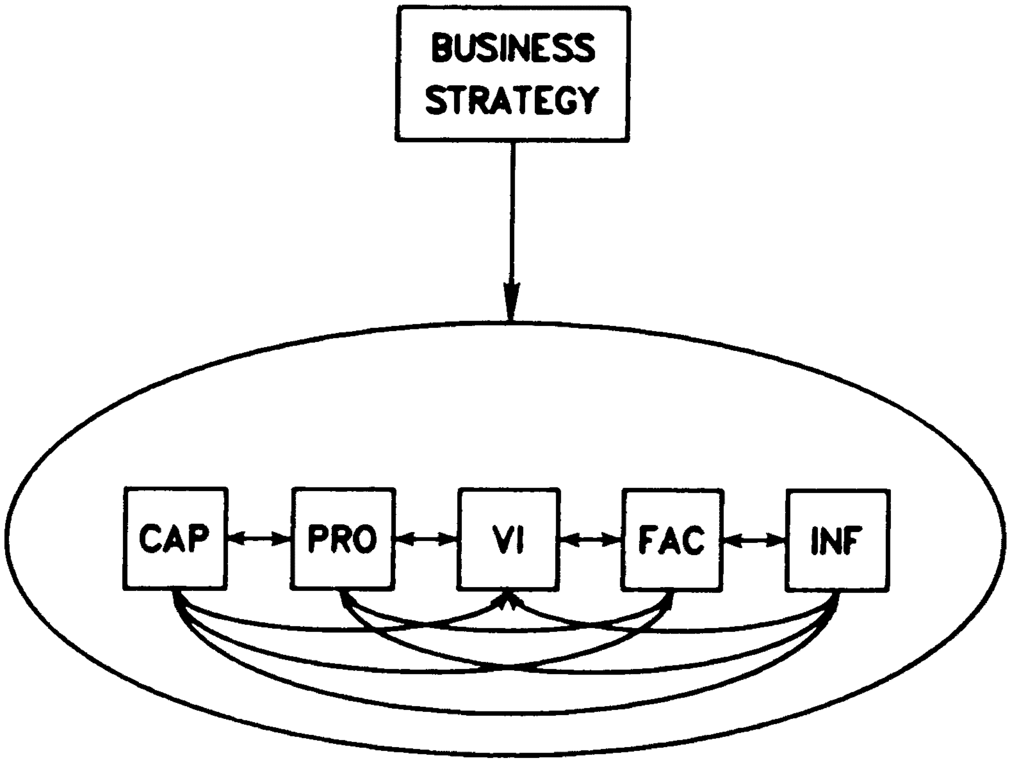
The "Predominant" View of Functional Attributes



CAP – Aggregate Capacity
PRO – Process
VI – Vertical Integration
FAC – Facilities
INF – Infrastructure

Figure 3.2

The "Realistic" View of Functional Attributes



is one of four alternative methods of operationalizing the strategy construct - the other three methods being textual descriptions, measurement of parts of strategies, and multivariate measurement (Hambrick, 1980).[5]

The strength of using typologies for strategy research, particularly in comparison to the other three methods, is in the underlying logic and the notion of breadth which is inherent.[6] Andrews (1971) defines strategy as "a pattern of decisions" which are internally consistent and interrelated. Typologies endeavor to capture both the comprehensiveness and integrative nature of strategy.

In developing a set of typologies for this research, describing the capacity implications of the simple "differentiation/cost leadership" dichotomy is not expected to be a fruitful endeavor. Several reasons can be offered for this conclusion. First, Porter (1980, p. 37) defines "differentiation" as "creating (a product or service) that is perceived industrywide as being unique." Porter also recognizes that "differentiation" can take many forms, such as brand image, technology, or service. The problem is that each of these three "forms" of differentiation has different implications for manufacturing - one general "model" of differentiation is erroneous and an oversimplification. To some extent,

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[5]Porter's (1980) three generic strategies - overall cost leadership, differentiation, focus - are an example of a typology. Textual description is basically case study research. Measurement of parts of strategies is typified by the linkage between functional strategies and performance. Multivariate measurement endeavors to take a comprehensive view of the construct, such as the Schendel and Patton (1978) model of strategy in the beer industry.

[6]By contrast, textual descriptions can be criticized by being too situation-specific. <u>Generalization</u> and <u>replicability</u> across organizations is thus hampered. The two measurement methods are equally wanting in that either <u>insufficient breadth</u> exists to describe the full extent of strategy (measurement of parts), or a central "thread" or internal logic is not apparent even if more <u>parts</u> are measured (multivariate measurement).

the same statement can be made about a single "cost leadership" model. Factor dominance (discussed in 2.43) has important implications here - consider the differences in achieving cost leadership in footwear as contrasted to steel. In fairness to Porter, the "differentiation/cost leadership" model was probably intended to mainly convey the broad avenues on which businesses compete, and not the specific functional policies which must be adopted to support the strategies.

Following, then, is an expanded set of typologies which is deemed to offer an improved understanding of manufacturing consequences. The set is largely based on the summary of 2.43 - two types of "differentiators" (Product Innovator, Marketing Intensive) and three "low cost" types (Capital Dominated, Labor Dominated, and Raw Materials Dominated). One modification and one subtraction from the set are proposed. The "Custom Producer" is recognized as being fundamentally different than the manufacturer of standard products. The Raw Materials-Dominated Low Cost strategy is dropped. Not enough is known about the capacity implications of this type to be able to offer specific testable statements.

Figure 3.3 shows a conceptual diagram of how these types are related. Several assumptions are implied in this schematic. First, the manufacturing of custom products is fundamentally different from standard products. The custom product could also be "innovation" or "marketing" oriented, however this distinction will be considered as irrelevant to capacity policy. Second, products sold by the "differentiated" business command a price premium, and products sold by the "low cost" business are priced equal to or lower than the competition.[7] The basis for

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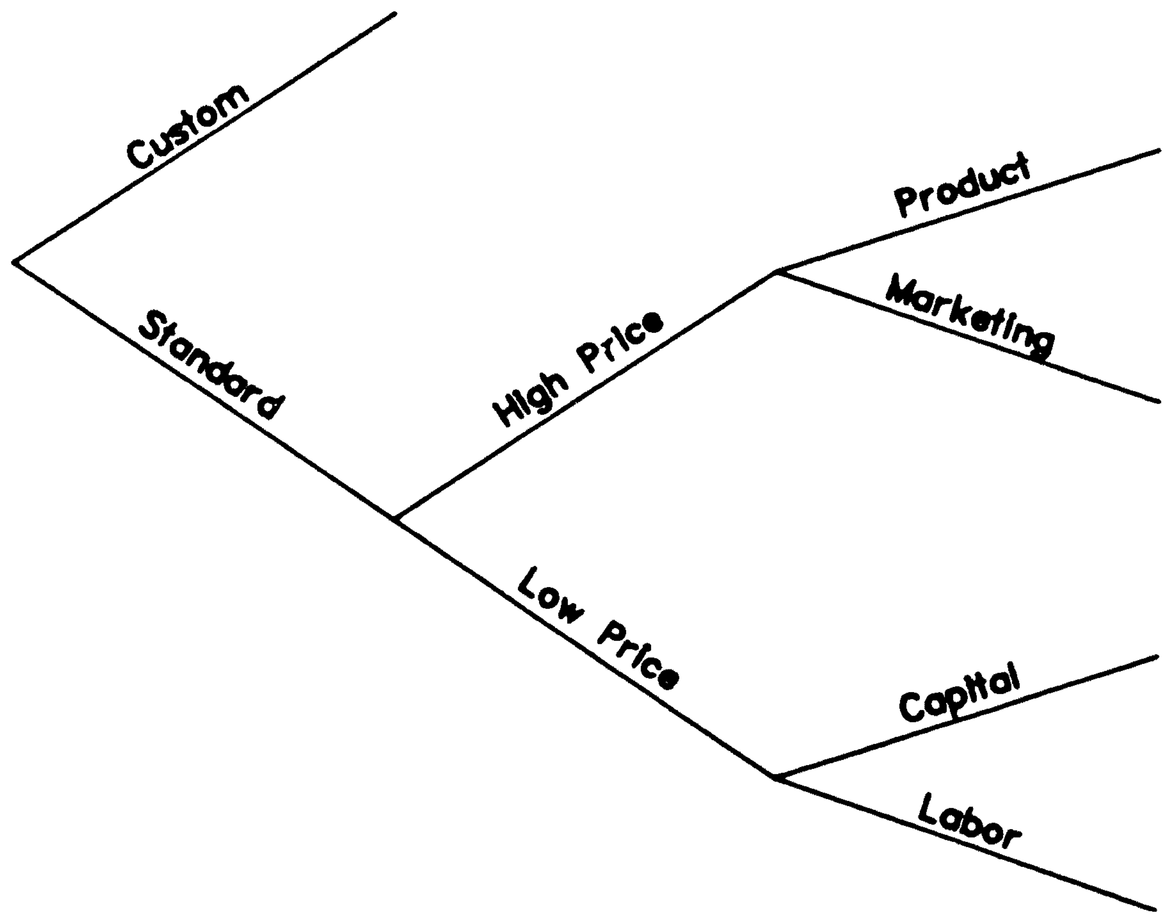
[7]A further assumption is that high relative prices also correlate

Figure 3.3

Relationship Among the Strategy Types



differentiation of a standard product is thus either innovation or marketing. Obviously, the types are not likely to be mutually exclusive in all cases, nor are the assumptions immune to violation. The schematic does, however, provide a framework for developing some logical concepts about manufacturing.

The descriptions to follow are multi-faceted. For each type, the reasoning as to why their manufacturing systems should differ will be given. In particular, expected capacity utilization will be addressed in addition to the broad trade-offs in manufacturing which are likely to be made. To reiterate from 3.31, it is a mistake to view aggregate capacity policy in isolation from the other manufacturing policy decisions.

In the following subsections, the distinctions between a manufacturer of custom and standard products will first be discussed. Next, salient characteristics of the two "differentiators" will be identified. A number of hypotheses will be stated which compare the "differentiators" to each other. The "low cost" businesses will then be described and hypotheses stated. In addition, a number of hypotheses which compare the "differentiators" as a group to the "low cost" types (also as a group) will be presented.

3.421 Custom Producer

A starting point in understanding the difference in this type is to examine a simplified three-stage sequence of how a business meets demand for its product (Figure 3.4). The sequence can be briefly explained as

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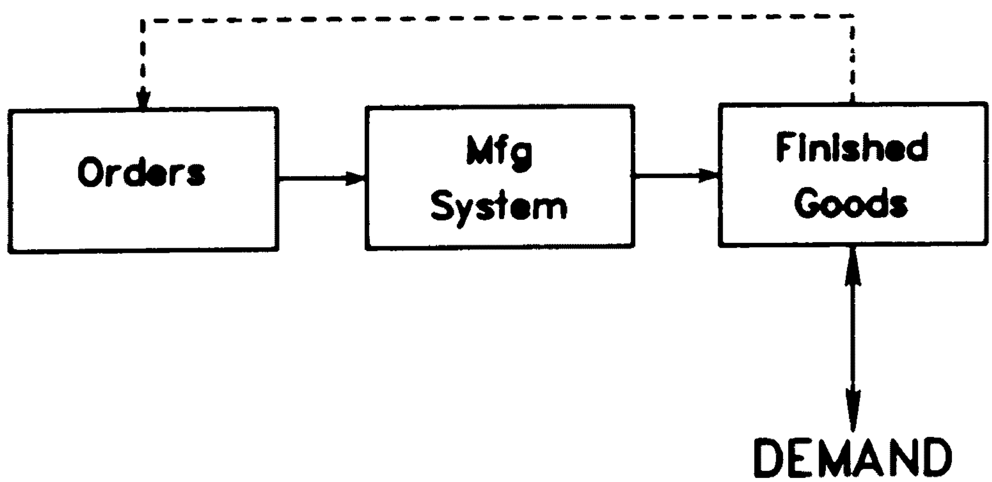
with high relative quality. This relationship has been found most recently by Phillips, Chang, and Buzzell (1983).

Figure 3.4

The Sequence of Production



follows. Orders for the product are scheduled into the manufacturing system. Once the order is completed, the product is placed into a finished goods inventory. Demand for the product is then filled from inventory. As the inventory is depleted, new orders are triggered, and the entire cycle is repeated.

The focus in the research to this point has been solely on the second "block" - the manufacturing system. The concern has been on understanding circumstances under which the business will be able to adapt (or not adapt) its capacity to demand and/or the prevailing competitive conditions. Wild (1980), however, recognized that an alternative to adapting capacity is to moderate demand in order to eliminate or reduce the need for adjustments in system capacity:

> . . . it is difficult in the short term to change capacity in a process plant; a plant with highly skilled labor may be the same. Possible approaches (to moderation) include provision of excess capacity in order to increase the probability of meeting high, or even maximum demand (ambulance service, power station); provision of excess capacity, yet insufficient to meet maximum demand (customers will be lost); or using stock to absorb demand fluctuation (e.g. building supplies, Christmas cards) (p. 98).

Wild also hypothesized that operations management will indeed prefer to moderate the demand fluctuations felt by manufacturing, and therefore to eliminate or reduce the need for capacity adjustment.

The notion, then, is that order backlogs and finished goods inventories serve to "shield" the manufacturing system from demand swings and will thus tend to boost capacity utilization *ceteris paribus*. For example, DeVany and Frey (1982) found that order backlogs were widely used in the steel industry, and significantly impacted capacity utilization:

> A system of rationing by queues exists which is stable and orderly. . . The reduced intertemporal variance of demand narrows the range over which the firm produces, lowering expected cost, and reduces the capacity required to fill demand at any level of reliability (p. 450).

Similarly, Scherer (1980, p. 210) noted that the first reaction of rayon producers to a decline in demand was typically to maintain full capacity production and build up inventories. In a sense, finished goods inventories are a means of "storing" capacity.

The point of this discussion is that Figure 3.4 represents a manufacturer of standard products - in other words, the product can be stocked. The Custom Producer, however, does not have this luxury. Each item is "made to order," and consequently cannot be stocked.[8] The lack of a finished goods inventory thus provides less "shielding" for the manufacturing system from changes in demand. As Scherer noted, a business can usually keep the manufacturing system operating normally and simply build inventories if demand drops. The business is then making a conscious choice of inventory carrying cost versus the cost of carrying excess capacity. This option does not exist for the Custom Producer - if demand falls (as evidenced by the order backlog), idle capacity would be the result.

Excess capacity would thus be more likely for the Custom Producer in relation to the standard products manufacturer because of the lack of finished goods. Additional arguments, however, can be noted. The DeVany (1976) notion of a linkage between capacity and customer balking at an order queue is relevant here. Intentional excess capacity would result in low order backlogs and high customer service. This is a key to the success of the business, since it is in a sense "selling" service and its production capability.[9] Furthermore, Caves and Porter (1978)

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[8]The situation for the Custom Producer is analogous to the service business - the "product" cannot be stored.

[9]Possible situations can be cited where the "Custom Producer" may also be manufacturing a unique product which is unavailable elsewhere.

found that custom producers exhibited a positive relationship with share instability - again indicating the likely existence of excess capacity.

Flexibility and dependability are extremely important to the Custom Producer - hence the value of excess capacity. Since this type is not geared to volume production of standard products, it is more likely to be job-shop oriented.[10] Efficiency is of lesser importance to this type than flexibility or dependability.[11] One of the means a business can use to improve efficiency is maintaining a large backlog. Larger backlogs improve the ability of the business to efficiently schedule its production. As an example, an auto assembly plant routinely operates with a four to six week backlog of production orders. A backlog of this size is usually necessary so that an optimal "model mix" can be scheduled on the production line.[12] The larger backlog, though, is counter to the "service" notion important to this type (the DeVany notion of customer balking at an order queue discussed previously). The secondary importance of efficiency would likely result in low vertical

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In such a situation, this type is like the "Product Innovator" in that volume production must be attained quickly before imitators appear. If volume production is not achieved and large backlogs result, imitators are more likely to appear and diminish the business's competitive advantage.

[10]The "job shop" orientation is likely to be highly sensitive to "rhythmic" labor inputs (the key production input is skilled labor), thus lending additional credence to the existence of intentional excess capacity.

[11]Despite the lower need to emphasize efficiency, the firm may appear to be so (in terms of investment efficiency) because of no finished goods inventories and little need for raw materials.

[12]For example, restrictions exist on the assembly line balance such that certain body styles or options (e.g. air conditioning) have to be scheduled in a particular order and frequency. A large backlog enables the production scheduler to arrive at a "good" schedule much more easily.

integration. Vertical integration may be desirable only for reasons of "uniqueness" or lead time (required production items may not be readily available from outside suppliers, if available at all), however not for reasons of cost.

3.422 Differentiation

3.4221 Product Innovation

The most effective means of describing Product Innovation is to draw a contrast with the Marketing Intensive type. Abernathy, Clark, and Kantrow (1983) point out that numerous businesses compete on the basis of "repackaging established technology to reach new markets," an example of which is lightweight, low-cost chain saws. The authors noted that the introduction of these new saws constituted only incremental change in the product and process, yet major change in the channels of distribution and advertising. The dilemma for the chain saw manufacturer is that the new "technical configuration" can be readily duplicated by the competition (in terms of manufacturing) and as a result offers uncertain ground for building a sustainable competitive advantage. Sustainable competitive advantage must thus be supported by a genuinely "differentiable production process" in the sense that the manufacturing of a comparable product by the competition is not easy (Williams, 1983). "Product differentiation" can thus be imparted (a unique process) and supported by (high service levels) the manufacturing system.

The production process which plays a role in "product differentiation" is assumed to be possessed by the Product Innovator and not the Marketing Intensive. Spital (1983) gives an example from the semiconductor industry:

> Innovators may be able to gain and sustain market share if customers buy on the basis of technical performance and reliability. . . The innovating company is often able to use its resources during its lead time to improve the technical performance and reliability of its components. These circuits are not simply designed once and then run in large quantities to yield learning economies. They are redesigned on an ongoing basis and the production process is being "tweaked and tuned" to give a better yield of parts. A circuit may be redesigned to make it less susceptible to variations in the production process (p. 63).

The product edge is thus partially embodied in the production process. The embodiment of competitive advantage in tangible assets is important in that imitation cannot occur easily. Of course, given enough time the competition can buy new capital equipment and put in place a manufacturing system capable of producing a similar product. The lead time element, though, is important in the sense that substantial market share and profits can be reaped before the competition can effectively respond. By the time the competition does respond, the Product Innovator can then respond by offering the next round of new technology.

Polaroid offers an example of the "production process embodiment" factor. For many years the company subcontracted its film production to its chief rival, Kodak. Polaroid, however, pioneered the coating process which applied the special instant developer to the film. This process was maintained in-house and was extremely difficult to duplicate. Galbraith and Kaufman (1978) have termed this strategy as avoiding "non core" investment when markets and technologies are rapidly shifting. Investment is thus concentrated on activities which are truly unique, proprietary, or crucial to the success of the business.

The Product Innovator thus attempts to grow and profit by offering products which are uniquely "differentiated" through manufacturing. Dependability of product delivery is of major importance, since an objective of this type would be to satisfy as much demand as possible before imitative products appear on the market. When imitative products do appear, product change is necessitated - hence product flexibility of the manufacturing system is also important.

The need to achieve dependability and flexibility, however, is moderated by two factors. Maximum flexibility - such as the exclusive use of subcontractors - is usually not achievable or desirable. This strategic type is likely to invest in its own production facilities in order to supply unique process technology for the product (for example, Polaroid and its film production) or for quality control considerations (such as in a complex assembled electronic product). Particular attention, however, must be paid to the production process selection. Manufacturing would most likely be limited to labor-intensive processes with minimal automation, or automated processes which could be written off quickly in order to not fall into a trap of investing in non-flexible processes. The second moderating factor, particularly for dependability, is that products which are technologically complex should not be easy to imitate. Lead times before imitators appear should be extensive.

As contrasted to the importance of flexibility and dependability, the achievement of investment and cost efficiency is not as critical to the Product Innovator as the other types. Obviously, costs and margins must be kept "in line" to adequately fund product research and development efforts - the lifeblood of this strategy. However, achievement of efficiency is not the most important task for the manufacturing system.

3.4222 Marketing Intensive

The Marketing Intensive achieves growth through superior marketing, not superior product technology. Potential users of the product are persuaded to initially try it, to possibly switch from a competing brand, or to use the product more frequently. While new products may be periodically introduced, the new products are likely to be simple product line extensions (e.g. a new salad dressing flavor) which uses existing production processes.

In contrast to the Product Innovator, the Marketing Intensive type is less likely to achieve differentiation as a part of the manufacturing system. Royal Crown Cola, for example, has been considered as an innovator in the soft drink industry. The company was the first to introduce diet and no caffeine cola soft drinks. Because of the nature of the syrup production process (basically batch mixing of ingredients), the product could be easily imitated by the competition. Since the manufacturing system could not generate a true sustainable advantage, the basis of competition would thus focus on mostly brand image and distribution. Coca-Cola and Pepsi have been able to exploit more massive marketing resources to quickly overcome any "first mover" advantage gained by Royal Crown.[13]

Like the Product Innovator, flexibility and dependability are important to this strategy type. However, it can be argued that the differences in these two criteria for the two strategy types are likely to be quite pronounced. First, this strategy type is expected to be less likely to heavily invest in manufacturing facilities. Unlike the Product Innovator, the competitive edge of this type is <u>not</u> tied to its

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[13]The success of Miller Brewing is comparable. The introduction of a light beer was not unique or difficult in terms of demands on the manufacturing system. The business succeeded because the product was perceived by the heavy beer drinker as an acceptable alternative to regular beer.

production skills - marketing skills and access to distribution channels are by far the more important. Since little competitive advantage is thus likely to be achieved with the manufacturing system, this type is most likely to purchase its production in total or add very little value in manufacturing (e.g. an assembler of relatively standard components).[14] An illustration of the former case is M. Marion Wineries of California. The company grows no grapes or produces no wine of its own. Instead, M. Marion contracts for its entire production with a number of independent wineries. The "value added" by Marion thus takes the form of promotion, packaging design, and distribution.

However, dependability of service can be argued to be critical to the Marketing Intensive. Since the differentiable process does not exist, imitative products are anticipated to <u>readily</u> appear. When any of a number of virtually identical products can be selected by the user, the level of service becomes important. Service level is first and foremost manifested in product availability. If the preferred product choice is not immediately available, the user may purchase a competing brand (again assuming that the products are largely identical). The ability to maintain high service dependability - uninterrupted delivery or high finished goods levels - is thus an important competitive factor. The impact of service and product availability has been seen recently with Cabbage Patch dolls. Coleco was not able to meet demand levels with its capacity, and as a result imitative products soon appeared on the market.

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[14] Interestingly, the Marketing Intensive can conceivably be a <u>customer</u> of the Product Innovator. An example of this situation exists in the video cassette recorder (VCR) industry. Despite the myriad of brand names available in the U.S., all products are manufactured by a small number of Japanese companies.

Like the Product Innovator, investment and cost efficiency are not critical to the success of this strategy type. Again, costs and margins have to be controlled so that marketing efforts can be properly supported.

3.4223 Statement Of Hypotheses

The preceding strategy type descriptions have indicated the relative orientation of each differentiation type towards efficiency, flexibility, and dependability. A number of the independent variables incorporated in the regression models of capacity utilization (models I thru IV) can be equated to these three operating criteria. These variables are listed in Table 3.4. For each variable, an indication is given of the "criteria" which are impacted. Finished goods inventory, for example, can be construed as an indicator of dependability of service. In other words, the higher the inventory level, the higher the level of customer service provided. The high inventory, however, will adversely impact investment efficiency.

The objective in essence is to compare a number of the <u>independent</u> variables among the strategy types. The notion is that these independent variables should differ in a consistent and predictable manner.

The hypotheses to follow for the "Differentiators" are summarized in Table 3.5. The format of the hypotheses compares the "Differentiators" not only on capacity utilization, but also on other manufacturing policies.

First, the Product Innovator is distinguished by the "differentiable" manufacturing system. In this sense, the Product Innovator is thus more likely to invest in manufacturing assets. This facet is evi-

Table 3.4

Summary of Policy Decisions and Performance Criteria

Policy Decision & Measure	Operations Performance Criteria		
	Efficiency	Flexibility	Dependability
<u>Aggregate Capacity</u>			
Capacity Utilization	X		X
"Economies of Capacity"	X		X
<u>Process Technology</u>			
"Lumpiness of Investment"	X	X	
Production Process Type	X	X	
Capital Intensity	X	X	
Fixed Cost	X	X	
<u>Infrastructure</u>			
Order Backlog	X		X
Finished Goods Inventory	X		X

Table 3.5

"Diffferentiation" Hypotheses

Hypothesis	Strategy Type	Variable	Relationship To Other Differentiator
5_a	Product Innovator	Capital Intensity	Higher
5_b	Product Innovator	Fixed Costs	Higher
5_c	Marketing Intensive	Capacity Utilization	Lower
5_d	Marketing Intensive	Order Backlog	Lower
5_e	Marketing Intensive	Finished Goods Inventory	Higher

dent in both higher capital intensity and fixed costs for the Product Innovator, as stated by the following hypotheses:

H_{5a}: Capital intensity of the Product Innovator is significantly higher than the Marketing Intensive.

H_{5b}: Fixed costs of the Product Innovator are significantly higher than the Marketing Intensive.

High service dependability, however, is most crucial to the Marketing Intensive. Differentiation must be achieved through service rather than the production process itself. High service is associated with rapid product delivery. As summarized in the following hypotheses, high service levels are manifested through maintaining excess capacity, low order backlogs, and/or high finished goods inventories:

H_{5c}: Capacity utilization of the Marketing Intensive is significantly lower than the Product Innovator.

H_{5d}: Order backlog of the Marketing Intensive is significantly lower than the Product Innovator.

H_{5e}: Finished goods inventory of the Marketing Intensive is significantly higher than the Product Innovator.

3.423 Low Cost

3.4231 Low Cost-Capital Dominated

The success of a business pursuing this strategy truly hinges on its manufacturing prowess and ability to produce efficiently. The business is by definition attempting to be the price leader by virtue of its overall cost position.[15]

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[15]Such "low cost" should be achieved not only in manufacturing, but other functional areas as well. See 4.311 for Porter's (1980) definition of "cost leadership."

Cost efficiency and investment efficiency are thus of utmost importance. Cost efficiency, of course, is also critical to the "Low Cost-Labor Dominated" strategy. However, by definition the core production technology is different. The "Capital Dominated" type is the classic case of the importance of "economies of scale" (e.g. steel production, electric power generation).[16] Investment efficiency thus should be particularly evident in comparison to the other strategy types. Utilization and backlog levels would likely be high in order to operate the process at peak efficiency.

Because the major differences of this strategy are largely manifested in the nature of the manufacturing process, flexibility and dependability of service could also be expected to significantly differ from the other strategy types. The more capital-intensive the process, the more likely that the process is also product-specific. Product flexibility is subsequently also low as is volume flexibility - fixed costs are likely to be high.

3.4232 Low Cost-Labor Dominated

Like the "Low Cost-Capital Dominated" type, the importance of manufacturing to this strategy type is preeminent. And, like the capital-dominated type, the business is attempting to assume price leadership as a result of its manufacturing efficiencies.

The key difference, of course, between these two low-cost types is the nature of the manufacturing technology employed. The particular technology choice for a business is dictated by the characteristics of

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[16]The implications of technology on capacity utilization were summarized in section 2.2, and will not be repeated here.

the product-market, not necessarily the strategy selected. In other words, the likelihood of two different businesses in the same industry both pursuing a "low cost" strategy while using different core manufacturing technologies (capital-intensive and labor-intensive) is quite low. For example, all primary steel producers and oil refiners are capital-intensive - that simply is the nature of the process required for the product. Conversely, clothing and footwear manufacturing is labor-intensive because of the product-market characteristics - a great deal of product variety, variation in the raw material (e.g. leather), frequent product line changes.

Thus, "low cost" can be achieved by either route (labor-intensive or capital-intensive), but probably not in the same industry. The task here, however, is to compare the characteristics of the "Low Cost-Labor Dominated" type with the other strategy types. The comparison with the other low-cost type is the most straightforward. Both types would likely strive for high capacity utilization and backlogs - again to boost cost efficiency, but to the sacrifice of service dependability. Investment efficiency, however, is likely to be different. While economies of scale in "hardware related" capacity are critical to the "Capital Dominated" type to achieve low cost, "economies of scale" as defined in this research are likely to have a different significance for the "Labor Dominated" type. "Low cost" may instead be achieved by having the lowest factor inputs (e.g. locating the plants in low labor cost regions or countries), attaining the highest productivity as a result of employee skills, or through selective improvements in the design of the product or process.[17] Again, simply because of the nature of the

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[17]The latter two factors - employee skills and selective process/

respective manufacturing processes, the labor-intensive type is more flexible (both product and volume).

3.4233 Statement Of Hypotheses

The differences between the two "Low Cost" types are expected to be largely a function of the respective manufacturing process characteristics. Simply put, the "Capital Dominated" producer is more likely to use a continuous process. For example, the most capital intensive facilities (steel or paper mills, power plants, refineries) tend to employ continuous processes. Such a condition would result in higher fixed costs and higher capacity utilization *ceteris paribus*. Similarly, such technology would also be most likely to lend itself to economies accruing to those producers with facilities having the largest capacity (hence the "economy of capacity" hypothesis). The hypotheses to compare the "Low Cost-Capital Dominated" and "Low Cost-Labor Dominated" types are summarized in Table 3.6 and the following:

H_{5f}: The capacity utilization of the "Capital Dominated" type is significantly higher than the "Labor Dominated" type.

H_{5g}: The production process of the "Capital Dominated" type is significantly more "continuous process" oriented than the "Labor Dominated" type.

H_{5h}: Fixed costs of the "Capital Dominated" type are significantly higher than the "Labor Dominated" type.

H_{5i}: "Economy of capacity" of the "Capital Dominated" type is significantly higher than the "Labor Dominated" type.

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product improvements - can be likened to economies of "experience."

Table 3.6

"Low Cost" Hypotheses

Hypothesis	Strategy Type	Variable	Relationship To Labor Dominated
5_f	Capital Dominated	Capacity Utilization	Higher
5_g	Capital Dominated	Production Process	More Continuous Process Oriented
5_h	Capital Dominated	Fixed Cost	Higher
5_i	Capital Dominated	"Economies of Capacity"	Higher

3.424 Summary Of Strategy Hypotheses

The preceding hypotheses have compared "Differentiators" to other "Differentiators," and likewise for the "Low Cost" types. The next "set" of business strategy hypotheses, however, compares "Differentiators" as a group to "Low Cost" types as a group to Custom Producers. The notion presented by these hypotheses is simply that "differentiators" are much more oriented towards flexibility and dependability than the "Low Cost" types. Conversely, the "Low Cost" types are more concerned with policies which opt for maximum efficiency. The hypotheses comparing "Differentiators" to "Low Cost" types (summarized in Table 3.7) are stated as follows:

H_{5j}: Capacity utilization of the "Low Cost" types is significantly higher than the "Differentiators."

H_{5k}: "Lumpiness of investment" of the "Low Cost" types is significantly higher than the "Differentiators."

H_{5l}: The production processes of the "Low Cost" types are significantly more "continuous process" oriented than the "Differentiators."

H_{5m}: Capital intensity of the "Low Cost" types is significantly higher than the "Differentiators."

H_{5n}: Fixed costs of the "Low Cost" types are significantly higher than the "Differentiators."

H_{5o}: "Economy of capacity" of the "Low Cost" types is significantly higher than the "Differentiators."

H_{5p}: The order backlog of the "Low Cost" types is significantly higher than the "Differentiators."

H_{5q}: Finished goods inventory of the "Low Cost" types is significantly lower than the "Differentiators."

This list of hypotheses serves to summarize the discussion of 3.422 and 3.423.

Table 3.7

"Differentiation" vs. "Low Cost" Hypotheses

Hypothesis	Variable	Low Cost Compared to Differentiation
5_j	Capacity Utilization	Higher
5_k	"Lumpiness of Investment"	Higher
5_l	Production Process	More "Continuous Process" Oriented
5_m	Capital Intensity	Higher
5_n	Fixed Costs	Higher
5_o	Economy of Capacity	Higher
5_p	Order Backlog	Higher
5_q	Finished Goods Inventory	Lower

The last set of hypotheses deals with the Custom Producer. The nature of this type is that the "product" dictates a very flexible production process - much more so than a maker of standard products. Likewise, given no or minimal finished goods inventories, "cushioning" of the manufacturing system can only be provided through order backlogs. Such backlogs are thus likely to be much larger than the standard product producer, which has the opportunity to fill orders from inventory. Two statements can therefore be made about this type:

H_{5r}: The production process of the Custom Producer is significantly more "job shop" oriented than the other strategy types.

H_{5s}: The order backlog of the Custom Producer is significantly higher than the other strategy types.

H_{5t}: Finished goods inventory of the Custom Producer is significantly higher than the other strategy types.

To test these business strategy hypotheses, ideally a control (or controls) for the environment must be introduced. Several possibilities exist, for example the product life cycle. For this research, a single control for industry growth will be employed. Although multiple controls may conceptually be more desirable, it is felt that the resulting smaller sample sizes would only further compromise the analysis.

A control for slow to moderate growth environments is ideal for this analysis. The reason for this conclusion is twofold. First, it can be argued that the manufacturing objectives of the strategy types - particularly "differentiators" versus "cost leaders" - should be comparable during rapid growth. Gold (1974), for example, found an emphasis on meeting demand (not cost reduction) in the Japanese steel industry:[18]

> The evidence suggests that continuing increases in the size of blast furnaces in Japan have yielded neither substantially declining average unit operating costs nor substantially declining capital requirements per unit of new constructed capacity, especially beyond 3500 cubic meters. . . But such increases in scale have undoubtedly been rewarding through facilitating the rapid expansion of steel output needed to help satisfy profitable demand in Japan and overseas (p. 14).

A similar argument - need for rapid capacity growth - can be made for the "differentiators." In this case, however, the objective would be to achieve maximum production before the competition could introduce suitable imitations.[19]

The second part of the argument for controlling for industry growth uses the underlying assumption that the business must concentrate its resources on successfully implementing one of the strategy types if it is to be a high performer. Porter (1980, p. 241) notes that the firm can do well <u>regardless</u> of the strategic approach taken <u>prior</u> to the transition to maturity. The business does not have to be the most differentiated or have the lowest overall cost. Maturity will force businesses to confront the need to choose among the strategy types. The applicability of a strategy type to analyzing an introductory, growth, or declining industry is thus unclear.

3.43 The Influence Of Manufacturing Policy On Performance

This test will compare the manufacturing policies by strategy type based on their influence on performance. This test is an important one.

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[18]The implication is that the Japanese are competing on the basis of cost.

[19]This argument is not true for the Custom Producer. Nonetheless, growth will still be used as a control for this type.

For example, even if a linkage between capacity policy and business strategy can be demonstrated through the previous hypotheses, the argument doesn't necessarily follow that the determinants of performance are different between the strategy types. For example, capacity utilization could conceivably have a positive effect on performance in all cases.

The hypothesis for this test can be stated as:

H_{5u}: The manufacturing policies of the different strategy types will have significantly different influences on their respective performance.

The underlying notion explored here is that manufacturing is indeed a "competitive weapon" and will make a difference in the performance of any business irrespective of the strategy which is chosen (Woo and Cool, 1983). A counterargument, however, can be offered. The "Marketing Intensive," for example, should first and foremost have the skills and resources to achieve its competitive edge through marketing and sales programs. Alternatively stated, each of the four business strategy types must have a certain "distinctive competence" to be a high performer; i.e. what the business does particularly well. To illustrate, the performance of the "Marketing Intensive" would likely rise and fall largely on its ability to market, not manufacture.

These competing points of view can be resolved by viewing them as a matter of degree. Those businesses which would logically require a distinctive competence in manufacturing - the two "Low Cost" strategies - should show a large performance differential between businesses as a function of capacity utilization. The other three strategy types would show a smaller performance differential; for these firms sheer success or failure, however, is likely to rest on other factors, such as the ability to market or innovate. In summary, manufacturing characteristics would be expected to impact performance for all business types, however the degree of impact will likely vary by strategy type.

The heart of the regression model used to test this hypothesis can be stated as follows:

ROI = f(CU, CAP INCR, PROCESS, CAP INT, FIXED, ECON CAP, BACKLOG, FIN GOODS) (VI)

All of the above variables have been defined and used in previous models. A number of additional non-manufacturing variables which should be significantly associated with ROI will also be incorporated into Model VI to reduce misspecification errors.

3.5 Chapter Summary

Hypotheses 1_a thru 2_k represent the independent variables used to explain variance in capacity utilization. The effect of many of these variables is expected to be contingent upon seller concentration, production process, or growth. To assess these contingencies, the regression submodels will be tested against different data subsamples (e.g. high growth and low growth). Hypotheses 3_a and 3_b will be used to test the effect on the model of two additional contingent variables - the product life cycle and industry type.

The next set of hypotheses (4_a - 4_i) is used to assess the impact of capacity utilization on performance. Although a positive association is generally expected, several situations are posed which would provide differing results.

The tests of the effect of business strategy on capacity utilization and a series of independent variables (i.e. capital intensity) were described in Hypotheses 5_a thru 5_t. Hypothesis 5_u examines the effect of manufacturing policies on performance. In summary, these tests will in total look at the consistency between business strategy, capacity policy, and business performance.

CHAPTER IV

DEFINITION OF VARIABLES AND METHODOLOGY

This chapter is organized into five main sections. The first section provides a brief discussion of the PIMS data base. The pertinent feature, advantages, and drawbacks of using this data base are included. The second section defines the variables which will be used to test Hypotheses 1_a through 3_b. This section will also outline the samples to be used and the statistical analyses to be performed. The third section explains the statistical analyses and samples used for the capacity utilization - performance tests (Hypotheses 4_a to 4_i). The fourth section deals with the business strategy effect. The bulk of the section is devoted to the algorithm used to classify businesses into strategy types. The samples and statistical analyses are specified. The last section provides an overview of the data samples used for the capacity utilization modeling.

4.1 The PIMS Data Base

The data used for this research is drawn from the Profit Impact of Market Strategies (PIMS) project. The PIMS project is an ongoing, large-scale study of financial, competitive, market, functional, and organizational information. Approximately 600 corporations have submitted data on over 2,000 business units. Each business unit is defined as a "division, product line, or other profit center within its parent company, selling a distinct set of products or services to an identifiable group or groups of customers, in competition with a well-defined set of competitors" (Buzzell *et al.*, 1975).

The limitations and biases of this data base have been discussed at length by various authors (Anderson and Paine, 1978; Lubatkin and Pitts, 1983; Hambrick, MacMillan and Day, 1982; Galbraith and Schendel, 1983). Criticisms have generally focused on the biased nature of the sample, reliability of the data, and generalizations which can be made from the results. These concerns are addressed in the following paragraphs.

The sample can be biased in the sense that most businesses that participate in the PIMS project tend to be divisions of large corporations. In all likelihood these divisions enjoy the support of superior resources in comparison to the single business firm. As a result, the participating businesses are probably more sophisticated, more dominant within their markets, and more effective in general than the total populace of businesses in the United States. A secondary factor is the influence of intracorporate relationships. Strategy for the business may be partly determined by its role within the corporation (e.g. intracorporate sales and/or purchases). Similarly, pricing of related products and allocation of overheads costs may be beyond the control of the business unit. In summary, the businesses in the PIMS data base probably cannot be viewed as typical of business units in general.

The data reliability and quality issue is a potential problem simply because of the large number of businesses and variables (over 200), coupled with the judgemental nature of many of these variables (e.g. relative quality level). Inaccurate information and misinterpretation of questions by member firms is thus of concern. Two factors, however, commend the data collection effort. First, PIMS staff members help each business interpret and answer the questions, thus assuring a high degree of data comparability. This degree of assistance is missing from conventional questionnaire studies. Second, each company pays a substantial sum to participate in the PIMS project. The financial commitment would thus appear to doubly obligate the company to thoroughness and accuracy, otherwise meaningful conclusions from the data would be less likely. Phillips *et al.* (1983) tested for the reliability of these measures, and indeed found that independent observations taken over time from different questionnaire respondents tended to measure the same latent variable.

The last criticism - generalizations made from the results - represents a potential problem which is under the most direct control of the researcher. For example, a common focus of most PIMS-based research is to uncover "universal truths of the marketplace," such as the relationship between market share and ROI. Such relationships, however, may not apply equally well to <u>all</u> industry sectors, time periods, strategies, or sizes of businesses (Lubatkin and Pitts, 1983). Empirical analyses as a result may suffer serious distortions. Bass, Cattin, and Wittink (1978) have demonstrated that parameter estimates may be inaccurate when observations across heterogeneous industry groups are pooled. One of the tasks for the researcher, then, is to "de-pool" the sample so that such distortions are minimized.

Other criticisms of the data base have been voiced, such as the disguised identities of the businesses, and that analyses of PIMS data are largely limited to the capabilities of the accompanying statistical package (Analysis of Quantitative Data) (Woo, 1979, p. 104). Despite these various concerns, criticisms, and limitations, however, important considerations opt for the use of this data base. For one, the nature and quantity of information in PIMS is simply not available from any other source. Independently creating like data for research of this scope is impossible given the time and resource constraints. Second, the data base is widely used for strategy research, and the aforementioned criticisms are well known. In a sense, use of this data thus acts as a *de facto* control or "benchmark." The accuracy of results are at least less questionable with respect to data quality and the data gathering process.

4.2 Tests Of Hypotheses 1a Thru 3b

The three subsections to follow describe the operationalization of variables, subsamples of the data base to be used, and a summary of the statistical analyses and methodologies.

4.21 Specification Of Variables

Table 4.1 first lists the factors described for each of this first group of hypotheses from Chapter III. The table then names the PIMS variable which has been selected to operationalize the factor, the PIMS variable number, and the variable type (interval (I) or categorical (C)). If the variable is not predefined, a "T" (for transformation) is shown in the variable number column, and the calculation used for the transformation is shown in the "Description" column. Comments about each variable are offered where appropriate. All of the variables will be standardized prior to conducting any of the statistical analyses.

The following sections will briefly explain a few additional key

Table 4.1

Specification of Variables (Hypotheses 1_a - 2_k)

	Hypothesis and Factor	PIMS Variable	#	Type	Description/Discussion
	<u>DEPENDENT VARIABLE</u>				
	Capacity Utilization	Same	236	I	% of standard capacity utilized, including production for inventory.
	<u>INDEPENDENT VARIABLES</u>				
	Models I And II				
1_a	"Lumpiness of Investment"	Capacity Increment	454	I	Minimum amount by which capacity can be efficiently increased as a % of total capacity.
1_b	Demand Growth	Real Market Growth	366	I	Adjusted for price changes.
1_c	Demand Variability	Served Market Instability	465	I	Average percentage difference from an exponential trend of the time series.
1_d	Order Backlog	Same	63	I	% of revenues.

Specification of Variables
(continued)

	Hypothesis and Factor	PIMS Variable	#	Type	Description/Discussion
1_e	Regional Business	-	T	C	1 if #68 (location of market served) is "4" (regional within U.S. and/or Canada), 0 otherwise.
1_f	Production Process Type	-	T	I	1 if Small Batch, 2 if Large Batch/ Assembly, 3 if Continuous Process.
1_g	Fixed Capital Intensity	-	T	I	#345/#290. The ratio to gross book value to capacity is adjusted for relative price.
1_h	Fixed Costs	-	T	I	(((#122 - #117)/#201) X #345)/#290. The assumption is that depreciation is primarily a fixed expense, and other manufacturing expense are primarily variable. The ratio of depreciation to capacity is adjusted for relative price.
1_i	"Economy of Capacity"	-	T	I	#281/#290. Relative market share adjusted for relative price.
1_j	Finished Goods Inventory	Same	181	I	% of revenues.

Specification of Variables
(continued)

	Hypothesis and Factor	PIMS Variable	#	Type	Description/Discussion
	Models III And IV				
2_a	Seller Concentration	Same	460	I	Based on served market.
2_b	Product Differentiation	Marketing/ Revenue	162	I	A slightly different operationalization was used here than in the Esposito and Esposito model (advertising/revenue in the latter case).
2_c	Irregular Product Change	-	T	C	1 if #10 (frequency of product change) is "no regular pattern," 0 otherwise.
2_d	Purchase Frequency	Same	27	C	1 if weekly or more frequently to 6 if once every 5 to 10 years. Will be used as a continuous variable.
2_e	Entry	Same	70	C	1 if a competitor entered the served market and attained at least a 5% market share, 0 otherwise.
2_f	Exit	Same	71	C	Same concept as above.

Specification of Variables
(continued)

	Hypothesis and Factor	PIMS Variable	#	Type	Description/Discussion
2_g	Net Exports	Same	334	I	% industry export sales minus % industry imports.
2_h	Product "Youth"	Age of Product	3	I	1 if introduced prior to 1950, 2 if 1950-54, 3 if 1955-59, 4 if 1960-64, 5 if 1965-69, 6 if 1970-74, 7 if 1975 or later.
2_i	Technological Change	Same	11	C	1 if major product or process changes have occurred during the last 8 years, 0 otherwise.
2_j	Number of Customers	Buyer Fragmentation	348	I	No. of immediate customers which accounted for 50% of total sales.
2_k	Inflationary Pressures	Price-Cost Squeeze	341	I	The difference between selling price growth and cost growth.

points about several of the variables in Table 4.1. For the most part, these comments are required because of the unique operationalizations used for this research.

4.211 Capacity Utilization

PIMS measures capacity utilization as "the percentage of standard capacity utilized on average during the year, including production for inventory." Since standard capacity is expressed as the current dollar value of the units which can be potentially produced, capacity utilization would be net sales plus or minus the change in inventories divided by net sales. PIMS also provides guidelines to the reporting businesses for establishing standard capacity:

> For most manufacturing businesses, this will consist of 2 shifts, 5 days per week. For process businesses, a 3-shift, 6 day period is typical.

The net effect of this guideline is that standard capacity will be established on a comparable basis for all businesses.

4.212 Production Process Type

The production process variable has been specified for Model II. Table 4.2 shows the four production process variables contained in the data base. To ease comparisons of the process characteristics of various data samples, these variables will be combined into a single scale. In a sense, this scale replicates the process continuum of the product-process matrix (Hayes and Wheelwright, 1979a). Each business is then "located" on the scale by an index value.

As a first step in constructing the scale, all businesses which reported any sales derived from non-manufacturing activities (variable

Table 4.2

PIMS Production Process Variables

Variable	Description
90 - 93:	What percentage of this business's sales were derived from: (accuracy within 10 percentage points is adequate)
90:	Products manufactured singly or in small batches (production runs normally under 200)?
91:	Products manufactured in large batches or in an assembly line?
92:	Products manufactured using a continuous process?
93:	Non-manufacturing activities? (Service and distribution businesses should enter 100%)
	Total = 100%

93 greater than zero) were dropped from the sample. The reason for this step is to pointedly exclude companies which act as "middlemen" (buying and selling of goods). The number of businesses is not expected to be large, since at this point services and distribution businesses have already been excluded.

Two distinct methodologies for combining variables 90, 91, and 92 were identified. The first methodology simply computes a "score" for the production system. The score is derived by multiplying variable 90 by 1, variable 91 by 2, and variable 92 by 3; adding the three products; and finally dividing the sum by 3. A score of "1" thus represents a business whose products are manufactured totally in small batches; a "3" all continuous process. The potential problem with this method, however, arises for intermediate scores. A "2" could be either 100% assembly <u>or</u> varying mixes of the process types. Due to this problem of identification, the first method was rejected.

The second method - the one selected - employs a simple algorithm for assigning scores which alleviates the problem of combining different process types. A manufacturing system which is <u>predominantly</u> small batch is identified by Variable #90 showing a percent value of 51 or greater. A business falling into this category is assigned a score of "1." Similar rationales are used to assign score of "2" for predominantly large batch/assembly (Variable 91 is 51 or greater) and "3" for continuous processes (Variable 92 is 51 or greater). Process "continuity," then, is represented by high scores on this scale. Businesses which do <u>not</u> have a score of 51 or greater for any of the three variables (90, 91, or 92) will be excluded.

4.213 Capital Intensity and Fixed Costs

The capital intensity variable is to be incorporated in Models II, III, and IV; a fixed cost variable is likewise required for Model II. Since standard capacity is expressed as the current dollar value of the potential units produced, the opportunity is afforded to express both capital intensity and fixed costs in relation to capacity (instead of revenues). Gross book value and fixed costs (depreciation) are thus simply divided by standard capacity.

A further adjustment to these ratios is made for relative selling price (#290), since the capacity measure for each business will be inflated (or deflated) due to differences in selling prices. The resulting measures are more comparable on a unit basis.

4.214 Economy Of Capacity

The "economy of capacity" measure is specified in Model II. This concept is assumed to be captured in the measure of relative business size - relative market share (#281). This variable embodies "economy of capacity" and probably cumulative experience. However, since "economy of capacity" is intended to relate to the unit capacity of the business, relative share must be divided by relative price (#290). The resulting calculation is relative share in terms of units, not sales dollars.

4.215 Seller Concentration

This variable will be used in Models III and IV. Concentration of the served market instead of the industry will be used. Industry concentration is based on census data by SIC code, whereas the served market is essentially the perception of the reporting business. The latter is felt to be more accurate, particularly since product and geographic dimensions are probably narrower. Industry and served market measures are not necessarily highly related - Caves and Porter (1978) found only a +.20 correlation between the ratios. "Served market" instead of "industry" will thus be used if possible for any of the other variables (e.g. entry/exit, imports, real demand growth).

4.216 Regularity of Product Change

Product change is incorporated in Models III and IV. The concept is specified using a dummy variable, where businesses which have no regular pattern of product change are designated as "1." The reasoning is that businesses which have a regular pattern of product change (i.e. seasonal or annual) are more likely to structure their manufacturing systems to accomodate such change. Businesses with no regular pattern of change are thus more likely to experience lower capacity utilization when such change occurs.

4.22 Data Samples

This section describes the means of identifying the various data samples used. The content of these samples is summarized in Table 4.3.

The PIMS data base chosen is SPI4. In general, the data reported in SPI4 encompasses a succession of four-year periods.[1] Ratio-type variables are thus four-year averages.[2]

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[1]Two other data bases can be accessed if desired. SPI4L is the same as SPI4, except that only values from the most recent four-year period are contained. SPIYR contains annual (not four-year) data.

[2]Variables which report point or percent changes (e.g. growth rates) and scalars which will not change over time (e.g. type of business) will also be used.

Table 4.3

PIMS Data Samples

Sample/Variable(s)	#	Description
<u>Main Sample</u>		
Industry Type	2	Exclude businesses with values of 7 (services) or 8 (retail and wholesale distribution).
% of Sales Derived From Non-Manufacturing Activities	93	Exclude businesses with values greater than zero.
Location of Served Market	68	Exclude businesses with values of 5 (U.K.), 6 (Common Market), 7 (regional within Europe), or 8 (other). The assumption is that businesses which serve <u>only</u> foreign markets will also have overseas production facilities to serve these markets.
Supply Limitations	50	Exclude businesses with values of 1 (scarcity of materials).
	51	Exclude businesses with values of 1 (scarcity of energy).
	52	Exclude businesses with values of 1 (scarcity of personnel).

PIMS Data Samples
(continued)

Sample/Variable(s)	#	Description
Concentration Subsamples	460	High (>70%), Medium (40-70%), Low (<40%).
Process Type Subsamples	90,91,92	Small Batch, Large Batch/Assembly, Continuous Process
Market Growth Subsamples	366	Negative, Low to Moderate, High
Product Life Cycle Subsamples	4	Introductory, Growth, Mature, Decline
Industry Type Subsamples	2	Consumer (Durable, Nondurable), Industrial (Capital Goods, Raw/Semi-Finished Materials, Components, Supplies).

SPI4 contains one observation for each rolling four years of a business's data. For example, if a business submits data for the period 1975-1980, three observations will be found - one each for 1975-1978, 1976-1979, and 1977-1980. For this research only one observation will be used for each business in the data base (ideally the "last" available observation for each business).[3] However, since "turnover" is businesses participating in the PIMS project does occur, the "last" observation for each business may not be the most recent four-year period. Any bias which might be imparted by pooling different time periods is expected to be minimal, since variables such as industry demand growth, demand variability, and inflationary pressures have been incorporated. The use of four-year averages also tends to minimize the impact of year-to-year fluctuations.

4.221 Exclusions From The Data

Three types of businesses will be pointedly excluded from the data analysis - service businesses, businesses which manufacture their products internationally, and businesses which have experienced supply limitations. To date little research has been undertaken which addresses business strategies in service industries, let alone capacity strategies. These businesses are identified in the data base using the "industry type" variable (#2). As discussed in 4.212, businesses which report any sales from non-manufacturing activities (#93) are also excluded to insure a "pure" sample.

International manufacturing adds another degree of complexity to

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[3]Using multiple observations from each business could create problems in that the regression residuals will not be independent.

the analysis. Issues such as technology transfer, exchange rates, and the political climate of the host nation will influence the degrees of freedom the firm has in the design of a manufacturing system. These businesses are identified using the "location of served market" variable (#68).

The last business type excluded has experienced constraints on the ability to increase output by 10% due to a scarcity of inputs (materials, personnel, or fuels and energy). A business which responds affirmatively has thus indicated that capacity utilization may have suffered.

One business type which could be problematic produces raw or semi-finished materials. "Low Cost-Raw Materials Dominated" businesses were excluded from the discussion of business strategy types principally because of lack of knowledge about these types. Insufficient information, however, is contained in PIMS to directly identify this business type.[4] The extent of any inherent bias is a likely function of how many "pure" raw materials businesses are resident in the data (e.g. coal mining) versus businesses which involve significant additional processing of the material (e.g. lumber, iron and steel, aluminum).

4.222 Data Subsamples

Five subsamples of the "main" sample will be constructed to test the "contingency" effect of served market concentration, production process type, market growth, product life cycle, and industry type. The served market concentration measure will be split into "thirds"

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[4]The properties of such a business could probably be deduced - low purchases, low imports/exports, mature stage of the life cycle, etc. - however this approach is not preferred.

representing atomistic industries, partial oligopolies, and tight oligopolies. The Esposito and Esposito (1974) cut points of 40 and 70 will be used for purposes of replication. Three process type subsamples will be used: 1) small batch (value of the process variable is 1), 2) large batch or assembly (value is 2), and 3) continuous process (value is 3).

Three growth subsamples will be constructed. The cut points for these subsamples are 0% and 10%. The subsamples would thus distinguish between 1) negative real growth, 2) low to moderate real growth, and 3) high real growth. 10% real growth is chosen as the upper bound since this is usually the nominal value shown in business portfolio models for establishing "industry attractiveness" categories (Hedley, 1977).

The characteristics of these various subsamples are presented later in this chapter (4.5). Sample sizes, means, and analysis of variance will be discussed at this point.

4.23 Statistical Methods

Ordinary least squares regression is assumed to be appropriate for this analysis. Each of the estimates of the β's is expected to be a linear function of the Y values. Furthermore, the assumptions associated with the general linear model (e.g. properties of the error terms) are expected to be satisfied (Johnston, 1972, p. 122; Kleinbaum and Kupper, 1978, p. 136). The following subsections describe the successive steps used in running and testing the regression model.

4.231 Hypotheses 1a Thru 2k

The first phase of the hypothesis testing will be to run each of the regression models (I thru IV) separately using the entire data sample. Of particular concern at this juncture is violation of the linear dependence assumption (multicollinearity) within each submodel. To deal with this problem, variables that exhibit collinearity with a statistically stronger variable (a correlation of .3 or greater) will be eliminated. Although this deletion may result in a loss of information, the step is a necessary one.

The second phase will be to test the contingent effects of concentration, process type, and growth upon the models. To reiterate the discussion of 4.22, the concentration, process type, and growth subsamples will be constructed independently (i.e. combinations of the three contingent variables will not be attempted).[5] Two separate steps will be undertaken to test the contingency effect. First, for each independent variable one-way analysis of variance will be used to identify significant differences between each subsample and the total sample. For example, differences in the level of "lumpiness" of investment will be compared between the total sample and the negative real growth, low real growth, and high real growth subsamples. The second step will be to re-run both extended regression models (II and IV) for each of the subsamples. The objective is to see if the sign and/or significance of the effect on capacity utilization changes between the subsamples. The coefficients for the different subsample regression runs will also be

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[5]A potential loss of information or bias can occur using this subsample design if significant interaction occurs between the contingent variables (e.g. concentration and process type). The extent of any such interaction could be assessed using two- or three-way analysis of variance. However, since these contingent elements are not at the heart of the research, this step is not deemed necessary.

compared using the Fisher Z-test.[6]

The significance of individual regressions and of individual regression coefficients will be assessed using F- and t-statistical tests respectively.

4.232 Hypotheses 3a and 3b

These hypotheses state that the product life cycle and industry type will not significantly alter the capacity utilization models (II and IV) formulated above. To test these hypotheses, regression models II and IV will be rerun using product life cycle and industry type sub-samples. The results will then be compared using Chow tests. The Chow test is a test of equality between coefficients in two identical models based on two different sets of data (Chow, 1960).[7]

4.3 Tests Of Hypotheses 4a Thru 4i

The key independent variables (capacity utilization, growth, fixed capital intensity, seller concentration) are unchanged from the definitions in Table 4.2. All of these variables are continuous as are the specified interaction terms.

A second issue is to select an appropriate performance measure. Woo and Willard (1983) reviewed alternative measures of business performance and proposed a "framework which will reflect the key dimensions of performance." The authors found that a broad set of performance measures could be reduced to four primary dimensions - profitability,

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[6]See Appendix A for a description of the Fisher Z-test.

[7]See Appendix B for a detailed description of how this test is made.

relative market position, change in profitability and cash flow, and growth in sales and market share. The authors concluded that profitability (ROI) was the most revealing of the performance measures:

> Despite the problems inherent in ROI, results from this study would support the continued use of this measure. The profitability factor demonstrated the highest factor magnitude and significantly exceeded the magnitude of the second factor. ROI was also strongly correlated with its commonly suggested replacement, cash flow.

This conclusion agrees with the results of Reece and Cool (1978). The vast majority of the Fortune 1000 firms surveyed felt that ROI was the best approach to use in evaluating division performance. The corresponding PIMS variable which will be used is #172.

The data samples used for the testing of these hypotheses is the same as used for Hypotheses 1_a through 3_b. No further deletions or subsamples are deemed necessary.

Last, ordinary least squares regression will also be used for Model V for the same reasons stated in 4.23. The significance of individual regression coefficients will be examined using *t*-statistical tests.

4.4 Tests Of Hypotheses 5a Thru 5u

The three subsections to follow describe how the business strategy types are identified in PIMS, the growth and performance classifications, and the statistical tests performed.

4.41 Identification Of Business Strategy Types

This subsection outlines the methodology used to identify the five business strategy types. The methodology is based on the "decision tree" diagram shown in Figure 3.3. Each of the five types thus represents a combination of the four "decision nodes" in the figure.

The following discussion highlights the key points concerning each "node." These "decisions" are also summarized in Table 4.4.

4.411 Standard Versus Custom

Variable #9 reports whether the business's products are "more or less standardized for all customers, or designed or produced to order for individual customers." The Custom Producer is thus solely represented by a value of "1" on this variable. The other four strategy types are all manufacturers of standard products (a value of "0"), and this is the first step in their identification.

4.412 High Price Versus Low Price

The second "cut" separates businesses with high and low relative product prices. In essence this segregation is intended to establish the Porter (1980) "cost leadership/differentiation" dichotomy.

Other authors have used both relative price and relative cost (White, 1983; Woo and Cool, 1983). "Cost leadership" is then a combination of low relative price and low relative cost; "differentiation" is high relative price and high relative cost. Unfortunately, this method used by these authors is a misinterpretation of Porter's generic strategies and/or the PIMS data.

To understand the problem, the following quotes give the salient points of Porter's strategy definitions:

> Cost leadership requires aggressive construction of efficient-scale facilities, vigorous pursuit of cost reductions from experience, tight cost and overhead control, avoidance of marginal customer accounts, and cost minimization in areas like R & D, service, sales force, advertising, and so on (p. 35).
>
> . . . achieving differentiation will imply a trade-off with cost position if the activities required in creating it are inherently

Table 4.4

Strategy Type Identification

Classification	Variable No.(s)	Description
Standard vs. Custom	9	1 = custom product, 0 = standard.
High Price vs. Low Price	290	Low price - 1.00 or below, high price - above 1.00.
Product vs. Marketing	142,162	Product - the combination of high R & D (#142) and low marketing (#162), Marketing - low R & D and high marketing.
Capital Dominated vs. Labor Dominated	201	Capital - greater than low price average fixed capital intensity, Labor - less than low price average fixed capital intensity.

> costly, such as extensive research, product design, high quality materials, or intensive customer support (p. 38).

Both definitions imply that the overall cost position of a business includes not only manufacturing cost, but also R & D and marketing/service-related cost. The PIMS "relative cost" variable, however, includes "costs of materials, production, and distribution, but excludes marketing and administrative costs" (Strategic Planning Institute, 1978, p. 3-49). R & D is also excluded.

The "relative cost" variable therefore tells only half the story. In fact, arguments can be easily made that a "differentiator" should have lower "relative cost" (i.e. material, production, and distribution), especially if the business is the share leader in its market. Caterpillar and Coca-Cola, for example, could achieve low relative manufacturing cost through "buyer power," manufacturing scale, etc. The "differentiator," though, does not "pass" the cost reduction along in the guise of lower prices - the "savings" are instead used to support more intensive marketing programs, customer service, or product development.

The only reliable "first cut," then, is on relative price. Woo and Cool separated the data base into three parts using the relative price variable. They used splits of "1.00 and below" and "1.05 and above." The authors then dropped businesses with relative prices between 1.00 and 1.05. The implication is that these "moderately higher-priced" businesses are in some way different than businesses with much higher prices. Woo and Cool, however, did not supply any rationale or tests as to why this should be the case.

Subsequently, no clear-cut advantage to multiple cutpoints as opposed to using a single cutpoint for high and low price (1.00) can be offered. For this research a single cutpoint (1.00 and above) will therefore be used.

To summarize to this point, the two "Low Cost" types (Capital Dominated and Labor Dominated) are represented by a value of "0" on the Standard/Custom identifier, and a relative price of less than 1.00. Conversely, the "Differentiators" (Product Innovator and Marketing Intensive) also have value of "0" for the Standard/Custom identifier, but relative prices of 1.00 or greater.

4.413 Product Versus Marketing

This categorization is the least clear-cut of the four to make. The proposed method rests on the assumption that the key distinguishing feature between these two strategy types is the allocation of resources between marketing and technology. The Marketing Intensive, for example, should devote much more of its resources to marketing than technology.

The mean and median of total marketing expenses to sales and total research and development expenses to sales will be calculated for the "high price" sample. Based on these values, a cutpoint for each of the two variables will be selected which categorizes each business according to its level of both expenses (either "high" or "low"). The "Product Innovator," then, is identified by high R & D and low marketing expenses; conversely, the "Marketing Intensive" has low R & D and high marketing expenses. Obviously two other combinations are possible (the "low - low" and "high - high"). No hypotheses have been developed concerning either type. However, the reasonability of the cutpoints will be assessed by calculating the percent of sales accounted for by new products (both on an absolute basis and relative to the competition) for each of the four categories. Ideally, new product revenues should be higher for businesses with higher levels of R & D or marketing. Finally, for purposes of comparison manufacturing policy variable averages will also be calculated for the "high - high" type.

4.414 Capital Dominated Versus Labor Dominated

Variable #201 reports fixed asset intensity (gross book value/ revenue). The assumption for this final categorization is that low fixed asset intensity equates to labor dominance. The assumed cut point for distinguishing high versus low fixed asset intensity will be simply the average of the low relative price businesses (not the entire sample). The distribution, however, will also be examined to see if a more logical value is apparent.

4.42 Data Samples

The subsample used for the business strategy classification will be low to moderate growth industries (0-10% real growth). To reiterate, the reason for using this subsample is that the distinctions between strategy types should most clearly emerge in a moderate growth environment. The method used to identify this growth sample was previously discussed in 4.222.

4.43 Statistical Methods

Hypotheses 5_a thru 5_t essentially state the differences in the manufacturing policy variables which will be expected between the business strategy types. The testing will be performed via a series of Z-tests which compare the means of the pertinent manufacturing variables.

The major task in testing Hypothesis 5_u is to partition the data sample in order to test the effects of the different business strategies on the manufacturing - business performance relationship. The method used for this analysis will be to first run Model VI separately for each strategy type to allow the independent variables to take on a different value for each set of data. The coefficients for the respective strategy type regression runs will then be compared using the Fisher Z-test.

To conclude the discussion of statistical methods, Table 4.5 summarizes all of the statistical analyses to be performed which have been described in 4.2, 4.3 and 4.4. As mentioned previously, a minor drawback is that the researcher is limited to the analytical packages used with PIMS. This qualifier, however, can be largely discounted since the strength of this study's conclusions are more likely to rest on careful design of the tests and thoughtful qualitative analysis of the results, rather than the sheer methodological "horsepower" brought to bear.

4.5 Overview Of The Samples

The subsection of follow (4.51) discusses relevant facets of the construction of the main sample used. Next, 4.52 reports trends in the variables revealed by the various subsamples.

4.51 Sample Sizes

The following two exhibits present some overview information regarding the data samples used for the tests of hypotheses. Table 4.6 shows the relevant observation counts by the following categorizations: served market concentration, served market growth, type of production

Table 4.5

Summary of Statistical Analyses

Hypotheses	Description	Tests
1_a - 2_k	Tests of Capacity Utilization Models (I, II, III, IV)	OLS Regression, Fisher Z-tests
3_a - 3_b	PLC and Industry Type as Contingent Variables to Capacity Models (II, IV)	OLS Regression, Chow Tests
4_a - 4_i	Industry Effect of Capacity Utilization - Performance Relationship (Model V)	OLS Regression
5_a - 5_t	Comparisons of Manufacturing Policies of Business Strategy Types	Pairwise Z-tests
5_u	Comparison of Manufacturing Policies of High and Low Performers (Model VI)	OLS Regression, Fisher Z-tests

Table 4.6

Sample Sizes

Subsamples	Observations
TOTAL OBSERVATIONS	*887*
Concentration	
Atomistic	82
Partial Oligopoly	251
Tight Oligopoly	554
Growth	
Negative	354
Low/Medium	374
High	159
Production Process Type	
Small Batch	237
Large Batch/Assembly	507
Continuous	143
Product Life Cycle	
Introductory	8
Growth	151
Mature	682
Decline	46
Industry Type	
Consumer	
Durables	161
Non-Durables	131
	292
Industrial	
Capital Goods	151
Raw/Semi-Finished Matl.	91
Components	224
Supplies	129
	595

process, product life cycle, and industry type. Table 4.7 simply lists the abbreviated titles of the dependent and independent variables used in the exhibits to follow.

Prior to exclusions, the PIMS data base consisted of over 6,000 observations on approximately 500 variables. After the exclusions listed in Table 4.3 (service/non-manufacturing businesses, foreign businesses, businesses experiencing supply limitations), 887 observations were left. The value selected for the key variables was the four-year average. Although this choice was felt to be most appropriate for cross-sectional analysis, nevertheless some results were most likely distorted as a consequence (e.g. the effect of served market growth instability on capacity utilization). Such "distortions" will be discussed in more depth at the appropriate point in this chapter.

The relative sample sizes shown in Table 4.6 were for the most part expected. The majority of the sample is industrial businesses competing in tight oligopolies (four-firm concentration ratio greater than 70) in the mature stage of the product life cycle. The majority are also using predominantly an assembly line or large batch runs (greater than 200) as the means of production.

One anomaly, however, did surface. *A priori* a close correspondence would be expected between the demand growth rate and the product life cycle stage. For example, "introductory" and "growth" industries would experience high real growth rates; "mature" industries a low to moderate real growth rate; and "declining" industries negative real growth.[8]

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[8]In fact, PIMS defines an industry in the growth stage as "demand growing at 10% or more annually in real terms; technology or competitive structure still changing." The mature and decline stages are not defined by growth rate. For example, "maturity" is typified by products familiar to users and the technology/competitive structure is reasonably

Table 4.7

Legend for Reporting of Results

Variable "Shorthand"	Description
CAP UTIL	Capacity Utilization
Models I And II	
CAP INCR	Capacity Increment ("Investment Lumpiness")
SM GROWTH	Served Market Demand Growth
SM INSTAB	Served Market Demand Variability
BACKLOG	Order Backlog
REGIONAL	Regional Businesses
PROC TYPE	Production Process Type
CAP INT	Fixed Capital Intensity
FIXED	Fixed Costs
ECON CAP	Economies of Capacity
FIN GOODS	Finished Goods Inventory
Models III And IV	
SM CONCEN	Served Market Concentration
PROD DIFF	Product Differentiation
PROD CHG	Irregular Product Change
PUR FREQ	Purchase Frequency
SM GROWTH	Served Market Demand Growth
CAP INT	Fixed Capital Intensity
SM ENTRY	Served Market Entry
SM EXIT	Served Market Exit
NET EXPORTS	Net Exports (Exports Minus Imports)
PROD AGE	Product "Youth" ("Age of the Product")
TECH CHG	Technological Change
CUST CONCEN	Customer Concentration
P-C SQZE	Inflationary Presures ("Price-Cost Squeeze")

Such a correspondence existed for "high real growth" and the sum of "introductory" and "growth" businesses - a total of 159 observations for each. However, a rather large discrepancy was found in comparing the number of "declining" stage businesses (46) to businesses in served markets experiencing negative real growth (354). It is difficult to rationalize such a difference, except for possibly a natural reluctance on the part of a business to classify itself as being in a "declining" industry. The PIMS definition of a "declining" industry may also be partially at fault. An industry can be in the decline stage without the products being viewed as commodities (e.g. baby foods, cigars). Differentiation may still be achievable through brand name loyalty, exclusive distribution channels, etc. Although such an issue cannot be resolved here, it may be an appropriate area for future investigation.

4.52 Trends In Variable Means

A major reason for the development of subsamples is that a number of contingent relationships are expected which would impact the significance and/or direction of the correlation between any given independent variable and capacity utilization. Such contingent relationships can be viewed in two ways. One, the independent variable may vary systematically as a function of the contingent factor (e.g. the occasion of significant entry into the industry is likely to be impacted by the growth rate). Second, the effect of the variable on capacity utilization may also vary based on the contingent factor. In summary, to fully understand what is happening for each independent variable, its

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stable; the "decline" stage sees products viewed as commodities and exit starting to occur.

mean and its effect on capacity utilization must be compared between the subsamples. The purpose of this section is to review the former - the effect of the contingent factors on the means of the dependent and independent variables.

Table 4.8 reports the mean and standard deviation prior to standardization for all observations of the same set of variables listed in Table 4.7. The values in this table by themselves do not convey any key information, and as such are provided mainly for informational purposes.

The three sections to follow give a general discussion of the influence of concentration, growth, and process type on the means of the dependent and independent variables. The ANOVA package resident in PIMS which was used for this analysis compared the mean value for each particular subsample (i.e. atomistic, partial oligopoly, tight oligopoly) to the general mean of the overall sample. Although this statistical approach may not be as preferable as pairwise comparisons between the subsamples, nonetheless this evaluation of the overall appropriateness of concentration, growth, and process type as contingency factors is desirable.

4.521 Concentration Subsamples

Table 4.9 gives the results for the analysis of variance of the concentration subsamples. A number of the significant differences shown cannot be explained logically, nonetheless a few consistent patterns did emerge.

Curiously, the businesses in atomistic served markets exhibited the highest capacity utilization. This pattern is somewhat counter to what would be anticipated from the Esposito and Esposito work *ceteris paribus*

Table 4.8

Mean And Standard Deviation - Key Variables (All Observations)

Variable	Mean	Standard Deviation
CAP UTIL	74.04	14.95
Models I And II		
CAP INCR	17.03	20.45
SM GROWTH	2.63	10.94
SM INSTAB	8.06	6.35
BACKLOG	11.32	17.22
REGIONAL	.19	.39
PROC TYPE	1.89	.65
CAP INT	31.48	21.44
FIXED	17.16	12.93
ECON CAP	.62	.63
FIN GOODS	7.77	6.80
Models III And IV		
SM CONCEN	73.18	21.51
PROD DIFF	8.85	6.73
PROD CHG	.76	.42
PUR FREQ	2.79	1.04
SM ENTRY	.25	.43
SM EXIT	.17	.38
NET EXPORTS	2.30	8.06
PROD AGE	1.99	1.44
TECH CHG	.26	.44
CUST CONCEN	277.73	837.65
P-C SQZE	-0.81	4.27

Table 4.9

Analysis of Variance - Concentration Subsamples

Variable	Means (Standard Deviations)		
	Atomistic	Partial Oligopoly	Tight Oligopoly
CAP UTIL	.170 (.09)**	-.021 (.05)	-.015 (.03)
Models I And II			
CAP INCR	-.033 (.10)	-.089 (.05)**	.045 (.03)**
SM GROWTH	-.127 (.08)*	-.082 (.05)*	.056 (.03)**
SM INSTAB	-.142 (.11)*	-.065 (.05)	.051 (.03)**
BACKLOG	-.024 (.09)	.013 (.05)	-.002 (.03)
REGIONAL	.333 (.12)***	.041 (.05)	-.068 (.03)***
PROC TYPE	-.195 (.09)**	-.027 (.05)	.041 (.03)*
CAP INT	.329 (.10)***	-.148 (.05)***	.018 (.03)
FIXED	.182 (.10)**	-.169 (.05)***	.049 (.03)**
ECON CAP	-.474 (.04)***	-.256 (.04)***	.186 (.02)***
FIN GOODS	-.243 (.10)***	.092 (.05)**	-.006 (.03)
Models III And IV			
SM CONCEN	---	---	---
PROD DIFF	-.017 (.11)	-.065 (.05)	.032 (.03)
PROD CHG	-.106 (.11)	.020 (.05)	.007 (.03)
PUR FREQ	.042 (.10)	-.066 (.05)	.024 (.03)
SM ENTRY	-.120 (.10)	-.074 (.05)*	.051 (.03)**
SM EXIT	-.034 (.10)	.053 (.05)	-.019 (.03)
NET EXPORTS	-.271 (.07)***	-.066 (.05)	.070 (.03)***
PROD AGE	.057 (.11)	-.184 (.05)***	.075 (.03)***
TECH CHG	-.183 (.09)**	-.029 (.05)	.040 (.03)*
CUST CONCEN	.151 (.13)	.017 (.06)	-.030 (.03)
P-C SQZE	-.093 (.09)	-.114 (.05)**	.066 (.03)***
Sample Size	82	251	554

$*p \le 0.10$ $**p \le 0.05$ $***p \le 0.01$

- that utilization would be a "U-shaped" pattern with the partial oligopolies showing the lowest value. Part of the explanation may be that the atomistic subsample also exhibits the highest fixed capital intensity and fixed costs despite having a production process that appears to be more "job shop" oriented.

The most distinctive pattern among the subsamples emerges for the tight oligopoly. First, this subsample appears to be distinguished by a relatively higher growth rate. This finding agrees with tight oligopolies also being the "youngest" (PROD AGE), the most likely to have experienced significant technological change, and the most likely to have also experienced entry into the served market. The "picture" of high concentration is thus a high growth setting which may be concentrated simply because the industry is in its earlier stages and significant competition has not yet appeared. The concentration may likely decrease, though, as further entry occurs.

Second, the ability to remain concentrated is apparently enhanced by the production process used, which tends to be more "continuous process" oriented. Since the scale advantages accruing from such facilites could be significant, competition may be effectively foreclosed. Significant entry would thus have to occur at less than efficient scale.

Last, price increases that outpace cost hikes have been realized by the tight oligopoly. Again, this phenomenon seems to be on two fronts - one, due to the high growth rate, and secondly, the ability of the smaller competitive set to better achieve a consensus on pricing which is mutually beneficial.

A final mention of the "economy of capacity" variable (ECON CAP) is in order. The calculation is partially based on market share. One would expect in general that the high concentration sample would have the highest market share values for the corresponding businesses, and hence the highest "economy of capacity." This is in fact the case.

To reiterate, the purpose of the preceding discussion is to see if consistent and logical patterns in the data have emerged. Statements about the relationships to capacity utilization are obviously premature, and will be deferred until Chapter V.

4.522 Growth Subsamples

Table 4.10 shows the analysis of variance for the growth subsamples. Most of the results are consistent with and confirm the explanation of the concentration subsamples. A few discrepancies, however, did emerge.

As would be expected, businesses in high growth markets realized the highest capacity utilization. A significant downward trend in utilization emerged as the growth rate declines.

Part of the prior discussion on the concentration subsamples focused on explaining the high growth rate for the tight oligopoly. The same pattern is seen in Table 4.10. Served market concentration is highest for the high growth subsample, in addition to the incidence of entry and technological change.

Second, an underlying factor to explain high growth is once again the "youth" or "newness" of the product market. Analogous to this finding is that the capacity increment and fixed costs are highest for the high growth sample. The assumption in the former case is that the *absolute* size in revenues of high growth businesses is smaller than

Table 4.10

Analysis of Variance - Growth Subsamples

Variable	Means (Standard Deviations)		
	Negative	Low/ Medium	High
CAP UTIL	-.074 (.04)**	.006 (.04)	.152 (.07)**
Models I And II			
CAP INCR	-.084 (.04)**	.003 (.04)	.179 (.08)***
SM GROWTH	---	---	---
SM INSTAB	.152 (.04)	-.294 (.04)	.353 (.08)
BACKLOG	-.020 (.04)	-.078 (.04)**	.227 (.08)***
REGIONAL	-.053 (.04)*	.042 (.04)	.020 (.07)
PROC TYPE	.024 (.04)	-.014 (.04)	-.021 (.07)
CAP INT	.024 (.04)	-.025 (.04)	.006 (.08)
FIXED	-.044 (.04)	-.020 (.04)	.145 (.08)**
ECON CAP	-.060 (.04)*	-.040 (.04)	.227 (.08)***
FIN GOODS	.004 (.04)	-.012 (.04)	.018 (.07)
Models III And IV			
SM CONCEN	-.061 (.04)*	-.036 (.04)	.220 (.07)***
PROD DIFF	-.097 (.04)***	.022 (.04)	.163 (.07)**
PROD CHG	.003 (.04)	.013 (.04)	-.038 (.07)
PUR FREQ	-.006 (.04)	-.082 (.04)**	.206 (.08)***
SM ENTRY	-.081 (.04)**	.016 (.04)	.142 (.08)**
SM EXIT	-.035 (.04)	.014 (.04)	.046 (.07)
NET EXPORTS	-.092 (.04)**	-.042 (.04)	.304 (.08)***
PROD AGE	-.148 (.04)***	-.096 (.04)***	.555 (.08)***
TECH CHG	-.143 (.04)***	.038 (.04)	.229 (.08)***
CUST CONCEN	.001 (.04)	.033 (.04)	-.080 (.08)*
P-C SQZE	.160 (.04)***	-.051 (.04)*	-.237 (.08)***
Sample Size	354	374	159

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

businesses with lower growth rates. As a consequence, as the business grows (despite slower growth rates), the capacity increment becomes smaller as a percentage of revenue.[1] In the latter case, fixed costs as a percent of revenue will decrease for the same reasons; even more of a decreasing trend could be found if reinvestment did not occur.

The high growth samples provide the expected view of order backlogs - the highest backlogs are experienced by the high growth businesses. Last, marketing expenditures to revenues (PROD DIFF) decline as the growth rate decreases - another reasonable expectation.

One puzzling discrepancy emerged from the analysis of variance. *A priori* one would expect that the ability to control margins through pricing and costs (P-C SQZE) would be superior during high growth. Exactly the opposite trend was found, however. Reasoning for this result is not apparent, and therefore cannot be offered at this time.

4.523 Process Type Subsamples

Table 4.11 presents the analysis of variance for the process type subsamples. The results are particularly lucid for the two "extreme" samples - businesses using a small batch (i.e. job shop) compared to a continuous process production system.

As would be expected, continuous processes are utilized at much higher rates; conversely, small batch systems exhibit the lowest capacity utilization. A similar expected trend was found for capital intensity and fixed costs. The nature of the continuous process technology is such that it is most difficult to increase capacity efficient-

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[1]An underlying assumption here is that the absolute efficient capacity increment is fixed by the state of technology, and would only change as the result of significant technological change.

Table 4.11

Analysis of Variance - Process Type Subsamples

Variable	Means (Standard Deviations)		
	Small Batch	Large Batch/ Assembly	Continuous
CAP UTIL	-.138 (.06)***	-.046 (.03)*	.394 (.06)***
Models I And II			
CAP INCR	-.123 (.05)***	-.019 (.03)	.269 (.09)***
SM GROWTH	.009 (.06)	-.002 (.03)	-.009 (.08)
SM INSTAB	-.012 (.06)	-.075 (.03)***	.283 (.08)***
BACKLOG	.604 (.07)***	-.181 (.03)***	-.359 (.05)***
REGIONAL	-.134 (.05)***	-.035 (.03)	.345 (.09)***
PROC TYPE	---	---	---
CAP INT	-.217 (.05)***	-.084 (.03)***	.655 (.10)***
FIXED	-.229 (.06)***	-.083 (.03)***	.676 (.10)***
ECON CAP	.107 (.06)**	-.045 (.03)*	-.019 (.07)
FIN GOODS	-.177 (.06)***	.064 (.03)**	.065 (.07)
Models III And IV			
SM CONCEN	-.050 (.06)	-.030 (.03)	.191 (.07)***
PROD DIFF	.172 (.05)***	-.014 (.03)	-.235 (.08)***
PROD CHG	.018 (.06)	-.049 (.03)**	.143 (.07)**
PUR FREQ	.418 (.06)***	-.109 (.03)***	-.306 (.07)***
SM ENTRY	-.005 (.06)	-.028 (.03)	.109 (.08)*
SM EXIT	-.007 (.06)	-.031 (.03)	.121 (.08)*
NET EXPORTS	.272 (.07)***	-.104 (.03)***	-.082 (.06)*
PROD AGE	.074 (.06)	-.025 (.03)	-.033 (.07)
TECH CHG	-.024 (.06)	-.017 (.03)	.100 (.08)
CUST CONCEN	-.091 (.04)**	.091 (.03)***	.171 (.06)***
P-C SQZE	.147 (.06)***	-.006 (.03)	-.223 (.09)***
Sample Size	237	507	143

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

ly in small increments. A high value for "capacity increment" was in fact the case, with the opposite result found for small batch processes. Presumably due to the high investment required and the accompanying investment and operating economies of scale, the served markets for continuous process businesses were more highly concentrated.

If the assumption is made that continuous processes will most likely be used for undifferentiated commodity products, further reasonable interpretations can be made. One characteristic of an undifferentiated commodity is a high weight-to-value ratio, and long shipping distances are thus not economical. Regional markets are most likely to emerge, which indeed is the case for the continuous processes. Furthermore, one would expect such products to be most susceptible to margin squeezes and the least likely to incur expenditures for marketing (PROD DIFF). Again, both expectations are borne out by the subsamples.

The small batch (or "job shop") subsample provides an equally consistent picture. Here the assumption can be made that a process of this type is most likely to be used by a producer of low volume or custom capital goods.[10] Differentiation is likely to be high, which is supported by the marketing/revenue ratio, and also the least vulnerable to a margin squeeze. Capital goods would also be purchased less frequently than other products - again this is the case.[11] Last, the nature of a process which is used for a custom or low volume product is that backlogs are likely to be quite high and conversely finished goods low. Such an outcome was also found for the small batch subsample.

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[10]A further assumption inherent in this statement is that consumer products are unlikely to be custom made.

[11]In the operationalization of the "purchase frequency" (PUR FREQ) variable, higher values are an indication of less frequent purchases.

4.524 Summary

The purpose of the prior discussion was to ascertain if the dependent and independent variables behave as expected when viewed under the conditions of various subsamples. In general such expectations were realized. Of course, not all variables would be expected to be impacted by all of the subsample schemes. Irregardless, a number of logical patterns appeared.

The most glaring discrepancy was for the capacity utilization trend shown by the concentration subsamples. This issue will hopefully be resolved by the regression models of Chapter V.

CHAPTER V

DISCUSSION OF RESULTS - HYPOTHESES 1A THRU 4I

This chapter reviews results of the capacity utilization modeling (Hypotheses 1_a thru 4_i). The discussion is organized into three sections. The first section explains the results of the regression modeling of capacity utilization. In order, outcomes of the Manne model (Models I and II), Esposito and Esposito model (Models III and IV), and the product life cycle/industry type effect will be presented. The second section describes the effect of capacity utilization on performance Model V). The last section briefly summarizes the conclusions from this portion of the research.

5.1 The Capacity Utilization Modeling

The first two subsections are devoted to a presentation of the Manne and Esposito and Esposito models (both the initial replication and extensions). The third subsection briefly reports the test of the contingency effect of the product life cycle and industry on both models. Last, the results of a regression which combines the independent variables of both the Manne and Esposito and Esposito models will be shown.

5.11 Manne Model (Models I And II)

Two subsections are presented here - an overview discussion of the regression runs (Manne replication, extensions to this model, running the model with subsamples) and summary results of the hypotheses.

5.111 Overview Of The Models

The Manne model replication (Table 5.1) was only marginal at best. The sample variance explained by the model (R^2) is quite low (.015); likewise, the standard error of the residuals (SE) is high (.993). With regard to the five independent variables, three were in the expected direction (CAP INCR, SM GROWTH, BACKLOG), but only two were significant. SM INSTAB was significant but in the wrong direction.

Direct comparisons to Manne are impossible because the author did not undertake any large-scale empirical testing of his model. A few simplications and omissions necessary for this research, however, must be noted. For example, the influence of the time dimension was not included. Capacity utilization would be expected to increase with time given a positive demand growth rate, *ceteris paribus*. Representations of scale economies and the existence of multiple plants were proxied by the "CAP INCR" and "REGIONAL" variables. Last, one major confounding factor which must be mentioned is that the values of the continuous dependent and independent variables were four-year averages. The obvious effect of using averages is that year to year differences in capacity utilization are attentuated. This fact probably contributes to why the average instability in served market growth is significant in the wrong direction. Furthermore, the long "time frame" for the utilization measure would give management time to adjust capacity to bring utilization levels in line. Unfortunately, however, other efforts to test Manne's theories against a large scale data base have not proved

Table 5.1

Regression Results - Replication Of Manne (Model I)

Variable	β Coefficients
CAP INCR	-.028
SM GROWTH	.091***
SM INSTAB	.045*
BACKLOG	.049*
REGIONAL	.020
Constant	-.000
R^2	.015
SE	.993
d.f.	881
F	2.65
P	< .03

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

to be fruitful.[1]

The extended model (Table 5.2) proved to be much more successful. The signs for all of the independent variables except instability of served market growth (SM INSTAB) were in the expected direction. Four of the five variables from the Manne replication were significant at the .1 level or greater (SM INSTAB again being the exception). Of the additions to the model, the production process type, fixed capital intensity, and fixed costs were all highly significant and in the expected direction; ECON CAP and FIN GOODS both approached significance (probability levels of .11 and .18 respectively).

A concern of this operationalization was multicollinearity, particularly between fixed capital intensity and fixed costs. A correlation matrix of the β coefficients was computed, which essentially showed how the variables behaved relative to each other in the presence of the other variables included in the regression. The correlation for the case cited was indeed high (.71); however, since both variables were highly significant the decision was made to drop neither one from the model. The only other correlation found which was greater than .3 occurred between the order backlog measure and the production process type (.33). Again, both were included because of the high significance for each.

Finally, of particular interest in examining the "fit" of the subsample runs were the tight oligopoly and the low/medium growth businesses (Tables 5.3, 5.4, and 5.5). These subsamples were felt to be most

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[1]For an example, see Lieberman (1984a). The author specified several competing theories of capacity utilization, of which Manne was one. Data from the chemical industry was used for hypothesis testing. Of the eight independent variables specified by the author, only one was significant in the expected direction (variability in growth).

Table 5.2

Regression Results - Extension Of The Manne Model (Model II)

Variable	β Coefficients
CAP INCR	-.041*
SM GROWTH	.080***
SM INSTAB	.013
BACKLOG	.098***
REGIONAL	-.053**
PROC TYPE	.093***
CAP INT	.362***
FIXED	.077**
ECON CAP	.037
FIN GOODS	-.028
Constant	-.000
R^2	.215
SE	.886
d.f.	876
F	23.9
P	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

"representative" of the arguments for the hypotheses offered in section 3.1. In general, the results for these subsamples are consistent with expectations. Particularly for the case of the low/medium subsample, the fit is superior to the other subsamples with that set.

Except for the concentration subsamples, the constant terms for the regressions behaved consistently with the analysis of variance. The growth subsample constants showed an obvious declining trend as the growth rate declined. A similar trend - increasing utilization as the production process becomes more "continuous" - was exhibited by the process type constant terms. The concentration subsample constants, however, suggested an "inverted U" relationship, with the partial oligopolies displaying the highest utilization *ceteris paribus*. This finding is inconsistent with the analysis of variance (in this case, the atomistic subsample was highest), as well as the theory concerning the effect of concentration on capacity utilization. Further tests and possible explanations for this result will be addressed in sections to follow.

5.112 Technology/Demand Hypotheses

Table 5.6 summarizes the results of each of the technology/demand hypotheses and provides a brief discussion as appropriate. The remainder of this subsection is devoted to an expanded analysis of these results.

5.1121 "Lumpiness Of Investment"

This hypothesis was supported, albeit not as strongly as some of the other relationships. A significant negative correlation was found

Table 5.3

Regression Results - Model II (Concentration Subsamples)

Variable	β Coefficients		
	Atomistic	Partial Oligopoly	Tight Oligopoly
CAP INCR	-.232***	031	-.035
SM GROWTH	.110	.067	.109***
SM INSTAB	-.230***	.101**	.001
BACKLOG	.035	-.014	.142***
REGIONAL	.021	-.141***	-.054
PROC TYPE	.112	.069	.106***
CAP INT	.298**	.474***	.331***
FIXED	.084	.061	.094*
ECON CAP	-.422*	.197***	.040
FIN GOODS	.061	-.087*	-.002
Constant	-.140	.140**	-.046
R^2	.296	.257	.227
SE	.696	.867	.895
d.f.	71	240	543
F	2.98	8.29	15.9
P	< .005	< .001	< .001

$^{*}p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

Table 5.4

Regression Results - Model II (Growth Subsamples)

Variable	β Coefficients		
	Negative	Low/ Medium	High
CAP INCR	-.037	-.024	-.072
SM GROWTH	-	-	-
SM INSTAB	.014	.027	.030
BACKLOG	.092**	.107**	.085
REGIONAL	-.101**	-.005	-.089
PROC TYPE	.063	.095**	.139**
CAP INT	.320**	.468***	.252***
FIXED	.152**	-.008	.109
ECON CAP	.009	.062	.057
FIN GOODS	.038	-.080**	-.083
Constant	-.085**	.037	.110*
R^2	.201	.247	.211
SE	.884	.866	.898
d.f.	344	364	149
F	9.62	13.3	4.44
P	< .001	< .001	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

Table 5.5

Regression Results - Model II (Process Type Subsamples)

Variable	β Coefficients		
	Small Batch	Large Batch/ Assembly	Continuous
CAP INCR	-.026	-.062*	.030
SM GROWTH	.099*	.087**	.104**
SM INSTAB	.080*	-.031	.033
BACKLOG	.112**	.033	.123
REGIONAL	.002	-.083**	.006
PROC TYPE	-	-	-
CAP INT	.385***	.425***	.247***
FIXED	.093	.150**	-.024
ECON CAP	.061	.043	-.020
FIN GOODS	-.098*	.017	-.098*
Constant	-.128	.002	.279***
R^2	.232	.213	.224
SE	.930	.882	.704
d.f.	227	497	133
F	7.61	15.0	4.27
P	< .001	< .001	< .001

$^*p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

Table 5.6

Summary of Manne Model And Extensions (Hypotheses 1_a - 1_j)

Hypothesis	Independent Variable	Expected Sign	Discussion
1_a	CAP INCR	-	Supported. Particularly significant in atomistic industries.
1_b	SM GROWTH	+	Supported. Uniformly positive, especially significant for tight oligopoly.
1_c	SM INSTAB	-	Not Supported. Likely suffers from the use of four-year averages.
1_d	BACKLOG	+	Supported. Particularly significant for small batch.
1_e	REGIONAL	-	Supported.
1_f	PROC TYPE	+	Supported. More significant the higher the growth rate.
1_g	CAP INT	+	Supported. Highly significant in all regressions.
1_h	FIXED	+	Supported. Insignificant in some subsamples probably due to multicollinearity.
1_i	ECON CAP	+	Partial Support. Significant in the reduced model (5.13), growth exerts apparent contingent effect.
1_j	FIN GOODS	-	Not Supported.

as expected. Although the analysis of variance revealed some significant trends in "lumpiness" as a function of growth and production process type, the correlation to capacity utilization for the most part remained consistently negative and of the same magnitude. The sole exception was for the "atomistic" subsample, which was negative and highly significant. A possible explanation is that "lumpy" investment would be especially detrimental among competitors with small market shares, particularly if shares are limited for non-technological reasons (e.g. the existence of a strong, concentrated customer group).

5.1122 Demand Growth

This hypothesis was supported. The correlation with capacity utilization was uniformly positive and showed little variance in the magnitude of the coefficient. Arguments which could lead to a negative relationship (the preemption rationale or a low cost of overcapacity) did not appear in the subsamples. The tight oligopoly subsample was particularly significant in comparison to the other concentration subsamples. This finding could partially be a function of the higher served market growth rate experienced by the tight oligopolies. Alternatively, a small group of competitors may be able to respond more uniformly and effectively to high growth than a more fragmented group.

5.1123 Demand Instability

The expected negative relationship was not found in the overall model. The variable was also insignificant in most of the subsample runs. Two exceptions must be noted, however. Instability of demand was especially devestating in the atomistic subsample. Possibly the responses to changing demand would be more variable (and extreme) as concentration decreases, particularly since information concerning competitive moves would be more difficult to gather. Conversely, instability had a significant positive effect in the small batch subsample. Perhaps this is a testimony to the inherent flexibility of this production type. Nonetheless, these explanations are still quite tenuous given the suboptimal operationalization of this variable.

5.1124 Order Backlog

This hypothesis was supported. The expected positive relationship was observed in the overall model (using all observations) and most of the subsamples. From the analysis of variance, backlogs were significantly higher in the high growth served markets. Interestingly, though, among the growth subsamples the only insignificant relationship was for the high growth subsample. Despite the high absolute value, apparently less variance in capacity utilization resulted. Among the process types, the small batch subsample exhibited a significant relationship, while the others did not. Perhaps this suggests "lumpiness" of investment is a two-edged sword - that capacity build-up to meet backlogged demand is not likely to be done in large "chunks" and thus may be a slower process. Such capacity build-up may entail adding not only plant and equipment, but also hiring/training additional skilled labor.

5.1125 Regional Businesses

As expected, a significant negative relationship was found in the model which used all observations. No systematic differences among the subsamples were expected. No significant positive associations were found in any of the regressions.

5.1126 Production Process Type

The hypothesized positive relationship was found in the run of all observations and each of the subsample regression runs (though not significant in all of them). Growth was expected to have a contingent effect on this variable. The magnitude of the β coefficients increased as the served market growth increased. Perhaps the less flexible the production process (i.e. the orientation towards large scale production) the more the benefit derived as growth rises.

5.1127 Capital Intensity, Fixed Cost

Both of these variables were positive and significant as expected. No contingent relationship was expected to be present for either variable among the subsamples. The significance of FIXED, however, differed among the subsamples. Apparently the multicollinearity problem mentioned previously was more severe in some of the subsample runs. No attempt was made to assess the extent of or correct this problem.

5.1128 "Economy Of Capacity"

A positive relationship as anticipated was found in most of the regression runs. Although close to the .1 level, unfortunately the bulk of the coefficients were insignificant. As expected by theory, growth appeared to have a contingent effect - high relative capacity proved to be more advantageous the higher the growth rate.

5.1129 Finished Goods

A negative but insignificant association was found in the model using all observations. A contingent relationship was expected with process type, the rationale being that large scale systems would be more difficult to "shut down." Finished goods would build, and then subnormal capacity utilization would eventually result. A significant negative coefficient was found for continuous processes, however the same value was also found for small batch systems. Similar to demand instability, uncovering the true relationship also would be clarified if a dynamic model using annual data was structured.

5.113 Summary

As a final step, a reduced model (SM INSTAB and FIN GOODS were dropped) was rerun using all observations (Table 5.7). The reason for this step was to formulate the simplest possible model adequate for describing the data. "Economy of capacity" was retained because of its near significance in the full model, and indeed was significant in this run. The only other change of note was that REGIONAL was slightly less significant in the reduced model. Otherwise, the independent variables retained their original sign, magnitude, and significance.

To summarize, the modeling in this section was based on the pioneering work of Manne (1967), which has nonetheless not undergone extensive empirical scrutiny. This model was replicated, extended, and then finally tested using a variety of subsamples. Although the replication was not particularly successful, the extensions significantly improved the accuracy of the model.

Two of the extensions to the Manne model were felt to be particularly noteworthy. First, despite the inclusion of investment- and cost-oriented variables, the type of production process used also turned out to be highly significant. The "technology" dimension has been defined by past authors in only broad terms such as capital intensity. To the author's knowledge this is the first attempt to specifically look at limitations imposed by the operating characteristics of the manufacturing system. As an extreme example, a job shop and continuous process with equivalent capital intensity, fixed costs, etc. would still operate at different utilization levels simply because of the inherent operating characteristics of the respective processes. Although this result "seems" to be intuitive, this research has demonstrated its "statistical truth."

Second, the notion that the business with the largest capacity will also have the highest capacity utilization *ceteris paribus* was also supported. This research is also the first attempt to empirically test this effect. In a sense the truth of this relationship provides some underlying rationale for preemptive capacity addition. Traditionally the preemptive strategy has been viewed as a dynamic process involving a complex interaction among capacity additions, demand, pricing, and costs which behave according to the experience curve. The net result of this process justified the importance of high market share. The relationship here is slightly different - that customers will be attracted to the business with the largest capacity because the queues will not be as long. Note that this reasoning would expect to hold even if preemptive pricing was not pursued.

Table 5.7

Regression Results - Reduced Model II (All Observations)

Variable	β Coefficients
CAP INCR	-.040*
SM GROWTH	.080***
SM INSTAB	-
BACKLOG	.106***
REGIONAL	-.045*
PROC TYPE	.093***
CAP INT	.363***
FIXED	.077**
ECON CAP	.041*
FIN GOODS	-
Constant	-.000
R^2	.214
SE	.887
d.f.	878
F	29.8
P	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

5.12 Esposito And Esposito Model (Models III And IV)

Two subsections will follow - analysis of the regressions (Esposito and Esposito replication, extensions to this model, subsamples) and summary results of the the tests of hypotheses.

5.121 Overview Of The Models

The Esposito and Esposito replication (Table 5.8) performed well - certainly much better than the initial Manne modeling. All of the hypothesized effects were significant and in the expected direction. As in the Manne model, fixed capital intensity and served market growth were both positive and highly significant. Interestingly, "product differentiation" in this research was highly significant. In the original Esposito and Esposito model this variable was insignificant and incorrectly signed. It must be noted that the operationalization differed between the two cases. The original model alternately used a dummy variable which represented industries with advertising/sales ratios of 2% or greater and the continuous advertising/sales ratio. In this research the continuous marketing expenditure/sales ratio was employed. In addition to advertising, the latter measure includes sales promotion, sales force expenditures, market research, and administration.

Perhaps the "centerpiece" of the replication, however, was the effect of concentration. Several hypotheses were posed in 3.21 concerning the concentration - capacity utilization association. The overall relationship between concentration and capacity utilization was expected to be significant, however a direction could not be specified due to the anticipated U-shaped relationship. A series of subhypotheses was specified to test for this effect.

Table 5.8

Regression Results - Replication Of Esposito And Esposito (Model III)

Variable	β Coefficients		
	I	II	III
SM CONCEN	-.046*	-	-
PARTIAL OLIG	-	-.005	-
TIGHT OLIG	-	-.034	-
SM CONCENSQ	-	-	-.052**
PROD DIFF	-.125***	-.124***	-.125***
PROD CHG	-.075***	-.075***	-.075***
PUR FREQ	-.058**	-.059**	-.056**
SM GROWTH	.113***	.111***	.114***
CAP INT	.394***	.394***	.395***
Constant	.000	-.000	.000
R^2	.215	.214	.215
SE	.886	.887	.886
$d.f.$	880	879	880
F	40.1	34.1	40.2
P	< .001	< .001	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

The results of these different operationalizations of concentration are shown in Runs I, II, and III of Table 5.8. Run I uses simply the four-firm concentration ratio; Run II dummy variables for "partial oligopolies" (concentration ratio between 40 and 69) and "tight oligopolies" (a concentration ratio of 70 or above); and Run III simply uses the squared four-firm ratio.

The dummy variables (Run II) clearly did not reveal the existence of a "U-shape" - if anything, a mildly decreasing linear trend emerged (though insignificant). Both of the runs using simple variants of the four-firm concentration ratio were negative and significant. Virtually no difference could be witnessed in the overall fit of the three runs (based on R^2 and SE). The conclusion reached was to use the simple four-firm measure for the remainder of the modeling.

The rationale behind why the U-shaped effect did not appear is not obvious. The only apparent difference between the models is the measure used for concentration. Esposito and Esposito based their variable on the SIC four-firm concentration ratio; this research relied on the four-firm served market concentration ratio. Use of served market data was felt to be superior, since it is more perceptual in nature and hopefully "adjusts" for factors such as strategic groups or regional competition.

Further comparisons can be made with Lieberman (1984*b*). The author found the expected U-shaped relationship between excess capacity and a measure of seller concentration (the Herfindahl index). These results, however, appear to be biased due to the nature of the sample used (the chemical industry). The minimum point in the "U" was found at a Herfindahl index value of .5, which in reality is a relatively <u>high</u> level of seller concentration.[2] For comparison, the seller concentration cut-point for "tight oligopolies" in this research was a four-firm concentration ratio of 70. For much lower index values, then, conceivably a negative association would also be found between capacity utilization and seller concentration.

Given the results in this research, the argument that excess capacity is a function of coordination problems among the firms in an industry cannot be supported. However, excess capacity may exist for other reasons - such as to serve as an entry barrier (see 2.34). If the entry barrier explanation is plausible, the negative relationship found in this study would be expected.

The extended model (5.9) improved upon the replication. The original set of variables used in the replication all remained significant. Of the seven independent variables added, all were in the expected direction.[3] Only two of the seven variables, however, were significant at or above the .05 level (CUST CONCEN and P-C SQZE), although three additional variables approached significance at the .1 level - SM ENTRY (.12), NET EXPORTS (.13), and PROD AGE (.16). In sum total these extensions to the replication increased R^2 (.215 to .243) and reduced the standard error (.886 to .870). Admittedly, these improvements are marginal given the number of variables added to the model.

Problems of multicollinearity were not expected to be as potentially severe as for the Manne modeling. Examination of the correlation

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[2]The Herfindahl index is defined as $\sum S_i^2$, where S_i is the market share of each firm i. An index of .5, for example, could thus indicate two firms with identical market shares of .5 (a four-firm ratio of 100).

[3]The direction of P-C SQZE, however, was not specified.

Table 5.9

Regression Results - Extension Of The Esposito And Esposito Model (Model IV)

Variable	β Coefficients
SM CONCEN	-.042*
PROD DIFF	-.172***
PROD CHG	-.076***
PUR FREQ	-.041*
SM GROWTH	.133***
CAP INT	.401***
SM ENTRY	-.035
SM EXIT	-.016
NET EXPORTS	.034
PROD AGE	-.032
TECH CHG	-.003
CUST CONCEN	.137***
P-C SQZE	.067**
Constant	.000
R^2	.243
SE	.870
d.f.	873
F	21.5
P	< .001

$*p \leq 0.10$ $**p \leq 0.05$ $***p \leq 0.01$

matrix of the β coefficients revealed only two correlations above .2 - between PROD DIFF and CUST CONCEN (-.34), and PROD DIFF and CAP INT (.24). Since all of these variables were highly significant, no adjustments were deemed necessary.

Again, the regression runs with subsamples were used primarily to assess the contingent effect on the individual independent variables (Tables 5.10, 5.11, 5.12, and 5.13). Consistent with the Manne models, the low/medium growth subsample provided a superior fit in comparison to the other growth subsamples. Surprisingly, the partial oligopoly subsample also appears to be somewhat more exacting than the tight oligopolies.

With the exception of the concentration subsamples, the regression constants behaved as anticipated. A pronounced positive relationship was displayed for the growth subsamples; continuous processes also emerged as having the highest capacity utilization *ceteris paribus*. A negative trend with increasing concentration, however, was the case for the concentration subsample - once again casting doubt on the existence of the "U-shaped" association.

Last, the pooling of the atomistic and tight oligopoly subsamples did not appear to shed any new "light" on the analysis. This pooling was added since the atomistic and tight oligopoly subsamples are expected by theory to behave similarly (hence the basis for the "U"). Since this relationship is not evident, pooling would thus not provide any clarification. Furthermore, the pooling masked several apparent contingent relationships which will be discussed in depth in the next subsection.

Table 5.10

Regression Results - Model IV (Concentration Subsamples)

Variable	β Coefficients		
	Atomistic	Partial Oligopoly	Tight Oligopoly
SM CONCEN	-	-	-
PROD DIFF	.152	-.305***	-.147***
PROD CHG	-.282***	-.023	-.055*
PUR FREQ	-.019	-.039	-.035
SM GROWTH	.031	.072	.156***
CAP INT	.429***	.445***	.383***
SM ENTRY	-.085	-.018	-.050*
SM EXIT	.128*	.004	-.037
NET EXPORTS	.174*	.029	.034
PROD AGE	-.054	.018	-.031
TECH CHG	.120	.019	-.028
CUST CONCEN	-.099	.231***	.121***
P-C SQZE	.071	.074*	.064**
Constant	.094	.037	-.023
R^2	.347	.289	.241
SE	.670	.849	.887
d.f.	69	238	541
F	3.05	8.04	14.3
P	< .003	< .001	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

Table 5.11

Regression Results - Model IV (Pooled Concentration Subsamples)

Variable	β Coefficients	
	Partial Oligopoly	Atomistic & Tight
SM CONCEN	-	-
PROD DIFF	-.305***	-.130***
PROD CHG	-.023	-.086***
PUR FREQ	-.039	-.034
SM GROWTH	.072	.153***
CAP INT	.445***	.383***
SM ENTRY	-.018	-.055*
SM EXIT	.004	-.024
NET EXPORTS	.029	.042
PROD AGE	.018	-.044
TECH CHG	.019	-.012
CUST CONCEN	.231***	.106***
P-C SQZE	.074*	.064**
Constant	.037	-.051
R^2	.289	.238
SE	.849	.871
d.f.	238	622
F	8.04	14.9
P	< .001	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

Table 5.12

Regression Results - Model IV (Growth Subsamples)

Variable	β Coefficients: Negative	Low/ Medium	High
SM CONCEN	-.065*	-.015	-.034
PROD DIFF	-.238***	-.155***	-.117*
PROD CHG	-.050	-.106***	-.025
PUR FREQ	-.002	-.066*	-.103*
SM GROWTH	-	-	-
CAP INT	.386***	.468***	.325***
SM ENTRY	-.023	-.063*	-.056
SM EXIT	.032	-.065*	.115*
NET EXPORTS	-.072*	.082*	.104*
PROD AGE	-.019	-.011	-.107*
TECH CHG	.014	-.038	.048
CUST CONCEN	.214***	.101**	.077
P-C SQZE	.028	.113**	.055
Constant	-.125***	.025	.219***
R^2	.246	.290	.217
SE	.859	.841	.895
d.f.	341	361	146
F	9.26	12.3	3.38
P	< .001	< .001	< .001

$^*p \le 0.10$ $^{**}p \le 0.05$ $^{***}p \le 0.01$

Table 5.13

Regression Results - Model IV (Process Type Subsamples)

Variable	β Coefficients		
	Small Batch	Large Batch/ Assembly	Continuous
SM CONCEN	-.012	-.042	-.072
PROD DIFF	-.166**	-.150***	-.353***
PROD CHG	-.148**	-.063**	.039
PUR FREQ	-.011	-.072*	.056
SM GROWTH	.209***	.118***	.137**
CAP INT	.439***	.493***	.170***
SM ENTRY	.012	-.066*	-.058
SM EXIT	-.057	-.015	.008
NET EXPORTS	.133***	-.049	-.037
PROD AGE	-.135**	-.010	.144**
TECH CHG	-.112**	.050	-.053
CUST CONCEN	.288**	.129***	.246**
P-C SQZE	.086*	.072*	.030
Constant	-.025	-.037	.287***
R^2	.292	.244	.346
SE	.892	.865	.646
d.f.	223	493	129
F	7.09	12.2	5.26
P	< .001	< .001	< .001

$^*p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

5.122 Industry Hypotheses

Table 5.14 summarizes the results of each of the industry hypotheses and includes a summarized discussion of each conclusion if suitable. The rest of this subsection attends to furnishing more complete analyses of these results.

5.1221 Seller Concentration

The series of hypotheses for seller concentration received mixed support. The variable was consistently negative in the subsamples, though insignificant in the majority. Although this variable was negative and significant in the regression run using all observations, the dummy variable approach used to deal with a suspected non-linear relationship was not successful.

Although no contingent effects were expected between the subsamples, an increasingly negative coefficient was observed as the production process type progressed from small batch to continuous. Such a trend can be interpreted as consistent with other subsample trends in that parallels exist between concentration and scale of the production system.

5.1222 Product Differentiation

This hypothesis was strongly supported - a consistently negative coefficient was observed. Among the subsamples, the negative relationship to capacity utilization was particularly strong for continuous processes. Such a result appears to be logical, since businesses using this type of process would most likely be manufacturing undifferentiated goods. Trying to achieve differentiation (such as competing

Table 5.14

Summary of Esposito And Esposito Model And Extensions (Hypotheses 2_a - 2_k)

Hypothesis	Independent Variable	Expected Sign	Discussion
2_a	SM CONCEN	+ or -	Partial Support. Negative and significant in main model, U-shaped relationship not found.
2_b	PROD DIFF	-	Supported. Very significant for continuous processes, more negative as growth declines.
2_c	PROD CHG	-	Supported. Uniformly negative, regularity of change more critical than frequency.
2_d	PROD FREQ	-	Supported. Contingent effect exerted by growth.
2_e,2_f	ENTRY, EXIT	-	Partial Support. Contingent effect observed for concentration, growth.
2_g	NET EXPORTS	+	Partial Support. Mild insignificance in main model, contingent effect for concentration, process type.
2_h	PROD AGE	-	Partial Support. Mild insignificance in overall model, contingent effect for process type.
2_i	TECH CHG	-	Not Supported. Correct sign, insignificant in main model.
2_j	CUST CONCEN	+	Supported. Very significant, particularly as growth/concentration decreases.
2_k	P-C SQZE	+ or -	Supported. Positive and significant.

on the basis of service rather than cost) would thus tend to lower utilization substantially.

Decreasing growth also exhibits an increasingly negative effect on PROD DIFF. Although the conventional notion is that competition on price increases as growth declines, perhaps competition also intensifies on the service dimension (e.g. maintaining excess capacity to better fill customer orders).

5.1223 Product Change

This variable was significant in the overall model (Table 5.15) and is consistently negative in the various subsamples. The result gives credence to the notion that what matters is not the frequency of product change, but rather whether such change occurs on a regular basis. The ability to plan for and effectively manage new product introductions is thus substantially enhanced.

Product change was expected to be most irregular for the continuous processes, which was borne out in the analysis of variance. Product change is less likely with the inflexible, capital intensive continuous process, which therefore makes any such change more likely to be irregular. Curiously, however, the regression relationship was not impacted. To the contrary, the continuous process subsample showed the only positive coefficient (though insignificant).

5.1224 Purchase Frequency

This hypothesis was supported, and the relationship was consistently negative in the subsamples. No contingent effect was expected to be viewed among the subsamples, however an apparent negative linear relationship with growth emerged. The tendency simply may be that as growth slows businesses are less willing to carry excess capacity to serve customers who purchase infrequently.

5.1225 Entry, Exit

The expected negative relationships were found in the regression run using all observations, however only approached significance. The expected contingent effects did appear. Significant entry was anticipated to be most detrimental in the tight oligopoly, principally because the share of market captured by the entrant is likely to have more effect on an individual competitor if the number of competitors is small. Entry is also most likely to be felt by the incumbents when growth is slow. The entry variable turned out to be significant for both the tight oligopoly and low/medium growth subsamples. Apparently growth has to be at least non-negative in real terms for a significant effect to occur. Realistically, the analysis of variance showed that significant entry has occurred infrequently in negative real growth markets - an extremely logical finding.

Like entry, the exit variable displayed the hypothesized negative coefficient in the run using all observations, however was highly insignificant (i.e. .30). Interesting opposing effects were seen in the concentration and growth subsamples. A strong positive effect for exit in atomistic industries progressed to a negative effect in the tight oligopoly. Apparently as concentration increases, more of a tendency to "fight" over vacated share occurs. Thus, in the least concentrated case, the influence of exit is simply to increase the utilization of remaining competitors.

A comparable relationship was found for growth. High growth likely provides "room for everybody;" firms may be principally concerned with meeting their own orders, and exit of a significant competitor provides an unexpected incremental "boost" to utilization. Lower growth rates, however, prompt more of a willingness for rivals to add capacity in hopes of gaining the potential incremental business.

5.1226 Net Exports

Partial support was found for this hypothesis. The expected sign was realized in the regression run using all observations, though slightly insignificant (.13). In the subsamples this factor provided the most boost to capacity utilization in the atomistic and small batch subsamples. The underlying consistency here may be that exports provide the biggest boost for industries which have significant barriers to further concentration, such as required small-scale production technology.

5.1227 Product "Youth," Technological Change

Partial support was also found for the product "youth" hypothesis. The variable was slightly insignificant in the run using all observations. A contingent relationship with process type was anticipated and indeed appeared. The small batch and continuous process subsamples had opposing effects on capacity utilization. Apparently irrespective of "youth," an expensive large scale manufacturing system makes it essential to analyze and understand capacity plans of the competition.

The technological change variable had neither a consistent sign or significance in the various regression runs. This variable likely suffered from its definition by PIMS. The time frame for the data on technical change was "within the past 8 years" - probably too removed in some cases to have an immediate influence on capacity utilization.

5.1228 Customer Concentration

The expected positive association with capacity utilization was highly significant in the overall regression run (Table 5.15) and consistently positive in the subsamples. It should be noted that the measure used is the number of customers which account for 50% of sales. A high score for this variable thus indicates low customer concentration.

Contingent effects can be seen for the growth and concentration subsamples. From the analysis of variance, the absolute number of buyers is lowest during high growth. The regressions show that the ability of the business to broaden its customer base (i.e. reduce their bargaining power) is especially important as growth slows. Similarly, a tight oligopoly should be better able to exert influence over its customer base - customers would be less able to "play off" one supplier against another. Of course, this influence diminishes as concentration decreases - hence the greater importance of having a broad customer base in the partial oligopoly.

5.1229 Inflationary Pressures

This hypothesis was supported. Although a direction was not specified, the effect was consistently positive in the regression runs. Apparently when cost increases outstrip the ability to raise prices, the overriding tendency is to use existing assets more intensively, rather than invest in new "cost reducing" capacity. No evident pattern was found among the subsamples.

5.123 Summary

To complete the analysis, a reduced model was rerun using all of the observations (Table 5.21). SM EXIT and TECH CHG were dropped from the model shown in in Table 5.9, largely because of their higher insignificance. SM ENTRY, NET EXPORTS, and PROD AGE were all retained because of their near significance in the original formulation. In the reduced model the independent variables for the most part maintained their original sign and magnitude. SM ENTRY in this case was significant at the .1 level; NET EXPORTS and PROD AGE were again slightly insignificant. R^2 and SE remained unchanged between the two models.

In summary, the replication of the Esposito and Esposito research proved to be moderately successful. The major setback was an inability to reproduce the "U-shaped" association of concentration and capacity utilization which was found by the authors. Conversely, however, several theoretical relationships which were not supported by the data in the Esposito and Esposito research were found to be significant in this instance ("product differentiation" is the major case in point). A different operationalization for the effect of industry type (consumer or industrial) also proved to be successful.

The extensions to this initial model for the most part applied theory which had been previously applied to explaining phenomena such as instability in market share and/or investment. Variance in capacity utilization (or, if you will, "capacity utilization instability") is obviously closely aligned with these concepts, however with one important difference. Market share may be very unstable, however very little change in capacity utilization may occur if the manufacturing system is sufficiently flexible to adapt. The technological dimension is therefore important.

5.13 Contingent Effect Of The Product Life Cycle And Industry Type

Hypotheses 3_a and 3_b stated that neither the product life cycle nor the industry type would significantly impact either of the capacity utilization models. The essence of such a test, for example, was to compare the results of separate regression runs for two different subsamples with a regression run using the pooled subsamples. Thus, for complete testing, three paired comparisons are required for the product life cycle stages (the small sample size for the Introductory stage precluded any testing), with just one comparison needed for industry (Consumer versus Industrial). Models II and IV were used as the basis for comparison. The summarized Chow test results are shown in Table 5.16. The regressions of these separate subsamples are found in the Appendix (C, D, E, and F).

Hypothesis 3_a - lack of effect by the product life cycle - was strongly supported by the Chow Tests. None of the pairwise comparisons for either model indicated that the resulting regressions were significantly different (the calculated F value was less than the test statistic). Hypothesis 3_b, however, was not supported. For both models the regression results differed significantly between the Consumer and Industrial subsamples. Examination of the pertinent regressions (Appendixes D and F) show some rather striking differences. No systematic explanation, however, can be offered as to why these differences are logical. The results of the regression models which have been reported must therefore be interpreted with some caution, since pooling of Consumer and Industrial businesses may not be appropriate.

Table 5.15

Regression Results - Model IV (All Observations)

Variable	β Coefficients
SM CONCEN	-.042*
PROD DIFF	-.171***
PROD CHG	-.074***
PUR FREQ	-.041*
SM GROWTH	.133***
CAP INT	.401***
SM ENTRY	-.038*
SM EXIT	-
NET EXPORTS	.034
PROD AGE	-.034
TECH CHG	-
CUST CONCEN	.138***
P-C SQZE	.067**
Constant	.000
R^2	.243
SE	.870
d.f.	875
F	25.5
P	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

Table 5.16

Chow Test Results - Hypotheses 3_a And 3_b

Submodel	Subsample	Calculated F Value	Test Statistic (.05 Sig.)	Support
Manne Model (Model II)	Product Life Cycle			
	Growth vs. Mature	.63	1.80	*
	Growth vs. Decline	.67	1.80	*
	Mature vs. Decline	.68	1.83	*
	Industry			
	Consumer vs. Industrial	2.22	1.80	
Esposito & Esposito Model (Model IV)	Product Life Cycle			
	Growth vs. Mature	.45	1.73	*
	Growth vs. Decline	1.04	1.73	*
	Mature vs. Decline	.88	1.76	*
	Industry			
	Consumer vs. Industrial	1.95	1.73	

5.14 Combined Model

As a final step to the capacity utilization modeling, the reduced Manne and Esposito and Esposito models (Tables 5.7 and 5.15 respectively) were combined and run as one regression. The action made sense, particularly since a few variables (fixed capital intensity and served market growth) were common to both models.

The results (shown in Table 5.23) are particularly gratifying. The two models appear to complement each other well. In comparison to the separate models, all of the independent variables except one (CAP INCR) had the same or higher significance. NET EXPORTS and PROD AGE (which were both insignificant in the separate model) have now achieved significance. R^2 increased to .270 (which would be largely anticipated simply due to the increase in the number of independent variables) and the standard error decreased to .855 (from .887 and .870 in the separate runs).

The reasoning behind CAP INCR becoming highly insignificant is difficult to assess. The correlation matrix of the β's revealed no high correlations with any other variable.

5.2 The Capacity Utilization - Performance Modeling

The purpose of this section is to review the modeling of the capacity utilization effect on ROI. To recount the reason for this effort, a logical extension to the modeling of capacity utilization is to understand in what environments capacity utilization is (or is not) important to performance.

Table 5.17 gives the results of the analysis. The model includes a number of direct effects on ROI (such as concentration), however the

Table 5.17

Regression Results - Models II And IV Combined (All Observations)

Variable	β Coefficients
Model II	
CAP INCR	-.009
SM GROWTH	.118***
BACKLOG	.115***
REGIONAL	-.070**
PROC TYPE	.088***
CAP INT	.339***
FIXED	.086**
ECON CAP	.076***
Model IV	
SM CONCEN	-.086***
PROD DIFF	-.149***
PROD CHG	-.077***
PUR FREQ	-.060**
SM ENTRY	-.044*
NET EXPORTS	.040*
PROD AGE	-.045*
CUST CONCEN	.135***
P-C SQZE	.068**
Constant	.000
R^2	.270
SE	.855
d.f.	869
F	18.9
P	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

major interest lies with the interaction terms. The last two columns of the table show the hypothesized effect of each variable on ROI and the magnitude, sign, and significance of the corresponding β coefficient. The last three variables (Product Age, Customer Concentration, Price-Cost Squeeze) were included to simply increase the explanatory power of the model and somewhat reduce errors due to misspecification. No hypotheses were specified for these variables (hence the "NS" designation - "not specified" - in the Hypothesized Effect column).

The four primary variables (capacity utilization, concentration, industry growth, and capital intensity) were all significant and in the hypothesized direction - a key first step in being able to draw any conclusions about the interaction terms. Of the five interaction terms, four were in the expected direction - the exception being the CU * GROW * CI variable. The interaction of capacity utilization and concentration was significant at the .05 level, while the capacity utilization - capital intensity interaction approached significance (.19).

To summarize, no matter <u>what</u> the environment, capacity utilization had a positive effect on performance as measured by ROI. The contingent environments which were tested (very few of which were significant) simply caused the overall effect to be slightly more positive <u>or</u> less positive. Despite the insignificance of the majority of the interaction terms, the correct signing of these variables is encouraging. Like the capacity utilization models, a further step which could be pursued would be to test the robustness of these results with various subsamples. This step, however, will not be undertaken at this juncture.

Table 5.18

Regression Results - Capacity Utilization Effect on ROI (Model V)

Hypothesis	Variable	Hypothesized Effect	β Coefficients
4_a	Capacity Utilization (CU)	+	.286***
4_b	Capital Intensity (CI)	-	-.315***
4_c	CU * CI	+	.031
4_d	Industry Growth (GROW)	+	.051*
4_e	CU * GROW	-	-.010
4_f	CU * GROW * CI	+	-.016
4_g	Concentration (CON)	+	.174***
4_h	CU * CON	+	.059*
4_i	CU * CON * CI	-	-.013
	Product Age	NS	-.048*
	Customer Concentration	NS	.069**
	Price-Cost Squeeze	NS	-.054**
	Constant		-.009
	R^2		.142
	SE		.926
	d.f.		874
	F		12.1
	P		< .001

$*p \leq 0.10$ $**p \leq 0.05$ $***p \leq 0.01$

5.3 Chapter Summary

For the large part the various modeling efforts reviewed in this chapter met expectations. The Manne replication was less than satisfactory, however the hypothesized extensions substantially improved the explanatory power. By contrast, the Esposito and Esposito replication provided good results, although the "U-shaped" effect of concentration could not be reproduced. The extensions to this model, however, were only moderately effective. In both cases, the use of subsamples revealed a number of significant contingent effects. The product life cycle as predicted has no effect on the modeling, however the industry type unexpectedly did. The last portion of the capacity utilization modeling showed improved results by combining the two reduced models.

The capacity utilization - performance model examined the interaction of capacity utilization, concentration, growth, and capital intensity as it influences ROI. The results were mildly encouraging. The interaction terms were generally signed as expected, although the majority were insignificant.

CHAPTER VI

DISCUSSION OF RESULTS - HYPOTHESES 5A THRU 5U

This chapter discusses the results of the effect of business strategy on the manufacturing policy variables (Hypotheses 5_a thru 5_u). The results are presented in four subsections. The first subsection reviews the broad attributes of the strategy subsample classifications. The second subsection explains the results of the comparison of manufacturing policy variables between strategy types. The next subsection reports the effect of these same manufacturing policy variables on performance, again by strategy type. The last subsection summarizes the conclusions of this chapter.

6.1 Overview Of The Strategy Samples

Derivation of the strategy subsamples started with the businesses competing in mature industries (a total of 682). As discussed in Chapter III, a control for growth was felt to be necessary when making the strategy comparisons.

A point of Chapter IV, though, was that the "mature industry" businesses have reported some widely varying real growth rates - in fact, negative in a large number of cases. Despite the differences in real growth rates, the "mature" sample was used for the analysis. From the Chapter III discussion the most critical adjustment is to segregate high growth industries, which the "mature" classification effectively does. "Mature" businesses have also been used almost exclusively as the PIMS sample in other business strategy research. Comparability of these results with prior work is therefore enhanced.

However, unlike other research no distinction has been made here between consumer and industrial businesses or "high" and "low" performance levels. Despite the apparent differences found in Chapter V between the capacity utilization models of consumer and industrial businesses, no *a priori* justification can be offered as to why a consumer/industrial split is necessary for the strategy comparisons. Furthermore, all of the mature businesses have been used in the classification algorithm, rather than arbitrarily dropping part of the sample so as to "sharpen" differences by using extremes. More will be said about exclusions in the following paragraphs.

The initial results of the classifcation algorithm - specifically the size of the strategy subsamples - are shown in Table 6.1. To reiterate the sequence, Custom Producers were first split from the rest of the businesses. The split was made solely on the basis of a PIMS question concerning the custom nature of the firm's products. Neither expenditure levels nor pricing entered into this step.

Next, the "high price - low price" split was made (relative prices of above 100 and 100 or below respectively). For the "high price" sample, the mean and median in addition to a histogram for both total R & D expenses/revenue and total marketing expenses/revenue.[1] Based on this examination values of 2% (for R & D) and 10% of revenues (for marketing) were used to establish the cutpoint for the "high - low"

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[1]The histograms both revealed reasonable approximations of a normal distribution.

Table 6.1

Sample Sizes - Strategy Types

Strategy Type	Observations
Custom Producer	148
Differentiation	
Product Innovation (High R & D, Low Mktg.)	63
Marketing Intensive (Low R & D, High Mktg.)	72
Combination (High R & D, High Mktg.)	58
Other (Low R & D, Low Mktg.)	160
Subtotal	353
Low Cost	
Low Cost-Capital	57
Low Cost-Labor	124
Subtotal	181
Total Sample	682

classification. In both cases the value selected was slightly greater than the median and roughly approximated the mean.

A secondary issue of establishing cutpoints is "how many." For example, two cutpoints would then split the data into three samples - the two "extreme" subsamples would then be used for the analysis. Such a step was judged to be unwarranted. Selection of <u>any</u> cutpoint is admittedly somewhat of an arbitrary process; expanding the number of values used will also increase the arbitrariness. For the sake of comparison, several subsamples were constructed using multiple cutpoints. No additional insights were gained over the use of a single value.[2]

Next, a cutpoint for capital intensity with the "low price" sample was established. A method similar to the prior description was used. The value selected for gross book value was 50% of revenues.

As a last step, the four combinations of R & D and marketing categorizations ("high" or "low" for each) for the "high price" businesses were formed. Although the primary interest is in the two "high/low" combinations ("Product Innovation" and "Marketing Intensive"), the other two samples are included purely for purposes of comparison. The observation counts for the four "differentiation" types are included in Table 6.1.

Other than simply looking at the relative observation counts for the subsamples, an additional check of "reasonability" was deemed to be necessary. In other words, on a broad-brush basis, do the subsamples exhibit "reasonable" and "consistent" characteristics? The additional

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[2]Another step taken was to inspect ther plot of the sum of R & D and marketing expenses to revenue, using R & D/revenue and marketing/revenue as the axes. The rationale was that natural "clusters" might emerge. No clearly defined groups, however, could be easily identified.

check was made on new products as a percent of sales. The "new product" variable was selected since it is the focal point of the Miles and Snow (1978) strategy classes, and is strongly implied by Porter (1980) as an outcome of pursuing either the Cost Leadership or Differentiation mode of competing.

Figure 6.1 and Table 6.2 show the subsamples compared on new product activity. Figure 6.1 shows the trends of the "Differentiation" subsamples for new products as a percent of revenues and new products relative to the competition.[3] A consistent trend in both exhibits is seen - that new product activity increases as <u>either</u> R & D or marketing expenditures increase. Furthermore, the highest values are shown by the businesses which have combined high levels of both R & D and marketing. Table 6.2 expands the relative new product activity to the "Low Cost" strategy types. Custom Producers are not included since it is unclear what the new product activity of this type would be and how it should compare to the other subsamples. The table indicates that both Low Cost types have lower relative new product activity than any of the Differentiators.

These results of the algorithm are encouraging, since the new product trends match expectations. The classification is simple and straightforward, since only price, expense, and investment levels are employed. Furthermore, no exclusions for "non-extreme" businesses were taken. The results could probably be "fine tuned" if both relative R & D expenses and relative marketing expenses were accessible, however such

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[3]Relative new products are calculated by PIMS as the percent new products for the business in question minus the average percent new products for the three largest competitors.

Figure 6.1

New Products - Differentiation Strategy Types

NEW PRODUCTS - % OF SALES

R & D \ MARKETING	LOW	HIGH
LOW	1.83	6.60
HIGH	9.15	13.43

NEW PRODUCTS - RELATIVE % OF SALES

R & D \ MARKETING	LOW	HIGH
LOW	+.89	+1.60
HIGH	+1.27	+2.74

Table 6.2

Relative % New Products - Strategy Types

Strategy Type	Relative % New Products
Custom Producer	-
Differentiation	
Product Innovation	1.27
Marketing Intensive	1.60
Combination	2.74
Other	.89
Low Cost	
Low Cost-Capital	-.24
Low Cost-Labor	.49

data is not collected by PIMS.[4] Nonetheless, the samples appear to be eminently suitable for the hypothesis testing - in short, businesses which are quite similar in terms of a key activity such as new products will still reveal significantly different manufacturing properties.

6.2 The Manufacturing Policy Variable Comparisons

The next four subsections present the conclusions which are drawn from comparisons of the manufacturing policy variables. In order, these subsections compare Product Innovation to the Marketing Intensive, Low Cost-Capital to Low Cost-Labor, the two Differentiation types to the two Low Cost types, and the Custom Producer to the Differentiation and Low Cost types.

6.21 Product Innovation Versus Marketing Intensive

The results of these comparisons are shown in Table 6.3. The table shows the mean and standard deviation for each variable, then gives the appropriate hypothesis associated with each. Not all variables, however, have hypotheses stated for them.

The five hypotheses were intended to address two notions. First, the Product Innovation type is more likely to invest in manufacturing assets, since in this case the achievement of differentiation through the manufacturing system is fundamentally important. Such investment is represented by capital intensity and fixed costs. Both hypotheses here are supported - both variables are significantly higher for the Product

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[4]Very coarse information on relative expenditure levels (e.g. "more," ",much more") is gathered for the marketing "components" only (e.g. advertising, sales force), however is really not adaptable to the intended purpose.

Table 6.3

Manufacturing Policy Variable Comparisons - Differentiation Strategy Types

Variable	Mean(Standard Deviation)			Hypothesis	Z Statistic	Support
	Product Innovation	Marketing Intensive	"Combination"			
Capacity Utilization	.023(1.033)	-.306(1.093)	-.320 (.909)	5_c	-1.80	*
Capacity Increment	-.146 (.890)	.037 (.989)	-.120 (.967)			
Process Type	.017 (.814)	-.051 (.744)	-.450 (.951)			
Capital Intensity	.131 (.970)	-.383 (.832)	-.367 (.544)	5_a	3.27	*
Fixed Costs	.166 (.904)	-.292 (.935)	-.281 (.704)	5_b	2.90	*
"Economy Of Capacity"	.397(1.329)	.067(1.030)	.113(1.247)			
Backlog	-.068(1.036)	-.289 (.810)	.017 (.951)	5_d	-1.36	
Finished Goods	.479(1.455)	.090 (.824)	.366 (.885)	5_e	-1.88	
Sample Size	63	72	58			

Innovation type, despite little difference exhibited in the type of production process used.

The second notion was that the Marketing Intensive must therefore use the manufacturing system for differentiation through service; i.e. maintain higher excess capacity for rapid delivery, keep order backlogs low, and/or maintain finished goods inventories at levels sufficient to insure high product availability. The findings partially mirror this notion. First, capacity utilization is indeed significantly lower for the Marketing Intensive. This result also parallels the findings of the capacity utilization regression model, in that lower capital intensity and lower fixed costs do indeed lead to lower capacity utilization. The difference in order backlog is in the expected direction, however does not achieve significance. Last, the finished goods inventory difference is not in the expected direction. Perhaps in the same vein as fixed assets, some inclination still exists to minimize finished goods levels given a minimal service level. However, reasoning as to why the Product Innovation should be relatively <u>higher</u> cannot be ascertained.

For purposes of comparison, the "Combination" sample is also shown (distinguished by high levels of both R & D and marketing). Values of the policy variables do not exhibit a pattern which can be readily interpreted in relation to the other two types. In the majority of cases, the mean value falls between the scores of the Product Innovation and Marketing Intensive, however is a closer approximation to the values of the Marketing Intensive. The sole major difference is that the type is more job shop-oriented, as evidenced by its low score on the process type variable. Why this relationship should hold cannot be explained. Nonetheless, in total this type does not exhibit a distinctive pattern.

6.22 Low Cost-Capital Versus Low Cost-Labor

The results of these comparisons are shown in Table 6.4. In this case four hypotheses were formulated, all of which revolve around the fundamental expected difference between the two types in the factor intensity of the manufacturing system. In summary all four differences are in the expected direction, however only two were significant. Capital intensity is obviously higher for the Low Cost-Capital subsample, since this was a basis for defining the two subsamples. In addition the Low Cost-Capital type has a production process which is more "continuous" oriented (Hypothesis 5_g) and fixed costs which are also higher (Hypothesis 5_h). As might be expected from the capacity utilization modeling in the prior chapter, capacity utilization is also higher for the Low Cost-Capital subsample, although a significant difference is not present. The "lumpiness of investment" - the amount by which capacity can be efficiently increased - is also apparently higher (although no hypothesis was stated).

The variable which is most problematic is "economy of capacity." This element deals with the notion that the average size of capacity is likely to be larger for businesses using capital intensive processes. This statement is based on the idea that industries with capital intensive processes will tend to be more concentrated *ceteris paribus*. As a consequence market share and the size of capacity for the "representative" firm will be larger. The relationship is in the expected direction but is not significant. This test is admittedly tenuous for several reasons. One, despite the higher capital intensity, minimum efficient scale may be low enough for these various manufacturing systems

Table 6.4

Manufacturing Policy Variable Comparisons - Low Cost Strategy Types

Variable	Mean(Standard Deviation)		Hypothesis	Z Statistic	Support
	Low Cost-Capital	Low Cost-Labor			
Capacity Utilization	.273(1.038)	.097(1.004)	5_f	1.07	
Capacity Increment	.255(1.244)	.075(1.049)			
Process Type	.680 (.976)	.002 (.959)	5_g	4.36	*
Capital Intensity	1.290(1.222)	-.473 (.520)			
Fixed Costs	.845(1.552)	-.442 (.631)	5_h	6.04	*
"Economy Of Capacity"	-.131 (.878)	-.157 (.873)	5_i	.19	
Backlog	-.238 (.696)	-.141 (.809)			
Finished Goods	.052 (.890)	.123 (.977)			
Sample Size	57	124			

such that it is met or exceeded by the majority of the competitors.[5] Second, the operationalization is probably not optimal. The preferred measure would be based on absolute market share, rather than the relative market share measure employed. Relative market share, however, was superior for the capacity utilization modeling. The decision was made to stay consistent and not develop a different measurement scheme.

6.23 Differentiation Versus Low Cost

The results of the Differentiation - Low Cost comparison are shown in Table 6.5. This table compares the average of the Product Innovation and Marketing Intensive types to the average for the Low Cost-Labor and Low Cost-Capital types. The two other Differentiation subsamples were not included in these tests. Of the eight hypothesized differences, seven were in the expected direction and four were significant. The only dubious result was for "economy of capacity," which once again is expected to suffer from the problems mentioned earlier. These findings are satisfying in their consistency, regardless of the significance in all cases.

These particular summary tests provide the best comparability to other business strategy research (Hambrick, 1983a; Woo and Cool, 1983).[6] To cite the similarities, Woo and Cool found that the "cost leadership" sample had higher capacity utilization; the "differentiation" sample had higher levels of finished goods and more of a tendency

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[5]A similar effect would also occur if the market was sufficiently large to allow a substantial number of competitors at MES.

[6]Hambrick compared "prospectors" and "defenders;" Woo and Cool used the Porter "cost leadership"/"differentiation" types as the basis for their tests.

Table 6.5

Manufacturing Policy Variable Comparisons - Differentiation And Low Cost

Variable	Mean(Standard Deviation)		Hypothesis	Z Statistic	Support
	Differentiation	Low Cost			
Capacity Utilization	-.153(1.078)	.153(1.018)	5_j	2.55	*
Capacity Increment	-.048 (.948)	.132(1.117)	5_k	1.65	*
Process Type	-.019 (.778)	.215(1.015)	5_l	2.32	*
Capital Intensity	-.143 (.935)	.083(1.151)	5_m	1.93	*
Fixed Costs	-.078 (.949)	-.036(1.178)	5_n	.35	
"Economy Of Capacity"	.221(1.196)	-.148 (.874)	5_o	-3.05	
Backlog	-.186 (.929)	-.171 (.777)	5_p	.15	
Finished Goods	.271(1.178)	.101 (.951)	5_q	1.37	
Sample Size	135	181			

to produce in small batches. Hambrick found that the "defenders" exhibited higher capital intensity (gross fixed assets/employee) than the "prospectors."

A number of differences, however, were seen. Woo and Cool found no difference in capital intensity between the types; Hambrick detected no difference in the capacity utilization of the types. The Woo and Cool samples also showed an interesting finding in that new product activity for the "cost leadership" type was higher than the "differentiation" strategy - somewhat different than the trend shown in Table 6.2. The Woo and Cool results are somewhat confounded since businesses engaged in making custom products were not dealt with separately.[7]

6.24 Custom Producer Versus Other Types

Table 6.6 presents the manufacturing policy variable averages for the Custom Producer and results of the hypothesis testing. The three hypotheses offered for this type simply revolve around its unique aspect - manufacturing of a non-standard product. This fact then leads to the argument for extreme flexibility of production process; i.e. a small batch or "job shop" orientation. Secondly, because of the "produce to customer specification" concept, order backlogs are thus much likely to be higher and finished goods lower in comparison to a producer of standard goods. All three hypotheses are strongly supported.

A cursory examination of the remaining variables shows some interesting internal consistencies in the Custom Producer sample. First, be-

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[7]No difference between the two types, however, was found for the "customization" variable. As might be expected custom products can also be either high or low priced relative to <u>their</u> competition. This, however, does not recognize the expected fundamental difference in the manufacturing system of the Custom Producer.

Table 6.6

Manufacturing Policy Variable Comparisons - Custom Producer Versus Others

Variable	Mean(Standard Deviation)	Hypothesis	Z Statistic		Support
			Custom Vs. Differentiation	Custom Vs. Low Cost	
Capacity Utilization	.072 (.968)				
Capacity Increment	-.060(1.022)				
Process Type	-.411 (.887)	5_r	-3.96	-5.96	*
Capital Intensity	.010 (.787)				
Fixed Costs	-.010 (.794)				
"Economy Of Capacity"	-.163 (.724)				
Backlog	.707(1.427)	5_s	6.29	6.70	*
Finished Goods	-.592 (.737)	5_t	-7.31	-7.45	*
Sample Size	148				

cause of the "job shop/small batch" process orientation, the "lumpiness of investment" should be lower than the other types. Additional capacity can be added in relatively "fine" amounts. Such a difference was found in the samples, although does not appear to be statistically significant. Second, a "job shop/small batch" manufacturing system might be expected to have relatively low capacity utilization *ceteris paribus*. This statement was confirmed by the capacity utilization modeling. However, offsetting factors are the small "lumpiness" in capacity change and the high order backlog - both of which would lead to higher capacity utilization. Capacity utilization for the Custom Producer thus falls between the Differentiation and Low Cost types. Such a finding would not be intuitive if only the type of process was considered in formulating the expected association.

6.3 The Manufacturing Policy - Performance Effect

The following four subsections review the regression models by strategy type used to explain ROI. To reiterate the purpose for this step, the intent is to test the uniformity of the effect of the manufacturing policy variables on ROI. For example, is high capacity utilization of equal importance to all strategy types in achieving high performance? Hypothesis 5_u has stated that such differences in effect will be found among the strategy types, i.e. the magnitude, sign, and/or significance of individual variables will differ. The comparisons from the prior subsections will also be particularly helpful in interpreting the outcomes.

The model used for these tests included the eight manufacturing policy variables described in the prior section in addition to a series of additional variables used for the capacity utilization modeling which should also impact ROI. These additions are made, of course, in order to reduce errors due to misspecification. The completed list of variables is shown in Table 6.7. The regression results, however, will only be reported for the manufacturing policy variables.

6.31 Product Innovation Versus Marketing Intensive

Table 6.8 shows the regressions on ROI for the Product Innovation and Marketing Intensive strategy types. In addition to the β coefficients for each of the independent variables, the significance of difference between corresponding pairs of coefficients was calculated using the Fisher Z-test (see Appendix A for a description of the test).

A number of interesting differences emerged. First, although the capacity utilization levels of these two types differed significantly, virtually an equal effect is seen on ROI. Thus, maximization of capacity utilization is equally important within the constraints and objectives of the respective strategy types. As might be expected simply because of its statistical association with ROI, capital intensity has a negative impact in both cases. Capital intensity, however, is much more damaging to the Marketing Intensive. This finding is consistent with the Z-test results in Table 6.3 - that the Marketing Intensive is much less capital intensive than the Product Innovator. These results thus emphasize the importance of minimizing investment in plant and equipment for the Marketing Intensive. The difference based on the Fisher Z-test, however, is not significant.

High backlogs are also much more detrimental to the performance of the Marketing Intensive. Since this type was expected to emphasize its

Table 6.7

"Complete" Regression Model - Performance Of Strategy Types

Variable
<u>Dependent</u>
Return On Investment
<u>Independent - Hypothesis Testing</u>
Capacity Utilization
Capacity Increment
Process Type
Capital Intensity
Fixed Cost
Economies Of Capacity
Order Backlog
Finished Goods
<u>Independent - Other</u>
Served Market Growth
Served Market Concentration
Product Differentiation
Product Change
Purchase Frequency
Regional
Entry
Product Age
Customer Concentration
Net Exports
Price-Cost Squeeze

Table 6.8

Regression Results - Differentiation Strategy Types (Model VI)

Variable	β Coefficients: Product Innovation	β Coefficients: Marketing Intensive	Sig. Of Difference
CAP UTIL	.357**	.363**	
CAP INCR	.163	.065	
PROC TYPE	.002	.154	
CAP INT	-.512**	-.718***	
FIXED	.138	.070	
ECON CAP	-.065	.357***	**
BACKLOG	.004	-.328*	
FIN GOODS	-.261***	-.483***	
Constant	.120	.019	
R^2	.413	.510	
SE	.711	.832	
d.f.	43	52	
F	1.59	2.85	
P	< .1	< .001	

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

ability to provide service to the customer, such a finding is wholly compatible. Once again, however, the magnitude of the β coefficients is not significantly different, although significance in the respective equations is. Contrary to the service notion is that finished goods are much more harmful to the Marketing Intensive's performance. The unexpected direction of difference, though, is consistent with the Z-test in Table 6.3.

Last, "economy of capacity" is highly important to the Marketing Intensive. The reason, however, is not expected to totally relate to manufacturing. To reiterate, this measure is market share-based. Market share could be much more crucial to the Marketing Intensive simply because of economies occurring from large-scale advertising and/or distribution. Such is apparently not the case for the Product Innovation type.

6.32 Low Cost-Capital Versus Low Cost-Labor

The regression results for the Low Cost types are given in Table 6.9. A striking dichotomy is illustrated by the capacity utilization and capital intensity variables. Given the higher capital intensity of the Low Cost-Capital type (from Table 6.4), the key here is to achieve the highest possible capacity utilization. The pricing cuts which some capital-intensive businesses will take to maintain production levels testifies to this scenario. In a sense the results confirm the suspicion in 3.44 that capacity utilization is <u>especially</u> important in a capital intensive environment. Such an interpretation, however, must be made with caution. The importance of minimizing capital intensity cannot be discounted given the significance of the constant in the Low

Cost-Capital model. Such an effect is most likely directly related to the higher capital intensity of the sample.

Conversely, given a labor-intensive manufacturing system, the key appears to be carefully watching the overall level of plant and equipment investment. In this case capacity utilization is not important to ROI. Apparently some flexibility of investment does exist, though. The opposite signs for the fixed cost variable may be once again plausible given carefully controlled capital-labor substitution in the Low Cost-Labor case.

High finished goods levels are much more harmful to the Low Cost-Labor type. The reasoning here is simply that finished goods must be more carefully controlled since inventory represents a higher proportion of total investment in comparison to the Low Cost-Capital businesses.

Explanations of the remaining variables can be quickly dispatched. Economy of capacity (again market share related) is important to profitability in both cases, as might be expected. Capacity increment has a significant effect on profitability of the Low Cost-Capital type. The reasoning behind such a result, however, is not readily apparent. The remaining variables demonstrated no expected or explainable differences in sign, significance, or magnitude.

6.33 Differentiation Versus Low Cost

Table 6.10 gives the regression results for the combined Low Cost and Differentiation subsamples. In general very little difference in the relative importance of the variables to profitability can be seen. Nonetheless, a few minor divergences (though not significant) must be recognized.

Table 6.9

Regression Results - Low Cost Strategy Types (Model VI)

Variable	β Coefficients: Low Cost-Capital	β Coefficients: Low Cost-Labor	Sig. Of Difference
CAP UTIL	.523***	.125	**
CAP INCR	.151*	.089	
PROC TYPE	.130	-.006	
CAP INT	-.120	-.606**	*
FIXED	-.081	.115	
ECON CAP	.219**	.387***	
BACKLOG	-.130	-.019	
FIN GOODS	-.106	-.229**	
Constant	-.272*	-.046	
R^2	.707	.421	
SE	.500	.855	
d.f.	37	104	
F	4.69	3.98	
P	< .001	< .001	

$^{*}p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

Table 6.10

Regression Results - Differentiation And Low Cost Strategy Types (Model VI)

Variable	β Coefficients		Sig. Of Difference
	Differentiation	Low Cost	
CAP UTIL	.291***	.270***	
CAP INCR	.177**	.213***	
PROC TYPE	-.017	.091	
CAP INT	-.500***	-.355***	
FIXED	.074	.038	
ECON CAP	.130*	.315***	*
BACKLOG	-.107	-.023	
FIN GOODS	-.310***	-.256***	
Constant	.053	-.002	
R^2	.398	.396	
SE	.841	.842	
$d.f.$	115	161	
F	3.99	5.56	
P	< .001	< .001	

$*p \leq 0.10$ $**p \leq 0.05$ $***p \leq 0.01$

First, the different signs of the Process Type variable are logical. Since a prime objective of the Differentiation type is flexibility, the motivation to remain as a batch or assembly producer is strong. Moving more towards the continuous process "end" of the scale thus impairs profitability. Although the magnitude of the coefficient is small, the opposing effect is intriguing. Second, the reasoned higher service orientation of the Differentiation types is manifested in a higher negative effect for the order backlogs. Lastly, the greater importance of manufacturing scale to the Low Cost types is found in the higher value for "economy of capacity" coupled with the lower negative impact of capital intensity. It still must be emphasized, however, that a number of these variables are not significant in the regressions or are not significantly different between the strategy subsamples.

Some comparisons can be made with the findings of Woo and Cool (1983). The authors also analyzed the impact of functional attributes on profitability for Cost Leadership and Differentiation strategies. The only result which parallels this study is that capital intensity has a damaging effect on ROI; furthermore, the β coefficient for the Differentiation type is much more negative than the Cost Leadership type. The dissimilarities were due to the effect of capacity utilization (substantially higher impact for the Differentiation strategy) and finished goods (positive for the Differentiation strategy).

The implication of these regressions is simply that while the variable means differ between the strategy types, their effect on profitability is reasonably consistent. In other words, given the broad overall thrust of a business strategy on the design of the manufacturing system, the objective is still to maximize capacity utilization, minimize capital investment, etc. to whatever extent possible.

6.34 Custom Producer Versus Other Types

Tables 6.11 and 6 12 compare the Custom Producer to the Differentiation and Low Cost strategy types respectively. These analyses are perhaps less revealing than the preceding subsections. A few differences merit mention. Capacity utilization is a much less important contributor to profitability, though the difference is not significant in either case. Secondly, the impact of moving the manufacturing system away from "batch" processing is more detrimental for this type.

6.4 Chapter Summary

A majority of the hypotheses concerning the difference in manufacturing policy variables between the strategy types was supported. A tie therefore appears to at least exist between business strategy and the design of the manufacturing system - e.g. the choice of process technology, the chosen level of investment in plant and equipment or inventories, the fixed costs to be borne. Furthermore, the tie extends to even more of a fundamental notion than the simple "Cost Leadership/ Differentiation" dichotomy. A different manufacturing system is required depending on the path chosen for achieving differentiation (e.g. unique products, service) or the factor intensity of the process (e.g. capital- or labor-dominated).

Varying effects of these manufacturing policy variables by strategy type on performance, however, were for the most part not evident. Apparently irrespective of strategy, the objectives of any manager in operating the manufacturing system are much the same - maximize capacity

Table 6.11

Regression Results - Custom Producer And Differentiation Strategy Types (Model VI)

Variable	β Coefficients: Custom Producer	β Coefficients: Differentiation	Sig. Of Difference
CAP UTIL	.117*	.291***	
CAP INCR	.005	.177**	
PROC TYPE	-.048	-.017	
CAP INT	-.359***	-.500***	
FIXED	.107	.074	
ECON CAP	.212**	.130*	
BACKLOG	.028	-.107	
FIN GOODS	-.147*	-.310***	
Constant	-.172*	.053	
R^2	.200	.398	
SE	.744	.841	
$d.f.$	128	115	
F	1.68	3.99	
P	< .05	< .001	

$^*p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

Table 6.12

Regression Results - Custom Producer And Low Cost Strategy Types (Model VI)

Variable	β Coefficients: Custom Producer	β Coefficients: Low Cost	Sig. Of Difference
CAP UTIL	.117*	.270***	
CAP INCR	.005	.213***	**
PROC TYPE	-.048	.091	
CAP INT	-.359***	-.355***	
FIXED	.107	.038	
ECON CAP	.212**	.315***	
BACKLOG	.028	-.023	
FIN GOODS	-.147*	-.256***	
Constant	-.172*	-.002	
R^2	.200	.396	
SE	.744	.842	
$d.f.$	128	161	
F	1.68	5.56	
P	< .05	< .001	

$^{*}p \le 0.10$ $^{**}p \le 0.05$ $^{***}p \le 0.01$

utilization, minimize inventories, etc. The differing means of these variables, though indicate that the manager still must function within broad constraints.

In a sense these results also provide some justification for the classification procedure used to identify the strategy types. The producer of custom goods definitely is a different "animal" with regard to manufacturing policy. Secondly, elements such as relative price and key investment or expenditure levels is all that is needed to categorize the businesses - relative manufacturing cost is not a critical factor.

CHAPTER VII

CONCLUSIONS AND IMPLICATIONS

In this study the broad goal was to further the understanding of some policies within a functional area - in this case, manufacturing. The vast majority of research into strategy content has focused on the corporate or business level, with very little investigation of the functional implications. By contrast, this study uses the business strategy concept only as a starting point for developing and testing theory concerning manufacturing strategy. Furthermore, existing theory concerning manufacturing has had only limited empirical testing.

This study only looked at one area of manufacturing - specifically, capacity policy. Capacity policy has been loosely defined via three issues - "how much, when, and what type." The focus here is on "how much" capacity should be added (or dropped from) the manufacturing system. Although other areas of manufacturing policy were not specifically incorporated into the analysis (such as vertical integration), it was important to recognize the interaction between capacity policy and, for example, the choice of production process.

Essentially this study examined four different aspects of capacity policy. First, regression models were formulated which in turn were intended to understand 1) the technological and demand influences and 2) the effect of the competitive environment on capacity policy. "Capacity policy" - the dependent variable in both models - was represented by capacity utilization. Next, hypotheses were tested which surveyed the effect of capacity utilization on performance as contingent upon a number of industry/technology variables. The effect of business strategy was then specifically incorporated into the last two analyses. Capacity utilization and a series of other manufacturing variables were compared by business strategy type. Last, the consistency of the effect on performance - again between the strategy types - was investigated.

The remainder of the chapter will summarize what has been learned from this study. The results of the analyses discussed above will first be reviewed. The contributions of these efforts to both policy research and the management of manufacturing will be presented along the way. Discussions of the methodological contributions and suggestions for future research will then follow.

7.1 Summary Of Findings

The following three subsections in turn discuss the results of the capacity utilization modeling, the effect of capacity utilization on performance, and the business strategy effect.

7.11 Capacity Utilization Modeling

Two different "models" of capacity utilization were formulated and tested. In the first instance, capacity utilization was modeled as a function of a series of technology and demand factors. The initial model attempted a replication of the work of Manne (1967), which produced frankly poor results. Only two of the five independent variables were significant in the expected direction (served market growth and backlog levels). Unfortunately these results mirrored the findings of Lieberman (1984a), who also found little support for the Manne model. The basic premise of this model - that capacity expansion moves are largely determined by plant investment scale economies - apparently fails to hold.

The extensions to this basic model proved to be much more satisfactory. Variables for the financial characteristics of the manufacturing system (capital intensity, fixed costs), type of production process, relative size of capacity ("economy of capacity"), and finished goods inventories were added. R^2 increased from .015 to .215 and the standard error was lowered from .993 to .886.

Admittedly, much of the improvement in the modeling was due to the inclusion of capital intensity. Nonetheless, the findings for particular variables must be emphasized here. The type of production process was highly significant in explaining capacity utilization - even though fixed cost and investment variables were <u>also</u> included in the model. The result lends credence to the fact that processes have vastly different operating characteristics. For example, a synthetic fiber plant tries to operate at high utilization levels simply because it is inordinately expensive to stop and restart the process - machinery and piping must first be totally cleaned. This research is the first to operationalize "production process" in the modeling of capacity utilization. Second, the notion that relative size of capacity influences capacity utilization was found to be true for manufacturing businesses (previous theory and empirical testing addressed service businesses, such as airlines). As summarized in Chapter V, this result also has implications for the concept of preemptive capacity addition.

The primary shortcoming of the Manne modeling is that the effect of competition on "optimal" capacity expansion (or capacity utilization) is ignored. This viewpoint is appropriate in regulated industries such as public utilities, which have been the focus of a large number of modeling efforts. The capacity decision therefore reduces to a "technical" issue of cost minimization.

The Esposito and Esposito (1974) modeling was therefore included to address this deficiency. A comparable research strategy was also used here - replication of the original work complemented by extensions. The replication produced mixed results. All of the hypothesized relationships were significant (seller concentration, product differentiation, regularity of product change, purchase frequency, industry growth, capital intensity). A key part of the "competition" effect, though, was the "U-shaped" relationship between seller concentration and capacity utilization. The "U" was expected because of the "coordination" phenomenon which should exist in tight oligopolies and atomistic industries, but not in partial oligopolies. Instead, a significant negative linear association was found, which is counter to the results of both Esposito and Esposito and Lieberman (1984*b*).[1]

Some justification for this result is plausible, however. Excess capacity can be held as a deterrent to entry - when entry is threatened, output can be expanded and prices reduced. Alternatively, the higher excess capacity as concentration increases could reflect failed attempts at preemption (particularly where rivalry among the competitors is high).

Other results are particularly noteworthy to the practicing

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[1]Lieberman's results, however, are likely biased due to the relatively high concentration level of the sample.

manager. "Product differentiation" (as measured by relative advertising) exhibited a significant negative association with capacity utilization. This finding is consistent with the comparison of business strategy types - capacity utilization was significantly lower for the "Differentiators" than the "Low Cost" types.[2] The implication, therefore, is that efficiency through high capacity utilization is secondary to the firm which tries to succeed through "product image" or "service." Second, "irregularity of product change" was particularly damaging to capacity utilization - plants must be closed down for retooling, production inventories require re-stocking, employees need retraining, etc. To reiterate, the damaging aspect was irregularity of product change, not frequency. The interpretation is that product change can be an effectively managed process - rapid "change" need not impair efficiency as a consequence.

The extensions to the model showed that not only is concentration important, but stability of the competitive environment is also critical. Events which can "destabilize" the industry and create fluctuations in excess capacity include factors such as entry, exit, and import/export competition. Buyer/supplier relationships were also shown to play a role as a significant influence in the "competitive environment." For example, a weak or fragmented group of buyers has generally been thought of in conjunction with the seller's ability to control pricing. This research has shown that a similar notion - "weak" buyers - may also extend to better control of asset utilization. On a slightly different note, a business which is caught in a "squeeze" between sup-

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[2]Relative advertising was not used in the identification of the "Differentiator" type.

pliers and buyers (e.g. declining margins) tends to react by "forcing" more production out of existing assets, rather than opting for the construction of newer, more cost-efficient facilities.

For both models the use of carefully constructed subsamples provided substantial additional insight to these results. For example, the effect of exit from the industry had significant but opposite effect on capacity utilization depending on the growth rate. Past research in the strategy literature has tended to use the product life cycle as the principal contingent factor. The concept, though, has received much criticism from various circles as to its applicability and accuracy. The approach here - to use more fundamental constructs based on growth, industry structure (concentration), and technology (production process type) - is felt to have provided results superior to the product life cycle. In fact, the effect of the product life cycle on the modeling was shown by a separate test to be insignificant. A similar test to verify that pooling of the consumer and industrial businesses had no effect on the results was not as successful. This matter will be further discussed in the considerations for further research.

In summary, the insights provided by these two models proved to be complementary rather than competing. In reality technological and competitive factors must both be considered when planning for effective utilization of capacity. The overwhelming past experience (and research, for that matter), however, has gravitated towards the technological dimension. Modeling which combines the factors of both models could perhaps be most successfully applied to the objective comparison of the manufacturing characteristics and performance (in terms of capacity utilization) of different businesses, such as might be found in a typical corporate portfolio. Much as PIMS has developed "PAR" reports to assess how any given business "stacks up" against other businesses with similar characteristics, perhaps the same type of "tool" can be developed for the analysis of functional or operating performance. The point is that a model of the overall financial performance of a business provides little guidance to the manager in terms of planning and control at the functional level. The modeling of capacity utilization is perhaps a step in that direction.

7.12 The Capacity Utilization - Performance Relationship

Given the myriad of uncertainties with which the operating manager must deal, the implication of the results of this modeling is simple - always try to maximize capacity utilization. For the worst case scenarios increased capacity utilization only detracts minimally from ROI. Conversely, other circumstances (such as high concentration) result in capacity utilization giving profitability an extra boost.

One caveat to this conclusion must be added, however. The research did not check for the existence of a "U-shaped" relationship of capacity utilization to cost. Theoretically, if capacity utilization rises beyond some optimal point, operating costs will begin to rise. Additional maintenance expense is required, overtime, etc. ROI would then be damaged *ceteris paribus*. Thus, in addition to the industry effect line of reasoning, some characteristics of the technology might also contribute to a negative impact.

7.13 The Business Strategy Influence

The two phases of analysis here - comparison of manufacturing policy variable means among the business strategy types and the effect of these variables on performance (also by strategy type) - proved to be complementary. The design of the manufacturing systems appeared to be reasonably consistent with the respective business strategies. For example, comparative values for backlog, capital intensity, type of production process, etc. were predicted with reasonable accuracy. Some major differences thus were seen between the strategy types in how they approach manufacturing.

Despite these differences, consistent relationships to ROI generally emerged. For example, even though the Differentiation types were found to have significantly lower capacity utilization than the Low Cost types, the effect of capacity utilization on performance was virtually the same in both cases.

Two interesting contrasts, though, with the Low Cost and Differentiation types should be described. First, given a capital-intensive manufacturing system (many times which might be dictated largely by the nature of the product), the objective is simply to maximize capacity utilization. The Low Cost-Labor type appears to have somewhat different objectives. In this case, capacity utilization takes a "back seat" to minimizing capital investment. Proposals for capital-labor substitution should thus receive special scrutiny. A second effect is that if capital investment is minimized, then minimization of inventories becomes relatively more important.

Second, the Marketing Intensive was hypothesized to be less prone to make significant manufacturing investment and more likely to be service oriented than the Product Innovation type. In general, the comparison of means substantiated these claims. The regressions on ROI provided similar conclusions - that capital intensity and high order backlogs are much more damaging to the profitability of the Marketing Intensive.

Several implications for policy research can be drawn from this comparison of the strategy types. First and foremost, further research into functional policies will most likely require the development of increasingly sophisticated and detailed business strategy typologies. The simple "differentiation/cost leadership" framework provides insight into the overall basis of competition among firms. The limitation is that the firm can achieve "differentiation" through several different paths, all of which are likely to have radically different implications for the respective functional policies. The specific "avenues" of differentiation therefore need to be defined. Description of the two Differentiation and two Low Cost types is intended to be a movement in that direction.

A "twist" to this need is that consideration at the functional level may help one "back in" to a better definition of business strategies. The case in point for this research was the Custom Producer. The realization was reached that this type is fundamentally different from other types simply because of the manufacturing process. Factors used for classification of the other types - relative price, R & D/marketing expenses, capital intensity - are simply not relevant here. Other researchers have not recognized this difference and have tended to simply lump custom and standard producers together.

It appears clear that linkages do exist between business strategy and capacity policy. It appears to be equally clear that future business strategy research can benefit greatly from a more careful delineation of the functional consequences.

7.2 Methodological Contributions

Any methodological contributions of this research do not rest in the area of application of more powerful or sophisticated techniques which can be brought to bear in the analysis of strategy issues. Instead, the focus has been on theory and simple methods. For example, ordinary least squares regression was used for most of the analysis. Contingent effects were studied using a straightforward series of data subsamples. Identification of strategy types was accomplished with a very basic classification scheme.

The emphasis on simplicity was intentional in that hopefully the power of logic would prevail and results would not be muddied by the methods used. For example, the examination of contingent effects was expanded beyond the product life cycle (or industry type) factor most typically used. The product life cycle represents a whole series of interacting phenomena - the researcher is farther ahead by dealing directly with these underlying characteristics. The three contingencies used in this research proved to be more revealing - differences caused by these contingencies were more easy to explain and understand.

A similar view can be taken of the strategy classification algorithm. While the use of a simple algorithm is not unique, it provides significant advantages over competing methods (such as clustering). One needn't worry about when to stop the clustering program, how many clusters are appropriate, or how to interpret the results. The ability to simultaneously consider a larger number of factors doesn't outweigh the advantage of simplicity.

7.3 Directions For Future Research

Possible directions for future research can be easily seen simply from the limitations of this work. Two avenues of pursuit pertain to the investigation of the capacity issue, however one additional item has much broader implications.

First, the analysis of capacity utilization using a time series model (rather than the cross-section approach used here) should complement these results and perhaps explain some of the deficiencies. Of major interest would be the impact of demand variability on capacity utilization, which was found as insignificant in this modeling. Part of the problem was most likely related to the use of four-year averages, however the dynamic approach should more fully reveal the effect of this variable. Second, the interaction among backlogs, capacity, finished goods, and capacity utilization would be of interest. Such an investigation would provide some insight into the effect that marketing policies have on manufacturing. Last but not least, industry characteristics which spur such phenomena as preemptive capacity addition, the nature of capacity growth in maturity (the "accelerator" versus "vintage" model), or capacity contraction and exit can be more adequately analyzed.

A dimension not explored in this research which could have a potentially major influence on capacity is corporate strategy. For example, the existence of "buyer/supplier" relationships within the corporation would likely dictate that the respective business units cannot make capacity decisions which are totally independent of one another. Such a constraint might be especially true if the production facilities are shared by business units.

Stepping back from these capacity issues, a particularly puzzling result from the research is the significant difference in the capacity utilization modeling for the consumer and industrial business subsamples. Variables were incorporated into the model which should have transcended any differences - e.g. purchase frequency, customer characteristics. Whether such differences in the models are due to peculiarities of the data or true fundamental differences in the manufacturing characteristics of the businesses is difficult to assess and is beyond the scope of this research. PIMS researchers have typically dealt with businesses of only one type at a time, with industrial businesses usually dominating (probably due to the larger sample size). Why it truly is not logical (i.e. theoretically what are the differences) or appropriate to pool these businesses has never been addressed. Although this concern may be a minor one, it seems that a fundamental requirement is to truly understand the properties and differences inherent in the data sample that one is manipulating.

APPENDICES

Appendix A

Fisher Z-Test Of Regression Coefficients

<u>Hypotheses</u>

Null $H_0: \beta_{1,A} = \beta_{1,B}$

Alternate $H_a: \beta_{1,A} \neq \beta_{1,B}$

where:

A = sample A

B = sample B

<u>Test Statistic</u>

$$Z = \frac{\beta_{1,A} - \beta_{1,B}}{\sqrt{S^2_{\beta_{1,A}} + S^2_{\beta_{1,B}}}}$$

where:

$S^2_{\beta_{1,A}}$ = the standard error of $\beta_{1,A}$

$S^2_{\beta_{1,B}}$ = the standard error of $\beta_{1,B}$

<u>Critical Value</u>

$$|Z| = Z_{1-\alpha/2}$$

Appendix B

Chow Test

Hypotheses

Null $H_0: \sum_{i=1}^{N_1} U_1^2 + \sum_{i=1}^{N_2} U_2^2 = \sum_{i=1}^{N_p} U_p^2$

Alternate $H_a: \sum_{i=1}^{N_1} U_1^2 + \sum_{i=1}^{N_2} U_2^2 \neq \sum_{i=1}^{N_p} U_p^2$

where:

$\sum U^2$ = the sum of the squared residuals

N_1 = number of observations in sample 1

N_2 = number of observations in sample 2

N_p = number of pooled observations $(N_1 + N_2)$

Test Statistic

$$F_T = \frac{\left(\sum_{i=1}^{N_p} U_p^2 - \sum_{i=1}^{N_1} U_1^2 - \sum_{i=1}^{N_2} U_2^2 \right) / K}{\left(\sum_{i=1}^{N_1} U_1^2 + \sum_{i=1}^{N_2} U_2^2 \right) / (N_p - 2K)}$$

where:

K = the degrees of freedom

Critical Value

$$F_T \geq F_{(K,\ N_p - 2K)}$$

Appendix C

Regression Results - Manne Model And Extensions (Product Life Cycle Subsamples)

Variable	β Coefficients		
	Growth	Mature	Decline
CAP INCR	-.054	-.042	.043
SM GROWTH	.107**	.110***	.042
SM INSTAB	-.009	.029	-.150
BACKLOG	.034	.099***	-.106
REGIONAL	-.056	-.051*	-.093
PROC TYPE	.196***	.057*	-.075
CAP INT	.326***	.366***	-.283
FIXED	.093	.082*	.598*
ECON CAP	.047	.026	.014
FIN GOODS	-.031	-.023	.053
Constant	-.118*	.025	.147
R^2	.223	.224	.206
SE	.892	.882	.709
d.f.	140	671	35
F	4.02	19.4	.91
P	< .001	< .001	< .55

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

Appendix D

Regression Results - Manne Model And Extensions (Industry Type Subsamples)

Variable	β Coefficients	
	Consumer	Industrial
CAP INCR	-.151***	.010
SM GROWTH	.166***	.056*
SM INSTAB	-.062	.048*
BACKLOG	.131	.107***
REGIONAL	-.088*	-.035
PROC TYPE	.046	.101***
CAP INT	.582***	.312***
FIXED	.049	.072*
ECON CAP	.095*	.034
FIN GOODS	-.044	-.008
Constant	.087	-.015
R^2	.285	.207
SE	.847	.887
d.f.	281	584
F	11.2	15.2
P	< .001	< .001

$^{*}p \leq 0.10$ $^{**}p \leq 0.05$ $^{***}p \leq 0.01$

Appendix E

Regression Results - Esposito And Esposito Model Aand Extensions (Product Life Cycle Subsamples)

Variable	β Coefficients		
	Growth	Mature	Decline
SM CONCEN	-.136*	-.039	-.128
PROD DIFF	-.105	-.209***	.263*
PROD CHG	-.044	-.093***	-.158
PUR FREQ	.015	-.052*	-.158
SM GROWTH	.210***	.124***	.200
CAP INT	.420***	.392***	.286*
SM ENTRY	-.040	-.054*	.027
SM EXIT	.026	-.023	.064
NET EXPORTS	.056	.032	-.019
PROD AGE	-.103*	.011	-.019
TECH CHG	-.093*	.029	-.036
CUST CONCEN	-.001	.150***	.286
P-C SQZE	.040	.072**	.095
Constant	-.021	.010	.211
R^2	.237	.268	.239
SE	.884	.857	.693
d.f.	137	668	32
F	3.26	18.8	.77
P	< .001	< .001	< .7

*$p \le 0.10$ **$p \le 0.05$ ***$p \le 0.01$

Appendix F

Regression Results - Esposito And Esposito Model Aand Extensions (Industry Type Subsamples)

Variable	β Coefficients	
	Consumer	Industrial
SM CONCEN	-.038	-.037
PROD DIFF	-.125***	-.223***
PROD CHG	-.010	-.079**
PUR FREQ	-.039	-.046
SM GROWTH	.161***	.124***
CAP INT	.621***	.339***
SM ENTRY	-.047	-.035
SM EXIT	-.014	-.028
NET EXPORTS	-.134**	.066**
PROD AGE	-.069	-.022
TECH CHG	.076*	-.032
CUST CONCEN	.139***	.261**
P-C SQZE	.149***	.028
Constant	-.018	.025
R^2	.338	.226
SE	.815	.877
d.f.	278	581
F	10.9	13.1
P	< .001	< .001

*$p \leq 0.10$ **$p \leq 0.05$ ***$p \leq 0.01$

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