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CAPACITY UTILIZATION AND INVESTMENT IN MANUFACTURING:
A THEORETICAL AND EMPIRICAL EXPLANATION

A Dissertation Presented

By

PATRICIA MOTTRAM ANDERSON

Submitted to the Graduate School of the
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Bonnie J. Webster not only efficiently typed the final copy of this dissertation, but also straightened out many problems of grammar and composition.

Responsibility for any errors in this research belongs to the author.

ABSTRACT

Capacity Utilization and Investment in Manufacturing: A Theoretical and Empirical Explanation

May, 1977

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Directed by: Professor Sidney C. Sufrin

The purpose of this research is to investigate the determinants of capacity utilization and investment in manufacturing businesses, using cross-section regressions and industrial organization or business variables. If the variables influencing capacity utilization and investment are known, business managers should be able to plan and manage capacity more effectively, thus improving profitability, i. e., return on investment. Increased knowledge about capacity utilization and investment may help business managers plan investment programs, and may help government plan more effective tax and interest rate policies for encouraging or discouraging business investment.

In competitive economic theory, excess capacity results from imperfect competition or knowledge, and results in misallocation of resources. The cost to a firm of carrying excess capacity must be weighed against benefits of increased market share and putative profits from having additional capacity to meet unexpected demand increases. Excess capacity can be used as a barrier to free entry into a market. Capacity utilization is an important determinant of investment in the capacity-accelerator theory of investment.

A business, the unit of the investigation, is a part of a parent company and produces a product for a narrowly-defined market. Manufacturing capacity is defined as potential output produced by the normal number of hours, shifts, and days worked per week with the usual allowances for vacations, downtime, and overtime. Plant and equipment used only in emergencies are not included in normal capacity. The investment dependent variable used in this study is the per cent change in plant, equipment, and net working capital (cash, short term assets, accounts receivable, plus inventories less current liabilities).

The hypotheses of this study were: 1) that regression coefficients of specific variables in the following groups: market position, product characteristics, production and productivity, finance, external environment, internal environment, and customer characteristics, would be significantly different from zero in explaining capacity utilization; 2) that the rank order of these standardized regression coefficients in hypothesis 1 would be different for the six different types of business, and 3) that new investment could be explained by: sales change, capacity utilization, profitability, and capital stock variables. Evidence found in cross-section studies of 625 manufacturing businesses in 1970-1973 and 515 manufacturing businesses in 1971-1974 in data banks of the Profit Impact of Market Strategy (PIMS) Project was not sufficient to reject the hypotheses, and afforded some statistical support.

In general, the most important variables for explaining capacity utilization were found to be: capital intensity, real market growth, market share, sales force expense/revenue, entry of competitors, and new investment. Real sales growth and capacity utilization were found to be important variables in explaining new investment. This evidence is consistent with evidence found in other research studies that capital intensity and some nonlinear indicator of size influenced capacity utilization, and that there was support for the capacity-accelerator theory of investment.

Capacity utilization and investment equations were specified for future use in a simultaneous model which would also contain a PIMS return on investment equation.

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CHAPTER I

INTRODUCTION

Purpose

The purpose of this research is to further the understanding of how manufacturing capacity utilization is related to some relevant variables which are of interest to and, hopefully, under the control of business managers. By learning which variables influence capacity utilization, a business manager may be able to achieve a more efficient capacity utilization rate and plan effective investment programs. The capacity utilization rate has been used in research with other variables to explain investment and return on investment.

Definition and measurement. Although capacity concepts have been discussed in economic literature at least since the 1920s, consensus concerning measurement of capacity utilization has been reached only in the 1970s. Manufacturing capacity is usually defined in terms of potential output that can be produced in the normal days and shifts worked per week, with the usual allowances for vacations, downtime, and overtime. Older plant and equipment, used only in emergency periods to meet peaks in demand, are not included in this definition of normal capacity. Underutilized capacity is called excess capacity. A capacity utilization rate, which is the ratio of actual output to normal capacity output, measures the extent to which potential capacity is utilized. Concepts and measurement are discussed in Chapter IV.

Theory

Capacity is included in several business and economic theories: 1) macroeconomic theory, 2) microeconomic theory, 3) financial management, and 4) industrial organization. Chapter II reviews the theoretical treatment of capacity, capacity utilization, and related variables.

Investment. In macroeconomic theory, capacity utilization is an important variable used to explain net new investment. Although macroeconomic theory usually deals with such aggregates as United States manufacturing, the analysis is also appropriate for business. Investment is a change in capital, that is, a change in plant and equipment. If demand needs to be stimulated, one way that the government can stimulate aggregate demand, according to theory, is to encourage private investment through policies affecting taxes, the interest rate, and government deficits. If industrial capacity is underutilized, government policies designed to encourage private investment obviously become difficult to apply successfully.

Excess capacity. Excess capacity, or underutilized capacity, is included in microeconomic theory, financial management considerations, and industrial organization propositions. In microeconomic theory, excess capacity persistently occurs under conditions of imperfect competition, and results in misallocation of resources or inefficient use of resources. Capacity utilization can be a strategic decision in financial management. The costs of carrying excess capacity, in anticipation of increases in demand for a product, must be weighed against the benefits of increased market share and profits which become possible with additional capacity available to meet demand increases and peaks in demand. Uncertainties in the supply of inputs and demand for output, and environmental factors outside the control of management may make flexibility, in the form of excess capacity, desirable.

According to industrial organization propositions, this flexible excess capacity can be used as a barrier to new entry such that new competitors will be discouraged from entering a market. It is alleged that ALCOA used excess capacity to discourage entry into the aluminum market (U. S. v. Aluminum Co. of America, 1950). Since overhead costs remain the same whether or not excess capacity is used, a business may be tempted to use price discrimination, that is, to sell the same product at different prices in different markets, in order to use excess capacity by reducing the price of a product in one of the markets (Bain, 1968; Clark, 1923).

Approach. Theory gives more insights into the effects of capacity utilization than into its determinants and measurement. The industrial organization approach, with some aspects of financial management, seems to be the most appropriate approach for studying capacity utilization because the structural variables of industrial organization seem closer to the real world than the variables of microeconomic and macroeconomic theory. Although industrial organization was developed to study industries, the approach can be adapted for studying businesses. Industrial organization structural variables include: extent of market power for buyers and sellers, barriers to entry of new firms, product differentiation, growth rate of market demand, and vertical integration

(Scherer, 1971; Bain, 1968; Caves, 1972; Esposito and Esposito, 1974).

Possible Models, Empirical Studies, Data

Models. There are several types of models that can be used to study capacity utilization. These are: 1) management science models, 2) cost-benefit analysis, 3) input-output analysis, and 4) multiple regression analysis. These are described in Chapter III.

Empirical studies. Chapter III also reviews empirical studies which include capacity utilization as a variable. Most of these studies use time-series or cross-section regression analysis in models of one or more equations. Studies explaining investment and return on investment find that capacity utilization is an important and significant explanatory variable (Meyer and Glauber, 1964; Eisner, 1972; Hirsh *et al.*, 1973; Gale and Donaldson, 1975). However, only two studies have attempted to explain capacity utilization (Esposito and Esposito, 1974; Lim, 1976). More studies explaining capacity utilization are needed if only to confirm or contradict the findings of these two studies.

Investment is the explained variable in most of the above studies. PIMS (Profit Impact of Market Strategy) cross-section studies use capacity utilization as one of the variables explaining profitability which is defined as return on investment (Gale and Donaldson, 1975). In cross-section studies, Esposito and Esposito use industrial organization variables, and Lim uses economic variables and compares Malaysian and foreign firms to explain capacity utilization.

Data. One possible reason for the lack of a number of empirical studies explaining capacity utilization is the lack of suitable data. Chapter IV explains the history of problems concerning data collection, and describes data which are available on the industry level or on the business level.

The level of the individual establishment is used for this study of capacity utilization. A business produces a product for a market. A parent company, made up of many businesses, may be diversified such that the capacity utilization rate for the company reflects an average over the businesses and hides the determinants of capacity utilization. The problem is similar for an industry or an industry group at the two-digit Standard Industrial Classification (SIC) level, which is a collection of many types of diversified firms making many products. Business level data from the PIMS data bank are used in this study (Chussil and Land, 1976). The PIMS data bank is described in Chapter IV.

Research Approach

Parsons and Schultz (1976) suggest that, for marketing, when there is no well-developed theory to use as a guide, an econometric approach would include developing a theory in addition to making and testing models. The following theory is proposed in this study.

Proposed theory. The capacity utilization rate depends both on internal conditions within the firm which can be controlled by business managers, and on external conditions in the environment of the firm, some of which are beyond the control of business managers. Internal conditions refer generally to the characteristics of developing, producing, financing, and marketing a product. External conditions refer to actions of competitors and customers, technological change, and the growth rate of market demand. These variables may be grouped into industrial organization categories: external growth of the market and barriers to entry are related to the environment with the market power of customers, competitors and the business itself; other variables such as product differentiation and vertical integration are related to the business.

Variables and data. It is not possible to make hypotheses about the groups of variables mentioned above because these are merely arbitrary aggregate categories chosen to organize an approach for studying capacity utilization. In order to make hypotheses, more specific variables are introduced in Chapter V and operationally defined in the Appendix to Chapter V.

Because attempts to investigate capacity utilization for a group of heterogeneous businesses may miss the important determinants of capacity utilization, different types of businesses will also be studied separately. Separate regressions will be computed for: 1) consumer durables, 2) consumer non-durables; and industrial: 3) capital goods, 4) raw or semi-finished materials, 5) components, and 6) supplies.

Analysis. Regression studies of investment, regression studies which use industrial organization variables to explain profitability, and the two regression studies which use capacity utilization as a dependent variable can be used as a guide for planning the proposed cross-section regressions. Research issues and computing procedures are in Chapter V. Results are in Chapters VI, VII, and VIII.

Cross-tables programs from the Analysis of Quantitative Data (AQD) program library will be used in preparing for and interpreting regression analysis. Standardized regression coefficients will be computed to determine rank order of importance of the variables. Separate regressions will be done for averages of the 1971-1974 and 1973-1974 periods in the PIMS SPI14 data bank. Then, data from the 1970-1973 PIMS SPI03 data bank will be used. Results will be displayed in tables similar to Table 3 in Chapter V.

Summary and Conclusion

By learning what variables influence capacity utilization, business managers may be able to plan and manage capacity more effectively; this may improve profitability, i.e., return on investment. Increased knowledge about capacity utilization may help business managers to plan efficient investment programs, and may help the United States government to plan tax and interest-rate policies for encouraging or discouraging private investment.

External validity. Since the PIMS data bank is not a random sample of businesses, results cannot be generalized beyond PIMS-type businesses. Results can be generalized for the PIMS data bank only for the time periods of the study. This study might identify some variables which will be helpful in explaining capacity utilization for other situations, but such variables must be tested in other situations.

Future research. To be complete, research should include both a study of the influence of other variables on capacity utilization and a study of the influence of capacity utilization on investment and return on investment. The interrelationships among these three important variables can be modeled in a three-equation model. This model could be estimated using simultaneous equation regression techniques. As resources do not permit making the complete model at this time, it is suggested for future research.

CHAPTER II

CAPACITY UTILIZATION AND THEORY

"Economic theory is replete with use of the term capacity, yet comparatively little attention is devoted to a precise theoretical statement of the concept" (Klein, 1960, p. 272). Parts of microeconomic theory, financial management theory, macroeconomic theory, and industrial organization theory include capacity and capacity utilization. Microeconomic theory and financial management theory are concerned with allocation of scarce resources within firms. Firms make decisions about what capital and other inputs to acquire and how to use their inputs, given demand, tax, cash flow, and other constraints. Interactions of several firms may be included. Macroeconomic theory and industrial organization theory deal with groups or aggregates of firms. Macroeconomic theory is relevant for public policies about employing factors of production and encouraging or discouraging private investment. Industrial organization theory considers interactions of industrial structure, conduct, and performance.

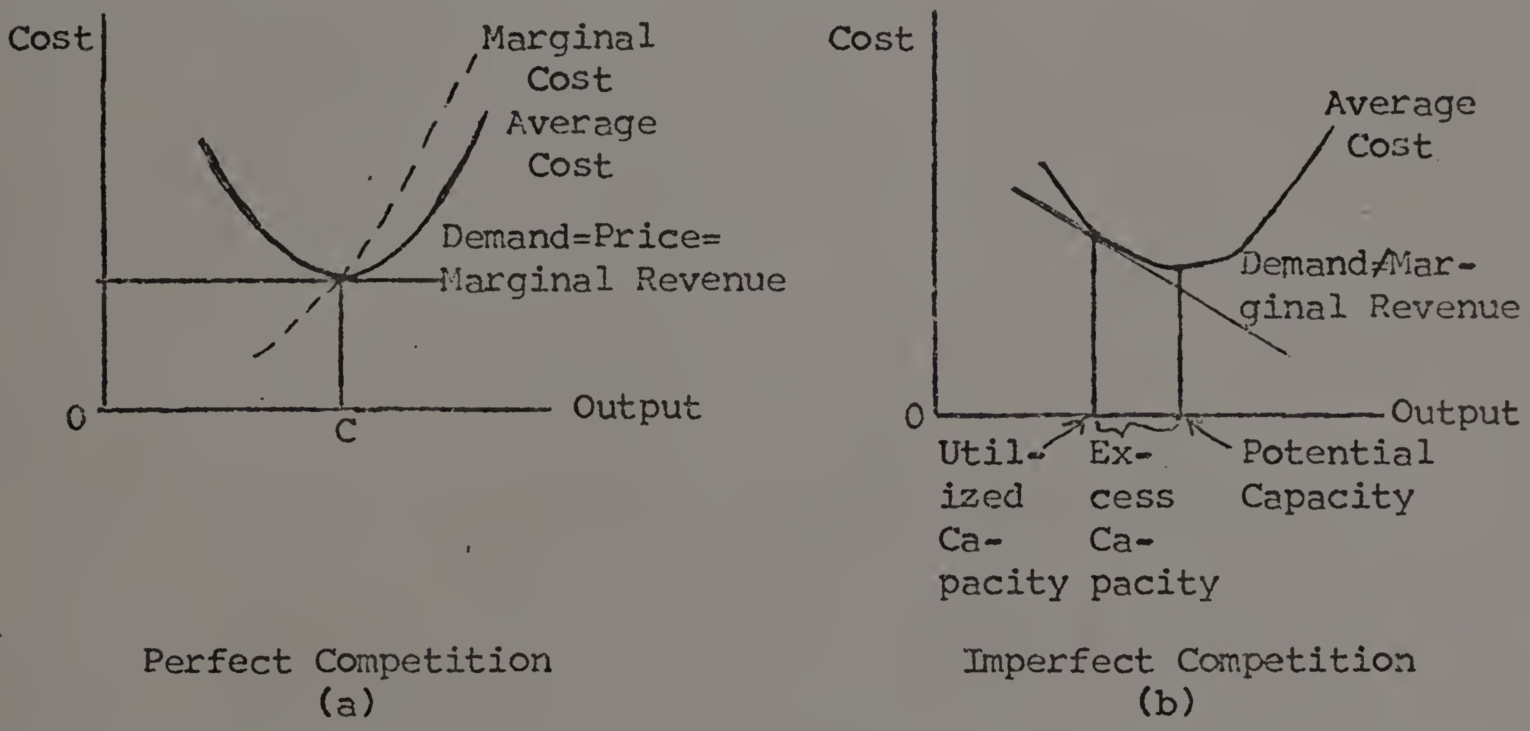
Theory versus Reality

There exists some discrepancy between trends in the real world and trends in economic theory. While the United States economy has become more oligopolistic over the years, and changes have occurred in technology, industry structure, government policy, and management methods; economic theory has proceeded in the opposite direction: refining the theory of perfect competition, exploring general equilibrium models, and studying decision making but not decision-making institutions. Exceptions include the theories of imperfect competition and product differentiation initiated by Edward Chamberlin and Joan Robinson, the applied field of industrial organization, and Wassily Leontief's input-output equilibrium analysis. While the real world has dynamic, diversified corporations, microeconomic theory typically has the static one-product firm. An example of recent capacity utilization theory is Calvo's (1975) neoclassical one-sector model of the desirability of different rates of capacity utilization when capacity depreciates as a function of the intensity at which it is operated. Calvo ignores technological change, and finds only one golden-rule capital/labor ratio. Except for the reference to Calvo, the above remarks were included in Robert Gordon's presidential address to the December, 1975, meeting of the American Economic Association. Gordon asked economists to be relevant with as much rigor as possible, to avoid unrealistic models which emphasize rigor regardless of relevance, and "to ask--and try to answer the really big questions" (Gordon, 1976, p. 12).

Microeconomic Theory

Although capacity plays a less important role in microeconomic theory than in macroeconomic theories of business cycles, the former has a more satisfactory development (Klein, 1960). In perfect competition, full capacity can be defined as the output level associated with full competitive equilibrium. This point occurs at the minimum point of a firm's average cost curve. In perfect competition, the firm is assumed to acquire homogeneous inputs of labor and capital and produce a homogeneous product, all units of which can be sold at a price set by the market. Figure 1a shows that capacity equilibrium with zero profits occurs at output OC where marginal cost equals average cost, price, and marginal revenue.

FIGURE 1.--Capacity utilization in perfect and imperfect competition



Source: Klein, 1960, pp. 272-73.

Figure 1b shows that there is excess capacity in imperfect competition, and utilized capacity output occurs above the minimum point on the average cost curve (Klein, 1960; Chamberlin, 1933).

Freedom of entry in the case of imperfect competition creates excess capacity (Kaldor, 1935). For slightly different products with highly price-elastic demand, a producer can attract some customers from competitors by lowering price, and lose customers by raising price.

Resulting excess capacity comes from a greater diversity of commodities. Since consumers are offered either variety or cheapness instead of a choice between these alternatives, it cannot be argued that excess capacity occurs because consumers prefer variety to cheapness.

Technical concepts. Conversion of inputs to outputs is modeled in a production function in which output flow is a function of labor input flow in terms of actual employment, and of capital services flow. Capacity output would be associated with fully utilized labor and capital and other factors of production; this is a technical concept. If labor services are not fully employed, the unemployment rate ideally reveals the percentage of the labor force out of work and looking for a job. The capacity utilization rate indicates the extent to which more factors of production than just labor are employed. Capacity utilization data may reveal more about overall economic efficiency than the unemployment rate (Klein, 1960).

Economic concepts. Economic considerations enter when capacity is defined with respect to costs. Although more plant cannot be built or more men used per machine in the short run, real-world output can be increased by working more days or shifts than the normal number of days or shifts per week. Output can be decreased by shorter hours or layoffs. Output can also be changed by buying some inputs usually made, or vice versa. Costs enter firm decisions concerning capacity utilization in the real world because crash programs involving extra overtime may increase the cost-per-item-produced substantially, or even prohibitively. One advantage of excess capacity is that it allows the firm to meet sudden increases in demand without expensive crash programs.

Excess capacity. According to Knight, the primary problem under uncertainty, which is present in the real world, is deciding what to do and how to do it; the actual execution of the activity becomes secondary (Williamson, 1971). If the firm errs in deciding what to do and how to do it, excess capacity or sub-optimal capacity utilization may occur.

There are two types of excess capacity: peak load and on stream. In peak-load excess capacity, older plant and equipment are used only in periods of peak demand. This excess capacity is not counted as capacity under the currently accepted definition of capacity. In on-stream excess capacity, capacity exceeds demand in the long run. If on-stream excess capacity is present when output is declining, this may be considered normal. If on-stream excess capacity is present when output is growing, this may be viewed as a response to the threat of potential entry (Boyle, 1972). Excess capacity, then, can be attributed to: environmental factors beyond the control of the firm, a firm's decision to impede entry by other firms, and errors made by the firm in an uncertain world.

Technically, capital is idle for two shifts and the weekend when a firm operates one shift for five days a week. Operating only one shift may be advisable from an economic and social point of view. Additional shifts and overtime may increase costs such that one-shift operation is more economical. People may prefer not to work nights and weekends (Winston, 1974).

Overhead costs. Overhead costs are those that cannot be traced directly to particular units of a business; these costs do not vary proportionally with output (Clark, 1923). Clark's (1923) book is a "study of discrepancies between an ever-fluctuating demand and a relatively inelastic fund of productive capacity, resulting in wastes of partial idleness, and many other economic disturbances. Unused capacity is its central theme." J. M. Clark's (1923, 1935) theory of capacity utilization and overhead costs is summarized below.

Unused productive capacity 1) may occur when demand drops cyclically, 2) may be in the form of old equipment kept for use in periods of peak demand, or 3) may be inherent in the production process. That is, the capacity of some factors of production can be utilized fully only by having some other factors work at low efficiency, whether single or joint products are produced. Although economies result from developing unused capacities of productive factors, at some point the costs of adding output exceed average costs.

The capacity factor is the percentage of the full capacity of the plant which is utilized. This appears in short run business fluctuations or with building in advance of expected growth in demand for a product because in the long run, plant size would adapt itself to any steady rate of output. Demand for industrial goods fluctuates more suddenly and violently than demand for finished consumer goods because industrial-goods customers buy at the cheapest time, and can time purchases so they can be obtained at the best cost. The physical need for new equipment fluctuates more intensely than demand for finished products because it depends on the rate of growth of demand, not on total demand. Since the acceleration of demand is bound to be minus nearly half the time, there is a chronic decline in demand for the makers of capital goods. Clark asserts that the dependence of profit on sales and the timing of capital expenditures are two facts of the first magnitude as causes of business cycles. Further, private financial accounting distorts the relative amounts of fixed and variable costs, making it seem that most costs are variable when most costs are really constant.

The economies of full utilization of capacity are commonly spoken of as the law of increasing returns. While a large plant is more efficient than a small plant at full capacity, the economies of integration are limited after some point at which the firm becomes too large. Because the economies of utilizing unused capacity are very great, they may lead to cut-throat competition. A steady capacity utilization rate is preferable to a fluctuating capacity utilization rate because it is more expensive to run a plant where output fluctuates between 60 per cent and 120 per cent of normal capacity than to run it at a 90 per cent steady utilization rate because, in the former case, employees reduce productivity in order to keep their jobs.

There are two kinds of savings from technological change represented by the introduction of mechanical equipment: 1) the new device is introduced and working short of capacity, and 2) output grows and the machine can work at full capacity. Although producing to meet increased demand for the product may unbalance a production line, it is possible to plan a plant to accommodate this piecemeal expansion, generally at little extra cost. The supply of productive capacity in an industry adjusts itself to demand when producers construct additional facilities to take an opportunity to market more output at a profit. Profits may not occur until there is enough demand for full utilization of capacity.

Clark asserts that plant capacity is governed more by peak demand than by minimum or average demand. If business did not build for peak demand at the upswing of business cycles, one of the chief causes of business cycles would disappear. In addition to excess capacity built at peak demand, excess capacity also occurs when new plants make older plants semi-obsolete and unprofitable, such that they are used only for peak demand. Excess capacity is reduced when inefficient plants are weeded out. Even if industry should work to produce stock in depressed times, and much peak output could be shifted to the troughs, Clark concludes that there are strong forces at work which naturally tend to produce an oversupply of permanent capital, and there are decided indications that such an oversupply exists.

Recent concepts. Building on the 1967 proposition of Drèze and Gabszewicz that in competitive equilibrium there is an optimum number of firms, each of which is operating with excess capacity on the average under specific assumptions, Sheshinski and Drèze (1976) conclude that competition and free entry lead to excess capacity on the average. The reason for this conclusion is that when capacity output (output for which average cost is a minimum) is exceeded, the corresponding profits are larger than the losses that would be incurred when capacity output is not reached. An important contribution of the Sheshinski-Drèze study is to replace the unrealistic assumption of identical firms and uniformly allocated output under fluctuating demand with the assumption of a variety of plants and an allocation of output which minimizes production costs. When plants of different design exist, some of them may be idle at low levels of demand; mathematical programming can be used to aid efficient investment and production decisions.

The importance of the Sheshinski-Drèze study is that it is a recent theoretical approach to excess capacity, stated in propositions which are proved using calculus, that recognizes a real-world situation of non-homogeneous firms, excess capacity and fluctuating demand. That is, excess capacity is treated as an expected situation that occurs under conditions of fluctuating demand, instead of as an undesirable condition that disappears in competitive equilibrium.

Financial Management

Goal. In financial management, the goal of the firm is assumed by some to be maximization of the market value of the stockholders' equity, through management decisions on investment, financing, and dividends (Van Horne, 1974; Weston and Brigham, 1972; Masson, 1971). Others claim that stockholder interest is only one of several vested interests, those of: stockholders, employees, customers, the general public, and government; to consider in making company policy (Donaldson, 1963).

Theory versus practice. Donaldson (1963) claims that where theory and practice diverge, it will be financial theory and not management practice that will have to change. Management decisions concerning investment affect capacity utilization. There can be important differences in the way professional management and stockholders approach a measurement of financial performance, investment, sources of funds, and assumption of risk. With respect to investment, management may use an internal rate of return criterion indicated by past performance, while stockholders would, in addition, use external criteria such as return on competing organizations with comparable risks. This conflict of attitude toward profitability may lead to differences in major policy decisions which would affect both the cut-off rate on acceptable investment opportunities and the assets committed to perpetuate existing investments (Donaldson, 1963).

Grabowski and Mueller (1972) build on the Marris (1963) model that focuses on investment and dividend decisions. This model hypothesizes that managers' compensation is more closely tied to firm size than to profitability. Managers invest to a point where the marginal rate of return is below the level that maximizes stockholder welfare. The point is that more earnings are retained from profits to increase company size than would be retained if the goal were to maximize stockholder welfare. However, a growth-oriented management must be aware of capital market reactions to its investment policy. Hence, managers must balance growth-producing research and development and investment against security-producing dividend payments which would maximize the stockholder welfare. Concluding that the simultaneous approach demonstrates the theoretical interdependence between decision variables, Grabowski and Mueller (1972) formulate a managerial model that includes stockholder welfare as one of the factors, but not the only factor, affecting investment and dividend decisions. They claim that this is conceptually and statistically superior to a model which maximizes pure stockholder welfare.

Excess capacity. It is not always possible to predict demand fluctuations. Not only is demand unpredictable, but also it changes somewhat continuously while capacity may increase in steps. Therefore, a firm's capacity may be sometimes less or more than needed (Giglio, 1970).

Excess capacity may be a rational management decision. Financial decisions influence the timing of additional plant and equipment expenditures; that is, it may cost less to build additional capacity in advance of anticipated increases in demand. Also, since it takes time from the decision to invest to the completion of an investment project, it may pay to have more capacity than needed to meet increases in demand (Alchian, 1970; Winston, 1974). Peak-load capacity is needed for seasonal fluctuations in supply of inputs or cash to buy them. A cannery that works mostly in harvest seasons would plan peak-load capacity because the inputs are perishable (Winston, 1974).

From a management science point of view, excess capacity exists in at least one process when the number of constraints exceeds the number of processes. Changing the product mix changes the slack capacity from one process to another. It may be uneconomical or even impossible to balance facilities when costs and prices change continuously. Changes in the product mix also may unbalance facilities (Phillips, 1963).

Macroeconomic Theory

Macroeconomic theory includes investment, aggregate production functions, and other aggregates. There are certain distinctions between investment, capital stock, and capital services that are relevant here (Winston, 1974). Output is produced by capital services, not by capital stock, which is a proxy for these services. Investment has two roles. First, as a factor of production, investment is a change in capital services and increases income. Then, as a part of aggregate demand, investment is a change in capital stock; that is, investment (I) consists of adding capital stock (K_t) to existing capital stock (K_o): $I = K_t$. Changes in capacity utilization affect the entire stock of capital, $K_o + K_t$. To grow, one either saves or borrows to invest in capital stock which will increase income, savings, and investment. If the productivity of capital services is constant, with increased capacity utilization the productivity of the capital stock will rise. In this way, an increase in capacity utilization can be a substitute for an increase in the savings rate.

Although investment is in the macroeconomic section of this paper, the concept of investment is also relevant for individual firms because an individual firm also saves and invests. Individual firms were included in the microeconomic and financial management sections of this chapter. Macroeconomic investment represents the aggregate of individual firm actions.

Putty-clay. The concept of capacity utilization interferes with the putty-clay theory in which investment putty hardens into clay. The output of a plant can be varied by varying the number of shifts or days worked, so that even if the number of workers per machine per shift is constant, the putty does not harden into clay (Winston, 1974). Also, the output of a plant can be varied by a make-versus-buy decision on inputs. A plant that buys inputs can buy more or fewer inputs according to need. A relatively less-capital-intensive firm can change from making to buying inputs more easily than a relatively more-capital-intensive one.

Savers and investors. Both Fisher's (1930) and Keynes' (1964) 1930s theories assume perfect competition in capital markets and ignore the effect of taxes on investment. In Fisher's theory of interest, which is an equilibrium theory of capital but not a theory of investment, the saver and investor are the same person. However, in Keynes' theory, in which the investment function includes the accelerator defined below, there is a dichotomy between the consumer-saver and the entrepreneur-investor (Kuh, 1963). The problem of relating these theories to the real world is that while, in theory, persons save, and persons and entrepreneurs invest, the saver-investor also may be a corporation. Corporations save, through retained earnings, and invest their retained earnings and/or the savings of individuals and other corporations. The real-world situation is more complex than theory indicates.

About two-thirds of total sources of funds in manufacturing come from retained earnings (Kuh, 1963; Sufrin and Anderson, 1976). Corporate profits are positively correlated with retained earnings, which are retained from return on investment, and with investment. The greater the profits, the greater the retained earnings; and the greater the retained earnings, the greater the investment (Kuh, 1963). Heavy reliance on retained earnings can lead to misuse of resources from the macroeconomic point of view (Kuh, 1963; Sufrin and Anderson, 1976). However, use of retained earnings may be good financial management from a narrow point of view of the firm because retained earnings may be less expensive and more readily obtainable than funds from other sources. The goals of managers and stockholders would conflict here, as pointed out in the financial management section.

Accelerator principle. The accelerator is an important factor in the macroeconomic theory of investment. Clark's 1917 accelerator, in which the capital-output ratio equals some constant, assumes that production costs are constant although they are not constant in the real world. The more recent flexible accelerator relates investment positively to the level of output and negatively to the stock of capital. For I_t = net investment at time t, O_t = output at time t, α = the accelerator, λ = the Koyck weight, and depreciation, δ, proportional to last period's capital stock, K_{t-1}, = δK_{t-1}, Clark's accelerator is shown in equation (1) below, and the flexible accelerator is shown in equation (2):

$$(1) \quad K_t = \alpha O_t$$

$$(2) \quad I_t = \alpha(1-\lambda)O_t - (1-\lambda-\delta)K_{t-1}$$ (Evans, 1969, p. 84).

The flexible accelerator is equivalent to Chenery's capacity form of the investment function where net investment is a function of some constant times the ratio of actual output to full capacity output (Evans, 1969). Cyclical changes in output, the main ingredient of the accelerator principle along with capital, are also correlated with changes in profits (Kuh, 1963). Capacity utilization has been used in models to represent such cyclical changes (Evans, 1969).

Both Clark's accelerator and the flexible accelerator assume that net investment goes to zero and gross investment equals depreciation. This is not necessarily the case in a dynamic economy with technological change where, because of external factors, equipment may become obsolete before it is fully depreciated. For example, the new post-war Japanese and German steel plants were much more efficient than the existing steel plants in the United States (Perry, 1973).

Marginal efficiency of investment and marginal cost of funds. In theory, firms invest up to the point where the marginal efficiency of investment (meI) equals the interest rate (i). The main determinants of meI are output and capital. If capital markets are not perfect, firms invest until the rate of return on the last investment equals the marginal cost of funds (mcf) for this last investment. This mcf will equal the market interest rate only if this interest rate does not change with the amount of borrowing by the firm (Evans, 1969). The interest rate usually does change. In reality, there is not an "interest rate," but there are different interest rates for retained earnings, equity, and bonds, depending on the degree of risk involved.

According to the bifurcation hypothesis, i is an important determinant of I in boom years and cash flow is important in recessions; hence, monetary policy can be used to stop booms but not recessions.

Evidence for this hypothesis is not conclusive. Further, if the synchronization hypothesis, that output and cash flow increase in proportion, holds, then the intersection of meI and mcf, which determines I, will be in the same relative position either in a boom or in a recession (Evans, 1969).

The neoclassical theory of capital accumulation, in which investment demand or the demand for capital responds to changes in relative factor prices and depends on the interest rate, is difficult to reconcile with the econometric theory on investment and does not have convincing econometric support (Jorgenson, 1963). In econometric research, current investment is explained by some lagged function of past investment plus other variables. In Jorgenson's (1963) theory, actual and intermediate investment depends on past changes in desired capital stock. Also replacement investment is a constant fraction of capital stock, a claim for which Eisner (1974b) finds little support or agreement. Jorgenson's theory is supported by his time-series regressions using Office of Business Economics (OBE) Securities and Exchange Commission (SEC) quarterly data for 1948-1960. His approach has been described as correct (Christ), important (Mansfield), and attractive but crude (Borch). Considering that a realistic theory of investment would be very complex, such that it would be impossible to test, intuition might be a good guide in selecting which sets of data to analyse (Christ, Mansfield, and Borch, 1963).

Eisner and Jorgenson have different approaches to the study of investment. For Jorgenson, the three main elements in an investment function are: the determination of desired capital stock, an adjustment process in which investment moves capital stock towards desired stock, and a depreciation function indicating the extent of replacement investment. In Eisner's approach, desired capital stock should depend on production functions and supply and demand functions for inputs and outputs, as perceived by business decision makers.

Investment theory related to tax policy. Controlling investment by tax credits and accelerated depreciation allowances has become a permanent part of United States fiscal policy. Tax policy affects investment through the price of capital services. The Hall-Jorgenson (1971) theory of investment is based on the theory of optimal capital accumulation. A goal of the firm is either to maximize its market value, or to maximize profit defined as current revenue less current outlay less the rental value of capital services. The first goal implies that the marginal product of each current input equals its price, and the marginal product of each capital service equals its rental. Both approaches lead to the same theory of the firm. Although not included in the Hall-Jorgenson theory stated above, capacity utilization affects the per-unit price of capital services. The fewer the units produced, i.e., the lower the capacity utilization, the higher the overhead cost that is allocated to each unit.

Empirical findings which support theory. Empirical research has shown that: 1) the accelerator and capacity functions work with Pascal inverted-V lags but not with Koyck geometrically declining lags, 2) long-term investment is determined by the production function, but profits (a liquidity variable), sales and cash flow are important short run determinants, and 3) the interest rate is a significant variable in the investment function. This last finding disagrees with Jorgenson's findings above. Further, 4) expectations are important, 5) sales variables have long and short lags while financial variables have long lags, and 6) assuming constant capacity utilization, linear homogeneous production functions and constant long run factor proportions, the long run elasticity of capital with respect to the level of output is unity. Financial lags are long because plans are not changed once funds are committed (Evans, 1969).

Industrial Organization

Industrial organization is concerned with the relationships among structure, conduct, and performance variables in industries. Structure represents "those characteristics of the organization of a market that seem to exercise a strategic influence on the nature of competition and pricing within the market" (Bain, 1968, p. 7). Structural variables include: market power of buyers and sellers, vertical integration, product differentiation, barriers to entry of new firms, and the growth rate of market demand (Bain, 1968; Scherer, 1971; Caves, 1972; Vernon, 1972). Conduct which includes "patterns of behavior which enterprises follow in adapting or adjusting to the markets in which they sell or buy" (Bain, 1968, p. 9), refers to policies concerning pricing, output, sales promotion expense, product design, and interaction with competitors. Conduct interacts with structure in affecting performance, which refers to the "composite of end results which firms in any market arrive at" through their conduct (Bain, 1968, p. 10). The performance dimension of interest in this research is technical efficiency which refers to: 1) the extent to which the firms are of optimal scale to obtain lowest costs (both horizontally and vertically), 2) the long-run rate of utilization of plant capacity, and 3) whether firms operate at the minimum cost curves of economic theory (Vernon, 1972). Although Bain ignored the third category, internal efficiency of firms, in his research, this may be the most important source of inefficiency in the economy because firms with market power can operate at higher costs than competition would enforce (Vernon, 1972, p. 48). Bain found, in his data for 20 industries, that most industry output was supplied by plants of reasonably efficient scale, and industries typically had an inefficient fringe (Bain, 1968).

Government policy related to industrial organization theory is antitrust regulation of firms that intentionally or unintentionally injure competition or tend to create a monopoly. There are two aspects of this policy: how much power firms should have, and what kind of performance is best for the United States economy. A high concentration ratio (per cent of industry value of shipments or assets accounted for by the top four or top eight firms), extensive product differentiation supported by heavy advertising, and/or vertical or horizontal integration may raise cost barriers to entry and result in excessive profitability. Such conditions may attract the attention of the Federal Trade Commission or the Antitrust Division of the Department of Justice, the government agencies charged with preserving competition.

Capacity utilization is included in the technical efficiency dimension of industrial organization performance. Industrial organization variables can be used to form a testable theory explaining capacity utilization. This has been done by Esposito and Esposito (1974) on the industry level. Industrial organization variables also might be used to form a testable theory explaining capacity utilization at the business level. This is the purpose of the present research. The effect of some of the industrial organization variables on capacity utilization is hypothesized, tentatively, as follows. Ceteris paribus, the capacity utilization rate is directly related to market power of sellers and inversely related to market power of customers or buyers because the firms with much market power can influence the market situation more than can firms with little market power. Ceteris paribus, capacity utilization is directly related to the growth of market demand. If demand exceeds capacity, then new capacity may be needed. If more capacity is added than needed to fill present demand, capacity utilization can drop until future increases in demand again raise utilization. The relationship of capacity utilization to other variables is discussed below.

Excess capacity and barriers to entry. The capacity utilization rate is inversely related to the amount of entry into a market because output produced by a new entrant would reduce the output required of existing firms, ceteris paribus. The higher the barriers to entry, the less entry would be expected. If there is no new entry into a market over time, and if the firms in the market are not of optimum size, there is further evidence that excess capacity is used as a barrier to entry (see Boyle, 1972; Wenders, 1971). Bain (1962) explains how to determine optimum size.

Low barriers to entry might create excess capacity if the increased supply of a product resulting from entry of new firms exceeds demand for the product (Kaldor, 1935). Expectations about timing of entry of rivals, interacting with the interest rate, may influence investment decisions and result in excess capacity (Kamien and Schwartz, 1972).

Vertical integration. In industrial organization terms, a vertically integrated parent company may own businesses that provide raw materials, businesses that process these raw materials into producers' goods, businesses that make consumer goods, and businesses that sell goods to consumers (Scherer, 1971). In PIMS terms, vertical integration refers to the extent to which a business makes or buys inputs, and also to the extent to which a business shares facilities and marketing programs and buys components from or sells components to other businesses in the parent company (see PIMS, 1975).

Vertical integration has no place in a theory that assumes automatic adjustment of supply to demand through the price mechanism, zero costs of operating competitive markets, and no uncertainty. However, in the real world of transaction costs, transactional failures in markets, and uncertainty, vertical integration has advantages and becomes an important structural variable (Coase, 1937; Williamson, 1971).

Vertical integration might occur if external conditions in the business environment change. For example, if there are continued shortages of oil, oil firms might integrate backward into non-petroleum chemicals (Carruth, 1976). Technological changes in the semiconductor industry have caused makers of integrated circuits to integrate forward to making digital watches and calculators and selling these to consumers. This has caused assemblers of semiconductor-component products to investigate integrating backwards to manufacturing semiconductors ("The Semiconductor," 1974).

If final cost or performance is uncertain, vertical integration avoids the problem of who should bear the uncertainty, supplier or user of an item. A vertically integrated firm can also avoid sales tax on intermediate items that are made instead of bought, circumvent sales quotas and price control, and avoid questions of who compensates whom in case of oversupply or undersupply of some item.

Of interest to antitrust, vertical integration may increase financial requirements and thus raise barriers to entry (Williamson, 1971). Now that advanced computer technology has reduced costs of managing (planning, organization, and control) in large, diversified firms, vertical integration increases firm costs less than it did without this new technology (McKean and Weston, 1971).

Product differentiation. While differentiability, a trait of market structure, refers to an inherent characteristic of certain kinds of goods, differentiation results from actions by sellers to distinguish their products. Differentiation can be achieved by advertising, sales promotion, service, location of outlets, and physical variations in the product such as quality and design. Heavy advertising expenditures are the mark of attempts at product differentiation, not proof of its success. If product differentiation is based on brands, there would be high selling costs; if based on product design, there would be periodic changes in quality; if based on customer service, there would be integration of distribution facilities (see Bain, 1968; Caves, 1972; Chamberlin, 1933; Vernon, 1972).

In theory, economists have defined product differentiation in terms of cross elasticity of demand which can be interpreted as the percentage of change in the quantity of B sold due to a one per cent change in the price of A. With high cross elasticity, a small change in the price of A will result in a large change in quantity of B sold. A differentiated product has low cross elasticity. The problem is that it is difficult to obtain information about cross elasticities of demand (Vernon, 1972; Bain, 1968).

In Bain's sample of 20 industries, high concentration was associated with negligible product differentiation; however, great product differentiation was usually associated with high concentration, and moderate to low concentration was usually associated with slight product differentiation (Bain, 1968). Comanor and Wilson (1967) expected to find that industries which had high profitability related to high concentration and high barriers to entry would have high advertising, but they did not. Vernon did not accept the interpretation that high advertising causes high barriers to entry. He concluded that the use of advertising as a measure of product differentiation was hard to support theoretically. He suggested that one problem with testing hypotheses is the lack of adequate data; this could be improved by having firms make data available to independent researchers (Vernon, 1972).

Vernon, in reviewing several studies, found support for the effect of high concentration and high barriers to entry on high profitability or return on investment, and an unclear effect for product differentiation as a barrier to entry. Bain's (1968) findings suggested some relation of product differentiation to technical efficiency, which, like profitability, is a performance variable of industrial organization. Capacity utilization and chronic excess capacity are aspects of technical efficiency. Bain's findings also suggested a relationship of entry conditions to chronic excess capacity, but a statistically significant relationship was not established in either case.

Summary

From different points of view, microeconomic theories of the firm, macroeconomic theory about aggregates, management science, and industrial organization concepts of structure, conduct, and performance suggest relationships among capacity utilization, investment, return on investment, and related variables. That these points of view do not always suggest the same relationships may be understood by recognizing with others (Gordon, 1976; Donaldson, 1963; Winston, 1974; Jorgenson, 1963; Williamson, 1971) that theory sometimes differs from the real world.

Slicter (1928) deplored excess capacity at a time when microeconomic theory, which emphasized perfect competition and assumed no excess capacity, was more fully developed than the other theories of this section. Keynes had not published his General Theory of macroeconomics, and financial management and industrial organization were new fields (Bain, 1968, p. x, reported that E. S. Mason created and developed industrial organization and introduced it to Bain in the

1930s). The environment, even the theoretical environment in 1976 is different from that of the 1930s. Some excess capacity is considered desirable or necessary from the point of view of industrial organization and financial management. These theories seem to be more appropriate than economic theory for analysing real-world problems.

The existence of a capacity utilization rate implies that manufacturing capacity is not always used fully, i.e., that utilization at less than 100 per cent of capacity is possible. Capacity utilization may not always be the same for all types of businesses or for the same business in different time periods. That is, capacity utilization is not a constant 100 per cent, but can vary over time and type of business. This implication is inconsistent with the assumptions of neoclassical microeconomic theory of the firm.

Real-world financial managers might consider capacity utilization rates in deciding whether to add to capacity by investing in additional plant and/or equipment. Varying capacity utilization in response to changes in the environment of the firm may be a rational management decision which has a cost-benefit tradeoff. By operating at less than full capacity, a firm is able to increase its capacity utilization rate to meet sudden, unexpected increases in market demand at a reasonable cost. That is, if machinery and plant exist and do not have to be built or purchased, they can be used when demand increases. Or, new plant and equipment can be planned to handle more output than is currently demanded because a growth in demand is anticipated. Interest rates and other factors that determine investment costs may be more favorable at times other than when capacity increases are needed; hence, capacity may be added in anticipation of growth in market demand.

For the firm to operate profitably, costs must be less than revenues. A manager's choice of a capacity utilization rate depends on a tradeoff between 1) having a high capacity utilization rate to use the existing plant and equipment so that revenues from using capacity will offset costs of having this amount of capacity; and 2) keeping the capacity utilization rate low enough that it can be flexible upward in the case of growth of market demand without high costs of overtime and/or emergency procedures to meet demand peaks. The point of capacity utilization chosen may be different for different types of businesses.

Certain variables affecting capacity utilization may be under control of the firm; other variables affecting capacity utilization may be outside the control of the firm. Government policies are in the latter category. Government policies may be based on studies of capacity utilization data collected by the government. These data are usually published at the industry level and will be described in Chapter IV. Government policy influencing plant decisions about capacity utilization includes fiscal tax policy such as the investment tax credit; and monetary policy concerning interest rates which are a factor in the cost of acquiring investment funds. Capacity policies of competitors, customers, and suppliers are also outside the control of the firm to the extent that firms act independently. Policy under control of the firm includes the capacity utilization rate and the extent, timing, and financing of new investment in plant and equipment. These policies influence return on investment.

CHAPTER III

CAPACITY UTILIZATION IN RESEARCH

Models used in capacity utilization studies include: management science models, cost-benefit analysis, input-output analysis, and regression analysis. Choice of a particular model depends on the research goal. Many of the existing models which include capacity utilization are multiple regression models. Both time-series and cross-section and both single-equation and multiple-equation regression models have used capacity utilization as a variable. A brief description of these models, and research results from empirical studies using regression models are included below.

Models

Management science models. Management science capital budgeting models enable business managers to maximize or minimize some objective function either in selecting investment projects for expanding capacity subject to constraints, or in selecting a product mix for which capacity may be a constraint (Monroe et al., 1974). If capacity is a tight constraint, indicating that utilization is already high, some desirable product mix may be impossible unless new plant, equipment, and/or other capacity is added. For example, in a capital shortage, duPont might concentrate on its most profitable products. This would cause shortages in other businesses that need the less profitable products, such as man-made fibers (Carruth, 1976).

Cash constraints and other relevant constraints may be included in management science models. Plant and equipment capacity is not necessarily the binding constraint; using a correctly formulated model may be a way of finding whether it is. In addition to linear programming (LP) models (Dorfman, 1953) which permit fractional outcomes, either integer programming (IP), which permits only integer outcomes, or mixed-integer programming can be used (Adams and Zoltners, 1976; Barchi et al., 1975). An integer outcome is to build a plant or not, or to buy a machine or not. Mixed-integer programming permits both integer outcomes and fractional outcomes.

Alternatively, a stochastic capacity model is available to help determine the optimal amount and timing of capacity expansions for situations where demand or the life of a facility is stochastic (Giglio, 1970). Capacity may also be expanded in stages, using a dynamic programming model (Erlenkotter, 1974).

Cost-benefit analysis. Cost-benefit analysis can be used by business managers to maximize the present value of all benefits of any action less the present value of all costs of the action subject to certain relevant constraints, some of which can be non-pecuniary (Prest and Turvey, 1965). This technique may be used to weigh the costs against the benefits of utilizing capacity beyond normal use versus adding new plant and equipment. Cost-benefit analysis has been used both in public investment decisions and in private decisions about human capital (Anderson, 1968).

Like management science techniques, cost-benefit analysis can be used for decision problems in a single business. A manager's goals:

to keep the firm going, saleable, and profitable; and to attain a better job or other rewards (Sufrin, 1975), would be relevant to modeling the problem and selecting appropriate variables and data. A different approach would be to study relationships among capacity utilization and other variables in order to develop some generalizations about a group of businesses. Input-output analysis or a regression model may be appropriate for this approach.

Input-output analysis. Leontief's (1951) input-output analysis is a special case of linear programming in which the number of variables equals the number of equations. Input-output analysis is related to the general equilibrium analysis of economic theory such as that of Walras. In the input-output system of simultaneous equations, outputs of some sectors of the economy become inputs to other sectors (Dorfman, 1953). Interrelationships among sectors are built into the equations. For example, a bottleneck in one sector might affect capacity in other sectors (Baumol, 1965; Dorfman et al., 1958; Klein, 1960). Research goals in using input-output analysis to study capacity utilization could include finding bottlenecks in some sectors which affect capacity utilization in other sectors.

An input-output system could be used to simulate effects of certain policies designed to increase capacity utilization. Klein (1960) suggested that an input-output system could be used for looking at capacity measures of interrelated industries. The problem is to change industry outputs toward capacity levels so that the new levels still satisfy the input-output equations. To do this, Manne ordered industries by per cent of capacity utilization and increased final demand to bring industries, one by one, to full capacity (Klein, 1960). The problems with Manne's approach are that it implies that full capacity is desirable and that the government can raise final demand sufficiently to achieve it. Neither the desirability of full capacity output nor the success of government programs in achieving it has been established.

Multiple regression analysis. In multiple regression analysis, a variable called the dependent variable is explained in terms of a group of variables called independent variables in a regression equation. If more than one equation is used, the dependent and independent variables become jointly dependent. That is, a variable such as capacity utilization not only may appear on the left-hand side of one equation to be explained by other variables, but also may appear on the right-hand side of another equation with other explanatory variables (Kmenta, 1971).

Time-series regressions study relationships among variables over time and are useful for short run studies. Because only a few years of data may be available before a structural change or disturbance, such as war, changes the structure of the equations, quarterly data are used to get enough degrees of freedom. Time-series regression studies that include capacity utilization as a variable often work with aggregate data. This aggregate data may obscure some micro details that would be helpful in understanding relationships among capacity utilization and other variables (see Meyer and Glauber, 1964). Instead of using average annual capacity utilization data for the United States as a whole and other aggregates, separate time-series regressions could be done for smaller groups. For example, separate regressions could be done for: primary and advanced-processing industries, durable goods and non-durable goods industries, selected 2-digit SIC industries, or groups of firms.

Cross-section regressions analyse a cross section of businesses or industries at a point in time. This point can represent some average figure for data representing a period of time (Mann, 1966; George, 1968; Gale, 1972; Shepherd, 1972). Using a period of years helps to minimize transitory effects. Cross-section regressions are useful for testing hypotheses about long-run relationships (Meyer and Glauber, 1964).

Ideally, pooled time-series, cross-section regressions would show cross-section relationships over time. These pooled regressions are more ambitious projects than either time-series or cross-section regressions done separately in both data collection and data processing requirements (Kmenta, 1971; Eisner, 1967b).

Simultaneous-equation models. The real world is complex; simultaneous-equation models can attempt to capture the complexities of the real world in systems having jointly dependent variables and several equations. To show how the capacity point changes with changes of prices and unit costs, Klein (1960) suggested a three-equation model to represent: 1) the technical condition of the production function, 2) the economic concept of minimum costs, and 3) zero profits. After these suggestions, Klein developed the Wharton Econometric Forecasting Model (Evans and Klein, 1967). Because relations in financial management are considered to be simultaneous, several simultaneous-equation financial management models also have been developed.

Economists Dhrymes and Kurz (1967) recommended that management make investment, dividend, borrowing, and equity decisions at the same time by estimating a number of jointly determined equations. Dhrymes and Kurz (1967) found that profits had a significant effect on investment in their multiple-equation model, but not in single-equation cross-section studies of others.

Simkowitz and Jones (1972) and Hansen (1967) suggested a time-series simultaneous-equation system for empirical research in finance. The simultaneous-equation approach also was recommended for overall corporate financial planning (Warren and Shelton, 1971). This analysis should include sales, level of assets, and earnings, and should provide the means of evaluating in advance the results of alternative strategies.

Summary. While management science models and cost-benefit analysis are appropriate for analysis of capacity utilization in a single firm, input-output and regression analysis can be used with groups of firms. Regression analysis, which has become a widely-used modeling technique for studying the relationships among capacity utilization and other variables in firms, industries, and the economy, can be done with time-series or cross-section data in models of one or more equations. Simultaneous models have been suggested by Klein (1960), Simkowitz and Jones (1972) and others.

Research Using Time-Series Regression Models

The time-series models summarized here usually work with aggregate United States data. The capacity utilization variable is used to explain aggregate investment or desired capital in these models. The deLeeuw, Meyer and Glauber, Evans, Jorgenson and Siebert, and Hall and Jorgenson models are single-equation models. The Wharton and BEA models have more than one equation. The Brookings model also has more than one equation, but is not included here because it omits the capacity utilization variable due to inadequate data (Duesenberry _et al._, 1965).

Early models. In Tinbergen's 1939 pioneering time-series model, fluctuations in investment were determined by earlier profits; the influence of other factors was uncertain. In 1952, Chenery attempted to demonstrate empirically the importance of capacity as a variable in the accelerator. His findings suggested that increases in capacity induced increases in output, but increases in output did not induce increases in capacity (Eisner and Strotz, 1963).

DeLeeuw. For 1947-1959, deLeeuw (1962) used current investment minus a weighted average of past investment as his dependent variable. The Federal Reserve index of capacity utilization, derived from regressions, was used as an independent variable. Other independent variables included retained earnings (profits after taxes less dividends), and Moody's series for industrial bonds. All four variables: investment spending (Commerce-SEC series deflated by the implicit GNP deflator for producer durables and non-residential construction), capital requirements (which depend on capacity utilization), internal funds, and bond yields; are quarterly, seasonally adjusted, constant-dollar (except for bonds) series. An expenditure lag was included. DeLeeuw's hypothesis that investment is a function of the other three variables is drawn from three theories: 1) investment as a function of the interest rate, 2) the modified acceleration principle, and 3) an approach which emphasizes capital market imperfections and risks associated with increasing the ratio of debt to earnings. DeLeeuw found that the association of investment with capital requirements held under a variety of lag assumptions, but the association of investment with internal funds and bond yields held only with inverted-V lags.

Meyer and Glauber. For quarterly data, Meyer and Glauber (1964) used an investment dependent variable, OBE-SEC data for plant and equipment expenditures, deflated by an implicit price deflator for producer durables and non-residential construction. Capacity utilization, a ratio of the Federal Reserve index of Industrial Production to the McGraw-Hill capacity index, was an independent variable. Other independent variables included: dummy variables for the four quarters, retained earnings plus depreciation, deflated by the investment price index, Moody's AAA corporate bond rate, and the change in Standard and Poors' stock price index. Investment lag weights were alternately zero and declining geometrically, and replacement investment was omitted (Jorgenson, 1971).

In a 1948 to 1958 time series for specific manufacturing industries and all manufacturing, the residual funds variable (profit plus depreciation less dividends) had higher simple correlations with investment. Capacity utilization did better in more complex, aggregate models, but not in less-aggregated models. Meyer and Glauber concluded that time series were incapable of distinguishing among a wide range of explanatory hypotheses (Meyer and Glauber, 1964).

Evans. For 1949 to 1963 quarterly data, Evans used an investment dependent variable similar to that of Meyer and Glauber but seasonally adjusted. Independent variables included the Wharton capacity utilization index, sales deflated by the wholesale price index excluding farm commodities, and the retained earnings and Moody's bond rate as in Meyer and Glauber. The investment time structure was modeled by a three-parameter rational lag function, and replacement proportional to averaged net capital stock was lagged five and six quarters (Evans, 1967; Jorgenson, 1971).

Capacity utilization had a small significant effect on investment in his preferred equations. Cash flow had the most important effect on manufacturing industries with relatively large fluctuations in sales. The interest rate had the most important effect on manufacturing industries with relatively small fluctuations in sales and in nonmanufacturing industries (Evans, 1967).

Jorgenson and Siebert. For 1949-1963, fifteen of the Fortune 500 large firms representing different industry groups were studied separately in order to compare the explanatory power of alternative theories of investment with respect to corporations. Jorgenson and Siebert concluded that neoclassical theory was superior to the accelerator theory based on output or capacity utilization and to the theory of expected profit based on the market value of the firm. These latter theories were judged to explain corporation investment better than the liquidity theory which was based on internal funds. Of the two neoclassical theories, which were based on cost and production functions and assumed the cost of capital was independent of the firm, the theory that included capital gains in assets explained investment better than the theory that excluded capital gains in assets. The point of departure for this study was Chenery's flexible accelerator. Since results depended on the lag structure, an appropriate lag structure was selected for each firm (Jorgenson and Siebert, 1968).

Eisner (1974b) did not share Jorgenson's enthusiasm for the neoclassical theory because it omits expectations. Desired capital stock should depend on expected future output, and current and expected future prices. Current and past values of variables have been used because not enough was known about expected values. Eisner has tried time-series regressions, but his preferred models have been cross-section models which are discussed later.

Hall and Jorgenson. At a Brookings conference in November, 1967, Hall and Jorgenson (1971) again claimed that their neoclassical model explained investment better than both Eisner's model of the flexible accelerator, and models containing combinations of capacity utilization and liquidity such as that of Meyer and Glauber above, and that their model could predict as satisfactorily. They used a polynomial distributed lag relationship between net investment and changes in desired capital. Data for 1935-1940 and 1954-1965 included: equipment manufacturing, structure manufacturing, non-farm, non-manufacturing equipment and non-farm, non-manufacturing structures in separate groups, from the Office of Business Economics (OBE) of the Department of Commerce. Tax policy was found to be highly effective in changing the level and timing of investment spending. For example, suspending the investment tax credit and accelerated depreciation from late 1966 to early 1967 had an important effect on restraining investment (Hall and Jorgenson, 1971).

In checking on these conclusions, Eisner (1974b) found that there was no effect of tax policy on investment if tax policy was tested separately from other changes in the cost of capital. Although rational businessmen should treat changes in tax policy as identical with other changes resulting in the same values of rate of return, cost of capital and other factors, real businessmen may, when the tax situation changes, examine their accounting and financial policy (Fisher, 1971). In commenting on Jorgenson's conclusion that real output is the most important single determinant of investment spending, Eisner pointed out that one way to deal with this is to recognize that investment is more affected by changes in demand viewed as permanent than by those viewed as transitory. Jorgenson's investment function implied, contrary to the thinking of Keynes, Eisner, and others, that modest changes in the interest rate or some tax parameters may have substantial effects on investment (Eisner, 1974b).

Wharton. In the 1952-3 to 1964-2 quarterly version of the Wharton model (Evans, 1969), capacity utilization is on the left-hand side in an identity equation. It is formed as a ratio of gross manufacturing output (in 1958 dollars) to maximum gross manufacturing output (in 1958 dollars). Capacity utilization is used as an explanatory variable in several equations.

Manufacturing investment in plant and equipment (in billions of 1958 dollars) is explained by capacity utilization, stock of manufacturing investment (in billions of 1958 dollars), cash flow in the manufacturing sector (in billions of 1958 dollars), Moody's average per cent yield on bonds, and the gross manufacturing output mentioned above. Capacity utilization is lagged one quarter, and the other explanatory variables use Almon polynomial lags. An alternative version of this investment equation includes investment anticipations of manufacturing firms (in billions of 1958 dollars) as an additional variable.

Other Wharton equations which include capacity utilization are: 1) an index of hours worked in manufacturing which is a function of gross output, change in gross output, capacity utilization, and the wage rate of manufacturing employees (in thousands of dollars per year); and 2) an index of hours worked in non-manufacturing which is a function of the non-manufacturing wage rate and capacity utilization. Forty hours equals 1.0 for an index of hours worked (Evans, 1969, p. 440).

Bureau of Economic Analysis (BEA). In the 1953-1 to 1964-4 version of the BEA Quarterly Econometric Model, capacity utilization is used both as a dependent and as an explanatory variable (see Hirsch et al., 1973). As a dependent variable, the Wharton index of capacity utilization, which includes mining and utilities in addition to manufacturing, is explained by private non-residential output (in billions of 1958 dollars) as a fraction of potential private non-residential output (in billions of 1958 dollars) and the ratio of actual consumer services to private non-residential gross national product divided by this ratio at peak activity. This equation was derived from another equation which includes variables for: 1) output/(civilian employment multiplied by average weekly hours), and 2) net stock of non-residential structures and equipment lagged one quarter/(civilian employment multiplied by average weekly hours). All variables for both equations are in logarithms.

The BEA investment equations use investment as a function of expected output (for which current and past output are proxies), capacity output, cash flow, and the supply of external funds reflected by long term bond yields. The nominal interest rate used in the Almon lags is replaced by a "real" interest rate which is the nominal rate less the four-quarter per cent change in the private GNP deflator. A capacity-output index is used instead of capacity utilization.

The capacity utilization variable is an explanatory variable in five other equations of the BEA model, for equations explaining: 1) average potential hours in the private sector, 2) average hours worked in manufacturing in the labor force, employment and hours sector, 3) the implicit price deflator for private non-residential output in the price-wage sector, 4) corporate profits and inventory valuation adjustment in the national income sector, and 5) merchandise imports in the import and export sector. Klein and Long (1973) also suggest such uses.

Summary. Time-series regressions which include a capacity utilization variable have been done for aggregate United States data, for firms, and for groups of firms and industries. Various time periods have been studied from 1935 to the present. These regressions have many variables in common. This could be so because all use the same source as a guide and/or because these are the important relevant variables. As deLeeuw mentions, these variables: investment spending, capital requirements (which depend on capacity utilization), internal funds, and bond yields are included in a model that is implied both by the interest theory and by the accelerator theory of investment and allows for risk.

Important differences in the models mentioned above are in the sources of data, definitions of the variables, and in lag structures. Assumptions about lag structures can have an important effect on results. Comparison of the various lags suggested--rational, declining weights, inverted V, Almon polynomial, and modified Almon--would require extensive discussion and is beyond the scope of this paper.

Both the choice of a modeling approach and the choice of variables for a model can affect the findings. Jorgenson and others used time-series regressions. Eisner used both time-series and cross-section regressions and seemed to prefer the latter. Others preferred cross-section regressions.

Research Using Cross-Section Regression Models

The cross-section models included in this section are single-equation models. Except for the Esposito and Esposito (1974) and Lim (1976) models, capacity utilization is used as an explanatory variable. In the other models, except for the PIMS LIM model (Gale and Donaldson, 1975), the explained variable is investment. The PIMS LIM model explains return on investment. Models explaining investment include the Meyer and Glauber (1964) model and several Eisner models. The larger PIMS PAR model will not be included due to lack of sufficient information. The PAR model includes the variables of the LIM model plus other variables.

Meyer and Glauber. Balance sheet and income statement data for 1951 to 1954 from the Securities and Exchange Commission (SEC) 10K data forms were used in these cross-section regressions. The capacity variable was a rather complex relationship of sales to gross fixed assets because no better measure of capacity utilization was available (Meyer and Glauber, 1964). Large manufacturing firms with high capital intensity and investment were in the sample. Firms with mergers were excluded. Results were a mild confirmation of the accelerator-residual funds hypothesis. Capacity, change in sales, and sales did better than residual funds in 1951 and 1954, but no model explained investment in 1952.

Eisner. Eisner (1960, 1967a, 1967b, 1972) has studied the determinants of investment in both time-series and cross-section regressions. He seems to show a consistent preference for cross-section regressions over time-series regressions for this research.

In 1960, he hypothesized that investment was a function of change in previous sales over a period of years and that the accelerator coefficient was higher the higher the proportion of change considered permanent. Secondly, the accelerator was higher for firms that can be considered close to capacity. His third hypothesis was that the accelerator coefficients were higher for firms with rising sales than for firms with falling sales. Past profits were not expected to be relevant per se because investment is made in response to future return on investment. McGraw-Hill data for 1949-1958 for 204 large non-financial corporations excluding retail and including 34 electric and gas utilities were used. All variables other than sales were divided by gross fixed assets of 1953 to eliminate heteroskedasticity due to variance in firm size. Investment was explained by several year-to-year sales-change and profits-change variables plus depreciation and the ratio of net to gross fixed assets. There was slight difference in deflated and undeflated results because the cross section washed out the price changes (Eisner, 1960). Results showed that an increase in sales to a level sustained for a number of years would eventuate in capital expenditures if the increase was considered permanent and not if the increase was considered temporary. The accelerator was non-linear with its effect concentrated among firms with rising sales and long-term rates of growth.

In 1967, based on regressions of McGraw-Hill 1955-1962 data for 800 firms, Eisner concluded that the role of change in past sales, used as a proxy for expected long run pressure of demand on capacity, was greatest in industry cross-section regressions. Firms apparently made capital expenditures immediately following higher profits (time series) but firms with higher profits did not make markedly greater expenditures than firms with lower profits (cross section). There was evidence that the pressure of demand on capacity affected investment, and evidence that expected future permanent long run earnings also affected investment (Eisner, 1967a).

In a study of log-linear relations of output with utilization of capacity, gross fixed assets, and number of employees in individual firm cross-section regressions, capacity utilization was found not to be significant. Eisner explained this as follows. Firms are seldom, if ever, in equilibrium. They adjust differently to short run changes in output which dominate the time-series variance, and long run differences in output measured in cross sections. They may change the capacity utilization rate significantly in the short run. McGraw-Hill data for 1955 to 1962 were used in this series of time-series and cross-section regressions (Eisner, 1967b).

A problem with the above research is that capacity utilization data were on a year-end basis, while output measures were for the year as a whole and free of seasonal variation. Commenting further on Eisner's use of micro data, i.e., the individual firm as the unit of observation, Hickman observed that one of the principle advantages of having the firm as the unit of observation is to allow for differing technologies among industries and to obtain greater homogeneity in data. Eisner did not do this. Jorgenson observed that Eisner, by introducing the rate of capacity utilization explicitly, successfully extended the applicability of the Cobb-Douglas production-function model to the level of the individual firm (Hickman, Jorgenson et al., 1967).

Using McGraw-Hill 1954-1958 (excluding 1956) data, mostly deflated, for 112 to 254 firms, Eisner (1972) found that, contrary to Jorgenson's findings, replacement and modernization investment was not a constant percentage of gross fixed capital assets. Replacement investment varied over time, and varied less than expansion expenditures; it moved up and down with expansion expenditures. Expansion expenditures were related to past and expected changes in sales and, to some extent, to capacity utilization, especially in cross-section regressions where random or transitory components of individual firm variance over time cancel out. Replacement and modernization expenditures were more positively related to depreciation and profit.

Esposito and Esposito. Inspired by Bain's (1962) empirical study of the relationship between market structure and excess capacity, Esposito and Esposito (1974) used an industrial-organization approach in studying capacity utilization as a dependent variable. Bain had found that chronic excess capacity (defined as persistent tendency toward redundant capacity at peak demand) appeared in three industries with low barriers to entry but not in six industries with substantial to high barriers to entry. Independent variables were market structure variables for 35 American industries on the three-digit SIC level.

Independent variables included: 1) dummy variables for four-firm concentration ratios of less than 40, 40 to 69, and 70 or more; 2) a dummy variable for producer-consumer goods, using the Kaysen-Turner, 1965, classification; and 3) a dummy variable for product differentiation using advertising/sales ratios of less than two per cent and two per cent or more. Additional independent variables included: 4) market growth of demand (measured as a 1966/1963 value of shipments ratio); and 5) assets/value added which measured capital intensity.

The dependent variable, representing capacity utilization, was (the difference between the McGraw-Hill 1965 preferred and 1963-1965 actual operating rates)/1965 preferred rates. The 1963-1965 period was used to represent a period of rising aggregate demand. The dependent variable was alleged to estimate the percentage of unutilized capacity in an industry. This seems to be an unemployment rate for capacity, with preferred capacity representing the labor force of employed plus unemployed, and actual capacity representing the employed.

Except for the product differentiation variable, all of the variables used by Esposito and Esposito were significant in explaining capacity utilization. Standardized regression coefficients showed that the order of variables in terms of decreasing relative importance was: concentration, market growth of demand, capital intensity, and producer-consumer dummy. Tendency to produce closer to full capacity was found for industries with: high or low concentration, rapid growth, high capital intensity, and consumer goods. These are possible variables to consider in further research.

Esposito and Esposito concluded that partial oligopolies with four-firm concentration ratios from 40 to 69 had more chronic excess capacity than tight oligopolies with concentration ratios of 70 or more, or atomistic industries with concentration ratios less than 40. The policy implication of their results was that deconcentration of highly concentrated industries would increase excess capacity in periods of growing aggregate demand.

Malaysian study. Lim (1976) used both the technical and the economic definitions of capacity given by Winston (1974) as dependent variables in a study comparing capital utilization of local and foreign establishments in Malaysian manufacturing. The technical definition (U_1) defined capacity as 24 hours per day, 365 days per year. The economic definition (U_2) adjusted the technical definition for actual intensity of use. U_2 is similar to the definition of normal capacity used in Chapter I and Chapter IV.

With 1972 data for industries which had been given four-digit codes similar to U. S. SIC codes, Lim used stepwise regression analysis to explain capital utilization with the following independent variables for U_2. E, number of employees, was a proxy for the size of operation. E^2 accounted for the nonlinear effect. Z, relative factor intensity, equaled PK/L which represented yearly cost of capital times capital stock divided by the number of workers on the largest shift. The cost of capital included interest plus depreciation minus a subsidy. X represented exports as a per cent of total domestic production. V, a dummy variable, had a value of unity for seasonal variation and a value of zero otherwise. B was a wage premium equal to bWL, the night shift differential times the wage rate times the number of workers on the prime shift. LS, a dummy variable, had a value of unity for incorporated industries and a value of zero otherwise.

U_2 was negatively related to E^2 and B, and positively related to the other variables. E, E^2, and Z were found to be the most important variables; X and V were not important. Lim concluded that high utilization of plant and equipment was related to size of the operation and capital intensity of the production process; he found no X-efficiency of capital related to nationality.

PIMS. The PIMS LIM model was designed for use in business planning situations for analysing strategic moves with respect to competitors, customers, and suppliers; and also for developing or acquiring new businesses. The dependent variable of this model was return on investment (ROI).

In the 1975 LIM model (Gale and Donaldson, 1975), ROI was explained by 29 variables which included 14 linear terms, three curvilinear terms, and 13 interaction terms. Capacity utilization was included as a linear term, a nonlinear term (squared), and in three interaction terms: interactions with quality, market share of the four largest firms, and number of customers. The quality variable was an estimate by each business of how customers judge product quality. The share variable represented the combined market shares in the SIC industry, expressed as a per cent. The number of customers was that number accounting for 50 per cent of a firm's sales. The 14 linear variables plus one other data entry can be used in computations by PIMS member firms.

The LIM model has been changed. At present, only the variables of the new model are known, not the curvilinear terms or interactions. Independent variables common to both the 1975 and the revised model are: market position, product quality, relative price, research and development expenses/sales, marketing expense/sales, investment/sales, fixed capital intensity, vertical integration, value added/employees, capacity utilization, long run industry growth, and share of the four largest firms. The 1975 LIM equation also had independent variables for: relative market share, and number of customers representing 50 per cent of sales. Additional independent variables in the revised LIM model are: relative buyer fragmentation, and percentage of total sales from new products.

Reports generated from the LIM regression print the PIMS mean value of each variable next to the value of each variable for the business, and indicate the impact of each variable on the estimate of ROI.

Summary. Cross-section regressions have used data from McGraw-Hill, the Securities and Exchange Commission, and PIMS for periods of time from 1949 to the present to study groups of large firms and businesses. Different dependent variables have been used. The capacity utilization variable was found to be significant in explaining investment and return on investment. One of the two regression studies explaining capacity utilization used industrial organization variables as the explanatory variables.

Some research found mild confirmation of the accelerator-residual funds hypothesis described in the macroeconomic theory section of Chapter II. The main finding of the industrial organization study was that deconcentration of tight oligopolies would increase excess capacity because partial oligopolies had more excess capacity than tight oligopolies.

Summary

Although a variety of models is available for research concerning capacity utilization, multiple regression models seem to be most popular. In these models, capacity utilization generally is used as an explanatory variable to explain, with other explanatory variables, investment and return on investment. Large, simultaneous equation models of the economy, such as the Wharton and Bureau of Economic Analysis models use time-series regressions. Single-equation models use time-series (Evans; Meyer and Glauber) or cross-section (Lim; Esposito and Esposito; Gale and Donaldson) analysis.

In the research surveyed, the only attempts to explain capacity utilization have been in the large time-series econometric models and in two single-equation cross-section models. In the econometric models, the explanations are in the form of identity-type relationships of actual to potential output. Behavioral equations are used in the Lim (1976) and Esposito and Esposito (1974) models.

This survey of research provides conflicting information concerning whether to use time-series or cross-section regression analysis for a study of capacity utilization. On the one hand, Eisner (1967b) claims that capacity utilization is a short run phenomenon. Time-series analysis is considered more suitable than cross-section analysis for modeling short run situations. On the other hand, the two published studies of capacity utilization, those of Lim and Esposito and Esposito, use cross-section analysis. This inconsistency is also evident in studies of investment, a more long run phenomenon, which Eisner studies using cross-section analysis, and the large models study using time series. A major factor in choosing between time-series and cross-section regression analysis may be the availability of appropriate data. Data sources will be discussed in Chapter IV.

CHAPTER IV

CAPACITY UTILIZATION CONCEPTS AND RELATED DATA

Concepts of capacity have changed over time. Because capacity utilization data are collected in relation to capacity concepts, some historical background is helpful in understanding the present state of the capacity utilization concept and presently available data.

Historical Background

Slicter and the TNEC hearings. Interest in less-than-full employment of both capital and labor services goes back to the late 1920s (see Clark, 1923; Slicter, 1928). At that time, approximate industrial capacity data were available only from trade journals and trade societies of a small number of industries. The cement industry operated at 72.4 per cent of capacity; the shoe industry, at slightly over half of capacity; men's clothing, at less than 3/5 capacity; printing, at 2/3 capacity; metal working, at about 5/7 capacity; and structural steel, at 56 per cent of average capacity. Slicter (1928) included these figures with his observations that despite a pressing need for more output, industry failed to operate even at its existing capacity. Further, under existing economic arrangements, restricting output was necessary for solvency. Such arrangements probably meant the existence of concentrated, oligopolistic industries in the real world in addition to the atomistic competitive industries of economic theory. Relating the capacity situation to the employment situation, Slicter implied that full utilization of capacity was preferable. Chapter II has shown that this is not always possible.

Citing Slicter, the Temporary National Economic Committee (TNEC) investigating the concentration of economic power reported that instead of being motivated by profits to utilize resources, oligopolists withheld resources from production and "shoved" risks and losses over on the public (Kreps, 1940, p. 116). The conflict between the goals of economic theory and financial management was evident here. However, the hearings were concerned mainly with the activities of concentrated oligopolists; that is, firms which had such large market shares that a few firms accounted for most of the value of industry shipments.

1962 hearings. Measures of productive capacity were examined in detail in the 1962 hearings of the Joint Economic Committee on the problem of measuring productive capacity. The hearings report stated that productive capacity was among the oldest, most used, and most important concepts in economic analysis ("Measures," 1962, p. 2). The hearings were held because: 1) capacity concepts were used constantly in arguments about the economic situation and related fiscal, monetary, wage, and employment policy; 2) experts disagreed as to the validity and usefulness of the different capacity measures; and 3) "achieving and maintaining a balance between the expansion of productive capacity and the expansion of effective demand is one of the most difficult and baffling problems of economic policy" ("Measures," 1962, p. 1).

Norton of the National Planning Association testified at these hearings that capacity utilization statistics were in the same position at that time as labor force and employment statistics had been in the 1920s (p. 3). The hearings report recommended that the Bureau of the Budget lead in organizing a cooperative effort of public and private agencies to develop standards for measuring capacity, set forth conventions for measuring capacity and its utilization, develop adequate measures of the stock of capital, and explore the feasibility of collecting capacity data through Census procedures or jointly with McGraw-Hill. It also suggested that more public and private research be done concerning the significance of capacity utilization data for public and private policy.

The Joint Economic Committee reported that general agreement defined capacity as the quantity of output that can be produced per unit of time with a given supply of plant, equipment, labor and materials, assuming that enough labor and materials are available, and that the limiting factors are plant and equipment plus the operating standards which determine the intensiveness of its use at capacity output levels. It also suggested two general categories for capacity definitions: 1) the engineering concept of maximum physical output without breakdown or exceptionally high marginal cost of operation, and 2) the economic concept of the output rate prevailing when the short run average cost per unit is a minimum. The economic definition included the reserve of older, less-efficient capacity that was used only in periods of peak short-run demand to protect the firm against loss of customers ("Measures," 1962).

Differing total-manufacturing, aggregate capacity utilization rates from 1947 through the second quarter of 1962 were included in the report of the Joint Economic Committee. For example, in 1958, the Federal Reserve capacity utilization rate was 76 per cent; the National Industrial Conference Board and *Fortune* magazine rates were 87 per cent, the McGraw-Hill year-end rate was 80 per cent; and the Wharton rate for total industrial production including mining and utilities was 84 per cent ("Measures," p. 16). These different rates and their biases, which were noted in this report, reflect differences in concepts of capacity and measurement techniques which will be discussed below.

New capacity utilization data. Until the 1970s, most capacity utilization data were provided by private surveys. These were usually on the 2-digit Standard Industrial Classification (SIC) level or more aggregated. Then, two new data sets became available: the private PIMS data bank for data on the business level, and the public BEA industry data collected by the Bureau of Economic Analysis of the Department of Commerce. Beginning in 1972, the PIMS data bank has data for capacity utilization and many other variables for a cross section of United States businesses from 1970 to the present (Schoeffler *et al*., 1974). The BEA quarterly capacity utilization data for selected 2-digit SIC industry groups from 1968 were published in the *Survey of Current Business* beginning in 1974 (Hertzberg *et al*., 1974). These data banks will be discussed at length later.

Summary. In the early part of this century consensus on capacity and capacity utilization was not extensive. There was a general idea about what these variables were, but not widespread agreement. Data were scanty and approximate. By 1962 there was interest, expressed at government hearings, in establishing a definition for capacity and capacity utilization and in collecting data for the United States industrial capacity and its utilization. Although private and public data sources existed, these did not agree on method or result. In 1974, two new data sources for capacity utilization rates became available, and there seemed to be more of a consensus on the definition of capacity and how to measure it and its utilization. Therefore, this is an appropriate time for empirical research about capacity utilization.

Concepts of Capacity

Full capacity. Full capacity is the firm's planned level of capacity utilization, the output that can be produced with normally used plant and equipment, excluding older equipment which is used only in emergencies (Perry, 1973; Winston, 1974; PIMS Data Forms, 1976, lines 235, 236). This concept implies the normal number of work days and shifts with allowances for the usual vacations, overtime, and maintenance. Higher utilization than this normal level will induce new investment (Klein, 1960; Klein and Long, 1973; Perry, 1973). These technical normal conditions are determined by costs (Winston, 1974). Some evidence exists for production near minimum average cost (Klein, 1962).

Engineering versus normal capacity. While engineering capacity is the physical capability of plant and equipment working 24 hours per day and seven days per week with unlimited labor and other inputs, normal capacity is the maximum level of output that can be produced in the usual hours, days, downtime, vacations, and overtime with existing plant and equipment. For PIMS, this is called standard capacity: "The sales value of the maximum output that this business can achieve with: 1) facilities normally in operation and 2) current constraints (e.g., technology, workrules, labor practices, etc.). For most manufacturing businesses, this will consist of two shifts, five days per week. For process businesses, a three-shift, six-day period is typical" (PIMS Data Forms, 1976, line 235).

Normal capacity is an economic construct, not directly observable, which can be measured only after agreement on guidelines as to what to measure (Hertzberg et al., 1974; "Measures," 1962). At this normal or standard level of output, the marginal productivity of additional inputs falls to zero, and marginal cost rises sharply and finally without limit (Hertzberg et al., 1974). The capacity output rate, if sustained over time, would induce neither net investment nor net disinvestment in private enterprise (Phillips, 1963). When guidelines are not followed in measuring capacity, capacity can be "found" in good times and "lost" in bad times (see Edmonson, 1974).

Make versus buy. Another problem related to failure to define capacity is created when capacity is changed by changing the amount of subcontracting. From the economic point of view, it is wrong not to change final output capacity; but from the point of view of the per cent change in gross output, it is wrong to report a change in value added (Phillips, 1963).

Excess capacity. When capacity utilization is less than 100 per cent of normal capacity, excess capacity exists. This excess capacity is the difference between u, the optimal or normal level of capacity utilization, and a, the actual level of utilization. The optimal level, u, can be less than or equal to the maximum available time for production, m, which is the engineering capacity described above. Excess capacity is u-a, i.e., unintended departures from the planned level of utilization (Winston, 1974). The significance of excess capacity due to inadequate demand may be different from that of excess capacity due to changes in: relative demand, prices, costs, product mix, or technology. Structural excess capacity, which, like structural unemployment, is due to technological change, may be as important as excess capacity due to inadequate demand (Phillips, 1963). Excess capacity indicates the extent to which society fails to use resources available for the production of goods (Phillips, 1963). The decision to have excess capacity may be a rational management decision, as explained below and in other chapters.

Bottlenecks. Using a linear programming approach, capacity is a bottleneck point. A bottleneck exists if a firm or firms cannot provide enough of a certain input to other firms. The capacity of a firm can change depending on which input is the bottleneck. This is an equilibrium concept. While input-output analysis can be used to trace bottlenecks in the economy or in a network of firms (see Klein and Long, 1973), Perry (1973) would ignore bottlenecks.

Capacity utilization. The capacity utilization rate or operating rate is actual output or utilization, a, expressed as a percentage of optimal output or utilization, u (Winston, 1974; Hertzberg et al., 1974; PIMS Data Forms, 1976, line 236). For use in an econometric model, Evans defines capacity utilization as actual output divided by maximum output. His maximum output seems to be more of an indicator of potential output based on the Wharton method of using peak output as maximum output instead of choosing between what we have called engineering capacity and normal capacity (Evans, 1969, pp. 255-256). Capacity utilization rates are sometimes computed as of the end of a year (see Hertzberg et al., 1974), or as an annual average (PIMS Data Forms, 1976, line 236).

Capacity Utilization Data

There are several sources of capacity utilization data: the Bureau of Economic Analysis (BEA) rates published in the Survey of Current Business; the Federal Reserve Board rates published in the Federal Reserve Bulletin; the Wharton School rates published in the Wharton Quarterly and available from the Wharton Econometric Forecasting group (EFA); McGraw-Hill rates, some of which are published in Business Week; and Conference Board rates available from the National Industrial Conference Board (Hertzberg et al., 1974). An additional data source is the PIMS data bank of the Strategic Planning Institute in Cambridge, Massachusetts. PIMS data are not published, but are used by members of PIMS after being disguised to protect the privacy of other members.

Coverage. The coverage of these sources differs. Except for PIMS data, which are on the business level, data from other sources are on the Standard Industrial Classification (SIC) two-digit level of industry groups, with some three-digit and four-digit SIC exceptions. Table 1 lists some of these industry groups and capacity utilization rates of the Bureau of Economic Analysis (BEA), Wharton, and the Federal Reserve Major Materials. The December, 1969, date was chosen for Table 1 because 1969 was a year of low unemployment, a year in which most industries might be assumed to be at their highest levels of capacity utilization. Coverage differs for these three sets of capacity utilization rates.

Wharton has a capacity utilization rate for all of the SIC two-digit manufacturing industry groups plus some industry groups in mining and utilities. Overall and separate rates are published for the manufacturing, mining and utilities categories.

The BEA has capacity utilization rates for certain two-digit industry groups, as well as rates for all manufacturing, durables, non-durables, primary processing, and advanced processing. For all manufacturing, durables, and non-durables, capacity utilization rates are also available in three asset classifications for companies with assets of: $100.0 million and over, $10.0 to $99.9 million, and under $10.0 million.

The Federal Reserve Board publishes capacity utilization rates for primary and advanced processing industries and total; and also

TABLE 1.--Selected industry capacity utilization rates for December, 1969

SIC Code and Short Industry Title[1]		Capacity Utilization Rates			
		Type[2]	BEA[2]	Wharton[3]	FR Maj. Matr.[4]
	Manufacturing				
20	Food and Kindred Products	a,n	82	96.6	
21	Tobacco Manufactures	a,n		79.5	
22	Textile Mill Products	•p,n	83	98.5	86.1
23	Apparel and Other Textile Products	a,n		93.5	
24	Lumber and Wood Products	p,d		95.7	
25	Furniture and Fixtures	a,d		92.5	
26	Paper and Allied Products	•p,n	92	98.8	95.1
27	Printing and Publishing	a,n		94.0	
28	Chemicals and Allied Products	•½a½p,n	84	97.2	89.0
29	Petroleum and Coal Products	•p,n	98	96.2	
30	Rubber & Misc. Plastic Products	•p,n	87	95.0	
31	Leather and Leather Products	a,n		85.8	
32	Stone, Clay, and Glass Products	•p,d	79	94.4	
33	Primary Metal Industries 331=d	p,d		100.0	93.7
34	Fabricated Metal Products	p,d		97.8	
35	Machinery, Except Electrical	•a,d	91	93.2	
36	Electric and Electronic Equipment	•a,d	76	92.9	
371	Motor Vehicles and Equipment	•a,d	88	86.4	
372-9	Other Transportation Equipment 372=d	•a,d	75	90.0	
38	Instruments and Related Products	a,d		95.2	
39	Misc. Manufacturing Industries	a,d		98.4	
	Mining				
12	Coal			94.2	
13	Oil and Natural Gas Extraction			97.9	
10	Metal Mining			98.9	
14	Stone and Earth Minerals			89.1	
	Utilities				
491	Electric Utilities			98.2	
492	Gas Utilities			98.9	
	All Manufacturing[2,3,4]		84	94.5	90.7
	Durables		82	93.7	91.0
	Non-durables		85	95.7	90.6
	Primary Processed		86		
	Advanced Processed		82		

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[1] Standard Industrial Classification Manual, 1972.

[2] Hertzberg et al., 1974. • = listed separately; "a" = included in advanced processing; "p" = included in primary processing; "d" = durables; "n" = non-durables.

[3] Klein and Long, 1973. Also has durable, non-durable, serv. rates.

[4] Edmonson, 1974. A two-digit SIC group may not have all of its industries. The rate 89.0 is for SIC 28 and 29 combined.

has a major materials series for metals, textiles, paper and pulp, chemicals and petroleum, durables and non-durables, and total, shown in Table 1.

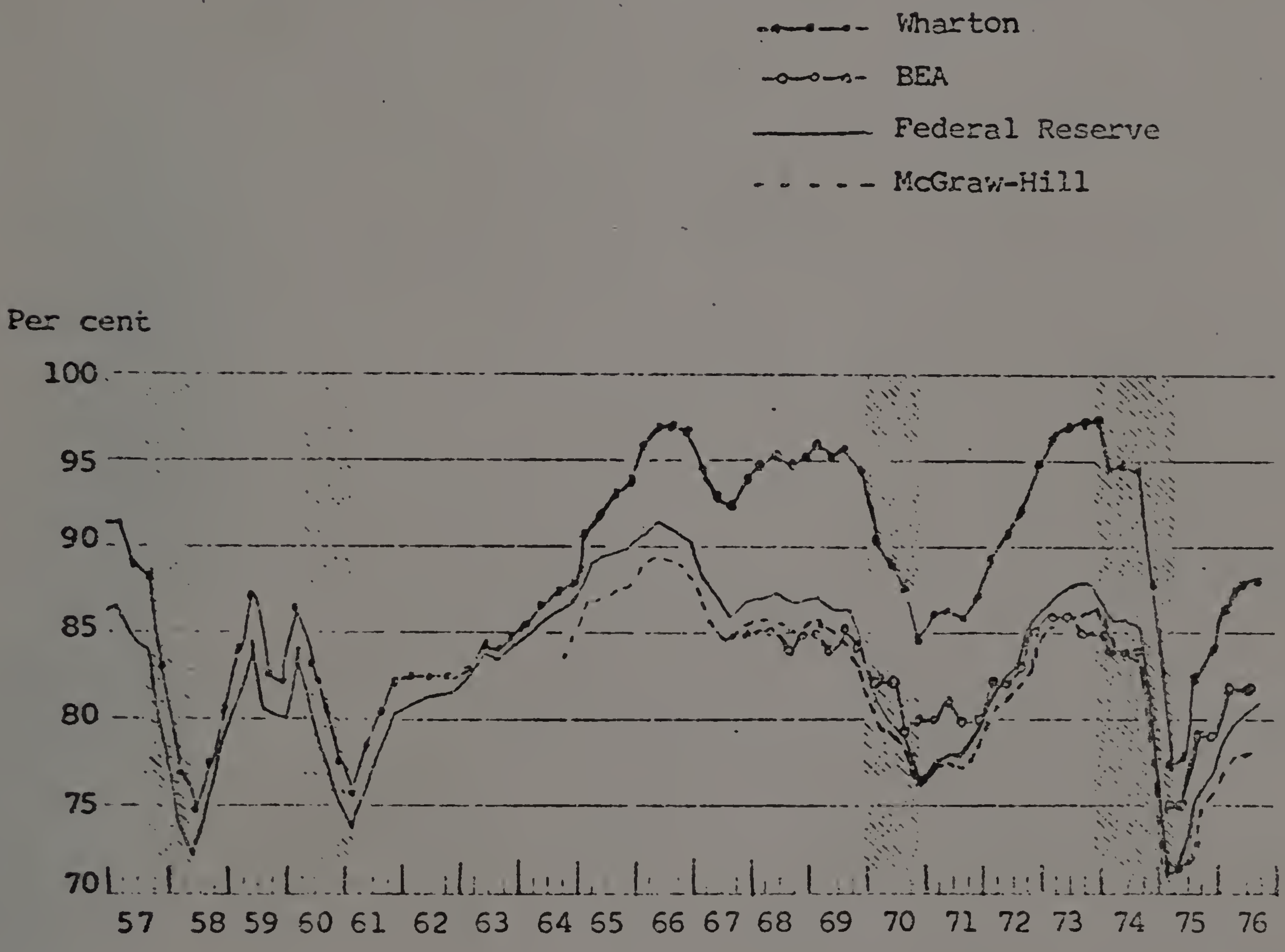
Conference Board capacity utilization rates are for durables, non-durables, and total. McGraw-Hill rates cover fifteen major manufacturing industry groups, those with SIC codes: 20, 22 & 23, 26, 28, 29, 30, 32, 333, 34, 35, 36, 371, 372, 373 & 374, and 38 (Esposito and Esposito, 1974, p. 193). Industry names associated with these codes are in Table 1.

A comparison of capacity utilization rates is plotted in Figure 2. The rates seem to move together from 1956 to 1966. Then, the rates diverge, and the Wharton rates become much higher than the others. The BEA rates do not seem to have the extreme ups and downs of the other rates shown in Figure 2.

<u>Timing, sample composition, and weights</u>. The timing and composition of the sample also differs from source to source. For example, the BEA rates come from a sample of about 2,400 companies which accounted for about 75 per cent of gross depreciable assets in 1969; while the Conference Board rates come from the 1000 largest companies with about 400 respondents, accounting for 48 to 49 per cent of 1967 total assets of companies with at least $10 million assets (Hertzberg *et al.*, 1974, pp. 54-55).

The weights used to aggregate firms into industries also vary. The BEA uses 1969 Internal Revenue Service gross depreciable asset rates and 1969 capacity weights. McGraw-Hill uses the Federal Reserve Board Index of Industrial Production value-added weights.

FIGURE 2.--Alternative measures of capacity utilization in manufacturing, 1957-76, seasonally adjusted



Source: Excerpted from: J. Ragan, "Measuring Capacity Utilization in Manufacturing," Federal Reserve Bank of New York Quarterly Review (Winter, 1976), p. 15.

Ragan's sources: Wharton Econometric Forecasting Associates; Board of Governors of the Federal Reserve System; McGraw-Hill Publications Company, Department of Economics; United States Department of Commerce, Bureau of Economic Analysis (BEA).

Note: Shaded areas represent periods of recession as defined by the National Bureau of Economic Research except for the latest recession, which is tentatively judged to have ended in March 1975.

Wharton uses peak period national income originating weights (Hertzberg et al., 1974). PIMS uses annual rates for about 600 businesses and does not aggregate them into industries as do the other sources of these rates.

Other differences in rates and comparisons are discussed in greater detail in Hertzberg et al. (1974), Perry (1973), Phillips (1963), and Ragan (1976). As indicated by Figure 2, there is much noise in the data, and we do not know which rates best match the real unknown parameters. It is possible that using different rates in the same model may give different results. However, the important distinction in this paper is that between business and industry data.

Finding the capacity utilization rates. There are three main methods of finding capacity utilization rates: the survey method, the peak-to-peak method, and the regression method. The most popular method is the survey method. McGraw-Hill asks for actual and preferred operating rates on a questionnaire. The BEA also asks for actual and preferred rates; a preferred rate achieves maximum profits or some other objective (Hertzberg et al., 1974). PIMS asks businesses to submit rates according to the PIMS definition given in the Concepts of Capacity section of this chapter. The Conference Board asks whether facilities are inadequate, sufficient, or more than adequate to meet current orders, and if more than adequate, to check a per cent range of underutilization. The idea of normal capacity is used in these surveys (Hertzberg et al., 1974; PIMS, 1975). A problem of bias in this survey method is that firms seem to "find" capacity in good times and "lose" it in bad times (Edmonson, 1974).

A second method of finding capacity utilization rates is the peak-to-peak method which Hertzberg et al. (1974) attribute to the Wharton model, but which Evans (1969) says the Wharton model no longer uses. The peak-to-peak method identifies peak values of the quarterly average of seasonally adjusted monthly values of the Federal Reserve Index of Industrial Production. These peaks represent 100 per cent capacity utilization. Straight lines are drawn between the peaks. Capacity output is read from the lines drawn. Actual output is divided by capacity output to obtain the utilization rate. A line drawn between the last two peaks is extended; if an actual value exceeds a peak, it becomes a new peak (Hertzberg et al., 1974). The problem with this method is that one cannot distinguish differences in intensity of utilization at different peaks (Perry, 1973).

A third method of finding capacity utilization rates is the Federal Reserve method which uses two regressions. Let Y_{1t} = the Department of Commerce series on capital stocks; Y_{2t} = the McGraw-Hill capacity-output index; and Y_{3t} = the ratio of the average of December-January values of the Federal Reserve Index of Production to corresponding values of McGraw-Hill operating rates. Then:

(3) $Y_{3t}/Y_{1t} = a_1 b_1^t u_t$, and

(4) $Y_{3t}/Y_{2t} = a_2 b_2^t v_t$,

where log a_i is the regression constant, log b_i is the regression coefficient for $i = 1$ to 2; and u_t and v_t are error terms. The two estimated values of Y_{3t} in every year are averaged (Phillips, 1963; deLeeuw, 1962). Problems with this method are: 1) that it does not reflect abrupt recent changes (Perry, 1973), and 2) that the averaging is justifiable only if it can be assumed that the error is random, and this is not known (Phillips, 1963).

PIMS data. Unlike other sources of capacity utilization data which are on the industry-group, SIC two-digit, level, the PIMS data are on the business level. The PIMS research data base contains data for about 400 variables, including averages for 1970-1973, 1970-1974, 1971-1974 as well as two-year averages, for example: 1970-1971 (called beginning) and 1972-1973 (called ending). Extreme values are compressed, and any missing value is filled in with a number close to the mean, treating consumer product businesses separately from industrial and other businesses (Land, 1975, pp. 2, 93; The PIMS, 1976).

PIMS data come from a survey of businesses which participate in the PIMS project. One sample includes about 620 participating businesses which belong to 57 or more companies and represent: consumer product manufacturers (19.8 per cent of total), capital equipment manufacturers (15.6 per cent), raw materials producers (11.9 per cent), components manufacturers (24.1 per cent), supplies manufacturers (16.5 per cent), and service and distribution (12.1 per cent) (Schoeffler et al., 1974). The data are considered to be ten per cent judgmental, and include some assumptions about the expected future business environment (The PIMS, 1976).

PIMS encourages clients to submit businesses: 1) in which top management is really interested, 2) for which no merger, sale or reorganization is planned in a few months, and 3) which have adequate records, are at least three years old, and are not under intense pressure. The data needed by PIMS are usually available in internal financial and marketing records and generally take about three man-days per business to collect. PIMS suggests that a costly data-gathering program should not be necessary; and that if in doubt about any questions, businesses should ask PIMS personnel for clarification. Data are edited by PIMS and returned to businesses to check for inconsistencies (The PIMS, 1976).

A business is defined as an individual operating unit or division which probably has its own: profit accounting, market share estimate, budget and planning, product development, identifiable marketing costs, and less than 60 per cent of its shipments sent to a down-stream subsidiary of its corporation.

For PIMS, "market" refers to a set of customers with similar requirements for products and/or services. Each business has an identifiable served market, i.e., customers in the same geographic area, customers desiring products with given technology like color television, or customers that prefer high product quality to low price. Different served markets exist for appliances bought by home owners and appliances bought by general contractors. The served market is usually smaller than the total market. A four-, five-, or six-digit SIC code is supplied either by the business or by PIMS.

The identity of a PIMS business is not disclosed. Each business decides on a disguise factor and uses it consistently on all dollar figures except: 1) size of typical transaction, 2) sales per employee, and 3) sales per salesman. PIMS uses the disguised figures in ratios. Results from data processed by PIMS must be reprocessed by a business to remove the disguise factor. Then the results can be used by managers of the business to evaluate strategic business plans, appropriation requests, and acquisitions.

Summary. Capacity utilization data are available from several sources on the two-digit SIC industry-group level and from one source on the business level. These data differ as to coverage, timing, sample composition, weighting, and in the method by which they are determined or computed. All of these differences result in different capacity utilization rates from different sources for the same time period.

Summary

At present, the concepts of capacity and capacity utilization are more clearly defined and understood than they were fifty years ago. More and better data are available now than have been available in the past. The data most suited to the research goal can be selected from the data described in Chapter VI. Chapter V includes an analysis of the various types of data which leads to the choice of a data set for this research.

CHAPTER V

RESEARCH DESIGN AND METHODOLOGY

Topics covered in this chapter include: research objectives and guidance from the literature, data and modeling research issues, background for hypotheses, and hypotheses and model design. Methodology and regression problems are also included. Operational definitions of the variables are in Appendix A.

Objectives and Guidance from Literature

Objectives. The purpose of this research is to further understanding of how manufacturing capacity utilization is related to some relevant variables of interest to and, hopefully, under the control of business managers. By learning what variables influence capacity utilization, a business manager may be able to achieve a more efficient utilization rate. The importance of achieving a more efficient utilization rate may be revealed by learning how capacity utilization and other variables influence investment and return on investment.

This research includes both exploration of influences on capacity utilization and exploration of the influence of capacity utilization. Of the total plan, which requires resources greater than those available for the present research, a part has been completed by the present research. The remainder is set aside until some future time when resources of this author or of others will permit continued study. The total plan is presented in order to show how the completed research fits into the whole scheme.

Guidance from theory and research. Theory should guide research. Chapter II has summarized several theories which explain investment, including the accelerator and residual funds theories. However, in the theories discussed in Chapter II, capacity utilization has been not so much explained as treated as an explanatory variable. Also, in the research reviewed in Chapter III, capacity utilization has been used as an explanatory variable, but several studies have explained investment. Capacity utilization has been explained, in a behavioral sense, in only two studies, those of Lim and of Esposito and Esposito. More studies of capacity utilization have been needed, if only to confirm or contradict the findings of these two studies.

Since there is little guidance from theory and research for explaining the determinants of capacity utilization, it is helpful to follow the advice of Parsons and Schultz (1976). They find, with respect to marketing, that there is no well-developed theory to guide them in developing useful models to explain and predict marketing behavior and serve as a guide to marketing managers. They suggest, therefore, that an econometric approach to marketing would include developing a theory in addition to expressing the theory in a model, designing a test for the model, choosing hypotheses and data, estimating the parameters of the model, and evaluating the usefulness of the model.

The capacity utilization problem resembles the situation of Adam Smith, who in 1776 in The Wealth of Nations developed a theory inspired by the competitive corn farmers and monopolistic guilds of his time. Similarly, Keynes (1935) developed a macroeconomic theory which admitted unemployment, about the time of the Great Depression in the 1930s; and Chamberlin (1933) and Robinson (1933) developed theories of monopolistic competition and imperfect competition after observing oligopolies. In a more modest sense, it was necessary to develop a theory of capacity utilization by making common sense inferences from the theories of Chapter II, the research in Chapter III, and observations about real-world businesses.

For this purpose, theory means: "an explicit and coherent system of variables and relationships with potential or actual empirical foundations, addressed to gaining understanding, prediction, or control of an area of phenomena" (Kotler, 1971, p. 7). The objective is to increase understanding of capacity utilization, as to how it affects and is affected by other variables.

Theory is more helpful as a guide to studying investment and return on investment, which represents profits. Firms in theory maximize profit. Investment in theory depends on capacity utilization, residual funds, stock of capital, and interest rates.

Data and Modeling Research Issues

Collect data or use existing data. Data can be collected in experiments, which are high in internal validity because some of the variance can be controlled by using both experimental and control groups. Or, data can be collected by the survey method for higher external validity but less control and no possibility to manipulate variables (see Kerlinger, 1971).

Since the intent of this research was to understand capacity utilization in manufacturing rather than to understand one manufacturing firm, experiments were not designed, and survey data were used. Since data are expensive to collect and some adequate data exist, this research used existing data.

Aggregate versus disaggregated data. The problem with using aggregate U. S. data is that much important detail relevant to policy decisions for business managers is lost. That is, tight capacity in some industries and loose capacity in others average out in the aggregate U. S. capacity utilization rate.

For example, in 1972, when quarterly capacity utilization rates for all manufacturing ranged from either 82 to 85 per cent (Hertzberg et al., 1974) or 86.4 to 93.2 per cent (Klein and Long, 1973), the aluminum, cement, basic chemicals, steel, zinc and textile industries were described as suffering from chronic excess capacity (Beman, 1974). However, when quarterly overall U. S. capacity utilization was not much different--ranging from either 85 to 86 per cent (Hertzberg et al., 1974) or 95.0 to 96.7 per cent--these industries had unforeseen capital shortages (Beman, 1974). Capacity utilization rates did not change much in the textile and chemical industries in 1972 to 1973. Rates ranged from 87 to 91 per cent for textiles and from 82 to 88 per cent for chemicals

(Hertzberg et al., 1974). In the same period there was a marked difference in the capacity utilization rates for two subgroups of a single SIC two-digit industry; aircraft capacity utilization rates ranged from 67 to 70 per cent, and motor vehicle rates ranged from 94 to 107 per cent (Hertzberg et al., 1974).

In 1969, a year which had the lowest labor unemployment rate of many years before or since, 3.5 per cent overall, capacity utilization rates in the four quarters ranged from 84 to 85 per cent (Hertzberg et al., 1974) or from 94.5 to 96.9 per cent (Klein and Long, 1973), indicating moderate or high capacity utilization, depending on the source of data.

As the low aggregate unemployment rate hid the fact that in 1969 the unemployment rate for black males aged 16 and 17 was 24.7 per cent, indicating a problem; while the rate for white males aged 35 to 44 was a low 1.4 per cent, indicating no problem (U. S., Handbook, 1975), the aggregate capacity utilization rate also can hide detail.

In addition to publishing aggregate capacity utilization data, the U. S. government also publishes data for SIC two-digit industry groups. There are 21 two-digit SIC manufacturing industry groups, with SIC codes in the 20s and 30s. Manufacturing is defined as the mechanical or chemical transformation of materials or substances into new products--usually for the wholesaler or industrial (Standard Industrial Classification Manual, 1972). McGraw-Hill computes capacity utilization rates for some of the 150 three-digit manufacturing industry groups and some of the 422 four-digit industries. Not all McGraw-Hill data are published (Esposito and Esposito, 1974; U. S., Annual Survey, 1972).

In industrial organization, an industry is a group of sellers who sell close substitute products to a common group of buyers (Scherer, 1971). In economic theory, such an industry is made up of homogeneous firms using homogeneous labor and capital inputs and producing one homogeneous product per firm. Industry output consists of perfect substitutes, sold under conditions of perfect competition such that all output produced can be sold at a price set by the market (see Klein, 1960).

Real-world industries are not so simple. SIC classifications can be too broad or too narrow. For example, most products of the SIC four-digit Soap and Other Detergent industry, SIC 2841, which is in the two-digit chemical industry, SIC 28, are cleaning agents; however they are not perfect substitutes. One cannot substitute a dishwashing machine detergent for a laundry-machine detergent, toilet soap or scouring powder. Other products of SIC industry 28 are plastics, drugs, explosives, and fertilizers, not all perfect substitutes. On the other hand, containers for food products can be substitutes, but industries producing these are: paper (SIC 26), plastic (SIC 28), glass (SIC 32), and metal (SIC 34) (Standard, 1972). The problem with industry-level data is that they have a lot of noise.

A further complication is that the leading firms in an industry are not usually the one-product firms assumed by theory. The same firm can be a leading firm in several industries. Procter and Gamble, a leading detergent maker (Tide), also has a large share in the paper diaper market (Pampers), and the potato chip market (Pringles) (Anderson, 1973). In addition, firms may be integrated backward from manufacturing to mining and agriculture, and forward from manufacturing to wholesalers and retailers.

Census establishments are less-diversified entities than parent companies and industries. Companies operating establishments in more than one location submit a separate report for each location. The establishment probably makes a less heterogeneous product than does a parent company. For Bureau of Census statistics, an establishment is classified into a particular four-digit industry if its production of the primary products of that industry has a greater value than its production of products of any other single industry (U. S., Annual Survey, 1972). A Census establishment is similar to a PIMS business which makes relatively homogeneous products, compared with parent-company or industry products, and has a particular served market, smaller than the market of the parent company or industry. Establishment data are aggregated to obtain four-digit SIC industry data, and further aggregated, using Federal Reserve Industrial Production (IP) weights, to the two-digit SIC level. In this process, averaging wipes out relevant detail. The BEA preserves some of this detail by creating the three asset-size classes explained in Chapter IV. Using industry level data requires much data processing to obtain compatible data, because data are available at different SIC-code levels.

The PIMS data base, having a business as its unit of study, has the most disaggregated data available. Therefore, it is more suitable for understanding relationships among capacity utilization and other business-level variables. An additional advantage of the PIMS data base is that data for related variables are available for the same businesses that provided the capacity utilization data. This avoids the problem of trying to make data, collected from several sources, compatible. For this reason, and also because the research goal is to learn about capacity utilization so that business managers can make strategic decisions, PIMS data are used in this research.

Time period. The PIMS data base has data banks for a variety of time periods, beginning in 1970, as described in Chapter IV. The 1971-1974 time period is used to begin this research because this period has the most observations of any data bank that includes the most recent data available, 1974. The 1970-1974 data bank has 414 businesses; the 1971-1974 data bank has 531 businesses. The larger number of businesses is needed in order to have enough observations for the separate types of business. Table 2 shows the number and per cent of businesses of each type in the 1971-1974 data bank. The service and distribution businesses are excluded from this study of manufacturing.

Within the 1971-1974 data bank, data are available for beginning averages (1971-1972), ending averages (1973-1974), and the average for the period. Results of separate regressions, done for ending

TABLE 2.--Distribution by type of business in the 1970 to 1974 data

Business Type	1971-1974			1970-1973	
	Number (1)	Per cent of Total (2)	Per cent of Mfg. (3)	Number (4)	Per cent of Mfg. (5)
Consumer Durables	25	4.7	4.8	46	7.4
Consumer Non-Durables	130	24.5	25.2	115	18.4
Industrial/Commercial/ Professional:					
Capital Goods	103	19.4	20.0	130	20.8
Raw or Semi-Finished Materials	59	11.1	11.5	82	13.1
Components for Incorporation into Finished Products	124	23.4	24.1	160	25.6
Supplies or Other Consumable Products	74	13.9	14.4	92	14.7
Services	14	2.6			
Retail and/or Wholesale Distribution	2	.4			
Total	531	100.0	100.0	625	100.0

Source: Columns 1 and 2 are from Chussil and Land, 1976, p. 103. Column 3 is computed from column 1. Columns 4 and 5 are computed from the PIMS SPI03 data bank.

and average data to see if the hypotheses hold for two-year and four-year periods, are reported in Chapter VI.

A further check on the hypotheses is to use another time period because it contains a different mix of businesses. Then, findings can be generalized to more years and more businesses. The number and per cent of manufacturing businesses by type of business in the 1970-1973 data bank are shown in Table 2. Results from the 1970-1973 time period are reported in Chapter VII.

There is no evidence that businesses in the PIMS data banks in 1970-1974 are typical of all businesses for all time. However, the findings represent groups of 515 and 625 businesses for at least the beginning part of the 1970s; and more is known about capacity utilization than was known before this study.

One or more equations in a model. The simultaneous-equation models suggested in Chapter II have been used in some of the research reviewed in Chapter III. When one equation is used, all of the explanatory variables are assumed to be independent of each other and without stochastic error. Actually, variables labeled "independent" are often jointly dependent with the dependent variable and are not fixed; that is, they have errors. This jointly dependent relationship may be represented by a model having more than one equation. An important reason for having more than one equation in a model is that this makes a more realistic model, one closer to the real world (Frederick, undated).

Since capacity utilization, investment, and return on investment seem, from theory and existing empirical studies, to be jointly dependent, the planned model has more than one equation. There are three equations: one for capacity utilization, one for investment, and one for return on investment.

Background for Hypotheses

The hypotheses in this section refer to variables and groups of variables found in the environment of a business manager. Operational definitions of these variables are in Appendix A of this study.

Theory. Capacity utilization depends both on internal conditions within a business which can be controlled by business managers, and on external conditions in the environment of the business, some of which are beyond the control of business managers. External conditions refer to actions of the government and of competitors and customers; technological change, and growth rate of market demand. Internal conditions refer generally to the characteristics of developing, producing, financing, marketing, and achieving a market position for a product, all of which are done in the environment of a parent company. Internal conditions may be partly under control of a business manager, and partly controlled by others.

The effect of these variables on the capacity utilization rate of a business may differ by type of business or product. For example, if a consumer product is by nature differentiable, it may be customary to market the product with media advertising. On the other hand, if an industrial product is by nature homogeneous, like a certain grade and kind of steel, media advertising may be nonproductive, and sales force selling may be customary.

Alternatively, some variables may be grouped into industrial organization structural categories. External growth of the market and industry and barriers to entry and exit are in the environment with technological change, the market power of customers, competitors, and the business itself. Internal variables such as the differentiation of the product and the vertical integration of the parent company are in the business. Vertical integration of the business is interpreted to mean the extent to which a business makes or buys inputs. The more vertically integrated business makes a higher percentage of its inputs. Chapter II implies relationships among industrial organization variables. Structural product differentiation is associated with advertising, sales promotion, changes in product design, and integrated distribution facilities. Sales promotion, product design and interactions with competitors are conduct variables.

It is not possible to make hypotheses about the groups of variables mentioned above because these are merely aggregate arbitrary groupings used to organize an approach to studying capacity utilization. In order to make hypotheses, the variables in each group are introduced and discussed below.

Market position. Market share (X_1), per cent change in market share (X_2), importance of the product to customers (X_3), the ratio of media advertising to total revenue (X_4), and the ratio of sales force expense to total revenue (X_5) indicate the market position of the business. High market share implies a strong market position, and a per cent increase in market share indicates a strengthening of market position. A business also has a strong market position if its product is relatively important to its customers. Frey (1976) suggested X_3. Media advertising and sales force effort are attempts to obtain and hold market share. The better the market position of a business, the more the business can control some of its environment to achieve a higher capacity utilization rate than the rate of a business with a weaker market position. The sales force variable may not have the same positive effect on the capacity utilization rate as do the other variables in this group because it may be more closely related to product characteristics than to an attempt to obtain market position. That is, the sales force expense/revenue ratio may be high because the product is homogeneous and cannot be sold successfully by media advertising. Thus, a high sales force to revenue ratio may be associated with types of products having low capacity utilization. Media advertising may increase utilization or may be increased when utilization is low; therefore, its sign cannot be determined a priori.

Product characteristics. Other indications of characteristics of a product are the ratio of research and development expense to revenue (X_6) and the type of product (X_7), i.e. whether the product is a consumer product or an industrial product. A product with high research and development expense may be new or in the process of changing, and as a result, it is not important to pay attention to the capacity utilization rate until there is more experience with such a product. Therefore, the capacity utilization rate is inversely related to the amount of research and development expense for a product. This does not include process research and development expense which is not expected to have a significant effect on capacity utilization during the time span of this research because the product is already being produced. The type of production process: batch versus continuous process, might be a relevant variable in the production structure group below; however, there is not enough PIMS data to study this variable.

A consumer product business is expected to have a lower capacity utilization rate than an industrial product business because of the greater possibility for a change in customer demand for consumers. For example, if nails are needed to make a product, nails must be bought or a substitute found; but if a cleanser is needed for cleaning hands, bar soap, liquid soap, or a cleansing substitute for soap can be purchased, depending on preferences influenced by media advertising.

Production and productivity. Productivity (X_8), per cent change in productivity (X_9), per cent change in investment (X_{10}), capital intensity (X_{11}), the ratio of value-added to revenue (X_{12}), and the per cent change in this ratio (X_{13}) represent the production-productivity group. In the time period studied, an increase in productivity or high productivity relative to some earlier capacity may result in a relatively low capacity utilization rate because more output is being produced per person-hour than had been produced in the past. Addition to capital through an increased per cent change in investment is a factor in determining the capacity utilization rate, but depends on the amount of increase. That is, capacity beyond the needed capacity may be added, thus reducing the capacity utilization rate until demand catches up with capacity. Or, expected demand may be such that only the amount of needed capacity is added, maintaining a high capacity utilization rate. It is not expected that a business would add capacity when there is a low capacity utilization unless there is a very strong expectation of increase in demand. High capital intensity may be positively related to a high capacity utilization rate because it may be important, costwise, to plan capacity very accurately in a capital intensive business so that excessive costs do not result in negative profits.

A business that buys a large percentage of its inputs may be in a more flexible capacity position than a business that makes a large or increasing proportion and has a relatively high or increasing value added/revenue ratio. If demand falls, the buying business can reduce orders, but the making business has excess capacity, and a lower capacity utilization rate than the buying business. If demand rises, the buying business may be able to find substitutes if a bottleneck occurs in bought supplies.

Finance. Return on investment (X_{14}), the ratio of working capital/revenue (X_{15}), and the corporate debt/equity ratio (X_{16}) are financial factors affecting capacity utilization. The relationship between profitability or return on investment (ROI) and capacity utilization is jointly determined in that high capacity utilization can reduce costs and thus increase profitability, while high profits imply good management which would plan ahead to achieve high capacity utilization. ROI is the dependent variable of another equation in the proposed model for this paper, and has been shown to be significantly related to capacity utilization in the PIMS LIM model. Similarly, the working capital/revenue and corporate debt/equity ratios are positively related to the capacity utilization rate because they are indications of management's ability to get working capital and other funds to finance activities related to high capacity utilization. A business with inadequate working capital may not be able to buy enough inputs for full capacity operation. For example, the capacity utilization rate of a candy business can be reduced if the firm cannot afford to buy enough sugar and chocolate.

External environment. Real market growth (X_{17}), the industry growth rate (X_{18}), entry (X_{19}) and exit (X_{20}) of competitors, and technological change (X_{21}) are environmental factors affecting capacity utilization. The first two factors are positively associated with capacity utilization because higher growth rates can result in higher capacity utilization rates, other things being equal. The last three factors are negatively associated with the capacity utilization rate. Entry of competitors can take customers away from a business and result in reduced capacity utilization if growth of the market is inadequate to absorb the new competitor's output in addition to the output of businesses already in the market. Exit of competitors may, similarly, indicate that the demand in the market is not sufficient to take all the output supplied. Technological change can temporarily, or even permanently disrupt the production process or change demand for a product and thus lower the capacity utilization rate.

Internal environment. In industrial organization terms, a vertically integrated firm would own suppliers and/or distributors. A business can be a part of a vertically integrated parent company and can share production facilities (X_{22}) and/or marketing programs (X_{23}) with other businesses in the company, and/or buy inputs from these other businesses (X_{24}). Sharing in this way can increase control and flexibility and reduce risk and uncertainty, and either increase the numerator or decrease the denominator of the capacity utilization rate. That is, dependability of input supply would increase the numerator and flexibility without duplication of facilities would require less extra capacity for emergencies and decrease the denominator. The more sharing, the higher would be the capacity utilization rate.

Customer characteristics. There are two types of customers for a business: immediate customers and end users. The immediate customers are assumed to buy directly from the business and may, in some cases, be also the end users. The end users are assumed to buy from the immediate customers. The greater the typical amount purchased by each customer (X_{27}) and the larger the size of the customers of a business in comparison with the size of customers of competitors (X_{29}), the higher can be the capacity utilization rate. This is because it can be more predictable to deal with large customers and large orders than to accumulate enough small customers and small orders to achieve a high capacity utilization rate. On the other hand, the larger the number of customers (X_{25}), the larger the increase in customer concentration (X_{26}), the fewer the customers relative to competitors (X_{28}), and the higher the concentration of customer purchases, i.e. the proportion of total number of customers that accounts for 50 per cent of total sales (X_{30}), the lower will be the capacity utilization rate. Again, it is more predictable and less risky to deal with a few customers as long as a business has more customers than competitors have.

Hypotheses and Model Design

Hypothesis 1. Let Y represent the capacity utilization rate and let the X_i, as specified above, represent the explanatory variables, then:

$$(5)\quad Y = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3\pm\beta_4X_4-\beta_5X_5-\beta_6X_6-\beta_7X_7-\beta_8X_8-\beta_9X_9+\beta_{10}X_{10}$$

$$+\beta_{11}X_{11}-\beta_{12}X_{12}-\beta_{13}X_{13}+\beta_{14}X_{14}+\beta_{15}X_{15}+\beta_{16}X_{16}+\beta_{17}X_{17}$$

$$+\beta_{18}X_{18}-\beta_{19}X_{19}-\beta_{20}X_{20}-\beta_{21}X_{21}+\beta_{22}X_{22}+\beta_{23}X_{23}+\beta_{24}X_{24}$$

$$-\beta_{25}X_{25}-\beta_{26}X_{25}+\beta_{27}X_{27}-\beta_{28}X_{28}+\beta_{29}X_{29}-\beta_{30}X_{30}+e$$

The variables and expected signs for this hypothesis are listed in Table 3.

Hypothesis 2. For the variables in hypothesis 1, the significance and relative size of their standardized regression coefficients are different for different types of business. For the total group of all types of manufacturing businesses, more variables are expected

TABLE 3.--Format for displaying signs, ranks, and significance of standardized regression coefficients or contribution to R^2 for PIMS manufacturing businesses

PIMS No.	Expected Sign	Variable Name	All Mfg. Bus. Types	Type of Business					
				Consumer		Industrial			
				Durables	Non-Dur.	Capital	Raw, Semi	Compnts	Supplies
		Market Position							
268	+	Market Share							
270	+	% Chg. in Share							
31#	+	Import. to Cust.							
159	±	Med.Adv.Exp./Rev.							
149	-	Sls.Frc.Exp./Rev.							
		Product Character.							
134	-	Prd. R&D Exp/Rev.							
2#	-	Cnsmr. Bsns. Dummy							
		Pdn., Pdtivity							
245	-	Pdtivity (VA/ee)							
246	-	% Chg. in Pdtivity							
221	+	% Chg. in Investmt							
346	+	Capital Intensity							
109	-	Make-Buy (VA/Rev.)							
110	-	Chg. in VA/Rev.							
		Finance							
174	+	Return on Investmt							
198	+	Working Cap./Rev.							
89	+	Corp. Debt/Equity							
		External Environmt							
366	+	Real Market Grwth							
79	+	Industry Grwth Rate							
70	-	Entry of Competits.							
71	-	Exit of Competits.							
11	-	Technolog. Change							
		Internal Environmt							
47#	+	Share Pdn. Facils.							
49#	+	Share Mktg. Pgms.							
43	+	Purch. fm Compnt.							
		Customer Character.							
18#	-	No. of Customers							
21#	-	Cust. Conc. Incr.							
29#	+	Typical Purch. Amt.							
75#	-	Less Cust. Than							
76#	+	Larger Customers							
23	-	Conc. of Purchases							

Note: One-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level. R^2 is for regressions which include only significant variables. # means recoded as described in Appendix A.

to be significant than for various types, because the total contains characteristics for all types. Different customer characteristics are expected to be significant for different types of business. For example, the number of customers is more important for consumer non-durables, and the size of customers is more important for industrial components because there are more consumers than industrial customers, and consumers buy smaller amounts than industrial customers buy (suggested by W. Smith, 1977).

Operational definitions of the variables mentioned in hypotheses 1 and 2 are in Appendix A of this study. These hypotheses are tested in Chapters VI and VII.

Hypothesis 3. Hypothesis 3 is related to the investment theory of Chapter II and the investment research findings of Chapter III. Investment is directly related to: capacity utilization, cash flow, and output; and inversely related to the interest rate. In Chapter VIII, this hypothesis is restated for business-level data and tested. Operational definitions of the variables are in Appendix A of this study.

Hypothesis 4. Return on investment (ROI) is explained by the PIMS LIM equation as follows. ROI is directly related to capacity utilization, market growth and market share, relative price, product quality and vertical integration in the make-versus-buy sense (see Gale and Donaldson, 1975). ROI is inversely related to costs and capital intensity. The product quality variable is the difference between the percentage of goods considered by customers of the business to be superior and the percentage considered inferior, as estimated by the business. The PIMS LIM equation is being revised.

Model. The intent of the larger research plan is to use the latest version of the LIM equation or some modification of it as the ROI equation in a three-equation simultaneous model. The other two equations are the capacity utilization equation for all manufacturing businesses, which tests hypothesis 1, and an investment equation which tests hypothesis 3. The results for the capacity utilization and investment equations are in Chapters VI, VII, and VIII. The three-equation model is part of future research.

Methodology

Regression analysis. The purpose of this research is to investigate the influence of some variables on capacity utilization, and to investigate the influence of capacity utilization and other variables on investment and return on investment. Multiple regression analysis, a statistical technique which is used to compute the influence of explanatory variables on a dependent variable is appropriate for this purpose.

Time-series versus cross-section regressions. Capacity utilization variables have been used as explanatory variables in time-series regressions, and both as explanatory and dependent variables in cross-section regressions reviewed in Chapter III. Typically, aggregate relations have been estimated from time-series data, where an observation is a unit of time; and micro relations have been estimated from cross-section data where an observation may be a firm, business, or industry (see Kmenta, 1971, p. 201).

Time-series regressions deal with short-run relationships, while cross-section regressions deal more with long-run relationships. Research findings indicate that there are important insights to be gained from studying micro data. Micro data are available in the PIMS data bank, but they are, at present, in a form suitable for cross-section regressions, in two-year and four-year averages. Mann (1966), George (1968), Gale (1972), and Shepherd (1972) used averages.

In the really long run, which allows for change in plant and equipment, capacity utilization responds to changes in capacity. This study is interested in a shorter time in which capacity utilization responds to other variables, but it is not clear whether this shorter time is appropriately two years or four years. The four-year period represents a more steady-state structure and eliminates noise, while the two-year period eliminates some of the noise found in a one-year period which may be influenced by a particular stage of a business cycle in that year. The two-year period is studied most extensively because it is relatively shorter than the four-year period. The four-year period is studied occasionally for comparison.

A pooled time-series cross-section regression is preferable to obtain desirable disaggregation over time and cross sections, and to study the short-run influence of the explanatory variables on capacity utilization. Because annual data are not available during the time period allowed for in this research, pooling is not done.

Deflating the data. Deflating to allow for changes in price may be necessary in time-series regressions. In data where only two- or four-year averages are available and where ratios are used, this may not be necessary or possible (see Eisner, 1972).

Raw or standardized regression coefficients. Because coefficients from regressions using raw data do not allow for different relative sizes of the variables, standardized regression coefficients are computed to determine the rank ordering by size of the regression coefficients. The largest coefficient has a rank of one.

Significance of coefficients. An AOD program (see Chussil, 1976) computes a P-level for each regression coefficient. This is the same number for a given coefficient regardless of whether a raw or standardized coefficient is computed. A P-level of .95 means that a coefficient is significant at the five per cent one-tail level or the ten per cent two-tail level. Significance is explained in greater detail in the following chapter. In order to have some significant results at first, coefficients with a P-level of .90 or greater are considered to be significantly different from zero.

Specifying the equation. Theory should tell whether a variable should have a linear or nonlinear form. However, in this study, the capacity utilization model has many variables and the theory is not very helpful. Therefore, guided by Occam's razor and Friedman (1953), simplicity is the criterion, and the preliminary capacity utilization equation has only linear terms.

Linear terms and dummy variables. Linear terms can be actual values, ratios, dummy variables, or categorical variables. Disguise factors are used in PIMS data to protect contributing businesses. Therefore PIMS data consist of ratios, changes, and categorical variables.

There are two types of PIMS categorical variables which can be adjusted before they can be used in the proposed regressions. One type includes variables which have values of 0, 1, and 2 to represent certain stages. An example of the latter is a variable with a value of 1 to represent the beginning stage of a product life cycle, a value of 2 to represent the growth stage, etc. When these variables are used without adjustment, it is difficult to interpret the regression coefficients. Such variables are changed into a series of dummy variables, each variable having a value of 0 or 1. For example: X_1 has a value of unity for a value of the original variable, X, representing "less than," and a value of zero otherwise; X_2 has a value of unity if the value of the original variable represents "more than," and a value of zero otherwise. The intercept term of the regression represents the "same" category. If the coefficient of X_1 is significantly different from zero in a regression at the ten per cent level, then the "less than" category is significantly different from the "same" category. The sign of the coefficient determines the direction of difference. Details for specific variables are explained in Appendix A.

An example of the other type is a variable which has values of 1 through 9 to represent different purchase amounts or different purchase frequencies. The larger value of such variables goes with larger amounts, but the scale changes. The lowest amount may be one dollar, while the largest amount may be over $10 million. These ordinal values of 1-9 will be replaced by the midpoint of each category. The midpoint of the category of $10 to $999 is computed as ($999 - $10)/2.

Nonlinear terms were explored with guidance from cross tables explained below. Nonlinear terms can be logarithms, values raised to a power, or products of variables. One possible nonlinear interaction is that of the number of customers and size of purchase. The important variable is the combination of large purchase amount and number of customers, instead of amount and number used separately. If a variable which, in theory, should be significant is not, the reason may be that the equation is misspecified and the term in question is nonlinear instead of linear.

Three AQD programs are used in preparing or interpreting nonlinear terms. The frequency-distribution program prepares a one-way cross table which has a form similar to that of Table 2 in Chapter V, two-way cross tables, and three-way cross tables. Table 2 needs no further explanation.

For two-way cross tables, values of one variable can be plotted against values of another variable as shown in Table 4.

TABLE 4.--Return on investment as a function of capacity utilization

	Capacity Utilization												
		59%		69%		76%		82%		87%		93%	
Estimated Return	9		17		17		16		18		17		20
Actual Return	10		14		18		17		19		17		20

Source: Gale and Donaldson, 1975, p. 16.

The total sample has been equally divided into seven parts by the cutpoints of the return variable. The estimated return for firms with capacity utilization between 59 per cent and 69 per cent is 17 per cent, as shown in Table 4 (Gale and Donaldson, 1975, p. 15). The actual return for these firms is 14. Two-way cross tables can be used to explore nonlinearities. When the effect of middle values of the independent variable on the dependent variable is greater than the effect of high or low values, a nonlinear specification is indicated.

In three-way cross tables, the relationship of two explanatory variables to a dependent variable can be shown. Table 5 shows the relationship of both capacity utilization and share of four largest firms to return on investment. This table can be read as follows:

TABLE 5.--Combined effect of capacity utilization and share on return on investment

		Share of Four Largest Firms		
		37%	63%	
Capacity		9	12	18
	72%			
Utilization		15	18	21
	85%			
		18	19	17

Source: Gale and Donaldson, 1975, p. 21.

The combined effect of share greater than 63 per cent and capacity utilization between 72 per cent and 85 per cent results in a return on investment of 21 per cent. Three-way cross tables can be used to explore interactive effects of the independent variables on the dependent variable.

An important use of the cross tables programs is in understanding the PIMS data. If a variable is significant in theory but not in regression results, the data bank may not have sufficient data for a study of that variable. For example, only 25.8 per cent of the PIMS businesses in the 1971-1974 data bank report a major technological change in the products offered by the business and/or its major competitors, or in methods of production, during the last 8 years (Chussil and Land, 1976, p. 106; <u>PIMS Data Forms</u>, 1976, line 110). If none of these businesses produces consumer durables, then technological change does not vary for these businesses and cannot be used as a variable. This information is available in a one-way cross table.

Regression Problems

Non-constant variance. Heteroskedasticity, which violates the regression assumption of constant variance ($e'e = \sigma^2 I$), is usually a problem in cross-section regressions. It makes errors smaller by biasing σ^2 and $\hat{\beta}$. Therefore, the ordinary least squares regression estimation method is inefficient, i.e., it does not have minimum variance.

Heteroskedasticity is less of a problem when ratio data are used (Evans, 1969, p. 126n). To test for heteroskedasticity, regression residuals can be plotted against the independent variable in question. A definite pattern, as compared to random scatter of points, implies heteroskedasticity. The Goldfeld-Quandt test also tests for heteroskedasticity. In this test, an independent variable is chosen and values arranged in order of size. Leaving out some middle observations, separate regressions are done for the low-valued and high-valued observations. An F test determines heteroskedasticity (see Johnston, 1972, p. 219).

To correct for heteroskedasticity, the variables in group i can be weighted by 1/(the sum of squared deviations in group i); or specification of the equation can be improved; or regressions can be done on homogeneous subgroups. For example, separate regressions can be run on consumer and industrial businesses or for each type of business.

Correlation over time. Autocorrelation of residuals is usually a problem in time series, but in cross-section regressions the autocorrelation test (Durbin-Watson statistic less than or equal to two) can be used to test for nonlinearities. Autocorrelation violates the regression assumption that cov $e_i e_j = 0$, and has the same effects as those described above for heteroskedasticity (Kmenta, 1971).

Combined effects of variables. Multicolinearity, i.e., correlations between explanatory variables, is a feature of the sample. It can be reduced by increasing the sample size. The degree of multicolinearity can be estimated by looking at the off-diagonal terms of the correlation matrix for the pair correlation of any two variables for which multicolinearity is suspected. High correlations between explanatory variables indicate a high degree of multicolinearity. This causes large variances so that the effects of the two correlated variables cannot be separated from each other. Using all manufacturing businesses as one group in a regression will have less multicolinearity than using separate types of business because the group of all types has a larger sample size. Combined use of time-series and cross-section data is also helpful (Johnston, 1972).

Aggregation bias. While most economic theories are micro in nature, concerned with individual firms, econometric estimation and hypothesis testing are frequently macroeconomic, based on groups of firms (Theil, 1971). Theil explains aggregation bias as follows. Macroeconomic variables are usually defined as averages of the corresponding microeconomic variables; aggregation theory is concerned with transforming these micro-relations into macro-relations; aggregation bias may arise from such transformations. The analysis of aggregation is a special case of specification analysis. The objective is to find the relationship between the expectation of the macroeconomic coefficient vector and the underlying microeconomic parameters. The expectation of a coefficient of a macroeconomic variable includes the aggregation bias for the microeconomic parameters. This bias can come from aggregation over time or from aggregation over a cross section (Theil, 1971). The PIMS data used in this study are aggregated over time into two-year and four-year averages, and aggregated over different businesses and different types of businesses. Therefore, it is necessary to evaluate the possibilities for and problems of aggregation bias and to decide what to do about it.

Welsch and Kuh (1976) recognize the possibility of aggregation bias, but because the variance of the estimated macro-coefficients decreases as the number of units in the aggregation increases, conclude that it is sometimes plausible to use aggregate data. If the ratio of the variance of the macro parameter estimate for the ith unit to the variance of the macro parameter estimate is greater than unity, aggregation may be a reasonable alternative to the use of micro data.

After studying aggregate versus subaggregate models in local area forecasting, Dunn, Williams, and deChaine (1976) concluded that for the most benefit from statistical forecasting models, subaggregate data should be obtained and analysed if possible, especially if the subaggregate areas are expected to vary. Forecasts aggregated after using subaggregate data were found to be more accurate than those developed from aggregated data. In the PIMS data, this is interpreted to mean that using data for type of business to study capacity utilization gives more meaningful results than the use of aggregate data over all businesses.

Pooling of time-series and cross-section data has been suggested as a method of dealing with aggregation bias, except when the departure from the homogeneity assumption is so great that conclusions about the nature of relationships among variables are distorted (Bass and Wittink, 1975). There are three sets of possible assumptions: 1) the conventional assumption that regression coefficients are fixed, 2) the assumption that intercepts vary but slopes are fixed and common to all subgroups, and 3) the assumption that both slopes and intercepts are random variables. Choice of an assumption is determined by judgment, theory, and, sometimes, by tests. Bass and Wittink suggest that Maddala's variance components model be used to deal with assumption 2; however, this model is not operational at the University of Massachusetts at present.

Available methods of dealing with the possibility that coefficients are not fixed over a cross section include subgroups within this cross section, and dummy and interaction variables. Dummy variables, which allow for differences among intercepts for various subgroups, and interaction variables, which allow for different slope coefficients, can be used. Whether intercepts or slopes are significantly different from each other can be tested using a t-test (Kmenta, 1971). Dummy and interaction variables are used in this research.

Summary and Plan

The wider research objective is to investigate manufacturing capacity utilization and its relationships with investment and return on investment by studying them in a model of three equations, which has one equation to explain each of these three variables. Theory and research provide guidelines for explaining investment and return on investment, but there are few guidelines for explaining capacity utilization. Some variables explaining capacity utilization are internal to the business and others are in the environment of the business. The relative importance of the variables in explaining capacity utilization may be different for different types of businesses. The purpose of this research is to test hypotheses which explain capacity utilization and investment.

PIMS business-level data banks are used to test these hypotheses, beginning with the 1971-1974 data bank. Results are presented in tables having the form of Table 3.

For any data bank chosen, the service and retail businesses are removed, dummy variables are computed as explained in Appendix A, and the remaining data are divided into the six types of manufacturing businesses shown in Table 2. To test hypotheses 1 and 2, separate cross-section regressions are done for capacity utilization two-year and four-year averages and for different types of business in two time periods. Investment regressions are not done for separate business types because these are not needed to test hypothesis 3. Hypothesis 4 is not tested. Standardized regression coefficients are computed and rank ordered by size of coefficient. Significance tests determine whether a regression coefficient is significantly different from zero. Contributions of each variable to explaining the variance of the dependent variable are computed and ranked. Tests for heteroskedasticity and multicolinearity are made. Nonlinearities are studied using cross tables.

CHAPTER VI

PRELIMINARY RESULTS: CAPACITY UTILIZATION EQUATION

Because of the small amount of existing research using capacity utilization as a dependent variable, preliminary calculations were done before proceeding with extensive regression analysis. This included the following: 1) analysis of average capacity utilization rates in PIMS manufacturing businesses and comparison with United States output and employment, 2) frequency distributions of capacity utilization rates for selected time periods and types of business, 3) regressions of capacity utilization on small groups of variables for all PIMS manufacturing businesses in 1971-1974 and 1973-1974, 4) regressions of capacity utilization on all variables by types of business for the six separate types of business in 1973-1974, 5) cross tables using capacity utilization as a dependent variable with various pairs of explanatory variables, and 6) study of possible nonlinear forms for some explanatory variables for which the linear forms are not significant.

Mean Capacity Utilization Rates

Table 6 contains mean capacity utilization rates and standard deviations for all PIMS manufacturing businesses and for six different types: consumer durables, consumer non-durables, and the industrial businesses: capital goods, raw or semi-finished materials, components, and supplies. The means vary from period to period and

TABLE 6.--PIMS manufacturing capacity utilization rates: Means and standard deviations for all manufacturing and by types of business for selected periods, 1970-1974

		TYPE OF BUSINESS							
		Consumer			Industrial				
Period	Total Manu-fact.	Total Consumer	Dur-ables	Non-durables	Total Indust.	Capital Goods	Raw, Semi-Finished	Compo-nents	Sup-plies
	N=515	N=155	N=25	N=130	N=360	N=103	N=59	N=124	N=74
1971-1974	79.8 (16.1)	75.9 (15.1)	79.6 (16.3)	75.1 (14.7)	81.5 (16.2)	80.7 (16.8)	85.9 (12.3)	81.0 (17.1)	80.0 (15.8)
1971-1972	76.7 (17.1)	73.9 (16.1)	78.1 (17.4)	73.1 (15.7)	77.9 (17.4)	77.1 (17.8)	81.5 (14.7)	77.8 (18.2)	76.3 (16.7)
1973-1974	82.8 (17.1)	77.7 (16.1)	80.9 (17.3)	77.0 (15.7)	85.0 (17.0)	84.1 (17.7)	90.2 (12.1)	84.0 (17.8)	83.6 (17.4)
	N=625	N=161	N=46	N=115	N=464	N=130	N=82	N=160	N=92
1970-1973	78.6 (16.2)	78.0 (14.3)	78.1 (13.8)	77.8 (14.4)	78.8 (16.8)	76.3 (17.1)	83.8 (14.3)	78.7 (17.0)	77.7 (16.6)
1970-1971	75.3 (17.2)	75.7 (15.1)	73.7 (15.0)	76.4 (14.9)	75.2 (17.8)	73.2 (18.1)	79.1 (16.8)	74.8 (18.0)	75.0 (17.4)
1972-1973	81.9 (16.5)	80.2 (14.8)	82.4 (14.1)	79.2 (14.9)	82.5 (17.0)	79.8 (17.1)	88.6 (13.8)	82.6 (17.5)	80.5 (17.0)

Source: Computed from the PIMS 1971-1974 data bank. See Chussil and Land, 1976. Standard deviations are in parentheses below the corresponding mean. 1970-1973 means and standard deviations were computed from the PIMS 1970-1973 data bank. See Land, 1975.

from business type to business type. The information in Table 6 comes from two of the PIMS data banks: the 1971-74 data bank which includes 515 manufacturing businesses, and the 1970-73 data bank which includes 625 manufacturing businesses. When this research was done, two-year and four-year averages were available by type of business, but the annual data, one-year averages, were not.

Except for consumer non-durables, the lowest capacity utilization rate means are in the time period 1970-1971. The corresponding mean for consumer non-durables is in a related time period, 1971-72. Similarly, except for consumer businesses, the highest means are in the time period 1973-1974. The highest means for consumer businesses are in a related time period, 1972-1973. The timing for consumer non-durables seems to be slightly different from the timing for other types of business; consumer durables means are generally slightly higher than those for non-durables, and similar to but usually higher than the means for industrial capital goods, which are also durables.

Generally, the highest capacity utilization rates in any time period are those for industrial raw or semi-finished materials. This type of business has the highest mean in the table, 90.2 per cent for 1973-1974. Except in 1970-1971 and for industrial capital goods in 1970-1973, consumer non-durables businesses have the lowest capacity utilization means in a given time period. This type of business has the lowest mean in Table 6, 73.1 per cent in 1971-1972.

Within the two time periods, 1971-1974 and 1970-1973, the lower capacity utilization rates occur at the beginning of the time period, and the higher rates occur at the end. Industrial capacity utilization rates are higher than consumer capacity utilization rates except in 1970-1971 when there was very little difference as shown in Table 6. The range of means in Table 6 is from 73.1 to 90.1. The difference between them is 17.0, not much greater than one standard deviation. Standard deviations in Table 6 range from 12.1 to 18.2. The range of values for capacity utilization rates in PIMS data banks has been truncated so that rates below 40 per cent are reported as 40 per cent, and rates above 110 per cent are reported as 110 per cent, and extreme values are not in the data bank to distort the means (Chussil and Land, 1976).

The purpose of this study of means was to find out whether capacity utilization rates varied enough from business type to business type to justify separate regressions by type of business. Means do not provide any clear direction. Because PIMS data are not a random sample of businesses, the simple, restrictive statistical tests of differences in means were not done. Differences can be tested more appropriately in regression analysis even without a random sample because the regression analysis involves more variables than capacity utilization alone, and dummy variables can be incorporated into regressions to study differences in means (Frederick, 1977).

Capacity utilization, GNP, and employment. A comparison of capacity utilization rates with gross national product and employment figures, which might clarify behavior of capacity utilization rates over time, can be made using Tables 6, 7, and 8. The two-year and four-year averages in Table 8 are from the PIMS data used in regression analysis for this study. The one-year averages in Table 7 are from a smaller set of PIMS data which includes a small number of retail and service businesses as well as manufacturing businesses, and which does not include the type of business variable.

The GNP data selected for this comparison are the real gross national products for goods output because manufacturing businesses produce goods. This fractional GNP declined from 1973 to 1974, as shown in Table 7. The averaged data in Table 8 do not show this decline.

The employment data selected for this comparison are civilian non-agricultural employment data because manufacturing is in the civilian non-agricultural sector. From year to year in Table 7 and in the two-year averages in Table 8, this employment increased over time.

The capacity utilization data in Table 6 include means for total PIMS manufacturing businesses and for six separate types of business. For total manufacturing and for five types of business, the mean capacity utilization rates increased over time as indicated by the two-year averages. For consumer non-durables, the 1973-1974 average capacity utilization rate of 77.0 was lower than the 1972-

TABLE 7.--Real goods output gross national product, civilian non-agricultural employment, and PIMS business capacity utilization rates, 1970-1975, with changes and per cent changes[a]

Year	Real Goods Output Gross National Product[b]			Civilian Non-Agricultural Employment[c]			Capacity Utilization, Business[d]		
	GNP	Change	% Change	Emplmnt	Change	% Change	Cap Util	Change	% Change
1970	483.4			75,165			75.2		
1971	491.6	8.2	1.7	75,732	567	.8	76.0	0.8	1.1
1972	526.0	34.4	7.0	78,230	2,498	3.3	80.1	4.1	5.4
1973	568.6	42.6	8.1	80,957	2,727	3.5	84.1	4.0	5.0
1974	549.9	-18.7	-3.3	82,443	1,486	1.8	83.0	-1.1	-1.4
1975	531.1	-18.8	-3.4	81,403	-1,040	-1.3	n.a.[d]	n.a.	n.a.

[a] Change is from the preceding year. Per cent change is change divided by the amount in the preceding year.

[b] Economic Report of the President. Washington, D. C.: U. S. Government Printing Office, 1976, Table B-5, p. 177. Goods output GNP is in billions of 1972 dollars, quarterly at seasonally adjusted annual rates. 1975 figures are preliminary.

[c] Ibid., Table B-22, pp. 196-97. Civilian labor force age 16 and over, non-agricultural employment in thousands of persons. 1972 and 1973 are not strictly comparable with earlier years due to population adjustments. 1975 figures are preliminary.

[d] Computed from PIMS MAT14 data bank; 438 observations, which may include some non-manufacturing businesses. Since 1970-1975 capacity utilization means were available for only 210 businesses, the shorter period, 1970-1974, was chosen.

TABLE 8.--Comparison of annual average capacity utilization rates with real GNP and employment for selected time periods, 1970-1974

Period	United States Real Goods-Output			United States Non-Agricultural			PIMS Manufacturing Capacity Utilization		
	GNP	Change	% Change	Emplmnt	Change	% Change	Cap Util	Change	% Change
1970-1971	487.5			75,448			75.3		
1972-1973	547.3	59.8	12.3	79,594	4,146	5.5	81.9	6.6	8.7
1971-1972	508.8			76,981			76.7		
1973-1974	559.3	50.5	9.9	81,700	4,719	6.1	82.8	6.1	8.0
1970-1973	521.9			77,521			78.6		
1971-1974	534.0			79,340			79.8		

Source: Computed from Tables 6 and 7.

1973 rate of 79.2. This indication that consumer non-durables behave differently from other types of business over time should be checked with annual data which were not available during the time of this research. This difference also may be attributable to a difference in data banks. The bank containing 1973-1974 averages has 130 consumer non-durables businesses, while the bank containing 1972-1973 averages has only 115.

In Table 8, the per cent change in GNP and capacity utilization is higher from beginning to end in the 1970-1973 period than from beginning to end of the 1971-1974 period, but the per cent change in employment was lower. In Table 7, GNP and employment increased to a high point in 1973 and then either increased at a decreasing rate (employment, 1974), or decreased. Capacity utilization for 438 PIMS businesses in a 1970-1974 data base, and for 531 in a 1971-1974 base, decreased after 1973.

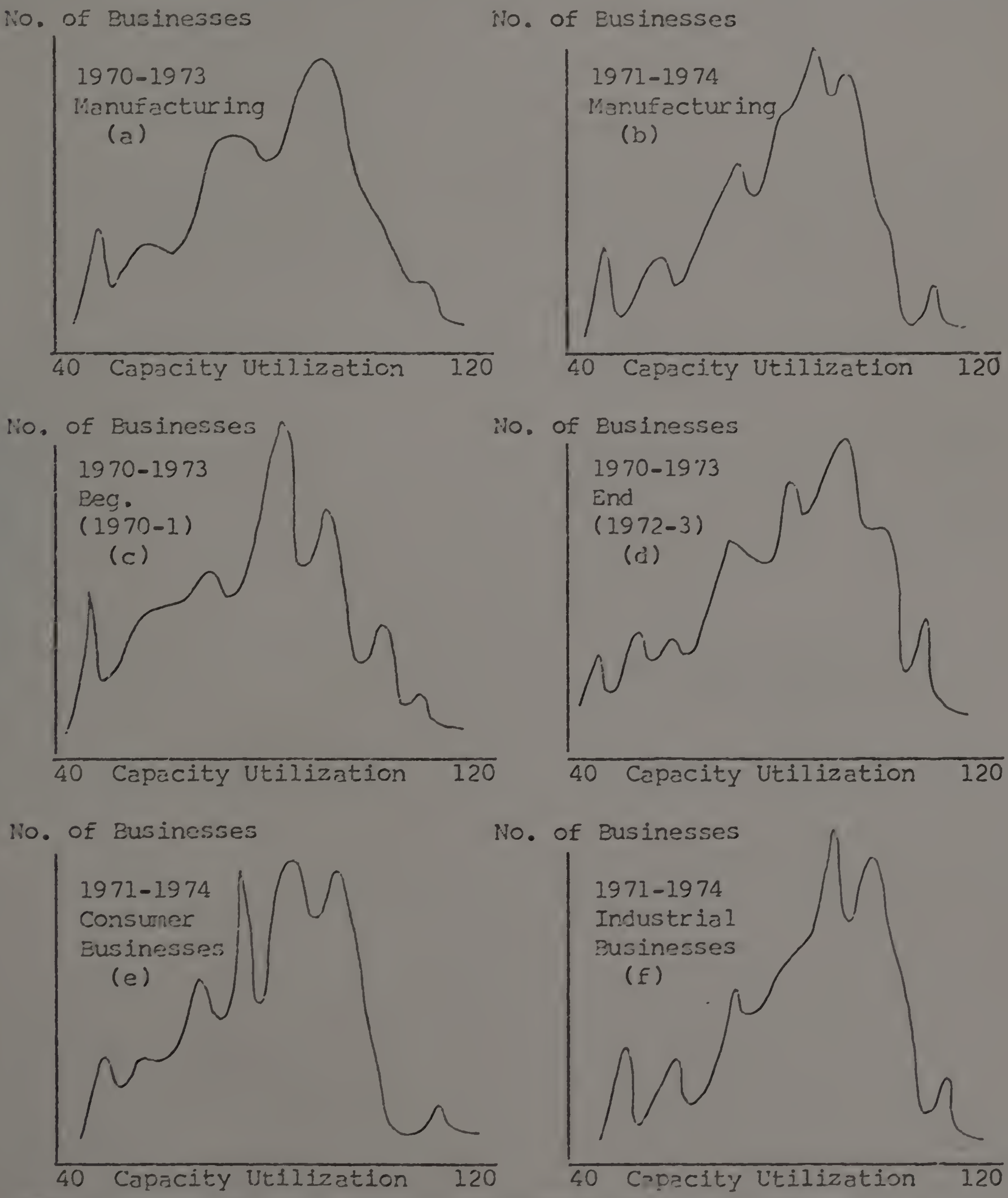
The responsiveness of capacity utilization (c) in a sample of PIMS businesses with respect to a change in real goods gross national product (p), computed as: $(-p/c)*(dc/dp)$, is about two-thirds in Tables 7 and 8. This means that a per cent change in the capacity utilization rate in the PIMS sample is about two-thirds of the per cent change in real goods gross national product for the same time period.

Frequency Distributions of Capacity Utilization Rates

Figure 3 shows the distributions of capacity utilization rates in the 1971-1974 and 1970-1973 data banks. For the former, distributions for consumer and industrial businesses are shown. For the latter, distributions for beginning and ending averages are shown. Distributions approach a normal distribution for all manufacturing, but are less regular for consumer and industrial businesses. The modal capacity utilization rate for each distribution in Figure 3 is about 90 per cent.

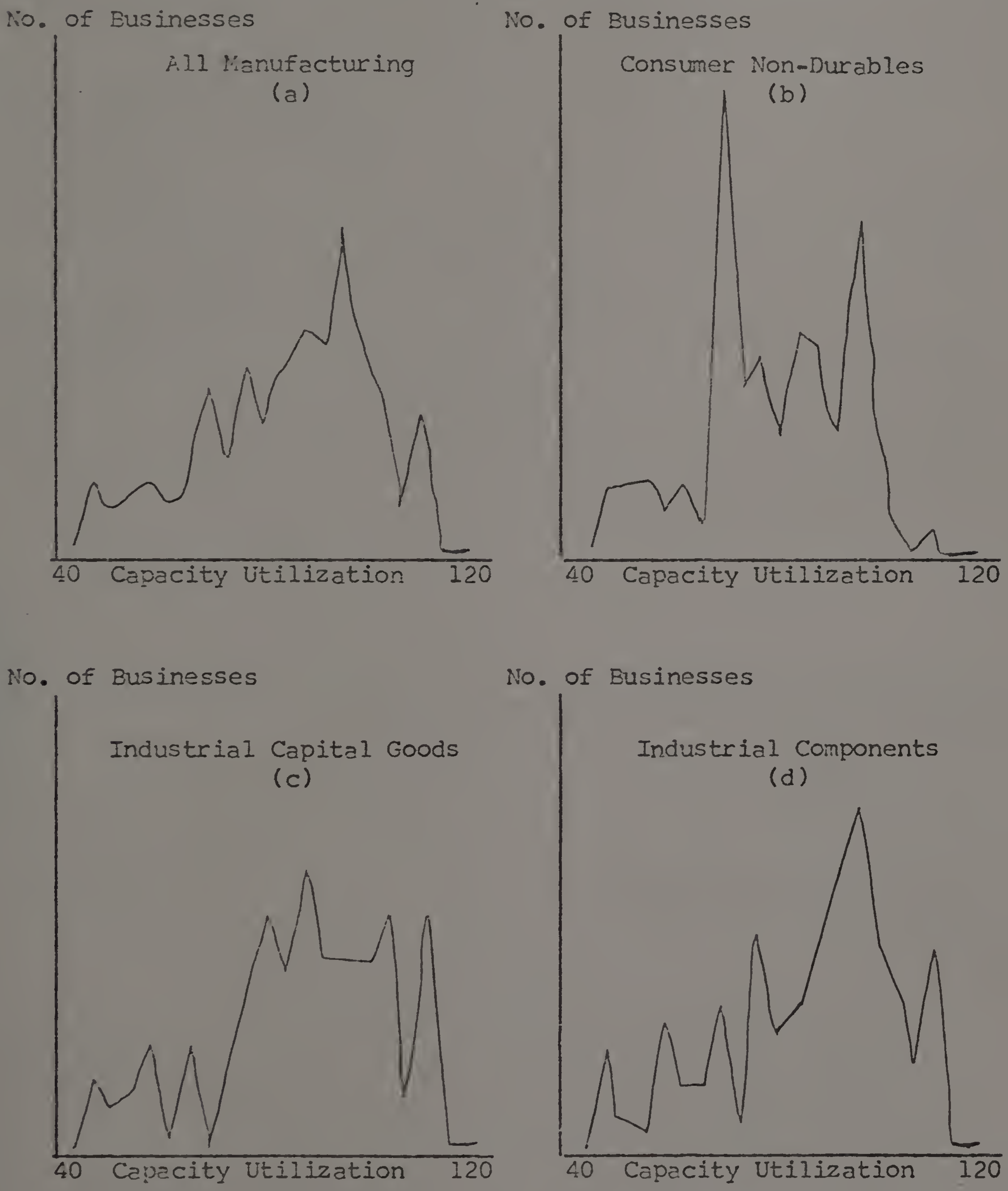
Figure 4 shows distributions of 1973-1974 capacity utilization rates for all manufacturing and for selected types of business. The total distribution tends to be less bi-modal than the distributions in Figure 3, but the separate types of business tend to have more than one mode. The modal capacity utilization rate for all manufacturing for 1973-1974 is about 95 per cent. This is similar to the mode for industrial components and one of the modes for consumer non-durables. The other mode for consumer non-durables is about 68 per cent capacity utilization. Modes for industrial capital goods are at: 88 per cent capacity utilization, 82 per cent, and over 100 per cent, as shown in Figure 4. Although PIMS inserts data "plugs" of certain values in place of missing information, there is little evidence that the plugs influence the modes because the plugs are not the modal values (see Chussil and Land, 1976; Land, 1975).

FIGURE 3.--Frequency distributions of capacity utilization rates for all PIMS manufacturing businesses in 1970-1973 and 1971-1974, for beginning and end of 1970-1973, for consumer and industrial 1971-1974



Source: Computed from the PIMS 1970-1973 and 1971-1974 data banks.

FIGURE 4.--Frequency distributions of capacity utilization rates for all PIMS manufacturing businesses and for selected types, 1973-1974



Source: Computed from the PIMS 1971-1974 data bank.

Regression by Groups of Variables

In Chapter V, variables expected to influence capacity utilization were categorized into several groups such that each group would represent an industrial organization or business concept. Since a relationship must be expressed between the concepts that we are studying and real-world data that are available, separate regressions of capacity utilization as dependent variable on the variables in each group as independent variables were done to see which items of data in the PIMS data bank best represented the concepts.

Regressions were done for average annual capacity utilization on each group of variables and also for all groups together for two time periods: 1971-1974 and 1973-1974. The longer time period is used in the PIMS LIM equation which explains return on investment; the 1973-1974, more short-run, time period was considered to be more suitable for a study of capacity utilization which is, after all, a short-term phenomenon. Strong relationships between dependent and independent variables would be expected to appear in both periods. Results for the separate regressions by groups of variables and for the regressions for all groups of variables together are in Table 9.

Table 9 includes both expected (in Chapter V) and computed (in Chapter VI) signs, and ranks of standardized regression coefficients, and an indication of the significance of the coefficients. The variable with the largest standardized regression coefficient has the

TABLE 9.--Signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS manufacturing by groups of variables and by all groups, 1971-74 data

PIMS No. for 73-4	Expected Sign	Variable	Separate Groups		All Groups		With Nonlinear Terms
			1973-4	1971-4	1973-4	1971-4	1973-4
		Market Position	R^2=.13	R^2=.12	R^2=.36	R^2=.33	R^2=.42
268	+	Market Share	2**	2**			
270	+	% Chg. in Share	4**		15		
31#	+	Import. to Cust.	3**	3**	12*	10*	21
159	±	Med.Adv.Exp./Rev.	-5*				
149	-	Sls.Force Exp./Rev.	-1**	-1**	-6**	-5**	-4**
		Product Character.	R^2=.07	R^2=.05			
134	-	Prd. R&D Exp/Rev.	-2**	-2**	-5**	-4**	-9**
2#	-	Cnsmr. Bsns. Dummy	-1**	-1**			
		Pdn., Productivity	R^2=.19	R^2=.19			
245	-	Productivity(VA/ee)					-11**
246	-	% Chg. in Pdtivity	3*				
221	+	% Chg. in Investmt	2**	2**	8*	3**	
346	+	Capital Intensity	1**	1**	1**	1**	1**
110	+	Chg. in VA/Rev.					8**
		Finance	R^2=.05	R^2=.06			
174	+	Return on Investmt	1**	1**	4**	7**	5**
198	+	Working Cap./Rev.					13**
89	+	Corp. Debt/Equity	2*	2*			
		External Environmt	R^2=.09	R^2=.07			
366	+	Real Market Growth	1**	1**	2**	8**	6**
70	-	Entry of Competits.	-2**	-4	-7**	-11*	-12**
11	-	Technolog. Change	-3*	-3*	-14		
		Internal Environmt	R^2=.02	R^2=.04			
47#	+	Share Pdn. Facils.					2**
49#	+	Share Mktg. Pgms.	2*				
43	+	Purch. fm Compnt.	3*	2*			
45	+	Sales to Compnt.	1*				
		Customer Character.	R^2=.11	R^2=.13			
19#	-	No. of Customers	-3**	-4**	-13	-13*	-18*
21#	-	Cust. Conc. Decr.					15*
24#	-	Cust. Conc. Incr.	-6*	-6*		-14*	-17*
29#	+	Typical Purch. Amt.	5*	3**	10*	6**	7**
75#	-	Less Cust. Than	-1**	-1**	-3**	-2**	-3**
75#	-	More Cust. Than	-4**	-5**	-11**	-12	-19
76#	+	Larger Customers	2**	2**	9*	9*	16*

Source: Computed from 515 businesses in PIMS 1971-1974 data bank.

Note: One-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level. R^2 is for regressions which include significant variables only. # means recoded as described in Appendix A.

highest rank, "1." The variable with the next largest coefficient has rank "2," and so on. Significance is indicated by **, *, or rank without ** or *. A one-tail test is used to determine whether the hypothesis H_o: $\beta = 0$ or either H_a: $\beta > 0$ or H_a: $\beta < 0$ is true, assuming that the sign of the β is known. ** indicates that H_a is true at the highest level of significance, one per cent. * indicates that H_a is true at the five per cent level of significance. Ranks are given for variables for which H_a is true at the ten per cent level of significance, but not for results for any less significant levels.

Computation of the standardized regression coefficients puts data in the form of deviations of an observation from the mean of all observations on that variable, divided by the standard deviation for that variable. The significance of a variable is the same and the R^2 is the same whether the variables are standardized or not (Kmenta, 1971).

R^2, the coefficient of multiple correlation, indicates the goodness of fit of the regression line, or the proportion of variance of the dependent variable explained by the independent variables. R^2 is given in Table 9 for each separate regression by a group of variables and for each regression using the combined groups of variables. The R^2 in Table 9 refers to the amount of variation in the dependent variable explained by the <u>significant</u> independent variables. R^2 for both significant and non-significant variables in a regression together would be higher. If the independent variables are uncorrelated, the sum of the R^2 for the regressions for separate groups of variables would equal the R^2 for the regressions on all groups combined. That the sum of R^2 for the separate groups is larger than the R^2 for the combined groups indicates that some correlation of variables from group to group exists. This situation will be explored in Chapter VII.

Input to the combined, all-group regressions in Table 9 consists of variables found to be significant in the separate regressions by group at the one-tail ten per cent level of significance or higher.

A dummy variable, which has a value of one for consumer goods businesses and a variable of zero otherwise, is included in each of the separate groups for the 1971-1974 period to determine whether capacity utilization for consumer businesses is lower than capacity utilization for industrial businesses. If this is the case, the coefficient for this dummy variable would have a negative sign.

Market position. Variables which represent market position of the business are market share, per cent change in share, importance of the product to the customer, media advertising expense/revenue, and sales force expense/revenue. In Chapter V a seller with greater market share or greater per cent change in share, or with a product that is higher in importance to customers was expected to have higher capacity utilization. Because higher advertising and sales expenses may be needed to stimulate sales of a product if capacity is underutilized than with high utilization, capacity utilization was expected to be inversely related to the ratios of media advertising/revenue and sales force expense/revenue. These expense relationships signal an environmental change that affects capacity utilization.

As shown in Table 9, the coefficient of the sales force expense/revenue variable, which has the highest rank, is significantly different from zero at the highest level, one per cent. This variable has the highest rank of the market position variables in regressions both for the market position group and for all groups combined, and it has the expected sign. Market share has second rank, the expected sign, and is also highly significant in its group; in the all-group regressions, share is not significant, probably because it is accounted for by some of the customer characteristics variables.

Third rank in this group goes to the importance-to-customers variable, suggested by Frey (1976); it also has the expected sign. There are two types of customers, immediate customers and end users. In both periods, end user coefficients have similar rank, but slightly smaller significance and slightly lower R^2. Therefore, importance to immediate customers was used as the variable in the all-group regressions, where it is also significant, although its rank is only 10 or 12 depending on the time period.

Fourth in rank in this group, with the expected sign, is the per cent change in share variable which is significantly different from zero in the 1973-1974 period for its group and in the all-group regressions. The consumer dummy variable is fourth in rank in the market position group for 1971-1974 and has the expected negative sign which indicates that consumer goods businesses have a lower mean capacity utilization rate than industrial goods businesses. This variable is not included in all the separate group listings in Table 9, but is mentioned in the text when significant. It is not significant in the all-group regressions, probably because other variables represent any differences in consumer and industrial businesses more effectively. Consumer non-durables businesses, which are 84 per cent of consumer businesses in the PIMS 1971-1974 data bank, are the least capital intensive and have the highest advertising expense/revenue ratios of the six business types.

Media advertising expense/revenue is fifth in rank in this group with the expected sign, but is not significant in the 1971-1974 regressions for this group or for the all-group regressions.

Product characteristics. Variables expected to influence or represent product differentiation characteristics included: product research and development (R&D)/revenue, the consumer goods dummy mentioned above, and a quality variable which is the difference in the per cent of products considered superior in quality by the customer and the per cent considered inferior. The coefficient for the consumer dummy variable, which ranked first in both time periods, and that for the product research and development variable, which ranked second, were both significant at the one per cent level and had the negative sign, suggested in Chapter V, in their group. The quality variable was not significant. In the all-group regressions, the product R&D variable ranked fifth in 1973-1974, and fourth in 1971-

1974. The consumer dummy was not significant, probably for the same reason given above.

Production and productivity. Productivity, change in investment, capital intensity, and make-or-buy variables are in this group which is concerned with the relative amount and use of capital plant and equipment. Capital intensity ranked first in this group and in the all-group regressions, was highly significant, and had the expected sign. The per cent change in investment variable, which becomes the dependent variable in the new investment equation discussed in Chapter VIII, ranked second in this group, third in 1971-1974 all-group regressions, and eighth in 1973-1974 all-group regressions. Excluded from Table 9, but included in regressions for this group are the consumer dummy which ranked third with the expected sign, and a variable for process research and development expense/revenue which ranked fourth with a negative sign in the 1971-1974 regressions. The per cent change in productivity variable ranked third in the 1973-1974 regressions for this group.

Finance. The finance group in Chapter V included return on investment, working capital/revenue, and corporate debt/equity. Return on investment (ROI), the dependent variable of the PIMS LIM equation had the highest rank in this group, was fourth and seventh in the 1973-1974 and 1971-1974 all-group regressions respectively, and was always of the highest significance and had the expected sign. ROI in this equation served as a proxy for good management characteristics, otherwise unquantifiable. The corporate debt/equity variable ranked second in the finance group and had the expected sign. The consumer dummy variable tied for first place in the finance group and was highly significant in this group but not in all-group regressions.

External environment. Growth rates, entry and exit of competitors and technological change make up the external environment group introduced in Chapter V. Real market growth ranked first in its group, and second and eighth in the all-group regressions in 1973-1974 and 1971-1974 respectively. It was highly significant and had the expected sign. The technological change coefficient ranked third in its group with the expected sign and ranked 14th in the 1973-1974 all-group regression. Entry ranked second and fourth in the 1973-1974 and 1971-1974 group regressions respectively, and ranked seventh and eleventh in the all-group regressions, having the expected negative sign in all regressions. The consumer dummy ranked second in the 1971-1974 regression for this group.

Internal environment. This group includes purchases from and sales to other components of the parent company, and shared production facilities, shared distribution programs, and shared marketing channels. Sales to components has the highest rank in the 1971-1974 regressions for this group, followed by shared marketing programs and purchases from components. All signs are positive, as suggested in Chapter V. In the 1971-1974 regressions, the consumer dummy ranks first, followed by the purchase from components variable. No variables in this group are significant in the all-group regressions. Common distribution channels is included as a variable in this group, but excluded from Table 9 for lack of space; it is not significant at the ten per cent level in any regressions.

Customer characteristics. This group includes number and size of customers and their relative number and size, the typical purchase amount and a dummy variable for increase in customers. The highest ranking variable is the less customers dummy of which the negative sign indicates that businesses with less customers than competitors have lower capacity utilization. There are two types of customers: 1) immediate customers and 2) end users who buy the product from other businesses if the business does not sell direct to the final consumer. While the importance to immediate customers is clearly a more useful variable than importance to end users in the market position group, this is not always the case in the customer characteristics group.

Separate regressions for customer characteristics variables were done for immediate customers and for end users. Immediate customers are included in Table 9 because they are closer to a manufacturing business; the end user regressions had slightly higher R^2, but results were similar. The resolution of the problem of whether to use immediate or end customers seems to be that in some cases the relevant customers are immediate, and in other cases, end customers are relevant. For example, the number of and the change in number of end users is relevant, but the purchase amount of the immediate customers is also relevant. The former is an indication of demand for the product, which would originate with end users. The latter represents a habitual way in which the immediate customer operates with respect to the amount purchased from a manufacturing business.

Most of the variables in the customer characteristics section were significant in regressions for this group, and many were significant in the all-group regressions. The consumer dummy was significant in a regression for this group using 1971-1974 data. Among the higher ranking variables in this group are having less customers than competitors, and having larger customers than competitors. Also, capacity utilization was positively related to number of customers and typical purchase amount.

An interesting development which occurred when end customers were used in the all-group regressions is that the media advertising/revenue variable became significant, ranking ninth in 1973-1974; in the same period, corporate debt/equity became significant, ranking eleventh; and in 1971-1974, process research and development became significant, ranking 14th. None of these three variables was significant in the immediate customer all-group regressions.

Summary. Results presented in this section are only preliminary. They are discussed further in Chapter VII in comparison with other results.

Regressions by Type of Business

Normal capacity utilization is expected to vary with type of business because different types of business are expected to have different types of capacity requirements and different reasons for deviating from normal capacity utilization in the same time period and in different time periods.

Table 10 contains the ranks; signs, and significance of standardized regression coefficients for variables explaining capacity utilization for all PIMS manufacturing business and by type of business: consumer durables, consumer non-durables, industrial capital goods, industrial raw or semi-finished materials, industrial components, and industrial supplies for the 1973-1974 period. As for Table 9, variables significant at the one-tail ten per cent significance level or more significant are included. This level was chosen a priori in order to have some reportable results. It was not known at that time that, in these regressions,if a variable is significant at all, it is usually significant at the highest, one per cent, level. Variables having lower ranks are less significant. Since there is little theory and research to give evidence concerning which variables influence capacity utilization, it is reasonable to expect that any variable with real influence would overcome the noise in the data and be significant at the five per cent level or higher and would be among the top ten in rank. In Table 10, from three to nine variables are significant at the five per cent level or higher for a type of business.

Regressions for Table 10 were done by starting with all variables listed in the table. Preliminary regressions for separate groups of variables were not done. Nevertheless, there are some significant variables in each of the separate groups. Some variables: media

TABLE 10.--Signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS manufacturing total and by type of business, 1973-1974 period

PIMS No.	Expected Sign	Variable Name	All Mfg. Bus. Types N=515	Type of Business					
				Consumer		Industrial			
				Durables N=25	Non-Dur. N=130	Capital N=103	Raw, Semi N=59	Compnts N=124	Supplies N=74
			R^2=.40	R^2=.40	R^2=.49	R^2=.39	R^2=.68	R^2=.50	R^2=.43
268	+	Market Share							
270	+	% Chg. in Share	15*						
31#	+	Import to Cust(I)	19						
159	±	Med.Adv.Exp./Rev.	9*		6**	1**		-7*	
149	-	Sls.Frc.Exp./Rev.	-4**	-1**		-7*		-1**	
134	-	Prd. R&D Exp/Rev.	-5**				-3**	-2**	
2#	-	Cnsmr. Bsns Dummy							
245	-	Pdtivity (VA/ee)	-10**				-4**		
246	-	% Chg. in Pdtivity		2*			8**		
221	+	% Chg. in Investmt	12						
346	+	Capital Intensity	1**		2**	2**	2**	5**	1**
109	-	Make-Buy(VA/Rev.)							
110	-	Chg. in VA/Rev.							
174	+	Retrn on Investmt	3**				1**		
198	+	Working Cap/Rev.	11**						
89	+	Corp. Debt/Equity	18		4**	4**			
366	+	Real Market Grwth	2**		1**		6**	4**	
79	+	Ind. Grwth Rate							
70	-	Entry of Compets.	-9**				-5**	-3**	
71	-	Exit of Compets.	-17		-7**				
11	-	Technolog. Change							-2**
47#	+	Share Pdn.Facils.	8**						
49#	+	Share Mktg. Pgms.			5**				-7
43	+	Purch. fm Compnt.							
45	+	Sales to Compnt.				5**			-3*
18#	-	No. of Customers	-6**E		-3**E			8*I	
21#		Cust.Conc.Decr(E)		3					
21#	-	Cust.Conc.Incr	-14*E			-8**I	-7**		-4*
29#	+	Typicl Purch. Amt.	13*I						
75#	-	Less Cust. Than	-7**		-9*	9*			-5*
75#	-	More Cust. Than				6*			
76#	+	Larger Customers	16					6*	
76#	-	Smaller Customers				-3*			
26#	-	Purchase Freq.(E)							-6
23	-	Conc. Purchases(I)			-8**		-9*		

Source: Computed from PIMS 1971-1974 data bank.

Note: One-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level. R^2 is for regressions which include significant variables only. # means recoded as described in Appendix A. E = end user; I = immediate customer.

advertising expense/revenue, sales force expense/revenue, capital intensity, real market growth, and increase in concentration of customer purchases, are significant for several types of business. The most confusion is in the customer characteristics group of variables in which different PIMS variables represent customer characteristics for different types of business. For example, decrease in end user concentration is significant only for consumer durables; purchase frequency of end user is significant only for industrial supplies, and having more customers than competitors is significant only for industrial capital businesses.

Capital intensity has the highest rank in general. It ranks first for all manufacturing and industrial supplies; second, for industrial capital and raw or semi-finished materials; fifth, for components. Real market growth ranks first for consumer non-durables, second for all-manufacturing, and fourth and sixth for industrial components and raw or semi-finished materials. Return on investment is third in importance for all manufacturing, first in rank for industrial raw or semi-finished materials, but not otherwise significant. These three variables, which are the first three in rank for all manufacturing, represent three of the different groups of variables that were studied separately in regressions for Table 9.

Market position and customer characteristics. Results for these groups of variables are the most interesting and baffling of the results in Table 10. Both of these groups attempt to represent power: market power of the customer and market power of the seller or business. The question to be answered in these sections is: "Who is the customer?" There are two types of customers: immediate customers who buy from a business, and end customers who buy from a customer of the business. In some cases the immediate customer also may be the end user. The distinction between immediate customers and end users is made in marketing literature, but not in industrial organization published research because data on the business level have not been available. This distinction may be important for a business manager who makes strategic decisions about capacity utilization.

Industrial demand is a derived demand. It is relatively inelastic and fluctuates more widely than demand for consumer goods. Industrial orders are larger in size than consumer orders, and industrial goods are purchased less frequently with longer negotiation before sales. There are only about 3.5 million individual industrial buying units but there are about 60 million households (Rich, 1970) and about 72 million consumers (Howard, 1970). These sources did not mention the number of wholesalers and retailers who may buy for the industrial or consumer customers.

Personal selling is more important than advertising for industrial goods because there are fewer customers, and they need more technical information. Advertising serves as an educational door-opener for salesmen (Rich, 1970). At first, technical industrial products are sold direct by the sales force; then, by jobbers as the product gains in acceptance and volume grows. Later, fewer jobbers are used as the business sells direct to larger customers; and finally, no jobbers are used (Vance, 1970).

Consumer goods are sold in major retail outlets, usually via a wholesaler, and also direct: door to door, direct mail, by phone, vending, or media advertising. Supermarket Week has predicted that before long, a small group of retail organizations will control no less than 80 per cent of the total volume of all mass distributed brands that are pre-sold by advertising (Minichiello, 1970).

The greatest difference in business types is probably that between consumer non-durables and industrial capital goods. The former are frequently purchased at relatively low prices by many end users in retail stores. The latter are usually purchased infrequently, have a relatively high price per item, and may be bought directly from the manufacturer. There may be a long planning period. These are the two extremes; the other types of business are somewhere between these extremes (suggested by Smith, 1977). In Table 10, immediate-customer variables seem to be significant for industrial businesses in the customer characteristics group, and number of end users is significant for consumer non-durables.

Separate regressions were done for end users and immediate customers for Table 10. The type of customer for which the coefficient had the highest significance and the multiple correlation coefficient was the highest was chosen. For all manufacturing and for consumer non-durables, the more end users, the lower the capacity utilization was. The more immediate customers for industrial components, the higher was the capacity utilization. An increase in end user concentration for all manufacturing and for raw or semi-finished materials and supplies was associated with a decrease in capacity utilization. A decrease in end users concentration was associated with an increase in capacity utilization. An increase in immediate customer concentration for industrial capital goods was associated with a decrease in capacity utilization. All manufacturing, consumer non-durables, and industrial supplies businesses with less customers than competitors had lower capacity utilization. Industrial capital businesses with more or less customers than competitors had higher capacity utilization. All manufacturing and industrial components businesses with larger customers than competitors had higher capacity utilization. The more frequent the purchases of supplies end users, and the more concentrated the purchases of non-durables and raw or semi-finished materials immediate customers, the lower the capacity utilization was.

Market position. This is a most interesting and surprising group of variables because market share, which is usually used as a major variable in industrial organization studies, loses its relative importance both when other groups of variables are added and in separate regressions by type of business. The ratio of sales force expense to revenue is first in rank for consumer durables and for industrial components, fourth in rank for all manufacturing, and seventh in rank for industrial capital goods. This variable also ranked first in the group regressions of Table 9. Similarly, media advertising expense/revenue ranks first for industrial capital goods, sixth for consumer non-durables, and ninth for all manufacturing. This variable has a positive coefficient except for industrial components. Also, except for industrial components, regression results imply that as media advertising expense/revenue increases, capacity utilization increases. This coefficient also had a negative sign in the market position regressions in Table 9, but was not significantly different from zero in the all-variable regressions. The expected negative sign was found for sales force/revenue which implies that as sales force/revenue increases, capacity utilization rates are lower. It may be that products which are traditionally sold by sales force effort are products which have low capacity utilization rates. Per cent change in market share ranks fifteenth in all manufacturing, but is not significant for separate types, nor is importance to the customer, which was significant in the all-variable regressions of Table 9.

Product characteristics. The ratio of research and development expense to revenue ranked second for industrial components businesses, third for raw or semi-finished materials businesses, and fifth for all manufacturing, and was significant at the one per cent level. The negative sign indicates that capacity utilization is higher, the lower the research and development expense/revenue for a product. The process research and development expense variable was not significant.

Production and productivity. Capital intensity is the only variable in this group that is significant for most business types.

Productivity and per cent change in productivity are significant for some businesses. Productivity was not significant in separate regressions for this group in Table 9. Per cent change in investment, which ranked second in its group in Table 9, is not significant for any type of business in Table 10. Some variables in other groups may make up for some of the effect of new investment. Although pair correlation coefficients for any two variables in Tables 9 and 10 are generally less than .5, some multicolinearity may exist. Except for per cent change in productivity, variables in this group have the expected sign. It was expected that capacity utilization would decrease with increased productivity because then existing capacity would be used more efficiently and more could then be produced with the same capital stock. For consumer durables and industrial raw or semi-finished materials, capacity utilization increases with a positive per cent change in productivity; this variable is not significant for other business types.

Finance. Return on investment has the highest rank in this group in both Table 9 and Table 10, but is significant for only one type of business, industrial raw or semi-finished materials. Corporate debt/equity ranks fourth for consumer non-durables and industrial capital; this variable represents the financial state of the parent company, of which a business is a part, but not necessarily a representative part. All signs are as expected.

External environment. Although real market growth is significant for more types of business than other environmental variables, entry of competitors is also important, having third rank for components, fifth rank for raw or semi-finished materials, and ninth rank for the total manufacturing. Exit of competitors is seventh in importance for consumer non-durables but only seventeenth for the total group since it is not significant for any other business type. Technological change is second in importance for supplies but is not significant for any other group or for the total. All signs are as suggested in Chapter V. As in the small regressions, real market growth and the entry variable are the most important environmental variables.

Internal environment. In this group of variables there is a difference in significance in the type of business and all-manufacturing regressions. Shared production facilities ranks eighth in all manufacturing and is significant at the one per cent level, but it is not significant for any type of business. Shared marketing programs and sales to components are each significant for two types of business but not for all manufacturing. Capacity utilization is higher for shared marketing programs for consumer non-durables, and lower for shared marketing programs for industrial supplies. Capacity utilization is higher for industrial capital sales to components, but lower for industrial supplies sales to components. The business types having the positive coefficient for these coefficients have 130 and 103 observations compared with 74 observations for the type having the negative sign. The positive coefficients are more highly significant than the negative ones. Therefore, the sign may be as expected, and the acceptance of a negative sign for industrial supplies should depend on further research.

Summary. As expected, rank and significance of the coefficients of variables associated with capacity utilization differ for different types of business. The higher ranking variables are usually highly significant at the one per cent level. The multiple correlation coefficient ranges from .39 to .68 for regressions in Table 10, showing a relatively good fit for cross-section regressions. R^2 is about .4 for consumer durables, industrial capital, and supplies; and about .5 or higher for consumer non-durables, and industrial raw or semi-finished materials and components.

Only the linear form of variables is used in these preliminary regressions. This probably is not representative of the real world, but it is a start towards identifying significant variables. The next step is to consider nonlinear forms for some variables. Again, there is little guidance from the literature, so cross tables will be used to investigate nonlinear forms in the PIMS data bank.

Cross Tables

The purpose of computing cross tables is to use them as an aid in understanding interactions among variables and nonlinearities. Chapter V explains how cross tables computed by the AQD programs present the effect of two variables on a third variable. Cross tables can be used to show the effect of selected pairs of variables on capacity utilization. The 1973-1974 capacity utilization rate is the dependent variable in these cross tables. For these cross tables, cut points, which are in parentheses, were determined by a computer program which divided the number of businesses evenly among cells except in yes-no situations. The cells represent "high," "medium," and "low" categories for the explanatory variables. A cell contains both a capacity utilization mean for that cell and the number of businesses having that capacity utilization mean.

Figure 5: analysis by type of business. In Figure 5, the mean capacity utilization rates for 1973-1974 are given by type of business for three levels of several selected variables. For example, for consumer durables businesses with market share less than or equal to 14.2 per cent in the served market, the mean capacity utilization rate was 77.8 per cent. There were ten businesses in this category in 1973-1974. In the same period, 19 industrial raw or semi-finished materials businesses with a market share greater than 14.2 per cent but less than or equal to 28.4 per cent had a mean capacity utilization rate of 92.6 per cent.

Except for consumer non-durables businesses, capacity utilization is lowest for businesses with a low market share and a range of from 71 to 87 per cent mean utilization in 1973-1974. Highest capacity utilization occurs with market shares between 14.2 per cent and 28.4 per cent except for industrial supplies which have highest capacity utilization for shares greater than 28.4 per cent. This implies a nonlinear form for the market share variable. A cross table for 1972-1973 data also implies this nonlinearity. In Figure 5, high market share is the modal share for consumer non-durables and

FIGURE 5.--1973-1974 capacity utilization means by type of business for selected variables separated into low, medium, and high value cells by two cut-points to equalize number of businesses (shown in parentheses) in each cell

	Market Share			Profitability		
	(14.2)	(28.4)		(13.3)	(30.7)	
Consumer Durables	77.8 (10)	85.0 (11)	77.1 (4)	68.7 (8)	85.0 (13)	91.8 (4)
Consumer Non-Durables	75.4 (41)	78.0 (36)	77.7 (53)	74.2 (54)	76.3 (36)	81.6 (40)
Industrial Capital Goods	80.4 (25)	86.8 (42)	83.3 (36)	84.4 (45)	82.4 (32)	85.3 (26)
Industrial Raw, Semi-Fin.	87.0 (18)	92.6 (19)	91.2 (21)	87.4 (13)	88.2 (20)	93.6 (25)
Industrial Components	82.3 (55)	86.4 (36)	84.7 (32)	76.3 (24)	82.8 (46)	88.8 (63)
Industrial Supplies	71.3 (23)	88.2 (26)	90.0 (25)	79.3 (27)	84.3 (25)	87.9 (22)
	R^2 = 0.10			R^2 = 0.10		

	Per Cent Change in Investment			Media Advertising/Revenue		
	(5.19)	(13.53)		(.07)	(.46)	
Consumer Durables	68.7 (4)	81.8 (11)	84.6 (10)	79.1 (6)	80.8 (4)	81.6 (15)
Consumer Non-Durables	74.9 (44)	77.4 (45)	79.0 (41)	85.6 (20)	75.2 (23)	75.6 (87)
Industrial Capital Goods	79.7 (32)	86.7 (34)	85.3 (37)	81.4 (33)	85.5 (38)	85.0 (32)
Industrial Raw, Semi-Fin.	90.0 (22)	90.8 (22)	90.4 (14)	90.0 (30)	91.2 (22)	89.4 (6)
Industrial Components	81.5 (44)	83.5 (35)	87.2 (44)	87.6 (63)	82.8 (48)	70.8 (12)
Industrial Supplies	83.4 (26)	85.5 (25)	81.5 (23)	81.9 (36)	88.8 (26)	76.8 (12)
	R^2 = 0.07			R^2 = 0.10		

	Product R&D Expense/Revenue			Sales Force Expense/Revenue		
	(.56)	(1.85)		(2.96)	(5.74)	
Consumer Durables	81.9 (8)	87.8 (11)	66.8 (6)	94.8 (5)	78.7 (15)	73.3 (5)
Consumer Non-Durables	76.7 (66)	80.6 (34)	73.8 (30)	79.8 (24)	79.0 (47)	74.4 (59)
Industrial Capital Goods	83.6 (16)	86.9 (30)	82.7 (57)	85.8 (34)	84.0 (33)	82.4 (36)
Industrial Raw, Semi-Fin.	93.0 (14)	92.8 (21)	86.6 (23)	91.4 (38)	91.8 (11)	82.8 (10)
Industrial Components	85.8 (47)	89.6 (37)	76.9 (39)	89.7 (57)	86.2 (34)	71.7 (33)
Industrial Supplies	86.5 (28)	87.2 (27)	73.9 (19)	86.6 (13)	81.9 (34)	84.2 (27)
	R^2 = 0.12			R^2 = 0.12		

Source: Computed from the PIMS 1971-1974 data bank.

raw or semi-finished materials; the modal share for consumer durables, industrial capital goods, and industrial supplies is between 14.2 per cent and 28.4 per cent; the modal share for industrial components businesses is less than 14.2 per cent, as shown in Figure 5.

Capacity utilization is highest for businesses in the most profitable group, those with profit/investment greater than 30.7 per cent. This is also true for businesses with profit/investment greater than 25.9 per cent in the 1972-1973 period. The high profitability group is the modal group in Figure 5 for industrial raw or semi-finished materials and components businesses. The lowest profitability group, which has the lowest capacity utilization rates except for industrial capital goods, is the modal group for consumer non-durables, industrial capital goods, and components. Consumer non-durables have profitability between 13.3 and 30.7 per cent as the modal group. These businesses change from a capacity utilization rate of 68.7 per cent to a rate of 85.0 per cent from the lower to the medium profitability groups, a larger change than for any other type of business.

Highest capacity utilization is evenly distributed between the business types with per cent change in investment between 5.19 per cent and 13.53 per cent, and those with per cent change in investment over 13.53 per cent. This is an average annual per cent change for the period 1973-1974. The highest capacity utilization rates for consumer durables and non-durables and industrial supplies are in the highest investment group. The modal investment change group for the consumer businesses is the middle group; this is also the modal group for industrial raw or semi-finished materials. The mode for industrial capital goods and components businesses is the highest group, and the mode for industrial supplies is the lowest. In the 1970-1973 period, not shown in Figure 5, cut points are lower: 1.28 and 11.18. As above, there are three types of business with highest capacity utilization means in the medium and high investment cells. Consumer non-durables and industrial capital goods and components are in the high cells.

Media advertising expense/revenue over .46 per cent is associated with the highest capacity utilization for consumer durables, but other types of business have the highest capacity utilization rate associated with lower media advertising expense/revenue. Advertising/revenue between .07 per cent and .46 per cent is the modal group for industrial capital goods businesses. The modal group for consumer non-durables and other industrial businesses is media advertising expense/revenue of less than or equal to .07 per cent. The mean advertising/revenue ratio is 1.52 for all manufacturing in this period with a standard deviation of 3.95. Since the mean is in the highest advertising/revenue subgroup; that is, since it is higher than .46, this implies that a few businesses have a very high advertising to revenue ratio. In 1972-1973 only industrial capital goods and raw or semi-finished materials have the highest capacity utilization means in the high advertising cells.

Except for industrial raw or semi-finished materials, capacity utilization is highest for businesses with product research and development expense/revenue between .56 and 1.85. The lowest capacity utilization rates are for all businesses with product research and development expense/revenue greater than 1.85. The 1972-1973 period has similar results. This seems to imply that if product research is directed toward changing products, changing products may temporarily disrupt a formerly efficient system. Different types of business have different modes for this variable, as they have for other variables in the cross tables shown in Figure 5.

Except for industrial supplies in both time periods, and also for consumer durables in 1972-1973, the highest capacity utilization means occur in cells for sales force expense/revenue less than about three per cent.

Analysis of Figure 5 has not revealed that the different types of business behave alike with respect to the above variables or that the businesses can be grouped into consistent subgroups. Although some of the variables rank first in regressions by separate type of business, such as media advertising expense/revenue, sales force expense/revenue, and return on investment; others, such as share and per cent change in investment, have a low rank or are not significant in Table 10. Further study of cross tables is needed to understand these variables if they are to be included in an overall regression for all manufacturing.

In some cross tables for the 1971-1974 period not included in Figure 5, there was no separate pattern for capacity utilization means in separate types of business by customer characteristic.

Capacity utilization was highest for middle customer groupings: for 100,000 to about ten million users, and for 50 to 999 immediate customers. Capacity utilization means were highest for high capital intensity for every type of business.

Figure 6: analysis of selected cross tables. In Figure 6, relationships of several pairs of variables to capacity utilization are shown. For example, in 1973-1974, the mean capacity utilization rate for the 80 businesses with market share less than or equal to 14.2 per cent and with profitability less than or equal to 13.3 per cent was 76.3 per cent.

When the independent variables are market share and media advertising expense/revenue, low capacity utilization is associated with low share and high advertising expense/revenue. High capacity utilization is associated with high or medium share and low advertising expense/revenue. This implies that high advertising expense/revenue is more likely to be a characteristic of businesses with low capacity utilization and low share than a possible strategy for increasing capacity utilization. This is especially relevant for the industrial components and supplies businesses in Figure 5.

High capacity utilization is associated with high market share and low sales force expense/revenue. Low capacity utilization is associated with low market share and high sales force expense/revenue. As in the case for media advertising, high sales force expense/revenue seems to be a characteristic of businesses with low capacity utilization. In Figure 5, this conclusion is relevant for all types

FIGURE 6.--Combined effect of paired variables on mean 1973-1974 capacity utilization rates in manufacturing businesses, equalizing number of businesses (shown in parentheses) in each cell

Media Advertising/Revenue

		(.07)	(.46)	
Market Share	(14.2)	80.9 (68)	82.9 (47)	73.9 (57)
	(28.4)	87.9 (59)	86.3 (61)	81.9 (50)
		87.7 (61)	83.7 (53)	79.3 (57)

R^2 = 0.06

Sales Force Expense/Revenue

		(2.96)	(5.74)	
Market Share	(14.2)	86.8 (58)	77.5 (57)	73.0 (57)
	(28.4)	88.3 (53)	87.7 (62)	80.6 (55)
		88.4 (60)	82.7 (54)	79.5 (57)

R^2 = 0.09

Profitability

		(13.3)	(30.7)	
Market Share	(14.2)	76.3 (80)	78.7 (55)	85.8 (37)
	(28.4)	82.1 (59)	85.4 (57)	89.6 (54)
		78.6 (32)	82.9 (60)	86.2 (79)

R^2 = 0.06

Per Cent Change in Share

		(-.08)	(5.24)	
Market Share	(14.2)	77.6 (53)	77.3 (57)	82.2 (62)
	(28.4)	82.2 (45)	88.3 (60)	85.4 (65)
		80.0 (59)	85.5 (68)	85.6 (44)

R^2 = 0.05

Sales Force Expense/Revenue

		(2.96)	(5.74)	
Media Adv./ Rev.	(.07)	88.9 (88)	83.6 (58)	80.1 (42)
	(.46)	89.0 (53)	85.1 (59)	78.7 (49)
		82.8 (30)	79.4 (56)	75.7 (78)

R^2 = 0.08

Product R&D Expense/Revenue

		(21.23)	(32.60)	
Media Adv./ Rev.	(.07)	86.4 (74)	89.8 (53)	80.2 (61)
	(.46)	80.9 (60)	89.4 (53)	83.3 (48)
		79.2 (45)	82.1 (54)	74.3 (65)

R^2 = 0.08

Real Market Growth

		(3.23)	(11.42)	
Entry	No	77.9 (131)	84.5 (124)	91.2 (105)
	Yes	73.9 (41)	77.0 (46)	85.3 (66)

R^2 = 0.11

Exit

		No	Yes
Entry	No	84.6 (315)	80.5 (45)
	Yes	79.9 (100)	79.3 (53)

R^2 = 0.02

Real Market Growth

		(3.23)	(11.42)	
Tech. Change	No	76.5 (131)	83.8 (128)	90.8 (123)
	Yes	78.5 (41)	78.6 (42)	84.0 (48)

R^2 = 0.10

Source: Computed from the PIMS 1971-1974 data bank.

of business, but especially for consumer durables and industrial components.

Market share and profitability seem to interact in their relationship with capacity utilization. Low capacity utilization is associated with low share and low profitability, while high capacity utilization is associated with medium share and high profitability. The cell with low share and low profitability and the cell with high share and high profitability have relatively more observations than the other cells.

High capacity utilization is associated with a medium market share and medium per cent change in share in Figure 6. Low capacity utilization is associated with low share and low or medium change in share. The interaction between these variables is not clear.

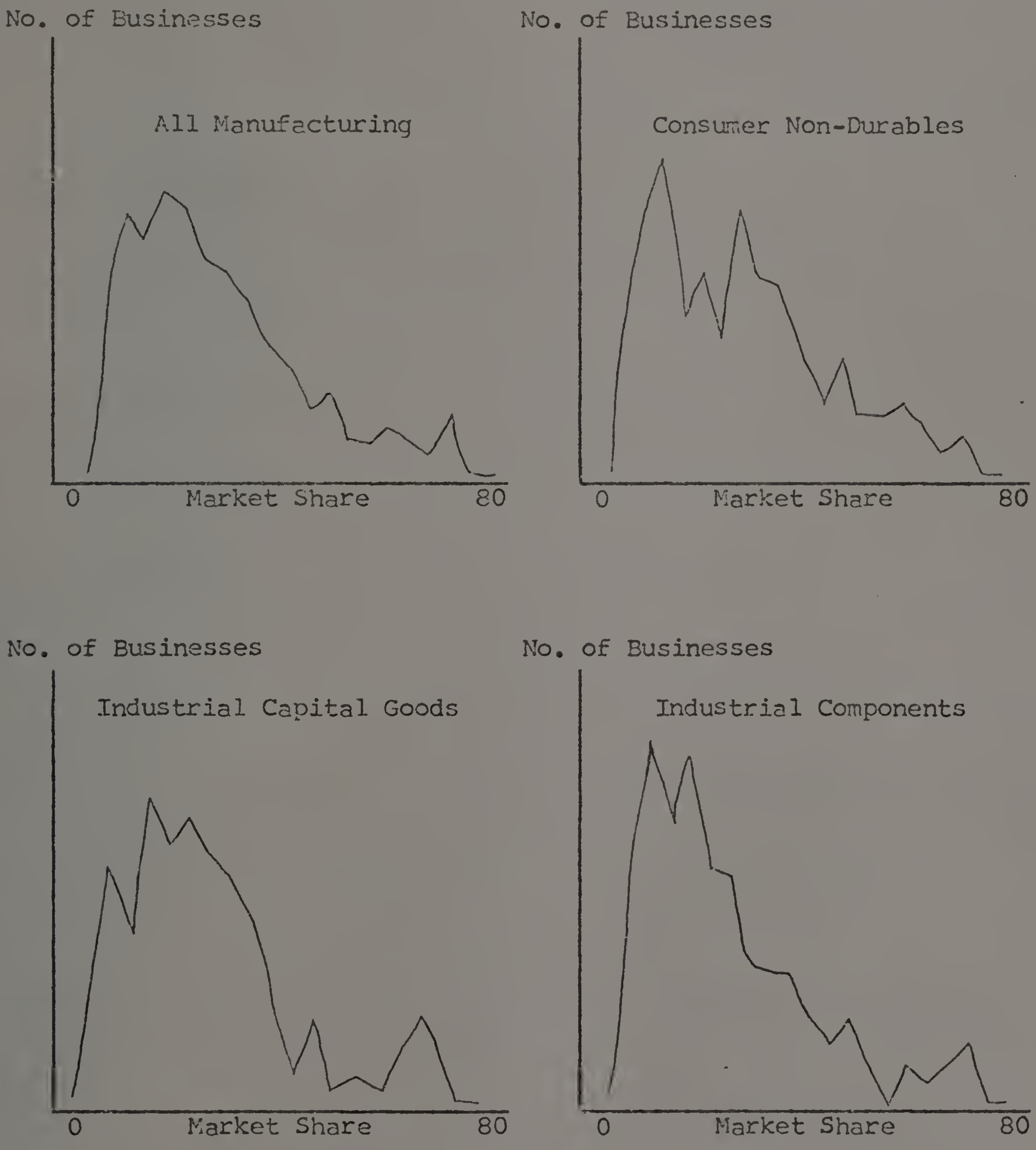
Capacity utilization decreases as sales force expense/revenue increases, while capacity utilization increases and then decreases as advertising expense/revenue increases. High capacity utilization is associated with low advertising and sales expense/revenue, and low capacity utilization is associated with high advertising and sales expense/revenue. It is tempting to use these two variables as an interaction variable, but Figure 5 shows that these variables have very different effects on different types of businesses. For example, low sales force expense is associated with 94.8 per cent capacity utilization in consumer durables and 79.8 per cent capacity utilization in consumer non-durables; but low advertising expense is associated with 79.1 per cent capacity utilization for durables and 85.6 per cent capacity utilization for non-durables.

High capacity utilization is associated with medium advertising expense and medium research and development expense, while low capacity utilization is associated with high advertising expense and high product research and development expense/revenue ratios.

Capacity utilization does not increase as much with real market growth and technological change as with no technological change. Capacity utilization is higher without technological change except when growth is low. Capacity utilization is also higher without entry of competitors under any growth or exit conditions as shown in Figure 6. Utilization is highest with neither entry nor exit.

Figure 7: market share. Market share is a very elusive variable at this point in the research. A favorite industrial organization variable used to represent market power, it is not significant in any regressions in Tables 9 and 10 except in its own group of variables. Since this lack of significance may be due to misspecification, one more investigation was made for market share and is shown in Figure 7. Figure 7 contains selected frequency distributions for all manufacturing and for the three types of business having the most observations in the 1971-1974 data bank. The modal market share for all manufacturing is about 19 per cent. This is about the same as the mode for industrial capital goods and a second mode for industrial components. The main mode for industrial components is market share of about nine per cent. This is about the same as the mode for consumer non-durables, which has a

FIGURE 7.--Frequency distributions of market share for all PIMS manufacturing businesses and for selected types, 1973-1974



Source: Computed from the PIMS 1971-1974 data bank.

secondary mode of about 30 per cent market share.

Similar distributions were plotted for advertising expense/ revenue, entry, and capital intensity. These did not show much difference among the different types of business.

Summary. Analysis of Figures 5, 6, and 7 sometimes points out differences in different types of business, and sometimes does not. Most of the variables in Figure 5 explain about one tenth of the variance in capacity utilization when paired with the type of business variable. Except when real market growth is paired with technological change or entry, in Figure 6 the variable pairs explain less than one tenth of the variance in capacity utilization. Frequency distributions in Figure 7 for market share show similar shapes but slightly different modes.

Nonlinearities

Specification error occurs when a relevant explanatory variable is omitted from the regression equation. If the omitted variable is correlated with other variables, their coefficients will be biased and inconsistent unless the correlation disappears as the sample size increases. If two variables are highly correlated, their coefficients may not be significant, but their joint effect will be significant in an F test (Kmenta, 1971). Omitting a squared form of a variable when it should be in a regression equation results in specification error. Also, the joint effect of two correlated variables may be captured in an interaction term that would include the product of the two variables. Squared and product terms are nonlinear forms. Both alter the slope of the regression line.

Cross tables similar to those in Figures 5 and 6 were studied to see if a nonlinear form for certain variables would influence capacity utilization more than a linear form. Particular attention was paid to variables that were expected to be significant and were not significant. Variables for which cross tables indicated a possible nonlinear form which did not conflict with theory or common sense are in Table 11.

Interactions. The left-hand variable of each interaction term in Table 11 is a dummy variable which has a value of unity for the situation stated in Table 11 and a value of zero otherwise. This dummy is multiplied (*) by the variable on the right hand side of the *. The first interaction variable is interpreted as follows. The combined effect of a large purchase amount (over $55,000) and frequency of purchase is that capacity utilization is higher the more frequently large purchases are made.

Squared terms. The effect of certain variables on capacity utilization was greatest for middle values of these variables, with smaller effects for the high and low values of the variables. This effect can be represented by including a squared term in addition to a linear term for a variable. This was done for market share, number of end users, number of immediate customers, media advertising expense/revenue, and product research and development expense/revenue. The sign of the coefficient of the squared term would be the opposite

TABLE 11.--Nonlinear terms suggested by cross tables for PIMS manufacturing businesses, 1973-1974

Interaction Terms

1. Purch. amt. over $55,000 * purch. frequency of immed. customers
2. Market share over 28.4% * number of end users
3. Sales force exp./revenue less than 5.74% * number of end users
4. Decrease in end user concentration * number of end users
5. Over 5% end user purchs. from bsns pdts. * number of end users
6. Number of end users less than 65 * per cent chg in market share
7. Larger customers than competitors * number of immed. customers
8. Purch. amt. over $49,999 * purch. frequency of end users
9. Media adver. exp./revenue less than .46% * value added/revenue
10. Entry of competitors * real market growth
11. Technological change * real market growth
12. Over 23.5% end users buy 50% bsns pdts. * importance to end user
13. Market share between 14.2% and 28.4% * per cent change in share
14. Market share between 14.2% and 28.4% * profitability

Squared Terms

1. Market share
2. Number of end users
3. Number of immediate customers
4. Media advertising expense/revenue
5. Product research and development expense/revenue

Source: Computed from the PIMS 1971-1974 data bank.

Note: The left-hand variable mentioned for each interaction variable is a dummy variable with the value of unity.

of the sign of the linear term because of the nonlinearity. All of this is discussed in greater detail in Chapter VII. Chapter VI contains only preliminary, exploratory work.

Preliminary results. Results of a regression using nonlinear terms and 1973-1974 data are reported in Table 9. Ranks of coefficients of nonlinear terms are omitted from Table 9 due to lack of space. All of the variables listed in Table 11 were included, but only four had significant coefficients. These have relatively low ranks. The interaction of concentration of end user purchases greater than 23.5 per cent * importance to user had a positive effect on capacity utilization, but was only 20th in rank and significant at the one-tail ten per cent level. There was a negative association of capacity utilization and: decrease in number of end users * number of end users (-10**), purchase amount over $55,000 * purchase frequency (-11**), and sales force expense/revenue less than 5.74 per cent * number of end users (-14).

The effect of the significant interaction variables was to change the rank order of coefficients in regression results, to eliminate some formerly significant variables, and to make significant some formerly non-significant variables. This can be seen by comparing the 1973-1974 all-group column of Table 9, which has no interaction terms, with the 1973-1974 column of results with nonlinear variables. Because there are relatively many results from regressions without nonlinear terms in Tables 9 and 10, and only one regression using nonlinear terms, in Table 9, further discussion of interaction variables is continued in Chapter VII following more research with these variables. Chapter VI contains only preliminary results.

Summary

Analysis of means and frequency distributions of capacity utilization rates, of regressions by groups of variables and by types of business, and of cross tables and nonlinearities, has resulted more in experience gained from working with PIMS data than in any definite conclusions. There is some evidence that experience with capacity utilization varies with the type of business. Evidence concerning the contribution of nonlinear terms is very tentative.

The main importance of Chapter VI research is that it makes possible the revisions in method and the further research described in Chapter VII.

CHAPTER VII

FURTHER RESULTS: CAPACITY UTILIZATION EQUATION

In this chapter, changes made as a result of preliminary studies in Chapter VI are described, and the results of further studies of the capacity utilization equation are presented and analysed.

Changes Made as Result of Preliminary Studies

After studying results of regressions in Tables 9 and 10 for regressions by groups of variables on all manufacturing, and regressions by type of business on all variables for the 1971-1974 data bank, several changes were made. These included changes in: time period, variables, grouping of variables, and significance tests. Further studies were made of market share, advertising expense/revenue, and interaction variables.

Time period. Because 1973-1974 represents a relatively depressed time period, the relatively more prosperous time period, 1972-1973, was used to see if results would be consistent in both time periods. This 1972-1973 time period is in a different data bank which has more and different businesses. Although the two data banks overlap in time for 1973, and in some particular businesses, they represent a slightly different period and composition of businesses. Therefore, results from regressions done on both data banks would have more external validity than results obtained from using only one data bank. Generalizations cannot be made to non-PIMS businesses without studies beyond PIMS data. Table 6 of Chapter VI shows the number of businesses for each type of business in the two data banks. The 1970-1973 data bank, which includes the 1972-1973 period, has more businesses of every type except consumer non-durables, and has 110 more manufacturing businesses than the 1971-1974 data bank.

Figure 2 in Chapter IV shows manufacturing capacity utilization rates measured by four different sources: Wharton, the Bureau of Economic Analysis (BEA), Federal Reserve, and McGraw-Hill. 1970 and 1974 were considered to be periods of recession as defined by the National Bureau of Economic Research (Ragan, 1976). Comparing Figure 2 with the dates of the PIMS data banks, the 1970-1973 data bank begins in a period of recession and ends in a prosperous period immediately preceding another recession. The 1972-1973 period of this data bank includes the approach to peak capacity utilization rates and the beginning of a downturn. The 1971-1974 data bank begins as the economy is leaving the recession of 1970, and ends in the recession of 1974. The 1973-1974 period of this data bank starts at peak capacity utilization rates and then capacity utilization drops sharply in 1974. Both of the shorter periods, which have been used in regression analysis for this paper, contain the peak, 1973, capacity utilization rates and some relatively lower capacity utilization rates. The difference is that the peak occurs at the end of the 1972-1973 period and at the beginning of the 1973-1974 period. The peak, in Figure 2, is about 98 per cent capacity utilization as measured by Wharton, or between 85 and 90 per cent as measured by the other sources. The low point at the beginning of 1972 or the end of 1974 is about 80 per cent as measured by the BEA, Federal Reserve, and McGraw-Hill and either 88 per cent or 78 per cent as measured by Wharton and shown in Figure 2. Table 6 in Chapter VI shows that the mean capacity utilization rates for PIMS manufacturing businesses were 81.9 per cent in 1972-1973 and 82.8 per cent in 1973-1974. These are consistent with the national figures excluding Wharton, but on the low side.

Variables. Some variables have been dropped from the regression equation for capacity utilization, some have been added, and variables have been regrouped. The consumer dummy variable has been dropped because regressions will be done by type of business, and this variable was not significant in any regression which included all variable groups. The corporate debt/equity variable was dropped because it was not in the 1970-1973 data bank and was not significant in regressions on all variables. The importance-to-customers variable was moved into the group of customer variables, and the product R&D expense/revenue joined the other expense/revenue variables in the market position group. Change in share was substituted for per cent change in share because the former is a more appropriate indicator of capacity utilization.

Share and advertising. Regressions were done for market share and advertising media expense/revenue to find whether the correct form was linear or nonlinear. There was some indication, in cross tables similar to those in Figures 5 and 6, of an inverted-V shape for the effect of each of these variables on capacity utilization. This shape is shown in Figure 8 below.

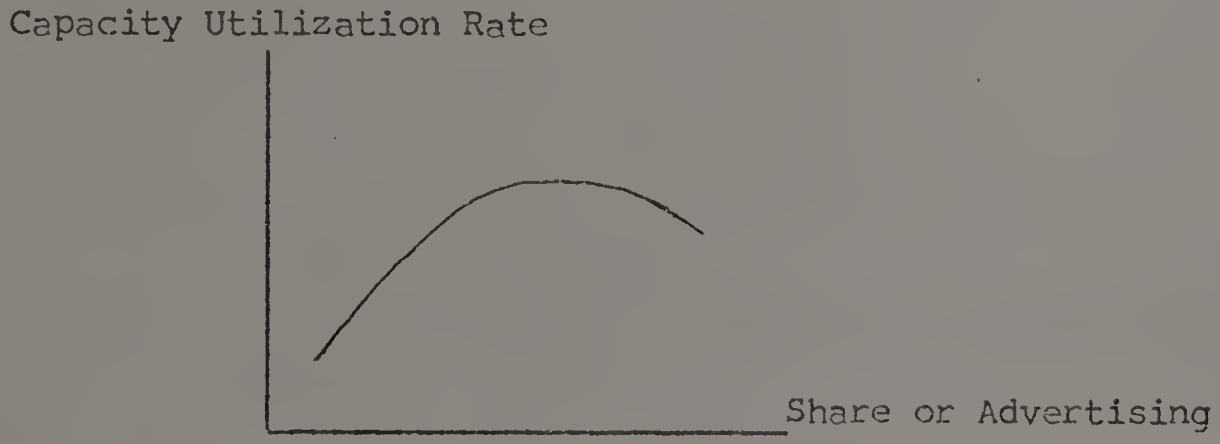


FIGURE 8.--Inverted-V relation of explanatory variables on capacity utilization

The equation for Figure 8 is:

$$(6) \quad Y = a + \beta_1 X + \beta_2 X^2 + e$$

where X refers to the independent variable and Y refers to the dependent variable (Kmenta, 1971, p. 452, Figure 11-5). The R^2 of this equation was compared with the R^2 of the following equation.

$$(7) \quad Y = a + \beta X + e$$

Significance of the variables in equation (6) and equation (7) was compared, both for the total of manufacturing businesses and by type.

Neither linear nor nonlinear form of the share variable had a coefficient significantly different from zero for consumer non-durables or industrial capital goods. The nonlinear form was significant for consumer durables, industrial supplies, and raw or semi-finished materials, and the linear form was not. Both linear and nonlinear forms were significant for industrial components and all manufacturing, but the nonlinear form was more significant and contributed more to R^2, the explanation of the variance of the dependent variable.

There was very little difference in significance and R^2 between the two forms of the advertising media expense/revenue variable. For simplicity, the linear form was used except for industrial supplies where the nonlinear form had a better fit, evidenced by the higher R^2.

In addition, market share and advertising expense/revenue were used, separately, as dependent variables, in regressions with each other plus the variables in the customer characteristics group as independent variables. About one-third of the variation in share was explained by these variables for all manufacturing and five types of business, and about one-half for consumer durables. Most explanatory variables were significant for some type of business. None to three variables were significant for a particular type. Significant variables included: number of end users, importance of the product of the business to the immediate customers, purchase amount of immediate customers, whether the business had less or more customers than competitors, and whether these customers were larger than those of competitors.

About one-tenth of the variation in media advertising expense/revenue was explained by the above-mentioned variables for all manufacturing and five types of business, and about one-third for consumer non-durables. None to two variables were significant for a particular type. Significant variables were the same as those for share and, in addition, whether customers were smaller than those of competitors.

Of importance here is the overlap of variables in explaining capacity utilization. For example, if share explains capacity utilization, and if number of end users explains share, can both variables be used to explain capacity utilization? This is discussed later in the chapter as information regarding capacity utilization regressions is presented.

Significance. Significance tests for all regressions done for Chapter VII are stricter than those done for the regressions in Chapter VI. One reason for less-strict tests in Chapter VI is that it was not known if very many variables would be significant, and an exploratory study should have some results to discuss. Preliminary studies in Chapter VI revealed that there were several highly significant (at the one per cent level) variables which contributed to the explanation of capacity utilization in the regressions.

In Chapter VI, a one-tail significance test was used. This tested the hypothesis: H_o: $\beta = 0$ against either H_a: $\beta < 0$ or H_a: $\beta > 0$, assuming that the sign of β is known. Because the sign of β is not always predictable a priori in the capacity utilization equation, a two-tail significance test will be used in future regressions. This tests the hypothesis: H_o: $\beta = 0$ against the hypothesis: H_a: $\beta \neq 0$. In terms of results in Tables 9 and 10, this means that variables significant at the PIMS .95 P-level are interpreted to be significant at the five per cent level in a one-tail test and at the ten per cent level in a two-tail test. Variables significant at the PIMS .90 P-level are interpreted to be significant at the ten per cent level for a one-tail test and not significant for a two-tail test. Variables with a .975 and a .995 P-level are significant at the five per cent and one per cent levels respectively for a two-tail test. Variables with a P-level of .99 are significant at the one per cent level for a one-tail test.

Interaction variables. Because results were not very significant for 1973-1974, and because the computing and testing of interaction variables was very time-consuming, fewer interaction variables were tested for the 1972-1973 data. Only the variables numbered 1, 4, 7, 11, and 14 in Table 11 of Chapter VI were tested. The method of testing was also changed. Instead of including interaction variables with all other significant variables in a regression equation, each interaction variable was tested separately and the results compared with those obtained from using the components of the interaction variable in a regression. For example, interaction variable XZ was computed from variables X and Z as explained in Chapter VI. Then, for the total of all businesses and for consumer non-durables, the following regressions were run.

(8) $Y = a + \beta X + \beta Z + e$

(9) $Y = a + \beta XZ + e$

The R^2 for equation (8) was always larger and the coefficients were more significant than the results for the interaction equation (9). Therefore, work on interaction variables ceased, and will be left to others.

Regression by groups of variables and by type of business. Finally, instead of regressions which used groups of variables for all manufacturing as in Table 9 of Chapter VI, or regressions which used all variables for each type of business as in Table 10 of Chapter VI, regressions will be done on groups of variables for each type of business. These are discussed in the next section.

Capacity Utilization Equation

In this section, regressions are done on separate groups of variables for each type of business. Then, all variables found to be significant for a type of business will be included in a regression for that type of business. Third, because ranking standardized regression coefficients may not be reliable if independent variables are correlated, the contribution to R^2 of the variables will be ranked. Finally, the variables found to be significant in the 1971-1974 data bank will be used in regressions with the 1970-1973 data, and the two time periods will be compared.

Regressions by groups of variables. Table 12 shows signs, ranks and significance of standardized regression coefficients for variables explaining capacity utilization for groups of variables for all manufacturing in the time periods 1970-1973 and 1972-1973,

TABLE 12.--Signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS manufacturing by groups of variables and type of business, 1972-1973

PIMS No.	Ex-pect-ed Sign	Variable Name	All Mfg. Types		Type of Business					
					Consumer		Industrial			
			1970-1973 N=625	1972-1973 N=625	Dur-ables N=46	Non-Dur. N=115	Cap-ital N=130	Raw, Semi N=82	Com-pmnts N=160	Sup-plies N=92
		Market Position	R^2=.13	R^2=.14	R^2=.21	R^2=.06	R^2=.22	R^2=.25	R^2=.16	R^2=.13
268	+	Market Share	2**	2**	2*			1*		1*
	-	Mkt. Shr. Sqrd.	-4**	-5*	-1*			-4		-2*
269	+	Chg. in Share		4**	3*		1**	-5	3	
159	±	Med.Adv.Exp/Rev					4*a			-3*a
149	-	Sls.Frc.Exp/Rev	-1**	-1**		-1*	-2**	-3*	-1**	
134	-	Prd.R&D Exp/Rev	-3**	-3**			-3**	-2*	-2*	
		Pdn., Pdtivity	R^2=.18	R^2=.18	R^2=.14	R^2=.12	R^2=.18	R^2=.33	R^2=.18	R^2=.12
245	-	Pdtivity (VA/ee)						-4		
246	-	%Chg.in Pdtivity						2*		
221	+	%Chg.in Investmt	2**	2**		2**	2**		2	2*
346	+	CapitalIntensity	1**	1**	1**	1**	1**	1**	1**	1**
110	-	Chg. in VA/Rev.	3					-3*		
		Finance	R^2=.04	R^2=.04	R^2=.00	R^2=.07	R^2=.03	R^2=.06	R^2=.06	R^2=.07
174	+	Retrn on Invstmt	1**	1**		1**	1*		1**	1**
198	+	Working Cap/Rev				2		-1*		
		ExternalEnvirnmt	R^2=.02	R^2=.04	R^2=.09	R^2=.19	R^2=.04	R^2=.03	R^2=.17	R^2=.10
366	+	Real Markt Grwth	2*	1**	-1*	1**			1**	
70	-	Entry of Compets		-3*					-2**	-1*
71	-	Exit of Compets				-3*				
11	-	Technolog. Chg	-1*	-2*		2*	-1*	-1	-3*	-2
		InternalEnvirnmt	R^2=.00	R^2=.01	R^2=.04	R^2=.10	R^2=.02	R^2=.02	R^2=.01	R^2=.03
49#	+	Share Mktg.Pgms.				1**				
45	+	Sls to Compnts.				2				
		CustomerCharact.	R^2=.10	R^2=.10	R^2=.13	R^2=.22	R^2=.15	R^2=.06	R^2=.15	R^2=.13
18#	-	No. End Users				-1**				3
21#	-	End Usr.Conc.Dec							-3*	
21#	-	End Usr.Conc.Inc	-6*	-5*		-6				-2*
31#	+	Import.Imm.Cust.	1**	1**		2**	1**		1**	
29#	+	Pur.Amt.ImmCust.	2**	2**		5*	2**	1*		
75#	-	Less Cust. Than	-3**	-4*		-4*	3*			-1*
75#	-	More Cust. Than				-3*				
76#	+	Larger Customers	4*	3**					2**	
76#	-	SmallerCustomers			-1*		-4			
26#	-	Purch.Freq.End		-6*						
23	-	Conc.Pur.Imm.Cus	-5*							

Source: Computed from PIMS 1970-1973 data bank.

Note: Two-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level. R^2 is for regressions which include significant variables only. # means recoded as described in Appendix A.

[a] Linear form for capital; nonlinear form for supplies.

and for the six separate types of business for 1972-1973. There are 625 businesses in this data bank: 46 consumer durables businesses, 115 consumer non-durables, 130 industrial capital, 82 raw or semi-finished materials, 160 industrial components businesses, and 92 industrial supplies businesses. The groups of variables include: market position, production and productivity variables, finance, external environment, internal environment, and customer characteristics. Definitions of these variables are in Appendix A.

Except for media advertising expense/revenue, all variables in the market position group are significant at the ten per cent, five per cent or one per cent level of significance for the total group of manufacturing businesses, but advertising expense/revenue (linear or nonlinear form) is significant only for raw or semi-finished materials businesses and industrial supplies, as shown in Table 12. Sales force expense/revenue is first in rank for consumer non-durables, industrial components, and all manufacturing; second, for industrial capital businesses; and third, for raw or semi-finished materials. The nonlinear combination of market share and share squared ranked first and second for consumer non-durables and industrial supplies, and was also significant for all manufacturing. Change in share ranked first for industrial capital businesses. Product research and development expense ranked second for industrial components and raw or semi-finished materials, and third for industrial capital businesses and all manufacturing.

In the production and productivity group, capital intensity ranked first for all regressions. Per cent change in investment, the dependent variable in the new investment equation of Chapter VIII, ranked second except in consumer durables, and in raw or semi-finished materials where per cent change in value added/employee ranked second. The sign of this last variable is consistently different from the expected sign. The computed sign is interpreted to mean that increases in productivity increase capacity utilization. The expected sign was predicted for the reason that with increased productivity there would be more output from the same capacity, other things being equal; therefore, utilization would be lower.

The above groups of variables contain variables that are somewhat under the control of the business manager. In the groups of variables below, control is more in the environment than in the hands of the business manager. However, this may help to explain why attempts by the business manager to increase capacity utilization may not achieve as high a capacity utilization rate as expected.

Return on investment, the dependent variable of the PIMS LIM equation, ranked first in the finance group of variables except for consumer durables, where no variable was significant, and for raw or semi-finished materials where working capital/revenue ranked first. Working capital/revenue is less significant than return on investment and is significant for only two types of business. It has a plus sign for consumer non-durables which would indicate more capacity utilization associated with more working capital/revenue, and a minus sign for raw or semi-finished materials which would indicate a negative relationship. This is one of the few sign exceptions; the sign of a coefficient is usually consistent for all types of business.

First-ranking variables differ for different types of business in the external environment group. Real market growth ranks first for consumer businesses and for industrial components. Technological change ranks first for industrial capital and raw or semi-finished components, and entry of competitors ranks first for industrial supplies. Signs are as expected except for technological change for consumer non-durables. Technological change is associated with high capacity utilization for consumer non-durables, but with low capacity utilization for the other types of business where it is significant.

In the internal environment, shared marketing programs and sales to components were significant only for consumer non-durables. Shared distribution programs and purchases from components were not significant in any regressions, and were excluded from Table 12.

Significance and ranks of customer characteristics variables vary for the different types of business. Importance of the products of a business to immediate customers, which is estimated by the proportion of the total annual purchases by the customer provided by this business, ranks first for industrial capital and components and all manufacturing and second for consumer non-durables. Number of end users ranks first for consumer non-durables and third for industrial supplies. The typical purchase amount of immediate customers ranks first for raw or semi-finished materials and is significant for consumer non-durables, industrial capital, and all manufacturing. Having less customers than competitors ranks first for industrial supplies; and having smaller customers than competitors ranks first for consumer durables businesses as shown in Table 12.

Regressions on all significant variables by type of business. All significant variables noted in Table 12 for a given type of business were used in a regression for that type of business. Results are reported in Table 13. From three to seven variables remain significant for a type of business in these regressions. Many variables that were significant in Table 12 are no longer significant in Table 13. The reason for this may become clear when comparing the R^2 in Table 12. The sum of the R^2 for any business type in Table 12 exceeds the R^2 for that type in Table 13. This indicates some double counting in explaining the variance of the dependent variable. That is, the effects of some of the independent variables overlap. This could be due to specification error; more variables are used than are needed to represent an abstract concept. This seems especially true in the market power sections: the seller power represented in the market position group of variables, and the buyer power represented in the customer characteristics group. In Table 12, the variable group explaining the largest amount of variance in capacity utilization varies with the type of

TABLE 13.--Signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS manufacturing total and by type of business, 1972-1973 period

PIMS No.	Expected Sign	Variable Name	All Mfg. Types 1970-1973 N=625	All Mfg. Types 1972-1973 N=625	Type of Business: Consumer Durables N=46	Consumer Non-Dur. N=115	Industrial Capital N=130	Industrial Raw, Semi N=82	Industrial Compnts N=160	Industrial Supplies N=92
		Market Position	R^2=.30	R^2=.30	R^2=.38	R^2=.36	R^2=.38	R^2=.44	R^2=.36	R^2=.30
268	+	Market Share						4**		1*
	-	Mkt. Shr. Sqrd.	-9					-5**		-4
269	+	Chg. in Share		7*	2**		5**	-3**		
159	±	Med.Adv.Exp/Rev					6*			-3* sq.
149	-	Sls.Frc.Exp/Rev	-3**	-3**		-5*			-3**	
134	-	Prd.R&D Exp/Rev	-5**	-5**			-2**			
		Pdn., Pdtivity								
245	-	Pdtivity (VA/ee)								
246	-	%Chg.in Pdtivity						2**		
221	+	%Chg.in Investmt	2**	4**			3**			7
346	+	CapitalIntensity	1**	1**	1**	2**	1**	1**	1**	2*
110	-	Chg. in VA/Rev.	-7*							
		Finance								
174	+	Retrn on Invstmt	4**	2**		3*	8		6	
198	+	Working Cap/Rev						-6*		
		ExternalEnvirnmt								
366	+	Real Markt Grwth		6*	-3**	1**			2**	
70	-	Entry of Compets		-8*					-4*	-5*
71	-	Exit of Compets				-6*				
11	-	Technolog. Chg				4*				
		InternalEnvirnmt								
49#	+	Share Mktg.Pgms.								
45	+	Sls to Compnts.								
		CustomerCharact.								
18#	+	No. End Users								6*
21#	-	End Usr.Conc.Dec							-7	
21#	-	End Usr.Conc.Inc	-9	-10						
31#	+	Import.Imm.Cust.		12			7*			
29#	+	Pur.Amt.ImmCust.	8*	11						
75#	-	Less Cust. Than	-6**	-9						
76#	+	Larger Customers	10	10					5	
76#	+	SmallerCustomers					-4**			

Source: Computed from PIMS 1970-1973 data bank.

Note: Two-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level. R^2 is for regressions which include significant variables. # means recoded as described in Appendix A.

business. The production-productivity group explains the most variance for industrial raw or semi-finished materials and components; the external environment explains most for consumer nondurables; the market position group, for consumer durables and industrial capital; and both market and customer groups, for industrial supplies.

In theory, explanatory variables in regression analysis are independent of each other. That is, they are not correlated with each other. The correlation matrix for all manufacturing businesses indicates generally low pair correlations for the variables in this study. Correlations are larger for separate types of business; however, even these correlations are rarely above .5. A correlation matrix helps to indicate multicolinearity. The degree of multicolinearity increases as the sample size decreases. When multicolinearity is high, the effects of highly correlated explanatory variables on the dependent variable cannot be separated. The correlation matrix does not indicate high multicolinearity, nor does it indicate the absence of multicolinearity.

The highest correlations in this matrix are not related to the regressions, but are the correlations used to check on the nonlinear versions of the share and advertising variables. Usually the variables enter the regression program in raw form and are standardized by the regression program. Share and advertising are standardized first, in order to square the standardized form. Therefore, there is a raw form of the share and advertising variables and a standardized form in the correlation matrix. These raw and standardized forms should have the same correlations, and they do.

Indication of interactions among independent variables can be seen by comparing regression results. Some variables change from significant to not significant when other variables are dropped from the regression equation. Indications are also shown in Table 14, discussed below.

Contribution of explanatory variables to explained variance. Aigner (1971) claims that standardized regression coefficients cannot be ranked if correlation exists between independent variables. Since the purpose of this study was to determine relative importance of explanatory variables and since the proposed method was by ranking, this issue must be explored further. A comparison of Table 13 with Table 14 is helpful in exploring this issue. Table 13 shows signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS total manufacturing and by type of business in the 1972-1973 period. Table 14 indicates the contribution to R^2, the multiple correlation coefficient, for variables indicated as significant in Table 13. An exception is that only the top eight variables for all manufacturing regressions were included in the study of contribution to R^2. If contribution to R^2 changed with a changed order of entry of variables into the computations, then a range of contribution is indicated in Table 14.

Table 14 shows that rank order could be determined for consumer businesses and for industrial raw or semi-finished materials, but not for the other industrial businesses. For example, if variable X

TABLE 14.--Rank of contribution to R^2, the multiple correlation coefficient, for variables explaining capacity utilization in Table 13. Also, heteroskedasticity check for selected variables, 1972-1973 data

			All Mfg. Types		Type of Business					
					Consumer		Industrial			
PIMS No.	Expected Sign	Variable Name	1970-1973 N=625	1972-1973 N=625	Durables N=46	Non-Dur. N=115	Capital N=130	Raw, Semi N=82	Compnnts N=160	Supplies N=92
		Market Position								
268	+	Market Share						5		$\underline{1-4}$
	-	Mkt. Shr. Sqrd.						6		5-7
269	+	Chg. in Share			$\underline{2}$		2-5	3		
159	±	Med.Adv.Exp/Rev					6-8			$\underline{1-4}$
149	-	Sls.Frc.Exp/Rev	2	$\underline{2}$		4			1-3	(sq.)
134	-	Prd.R&D Exp/Rev	3-6	$\underline{3}$			$\underline{2-5}$			
		Pdn., Pdtivity								
245	-	Pdtivity (VA/ee)								
246	-	%Chg.in Pdtivity						2		
221	+	%Chg.in Investmt	7				$\underline{2-5}$			5-7
346	+	CapitalIntensity	1	$\underline{1}$	$\underline{1}$	$\underline{3}$	$\underline{1}$	1	1-3	$\underline{1-4}$
110	-	Chg. in VA/Rev.	8					7		
		Finance								
174	+	Retrn on Invstmt	3-6			$\underline{5}$	6-8		4-5	
198	+	Working Cap/Rev						4		
		ExternalEnvirnmt								
366	+	Real Markt Grwth		5	$\underline{3}$	$\underline{1}$			1-3	
70	-	Entry of Compets							6	1-4
71	-	Exit of Compets				6				
11	-	Technolog. Chg				2				
		CustomerCharact.								
18#	+	No. End Users								5-7
21#	+	End Usr.Conc.Dec							7	
22#	-	End Usr.Conc.Inc		6						
31#	+	Import.Imm.Cust.					2-5			
29#	+	Pur.Amt.ImmCust.	3-6	4						
75#	-	Less Cust. Than	3-6	6						
76#	+	Larger Customers		6					4-5	
76#	+	SmallerCustomers					6-8			

Source: Computed from PIMS 1970-1973 data bank.

Note: When contribution to R^2 varies with order of entry into regression, a range of ranks is given. Only the top eight variables from Table 13 were ranked for total manufacturing. For underlined ranks, a heteroskedasticity plot of the residual against that variable was done. No heteroskedasticity was indicated.

contributes much to R^2 when entered first into the regression equation, but contributes less when entered after variable Z, then some of the variance in the dependent variable that was formerly explained by X is later explained by Z. Therefore, the range for X and Z would be indicated as 1-2 in Table 14.

In Table 13, for industrial components, the first three variables in rank are capital intensity, real market growth, and sales force expense/revenue. These are all in the 1-3 range in contribution to R^2 in Table 14. For consumer durables, ranks are the same in Tables 13 and 14. For consumer non-durables, ranks in Tables 13 and 14 are the same for capital intensity, but not for the other variables except exit of competitors.

It is not known to what extent others have explored this difference in variable ranks shown in Tables 13 and 14. Esposito and Esposito (1974) mentioned Aigner (1971) but ranked independent variables by size of standardized regression coefficients, noting that this ranking should be viewed with caution. In the sources for this paper, only the regression equations are presented and discussed and conclusions drawn. Since studying the real world entails noise in the form of defining and measuring variables, and using them as "independent" when they are not, it makes sense to select a few of the most significant and highest ranking variables to discuss as determinants of capacity utilization and to use a range of ranks rather than to compare ranks within a range. This is not to say that those variables discussed are the only determinants of capacity utilization, but they are the ones for which our evidence is strongest.

Comparison of 1971-1974 with 1970-1973. Regressions for the 1971-1974 period were discussed in Chapter VI. They contained a somewhat different set and order of variables, and the regression analysis proceeded differently. That is, in Table 9, regressions on separate groups of variables were done only for all manufacturing, and not for separate types of business. In Table 10, regressions were done on the entire group of explanatory variables, not just the ones found significant in regressions by group of variables. In addition, a one-tail significance test was used in Chapter VI and a stricter, two-tail test was used in Chapter VII.

There are two ways to compare the two time periods. One way is to use the variables listed as significant for each type of business in Table 10 with the 1972-1973 data. Table 10 is based on 1973-1974 data from a different data bank. This was done, and results are shown in Table 15. Another way is to compare results for all manufacturing in the two-year and four-year time periods; that is, to compare Table 9 of Chapter VI with Tables 12 and 13 of Chapter VII.

Comparison of Tables 10 and 15. Table 15 shows that when the variables found to be significant in 1973-1974 period regressions are used in regressions for the 1972-1973 period of a different data bank, the rank order of these coefficients is slightly different, and fewer variables remain significant at the higher standards

TABLE 15.--Signs, ranks, and significance of standardized regression coefficients for variables explaining capacity utilization for PIMS manufacturing by groups of variables and type of business, 1972-1973

PIMS No.	Ex-pect-ed Sign	Variable Name	All Mfg. Bus. Types N=625	Type of Business					
				Consumer		Industrial			
				Dur-ables N=46	Non-Dur. N=115	Cap-ital N=130	Raw, Semi N=82	Com-pmnts N=160	Sup-plies N=92
		Market Position	R^2=.32	R^2=.11	R^2=.32	R^2=.19	R^2=.44	R^2=.37	R^2=.26
268	+	Market Share							
	-	Mkt. Shr. Scrd.							
269	+	Chg. in Share							
159	±	Med.Adv.Exp/Rev				3•			
149	-	Sls.Frc.Exp/Rev	-5••			-2••		-3••	
134	-	Prd.R&D Exp/Rev	-6••				-4	-5•	
		Pdn., Pdtivity							
245	-	Pdtivity (VA/ee)	-7••				-3••		
246	-	%Chg. in Pdtivity							
221	+	%Chg. in Investmt	4••						
346	+	Capital Intensity	1••		2••	1••	1••	1••	1•
110	-	Chg. in VA/Rev.							
		Finance							
174	+	Retrn on Invstmt	2••				2••		
198	+	Working Cap/Rev	9						
		External Envirnmt							
366	+	Real Market Growth	9•		1••		5	2••	
70	-	Entry of Compets	-8•					-4•	
71	-	Exit of Compets							
11	-	Technolog. Chg							-3•
		Internal Envirnmt							
47#	+	Share Pdn. Facils.	10•						
49#	+	Share Mktg. Pgms.			3•				
45	+	Sls to Compnts.							
		Customer Charact.							
18#	-	No. End Users			-4				
21#	-	End Usr.Conc.Dec.		1•					
21#	-	End Usr.Conc.Inc.	-12						
31	+	Import.Imm. Cust.	3•						
29#	+	Pur.Amt.Imm.Cust.	11•						
75#	-	Less Cust. Than	-7•						
75#	-	More Cust. Than							
76#	+	Larger Customers	9•					6•	
76#	-	Smaller Customers				-4			
26#	-	Purch. Freq. End							-2•

Source: Computed from PIMS 1970-1973 data bank.

Note: Two-tail significance: •• = 1% level; • = 5% level; rank without •'s = 10% level. R^2 is for regressions which include significant variables only. # means recoded as described in Appendix A.

for significance used in this chapter. The rank of the capital intensity variable is slightly higher overall in Table 15. This variable is significant for more types of business than is any other variable. Other consistently significant variables include: sales force expense/revenue, product research and development expense/revenue, and real market growth. Signs of the coefficients do not change as the data bank changes.

The R^2 in Table 15 refers to the fit of each regression equation when it contains all of the variables listed in Table 10 as significant for a type of business, even though these variables are not all significant in the regressions done for Table 15. The R^2 in Tables 15 and 14, which contain results for the 1970-1973 data bank, are lower than the R^2 in Table 10. This discrepancy is easier to explain for Table 14, because the significance test is weaker for Table 10. The R^2 for Table 10 includes the effects of variables which are significant at the one-tail, 10 per cent level, while the R^2 for Table 14 does not. The difference in R^2 between Tables 10 and 15 may be partly attributed to a difference in method of computing regressions. For Table 10, all variables entered the initial regressions, but for Table 15, only the variables significant in Table 10 entered the regressions. There may also be a difference in businesses and timing between the 1970-1973 and the 1971-1974 data banks that would explain these different results.

<u>Comparison of Table 9 with Tables 12 and 13</u>. Comparison of these tables is made only for all manufacturing because Table 9

regressions were not done for separate types of business. The differences are not as marked for these tables as they were for Tables 10, 14 and 15. This may be due to the averaging out of differences in type of business when the all-manufacturing group is used, and to the similarity of method. For the results in this section: first, regressions were done for groups of variables, and then regressions were done for all variables found significant in the group regressions. The first and second ranked variables in the market position, production and productivity, and finance groups of variables are the same in both time periods: sales force expense/revenue, market share, capital intensity, per cent change in investment, and return on investment. This is true for both the two-year and the four-year averages. The rank order of coefficients has changed somewhat in the external environment section. Technological change replaces real market growth in first place in the 1970-1973 period, and entry of competitors is no longer significant. Entry is significant only at the ten per cent level, one-tail, in 1971-1974, so this is not really a change. Importance of the product of a business to its customers, which is in the market position section of Table 9, and in the customer characteristics section of Table 12, is first in rank in its section in Table 12. Number of end users and having more customers than competitors, which were highly significant in Table 9, are not significant in Table 12, but increase in concentration of end users, and purchase frequency of end users have become significant in Table 12.

Comparing regressions on all variables for all manufacturing in Tables 9 and 13, most of the variables significant in the two-year and four-year time periods in 1971-1974 are also significant in the 1970-1973 data bank, although the rank order is different. Capital intensity ranks first consistently. Sales force expense/revenue, per cent change in investment, and return on investment have higher ranks in the 1970-1973 data, and the customer characteristics variables have lower ranks. The rank of the product research and development expense/revenue variable is relatively unchanged. The R^2 of .36 and .33 in Table 9 is not much different from the R^2 of .30 and .30 in Table 13. Therefore, some generalizations can be made from the two data banks, but these generalizations can state only that the top five or six variables in rank were significant in both data banks and had the expected signs. Nothing specific can be said about ranks of individual variables.

Share and advertising. The overlap of these variables with the variables of the customer characteristics group in explaining capacity utilization was suggested in an earlier section of this chapter. Evidence in Table 12 suggests that this overlap is not as extensive as anticipated because some of the overlapping variables are not significant in their separate group regressions and thus do not enter the regressions which include all groups of variables. The remaining overlapping variables are the following. Number of end users overlaps with advertising in the consumer non-durables businesses and with share and advertising for industrial supplies. Importance to the immediate customer overlaps with share and advertising for all manufacturing and with share for industrial capital businesses. Share and advertising overlap with typical purchase amount for all manufacturing and industrial capital. Having less customers than competitors overlaps with share and advertising for all manufacturing, with advertising for consumer non-durables, and with share for industrial capital. Having more customers than competitors overlaps with share and advertising for consumer non-durables. Having larger customers than competitors overlaps with share for all manufacturing and industrial components, and having smaller customers overlaps with advertising for industrial capital businesses.

Very few of the overlapping customer characteristics variables are significant in Table 13. Except for industrial capital businesses, these overlapping variables are low in rank and significant only at the ten per cent level.

Top Six Variables by Type of Business

In this section, results shown in Table 10 for the 1971-1974 data bank and results shown in Table 13 for the 1970-1973 data bank are compared by type of business. As explained previously, the variables, grouping of variables, mix of businesses, time period, computing procedure, and significance testing are somewhat different for the two tables.

Consumer durables. There were only 25 consumer durables businesses in the 1971-1974 data bank, and only three variables were found to be significant. These were: sales force expense/revenue, per cent change in productivity, and decrease in end user concentration. The lower the sales force expense/revenue, and the higher the per cent change in productivity and the greater the decrease in end user concentration, the greater was the capacity utilization.

The 1970-73 data bank had almost twice as many consumer durables businesses, 46; and three variables met the stricter significance test. These were: capital intensity, change in market share, and real market growth. The higher the capital intensity, the greater the per cent change in share, and the lower the real market growth, the higher was the capacity utilization.

Three variables explained 40 per cent of the variance in capacity utilization in 1973-1974, and 38 per cent in 1972-73, but these were not the same three variables. Results from the latter data bank, which has almost twice as many observations as the former, may be more convincing, or the time period may make the difference. Other studies are needed for more evidence.

Consumer non-durables. For 130 consumer non-durables businesses in 1973-1974, and 115 in 1972-1973, real market growth had the highest standardized regression coefficient, and capital intensity had the next highest one. Nine significant variables explained 49 per cent of the variance in capacity utilization in the former period and six significant variables explained 36 per cent in the latter.

Number of end users, corporate debt/equity, shared marketing programs, and media advertising expense/revenue were next in rank in 1973-1974. The higher the: real market growth of the served market, capital intensity, corporate debt/equity, sharing of marketing programs, and media advertising expense/revenue; and the smaller the number of end users, the higher was the capacity utilization rate.

Return on investment, technological change, sales force expense/revenue, and exit of competitors were the third through sixth variables in rank in 1972-1973. The higher the return on investment, the more technological change, the lower the sales force expense/revenue and if there were no exits of competitors, the higher was the capacity utilization for consumer non-durables.

In the two data banks there was a difference of 15 businesses for consumer non-durables, but there may be a different mix of businesses. Only two variables were significant for the two groups: real market growth and capital intensity. The high rank of real market growth was peculiar to consumer non-durables, but capital intensity ranked first for four types of business, and second for the other two types.

Industrial capital goods. Nine variables were significant in explaining 39 per cent of capacity utilization variance for 103 industrial capital goods businesses in 1973-1974, and eight significant variables explained 38 per cent in 1972-1973 for 130 businesses. Three variables were common to both time periods, but had different ranks. These were: media advertising expense/revenue, which ranked first in 1973-1974 and sixth in 1972-1973; capital intensity, which ranked second in 1973-1974 and first in 1972-1973; and having smaller customers than competitors, which ranked third in 1973-1974 and fourth in 1972-1973.

In 1973-1974, the higher the: media advertising expense/revenue, capital intensity, debt/equity ratio, sales to components, and if there were more but not smaller customers than competitors, the higher the capacity utilization was. In 1972-1973, the higher the: capital intensity, per cent change in investment, change in market share, and media advertising expense/revenue; and the lower the product research and development expense/revenue and smaller customers than competitors, the higher the capacity utilization was.

Raw or semi-finished materials. Nine variables were significant in explaining 68 per cent of capacity utilization variance for 59 raw or semi-finished materials businesses in 1973-1974, and six significant variables explained 44 per cent in 1972-1973 for 82 businesses. This type of business has almost the smallest number of observations, but the highest R^2. The two variables significant in both data banks were capital intensity, which was second in 1973-1974 and first in 1972-1973; and per cent change in productivity, which was not among the top six in 1973-1974 but ranked second in 1972-1973.

In 1973-1974, the higher the: return on investment, capital intensity, and real market growth; and the lower the: product research and development expense/revenue, productivity, and entry of competitors, the higher the capacity utilization was. In 1972-1973, the higher the: capital intensity, per cent change in productivity, and market share; and the lower the: change in market share, squared market share, and working capital/revenue, the higher the capacity utilization was. The 1972-1973 market share variables confirm the indication of the cross tables for 1973-1974 that there was lower capacity utilization for high and low market shares than for some middle share. This may be that in the middle, there is flexibility to move share up or down, but at the extremes, flexibility may be only on one side.

Industrial components. Eight variables were significant in explaining 50 per cent of capacity utilization variance for 124 industrial components businesses in 1973-1974, and seven significant variables explained 38 per cent in 1972-1973 for 160 businesses. Four variables were common to both time periods, but, as usual, had different ranks. These were: sales force expense/revenue, which ranked first in 1973-1974 and first in 1972-1973; entry of competitors, which ranked third in 1973-1974 and fourth in 1972-1973; and having larger customers than competitors, which ranked sixth in 1973-1974 and fifth in 1972-1973.

In 1973-1974, the higher the real market growth and capital intensity, the lower the: sales force expense/revenue and product research and development/revenue; and if there were larger customers than competitors, but no entry of competitors into the market, the higher the capacity utilization was. In 1972-1973, the higher the: capital intensity, real market growth, and return on investment; the lower the sales force expense/revenue, and if there were larger customers than competitors, but no entry of competitors into the market, the higher the capacity utilization was.

Industrial supplies. Seven variables were significant in explaining 43 per cent of variance in capacity utilization for 74 industrial supplies businesses in 1973-1974, and seven also were significant in explaining 30 per cent in 1972-1973 for 92 businesses. Only one variable, capital intensity, was common to both time periods. This was the only type of business for which nonlinear forms of both share and advertising were significant.

In 1973-1974, the lower the capital intensity, the higher the sales to components, the more frequent the purchases, and if there were: increase in concentration of end user purchases, less customers than competitors, and technological change, the lower the capacity utilization was. In 1972-1973, the higher the: market share, capital intensity, and number of end users; and the lower the squared advertising expense/revenue and squared market share, the higher the capacity utilization was. Entry of competitors was associated with lower capacity utilization. As for industrial raw or semi-finished materials, there was a tendency for increased capacity utilization to be associated with middle values of market share in 1972-1973 as suggested by the cross tables for 1973-1974.

Summary. There was little overlap in the top six significant variables for any type of business in the two time periods. Several reasons for this were given above. Results from the 1972-1973 data may be more reliable, since they are from a larger data bank in a more stable time period, and come from variables which have survived separate group regressions.

Summary and Conclusion

Summary. As a result of the preliminary studies in Chapter VI, several changes were made in data and method. To get a bigger sample and more of the upswing of the business cycle, the time period was changed from 1973-1974 to 1972-1973. The former was a period of decreasing capacity utilization, although there was an increase at the beginning of the period. The latter was a period of increasing capacity utilization although there was a decrease at the end of the period. This change increased the number of reporting manufacturing businesses from 515 to 625, an increase of 110. Many businesses were in both banks; however, distribution by type of business changed slightly. Distribution is shown in Table 6 of Chapter VI. Some variables used in preliminary studies were dropped, and others not previously used were added. Nonlinear forms were tested further and abandoned except for market share and, for industrial supplies businesses, advertising.

Stricter significance tests had little effect on the results since most variables used were generally highly significant. Assigning some variables to different groups did not change the significance of these variables.

Forty-eight regressions were done, making capacity utilization the dependent variable for each regression. Explanatory variables were used in separate regressions for each group of variables: market position, production and productivity, finance, external environment, internal environment, and customer characteristics. For each group, separate regressions were run for the six types of business: consumer durables, consumer non-durables, industrial capital, raw or semi-finished materials, industrial components, and supplies. Regression for all manufacturing businesses combined was also done. Results were reported in Table 12.

Eight further regressions were done. Capacity utilization was the dependent variable in each of these regressions reported in Table 13. All explanatory variables that were significant in the Table 12 regressions were used in these further regressions for business types separately and combined.

Because explanatory variables assumed to be independent were not necessarily independent in the imperfect world of data, interdependence of explanatory variables was studied. Standardized regression coefficients were rank ordered for independent variables, and a similar rank order indicated contribution of variables to an explanation of the variance in the dependent variable.

Comparison of Table 13, which ranks the standardized regression coefficients by size beginning with a high rank of one, with Table 14, which ranks contribution to explained variance, shows that the explanatory variables are not entirely independent for all types of business. However, these tables and the correlation matrix of these variables indicate that there is not a high degree of correlation among explanatory variables. This indicates that the degree of multicolinearity is not high, and the separate effects of explanatory variables on the dependent variable can be implied from the regression results. To be conservative, one might say, for example, that the effect of the two highest-ranking variables is greater than the next three variables in the rank order, but that the effect of the explanatory variable with the highest rank is not necessarily greater than that of the variable with second highest rank.

A further indication of interaction among explanatory variables is that the R^2 for the separate groups of variables in Table 12, when added, totals to a higher R^2 than that shown in Table 13 for a regression done on the combined groups of variables. One explanation for this is that all variables significant in the former regressions are not significant in the latter regressions, but this is also an indication of the interdependence of the explanatory variables.

Heteroskedasticity, which results in inefficient estimates of the regression parameters by the regression coefficients, does not seem to be a problem in this study, as indicated in heteroskedasticity tests noted in Table 14. Use of ratio data in the PIMS data bank probably has reduced the problem of heteroskedasticity in this study.

Reservations. The consideration of results of preliminary regression studies using 1973-1974 data in Chapter VI and further studies using 1972-1973 data in Chapter VII must take into account the above explanation of data, method of computation, and difference between theory and real-world data. Comparison of results in

Chapters VI and VII indicates little overlap in the top six variables which explain capacity utilization for a type of business. This may be due to different time periods, businesses, and/or methods of analysis. Grouping by type of business may hide the possibility that a particular capital-intensive industrial components business is more like industrial supplies businesses than like other industrial components businesses.

Only the few variables which consistently have high significance and high ranks regardless of data bank or method will be considered to rise above the noise in the data such that some generalization can be made. Results for other variables may have meaning for particular business managers in specific business situations.

Comparison with other research results. The two other studies which use capacity utilization as a dependent variable are the Lim (1976) study of 350 manufacturing establishments which represent 28 four-digit SIC-type industry groups in West Malaysia, and the Esposito and Esposito (1974) study of 29 three-digit and five four-digit SIC United States manufacturing industries.

By stepwise regressions, Lim found eight significant variables at the one per cent level (tail not specified) which explained 33 per cent of the variance in capacity utilization in his second equation. The most important variables were number of employees and relative factor intensity which had a positive effect on capacity utilization, and number of employees squared, which had a negative effect. Lim's first equation dealt with the technical definition of capacity as 24 hours a day and seven days a week, a criterion not used in this research.

Ranking standardized regression coefficients, the Espositos found four significant variables at the five per cent two-tail significance level or higher which explained 31 per cent of the variance in capacity utilization in their second equation. Capacity utilization was lower for industries with medium concentration than for those with high or low concentration. Capacity utilization was higher for capital intensive industries and industries with market growth than for industries that were less capital intensive or had less growth. Producer goods industries had lower capacity utilization than consumer goods industries. The Espositos' first equation included a dummy variable for high concentration that was not significant and was omitted from the second equation.

Even though Lim, the Espositos, and this study use different variables, data, and countries, some results are similar. R^2 for regressions for all sources is about .3 when manufacturing is not disaggregated by type of business. Capital intensity and size are high ranking and significant. From a cost view, it seems important to utilize capital equipment as fully as possible in a capital intensive business. Size is indicated in different ways in the three studies, but it always has a nonlinear effect on capacity utilization with diminishing utilization for the largest sizes. Lim uses number of employees and number of employees squared to indicate size; the Espositos use medium and high concentration dummy variables; and the present research uses market share and squared market share. While these variables are not strictly comparable, it is reasonable to expect that many employees, high concentration, and large market share all imply large size. The three studies indicate diseconomies of scale for capacity utilization; that is, the highest capacity utilization is associated with medium size.

That the size variable is more important and significant in the other studies than in this study may be explained by the use of customer characteristics and other variables from PIMS data banks that more effectively represent size in this study. Even in this study, share is significant for raw or semi-finished materials businesses and industrial supplies, and share squared is significant for all manufacturing in 1970-1973.

Given the different variables and data of these three studies, it is reasonable to expect that common results are based on true parameters. That is, some signals are heard above the noise in the data. These indicate that only about one-third of the variance in capacity utilization can be explained at present and that capital intensity and some indication of size or market position are important factors in explaining it.

Analysis of results. The results are now winnowed from the view of a business manager. The manager can control some variables such as product research and development, media advertising amounts, and sales force size. However, the manager has less control over the expense for these items and revenues due to unanticipated price changes, discontinuities in adding and subtracting people, supplies, and account agencies, and miscellaneous random shocks in the environment. Through accounting, finance, marketing and production decisions, the manager can attempt to control market share, productivity, new investment, capital intensity, return on investment, entry and exit of competitors, technological change, and the number, size and purchase amounts of customers, but these all are affected by the environment also. The type of product line chosen may dictate capital intensity. For example, products made automatically by machines need relatively more machines than products which require much hand work.

Widely accepted methods of doing business for certain products may require a certain level of advertising, sales force effort, and research to maintain market share. The manager must know the objectives of the business, and plan strategies that are consistent with such objectives and with the resources of the business. Results of this research will have different messages for different managers having different goals, resources, and preferences. A manager should ask which type of business a particular business is essentially like, and not classify it into a particular type of business merely because it produces the products of that type of business.

A further analysis of these results is in Chapter IX.

CHAPTER VIII

THE INVESTMENT EQUATION

Hypothesis 3 in Chapter V suggests some determinants of new investment. Empirical studies of the determinants of new investment, generally defined as an increase in capital stock, usually emphasize sales or output, profitability, or changes in these variables. The existing stock of capital and capacity utilization also may be included. In these studies, regression analysis has been used on either aggregate United States data, industry data, or data for large manufacturing or non-financial firms (Eisner, 1960, 1967a, 1967b, 1972, 1974b; deLeeuw, 1962; Kuh, 1963; Jorgenson, 1963, 1971; Meyer and Glauber, 1964; Evans, 1967; Evans and Klein, 1967; Hirsch et al., 1973; Winston, 1974; Birch and Siebert, 1976). Now, more-disaggregated data on the business level from the private data base of the Profit Impact of Market Strategy (PIMS) Project (Smith, 1976) can be used to add more evidence to the study of new investment.

Private investment is made by businesses. Government monetary and fiscal policies sometimes adjust the interest rate or taxes to stimulate or discourage private investment. Do business managers change investment plans as the interest rate and taxes change, or do other factors have a greater influence on the amount and timing of new private investment?

In this study, regression analysis is used to investigate the quantitative relationship between new investment, the variables mentioned above and other relevant variables. Data include 625 manufacturing businesses in the 1970-1973 time period and 515 manufacturing businesses in the 1971-1974 time period. Most of the businesses in the later time period are included in the earlier time period. A business, which is generally part of a larger parent company, sells to an identifiable market, i.e., customers in the same geographic area, customers desiring products with a given technology like color television, or customers preferring high product quality to low price (The PIMS Data Manual, 1976). To preserve anonymity, dollar amounts are disguised by a scale factor known only to each business, and ratios, growth rates, or categories are used as variables.

Theory

Several conflicting economic theories of investment have been tested with conflicting results. These include: 1) the modified or capacity-accelerator theory that new investment is related to capacity utilization and changes in output, 2) the liquidity preference theory that new investment is related to internal funds and profitability, and 3) the theory that investment is a function of the real interest rate. These theories have been tested either in time-series or cross-section analysis or both. Time-series analysis captures a more short-run relationship while cross-section analysis tends to reveal a more long-run relationship. Accordingly, results differ with the type of analysis chosen (see Jorgenson and

Siebert, 1968; Jorgenson, 1971; Eisner, 1974b).

A business-level theory of new investment can be stated as follows. New manufacturing investment occurs: 1) to meet increasing demand for real output (Eisner, 1960, 1967), while capacity utilization is higher than would permit meeting this demand through increased utilization, and/or 2) to increase output to benefit from the general growth in demand evidenced by real market growth. That is, capacity utilization and growth of demand for the business and served market would have a positive effect on new investment.

However, market power, represented by market share, may have a negative, and possibly nonlinear, effect on new investment. A business with a large share may wish to increase sales beyond the amount needed to maintain existing share in this market for fear of attracting antitrust attention. If demand does not increase, there is no need to increase output to maintain share. A business with a smaller share may desire to increase share by increasing output whether or not demand increases, or by acquiring capacity ahead of market demand. A business with a very large share may need to invest to maintain share. Adding new products to the line may be positively related to new investment, but this may not show up because the PIMS served market is narrowly defined.

While new investment may be desirable from the marketing point of view above, another condition for new investment comes from the survival-of-business point of view, that the business or parent company be able to pay for this new investment. It is expected that a profitable business with a high return on investment or one with increasing return on investment can afford new investment more than an unprofitable one (Birch and Siebert, 1976). A mature business with declining profits may not need new investment. Alternatively, when existing facilities are too expensive to operate, new investment may be needed to lower operating costs and to increase profitability. Therefore, the sign of the profitability coefficient could be positive or negative. However, in this study it is difficult to confirm either sign because the data consist of two-year and four-year annual averages. Investment-related expense incurred in a profitable year increases costs and reduces profits for that year so that initial profitability leading to new investment within a calendar year will not show up in the data.

The same problem occurs for productivity changes. Whether productivity changes before or after new investment cannot be determined with PIMS data. The expected effect of productivity is negative because high productivity may make new investment unnecessary, other things being equal.

Material cost growth and selling price growth can induce investment; the former, by inspiring redesign of the product; and the latter, by increasing or maintaining profitability. Wage rate growth might have a positive effect on new investment if high labor costs result in a decision for a more capital intensive production process, or a negative effect on new investment by raising costs and reducing profits to a point at which the business cannot afford new investment.

Several of the time-series studies mentioned above use the Moody's AAA bond rate to represent the cost of capital needed to finance new investment. This AAA bond rate does not vary in cross section data, nor does it take account of the fact that there are many interest rates depending on the type, timing, and riskiness of financing and that interest is only one of several costs to consider when investing. PIMS does not include such cost data for businesses because fund-raising is done by the parent company.

Capital intensity, represented by a high ratio of investment to revenue or of the reproduction value of capital to capacity, should be negatively related to new investment because, except for replacement, all necessary capital would be already available. Newness, represented by a ratio of net book value of plant and equipment (net = gross - depreciation) to gross book value, has an uncertain effect on new investment because it could indicate either the beginning of a new investment phase (+) or that desired investment has been achieved (-). Value added/revenue is an indication of the extent to which a business makes inputs instead of buying them. A business which makes relatively more inputs than it buys can expand either by making more inputs, which may require additional investment, or by buying additional inputs, which would not. Sharing production facilities with other businesses in the parent company may provide flexibility and reduce the need for new investment to meet expanded output requirements.

Plant and equipment are not created instantaneously; it takes time from the realization that new investment is desired to the completion of new facilities and their use. Since new investment is a more long-run than short-run phenomenon, cross-section analysis is used, following Eisner.

Variables

Dependent variable. In the PIMS data bank, the term "investment" refers to a stock of existing capital which includes working capital as well as plant and equipment. Net working capital includes cash, short term assets, accounts receivable, and inventories less current liabilities. While investment in plant and equipment may be of interest from a government point of view, working capital should be included in investment from the business point of view because the working capital is needed to run the plant and equipment (VanHorne, 1974, p. 403, Table 16-1). A percentage change in this "investment" is referred to as % CHG INVESTMENTS, based on net investment figures. An increase in either net or gross investment would imply that there has been an addition to the stock; however, a decrease in gross investment stock would imply a sale, while a decrease only in net investment stock can be due entirely to depreciation. Appendix A explains per cent change computations.

Independent variables. The independent variables are those discussed in the theory section above and listed with expected signs in Table 16. Their definitions are in Appendix A.

TABLE 16.--Signs, ranks, and significance of standardized regression coefficients and ranks of contribution to the explained variance of new investment for variables in the new investment equation for manufacturing businesses

PIMS No.	Expected Sign	Variable Name	Coefficients[a] 1970-1973 R^2=.58	Coefficients[a] 1971-1974 R^2=.61	Contribution[a] 1970-1973	Contribution[a] 1971-1974
366	+	Real Market Growth				
367	+	Real Sales Growth	1**	1**	1	1
237	+	Capacity Util., Lagged	5**	6**	7	8
267	-	Market Share, Lagged		-8*		2-3
267		Market Share, Lagged, Sqrd.		10*		10
303	+	Per Cent New Prdts, Lagged				
305	+	Per Cent New Prdts, Change				
173	±	Profitability (ROI), Lagged	-6**		6	
175	-	Profitability (ROI), Change	-4**	-2**	9	4-7
337	+	Material Cost Growth		9*		4-7
338	±	Wage Rate Growth		-11		4-7
244	-	Pdtivity (VA/ee), Lagged	9		8	
340	+	Selling Price Growth	3**	3**	5	10
346	-	Cap. Intensity (Rep.GBV/Cap)		-5**		2-3
212	±	Newness Plant & Equip,Lagged	7**		2	
218	-	Investment/Revenue, Lagged	-2**	-4**	3	4-7
108	+	Make-Buy (VA/Rev.). Lagged	8*	7**	4	9
47#	-	Shared Production Facils.				

[a] Computed from the PIMS 1970-1973 data bank of 625 manufacturing businesses and from the PIMS 1971-1974 data bank of 515 manufacturing businesses. R^2 refers to regressions which include the significant variables only; R^2 from regressions including all variables is larger. Two-tail significance: ** = 1% level; * = 5% level; rank without *'s = 10% level.

Recoded as described in Appendix A.

Because the investment process is not simultaneous, new investment and the need for new investments do not necessarily occur in the same time period. The need occurs first unless a strategic decision has been made to increase market share. An attempt to represent this difference in time periods through lags has been made within the limitations of the PIMS data banks. Each data bank used in this study has a four-year time period. Means for the four-year period, and for the beginning and ending two-year periods are in these data banks, but one-year means are not. Lagged data are data for the earlier time period, which is 1970-1971 for the 1970-1973 data bank and 1971-1972 for the 1971-1974 data bank. Changes and growth rates are provided by the data banks for the four-year time period.

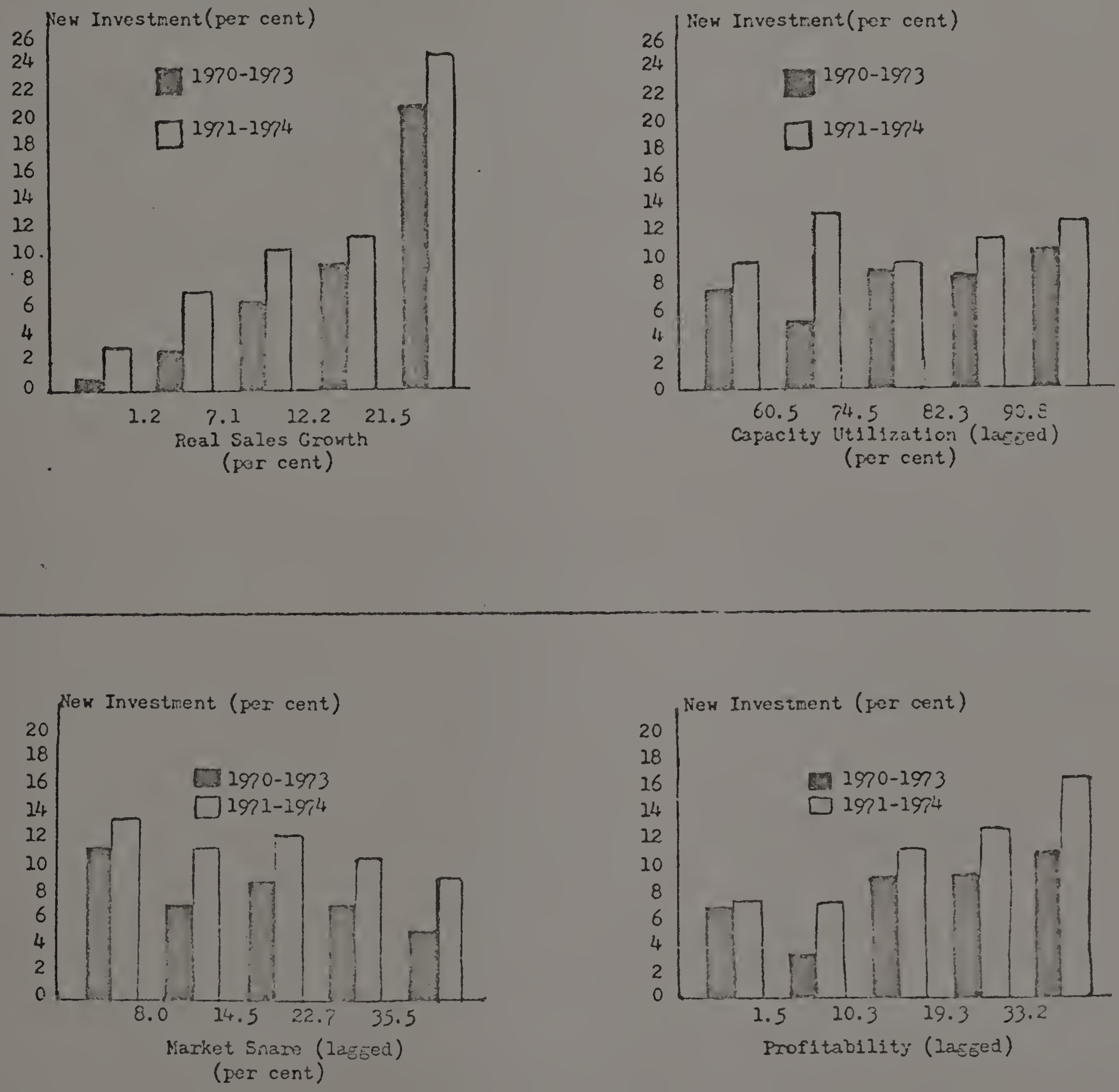
Empirical Results

Preliminary studies. Figure 9 contains cross tables of selected explanatory variables for new investment, equalizing the number of businesses in each cell. Cells contain means for new investment and the number of businesses for which each mean was computed. Two bar charts, which are related to the cross tables, show the effect of real sales growth and capacity utilization on mean new investment.

There is a marked increase in new investment at the highest category of real sales growth. When real sales growth is divided into five categories in Figure 9, this effect occurs in the highest

FIGURE 9.--Cross tables and bar charts of selected explanatory variables for mean new investment in PIMS manufacturing businesses, 1970-1973 and 1971-1974

		1970-1973				1971-1974		
		Capacity Utilization				Capacity Utilization		
		(68.1)	(83.8)			(69.8)	(85.2)	
Real Sales Growth	(4.8)	-0.99 (71)	1.45 (64)	2.43 (71)	(5.5)	4.10 (52)	4.71 (60)	5.04 (58)
	(14.1)	5.65 (58)	6.95 (84)	5.51 (68)	(14.5)	8.46 (56)	10.47 (61)	10.27 (57)
		15.47 (84)	16.55 (55)	18.95 (70)		18.70 (66)	18.34 (51)	21.90 (54)
		$R^2 = 0.25$				$R^2 = 0.21$		



Source: Computed from the PIMS 1970-1973 and 1971-1974 data banks.

Note: The cross tables contain investment means separated by two cut points into low, medium, and high value cells to equalize number of businesses (shown in parentheses) in each cell.

of the five, which includes businesses with new investment percentages greater than 21.6 in 1970-1973 and greater than 21.4 in 1971-1974. This effect also is consistent for all six types of business in cross tables with three sales growth categories not shown in Figure 9. The highest percentage of new investment occurs in the highest sales growth and capacity utilization categories in Figure 9. The lowest percentage of new investment occurs in the lowest sales growth and capacity utilization categories. These two variables explain about one-fourth to one-fifth of new investment depending on the time period.

In Figure 9, real sales growth of 21 per cent a year or more is related to 20 per cent or more new investment, while real sales growth of seven per cent to 21 per cent is associated with only about six to 12 per cent new investment. The range of six to 12 per cent new investment is associated with most capacity utilization rates. In 1970-1973, lagged capacity utilization of 74 per cent or more is associated with more investment than lower utilization, but in the 1971-1974 time period, the greatest per cent new investment is in the capacity utilization range of 61 to 73 per cent.

The effect of capacity utilization on new investment is smaller and less varied over cells than the effect of sales growth. The effect differs for different types of business and from time period to time period. For example, the middle cell has the lowest investment means for consumer durables and industrial components in 1970-1973 and for consumer non-durables, raw or semi-finished materials, and industrial supplies in 1971-1974. However, the middle cell has the highest investment means for consumer non-durables, industrial capital and raw or semi-finished materials in 1970-1973, and for consumer durables and industrial capital in 1971-1974. Cross tables showing effect by type of business are not included in Figure 9.

The bar chart for new investment and market share in Figure 9 shows that the per cent of new investment generally is smaller for larger market shares in both time periods. For example, new investment is highest, about 12 per cent, for market shares less than eight per cent; and it is lowest, about eight per cent, for shares greater than 35.5 per cent. The reverse relationship holds for new investment and profitability in both time periods in Figure 9.

Table 16 contains results computed in cross-section regressions for two time periods: 1970-1973 and 1971-1974. Expected and computed signs and the ranks of standardized regression coefficients are included. Because, strictly speaking, standardized regression coefficients cannot be ranked if correlation exists among independent variables (Aigner, 1971), the ranks of these variables according to their contribution to the multiple correlation coefficient, R^2, are also included in Table 16.

In Table 16, the variable with the largest standardized regression coefficient or the variable with the highest contribution to R^2 has the highest rank in its respective column. The variable with the next-largest coefficient or contribution has rank 2 and so on. Significance is indicated by ** or *. Because the signs of some coefficients are difficult to predict a priori, the significance test used is the two-tail test to determine whether H_o: $\rho = 0$ or H_a: $\rho \neq 0$ is true at the one per cent significance level (**), the five per cent significance level (*) or the ten per cent significance level ( ). Ranks are not given for variables significant at any less-significant levels. The significance test used here is different from the one-tail test of H_o: $\rho = 0$ against H_a: $\rho > 0$ or H_a: $\rho < 0$ in the AQD programs.

Whether the correlation between pairs of independent variables is sufficient to interfere with their ranking in this study is a question of judgment, since there is little discussion in the literature concerning this topic. Correlation matrices for the variables used in this study do not indicate a high degree of multicolinearity which would make it difficult to separate the effects of the highly correlated independent variables on the dependent variable. If variables X and Z are correlated, variable X would explain relatively more of the variance in the dependent variable if X entered the regression first; and Z would explain relatively more if Z entered the regression first. This causes the confusion in ranking standardized regression coefficients. Most of the pair correlation coefficients are below .5, which indicates relatively low correlation. The exception is the pair correlation coefficient for real sales growth and real market growth which is about .6. Only the former is significant in the regressions.

Heteroskedasticity, or non-constant variance (Kmenta, 1971, p. 249), is sometimes a problem in cross-section regressions. Heteroskedasticity tests were done by plotting the residual against the following independent variables in turn: real sales growth, profitability, and capacity utilization. No pattern of plotted points was found which would indicate heteroskedasticity. The reason may be that heteroskedasticity is less of a problem in regressions using ratio data (Kmenta, 1971).

The variable with the highest coefficient-size rank in Table 16 for both time periods was real sales growth. This also ranked first in contribution to R^2. This variable was chosen to represent the change-in-sales construct that Eisner found to be most important in his empirical studies. Real sales growth was positively related to new investment, as expected. Selling price growth was the only other variable on which the regressions in both time periods agreed in coefficient-size rank. Its coefficients ranked third and had the expected positive sign. Coefficients for profitability and change in profitability ranked sixth and fourth respectively in 1970-1973, but the coefficient for change in profitability ranked second in 1971-1974 and profitability was not significant. Similarly, the contribution to R^2 was higher for change in profitability in 1971-1974 than for the two profitability variables in 1970-1973. The capacity utilization coefficient was significantly different from zero at the one per cent significance level, two-tail, in both periods, but only fifth or sixth in coefficient-size rank and seventh or eighth in contribution to R^2.

Other highly ranked variables include: investment/revenue which ranked second in 1970-1973 and fourth in 1971-1974 and was either third, or fourth to seventh in contribution to R^2 in the two periods respectively; also, reproduction value of capital to capacity, called "capital intensity" here, which ranked fifth in 1971-1974 but was not significant in 1970-1973. These two variables had relatively high pair correlations of .46 in 1970-1973 and .51 in 1971-1974 which might indicate multicolinearity and difficulty of separating their influence on the dependent variable. Since both variables represent capital intensity, perhaps only one is needed. Only one of these variables was significant in 1970-1973, but experience with the 1971-1974 equation indicated that both should be included in that time period. Both had the expected sign.

The multiple correlation coefficients, R^2, were relatively high for cross-section regressions: .61 in 1971-1974, and .58 for 1970-1973. This indicated that the variables significant at the ten per cent level or at a higher level using a two-tail significance test explained between one-half and two-thirds of the variation in the dependent variable. Most of this variation was explained by real sales growth: .49 in 1970-1973, and .45 in 1971-1974. The next most important variables in contribution to R^2 were newness, which contributed .05, and investment/revenue, which contributed .01 in 1970-1973; and lagged market share, which contributed .02, .03, or .04, and capital intensity which contributed .06 or .03, depending on order, in 1971-1974.

Nine or ten variables were significant in each time period, but only six of these were significant in both time periods: real sales growth, capacity utilization, change in profitability, selling price growth, investment/revenue, and value added/revenue, as shown in Table 16.

Three interaction variables were tested separately and with other variables in both time periods. They were not as significant and did not contribute as much to R^2 as interaction variables as the variables did when they were used separately. The separate tests used equations like (8) and (9) in Chapter VII. Interaction variables were: 1) real market growth greater than 12 per cent and profitability, 2) market share less than 12 per cent and newness of plant and equipment, and 3) profitability greater than 23 per cent and market share.

Conclusion

The business-level results from this study of new investment tend to support the modified capacity-accelerator hypothesis of investment, that new investment is related to change in sales, and that capacity utilization is also a significant factor. There is some evidence that change in profitability also affects new investment in the PIMS manufacturing businesses for the two time periods studied. However, the largest part of new investment is explained by real sales growth. Up to ten variables have been found significant in explaining about six-tenths of new investment on the business level.

This study is of interest because it confirms the previous results of economic studies but on the business level. Since the PIMS data bank is not a random sample and since there may be some characteristics of the PIMS businesses which might make them unrepresentative, such as the fact that they participate in the PIMS Project, this study should be repeated with other business-level data if such can be found.

CHAPTER IX

SUMMARY AND CONCLUSIONS

Summary

Purpose. The purpose of this dissertation has been to investigate the determinants of capacity utilization and investments in manufacturing businesses by type of business using cross-section regressions and industrial-organization or business variables. If some variables influencing capacity utilization and investment can be determined in this disaggregated approach, this information may help business managers plan and manage capacity more effectively, thus improving profitability, i.e., return on investment. Increased knowledge about capacity utilization and investment may help business managers plan investment programs, and may help government plan more effective tax and interest-rate policies for encouraging or discouraging business investment.

Theory. Relevant theory has been reviewed in Chapter II. Excess capacity, or underutilized capacity is included in economic theory, and in propositions for industrial organization and financial management. In competitive economic theory, excess capacity results from imperfect competition or knowledge, and results in misallocation of resources. A strategic decision variable in financial management, the capacity utilization rate is partly under the control of managers and partly affected by environmental factors less controllable by managers. The cost to a firm of carrying excess capacity in anticipation of increases in demand for a product must be weighed against the benefits of increased market share and putative profits from having additional capacity to meet demand increases. Uncertainties in the supply of inputs and demand for output, and environmental factors may make flexibility, in the form of excess capacity, desirable. According to industrial organization propositions, this flexible excess capacity can be used as a barrier to free entry into a market.

Capacity utilization is an important determinant of investment in the capacity accelerator theory of investment. New investment is a change in capital, that is, a change in plant and equipment. One way that a government can change aggregate demand, according to theory, is to influence new private investment through policies affecting taxes, the interest rate, and deficits. If industrial capacity is underutilized, government policies designed to influence new investment in the manufacturing sector become difficult to apply successfully.

Research. Time-series and cross-section regression studies explaining investment and return on investment have found that capacity utilization is an important and significant explanatory variable (Meyer and Glauber, 1964; Eisner, 1972; Hirsch et al., 1973; Gale and Donaldson, 1975). However, few studies have attempted to explain capacity utilization (Esposito and Esposito, 1974; Lim, 1976). Existing research has been reviewed in Chapter III.

Definitions and data. The generally accepted definition of normal capacity (Klein and Long, 1973; Perry, 1973; Hertzberg *et al.*, 1974; and Winston, 1974) has been used in this study. Manufacturing capacity was defined as potential output produced by the normal number of hours, shifts and days worked per week with the usual allowances for vacations, downtime, and overtime. Plant and equipment used only in emergencies were not included in normal capacity. Underutilized capacity was called excess capacity. A capacity utilization rate, which is the ratio of actual output to normal capacity output, measured the extent of utilization of potential capacity.

Although capacity and capacity utilization have been discussed in theory and with respect to real-world conditions for at least fifty years, consensus has been reached for measuring these variables only recently. This consensus and resulting improvement in data have occurred so recently (1974) that not much research has been done to explain capacity utilization. Definitions and measures have been described in Chapter IV.

Approach. Theory has implied more about the effects of capacity utilization than about the determinants. Parsons and Schultz (1976) have suggested that, for marketing, when there is no well-developed theory to use as a guide, an econometric approach would include developing a theory in addition to making and testing models. Using their approach and grouping variables into industrial-organization or business-level categories, four hypotheses were stated in Chapter V. A business-level approach has been chosen as the most appropriate for studying the determinants of manufacturing capacity utilization and investment because this level more closely resembles the oligopolistic real-world businesses than do the approaches of economic theory. Macroeconomic theory has been helpful in investment studies.

A business produces a product for a narrowly-defined market. A parent company, made up of many businesses, can diversify such that the determinants of the capacity utilization rate for the company reflect an average over the businesses and obscure the true determinants of capacity utilization at the product-line level. The problem is similar for an industry, especially an industry at the two-digit SIC level which is a collection of establishments of many large, diversified firms making a variety of products.

Business-level data from the PIMS data base, described in Chapter IV, were used in this study (Chussil and Land, 1976). Operational definitions of the variables in Appendix A use the PIMS definitions.

The business-level categories are: market position, product characteristics, production and productivity, finance, external environment, internal environment, and customer characteristics. Industrial organization variables include: market position of business, competitors, and customers; product differentiation, vertical integration, barriers to entry, growth of market demand, and technological change.

Hypotheses. Four hypotheses were stated in Chapter V. Hypothesis 1 stated that regression coefficients of the variables introduced in Chapter V to explain capacity utilization were significantly different from zero at the ten per cent significance level or higher, and had the signs suggested in Chapter V. Hypothesis 2 stated that the rank order of the coefficients for these variables, and sometimes the signs, would be different for the six different types of business listed in Table 3 of Chapter V. Rank order was determined both by ranking standardized regression coefficients and by ranking the contribution of these variables to R^2, the explained variance of the dependent variable.

Hypothesis 3 explained investment in terms of variables used in the research cited in Chapter III. Hypothesis 4 was the hypothesis of the PIMS LIM equation which explained return on investment. Equations for hypotheses 1, 3, and 4 were planned for a three-equation model which would represent the jointly dependent relationship of the capacity utilization, investment, and return on investment variables.

Tests of hypotheses. Hypotheses 1, 2, and 3 were tested in this study. Results were presented in Chapters VI, VII, and VIII in Tables 9-16. Tables 9-13 and 15-16 contained the ranks, signs, and significance of the regression coefficients. Tables 14 and 16 contained the ranks of the contribution of the explanatory variables to explanation of the variance in the dependent variable. Results were computed in three stages: preliminary capacity utilization regressions in Chapter VI, further capacity utilization studies in Chapter VII, and investment regressions in Chapter VIII. Hypothesis 4 was not tested in this study nor was the three-equation model estimated.

Research Issues

At this point, it is relevant to review some of the research issues raised in Chapter V. These issues include: 1) whether to use aggregate or disaggregated data, 2) which time period to use, 3) whether to use one or more equations, 4) whether to use time-series or cross-section data, and 5) which nonlinear terms to use.

Level of aggregation. The level of aggregation for research should be appropriate for the research goal. Because the research goal of this research was to study business-level data and compare types of business, disaggregated data were used.

Many of the variables suggested in hypothesis 1 were significant in explaining capacity utilization, but, as suggested in hypothesis 2 of Chapter V, different variables were significant for different types of business. This conclusion was made possible by use of business-level data. Results from testing a modified version of hypothesis 3 with business-level variables were consistent with the results of research which used more-aggregated data.

Time period. Because the different time periods, 1970-1973 and 1971-1974, contained a different number of businesses and a different proportion of consumer businesses, some different variables, and a different segment of the business cycle, results were only approximately the same for both time periods. Therefore, generalizations must be made with caution except for the few variables, shown in Table 17, which showed consistent results under varying conditions. These variables, defined in Appendix A, will be included in the

TABLE 17.--Top five determinants of capacity utilization by rank order of standardized regression coefficient with sign of coefficient, listed by time period and by type of business for PIMS manufacturing businesses

1972-1973 Period	1973-1974 Period
Consumer Durables	
+ Capital Intensity	- Sales Force Expense/Revenue
+ Change in Market Share	+ Per Cent Change in Productivity
- Real Market Growth	+ Decrease in End User Concentra.
Consumer Non-Durables	
+ Real Market Growth	+ Real Market Growth
+ Capital Intensity	+ Capital Intensity
+ Return on Investment	- Number of End Users
+ Technological Change	+ Corporate Debt/Equity
- Sales Force Expense/Revenue	+ Share Marketing Programs
Industrial Capital Goods	
+ Capital Intensity	+ Media Adver. Expense/Revenue
- Product R&D Expense/Revenue	+ Capital Intensity
+ Per Cent Change in Investment	- Smaller Customers than Compets.
- Smaller Customers than Compets.	+ Corporate Debt/Equity
+ Change in Market Share	+ Sell Prdts to Cmpnts of Parnt Co.
Raw or Semi-Finished Materials	
+ Capital Intensity	+ Return on Investment
+ Per Cent Change in Pdtivity	+ Capital Intensity
- Change in Market Share	- Product R&D Expense/Revenue
+ Market Share	- Pdtivity (Value Added/Employee)
- Market Share Squared	- Entry of Competitors into Mkt
Industrial Components	
+ Capital Intensity	- Sales Force Expense/Revenue
+ Real Market Growth	- Product R&D Expense/Revenue
- Sales Force Expense/Revenue	- Entry of Competitors into Mkt
- Entry of Competitors into Mkt	+ Real Market Growth
+ Larger Customers than Compets.	+ Capital Intensity
Industrial Supplies	
+ Market Share	+ Capital Intensity
+ Capital Intensity	- Technological Change
- Media Adver. Exp./Rev.,Squared	- Sell Prdts to Cmpnts of Parnt Co.
- Market Share Squared	- Increase in End User Concentra.
- Entry of Competitors into Mkt	- Fewer Customers than Compets.

Source: Computed from PIMS 1970-1973 and 1971-1974 data banks using the AQD regression program for standardized regression coefficients. Coefficients of all variables listed above are significantly different from zero at the ten per cent two-tail significance level or higher. Most are significant at the one per cent two-tail level.

Note: Market share squared is omitted from the 1973-1974 study. Corporate debt/equity is not in the 1970-1973 data bank.

equations suggested for future research.

Number of equations. Only two of the three equations in the proposed three-equation simultaneous model were estimated in this research, and they were estimated separately. The third equation has been estimated by PIMS. These three equations: one for capacity utilization, one for new investment, and one for return on investment, belong in one model because the variables they explain are jointly dependent. This is evident because the dependent variables in some of the equations were significant explanatory variables in others.

Time-series versus cross-section analysis. Review of the research shows that the choice of time-series versus cross-section regression analysis often depends on the data available. If only cross-section data are available for the situation to be modeled and studied, either cross-section analysis must be made or time-series data must be collected. If the time-series data cannot be collected with existing resources, then either cross-section analysis must be made or the research must be postponed.

A related problem is that while capacity utilization represents a short-run situation, cross-section regressions are typically used to model long-run and changing situations. The decision to use the PIMS business-level data bank to secure disaggregated data is a decision to use cross-section regression analysis. While annual PIMS data were not available by type of business at the time this research was done, they are available now.

A timing problem arises for the three equations in the proposed simultaneous model. The problem is how to account for the short-run nature of capacity utilization decisions and the long-run nature of investment decisions and return on investment, when the only indications of time are the four-year averages, and the beginning and ending two-year averages in the PIMS data banks. If high capacity utilization indicates a need for more investment, there is a lag between the recognition of this need and the completion of a new investment project. Less time is needed if capacity is enlarged by adding overtime or another shift, buying existing plant and equipment, or buying more inputs than were previously bought. Capacity utilization rates for the beginning two years of a four-year data bank are used to represent this lag in the investment equation.

Annual data would be useful for pooled time-series cross-section regressions to represent the short-run nature of capacity utilization. Annual data would also be useful for specifying lags in the three-equation model. Data and time limitations, therefore, put the three-equation model and the pooled time-series cross-section model beyond the scope of the present research.

Aggregation bias. Another problem related to data availability is aggregation bias. As explained in Chapter V, aggregation bias arises when data are aggregated over time and over cross-section attributes. Pooling can reduce this bias (Bass and Wittink, 1975), but data for pooling were not available for this research. Disaggregation by type of business, as has been done, reduces aggregation bias. Further, forecasts aggregated from disaggregated data are more accurate than forecasts made directly from aggregated data (Dunn, Williams, and deChaine, 1976). A capacity utilization equation for all manufacturing businesses, aggregated from the results of regressions by type of business, is suggested below for use in the three-equation model.

Insights. Experience gained from working with much available data and little theory has confirmed the proposition that a theory, or at least the hypotheses, must be worked out first before data are consulted.

More theory and research on investment made the investment equation much easier to specify than the capacity utilization equations which did not have such theoretical and empirical support. However, research cannot reasonably be put aside because there is little guidance from previous work. This study may be a crude beginning, but it is a start. Even in this research, it was easier to do the capacity utilization equations of Chapter VII having already done the preliminary equations in Chapter VI.

Results

Determinants of capacity utilization. The top five determinants of capacity utilization for each type of business in 1972-1973 and 1973-1974 are shown in Table 17. As expected, these determinants differ for different periods and types of business, but several variables are listed repeatedly. These are, in order of frequency of listing: capital intensity, real market growth, market share, market share squared or change in share, sales force expense/revenue, entry of competitors, product research and development expense/revenue, return on investment, and per cent change in investment. Table 17 lists these variables in order of size of the regression coefficients. The variable with the largest coefficient is listed first for each type of business.

The coefficients of the variables listed in Table 17 are significantly different from zero as indicated by a two-tail significance test at the ten per cent level or higher. Most are significant at the one per cent, or highest, significance level. For a particular type of business, eight or less variables are significant determinants of the capacity utilization rate. Chapters VI and VII include results for all significant variables.

As might be expected, capital intensity is positively associated with capacity utilization. It is more important for a capital intensive plant to have high utilization because it is expensive to maintain a large amount of idle plant and equipment. In a sense, the utilization rate is built into the investment decision. This variable, capital intensity, is also significant in the research done by Lim and the Espositos. Real market growth is positively associated with capacity utilization for consumer businesses and industrial components. Businesses that can manufacture more products to meet growing market demand have greater capacity utilization as demand grows.

The sign of the coefficient for real market growth is positive except for consumer durables. Since there are relatively few consumer durables businesses in the PIMS data banks, the inverse relationship of capacity utilization and growth should not be accepted until further studies are made.

Some form of the market share variable has a significant effect on capacity utilization for all types of business except consumer non-durables. The most marked effect is for raw or semi-finished materials businesses which have the highest mean market share in 1972-1973 in Table 18. An interesting nonlinear effect in 1972-1973 data, especially for industrial supplies, is that capacity utilization rates are higher for medium market share than they are for high or low market share. This is also illustrated, for 1973-1974, in Figure 5 of Chapter VI by type of business. In Figure 5, nonlinearity is indicated except for industrial supplies businesses. Industrial supplies is one of the smaller groups of businesses. There were 92 supplies businesses in 1972-1973 and 74 in 1973-1974. This change in number could change the results from 1972-1973 to 1973-1974.

There is a negative relationship between sales force expense/revenue and capacity utilization which implies that the higher the sales force expense/revenue, the lower will be the capacity utilization. If sales force expense is constant in a time interval, less revenue occurring at a time of low capacity utilization would raise this ratio. However, these are cross-section regressions. This

TABLE 18.--Mean market shares, 1972-1973 and 1973-1974 periods, for PIMS manufacturing businesses by type of business

Type of Business	1972-1973		1973-1974	
	Market Share (per cent)	Uncertainty	Market Share (per cent)	Uncertainty
Consumer Durables	18.4	(1.4)	16.7	(2.4)
Consumer Non-Durables	22.5	(1.4)	26.0	(1.5)
Industrial Capital Goods	25.2	(1.5)	25.5	(1.6)
Raw or Semi-Finished Materials	26.4	(1.9)	25.2	(2.2)
Industrial Components	20.0	(1.3)	20.8	(1.5)
Industrial Supplies	23.6	(1.8)	25.1	(2.1)

Source: Computed from the PIMS 1970-1973 and 1971-1974 data banks.

Note: The uncertainty of the average is influenced by the number of observations in a cell as well as by the degree to which these observations are "normally" distributed, and thus may be helpful as an indicator of statistical significance. If the average of a cell does not fall within the range of an adjacent cell plus or minus its uncertainty, the difference between the cell averages is considered statistically significant (Chussil, 1976, p. 21).

might be interpreted to mean that businesses with characteristically low capacity utilization have high sales force expense/revenue, or that sales force expense/revenue is increased to increase a low capacity utilization rate. In Figure 5 of Chapter VI, the lowest capacity utilization means are associated with the highest sales force expense/revenue category for all types of business except supplies. High sales force expense/revenue is the modal category for consumer non-durables and industrial capital goods, the least capital-intensive businesses in Table 19. Low sales force expense/revenue is the modal category for raw or semi-finished materials and industrial components which are among the more highly capital-intensive businesses in Table 19.

TABLE 19.--Mean capital intensity, 1970-1973 and 1971-1974 periods, for PIMS manufacturing businesses by type of business

Type of Business	1970-1973		1971-1974	
	Capital Intensity (per cent)	Uncertainty	Capital Intensity (per cent)	Uncertainty
Consumer Durables	71.7	(8.0)	72.4	(11.0)
Consumer Non-Durables	64.9	(4.4)	54.2	(3.5)
Industrial Capital Goods	65.5	(4.5)	61.0	(4.6)
Raw or Semi-Finished Materials	154.9	(9.4)	141.0	(10.2)
Industrial Components	82.1	(5.1)	74.9	(4.9)
Industrial Supplies	99.7	(7.5)	94.4	(8.2)

Source: Computed from the PIMS 1970-1973 and 1971-1974 data banks.

Note: The uncertainty of the average is influenced by the number of observations in a cell as well as by the degree to which these observations are "normally" distributed, and thus may be helpful as an indicator of statistical significance. If the average of a cell does not fall within the range of an adjacent cell plus or minus its uncertainty, the difference between the cell averages is considered statistically significant (Chussil, 1976, p. 21).

Entry of competitors was associated with reduced capacity utilization for supplies businesses in 1972-1973, for raw or semi-finished materials businesses in 1973-1974, and for components businesses in both time periods as shown in Table 17.

Product research and development expense/revenue is negatively associated with capacity utilization for industrial capital goods in 1972-1973, and for industrial components and raw or semi-finished materials in 1973-1974. High product research and development expense may indicate that changes in product design or packaging are imminent and, because of expected changes, capacity utilization rates are relatively unimportant. Capacity utilization adjustments related to the change must be made before capacity utilization rates again become an important factor in strategic decisions.

In the two time periods and data banks studied, different determinants of capacity utilization are important for a given type of business. This lends support to the notion that capacity utilization is a specific, short-term phenomenon. However, the different mix of businesses in the two data banks, shown in Table 2 of Chapter V, may influence the results. The 1970-1973 data bank has 110 more businesses and a higher percentage of consumer businesses than does the 1971-1974 data bank.

Significant variables explained about thirty per cent of the variance in capacity utilization in these studies. A higher percentage of variance was explained for separate business types than for all types combined. Significant variables explained 68 per cent of the variance in capacity utilization for raw or semi-finished materials businesses in 1973-1974 as shown in Table 10 of Chapter VI. Other R^2, which indicate the proportion of variance of the dependent variable explained by the independent variables, are in Table 9 of Chapter VI, and in Tables 12, 13, and 15 of Chapter VII.

Results show a positive association of higher capacity utilization and capital intensity. In Table 19, the most capital intensive business type is raw or semi-finished materials. This type has the highest mean capacity utilization of all types in Table 6 of Chapter VI. Consumer non-durables are the least capital intensive of the business types in Table 19, followed by consumer durables and industrial capital businesses. These business types have correspondingly low capacity utilization rates in Table 6 in 1970-1971, but industrial capital has a higher rate than expected from its capital intensity for 1973-1974. Capital intensity is not expected to change markedly over time for a type of business, because it is related to the type of product produced.

Influence of environmental factors on capacity utilization. Concentration ratios, aggregated from the company level, are published on the four-digit SIC level for over four hundred manufacturing industries (Concentration Ratios in Manufacturing, 1975, Table 5, pp. 6-49). A company is defined as the total of individual establishments under one ownership within an industry. This can be all or part of a parent company. A parent company can operate in several industries. As market share indicates market position for a business in a relevant market, a concentration ratio indicates the market share of the top four, eight, twenty, or fifty companies in an industry by value of shipments or some other criterion. Because aggregate concentration ratios are not available for durables and non-durables categories, or for primary and advanced processing, and because classifying concentration ratios by type of business is an arbitrary and error-prone procedure, PIMS market share means by type of business are not compared with concentration ratios.

While the attempt to compare business market share and industry concentration failed, the effort pointed out the great diversity of products that might be included in any type of business. For example, paper, electronic equipment, and instruments can be classified as consumer goods, but electronic equipment and instruments also can be classified as industrial capital or components, and paper can also be classified as industrial components or supplies.

Consumer durables businesses have the lowest mean market share, and raw or semi-finished materials businesses have the highest mean share in 1972-1973 and 1973-1974 as shown in Table 18. Distribution of share for selected business types is in Figure 7 of Chapter VI. Industrial capital goods businesses have a relatively high mean share. Industrial components businesses have relatively low mean shares of the market.

Capacity utilization rates can respond to business-cycle fluctuations, product type, capital intensity of the production process, and market position of the business.

The relationship between output and employment changes and changes in capacity utilization rates for different types of business is shown in Table 20, where the per cent change in capacity utilization from the beginning of a period to the end of a period is shown for each type of business. Percentage changes in goods-output real GNP, which is relevant for the manufacturing sector, and in civilian non-agricultural employment, which is also relevant for manufacturing, are included for comparison. Per cent changes in capacity utilization for consumer durables and industrial raw or semi-finished materials from 1970-1971 to 1972-1973 and for industrial capital

TABLE 20.--Relationship between output and employment changes and changes in capacity utilization rates for different types of business

	Per Cent Change from Beginning Period to Ending Period	
	1970-1971 to 1972-1973	1971-1972 to 1973-1974
Real-Goods Output GNP[a]	12.3	9.9
Civilian Non-Agricultural Employment[b]	5.5	6.1
Type of Business:[c]		
Consumer Durables	11.7	3.7
Consumer Non-Durables	3.7	5.4
Industrial Capital Goods	9.0	9.2
Raw or Semi-Finished Materials	12.0	10.6
Industrial Components	10.4	8.1
Industrial Supplies	7.3	9.6
Total, All Types	8.7	8.0

[a] Computed from: Economic Report of the President. Washington, D. C.: U. S. Government Printing Office, 1976, Table B-5, p. 177. Goods-output GNP is in 1972 dollars, billions of dollars, quarterly at seasonally adjusted annual rates.

[b] *Ibid.*, Table B-22, pp. 196-97. Civilian labor force is age 16 and over; non-agricultural employment is in thousands of persons. 1972 and 1973 are not strictly comparable with earlier years due to population adjustments.

[c] Computed from PIMS 1970-1973 and 1971-1974 data banks. Per cent change is change divided by the amount for the preceding period.

and supplies and raw or semi-finished materials from 1971-1972 to 1973-1974 are of about the same magnitude as per cent changes in real-goods GNP for that period, and percentages are lower for other types of business. The only type of business that has per cent changes in capacity utilization of the same magnitude as the per cent changes in employment is consumer non-durables for 1971-1972 to 1973-1974. The fact that only about 56 to 60 per cent of PIMS manufacturing businesses operate only in the United States, as shown in Table 21, may confuse the above comparisons.

TABLE 21.--Number of PIMS manufacturing businesses by geographic location of the served market in 1970-1973 and 1971-1974

Geographic Location	1970-1973		1971-1974	
	Number	Per cent	Number	Per cent
Entire United States	372	59.5	291	56.5
All of Canada	17	2.7	12	2.3
U. S. and Canada	140	22.4	100	19.4
Regional within U. S. and/or Canada	53	8.5	51	9.9
United Kingdom	38	6.1	52	10.1
Common Market	0	0.0	1	0.0
Other	5	0.8	8	1.6
Total	625	100.0	515	100.0

Source: Computed from the PIMS 1970-1973 and 1971-1974 data banks.

Product types range from low-priced, frequently-purchased consumer non-durables to high-priced, infrequently-purchased industrial capital goods (suggested by Smith, 1977). Purchases of the former may be related to a psychologically appealing advertisement and/or disposable income; the latter may be designed during long planning periods to meet engineering specifications. The former have lower capacity utilization than the latter in the 1971-1974 period, but higher rates than the latter in the 1970-1973 period except in 1972-1973 when the rates are about the same. Other product types are between these extremes.

Another categorization for business types is into durable versus non-durable or primary versus advanced-processing groups. For 1970-1974, capacity utilization is higher for non-durables than for durables, and higher for primary than for advanced processing when the Bureau of Economic Analysis rates are compared (Economic Report of the President, 1976, p. 211). Classifying raw or semi-finished materials as primary, and making similar comparisons, Table 6 of Chapter VI shows similar relationships for 1970-1971, where consumer non-durables and raw or semi-finished materials have the highest mean capacity utilization rates. Raw or semi-finished materials businesses have the highest capacity utilization means of all types of business in all time periods in Table 6. The mean capacity utilization for consumer non-durables is lower than that for consumer durables and industrial capital goods in other time periods.

Determinants of new investment. The business level results from the study of new investment in Chapter VIII tend to support the modified capacity-accelerator hypothesis of investment theory, that new investment is related to change in sales, and that capacity utilization is also a significant factor. There is some evidence that change in profitability also affects new investment in the PIMS manufacturing businesses for the two time periods studied. However, the largest part of variation in new investment is explained by real sales growth. Up to ten variables are significant in explaining about six-tenths of new investment in this study.

Significance of Results

Significance for academic research. The significance of the results of this research for academic researchers is that some determinants of capacity utilization and investment appear both in this research, which uses business-level data, and in the studies of others who use more aggregated data. Some measure of capital intensity and some indication of size are important determinants of capacity utilization, according to this research as well as research of Lim (1976) and the Espositos (1974). Some measures of change in sales and of capacity utilization are important determinants of new investment for this research and for Eisner (1972). These common results show up in spite of different definitions, data, and methods of analysis.

Significance for the business manager. The results of this study suggest, not so much an answer, as a method of finding answers. A business manager needs to know how to ask the right questions (Drucker, 1974). To do so, the manager must know what the business of interest is like and how it differs from the data from which published findings are computed. The results of this research may serve as a guide for formulating the right questions to ask when making strategy decisions about capacity utilization and new investment. The information exposed by this research needs further processing in the mind and environment of a given business manager.

Business managers should keep certain practical considerations in mind when making marketing decisions (Wiegand, 1977) and also when making capacity utilization and investment decisions. Like marketing channels, capacity utilization rates and new investment decisions are subject to planning, but they often reflect circumstances largely beyond the control of anyone within the business and are often more diverse than generally suggested in the literature. The right decision for a vertically integrated channel or business may be the wrong one, even a fatal one, for a non-integrated channel or business. Different situations require different strategies with respect to marketing channels and capacity utilization. The proper strategy can be determined only after finding out what critical factors (Drucker, 1954) in the particular situation affect capacity utilization and to what extent these factors can be controlled by the manager.

Certain variables are found to be significant determinants of capacity utilization rates for certain types of business, and for utilization and new investment in certain time periods. Knowing the characteristics of a particular business and the features of the business environment that affect capacity utilization or investment in this particular business may help a business manager determine which factors can be controlled or manipulated, and which factors are less controllable. Then, decisions can be made as to controlling some factors and adjusting for less-controllable ones. (Which factors can be controlled may change with a change in the environment.)

Significance for government policy. Caves' (1972) industrial organization approach provides the basis for this discussion of government policy. Capacity utilization is an aspect of technical efficiency in market performance. Market performance in the United States is evaluated in terms of actual versus potential efficient employment of scarce factors of production, progressive additions to the stock of factors of production, and equitable distribution of real output. Policies embodied in antitrust laws and direct regulation are available to reduce gaps between actual and potential performance, but such policies do not deal equally with the goals mentioned above. It is difficult (because of pricing practices in concentrated industries) to maintain high employment and high capacity utilization without rising prices. It is difficult to stabilize investment.

Efficiency deals with how scarce resources are allocated among the unlimited possible uses. Excess capacity is wasted capital (Caves, 1972), but excess capacity exists because there are not enough scarce resources for all firms to operate at full capacity (Winston, 1977). There is some evidence of plants too small to be efficient where there is heavy product differentiation and advertising, but no known diseconomies of too-large plant capacity.

Firms with market power evidenced in high market share can behave persistently in a manner different from firms with smaller shares, and earn high profits and distort resource allocation. Power can be changed by antitrust action as when ALCOA was accused of using excess capacity as a barrier to new entry into the aluminum market (U. S. v. Aluminum Co. of America, 1950). Power can cause excess capacity as when duPont concentrated on its most profitable products during a capital shortage and caused shortages in businesses using the less profitable duPont products (Carruth, 1976).

Regulation of price collusion by antitrust may prevent some inefficient uses of capacity which makes costs higher than necessary. Revision of the Robinson-Patman Act so that sellers accused of price discrimination can show that price differences rest on cost differences (Caves, 1972) might also encourage more efficient capacity utilization.

Not all determinants of capacity utilization are entirely controllable by an individual business. In dealing with an antitrust case, the extent to which determinants are controllable and whether or not they are being controlled so as not to injure competition or tend to create a monopoly must be determined. What is easily controllable for one business may be less controllable for another. A complication for antitrust is that the parent company, not a business, may be the defendant. Such a company might have a portfolio of businesses diversified across many industries. Even so, antitrust policy, when considered case by case, is less aggregative than general fiscal and monetary policy.

The interrelationship between capacity utilization and investment implies that government policy directed towards encouraging new investment may be more effective in periods of high capacity utilization. This research has shown that much of the variation in new investment can be explained by factors other than the interest rate. The timing of high capacity utilization may be different for different types of business in a given time period and may depend on interrelationships among businesses. Government policy must take side effects into account and evaluate whether the policy brings more benefits than the side effects cause harm.

Capital intensity may be a function of the type of product produced; however, size can be controlled to some extent, and there is evidence in this research that businesses with high market shares (over 27 per cent) have lower capacity utilization than businesses with low shares. Size and share may be related to antitrust policy.

Technical Considerations

Limitations of results. Since the PIMS data banks do not have random samples of businesses, and since the time period of the data covers only five years, 1970-1974, one should be cautious about generalizing from one analysis. Variables found to be important in general in these regressions may not be important in a particular situation.

Statistical technique is based on an assumption of random samples where each observation has an equal chance of being chosen for a sample. Regression analysis is also based on certain assumptions, such as constant variance (no heteroskedasticity), independence of the independent variables (low degree of multicolinearity) and others. In the real world these assumptions are violated. Econometrics recognizes the possibility that assumptions are violated when real-world data are used, and provides tests for violations and methods of dealing with them. Examples of such for heteroskedasticity and multicolinearity are included in Chapters V through VIII.

The alternative to using ex post facto data from life situations is to use data manipulated in experiments (Kerlinger, 1973, pp. 400, 401, 405). This alternative has higher internal validity in determining whether the manipulation made a difference, i.e., causality, but lower external validity, i.e., representativeness or generalizability (Kerlinger, 1973, p. 325). In order to make generalizations, it is necessary to work with data from life situations even if they are imperfect. Being collected under conditions of continuous interaction between PIMS and member businesses, and being disaggregated to the level of an individual business, PIMS data may include less noise than other available data.

An understanding of capacity utilization and investment gained from studying PIMS data may help in understanding how to collect and process aggregate data for industries and for the economy.

Recommendations for the PIMS data bank. PIMS has begun work on a data bank of annual data which can be merged with an associated data bank of business characteristics including type of business (Land, 1977). It would be helpful to have semi-annual or quarterly data also. Then, if there are structural changes beyond a period of four years, or if the mix of businesses in the data bank changes, there would still be enough observations for time-series regressions. At present, there are only 210 businesses with annual data in the PIMS (MATIV) data bank for 1970-1975, but type of business data is not included. With more data points per year, business phenomena of short term duration can be studied for quarterly tactical decisions. For example, if, as asserted (Clarke, 1976), the cumulative effect of advertising occurs within a year, annual data will not reveal this effect.

An advantage and also a potential disadvantage is that PIMS data are primarily on the business level, and only some businesses of a parent company are in the data base. The disguise factors of the businesses and the need for non-disclosure make it impossible for a researcher to put together the businesses of a parent company; even then, not all of the businesses of the parent company would be available. The diversification of parent companies may add noise to what is being studied. The researcher should use the PIMS data bank for what it is best suited--business level studies. Researchers concerned with using corporations as entities may need to look elsewhere for data.

Data for costs of investment funds are not available in the PIMS data banks because investment funds are raised by corporations, not by their business subsidiaries. Therefore, these data cannot be used in the investment equation.

The PIMS data base has about 400 variables. Since it takes time to understand all of these variables, all relevant variables in the data base may not be in this study. Some variables of possible interest for capacity utilization studies are missing from the 1970-1973 data bank or have information for a relatively small number of businesses. These are per cent change in capacity (#101) and manufacturing process (#90, per cent batch; #91, per cent assembly; and #93, per cent continuous-process manufacturing). There are only 89 businesses with manufacturing process observations. There are only 47 observations for order backlogs (#63). A business enters zero on the data form if this variable is not relevant. Increase in capacity may temporarily lower capacity utilization. High capacity utilization is necessary to cover costs in continuous-process manufacturing which is very capital intensive (Drucker, 1974).

There are many categorical variables in the PIMS data base which have been recoded with midpoints of the categorical groups to replace category numbers in this research. Recoding is explained in Appendix A. Examples are shared facilities and number of end users. Since recoding programs are available and easy to use, it is probably best to retain the present form of these categorical variables. Each researcher can change them according to requirements of the research planned. A similar arrangement is suggested for the potential dummy variables which have, in the PIMS data base, more categories than zero and one. Examples are: increase, no change and decrease; or larger, equal, and smaller for the number and size of customers variables in Appendix A.

Suggestions for Future Research

Research needs. This research explored a big picture with little theory and existing research to use as a guide. Further research is needed to add detailed studies of parts of this big picture and more evidence concerning the significance and importance of the variables found to influence capacity utilization and investment in this study. Other time periods and other businesses should be studied.

More research is needed for building theory, and testing this theory in different circumstances. In a new, recently published, theory of capacity utilization (Winston, 1977), behavior of profit maximizing firms is consistent with behavior of the economy. Firms operate at a level of output above capacity if paid a high enough price to cover increased marginal costs. Sustained operation in excess of capacity will induce investment to reduce capacity utilization back to the least-cost level. Capacity is defined with respect to all resources, not just with respect to capital stock. Because input costs can vary rhythmically over calendar periods, the least-cost level of capacity utilization can be less than the maximum technical level of utilization. Therefore, idle plants and maximum aggregate output coincide because it is efficient for firms not to use their capital all the time. Resources are allocated efficiently with much idle capital because there are not enough available resources in the aggregate to utilize all the capital. Further, social excess capacity exists when plants are built too big to realize economies of scale, or target output is set too low due to lack of information. This theory is consistent with the findings of this research and suggests an additional variable, selling price growth, which is positively associated with capacity utilization. Selling price growth when tested had a coefficient significantly different from zero only at the one-tail 20 per cent level, when used alone or with a group of variables in equation (10) below.

Time-series regressions and pooled time-series cross-section regressions should be done for short-run and long-run insights. A simultaneous model of capacity utilization, investment, and return on investment should be made and estimated with ordinary least squares (OLS), two-stage least squares (2SLS) and three-stage least squares (3SLS) techniques.

Simultaneous equation model. Simultaneous equation models are being published more frequently as techniques for forming and estimating these models have improved. Two recent models which are relevant to this research are a labor force model about unemployment, which represents underutilized labor resources (Fleisher and Rhodes, 1976), and a model which applies a dynamic adjustment model to the Constant Elasticity of Substitution production function for Dutch manufacturing (van der Loeff and Harkema, 1976). The former claims that results from estimating unemployment and labor force participation in a simultaneous model lead to different conclusions than results from estimation of the single separate equations. In the latter, capital input data are obtained by a method which takes into account the degree of utilization of the capital stock, and a new nonlinear method of maximum likelihood estimation is introduced. The former is a cross-section model; the latter, a time-series model. The fact that these are recently published models indicates that simultaneous equations models can be estimated to achieve a better understanding of a situation that is available when using only one single equation model. This does not imply that the simultaneous model is always better; only that it is possibly better and should be investigated.

Results of this research, shown in Tables 9 through 16 of Chapters VI through VIII, lead to the following specification of the capacity utilization and investment equations for a simultaneous three-equation model which would also include the PIMS LIM equation for return on investment. The variables in the capacity utilization equation are those that were significant for several types of business and also for the total manufacturing group in both 1970-1973 and 1971-1974 time periods and for both four-year and two-year averages. The variables in the investment equation are those that were significant in both time periods.

Capacity utilization (Y_1) is explained by: capital intensity (X_1), growth (X_2), market share (X_3), market share squared ($X_4 = X_3^2$), sales force expense/revenue (X_5), entry of competitors (X_6), product research and development expense/revenue (X_7), change in market share (X_8), technological change (X_9), per cent change in investment (Y_2) and return on investment (Y_3).

$$(10) \quad Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 - \beta_4 X_4 - \beta_5 X_5 - \beta_6 X_6 - \beta_7 X_7$$

$$+ \beta_8 X_8 - \beta_9 X_9 + \beta_{10} Y_2 + \beta_{11} Y_3 + e$$

Both real market growth, which has been used in these regressions, and real sales growth, which is significant for investment results have been tested for X_2. The former is less correlated with other variables and results in higher R^2. Theory and hypotheses concerning these variables are in Chapter V.

Interaction terms can be used to incorporate the fact that the coefficient of a variable, X_i, is significant for some types of business and not for others (Gale, 1975a). A dummy variable, D_i, can be formed such that D_i has a value of unity for types of business with a significant coefficient for variable X_i and a value of zero otherwise. The corresponding interaction term, I_i, is formed by multiplying D_i by X_i. Such an interaction term can be substituted for variables X_2 through X_9, Y_2, and Y_3, using Tables 12 and 13 as a guide for making dummy variables. These interaction variables can be used as controls for differences in business types.

In a preliminary regression using equation (10) with these interaction terms for 1972-1973, coefficients of all variables except technological change were significant at the two-tail one per cent level. Technological change was significant at the two-tail 32 per cent level and contributed only .001 to R^2. Variables, listed by descending order of size of their standardized regression coefficients, with rank of contribution to R^2 in parentheses, were: capital intensity (1), real market growth (2), return on investment (5-6), sales force expense/revenue (3), entry (7), product research and development expense/revenue (4), market share (8-9), per cent change in investment (8-9), market share squared (10), and change in market share (5-6). All signs were as expected. R^2 was .3. Interaction terms were used for all explanatory variables except capital intensity.

The investment equation explains new investment (Y_2) with the following variables: capital intensity (X_1), market share (X_3), market share squared ($X_4 = X_3^2$), real sales growth (X_{10}), lagged capacity utilization (Y_1), lagged investment/revenue (X_{11}), lagged return on investment (X_{12}), change in return on investment (X_{13}), selling price growth (X_{14}), lagged value added/revenue (X_{15}), and newness of plant and equipment (X_{16}).

$$(11) \quad Y_2 = \beta_0 + \beta_1 X_1 - \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_{10} + \beta_5 Y_1 + \beta_6 X_{11} - \beta_7 X_{12}$$

$$- \beta_8 X_{13} + \beta_9 X_{14} + \beta_{10} X_{15} + \beta_{11} X_{16} + e$$

These variables are discussed in Chapters V and VIII.

The PIMS LIM equation described in Chapter V, explains return on investment, Y_3.

Before the simultaneous model is estimated, empirical tests of existence and direction of causality can be made. Cross-section and cross-lag tests are available to provide some empirical evidence for causality when theory is not an adequate guide. This evidence would be helpful to determine the direction of causality associated with the three "jointly determined" variables of the simultaneous model. Does capacity utilization determine investment or does investment determine capacity utilization, or are these jointly determined? In cross-section analysis, two interaction hypotheses can be set up, only one of which is consistent with the data. For example, Gale (1972a) found a significant effect of share on profitability in medium growth industries but not in rapid growth industries. This is consistent with the hypothesis that share affects profitability but not with the hypothesis that profitability affects change in share. In cross-lagged correlation analysis, with measures for two variables, A and B, at two points in time, some hypotheses concerning whether A causes B, B causes A, or both are caused by a common factor, will be consistent with the data and some will not be (Monroe, 1977; Blalock, 1964).

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APPENDIX A

OPERATIONAL DEFINITIONS OF VARIABLES

Procedure

Plan. The plan of this Appendix is as follows. Variables are listed in alphabetical order. The variable name is followed by the computer name and number of the PIMS variable chosen to represent this variable (Chussil and Land, 1976). Each variable is defined using the questions from the PIMS Data Forms (1976). Line numbers from the Data Forms are also included. Variable numbers and definitions are the same in both the 1971-1974 and 1970-1973 data banks.

Average, beginning, ending changes. In the PIMS data base, "AVG" refers to the entire period of the data bank, which, in the 1971-1974 data bank, is a 1971-1974 average. "BEG" refers to the two-year average for the beginning period, 1971-1972. "END" refers to the two-year average for the ending period, 1973-1974. "AVG" is used in four-year regressions; "END" is used for two-year regressions. Changes are from the beginning average to the ending average. "BEG" is used for lagged variables.

CHG is computed by the following change formula used for all PIMS change variables. Point change, c, is a function of variable y_i and years x_i.

$$(12) \quad c = \frac{\Sigma(y_i-\bar{y})(x_i-\bar{x})}{\Sigma(x_i-\bar{x})^2}$$ (Chussil and Land, 1976, p. 68)

PIMS computes % CHG as follows. For y_i = a variable in year i, x_i = a year, and b_2 = per cent change:

$$(13) \quad b_1 = \frac{\Sigma(\log_e y_i - \overline{\log_e y})(x_i-\bar{x})}{\Sigma(x_i-\bar{x})^2}$$

$$(14) \quad b_2 = (e^{b_1} - 1) * 100$$ (Chussil and Land, 1976, p. 68)

This is a compound growth rate.

Variables

Capacity utilization. CAPAC UTIL AVG, 236; BEG, 237; END, 238, is the percentage of standard capacity utilized on average during the year. Standard capacity is the "sales value of the maximum output that this business can achieve with (1) facilities normally in operation and (2) current constraints (e.g. technology, work rules, labor practices, etc.). 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" (lines 235, 236).

Capital intensity. REP GBV/CAPAC %, 346, is the ratio of gross book value of plant and equipment (line 223) to standard capacity (line 235) multiplied by .01 times per cent replacement at gross book value (line 225). Gross book value is the original value of buildings, real estate, manufacturing equipment, plus all transportation equipment owned on the average for each year. Replacement at gross book value is an estimate of current gross replacement cost of assets as a percentage of the most recent gross book value. Standard capacity is defined above.

Common distribution channels. COMMON DISTCHNL, 48, is the per cent of the sales of a business to customers also served by other components of the same company with four choices: 1) less than 25%, 2) 25% - 49%, 3) 50% - 74%, and 4) 75% or more (line 147). This variable has been recoded using the midpoints of the four categories: 12.5%, 37.5%, 62.5%, 87.5% instead of the values 1, 2, 3, and 4.

Concentration of purchases. CONCPUR END USR, 20; and CONCPUR IMM CUS, 23, represent the proportion of the total number of end users of immediate customers respectively that account for 50 per cent of the total purchases of the products of a business (lines 119 and 122).

Consumer business dummy. Computed from TYPE OF BUSINESS, 2, this variable is a dummy variable which has the value of unity for consumer businesses and zero for industrial businesses. Service and retail businesses are not included in this study. This variable is used only for regressions in which the six types of business are combined into one group.

Corporate debt/equity. COD CO DEBT/EQ, 89, is the corporate debt/equity ratio, rounded for security. No line number is given. This variable is not in the 1970-1973 data bank.

Customer concentration change. END USR STABIL, 21; and IMM CUS STABIL, 24, are variables reporting whether the proportion of customers accounting for 50 per cent of the total purchases of the products of the business has increased, decreased, or remained the same (lines 120 and 123). Instead of using the values of 1, 2, and 3 to indicate decrease, same, and increase, two dummy variables are formed from each stability variable. The decrease dummy has a value of unity for decrease and zero otherwise. The increase dummy has a value of unity for increase and zero otherwise.

Entry of competitors. ENTRY COMPETITS, 70, has a value of unity if there has been entry of a major competitor, having at least five per cent market share, into the served market in the last five years; otherwise, it has a value of zero. Since entry has occurred in the last five years for only 28.8 per cent of the businesses in the 1971-1974 data bank (Chussil and Land, 1976, p. 117), there may not be enough information for this variable (line 304).

Exit of competitors. EXIT COMPETITS, 71, has a value of unity if any major competitors, having at least five per cent market share, have dropped out of the served market in the last five years; otherwise, it has a value of zero. There is less information about exit than about entry. Only 18.5 per cent of the businesses claimed exit of a competitor (line 305, Chussil and Land, 1976, p. 117).

Importance to customers. IMPORT END USR, 30; and IMPORT IMM CUST, 31, measure the importance of the products of a business to end users and immediate customers of a business. This is the proportion of the typical customer's total annual purchases accounted for by purchases of the products sold by the business (lines 129, 130). There are five categories: 1) less than .25%, 2) between .25% and 1%, 3) between 1% and 5%, 4) between 5% and 25%, and 5) over 25%. These variables have been recoded from values of 1 through 5 to midpoints of the amounts mentioned in the five categories: .0125, .0625, .03, .15, and .5. Since end-user and immediate-customer variables are two highly correlated representations of the same concept, only one can be used at a time. The one with the higher significance level and contribution to explained variance is chosen.

Investment/revenue. INVEST/REV BEG, 218, is the ratio of the book value of average investment (line 228, defined for per cent change in investment, below) to net sales (line 201, defined for media advertising, below).

Industry growth rate. GRW RT IND63-72, 79, is the industry growth rate which is the per cent change in industry sales, including lease revenues, for the last ten years. If less than ten years of data are available, the rate is calculated for the available data (lines 415-425).

Less or more customers than competitors. BRDTHRE CUS NUM, 75, the breadth of the served market of a business, relative to the average of its leading competitors is estimated for the number of customers (line 327). The same is done for size of customers, BRDTHRE CUS SIZ, 76 (line 328). Instead of using 1, 2, and 3 to represent: less than, same as, and more than, these variables were recoded as were the change-in-customer-concentration variables above.

Make or buy. VA/REV AVG, 107; BEG, 108; END, 109; CHANGE, 110, is the ratio of value added (line 205, defined for productivity, below) to net sales (line 201, defined for media advertising, below).

Market share. MARKT SHARE AVG, 266; BEG, 267; END, 268; CHG, 269; %CHG, 270, refers to the "sales of a business as a percentage of the served market." The served market is the "total value of sales in the market actively served by this business" (lines 306 and 301). Market share data are collected annually.

Material cost growth. MATL COST GRWTH, 337, is the per cent change in "the percentage of purchase prices for the most important category(ies) of materials (including fuel and energy, if important) used by this business, relative to the level in 1973" (line 313).

Media advertising expense/revenue. ADV MED/REV AVG 157; END, 159, is the ratio of media advertising expenditures (line 212) to total revenue (line 201, also called sales). Net sales or total revenue, disguised, is the "revenue realized from goods shipped or services rendered net of (1) bad debts (2) returns (3) allowances." Lease revenue received from customers for use of equipment owned by this business and progress payments applicable to a given year are included. Orders not covered by invoices are excluded.

Newness of plant and equipment. NEWNESS BEG PER, 212, is the ratio of net book value of plant and equipment to gross book value of plant and equipment (line 224/line 223). Net book value is gross book value, defined for capital intensity above, net of accumulated depreciation to date, and expressed as an average for each year.

Number of end users and immediate customers. NUM END USERS, 18; NUM IMMED CUSTS, 19. The number of end users is determined by the following PIMS question: "During the most recent year for which you are entering data, within the served market, approximately how many end users were there for the products or services of this business: 1) 19 or fewer; 2) 20-99; 3) 100-999; 4) 1,000-9,999; 5) 10,000-99,999; 6) 100,000-999,999; 7) 1,000,000-9,999,999; 8) 10,000,000-24,999,999; and 9) 25,000,000 or more" (line 117). For the regressions, codes from 1 to 9 for these classes respectively are replaced by the midpoint of each product class, with the last three product classes taken together. Midpoints are: 10; 60; 550; 5,500; 55,000; 550,000; and 5,500,000. In single precision, computers are accurate to seven digits; therefore, the larger numbers have been recoded.

The number of immediate customers is assumed to be smaller than the number of end users. PIMS asks: "During the most recent year for which you are entering data, approximately how many immediate customers were served by your business? (NOTE: If this business sold directly and exclusively to end users, your answer to this question is simply a more detailed estimate than that given in Line 117, immediately preceding.) (Check one): 1) 3 or fewer; 2) 4-9; 3) 10-19; 4) 20-49; 5) 50-99; 6) 100-999; 7) 1,000-9,999; 8) 10,000 or more" (line 118). For the regressions, codes from 1 to 8 for these classes respectively are replaced by the midpoint of each product class. Midpoints are: 2; 7; 15; 35; 75; 550; 5,500; and 55,000.

Per cent change in investment. % CHG INVESTMTS, 221, is the per cent change in investment. Average investment for a year associated with a business includes both fixed and working capital at book value. Corporate investment not specific to the business is excluded. If a significant portion of total assets is leased, the capitalized value of the annual lease obligation, i.e. the book value of the assets as if they were owned, is included (line 228). This variable represents new investment, the dependent variable in the new investment equation.

Per cent new products. % NEW PRODS BEG, 303; CHG, 305, is an estimate of the percentage of total sales accounted for by products introduced during the 3 preceding years for this business (line 323).

Process research and development expense/revenue. PRC R&D/REV AVG, 137; END, 139, includes "all expenses for process improvements for the purpose of reducing the cost of manufacturing, processing, and/or physical handling of goods" by a business (line 208).

Product research and development expense/revenue. PRD R&D/REV AVG, 132; END, 134, is "all expenses incurred to secure innovations and/or advances in the products or services of this business." Improvements in packaging as well as in product design/features/functions are included. Expenses for process improvement are not included (line 207). Total revenue is explained for media advertising above.

Productivity. VAL ADD/EMP AVG, 243; BEG, 244; END, 245; % CHG, 246, is value added per employee, a measure of productivity. Value added is sales (line 201) minus purchases (line 204). Sales are defined for media advertising above. Purchases are the "value of raw materials, energy, components, assemblies, supplies and/or services purchased or consumed" by other companies or other parts of the parent company. Purchases exclude "(1) capital expenditures and associated expenses, (2) cost of modifying plant and/or equipment whether done in-house or contracted to others and (3) purchases for stockpile rather than use" (line 204). Since both net sales and purchases are disguised by the same disguise factor, value added (line 205) is also disguised. Therefore, some ratio, such as value added per employee, must be used in order to include this variable in a regression. The denominator of this ratio is net sales/(sales/employee) (Chussil and Land, 1976, p. 43). Disguise factors are provided by and known only by each business, and change from business to business.

Purchase frequency. PURFREQ END USR, 26, and PURFREQ IMM CUS, 27, indicates how often customers typically buy the products or services of a business. This is a selection decision, not a delivery schedule (lines 125 and 126). The categories are: 1) weekly or more frequently, 2) between once a week and once a month, 3) between once a month and once in six months, 4) between once in six months and once a year, 5) between once a year and once in five years, 6) between once in five years and once in ten years, and 7) other. In recoding this variable, time is stated in months, and the midpoint of each category is used instead of the number of the category as follows: .25, .62, 3.5, 9, 36, 90, and 150.

Purchase from components. PURC FR COMPONS, 43, is the percentage of total purchases of materials, supplies, etc. obtained by the business from other components of the same company (line 142).

Real market growth. REAL MKT GRWTH, 366, is the per cent change in the size of the served market divided by the index of prices with 1973=100 per cent. The size of the served market is the "total value of sales in the market actively served by a business." Size includes price changes and is comparable to the total revenue entry in line 201, having the same disguise factor (line 301). The index of prices is an estimate for each year of the percentage of selling prices charged by this business relative to the level in 1973. This percentage reflects changes in prices of identical products, not changes in the product mix (line 312).

Real sales growth. REAL SLS GRWTH, 367, is the per cent change in the ratio: net sales plus lease revenues/index of prices with 1973=100 per cent. Net sales or total revenue is explained for media advertising above. The index of prices is explained for real market growth above.

Relative product quality. SUPER-INFER AVG, 286; END, 288, is the difference in the percentage of products considered superior in quality by the customer and the percentage considered inferior (lines 316 and 318).

Return on investment. NTINC/INVST AVG, 172; BEG, 173; END, 174; CHG, 175, represents profitability which is the ratio of net income to the book value of average investment. Net income is the "operating profit of a business prior to deduction of (1) federal income taxes (2) corporate assessment for interest on corporate debt and (3) special non-recurring costs such as those linked to starting up a new facility" (line 217). Investment (line 228) is defined for per cent change in investment above.

Sales force expense/revenue. SLS FRC/REV AVG, 147; END, 149, is sales force expense divided by total revenue. Revenue is described for media advertising above. Sales force expense includes "(1) compensation and expenses incurred by salesmen, (2) commissions paid to brokers or agents, and (3) cost of sales force administration" (line 210).

Sales to components. SALS TO COMPONS, 45, is the per cent of total sales of a business made to other components of the same company (line 144).

Selling price growth. SELL PRIC GRWTH, 340, is a per cent change in the selling price index (line 312) which is an estimate for each year of the percentage of selling prices charged by a business relative to the level in 1973. This percentage should reflect changes in prices, not changes in the product mix.

Shared marketing programs. SHRD MARKET PRG, 49, indicates the extent to which the products and services of this business are "handled by the same sales force and/or promoted through the same advertising and sales promotion programs, as those of other components of the company" in the same three categories as for shared facilities below. This variable has been recoded as shared facilities was recoded (line 148).

Shared production facilities. SHARED FACILS, 47, indicates the extent to which a business shares its manufacturing or operating plant and equipment facilities and personnel with other components of the company in three categories: 1) less than 10% of plant and equipment, 2) between 10% and 80%, and 3) 80% or more. To retain more information than that given by the values of 1, 2, and 3 for these categories, this variable has been recoded using the midpoints of the categories: 5%, 45%, and 90% (line 146).

Technological change. TECHNOL. CHANGE, 11, has a value of unity if there have been "major technological changes in the products offered by the business and/or its major competitors, or in the method of production during the last 8 years;" otherwise, it has a value of zero (line 110).

Typical purchase amount. PUR AMT END USR, 28; and PUR AMT IMM CUS, 29, is the typical amount bought in a single transaction (lines 127 and 128). Categories are: 1) less than $1.00; 2) $1 to $9.99; 3) $10 to $99; 4) $100 to $999; 5) $1,000 to $9,999; 6) $10,000 to $99,999; 7) $100,000 to $999,999; and two higher categories. Codes from 1 to 9 for each class respectively were recoded using class midpoints: .5; 5; 50; 500; 5,000; 50,000; 500,000; and 5,000,000. This is one of the few undisguised dollar amounts requested by PIMS.

Wage rate growth. WAGE RATE GRWTH, 338, is the per cent change in the average hourly wage index which is an estimate of the average level of hourly wage rates paid by a business, relative to the level in 1973 (line 314).

Working capital/revenue. WRKCPTL/REV AVG, 196; END, 198, is the ratio of (average investment - net book value of plant and equipment) to revenue. Average investment (line 228) and revenue (line 201) have been defined above for per cent change in investment and media advertising. Net book value of plant and equipment is gross book value (line 223), defined for capital intensity above, net of accumulated depreciation to date. An average net book value for each year is entered on line 224.