CAPACITY POSITION AND FINANCIAL PERFORMANCE:

LONGITUDINAL EVIDENCE FROM

U.S. MANUFACTURERS

by

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ABSTRACT

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This research synthesizes research from the strategy, organization theory and operations management streams in exploring the competitive implications of firms' capacity over time. Data from archival sources are analyzed via Hierarchical Linear Modeling in exploring: 1) systematic relationships between capacity and financial performance that obtain over time; and 2) the role of strategic and environmental covariates in these relationships.

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CHAPTER 1

INTRODUCTION

Manufacturers today are more likely to face markets that are more complex and dynamic than at any other time in history. Recent evidence reported by the New York Times touts substantial capacity swings in one of the few remaining U.S. based shoe manufacturers, Allen Edmunds. Edmunds is reported to have reduced its production capacity by 8% only to increase it 33% fewer than three years later (New York Times, 2011). It may be some time before the long-term effects can be determined.

Decisions relating to a firm's capacity strategy and its capacity position can have important operational and economical effects on long-term performance. A firm operating in a capital intensive industry, for instance, is often required to make capacity decisions involving specialized equipment, large facilities, and technologies resulting in a large commitment of resources relative to capitalization (Porter and Spence, 1978). Further, the planning horizon for such decisions may likely extend for several years.

Organizations' capacity position will likely vary substantially over time because capacity decisions involve both timing – i.e., when to expand or contract – and by how much. A firm choosing not to expand at a time when others in the industry are doing so may miss important opportunities vital to long-term operations or greatly compromise its competitive position. A firm choosing to decrease capacity may also discover that it cannot readjust its capacity deficit adequately to meet unanticipated requirements, thereby leading to poor performance. On the other hand, a firm that simultaneously expands with other firms in the industry may be placing itself as well as competitors at increased risk, as the result of industry wide overcapacity positions (Lieberman, 1987).

A capacity strategy is, in part, used to ensure adequate resources for creative experimentation and innovation (Bourgeois, 1981). Excess capacity, as a strategy, may protect firms by providing emergency resources as buffers (Cyert and March, 1992; Anand and Ward, 2004; Dess and Beard, 1984), or providing excess capacity so that firms could seize opportunities should such opportunities emerge (Greenley and Oktemgil, 1998). Capacity strategies intended to bulwark an organization against unanticipated environmental changes may also permit a firm to preempt competitors by leveraging its capacity position to take advantage of changes in the environment ahead of its competitors.

An organization’s capacity position is often the culmination of decision-making processes that involve a number of factors (Bourgeois, 1981; Porter, 1980). If an organization carries too much spare capacity, operations may become inefficient. Too little spare capacity may result in a loss of sales or other constraints on action. (Hayes and Wheelwright, 1984; Bradley et al., 2010). The specific role that an organization’s capacity cushion takes in the strategic process is often influenced by the environment as well as organizational characteristics (Bradley et al., 2010). Both scholars and practitioners agree that most organizations operate with at least some slack (Cyert ad March, 1963), but the literature remains inconsistent with regards to its depiction of the performance effects of an organization’s capacity position over time.

Because the competitive value of a firm’s capacity position is a function of both time and sizing, a firm’s return on its capacity is likely to vary substantially over time. Some research has been undertaken involving firms’ capacity and their performances at particular junctures (Hendricks and Singhal, 1995; Daniel et al., 2004), but research into the ongoing performance consequences of capacity has been limited. Thus, a fuller view of the overall performance effects of firms’ capacity remains largely absent from the literature (Daniel et al., 2004). Table 1.1 lists the most recent empirical studies concerned with the relationship between a firm’s capacity and its performance.

The literature provides multiple justifications for the importance of capacity positions. For instance, firms may hold excess capacity to allow for a wider range in responses to environmental contingencies (Greenley and Oktemgil, 1998). Further organizations with excess capacity can afford to adopt structures that may not be a good fit for their respective environments because the excess capacity acts to buffer them from the consequences of the mismatch (Cheng and Kesner, 1997). Meyer (1982) also found evidence to suggest that excess capacity may act as a shock absorber for minimizing the effect of reductions in resources.

Capacity position plays an important role in firms' efforts to accommodate demand growth or variability (Olhager et al., 2001). Because capacity changes tend to be lumpy, require large capital investments, and have long lead times, decision makers must carefully weigh the advantages and disadvantages as to when capacity changes are needed (Olhager et al., 2001). According to Hayes and Wheelwright (1984) there are three strategies for responding to anticipated changes in demand: lead, lag or track (Olhager et al., 2001).

A lead strategy proposes to create excess capacity prior to increased demand forecasts. Firms tend to choose this policy if their objective is to never run short (Hayes and Wheelwright, 1984). A second approach, a tracking strategy, attempts to match a firm's capacity position to its forecasted demand. Its objective is to balance the likelihood of having excess capacity with the likelihood of facing a shortage (Hayes and Wheelwright, 1984). Finally, firms that take a wait-and-see approach often use a lagging strategy. A primary goal for these organizations is to maximize capacity utilization by delaying until absolutely necessary any position changes requiring additional capital investment (Hayes and Wheelwright, 1984).

Although many researchers have depicted excess capacity, a form of organizational slack, as having a positive effect on organizational performance (Cyert and March, 1963; Daniel, 2004), Davis and Stout (1992) and Jensen (1986) have found evidence to suggest that excess capacity may reduce or hinder firm performance by burdening the firm with excessive overhead. Yet both Bourgeois (1982) and Greenley and Oktemgil (1998) found evidence to suggest that excess capacity and its relationship with organizational performance is curvilinear. That is, excess capacity improves organizational performance only to a certain point, beyond which it begins to reduce performance.

Table 1.1 Empirical studies involving relationships between capacity position and firm performance

Study	Sample/data Source	Capacity Measures	Performance Measures	Results
Lieberman (1989)	40 Products from the Chemical industry over a 20 year period - (Dire of Chemical Producers, Synthetic Organic Chemicals, U.S. Trade Commission, U.S. Census)	$U_{i,t} = Q_{i,t} / 1/2(K_{i,t} + K_{i,t+1})$ = average capacity utilization for product i during year t VARGROW = standard deviation of market growth rate, based on historic growth rates for years t-3 through year t FRB = Federal Reserve Board index of capacity utilization in primary process manufacturing in year t	See Table 1., p 160	In general, firms made capacity expansion decision in a manner broadly consistent with the operations research models (especially the Newsboy and Whitt-Luss models) Industry capacity utilization is positively related to capital intensity and also to the rate of market growth. Utilization is negatively influence by demand variability as well as the actual size of the increment, inter-plant cost differences, and geographic dispersion.
Short et al. (2006)	2802 firms in 348 industries from 1995 to 2001 (COMPUTSTAT - single firms)	Slack = 7 year average (current ratio)	ROA	A firm's commitment to organizational slack over time was positively related to firm performance. However, slack negatively moderates the rate of performance changes over time. These findings suggest that organizations must balance keeping enough slack on hand to be responsive to opportunities while at the same time limit slack so as not to affect performance growth.

Table 1.1 - *Continued*

Cheng and Kesner (1997)	U.S. Airline Industry 1975 - 1979 (Handbook of Airline Statistics by CAB, 1976 and 1979)	Current Ratio = Current Assets/Current Liabilities (Available Slack) Equity-to-Debt Ratio (Potential Slack) Ratio of G&A-to-Sales = G&A/Sales (Recoverable Slack)	Number of Cities Served Number of Planes Ordered Average Coach Fare	Found support for the general prediction that organizational slack has differential effects on a firm's environmental response. Specifically, the relationship between a firm's slack and its response to environmental contingencies is positively affected by a firm's allocation to activities that enhance its operations or marketing effectiveness.
Hendricks et al. (1995)	128 Manufacturing Firms 1979 - 1990 (Trade and Industry Index (TRND) and Wall Street Journal Index)	Plant Level Capacity Utilization (for year of announcement) Industry Level Capacity Utilization (average 5 years) - (U.S. Census, Survey of Plant)	TABRET (Total Abnormal Return) = day 0 return for firm I, using a market model.	The findings indicated that capacity expansions significantly affect the market value of the firm. However, capacity expansions are negatively related to demand variability.

Table 1.1 - *Continued*

Greenley and Oktemgil (1998)	126 Leading British Firms (63 high performing, 63 low performing) - (Extel Microexstat database)	<u>Generated Slack:</u> • Cash flow/Investment • Debt/Equity • EBIT/interest Cover • Market/Book Value • Current Ratio = Current Assets/Current Liabilities • Sales per Employee <u>Invested Slack:</u> • Administration Costs/Sales • Dividend Payout • Sales/Total Assets • Working Capital/Sales	ROE ROI RONA ROS Sales Revenue	<u>High Performing Firms:</u>All measures of generated slack and Sales/Total Assets and Working Capital/Sales from invested slack are significantly related to ROE and RONA. ROI indicated a nonlinear relationship with the Current ratio. ROS was positively related to the Current ratio, Debt/Equity and Sales/Total Assets. Controlling the amount of resources invested in total assets and working capital with respect to sales is important for achieving flexibility that then impacts performance.<u>Low Performing Firms:</u>Neither generated slack nor invested slack are important determinants of performance, suggesting that critical levels of slack required for flexibility are not likely to be found in low performing companies.<u>Overall Differences:</u>High performing firms did not appear to carry more slack than low performing companies.
Ritzman and Safizadeh (1999)	144 U.S. Manufacturing firms (32 Job Shop, 46 Batch, 36 Production Line, 30 Continuous) in 15 Industries. Survey participants were selected from the Harris Industrial and Manufacturing Directory.	Capacity Utilization = the reported average annual capacity experienced / theoretically rated capacity	Performance = reported level assessing the relationship between in plant performance relative to other firms in the same industry.	For product-focused plants, the highest performing plants tended to be more capital intensive and have higher capacity utilization. The best performing product-focused plants gain competitive advantage by having increased machine flexibility and larger jobs.

Table 1.1 - *Continued*

Singh (1986)	64 U.S. and Canadian medium and large firms (Moody's Industrial, Transportation, Public Utility and OTC Industrial Manuals; 1974, 1975, 1976)	Absorbed Slack = (Selling + G&A + Working Capital) corrected for transaction volume in sales Unabsorbed Slack = Current Liabilities - (Cash + Marketable Securities)	Net Worth after Tax ROTA after Tax Subjective Performance Index (reported)	Findings reported that good performance is positively related to absorbed and unabsorbed slack. However, unabsorbed slack has no relationship with risk-taking, whereas, absorbed slack is related to increased risk taking. Good companies tended to be associated with higher levels of decentralization. However, firms with high-absorbed slack tended to reduce decentralization.
Bromiley (1991)	288 Firms in SIC 3000-3999 (COMPUSTAT and IBES)	Available Slack = Current Ratio Recoverable Slack = SG&A/Sales Potential Slack = • Debt-to-Equity Ratio • Interest Coverage Ratio	ROA ROE ROS Industry Performance = average ROA for firms with same 2-digit SIC (code).	Findings reported that slack appears to reduce risk taking. It is also suggested that slack allows room for risk taking but it is low performance that increases the level of risk taking, not slack per se.
Tan (2003)	17,000 Chinese SOE 1995-1996 (archive data)	Absorbed Slack = Capital Depreciation as a percentage of total capital assets Unabsorbed Slack = Retained Earnings as a percentage of total profit	ROA	Both absorbed and unabsorbed slack exhibit a curvilinear relationship with firm performance. It is suggested that there is an optimal level of slack, after which the relationship between slack and performance degrades as the cost of slack increases.

Researchers have long recognized that organizational studies are incomplete without the inclusion of an organization's environment (Hayes and Wheelwright, 1979; Aldrich, 2008; Porter, 1980; Dess and Beard, 1984; Sharfman and Dean, 1991; Cannon and St. John, 2007). Aldrich (1979) was one of the earliest researchers to suggest that the study of the organization-environment framework is fundamental to understanding organizational structure as well as organizational environments (Aldrich, 2008). Contingency theorists posit that an appropriate organizational form depends on the *fit* between the organization and its environment (Aldrich, 2008) In their review of six empirical studies focused on the relationship between organizations and their environments, Lawrence and Lorsch (1967) found evidence that organizational form should vary as a result of differences in task and environmental conditions. However, exactly how organizations must vary in response to changes in their environments is often debated (Lawrence and Lorsch, 1967; Aldrich, 2008; Pfeffer and Salancik, 1978).

In order for organizations to survive, they must effectively satisfy or exceed demand (Pfeffer and Salancik, 1978). That environments play central roles in much of the theoretical and empirical research into organizational effectiveness suggests that closer examination of environments would be useful in understanding the performance consequences of actions undertaken by firms (Pfeffer and Salancik, 1978). These actions include capacity position adjustments.

Organizational environments are by their very nature variable (Aldrich, 2008), with this variation often manifested across multiple dimensions. Tung (1979) noted that the *composition* of organizational environments is distinctly different from the *character* of organizational environments, suggesting that organizational environmental studies should incorporate both.

As environments become more stable, predictability improves, enabling organizations to develop standardized practices for dealing with environmental elements (Miller, 1988; Aldrich, 2008). Organizations operating in stable environments tend to more accurately forecast demand

and assess capacity requirements (Miller, 1988). Therefore, firms operating in stable environments are more likely to exhibit better performance.

As environments become less stable and more turbulent, predictability decreases, affecting the accuracy of demand forecasts and capacity requirements (Miller, 1988; Aldrich, 2008). Firms operating in these environments often face high levels of uncertainty and unpredictability and therefore tend to be challenged in order to maintain performance over time (Miller, 1988; Olhager et al., 2001).

While complexity has been used to describe the number of interrelationships and elements for planning and control tasks (Van Dierdonck and Miller, 1980), it has also been used as a measure for the number of firms in an industry (Boyd, 1990). Drawing on the Industrial Organization (IO) literature, competitive complexity, a sub dimension of environmental complexity, is frequently measured as market or industry concentration (Shugart, 1997). When there is high industry concentration or several strong leaders in an industry, competitiveness may remain strong but checked (Porter, 1980). Firms in industries with low concentration can avoid sharing information regarding their competitive position. These conditions tend to encourage firms to preempt competitors or engage in infighting, making the industry less stable (Porter, 1980).

A second sub-dimension of complexity identified by Cannon and St. John (2007) is process/facility complexity, defined differently from earlier definitions of complexity. Specifically, process structural complexity is a composite of three variables, i.e., the levels of mechanization, systemization and interconnections within and among the manufacturing processes (Kothe and Orne, 1989; Cannon and St. John, 2007). Increased process complexity tends to be associated with the more highly automated, capital-intensive processes associated with low cost strategies (Cannon and St. John, 2007). Indications of high process complexity are a high degree of mechanization, systemization and interconnection. Organizations pursuing an industry-wide cost leadership strategy tend to exhibit high process complexity (Kothe and Orne, 1989).

According to Porter and Spence (1982) the complexities of strategic capacity decisions that involve long lead times, lumpiness expectations regarding future demand as well as competitor's capacity decisions suggest that the optimal capacity positions of individual firms within the manufacturing industry possesses the potential to lead to significant payouts (Porter and Spence, 1982). Therefore, it is the objective of this research through synthesis of the literature from Operations Management, Industrial Organization and Strategy, to explore the relationship between a firm's capacity position and its performance over time relative to other organizations within its industry. By systematically studying the effects of strategy and environmental factors on firm's performance, this research attempts to take a more complete view regarding a firm's capacity position and its effects on overall firm performance over time.

Chapter Two synthesizes four hypotheses organized around two general research questions:

1) What is capacity position's effect on overall performance for firms within an industry?
2) What effects organizations' environments have on firms' capacity strategies and performance over time?

The four hypotheses were tested using secondary data sources, including COMPUSTAT and U.S. Economic Census data. The COMPUSTAT database is well suited to this study as a source of archival data because of the range of data covering a large number of years, variables and industries. A description and discussion of the Hierarchical Linear Modeling (HLM) models in Chapter 3 will be followed by research results in Chapter Four and a discussion of the implications of those findings in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Capacity and Operations Management

This chapter surveys literature concerning capacity's relationship with performance and introduces a contingency model of capacity and performance that will serve as the foundation for this research. The contingencies incorporated in this model reflect assertions from a variety of literatures regarding the effect(s) of an organization's environment. Following the development of the model, hypotheses are proposed and discussed. An outline of the literature surveyed follows in Table 2.1.

One of the most important decisions faced by an organization concerns the decision to make changes to its capacity position (Porter, 1980; Hayes and Wheelwright, 1984). For instance, a firm that chooses not to expand at a time when others in the industry are doing so may miss important opportunities vital to its long-term operations. On the other hand, an organization that reduces capacity, relative to its competitors, may find itself in a greatly compromised competitive position. A firm in this position may find that by reducing its capacity it may have trimmed production costs, but may no longer have sufficient capacity to respond to unexpected demand or growth

Conversely, a firm that simultaneously expands with other firms in the industry may be placing itself at an increased risk of suffering, along with its competitors, which frequently results in an industry wide overcapacity problem (Lieberman, 1987). Porter (1980) suggests, however, that for firms with excess cash reserves there are real advantages to consider. Firms operating in uncertain environments may be less risk averse because of their reserves and more likely to rush to expand capacity ahead of its competitors. Organizations that successfully implement a preemptive strategy often benefit from the first mover's advantage, resulting in shorter lead times for equipment orders, lower costs for construction, materials and equipment all of which position a firm to take advantage of increased demand when it occurs.

Table 2.1 Literature Review

Section	Theory Base
Capacity Position	Operations Management
	Strategy Literature
Capacity Strategy, and Performance	Operations Management
	Strategy Literature
	Industrial Organization
	Management
	Economics
Environments Dynamism and Complexity	Sociology
	Operations Management
	Management
	Organization Theory

Lieberman (1987) suggested that capacity decisions may evoke a "prisoner's dilemma", a perspective in which capacity can be either a competitive weapon or a competitive millstone. Capacity decisions are often made more complicated by their nature; even if the mechanics of the decision are straightforward, the lag between the decision and its realization is often measured in years and requires the commitment of resources well into the future (Porter, 1980). Compounding the problem of lead times is the fact that, often, capacity expansions are permanent. Thus, while a strategy to adjust capacity may be intended to improve organizational performance it may not deliver the desired outcomes. Adjusting a firm's capacity levels is a complex problem for the majority of manufacturers. Not only does it require a firm to assess a large number of options specific to its own operations, but it must also assess the position and expectations of its competitors as well as future demand for all (Porter, 1980). Thus, the importance of understanding the competitive implications of a firm's capacity position is a strong motivation for this research and a significant contribution for both researchers and operations practitioners.

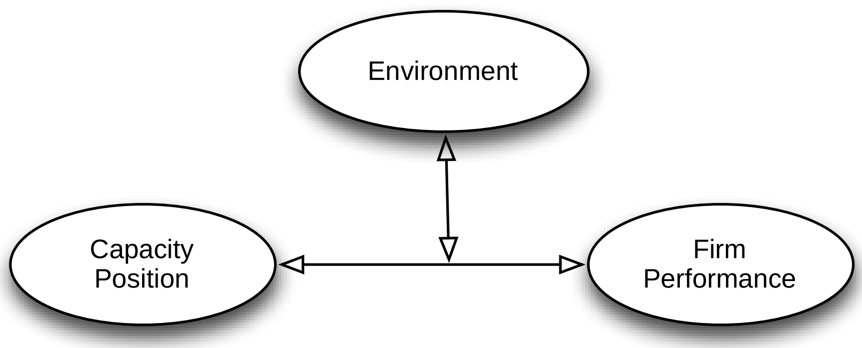


Figure 2.1 Theoretical Framework

2.1.1 Capacity Position

The term *capacity* takes on various meanings in the literature and is generally used to represent a ceiling on the rate at which a system can produce outputs or process inputs (Meredith and Shafer, 2010). In the most basic sense, production capacity is the ability of an organization to meet market demand (Hayes and Wheelwright, 1984). The inexactness of this definition is exacerbated by the fact that capacity can be measured either in inputs processed or outputs produced. For example, an airline might use the number of reservations as one measure of capacity and the number of available seat miles as another. Hayes and Wheelwright (1984) suggest that the definition of capacity is dependent on the type of production processes. A job shop may measure capacity in monetary terms whereas a continuous flow operation may express capacity only in terms of its actual outputs (Hayes and Wheelwright, 1984).

Over time, a firm attempts to anticipate and match demand by making capacity decisions related to the type, the size, and the timing of the capacity needed. Hayes and Wheelwright (1984) viewed the size and type of capacity to be that part of an organization's capacity strategy normally treated as the sizing decision. The timing decision of when to adjust capacity levels, however, is related to the difference between the demand forecasted and the available capacity (Hayes and Wheelwright, 1984). If the available capacity is greater than anticipated demand, anticipated capacity utilization tends to be low. If forecast demand matches or exceeds available capacity, anticipated utilization will be high (Olhager et al., 2001). Capacity utilization then, as a function of the timing decision, is an important component relating to a firm's capacity strategy.

Capacity utilization can be viewed as a capacity cushion, which is defined as the amount of capacity in excess of that needed to meet the expected demand (Hayes and Wheelwright, 1984). For example, a 20% capacity cushion is equivalent to an 80% utilization rate (Hayes and Wheelwright, 1984). Long-term capacity strategies may involve the use of excess production resources such as facilities, equipment or labor (Hayes and Wheelwright, 1984).

A capacity cushion can enable an organization to adapt successfully to external pressures, such as shifts in that firm's external environment, and can facilitate strategic changes such as product innovations or the adoption of new technologies (Bourgeois, 1981). As discretionary resources (Greenley and Okemgil, 1998) capacity cushions can be used to counter competitors' moves to accommodate unexpected demand changes, and exploit emerging opportunities (Greenley and Okemgil, 1998; Nohria et al, 1996; Daniel et al., 2004). Bourgeois (1981) suggested that having a cushion of excess resources enhances an organization's ability to survive by buffering it from environmental pressures.

Other advantages suggest that a firm may become more competitive with a capacity cushion by enabling it to be more responsive to demand (Hendricks, et al., 1995). Additionally, larger capacity cushions tend to be associated with reduced development and production lead time, making first-to-market and early-to-market strategies more feasible (Hendricks, et al., 1995).

The capacity position that a firm holds over time often reflects its capacity strategy and is explored in the next section.

2.1.2 Capacity Position as a Strategy

A firm's capacity strategy, as distinct from its capacity position, involves the pattern of capacity-related decisions or adjustments made over time (Hayes and Wheelwright, 1984). Capacity decisions involve both timing – i.e., when to expand or contract – and by what amount (Hayes and Wheelwright, 1984). The timing aspect of a capacity adjustment is concerned with balancing forecast demand for capacity with supply of capacity (Olhager et al., 2001). Using Olhager et al.'s (2001) definition, capacity demand surplus implies that there is insufficient capacity to satisfy demand. A capacity supply surplus, on the other hand, is indicative of excess capacity, such as a capacity cushion.

A capacity strategy is typically classified as one of three ideal types: lead, lag or track (Olhager et al., 2001). A lead strategy is based on the idea of a capacity supply surplus in which the objective is to maintain a capacity cushion. For a lead strategy with increasing demand, capacity is increased in anticipation of increased demand and if the demand trend is decreasing, capacity levels are reduced incrementally to demand levels (Hayes and Wheelwright, 1984, Olhager et al., 2001). A lag strategy, referred to as a capacity demand surplus, is based on the objective of maximizing capacity utilization, i.e., targeting capacity levels to remain at or below demand levels. Capacity is increased as a result of realized demand increases. If the demand trend is negative, a firm's capacity position is decreased in anticipation of decreased demand (Olhager et al., 2001). Lead and lag strategies are viewed as pure strategies, and often may not be practical, in which case a tracking strategy is used. A tracking strategy combines aspects of both the lead and lag strategies in order to track demand as closely as possible (Hayes and Wheelwright, 1984, Olhager et al., 2001).

A capacity strategy is crafted and pursued, in part, to ensure adequate resources for creative experimentation and innovation (Bourgeois, 1981). Capacity strategies can also be oriented toward competitors, whose moves may be preempted with timely expansion by one or more (perhaps coordinated) firms (Porter, 1980). Capacity cushions serve to protect firms by providing emergency resources as buffers (Cyert and March, 1992; Anand and Ward, 2004; Dess and Beard, 1984), but they also enable firms to seize opportunities by providing for sufficient slack should such opportunities emerge (Greenley and Oktemgil, 1998). Finally, excess capacity can provide firms with the means to develop and conduct critical training capabilities or back up systems without affecting production operations (Lawson, 2001).

The size of the capacity cushion maintained by an organization is often a strategic decision involving a number of options (Bourgeois, 1981; Porter, 1980). If an organization carries too much spare capacity, operations may become inefficient. Too little spare capacity may result in a loss of sales or other constraints on action (Hayes and Wheelwright, 1984; Bradley et al., 2010). The specific role that an organization's capacity cushion takes in the strategic process is often influenced by the environment as well as organizational characteristics (Bradley et al., 2010). Unfortunately, the literature is not consistent in its depiction of the performance effects of an organization's capacity position over time. In the next two sections, research involving capacity position and firm performance – whether for good or ill – is reviewed.

2.1.3 Capacity Position as a Competitive Millstone

Maintaining a capacity cushion does not necessarily translate into a more attractive competitive position. A recent example occurred in April, 2011, as a result of Japan's natural disasters. All production capacity for several of the Japanese auto manufacturers was wiped out, including reserves, making the firms unable to satisfy demand (WSJ, 2011).

In many industries, investments in capacity expansions are large, costly and irreversible (Porter, 1980). Capacity typically must be added in large increments, often raising the likelihood of overcapacity and price-cutting (Porter, 1980). For many firms, therefore, capacity cushions are difficult to justify in the short term (Cyert and March, 1992). Organizations may view capacity cushions as wastes of resources rather than as buffers against uncertainty (Nohria and Gulati, 1996). Further, in environments marked by resource scarcity, organizations are likely to be penalized more heavily for having more capacity than necessary (Hayes and Wheelwright, 1984). Decision makers who find themselves with capacity cushions may be more inclined to satisfice rather than optimize (Cheng et al., 1997), and they may structure their firms to further personal agendas rather than wealth creation (Child, 1972; Cheng et al., 1997). Decision makers, acting as agents of the firms' shareholders, will often act to maximize their own personal interests at the expense of the shareholder's objectives. (Jensen and Meckling, 1976).

Nohria and Gulati (1996) suggested that while too little slack discourages innovation by overly constraining experimental projects, too much slack could encourage a number of other issues. Cyert and March (1963) suggested that capacity cushions might encourage managers to relax discipline involving project approval for such projects as pet projects or other initiatives of questionable value in spite of increased risk or marginal returns. Alternatively, capacity cushions may encourage reduced penalties for early termination or poorly executed projects as a result of lost interest or boredom (Nohria and Gulati, 1996).

2.1.4 Capacity Position as a Competitive Weapon

A larger capacity cushion may translate into a competitive strength by enabling an organization to be more responsive to customer demand (Hendricks and Singhal, 1995). Research has suggested that a larger cushion may facilitate research and development (R&D) that can result in new products, services, processes and procedures often leading to valuable opportunities (Cyert and March, 1963; Bradley et al., 2010; Nohria and Gulati,1996). Cyert and March (1963) also found that firms making significant technological improvements tended to carry large cushions funded by earlier successes.

Lead-time is often reduced by increasing capacity (Hendricks and Singhal, 1995). Disruptions caused by outages, unexpected demand surges, and rescheduling can often be mitigated by capacity cushions (Hayes and Wheelwright, 1984). The prospect of quicker or more consistent delivery without the use of overtime or disruption is considered reasonable justification for the expense of the additional capacity cushion.

A capacity cushion as a buffer insulates the organization from external as well as internal variation (Cyert and March, 1963; Sharfman et al., 1988). Cushions have also been shown to reduce organizational infighting or other types of internal political behaviors by providing more resources (Cheng et al., 1997; Bradley et al., 2010).

Hayes and Wheelwright (Hayes and Wheelwright, 1984) suggested that the risk of having a capacity cushion in a growing market is quite low, as excess capacity will soon be deployed. Additionally, a capacity cushion may enable an organization to attract more opportunity in a growing market especially if competitors are resource constrained (Hayes and Wheelwright, 1984). Hendricks and Singhal (Hendricks and Singhal, 1995) determined empirically that capital markets favorably view firms announcing capacity expansions.

The preceding sections suggest that the research literature is of two minds with regards to capacity position and performance. On the one hand, a capacity cushion has been seen as an important competitive weapon. On the other hand, overly large cushions are seen as deleterious to performance. In much of the research literature, however, the dynamics of capacity and performance are unexplored even though capacity is almost universally treated as an asset whose value is realized over time. The work of Hendricks and Singhal (1995), for example, largely focused on short-term market reactions to capacity expansion announcements. In this research effort, time is intended to figure prominently. Its role is explored in more detail in the following sections.

2.2 Capacity and Performance Over Time

Diverse literatures are consistent in their treatment of a capacity cushion as a form of organizational slack (Cyert and March, 1963; Hayes and Wheelwright, 1984; Porter, 1980), and both scholars and practitioners agree that most organizations operate with at least some slack

(Cyert ad March, 1963). Because a firm's capacity is positioned in both space and time, the firm's return on its capacity likely will vary substantially over time. Some research has been undertaken involving firms' capacity and their performance at particular junctures (Hendricks and Singhal, 1995; Daniel et al., 2004), but research into the ongoing performance consequences of capacity has been limited. Thus, a holistic view of the overall performance effects of firms' capacity remains largely absent from the literature (Daniel et al., 2004).

Because of sizing, location and investment issues, capacity adjustments often involve large changes either well before or well after demand actually changes. The timeframe for a firm's capacity position, therefore, generally is substantially longer than simply that period of time over which capacity is being adjusted. It likely is the case, then, that multiple periods of organizational performance would typically be necessary to assess the long-term effects of capacity decisions.

Evidence in favor of a capacity cushion acting to boost performance comes from Greenley and Oktemgil (1998), who found that high-performing British companies tended to carry large capacity cushions but lower-performing firms did not. In an earlier study, Singh (1986) determined that the indirect relationship between good performance and risk taking was mediated by organizational slack, which, he argued, allowed for greater risk-taking. In that vein, Greenley and Oktemgil (1998) focused on the minimal level of slack necessary to maintain flexibility and found that, for low-performing firms, carrying less than that minimum was not a determinant of overall performance.

The literature suggests that one reason high-performers hold more slack than low-performers is that slack allows for a wider range in responses to environmental contingencies (Greenley and Oktemgil, 1998). Further, organizations with large capacity cushions can afford to adopt structures that may not be good fits for their respective environments because the excess capacity acts to buffer them from the consequences of the mismatch (Cheng and Kesner, 1997). Additionally, Meyer (1982) found evidence to suggest that capacity cushions act as shock absorbers that minimize the effect of environmental jolts.

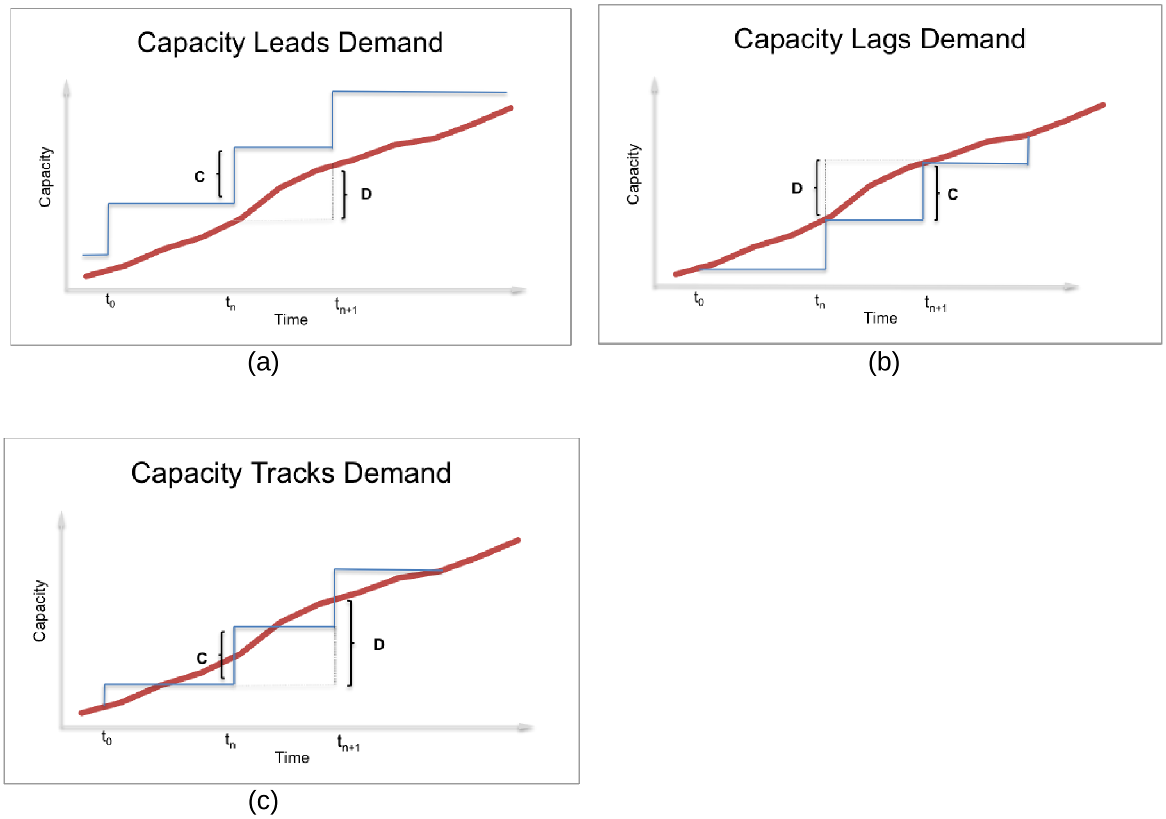


Figure 2.2 Capacity Strategies. a) Leading Strategy, b) Lag Strategy, and c) Tracking Strategy

Capacity cushions play an important role in firms' efforts to accommodate demand growth or variability (Olhager et al., 2001). Because capacity additions or reductions typically are not incremental, decision makers weigh the advantages and disadvantages as to when capacity changes are needed, i.e., whether prior to or after demand emerges (Olhager et al., 2001). According to Hayes and Wheelwright (1984) there are three strategies for responding to anticipated changes in demand: lead, lag or track (Olhager et al., 2001). A lead strategy creates capacity ahead of anticipated demand, lag anticipates decreased demand, and track anticipates no change in demand but attempts to match capacity levels with demand as closely as possible.

A leading strategy proposes to create excess capacity in anticipation of increased expected demand. As depicted in Figure 2a, a capacity addition, C, is incorporated to act as a buffer or cushion in period n prior to demand, D, being realized in t_{n+k}. One reason that a firm may be motivated to create a capacity cushion prior to demand is to reduce the likelihood of outages in the event of unexpected surges in demand or unexpected disruptions in supply (Hayes and Wheelwright, 1984). Additionally, adding capacity in anticipation of demand in a growing market may enable a firm to increase its market share ahead of its competitors who may be more concerned with short-term profitability (Hayes and Wheelwright, 1984).

Firms that take a wait-and-see approach often use a lagging strategy. A primary objective for a firm operating under this scenario is to maximize the average output rate given its design capacity by minimizing its capital investment in excess capacity (Hayes and Wheelwright, 1984). Delaying increases in its capacity position until demand materializes, as shown in Figure 2b, often provides a higher average rate of return on manufacturing investments (Hayes and Wheelwright, 1984). Since excess capacity is likely to be utilized almost immediately in a growth market (Hayes and Wheelwright, 1984), the benefit of a buffering effect from variations in expected demand or other disruptive events may be reduced. Additionally, waiting for demand to be realized before making adjustments to a firm's capacity position may be viewed as a more conservative approach that could lead to a loss in market position (Hayes and Wheelwright, 1984).

Figure 2c, a tracking strategy, depicts the scenario in which a firm attempts to match its capacity position with the average expected demand over time (Hayes and Wheelwright, 1984). The objective for a tracking policy is to balance the likelihood of having excess capacity with the likelihood of facing a shortage (Hayes and Wheelwright, 1984). In a growth market, a firm would attempt to anticipate long-term capacity requirements and make adjustments accordingly. If, however, the demand does not materialize, or is realized in a different period, the firm's ability to recover may be reduced to fewer options (Hayes and Wheelwright, 1984).

Many researchers have depicted organizational slack, of which a capacity cushion is a form, as having a positive effect on organizational performance (Cyert and March, 1963; Daniel, 2004). Davis and Stout (1992) and Jensen (1986), on the other hand, suggested that capacity cushions reduce or hinder firm performance by burdening the firm with excessive overhead. Yet both Bourgeois (1982) and Greenley and Oktemgil (1998) found evidence to suggest that slack's relationship with organizational performance is curvilinear. That is, slack improves organizational performance only to a certain point, beyond which it begins to reduce performance. Research has shown, however, that market participants generally view capacity expansions positively (Hendricks and Singhal, 1995), suggesting that the long-term effects of capacity cushions are by and large positive. Research has been consistent that facets of the environment in which the capacity is deployed also should be considered. The relationship between an organization's capacity position and its environment are thus discussed in the next section.

2.3 Capacity Position and the Environment

Researchers have long recognized that organizational studies are incomplete without the inclusion of the environment (Hayes and Wheelwright, 1979; Aldrich, 1979; Porter, 1980; Dess and Beard, 1984; Sharfman and Dean, 1991; Cannon and St. John, 2007). Aldrich (2008) was one of the earliest researchers to suggest that the study of the organization-environment framework is fundamental to understanding organizational structure as well as organizational environments (Aldrich, 2008). Contingency theorists posit that an appropriate organizational form depends on the *fit* between the organization and its environment (Aldrich, 2008) In their review of six empirical studies focused on the relationship between organizations and their environments, Lawrence and Lorsch (1967) found evidence that organizational form should vary as a result of differences in task and environmental conditions. However, exactly how organizations must vary in response to changes in their environments is often debated (Lawrence and Lorsch, 1967; Aldrich, 2008; Pfeffer and Salancik, 1978).

Tung (1979) noted that the *composition* of organizational environments is distinctly different from the *character* of organizational environments, suggesting that studies involving relationships between organizations and their environments should incorporate both. Emery and Trist (1965) suggested that organizational environments could be characterized as one of four ideal types referred to as *causal textures* and vary in terms of their increasing levels of uncertainty (Emery and Trist, 1965). Causal Textures, as defined by Emery and Trist (1965), refers to the processes that form relationships within the organizational environment, including reciprocal transactions (Emery and Trist, 1965). For example, causal textures range between stable or turbulent and simple or complex (Tung, 1979). Environmental elements in type one are often considered stable and randomly distributed. Elements in type four are unstable, turbulent and concentrated, making it the most uncertain organizational environment in which firms operate (Emery and Trist, 1965).

The composition of environments relates to the forces that comprise the focal unit's environment. Internal forces are those factors that affect the nature of the organization's products and services such as communication and networking processes within the organization's boundaries (Tung, 1979). External factors and components, such as customers, suppliers and competitors, make up or compose the external environment (Tung, 1979). This research is concerned with the external environment.

Environmental uncertainty as defined by Pfeffer and Salancik (1978) is the degree to which the future state of the environment cannot be predicted or anticipated. However, uncertainty is not necessarily indicated by change alone. In fact, environments can frequently experience considerable environmental change and still remain predictable (Pfeffer and Salancik, 1978).

Environmental unpredictability is the inability of an organization to accurately forecast the behavior of elements from its environment (Miller, 1988). It is often associated with turbulence or level of disorder and is used in the literature interchangeably with terms such as turbulence, volatility, and uncertainty (Davis et al., 2009). However, turbulence and volatility are more likely to connote a lack of environmental order whereas the term unpredictability is used to refer to the lack of pattern that disorder implies (Davis et al., 2009).

Environmental uncertainty is an important concept for organizing and operationalizing much of this research (Kotha and Nair, 1995). Duncan (1972), building on the work of earlier researchers (Emery and Trist, 1965; Terreberry, 1968), suggested that environmental uncertainty could be conceptualized in terms of two dimensions. The first dimension, the simple-complex dimension refers to the degree to which there is a small or large number of factors in a few environmental elements (Duncan, 1972). This dimension captures the essence of Pfeffer and Salancik's (1978) concentration component affecting the level of environmental uncertainty. Dess and Beard (1984) labeled the simple-complex dimension as complexity, shown in the environmental construct in Figure 2.3.

The second dimension, the static-dynamic dimension, refers to the degree to which the factors in an organization's environment are stable or changing over time (Duncan, 1972). This dimension is similar to the component affecting environmental uncertainty, referred to as the interconnectedness described by Pfeffer and Salancik (1978). Dess and Beard (1984) labeled the static-dynamic dimension as dynamism, shown as the first dimension of the construct representing the environment detailed in Figure 3. The next section will discuss the effect of the environment with regard to the relationship between a firm's capacity position and its performance.

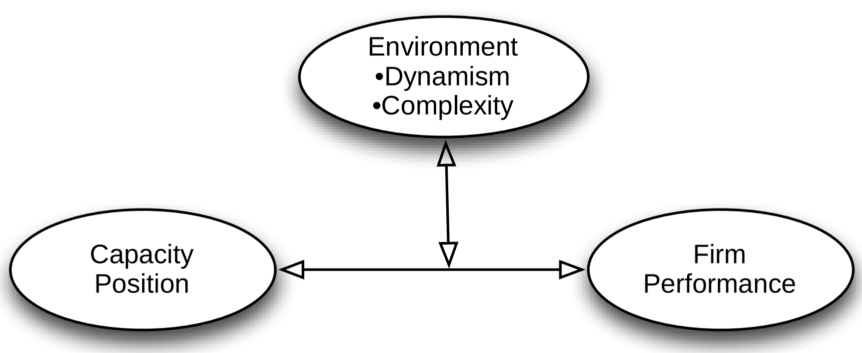


Figure 2.3 Detailed Theoretical Framework

2.3.1 Capacity Position and Dynamism

Duncan (1972) suggested that organizational environments could be described using two dimensions, the static-dynamic dimension and the simple-complex dimension. The first of these, the static-dynamic dimension, is the degree to which the organization's environmental elements remain stable over time (Duncan, 1972). Similarly, Aldrich (1979) suggested that the degree to which an organization's environment is stable or unstable is determined by the level of turnover in its environment as well as the extent to which its external environment is being disturbed by a change in the number of environmental interconnections (Emery and Trist, 1965; Terreberry, 1968; Aldrich, 1979, Sirmon et al., 2007). Aldrich (1979) referred to these characteristics as stability-instability and turbulence. Miller (1988) found that as environments become more stable, predictability improves, enabling organizations to develop standardized practices for dealing with environmental elements (Aldrich, 2008).

Dess and Beard (1984) determined that Aldrich's dimensions of stability-instability and turbulence were similar to Child's (1972) dimension of environmental variability and could more parsimoniously be represented by a single construct, environmental dynamism. While both sub-dimensions are necessary for conceptualizing and operationalizing dynamism, it is also important to capture the lack of predictability as a function of environmental change (Dess and Beard, 1984; Rasheed and Prescott, 1992).

Although both are facets of environmental uncertainty (Miller, 1980), unpredictability and dynamism are conceptually different in terms of what they measure (Bourgeois, 1980; Dess and Beard, 1984; Downey et al., 1975; Duncan, 1972; Miller, 1988). Predictability is a measure of the degree to which a firm's environmental state can be forecast and dynamism measures the variability or volatility of the environment (Boyd, 1990). Other terms used in the literature to refer to dynamism include turbulence (Tung, 1979), volatility (Bourgeois, 1985), and rate of change (Daft et al., 1988). When decision makers perceive one or more environmental components to be unpredictable, it is often the case that organizations may maintain slack resources – e.g., a capacity cushion – to offset the lack of predictability (Milliken, 1987).

As environments become more stable, predictability increases, enabling organizations to develop standardized practices and routines (Miller, 1988; Aldrich, 2008). Organizations operating in stable environments tend to more accurately forecast demand and assess capacity requirements (Miller, 1988).

As environments become less stable and more turbulent, predictability decreases, affecting not only the accuracy of demand forecasts but capacity requirements as well (Miller, 1988; Aldrich, 2008). Firms operating in these environments often face high levels of uncertainty and unpredictability and therefore tend to require larger capacity cushions (Miller, 1988; Olhager et al., 2001).

The second dimension suggested by Duncan (1972), complexity (and its subcomponents), is detailed in the next sections.

2.3.2 Capacity Position and Complexity

Environmental complexity is defined by many researchers as the heterogeneity and concentration of an organization's environmental elements (Child, 1972; Duncan, 1972; Dess and Beard, 1984; Keats and Hitt, 1988). While it has been the focus of many studies including environmental predictability (Duncan, 1972; Tung, 1979), effect uncertainty (Milliken, 1987), and dimensionality (Cannon and St. John, 2007), consensus among researchers as to these considerations remains elusive (Sharfman and Dean, 1991; Boyd et al., 1993, Dess and Beard, 1984; Cannon and St. John, 2007).

Duncan (1972), as one of the first researchers to focus on the relationship between organizations and their environments, identified two dimensions, one of which was used to characterize the perceived level of organizational complexity, i.e., the simple-complex dimension (Duncan, 1972). The simple-complex dimension accounted for similarity/dissimilarity among environmental factors as well as the number of organizational factors (Duncan, 1972). Duncan (1972) also suggested that studies involving organizations' decision-making capabilities could not be limited to internal components, but should consider external factors such as customers, suppliers, competitors and technologies (Duncan, 1972).

Aldrich (1979), critical of Duncan's (1972) measures of environmental uncertainty, suggested two dimensions of the six proposed for characterizing environmental variation (Aldrich, 2008). The first, labeled concentration-dispersion, represented the range over which resources are evenly distributed, not only in organizations' environments but also in their geographical locations (Aldrich, 2008). The second dimension, homogeneity-heterogeneity, represented the degree of similarity or lack thereof between the environmental elements in the population (Aldrich, 2008). While Aldrich (1979) disagreed with Duncan's (1972) units of analysis as well as whether to use objective or perceptual measures, Aldrich's dimensions of similarity-dissimilarity and the number of organizational factors generally correspond with Duncan's homogeneity-heterogeneity and concentration-dispersion dimensions respectively (Aldrich, 2008).

Building on the work of Child (1972), Duncan (1972), and Aldrich (1979), Dess and Beard (1984) later used factor analysis to determine that Aldrich's environmental dimensions of homogeneity-heterogeneity and concentration-dispersion formed a more parsimonious construct labeled environmental complexity (Dess and Beard, 1984). Competitive complexity, therefore, as one of two sub dimensions of environmental complexity, is detailed in the next section.

2.3.2.1 Competitive Complexity

There is a general consensus among researchers that environmental complexity involves a measure of the degree of heterogeneity and dispersion of environmental elements (Aldrich, 1979; Dess and Beard, 1984; Keats and Hitt, 1988), and most researchers have treated environmental complexity as a one-dimensional construct with mixed or inconclusive findings. Complexity, as depicted by Cannon and St. John (2007), is a multidimensional construct consisting of four factors: competitive complexity, market diversity, process/facility complexity and resource complexity. Of importance is the finding that different measures of complexity capture different dimensions of the relationship between environmental complexity and performance (Cannon and St. John, 2007).

Competitive complexity – competitive diversity – is frequently used as a proxy for environmental complexity (Aldrich, 2008; Dess and Beard, 1984; Cannon and St. John, 2007). As the number and diversity of environmental elements increases, decision makers struggle with their abilities to comprehend the relationships between them (Tung, 1979). Decision makers faced with more complex (heterogeneous) environments perceive the environment to be more uncertain, resulting in a greater need for information and knowledge (Dess and Beard, 1984; Cannon and St. John, 2007). Increased informational requirements may be due to additional organizational activities or more advanced levels of technical or intellectual capabilities needed for understanding between the customers, suppliers, technologies and sociocultural factors (Duncan, 1972; Cannon and St. John, 2007).

Competitive complexity has also been used to describe the number of interrelationships and elements for planning and control tasks (Van Dierdonck and Miller, 1980) as well as a measure of the number of firms in an industry (Van Dierdonck and Miller, 1980; Boyd, 1990). Drawing on the IO literature, competitive complexity is frequently measured as market or industry concentration (Shugart, 1997). According to Stigler (1964), the likelihood of detecting deviations from the norm in an industry is higher when industry concentration is low (Pfeffer and Salancik, 2003). One reason that this may be the case is that industries with a high concentration of firms or that appear to be homogeneous have higher information processing requirements (Keats and Hitt, 1988). Further, when there is high industry concentration or several strong leaders in an industry, such as in an oligopoly, competitiveness may remain strong but checked (Porter, 1980). If there is low industry concentration – i.e., many firms of comparable size and resource endowments – one or more organizations may try to preempt competitors, making the industry less stable (Porter, 1980).

Process complexity as a sub-dimension of environmental complexity is detailed in the next section.

2.3.2.2 Process Complexity

The second measure identified by Cannon and St. John (2007), process/facility complexity, is different from earlier discussions regarding complexity. Specifically, process structural complexity is a composite of three variables, i.e., the levels of mechanization, systemization and interconnections within and among the manufacturing processes (Kothe and Orne, 1989; Cannon and St. John, 2007). Increased process complexity tends to be associated with the more highly automated, capital-intensive processes associated with low cost strategies (Cannon and St. John, 2007).

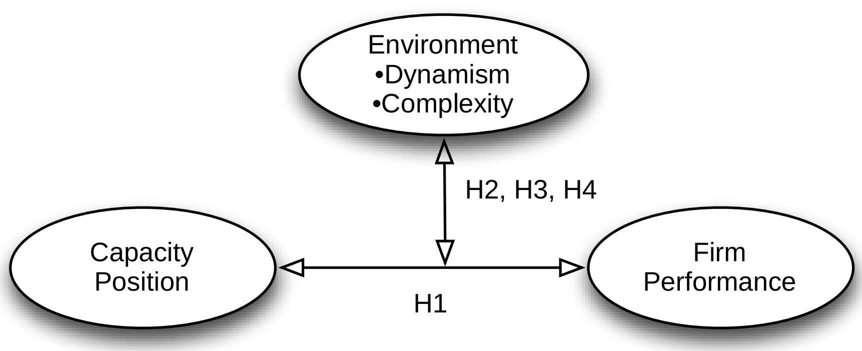


Figure 2.4 Hypothesized Relationships

Organizations that pursue an industry-wide cost leadership strategy will tend to exhibit high process complexity (Kothe and Orne, 1989). Indications of high process complexity are a high degree of mechanization, systemization and interconnection. Investments in plant equipment and technology are high with a strong emphasis on high volume and low cost. Because redundancy is low, equipment must be more reliable, supply sources more stable and production failure rates lower. These production facilities also tend to have high production standards, low levels of work in process (WIP), and high levels of automation (Kothe and Orne, 1989). Since the objective in this strategy is cost reduction, capacity cushions tend to be minimized (Kothe and Orne, 1989).

Organizations pursuing an industry-wide differentiation strategy are likely to exhibit a low degree of process complexity (Kothe and Orne, 1989). Production processes in these facilities are more likely to involve higher levels of operator control and be more subject to disruption in material flow. There also tends to be less product standardization and higher levels of raw materials (Kothe and Orne, 1989). Products are more likely to be less standard and, because cost considerations are less of a priority than customer satisfaction, excess capacity is often a consideration.

Synopses of the preceding literature are discussed and hypotheses proposed in the next section.

2.4 Research Hypotheses

Many researchers have depicted organizational slack, of which a capacity cushion is a form, as having a positive effect on organizational performance (Cyert and March, 1963; Daniel, 2004). Davis and Stout (1992) and Jensen (1986), on the other hand, suggested that capacity cushions reduce or hinder firm performance by burdening the firm with excessive overhead. Yet both Bourgeois (1982) and Greenley and Oktemgil (1998) found evidence to suggest that slack's relationship with organizational performance is curvilinear. That is, slack improves organizational performance only to a certain point, beyond which it begins to reduce performance. Research has shown that market participants generally view capacity expansions positively (Hendricks and Singhal, 1995), suggesting that the long-term effects of capacity slack are positive. This research therefore echoes this finding in hypothesizing a positive relationship between slack and firm performance over time.

H1: There is a positive relationship between a firm's relative capacity position and its performance over time.

As environments become more stable, predictability improves, enabling organizations to develop standardized practices for dealing with environmental elements (Miller, 1988; Aldrich, 2008). Organizations operating in stable environments tend to more accurately forecast demand and assess capacity requirements (Miller, 1988). Therefore, firms pursuing a cost leadership strategy tend to minimize capacity cushions (Kothe and Orne, 1989) and are more likely to exhibit better performance over time in stable environments.

As environments become less stable and more turbulent, predictability decreases, affecting accuracy of demand forecasts and capacity requirements (Miller, 1988; Aldrich, 2008). Firms operating in these environments often face high levels of uncertainty and unpredictability requiring larger capacity cushions in order to maintain flexibility (Miller, 1988; Olhager et al., 2001).

Building on these findings suggests that environmental dynamism will positively moderate the relationship between a firm's capacity cushion and its performance.

H2: Environmental dynamism will positively moderate the relationship between a firm's relative capacity position and its performance over time.

Complexity has also been used to describe the number of interrelationships and elements for planning and control tasks (Van Dierdonck and Miller, 1980). Additionally, it has been used as a measure of the number of firms in an industry group (Boyd, 1990). Drawing on the IO literature, environmental competitive complexity is frequently measured as market or industry concentration (Shughart, 1997). When there is high industry concentration or several strong leaders in an industry, such as in an oligopoly, competitiveness may remain strong but checked (Porter, 1980). If there is low industry concentration or firms tend to be comparable in size and resources, one or more organizations may try to preempt competitors, making the industry less stable (Porter, 1980).

Therefore, the level of competitive complexity will tend to positively moderate the relationship between a firm's cushion and its performance over time.

H3: Competitive complexity will positively moderate the relationship between a firm's relative capacity position and its performance over time.

Organizations pursuing an industry-wide differentiation strategy are likely to exhibit a low degree of process complexity (Kothe and Orne, 1989). Production processes in these facilities are more likely to involve higher levels of operator control and be more severely affected by disruption in material flow. There also tends to be less product standardization and higher levels of raw materials (Kothe and Orne, 1989). Products are more likely to be less standard and because cost considerations are less of a priority than customer satisfaction, excess capacity is often a consideration.

Therefore, it is expected that process complexity will negatively moderate the relationship between a firm's cushion and its performance.

H4: Process complexity will negatively moderate the relationship between a firm's relative capacity position and its performance over time.

CHAPTER 3

METHOD

3.1 Method

Decisions affecting capacity positions in organizations can be among the most critical relating to firms' operations. These decisions can affect competitiveness, flexibility, costs and profitability (Porter, 1980; Hendricks et al., 1995). Despite the importance of these decisions, however, little empirical work has been done to determine their long-term effects on performance (Hendricks et al., 1995).

In this chapter a methodology for exploring these effects is proposed. This chapter is organized as follows. First is a discussion of the overall methodology. This is followed by a discussion of the variables to be used in testing the hypotheses as proposed in chapter 2. It concludes with a discussion of the actual tests to be undertaken.

3.2 Methodology

From a theoretical perspective, problems of inference often occur when the relationships studied at one level are used to infer relationships at another level. Luke (2004) identified two such problems, the *ecological fallacy* and the *atomistic fallacy*. The ecological fallacy states that interpretation of relationships at the industry level cannot necessarily be generalized to the firm level. Similarly, the atomic fallacy suggests that inferences made at the firm level cannot be generalized to the industry level.

From a statistical perspective, problems can occur as a result of using single-level tools such as multiple regression to analyze multilevel data (Luke, 2004). The first problem is that all of the firm-level data pool into a single error term violating the basic assumption of data independence for multiple regression. Another problem is the result of ignoring the fact that the data are likely to be correlated. This leads to the incorrect assumption that the regression coefficients can be applied equally in all contexts (Luke, 2004).

Multi-level models are often deployed as analytical techniques in situations when the analyses of characteristics or processes at a higher level of analysis influence characteristics or processes at a lower level (Luke, 2004). In this study of the longitudinal effects of the environment on capacity position, there likely will be considerable variation from industry to industry within the manufacturing sector. This suggests that for each industry, the firm-level and industry-level influences on performance over time may be reflecting different underlying patterns.

Multi-level studies explicitly model the rate of change in each firm over time, referred to as random effects (Short et al., 2006). Both static and longitudinal performance parameters are simultaneously estimated. Multi-level modeling may also reduce the number of degrees of freedom because it uses simultaneous estimation techniques (Short et al., 2006). Additionally, there is no requirement for an equal number and spacing of data points for each firm, i.e., missing data is allowed. A distinct disadvantage of multi-level techniques, however, is that lower levels must be completely nested in only one higher level of analysis (Short et al., 2006).

3.3 Measures and Data

The influence of capacity position as a firm-level resource is expected to influence organizational performance. A capacity cushion represents a reserved resource that can potentially improve organizational performance over time (Short et al., 2006). Because we are interested in the relative effects of capacity position with respect to other organizations in the same industry, multi-level analysis is being used to study the industry and firm level effects and the relationship between them.

Boyd, et al. (1993) suggested that divergence between archival and perceived measures of environmental uncertainty make it important to consider the research perspective as a determinant of the appropriate approach (Boyd et al., 1993). Archival measures are considered to be more accurate for two reasons. The first reflects the concept that archival measures may be better suited to measuring external constraints (Boyd et al., 1993). Secondly, studies involving the fit between organizations and their environments are better served by archival measures (Boyd et al., 1993). Therefore, archival measures are used for this research.

The COMPUSTAT database is well suited to this study as a source of archival data because of the range of data covering a large number of years, variables and industries. To avoid industry classification and data-reporting problems, sampling is restricted to single business firms.

Table 3.1 presents details on the operationalization, measurement and source of the data for the constructs to be used in this study.

Table 3.1 Industry Operationalization and Measures

Construct	Industry-Level Operationalization	Estimation
Capacity Position	PPE	Estimated Firm Capacity Position - Property, Plant, and Equipment (GAAP - tangible fixed property used in the production of revenue (Compustat)) - $PPE = \dfrac{\%PPENT - \overline{\%PPENT}}{S_{\%PPE}}$
Dynamism	ISV	Instability of Sales – standard error of the regression slope ($Sales_{b1}$) divided by the mean value ($\overline{Y}$)
	ITE	Instability in total employment – standard error of the regression slope (EMP_{b1}) divided by the mean value ($\overline{Y}$)
Competitive Complexity	HHI	Herfindahl-Hirschman index as a measure of market concentration - $HHI = \sum_{i=1}^{n} S_i^2$ S_i = the ith firm's share of industry sales

Table 3.1 - *Continued*

	FIRM4	Market share held by 4 largest competitors – $FIRM\,4 = \sum_{i=1}^{4} S_i$ S_i = the ith firm's share of industry sales
Process Complexity	CAPINT	Average dollar value of the total long-term assets required to deliver a dollars worth of value (GAAP – invested capital (Compustat))
	SIZE	Average size of industry sales by industry – net sales (Compustat)
Firm Performance	ROA	Return on Assets
	ROI	Return on Investments
	Tobin's Q	(MVE + PS + Debt)/TA

3.3.1 Capacity Position

Organizational slack, as a form of capacity, is often the overarching firm-level construct most used in empirical studies involving capacity-performance relationships. (See Table 1.1) While various labels have been applied to the number and type of components comprising organizational slack, the variable used to operationalize it is most consistently focused on financial measurements. Thus, a firm's position with respect to slack as an operations function uses approximations of capacity position based on measures of property, plant and equipment reported in annual financial statements.

The book value of a firm's property, plant, and equipment (PPE) is used to represent its productive capacity. In this study, a firm's capacity position is operationalized as its relative position to other firms within the same industry in a two-step process. First, each firm's reported PPE is calculated as a percentage of total industry PPE, creating an industry index for each industry. Then each firm's percentage capacity position within the industry is standardized by industry. (See Table 3.1)

3.3.2 Process Complexity

Capital intensity, CAPINT, is the mix of property, plants, and equipment used for a production system (Hayes and Wheelwright, 1984) and is measured as the average dollar value of assets to produce one dollar's worth of output (GAAP – invested capital (Compustat)). Previous studies (Cannon and St. John, 2007; Kotha and Orne, 1989; Hayes and Wheelwright, 1984) suggest that operations producing large volumes or continuously running operations tend to be more complex because they are more likely to have highly automated, fully integrated processes (Cannon and St. John, 2007). These continuous, large-scale operations also tend to be capital intensive due to the specialized equipment that is often required to achieve the higher levels of scale and efficiency (Hayes and Wheelwright, 1984). Operations that tend to produce small quantities or specialized products, such as a job shop, tend to operate with general-purpose equipment. These operations are characteristic of simple processes with low capital intensity. Therefore, it would be reasonable to interpret increasing capital intensity as a proxy for process complexity.

Another characteristic of large firms with capital-intensive operations is that they tend to hold large asset accounts. In this study, the variable SIZE represents the average asset size by industry. Larger firms are more likely to operate larger facilities with more specialized equipment. As the scale and size of operations increase, process complexity also tends to increase (Hayes and Wheelwright, 1984).

CAPINT and SIZE were previously reported by Cannon and St. John (2007) as variables loading on their process complexity factor. These variables are similarly used in this research and are based on archival data available from Compustat, 2003 - 2007.

3.3.3 Competitive Complexity

A concentration ratio is an index frequently used to conceptualize the size distribution of firms within an industry (Shugart, 1997). The n-firm concentration ratio represents the total market share accounted for by the n-largest firms in an industry and is determined first by ranking all firms in an industry by the size of their market share, then dividing the sum of the n-largest firms by the total. N-firm concentration ratios have been institutionalized as tools by public policy makers for establishing standards for *competitiveness* based on levels of market concentration (Shugart, 1997). If the ratio is small, the industry will be characterized by a large number of relatively small firms. If the ratio is large, a few very large companies will dominate the industry. In this study, 4-firm (FIRM4) concentration ratios are used to capture measures of competitiveness within the manufacturing industry.

The advantage of concentration ratios is that they are simple. The disadvantage is that they do not capture the distribution of market shares among the n-largest firms. An alternative measure, the Herfindahl-Hirschman Index (HHI) takes into account both the size and distribution of market concentration within an industry. HHI is determined by summing the squared market shares of all firms within the industry and dividing by n, the number of firms in the industry. By summing the individual squared market shares, the largest firms are weighted more heavily than firms with smaller market shares. Therefore, as the distribution deviates from pure competition, the index increases. In industries that are less concentrated, i.e., HHI less than 1000, firms may more easily mask competitive moves or force competitors to conform. In industries that are more highly concentrated, there is likely to be more balance among competitors because of the potential for shared information, restricting opportunity for competition.

3.3.4 Dynamism

Industry level measures of dynamism were adapted without modification from previous research (cf., Dess and Beard, 1984; Cannon and St. John, 2007). Dynamism is operationalized as two indices of instability – sales and employment. To determine the index for sales, ISV, annual sales are regressed onto a time trend to obtain the resulting slope coefficients. Then the slope coefficients are divided by the average industry value of sales to create the Instability of Sales index, ISV.

Similar procedures were followed to calculate the Instability in Total Employment. Dynamism is generally assumed to be high in industries exhibiting high levels of instability.

3.3.5 Firm Performance

Firm level measures of performance were adapted without modification from previous research (cf., Dess and Beard, 1984; Cannon and St. John, 2007). Two measures of firm performance, Return on Investments (ROI) and Return on Assets (ROA), are frequently used as accounting-based measures of overall firm performance. However, ROA and ROI are often criticized as inadequate measures for economic rates of return (Cannon, 2008). Therefore, an approximation of Tobin's Q is included. ROA and ROI are retained for use in this study to remain consistent with prior research.

A third measure of performance, Tobin's Q, is a widely used market-based measure of firm performance. Pervious research has cited difficulty calculating exact values of Tobin's Q and as a result often resort to an approximation, calculated as

QHat = (MVE + PS + DEBT) / TA

where MVE is the market value of outstanding shares of common stock, PS is the liquidation value of all preferred stock shares outstanding, DEBT is the (book value of long-term debt + short-term liabilities – short-term assets, and TA is the total assets variable used in the calculation of capacity position (Cannon, 2008).

3.4 Tests of Hypotheses

Hypothesis 1 will be tested using Hierarchical Multilevel Modeling (HLM or RCM), a commonly used technique used for assessing the relationship between firm performance and capacity position over time (Hedeker, 2004; Short et al., 2006; Bliese and Ployhart, 2002). We begin with the fully unconditional null model without predictor variables

$$Performance_{tij} = \pi_{0ij} + e_{tij} \quad (1)$$
$$\pi_{0ij} = \beta_{00j} + r_{0ij} \quad (2)$$
$$\beta_{00j} = \gamma_{000} + \mu_{00j} \quad (3)$$

In this model, three levels of analysis represent the individual change in firm performance, with the firm at level 1 and levels 2 and 3 representing the variation in firms' performance within an industry and the variation between industries respectively. In this case, $Performance_{tij}$ (equation 1) represents performance at time *t* for firm i from industry *j*, π_{0ij} (equation 2), represents the mean performance of firm i in industry j at time 0, and β_{00j}, equation 3 represents the mean performance in industry j. The null model is used to estimate the within-firm, between-firm, and between industry variance. The overall mean γ_{000} is the grand mean for all firms and represents the overall initial value for performance at time 0. Deviations are represented by the error term, e_{tij}, the mean deviation in mean performance of firm i. The null model indicates that all firms have the same performance, i.e., intercept and slope, and any variation between them is a result of random error.

The basic model is then extended to include a firm-specific year effect by including fiscal year in equation (4) and random effects in equation (5) to account for the firm differences in Level 2 components, r_{0ij} and r_{1ij} between each firm's trend and the overall trend for all firms. Because we are looking for the most parsimonious model, we initially assume that the trend in performance over time is linear. In order to represent the data for five consecutive years, 2003 through 2007, the year variable will range from zero to four.

$$Performance_{tij} = \pi_{0ij} + \pi_{1ij} * (YR) + e_{tij} \quad (4)$$
$$\pi_{0ij} = \beta_{00j} + r_{0ij} \quad (5)$$
$$\pi_{1ij} = \beta_{10j} + r_{1ij}$$
$$\beta_{00j} = \gamma_{000} + \mu_{00j} \quad (6)$$
$$\beta_{10j} = \gamma_{100} + \mu_{10j}$$

To test hypothesis 1, i.e., there is a positive relationship between firms' capacity positions and their relative performance within an industry, we add a level 1 predictor variable, PPE, firm level capacity position.

$$Performance_{tij} = \pi_{0ij} + \pi_{1ij} * (YR) + e_{tij} \tag{7}$$

$$\pi_{0ij} = \beta_{00j} + \beta_{01j} * (PPE) + r_{0ij} \tag{8}$$
$$\pi_{1ij} = \beta_{10j} + r_{1ij}$$

$$\beta_{00j} = \gamma_{000} + \mu_{00j} \tag{9}$$
$$\beta_{01j} = \gamma_{010}$$
$$\beta_{10j} = \gamma_{100} + \mu_{10j}$$

Fixed or random effects can be incorporated into the model to determine the degree to which firm level covariates influence firm performance. Adding a level 3 predictor, SDYN, as a moderating variable allows for a test of Hypothesis 2: environmental dynamism will positively moderate the relationship between a firm's relative capacity position and its performance over time. Support for hypothesis 2 will hold if β_{01j} is determined to be positive in the following model.

$$Performance_{tij} = \pi_{0ij} + \pi_{1ij} * (YR) + e_{tij} \tag{10}$$

$$\pi_{0ij} = \beta_{00j} + \beta_{01j} * (PPE) + r_{0ij} \tag{11}$$
$$\pi_{1ij} = \beta_{10j} + \beta_{11j} * (PPE) + r_{1ij}$$

$$\beta_{00j} = \gamma_{000} + \gamma_{001} * (SDYN_j) + \mu_{00j} \tag{12}$$
$$\beta_{01j} = \gamma_{010} + \gamma_{011} * (SDYN_j)$$
$$\beta_{10j} = \gamma_{100} + \gamma_{101} * (SDYN_j) + \mu_{10j}$$
$$\beta_{11j} = \gamma_{110} + \gamma_{111} * (SDYN_j)$$

A level 3 predictor, SCC, is added as a moderating variable to the model to test hypothesis 3: competitive complexity will positively moderate the relationship between a firm's relative capacity position and its performance over time. Support for hypothesis 3 will hold if β_{01j} is determined to be positive in the following model.

$$Performance_{tij} = \pi_{0ij} + \pi_{1ij} * (YR) + e_{tij} \tag{13}$$

$$\pi_{0ij} = \beta_{00j} + \beta_{01j} * (PPE) + r_{0ij} \tag{14}$$
$$\pi_{1ij} = \beta_{10j} + \beta_{11j} * (PPE) + r_{1ij}$$

$$\begin{aligned}
\beta_{00j} &= \gamma_{000} + \gamma_{001} * (SCC_j) + \mu_{00j} \\
\beta_{01j} &= \gamma_{010} + \gamma_{011} * (SCC_j) \\
\beta_{10j} &= \gamma_{100} + \gamma_{101} * (SCC_j) + \mu_{10j} \\
\beta_{11j} &= \gamma_{110} + \gamma_{111} * (SCC_j)
\end{aligned} \tag{15}$$

A level 3 predictor, SPC, is added as a moderating variable to the model to test hypothesis 4: process complexity will negatively moderate the relationship between a firm's relative capacity position and its performance over time. Support for hypothesis 4 will hold if β_{01j} is determined to be negative in the model.

$$Performance_{tij} = \pi_{0ij} + \pi_{1ij} * (YR) + e_{tij} \tag{16}$$

$$\begin{aligned}
\pi_{0ij} &= \beta_{00j} + \beta_{01j} * (PPE) + r_{0ij} \\
\pi_{1ij} &= \beta_{10j} + \beta_{11j} * (PPE) + r_{1ij}
\end{aligned} \tag{17}$$

$$\begin{aligned}
\beta_{00j} &= \gamma_{000} + \gamma_{001} * (SPC_j) + \mu_{00j} \\
\beta_{01j} &= \gamma_{010} + \gamma_{011} * (SPC_j) \\
\beta_{10j} &= \gamma_{100} + \gamma_{101} * (SPC_j) + \mu_{10j} \\
\beta_{11j} &= \gamma_{110} + \gamma_{111} * (SPC_j)
\end{aligned} \tag{18}$$

CHAPTER 4

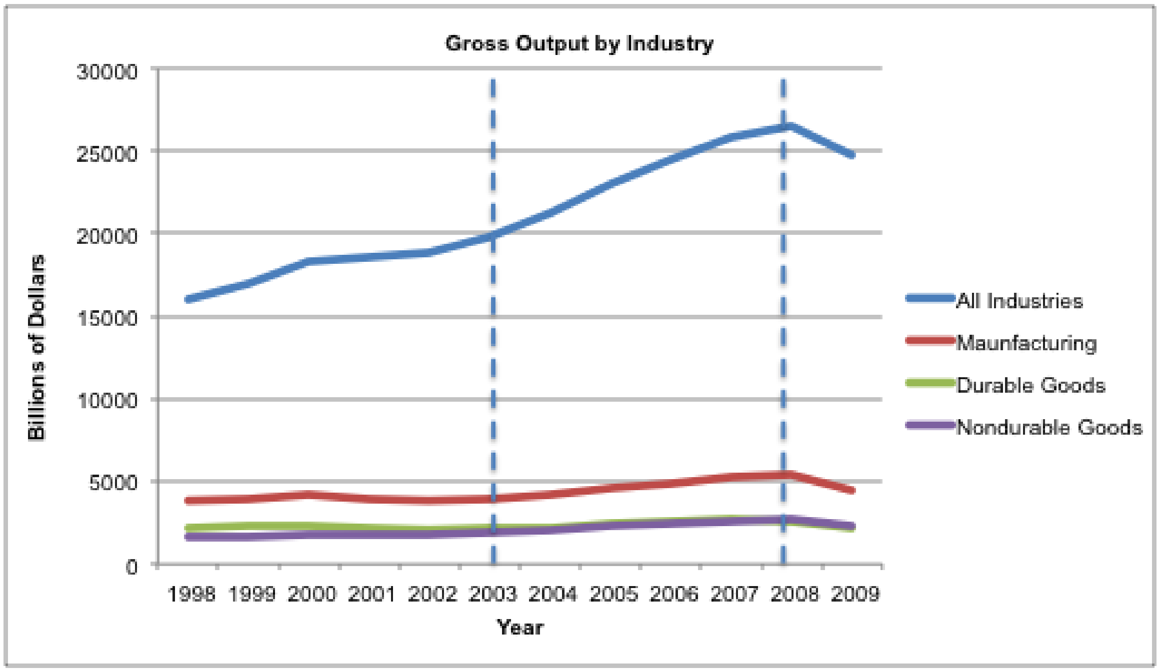
RESULTS

As discussed in Chapter 3, the hypotheses introduced in this research would be tested using Hierarchical Linear Modeling (HLM). HLM is a means by which nested, multilevel data can be analyzed and is often used to address three general research objectives: improved estimation of effects within individual firms, testing hypotheses regarding interaction effects across levels, and variance decomposition of total variance among levels (Raudenbush and Byrk, 2002; Luke, 2004; Tabachnick and Fidell, 2007). HLM requires of the researcher conformance to various assumptions, among these: 1) independent and normally distributed residuals with mean 0 and unit-level variance nested within the next higher level; 2) lower level predictors that are independent of higher level residuals, and 3) random errors at higher levels that are multivariate normal (Raudenbush and Byrk, 2002; Hoffman, 1997). Prior to the tests of hypotheses, substantial effort was undertaken to ensure conformance with these requirements. This chapter therefore reports not only results of tests of the hypotheses but also effort devoted to ensure the validity of these tests.

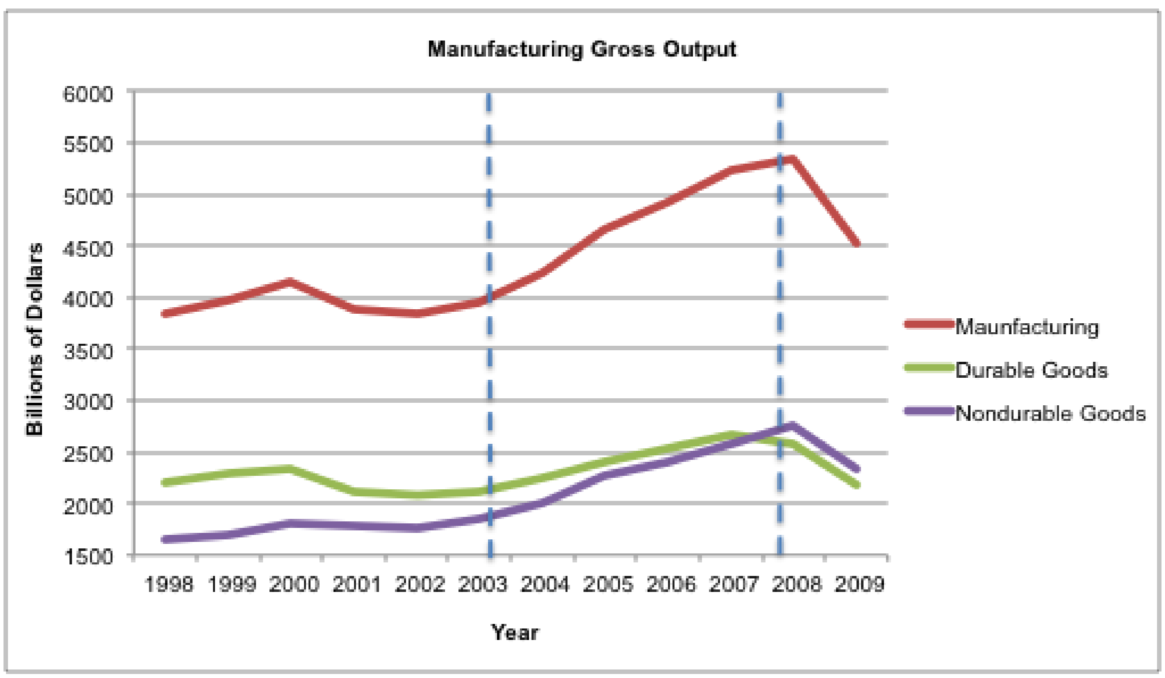
This chapter is organized as follows. First, efforts undertaken in gathering data are discussed, followed by an overview of the final dataset. Results of analyses with regard to conformance with HLM's requirements are then reported. Finally, results of the tests of the hypotheses are reviewed.

4.1 Data

In almost any empirical research effort, substantial care must be taken to ensure that tests of the hypotheses are not overwhelmed by factors outside the hypotheses' scope (Short, et al., 2006). To that end, the period of time selected for data gathering was chosen so as to minimize the effects of changes in the macro-economic environment on the capacity-performance



(a)



(b)

Figure 4.1 Gross output by Industry (GDP). Graphical representation of (a) all industries and (b) manufacturing industries.

relationships being studied. Based on data published by the U.S. Bureau of Economic Analysis (BEA), the years 1998 through 2009 were initially considered. Further examination of the BEA data suggested that, in manufacturing, output was generally increasing for the years 2003 through 2007 (Figure 4.1). It was anticipated that by focusing on such a period of continuous positive change, variation resulting from seasonal, cyclical, or environmental jolts might be minimized. Therefore, accounting data for all manufacturing firms from 2003 through 2007, inclusive, were sampled. Data were drawn from the Standard and Poor's Compustat databases – specifically the North American Annual and Industry-Specific, Segment, and Pension Data files – at both the firm and industry level.

4.1.1. Industry Measurements at the Firm Level

The U.S. Census Bureau profiles the U.S. economy every five years requiring firms with paid employees to report basic information such as location, line of business, sales, payroll, and legal form of organization. All establishments are classified on the basis of the North American Industry Classification System (NAICS) manual. Prior to 1997, the Standard Industrial Classification (SIC) system was used to classify firms. As a result, firms reporting economic and financial data prior to 1997 relied on SIC classifications. While most organization economic and financial data has been reclassified to include both NAICS and SIC classifications, practitioners and researchers alike continue to use SIC for industry classification. Reclassification between SIC and NAICS codes is complicated by the fact that some SIC codes do not have a comparable NAICS code. Therefore, to remain consistent with prior research, 4-digit SIC classifications were used as the basis for identifying manufacturing industries within the manufacturing sector for this analysis. For cases in which SIC codes have been assigned based on NAICS classifications, the NAICS description for that industry was used to establish the description for that industry's SIC code, Table 4.1.

An initial sample of financial data from approximately 3,000 manufacturing firms (SIC codes 2000 through 3999) was extracted from the Compustat databases. Each record contained a firm identifier (GVKEY), company data, and annual economic data. GVKEY is a unique identifier assigned by Compustat for each company (Standard and Poor's, 2011). Because firms can restate financials, multiple records for the same period often may be extracted. Therefore, these firms were subsequently identified and removed from the analysis to avoid duplicate or erroneously reported firm data. Firms reporting both domestic and international concerns were removed as well as those listing foreign operating locations.

In addition to firm level data, manufacturing sector data specific to firms were extracted because of this research's focus on segment related firm activities. Specifically, Compustat's segment data databases are the primary source for firm data that identifies a firm's reporting and operating methods as defined by FASB rules. According to Financial Accounting Standards Board (FASB) rules, a firm must report financial information for each segment in which it operates. Firms that: 1) were classified by their SIC code as manufacturers; and 2) had business segment sales approximately equal to total sales were assumed to be single-industry manufacturers, to which this study was limited.

Removing those firms in industries in which data were available for fewer than five firms further reduced the preliminary sample of 780 firms from 141 industries. Raudenbush and Bryk (2002) suggested a guideline of 10 observations per predictor for a multi-level analysis. Hoffman (1997) argued, however, that with regards to level-2 effects more power can be gained by using more groups with fewer individuals but also suggested that in order to detect cross-level effects, a larger number of individuals per group are needed. The decision to retain only firms in

Table 4.1 Industry groups and number of firms sampled

SIC Code	Manufacturing Industry	Single Industry Firms Sampled
2086	Bottled and Canned Soft Drinks and Carbonated Waters	7
2090	Miscellaneous Food Preparations and Kindred Products	6
2300	Apparel and Other Finished Prods of Fabrics and Similar Material	5
2330	Women's, Misses', and Juniors Outerwear	5
2510	Household Furniture	6
2833	Medicinal Chemicals and Botanical Products	6
2834	Pharmaceutical Preparations	82
2835	In Vitro and In Vivo Diagnostic Substances	26
2836	Biological Products, Except Diagnostic Substances	67
2844	Perfumes, Cosmetics, and Other Toilet Preparations	8
2870	Agriculture Soil Amendments*	5
2890	Asphalt and Concrete Release Agents*	7
3089	Plastics Products, NEC	10
3559	Special Industry Machinery, NEC	17
3571	Electronic Computers	8
3572	Computer Storage Devices	6
3576	Communication Network Equipment*	14
3577	Computer Peripheral Equipment, NEC	13
3661	Telephone and Telegraph Apparatus	12
3663	Radio and Television Broadcasting and Communications Equipment	21
3669	Communications Equipment, NEC	12
3672	Printed Circuit Boards	8
3674	Semiconductors and Related Devices	70
3679	Electronic Components, NEC	12
3690	Telecommunication Products*	8
3714	Motor Vehicle Parts and Accessories	8
3812	Systems and Instruments	9
3823	Process Variables; and Related Products	8
3825	Signals	15
3826	Laboratory Analytical Instruments	10
3827	Optical Instruments and Lenses	5
3829	Measuring and Controlling Devices, NEC	8
3841	Surgical and Medical Instruments and Apparatus	25
3842	Orthopedic, Prosthetic, and Surgical Appliances and Supplies	24
3845	Electromedical and Electrotherapeutic Apparatus	34

* Not specifically listed in 1997 U.S. Census SIC Code Table

industries with five or more firms was thought to be a reasonable middle ground between these suggestions. In sum, 587 firms distributed across 35 industries were retained for analysis. A distribution of those firms and their respective industries is depicted in Table 4.1. A listing of individual firms by SIC can be found in Appendix A.

To control for variation across industries, firm capacity (property, plant and equipment (PPE)) was standardized by fiscal year for each industry (PPE). In tests of the hypotheses, therefore, each firm's capacity position was expressed in relation to its industry average.

4.1.2. Industry-Level Measures

In addition to measures taken at the level of the firm, this research also availed itself of data exclusively at the industry level. Specifically, measures of industry-level dynamism, competitive complexity and process complexity were taken or formulated. Although two variables for each environmental dimension were observed (Dess and Beard, 1984; Nunnally, 1978; Cannon and St. John, 2007), multiple variables at higher levels in HLM raised the possibility of multicollinearity (Raudenbush, et al., 2011). An evaluation of the individual variables indicated a high degree of correlation (<0.98). In such circumstances, Tabachnick and Fidell (2007) suggest computing principal components and using those components as predictors instead of the individual variables. Therefore, prior to tests of the hypotheses these multiple measures were combined into single-variable indices tapping dynamism, competitive complexity and process complexity.

The process by which these indices were constructed involved principal components analysis with varimax (orthogonal) rotation. As seen in Table 4.2, the measures taken at the firm level demonstrated both convergent and discriminant validity. That is, those that were theoretically related loaded together (convergent validity) with no theoretically inappropriate cross-loadings (discriminant validity). The factor loadings were then used to create factor-based scores (Hair et al., 2002; Tabachnick and Fidell, 2007) for dynamism, competitive complexity, and process complexity (Hair et al., 2006). Additionally, prior research suggests that when scores on factors are estimated they are often more reliable than scores on individual observed variables (Hair et al., 2002; Tabachnick and Fidell, 2007).

Table 4.2 Factor Analysis

Factor Analysis: Maximum Likelihood / Varimax Rotated Factor Loading			
	Process Complexity	Competitive Complexity	Dynamism
sFIRM4	0.040632	0.832219	0.036335
sHHI	0.158619	0.981006	-0.111655
sISV	-0.131531	-0.142173	0.979083
sITE	-0.219076	0.063754	0.704142
sICAPT	0.963247	0.128116	-0.236095
sSALES	0.892041	0.082362	-0.160838

4.1.3. Performance Measures

As discussed in Chapter 3, multiple measures of firm performance have appeared in the literature (c.f., Dess and Beard, 1984; Cannon and St. John, 2007). For this research, three variables were chosen. These were Return on Assets (ROA), Return on Investments (ROI) and an approximation of Tobin's Q (QHat). ROA and ROI are frequently used accounting-based measures of performance and are often criticized as measures of performance. However, to facilitate linking this research with prior literature, ROA and ROI were included. Table 4.3 summarizes the performance measures for this study

Table 4.3 Performance Measures Summary

FY		2003	2004	2005	2006	2007
ROA	Avg	-0.35	-0.31	-0.31	-0.41	-0.42
	S.D.	1.35	1.27	1.32	1.75	1.90
	Min	-20.25	-15.74	-20.64	-21.55	-34.13
	Max	0.96	0.90	0.74	0.75	0.53
ROI	Avg	-0.59	0.16	-0.03	-0.12	-0.28
	S.D.	7.10	11.54	9.14	4.70	5.37
	Min	-106.90	-47.72	-95.09	-64.15	-39.46
	Max	79.72	251.59	194.13	70.81	100.47
QHat	Avg	0.27	0.25	0.21	0.18	0.21
	S.D.	0.24	0.23	0.62	0.68	0.55
	Min	-0.87	-0.95	-12.09	-10.11	-9.89
	Max	0.98	0.95	0.98	0.98	0.94

4.1.3.1 Financial Performance

ROA measures how well a firm leverages its debt and is operationalized as the ratio between a firm's earnings before interest and its total assets. Property, plant, and equipment (PPE) make up the three types of tangible assets listed on a firm's balance sheet (Libby et al., 1998) and account for the majority of these long-term firm assets. ROI is operationalized as the ratio of net income to invested capital. Both ROA and ROI are perspectives for the utilization of a firm's tangible assets. Considering the summary presented in Table 4.3, both ROA and ROI indicated slightly negative returns overall throughout the period of analysis.

4.1.3.2 Market Based Performance

The market value measure of performance, QHat, used in this study is an estimate of Tobin's Q (Tobin, 1969). It is operationalized as the ratio of a firm's market value to the replacement value of its assets. This approach, adapted from Cannon (2008), is often considered preferable to alternative financial measures due to its ability to draw on the market's assessment of a firm's financial condition. This is particularly important when multiple industries are being considered, such as in this study, and when the sources of variance are of interest. As was noted with ROI, financial measures do not necessarily distinguish between cash income and market value increases, often making it difficult to identify sources of variation (Wernerfelt and Montgomery, 1988; Cannon, 2008). Referring to the summary presented in Table 4.3, QHat appears to be positive, but slightly decreasing over the study period. This would, at first appearance, be a more accurate reflection of market indicators such as GDP.

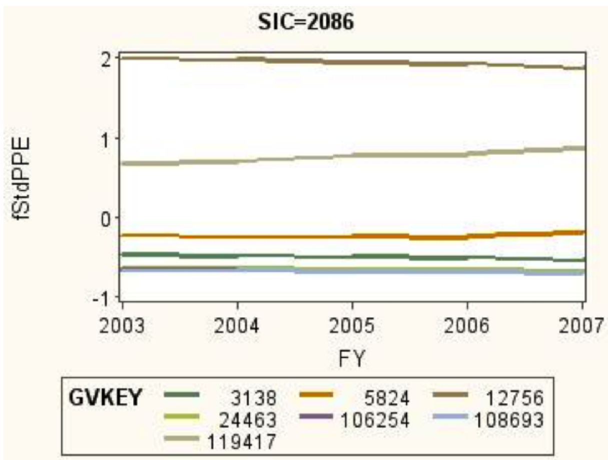
Pearson correlations shown in Table 4.4 indicate that the three performance variables tended to be weakly correlated over the study period. With the exception of the first year, FY=2003, ROI tended to be negatively correlated with ROA. ROA tended to be positively correlated with QHat. Correlations between QHat and ROI were mixed.

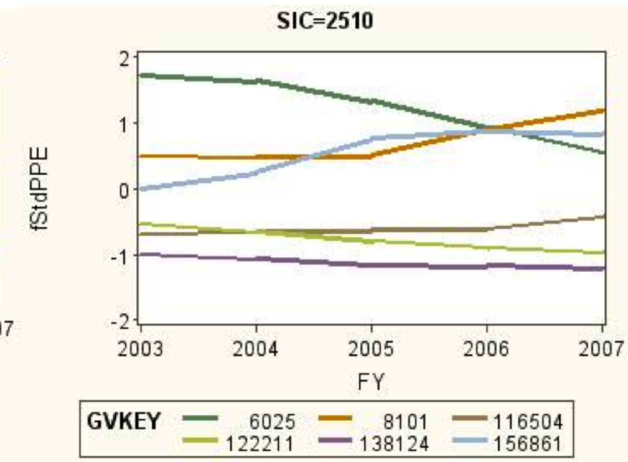
4.2. Analyses

Prior to formal tests of the hypotheses introduced in Chapter 2, graphical depiction of the data were used as a preliminary check. The null model, sometimes referred to as an unconditional means model, was initially analyzed for each of the three outcome performance variables – QHat, ROA, and ROI – to explore individual patterns of firm performance, patterns of performance within industries, and the variation in performance across industries. A graphical analysis of firms by industry (SIC) would suggest that firms pursuing a lead strategy would operate above the mean, firms pursuing a tracking strategy would operate at or near the mean, and firms pursuing a lag strategy would operate below the mean. Line plots for each industry would seem to indicate consistent patterns in relative capacity positions. Figure 4.2 contains a subset of the graphs for SIC 2086 (Bottled and Canned Soft Drinks and Carbonated Water), SIC 2510 (Household Furniture), SIC 3559 (Special Industry Machinery, NEC) and SIC 3679 (Electronic Components, NEC). These line graphs suggest that firms appear to follow particular patterns with regard to relative capacity.

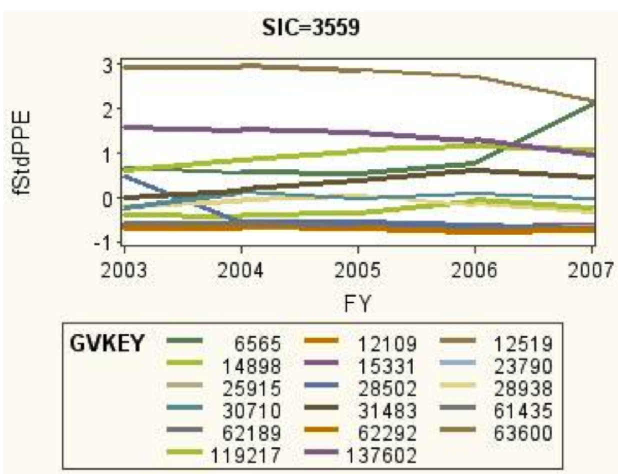
Table 4.4 Performance Correlations

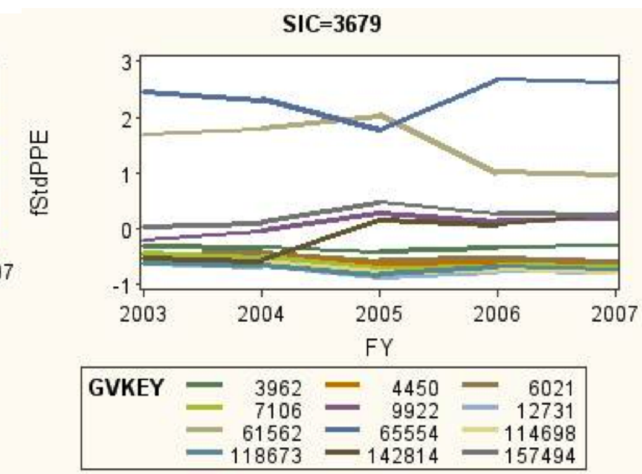
Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations															
	FY=2003			FY=2004			FY=2005			FY=2006			FY=2007		
	ROA	ROI	QHat	ROA	ROI	QHat	ROA	ROI	QHat	ROA	ROI	QHat	ROA	ROI	QHat
ROA	1	0.1513	0.0614	1	-0.3312	0.0813	1	-0.0736	0.1955	1	-0.1041	0.4321	1	-0.0617	0.4174
ROI	0.1513	1	-0.001	-0.3312	1	0.0076	-0.0736	1	-0.0461	-0.1041	1	-0.0208	-0.0617	1	0.0114
QHat	0.0614	-0.001	1	0.0813	0.0076	1	0.1955	-0.0461	1	0.4321	-0.0208	1	0.4174	0.0114	1





(a) (b)





(c) (d)

Figure 4.2 a) SIC 2086 - Bottled and Canned Soft Drinks, and Carbonated Water, b) SIC 2510 - Household Furniture, c) SIC 3559 - Special Industry Machinery, NEC, and d) SIC 3679 - Electronic Components, NEC.

Additionally, variation within firms and across industries collectively can be compared by inspection of the scatter diagrams shown in Figures 4.3 and 4.4. The scatter diagram in Figure 4.3 suggests substantial variation among firms by industry. Figure 4.4 suggests that there is substantial variation across industries in terms of firm market value performance outcomes (ROA) versus PPE. Similar graphical analysis for performance outcomes ROI and QHat also suggest variation across industries.

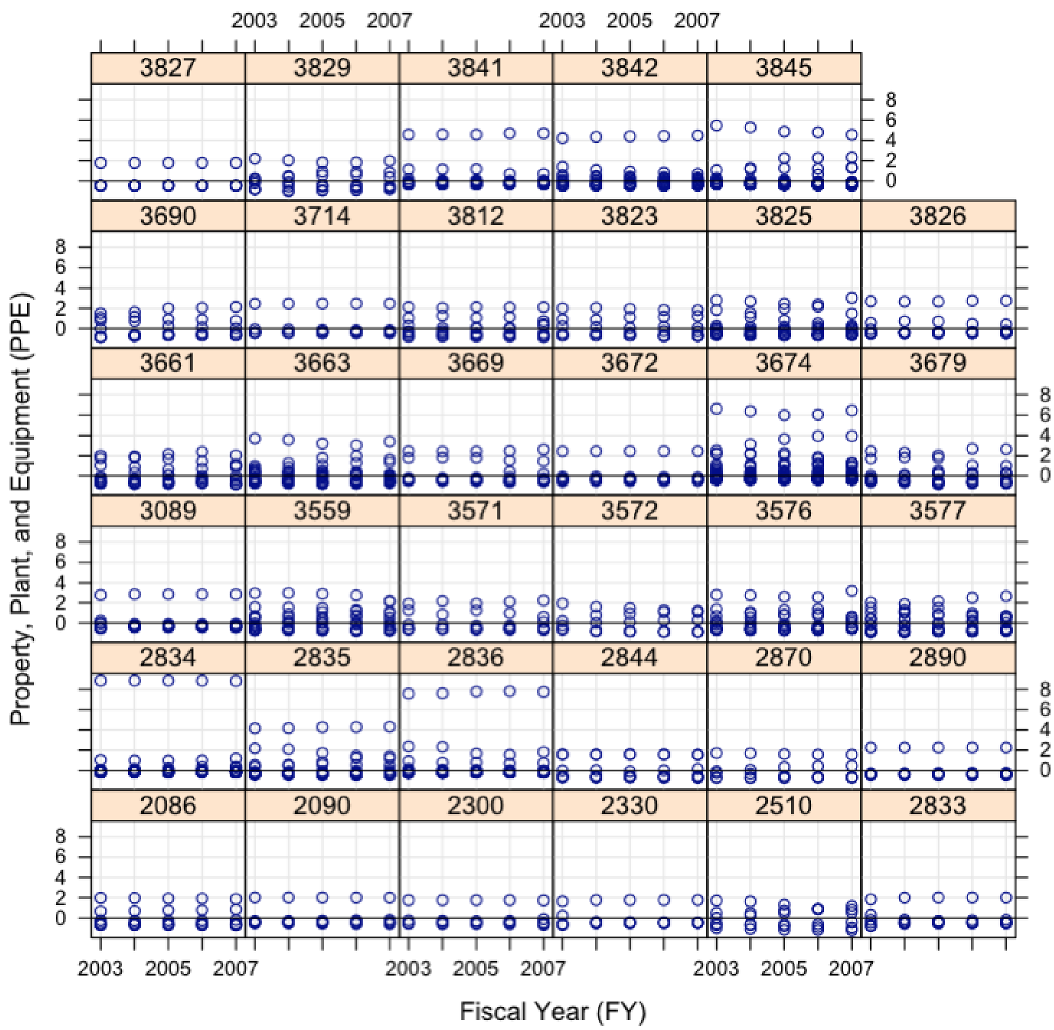


Figure 4.3 Variations Among Firms by Industry

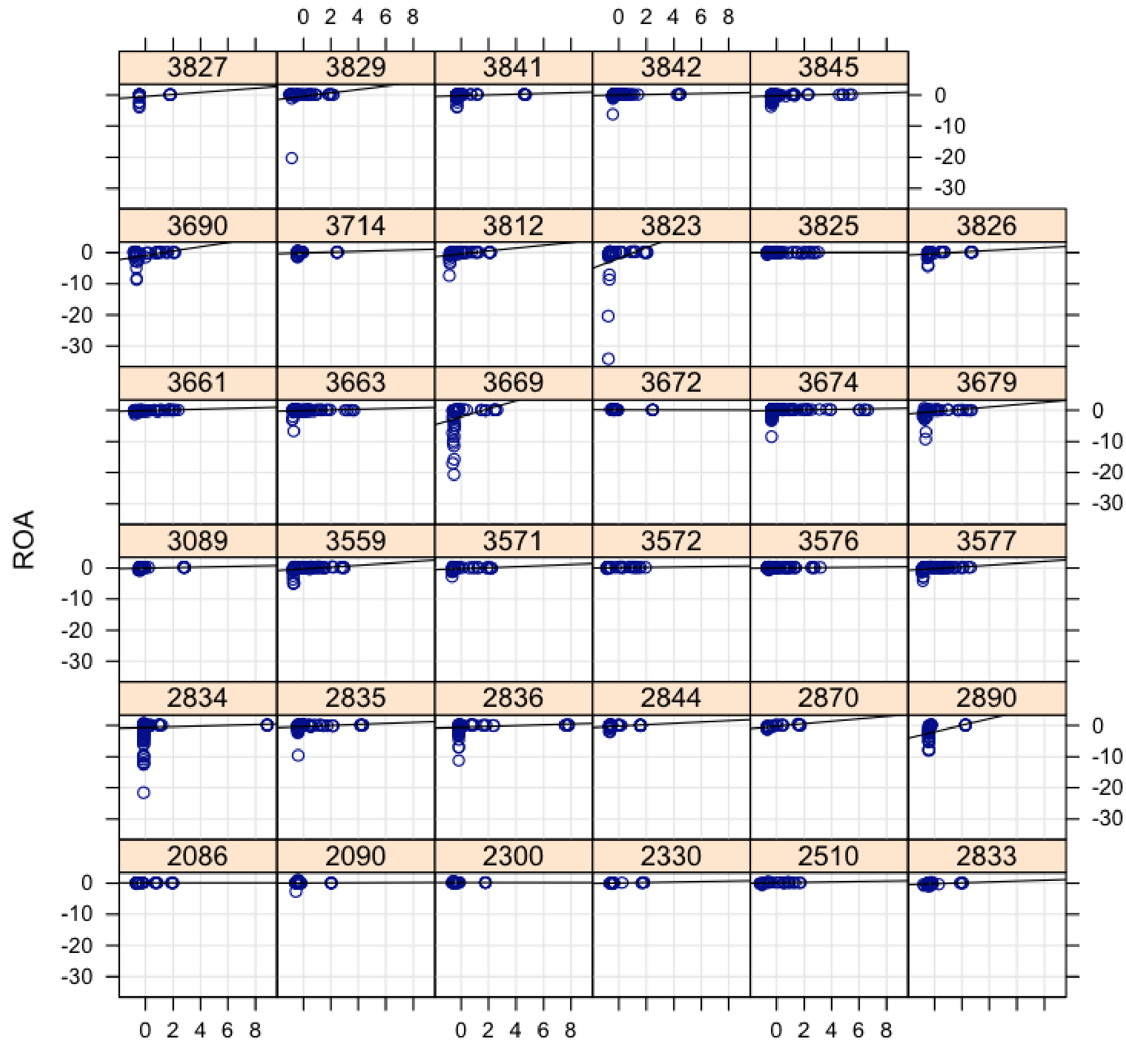


Figure 4.4 Variations Across Industries

4.3 Tests of Hypotheses

A total of seven sets of analyses were run using the three performance variables ROA, ROI and QHat. The first step was to run the base model to be used as the basis for subsequent model comparisons. The fully unconditional model with no predictors, i.e., the null or base model was analyzed to assess the potential variability at all levels. This model used three levels where level 1 represented firm-level (temporal) variation, level 2 represented within-industry variation and level 3 represented cross-industry variation. Models of increasing complexity were then created by expanding the base model to include primary variables – e.g. relative capacity position or industry factors representing dynamism, competitive complexity, and process complexity.

Firm's relative capacity position was positively associated with performance for all performance outcomes. However, only financial (ROA) performance was determined to be statistically significant. This finding suggests that over time better ROA performance is associated with increased capacity positions. Environmental dynamism was a significant moderator of the relationship between relative capacity position and firm performance for ROA and ROI. However, the effects of ROI were not in the hypothesized direction. While environmental dynamism was a positive moderator in the case of QHat, it was not found to be statistically significant. Competitive complexity positively moderated the relationship between relative capacity position and firm performance but was not significant for any measure of performance. The effects of competitive complexity were practically zero for both ROA and ROI and negative for QHat performance-capacity position relationships. Process complexity significantly moderated the relationship between ROA performance and relative capacity positions but had practically zero effect on all performance outcomes. Process complexity was not a significant moderator of the ROI or QHat performance-capacity position relationship. The results of these analyses are shown in Table 4.5 and discussed in more detail below.

4.3.1 Relative Capacity Position and ROA

The approach outlined by Raudenbush and Byrk (2002) to decompose the null model's total variance into estimates of its component variance was the first step in exploring firm level influences on performance. By dividing each measure of variance by the total variance, temporal, firm and industry effects were estimated. As shown in Table 4.5, 46% of the variance in ROA performance over the study period could be attributed to temporal effects within firms, 49% could be considered within-industry variation, and the remainder could be considered cross-industry variation. After parsing total firm performance variance into its components, the firm-level influence of firms' relative capacity position was assessed by comparing a restricted model to an unrestricted model. A restricted model was based on the assumption that all firms perform similarly over time. An unrestricted model was based on the assumption that firms' performance varies, and this model therefore allowed for a randomly varying rate of change in that performance. The differences in deviances between the restricted and unrestricted model were evaluated using the χ^2 test of equality to determine which of the two models exhibited better fit. Results of this test ($\chi^2 = 359.073$, df = 4, $p < 0.01$) suggest that the unrestricted model was a better fit over the analysis period with regard to ROA performance. This would imply that there was substantial variation between firms. The effects of this dynamic are illustrated in Figure 4.4, with ROA plotted against relative capacity positions.

Hypothesis 1 proposed a positive relationship between a firm's relative capacity position and its performance. Testing of this hypothesis was done by incorporating the firm's relative capacity position into the model. The fixed effects portion of the model was tested via a t-test and the χ^2 test was then used to validate the random effects portion of the model. The findings ($\chi^2 = 5.267$, df = 2, $p < 0.01$) suggested that the more complex model, after accounting for temporal effects, was significantly better. As shown in Table 4.5, a firm's relative capacity position had a small, positive but significant effect on firm performance. As regards random effects, a 95% confidence interval for the capacity position change's influence ranged from –0.136 to –0.035, suggesting that variation existed but its influence was small. These results imply that ROA performance, on average, improves with increases in relative capacity positions, with some firms experiencing smaller performance increases than others. Therefore hypothesis 1 was supported.

Expanding the model to include firm-level process complexity was used to assess additional firm-level influences of relative capacity position. A χ^2 test of difference in deviances suggested that the more complex model incorporating the effects of firm-level process complexity did not improve the model fit ($\chi^2 = 1.399$, df = 2). The main effect of firm-level process complexity was not significantly different from zero. Therefore, firm-level process complexity was excluded from further analysis.

Table 4.5 Results of Analyses

	Performance Variable		
	ROA	**ROI**	**Qhat**
Step 1. Apportioning variation to			
Temporal Effects (%)	46%	98%	98%
Firm Effects (%)	49%	2%	0%
Industry Effects (%)	6%	0%	2%
Step 2. Comparing restricted to unrestricted model			
Fit improvement (χ2 w/4 df)	359.073***	13.792**	979.2328***
Step 3. Testing for relative capacity (fStdRPPE) effect			
Fixed Effect	0.177	0.072	0.21
t test for H0: no effect	5.267***	1.150	1.47
Random Effect			
Upper interval limit (95% confidence)	-0.035	0.232	-682.713
Lower interval limit (95% confidence)	-0.136	-3.671	-507.356
Fit improvement (χ2 w/1 df)	14.324***	0.197	0.146***
Step 4. Incorporation of primary variables			
Estimated effect and t test for H0: no effect			
Firm level Process Complexity (fPC)	0.000	0.000	0.000
	-1.857	0.116	-0.948
PPE x Industry Dynamism (SDYN)	0.480	-0.335	17.735
	2.417**	-1.648*	0.305
PPE x Industry Competitive Complexity (SCC)	0.040	0.187	-0.255
	0.575	1.317	0.884
PPE x Industry Process Complexity (SPC)	-0.0001	-0.00002	-0.001
	-1.645*	-0.654	-0.82

*p < 0.1, **p < 0.05, ***p < 0.01

Hypothesis 2 posited that environmental dynamism positively moderates the relationship between firms' relative capacity position and their performance. Hypothesis 2 was tested by adding dynamism as a predictor (at the industry level) of the firm-level influences of capacity on performance. The results suggest that the moderating effects of dynamism are significant ($t=2.417$, $df = 513$, $p< 0.05$), moderately sized, and positive. This implies that, on average, larger capacity positions were associated with better ROA performance in more dynamic industries. Therefore hypothesis 2 was supported.

Hypothesis 3 posited that competitive complexity positively moderates the relationship between a firm's relative capacity position and its performance. Hypothesis 3 was tested by expanding the model to include a moderating factor, competitive complexity (at the industry level) predicting firm-level influences on the capacity-performance relationship. Although the point estimate for this effect was positive, evidence was not sufficient that this effect was different from zero. Therefore, hypothesis 3 was not supported.

Hypothesis 4 hypothesized that industry level process complexity would negatively moderate the relationship between a firm's relative capacity position and its performance. To assess the moderating effects of process complexity, a moderating factor was added (at the industry level). The findings indicated that this interaction effect, while modestly significant, was very small (-0.0001). The implication of this finding would be that industry-level process complexity has very little effect on the relationship between a firm's relative capacity position and its ROA. While Hypothesis 4 was therefore supported, as a practical matter this finding would seem to be minor. See Table 4.6 for a summary of the hypotheses.

4.3.2 Relative Capacity Position and QHat

Variation decomposition based on a fully unconditional model (Raudenbush and Byrk, 2002; Short et al., 2006) indicated that approximately 98% of variation in QHat performance was related to temporal effects with the remainder related to industry-specific influences. A comparison of the restricted and unrestricted models explored the potential of firms' relative capacity position as one of the firm-level influences. The restricted model assumed that all firms performed similarly over time. However, the unrestricted model accounts for differences in firms' performance by permitting a randomly varying trend to allow for variation in change as well as rate of change. The difference in deviances between the restricted and unrestricted model was evaluated using a χ^2 test of equality to determine if the restricted model was a better fit than the unrestricted model. The result of the test ($\chi^2 = 979.23$, df = 4, $p < .0001$) suggests that the unrestricted model was a better fit with regard to a firm's initial market value over the study period.

The next step tested hypothesis 1 by incorporating a firm's relative capacity position into the model. A t-test was used to evaluate the fixed effects portion of the model while a χ^2 test was used to evaluate the random effects. After accounting for temporal effects, the more complex model suggests that the effect of capacity position, on average, had a slightly positive influence on its market value. The results also indicated that there was considerable variation in firms' relative capacity positions. This finding was supported by the 95% confidence interval for firms' position change rate, which ranged from -682.72 to -507.36, suggesting that there was evidence of variation across firms with regard to relative capacity position and its effects on performance. The implication was that some firms' performance may improve more with increases in relative capacity position and others might experience reductions in performance following capacity increases.

To tease out additional influences of variability in firms' relative capacity position, firm-level process complexity was incorporated into the model. A test of the χ^2 test of differences in deviances suggests that the more complex model incorporating the effects of firm-level process complexity was a better fit ($\chi^2 = 0.763$, df = 2, $p < 0.0001$). The main effect of firm-level process complexity was practically zero and not significant, suggesting that firm's process complexity tended to be neutral with regard to market value performance at the beginning of the analysis period. The effects of incorporating firms' process complexity did not significantly alter the relationship between relative capacity position and market value performance. The fixed effects of relative capacity were insignificant. The finding for random effects indicated that the 95% confidence interval for position change rate's effect ranged from -851.804 to -336.152. This would imply that throughout the analysis period, firms tended to be below average with regards to relative capacity positions. Therefore hypothesis 1 was not supported in this set of tests.

Hypothesis 2 posited that environmental dynamism positively moderates the relationship between firms' relative capacity position and market value performance. This was tested by including the industry level factor, dynamism, as a predictor at the firm level. The interaction between firm-level capacity position and industry-level dynamism was used to assess dynamism's effects on the capacity-performance relationship. While the interaction was positive, its effect was not significant. Therefore, hypothesis 2 was not supported.

Hypothesis 3 posited that industry-level competitive complexity positively moderates the relationship between firms' relative capacity position and their performance. Hypothesis 3 was tested by incorporating a moderating factor, industry competitive complexity, and assessed by measuring the effect of the interaction on firm-level capacity position and performance. The findings indicated that the effects were both not significant and negative. Therefore, hypothesis 3 was not supported.

Hypothesis 4 proposed that industry-level process complexity negatively moderates the relationship between relative capacity and firms' market-value performance. The process for testing and assessing the moderating effects of process complexity was similar to the process used to test hypotheses 2 and 3. The findings indicated that the moderating effects of industry-level process complexity were not significant and practically zero. Therefore hypothesis 4 was not supported (See Table 4.6 for a summary of the hypotheses).

4.3.3 Relative Capacity Position and ROI

Firm-specific effects, using the method outlined by Raudenbush and Byrk (2002), were estimated to account for only 2% of total variation of a firm's ROI performance. The remaining 98% of variation was attributed to temporal effects within firms for the analysis period. Expanding the restricted model to incorporate randomly varying ROA trends resulted in a better fitting model ($\chi^2 = 13.792$, df = 4, $p < 0.01$). This implies that there was substantial within-firm variation regarding ROI performance.

The point estimate for capacity's influence on ROI was positive but not significantly different from zero. Therefore hypothesis 1 was not supported. The moderating effect of dynamism was significant but not in the hypothesized direction. The moderating effects of both competitive complexity and process complexity were not significantly different from zero. Thus these analyses resulted in no support for hypotheses 2, 3, and 4. Table 4.6 depicts a summary of all hypotheses across the three performance measures.

Table 4.6 Hypotheses Summary

		Performance Outcome		
Hypotheses		ROA	ROI	Qhat
H1:	There is a positive relationship between a firms relative capacity position and its firm performance.	Supported	Not Supported	Not Supported
H2:	Dynamism positively moderates the relationship between a firm's relative capacity position and its performance.	Supported	Not Supported	Not Supported
H3:	Competitive complexity positively moderates the relationship between a firm's relative capacity position and its performance.	Not Supported	Not Supported	Not Supported
H4:	Process complexity negatively moderates the relationship between a firm's relative capacity position and its performance.	Supported	Not Supported	Not Supported

CHAPTER 5

CONCLUSIONS

Firms operating in today's economic climate are faced with myriad decisions relating to capacity strategy. Prior research would suggest that a substantial capacity position could be either a blessing or a curse. Some have argued that excess capacity is costly and leads to poor performance (Davis and Stout, 1992; Jensen, 1986), while others have found evidence to suggest that excess capacity spurs innovation and buffers the organization from environmental uncertainties (Cyert and March, 1963; Daniel, 2004). Few if any of these studies have considered the long-term effects of firms' relative capacity positions. In this study, manufacturing firms' relative capacity positions are evaluated with regard to their effect on performance over time.

As noted in Chapter 1, this research embodies two broad questions concerning firms' capacity. The first question involves the relationship between a firm's relative capacity position and its performance over time as strictly a firm-level issue. The second question broadens the first to investigate the influence of firms' environments on the capacity-performance relationship. The results of this investigation are discussed in this chapter, concluding with a discussion of its limitations and suggestions for future research.

5.1 Capacity Position and Performance

Hypothesis 1 predicted a positive relationship between a firm's capacity and its performance over time. Firm-level performance was assessed from both accounting- and market-based perspectives. In two of the three instances of putting this hypothesis to a test, capacity was not significantly related to performance. However, the findings were mixed with respect to performance overall. While this would suggest that in general a positive relationship could be inferred between firms' capacity and their performance, a closer inspection of the underlying attributes of the financial measures may be warranted. One possible explanation for the mixed findings is that ROI performance may reflect multiple elements of firms' investments, not all of which are directly related to operational assets (Hilton, 1999).

The positive relationship predicted by hypothesis 1 between a firm's relative capacity and its performance over time was primarily supported by the concept that in cases in which a substantial portion of the variance in performance is at the firm level, a firm's capacity position can positively affect its performance outcomes. The fact that most organizations operate with some slack (Cyert and March, 1963) coupled with the concept of a curvilinear relationship between capacity positions and performance (Bourgeois, 1981), suggests that for some firms, the influence of capacity position on firm performance may be less positive than for other firms.

Another possible explanation for the results relating to the performance measures may be seen in the correlation analyses performed between ROA, ROI and QHat over the study period (Table 4.4). The measured degree and direction of the associations (Nunnally and Bernstein, 1994) between ROA, ROI and QHat, would seem to indicate that they might be reflecting different dimensions of firm performance.

In the multilevel analysis of this hypothesis, a null hypothesis of no relationship between firms' relative capacity positions and their performance could not be rejected at $\alpha = 0.01$ (Table 4.5) for a firm's ROA (financial) performance. Additionally, the greater precision at both levels 1 and 2 afforded by the estimates of effects uncovered by the HLM method (Short et al., 2006), bolster support for the argument that, over time, firms' capacity positions my be a strong influence of firm performance.

5.2 Environments and Capacity/Performance

Hypotheses 2, 3, and 4 predicted a series of environmental influences on the relationship between firms' relative capacity positions and their performance. Results of tests of these hypotheses are discussed in the next three sections.

5.2.1 Dynamism and Capacity/Performance

Hypothesis 2 predicted that dynamism would positively influence the relationship between firms' capacity and their performance. Higher levels of dynamism would indicate less predictability for firms, affecting both the accuracy of demand and capacity forecasts (Miller, 1988; Aldrich, 2008). The results of the analyses strongly supported the assertion of a moderating effect, but the direction of the relationship was not consistent with that asserted in the hypothesis (Table 4.5). In two of three instances – when ROA or QHat was the performance variable – dynamism's moderating effect was positive even though this moderator was not statistically significant across all three performance variables. This suggests that dynamism's role in the capacity-performance dynamic merits further theoretical development.

5.2.2 Competitive Complexity and Capacity/Performance

Hypothesis 3 predicted that competitive complexity would positively influence the relationship between firms' capacity strategies and their performance. In the multilevel analysis of this hypothesis, a null hypothesis of no moderating influence could not be rejected at $\alpha = 0.01$ (Table 4.5) when ROA, ROI (financial) or QHat (market-based) were the performance measures. However, moderation did have a negative moderating effect when a market-based measure, QHat, was employed. It is likely that because ROA and ROI are financial measures of performance, these results would be consistent with earlier research (Cannon and St. John, 2007). However, the mixed findings are an indication that a market-based measure may offer additional insight into both firm level and industry level firm performance.

5.2.3 Process Complexity and Capacity/Performance

Hypothesis 4 predicted that process complexity would have a negative moderating influence on the relationship between firms' capacity and their performance. In the multilevel test of this hypothesis, a null hypothesis of no negative influence could not be rejected at $\alpha = 0.01$ (Table 4.5) when ROI or QHat were the performance measure. Only when ROA was the performance measure did this hypothesis enjoy support. Firms operating with differentiation strategies are likely to have lower levels of process complexity, reflected by lower levels of tangible assets or debt. Therefore, it is likely that the financial performance ROA measure will be more significantly affected by higher levels of process complexity.

5.3 Research Limitations

Only when ROA was the performance measure were all hypotheses supported. Both QHat and ROI analyses resulted in no supported hypotheses. These mixed findings may be the result of 1) a fundamental misunderstanding of the relationships between relative capacity position, dynamism, competitive complexity and process complexity; or 2) inherent limitations of this research that may have interfered with a clearer interpretation of the relationships being studied. The later limitations are explored in the next section. For this reason, contributions of this study should be interpreted with caution.

5.3.1 Methodology Limitations

Although multilevel analysis allows the researcher to make certain inferences regarding the nuances of the relationships between firms and industry, there are limitations in the application of this approach that warrant caution. First, a multilevel analysis with longitudinal data requires that the study data be completely nested within a single higher level of analysis. For example, fiscal year is nested within firms, which are in turn nested within industries. The nesting requirements for HLM, therefore, preclude the inclusion of firms operating in multiple industries, which may have implications for interpreting corporate-level effects. Secondly, multilevel analysis assumes that the level 1 residuals with respect to time are independent. This assumption is potentially violated as a condition of the fact that fiscal year is firm dependent. Firms can, and do, adjust their fiscal years based on business considerations beyond the scope of this study.

Finally, the guidelines with respect to sample size requirements for hierarchical linear models continue to evolve. General recommendations (c.f. Raudenbush and Byrk (2002); Hoffman, 1997) for two-level models are well established in the literature. However, clear guidelines with respect to three-level models are less clear and often based on extrapolation of the recommendations for less complex models. While every attempt was made to adhere to these recommendations, future findings may reflect otherwise.

5.3.2 Data Limitations

The use of public data, such as that collected from Compustat, is another limitation of this study because such use excludes information for firms that are either: A) not publicly held; or B) not large enough for inclusion in the Compustat database. Restricting the analysis to single-industry firms also potentially threatened the generalizability of any findings.

5.4 Future Research Suggestions

The basis of this research rests in the synthesis of earlier Strategic and Industrial Organization studies exploring the influences manufacturing firms' capacity has on those firms' performance. Additionally, much of that research suggests that firms are not independent of their environments. As such, a complete analysis must also include aspects of firm's environments. The results of this study represent an important step in understanding the consequences of firms' capacity position since this study attempts to incorporate both temporal and environmental effects.

Future research could use multilevel analysis to analyze other cross-level effects beyond those explored here. Exploring, and potentially answering, questions relating to other factors such as innovation, technology, or structure, could demonstrate the value of contingency theories to research into manufacturing capacity. Multilevel analysis provides the tools to mitigate more commonly identified issues with longitudinal studies such as biased or inflated estimates of error. Multilevel analysis is shown to improve estimates of effects that reduce error (Short et al., 2006; Hoffman, 1997). This would suggest that researchers and practitioners alike would benefit from the increased confidence in their findings.

Two key contributions of future investigations of relative capacity positions hinge on the effective use of the role of time. The first contribution would be to mitigate any error relating to model misspecification by overcoming limitations of the model. Additionally, the ability of multilevel analysis to model predictors simultaneously at multiple levels should enable researchers to develop more accurate understandings of the factors relevant to firms' capacity strategies and their ultimate long-term capacity positions.

This study makes substantial progress towards resolving the ambiguity of capacity position as a millstone or as a competitive weapon. By explicitly modeling the effects of time on performance, multilevel analysis begins to account for the variance in performance related to firms' capacity positions at the firm level.

APPENDIX A

COMPANY LISTING BY SIC

SIC	TIC	Company Name
2086	CCE	COCA-COLA ENTERPRISES INC
	COKE	COCA-COLA BTLNG CONS
	ELDO	ELDORADO ARTESIAN SPRNGS INC
	FIZZ	NATIONAL BEVERAGE CORP
	JSDA	JONES SODA CO
	PAS	PEPSIAMERICAS INC
	PBG	PEPSI BOTTLING GROUP INC
2090	AIPC	AMER ITALIAN PASTA CO -CL A
	CHRN	CHINA HUAREN ORGANIC PRODS
	DMND	DIAMOND FOODS INC
	FARM	FARMER BROS CO
	GLDC	GOLDEN ENTERPRISES
	PSTA	MONTEREY GOURMET FOODS INC
2300	COLM	COLUMBIA SPORTSWEAR CO
	JCLY	JACLYN INC
	SGC	SUPERIOR UNIFORM GROUP INC
	UA	UNDER ARMOUR INC
	VLCM	VOLCOM INC
2330	3CHBD	CHAUS (BERNARD) INC
	BEBE	BEBE STORES INC
	CYDS	CYGNE DESIGNS INC
	NICH	NITCHES INC
	TAGS.1	TARRANT APPAREL GROUP
2510	FBN	FURNITURE BRANDS INTL INC
	GLDU	GUILDMASTER INC
	HOFT	HOOKER FURNITURE CORP
	SCSS	SELECT COMFORT CORP
	TPX	TEMPUR PEDIC INTL INC
	ZZ	SEALY CORP
2833	3PHLI	PACIFICHEALTH LABORATORIES
	3UGNE	UNIGENE LABORATORIES INC
	CYAN	CYANOTECH CORP
	MATK	MARTEK BIOSCIENCES CORP
	NTEC	NEOSE TECHNOLOGIES INC
	NUTR	NUTRACEUTICAL INTL CORP
2834	3ALRG	ALLERGY RESEARCH GROUP INC
	3BAZI	BAZI INTERNATIONAL INC
	3ELTP	ELITE PHARMACEUTICALS INC
	3EMIS	EMISPHERE TECHNOLOGIES INC
	3IAGX	IMAGENETIX INC
	3INSV	INSITE VISION INC
	3NVDL	NOVADEL PHARMA INC
	3NWBO	NORTHWEST BIOTHERAPEUTICS
	3SCLR	SCOLR PHARMA INC
	ADLR	ADOLOR CORP
	AGEN	AGENUS INC
	ALKS	ALKERMES INC

ALNY	ALNYLAM PHARMACEUTICALS INC
AMLN	AMYLIN PHARMACEUTICALS INC
ANDS	ANADYS PHARMACEUTICALS INC
APRI	APRICUS BIOSCIENCES INC
ARXT	ADAMS RESPIRATORY THERAPTCS
AUXL	AUXILIUM PHARMA INC
AVNR	AVANIR PHARMACEUTICALS INC
BIVN	BIOENVISION INC
BPAX	BIOSANTE PHARMACEUTICALS INC
BSTC	BIOSPECIFICS TECHNOLOGIES CP
BTRX.	BARRIER THERAPEUTICS INC
BUF	MINRAD INTL INC
CBRX	COLUMBIA LABORATORIES INC
CBST	CUBIST PHARMACEUTICALS INC
CEPH	CEPHALON INC
CGPI	COLLAGENEX PHARMACEUTCLS INC
CHTT	CHATTEM INC
CPD	CARACO PHARMACEUTICAL LABS
CRTX.	CRITICAL THERAPEUTICS INC
CYTK	CYTOKINETICS INC
DEPO	DEPOMED INC
DOVP	DOV PHARMACEUTICAL INC
DRRX	DURECT CORP
ENDP	ENDO PHARMACEUTICALS HLDGS
ENMD	ENTREMED INC
GNLB	GENELABS TECHNOLOGIES INC
GNVC	GENVEC INC
HITK	HI TECH PHARMACAL CO INC
HSP	HOSPIRA INC
ICGN	ICAGEN INC
IMGN	IMMUNOGEN INC
INGNQ	INTROGEN THERAPEUTICS INC
IPAH	INTERPHARM HOLDINGS INC
ISPH	INSPIRE PHARMACEUTICALS INC
KOSN	KOSAN BIOSCIENCES INC
LCI	LANNETT CO INC
LGND	LIGAND PHARMACEUTICAL INC
LLY	LILLY (ELI) and CO
MBRKQ	MIDDLEBROOK PHARMACEUTICALS
MBRX	METABASIS THERAPEUTICS INC
MDCO	MEDICINES CO
MDNU	MEDICAL NUTRITION USA INC
MEMY	MEMORY PHARMA CORP
MRNA	MARINA BIOTECH INC
MTEX	MANNATECH INC
MTXX	MATRIXX INITIATIVES INC
NKTR	NEKTAR THERAPEUTICS
NRGN	NEUROGEN CORP

	NRTID	INERGETICS INC
	NTMD	NITROMED INC
	NVLX	NUVILEX INC
	PHRM.	PHARMION CORP
	POZN	POZEN INC
	PPCO	PENWEST PHARMACEUTICALS CO
	QCOR	QUESTCOR PHARMACEUTICALS INC
	RELV	RELIV INTERNATIONAL INC
	RIGL	RIGEL PHARMACEUTICALS INC
	RMTI	ROCKWELL MED TECHNOLOGIES
	RNVS	RENOVIS INC
	SCLN	SCICLONE PHARMACEUTICALS INC
	SEPR	SEPRACOR INC
	SFSH	SINOFRESH HEALTHCARE INC
	SLXP	SALIX PHARMACEUTICALS LTD
	SNSS	SUNESIS PHARMACEUTICALS INC
	SYVC	SYNOVICS PHARMACEUTICALS INC
	THRX	THERAVANCE INC
	VAPHQ	VASO ACTIVE PHARMA INC
	VPHM	VIROPHARMA INC
	VTLV	VITAL LIVING INC
	VVUS	VIVUS INC
2835	3CONX	CORGENIX MEDICAL CORP
	3HMGN	HEMAGEN DIAGNOSTICS INC
	3OXIS	OXIS INTERNATIONAL INC
	ABI.3	APPLIED BIOSYSTEMS INC
	ABMC	AMERICAN BIO MEDICA CORP
	ALLP	ALLIANCE PHARMACEUTICAL
	AMAG	AMAG PHARMACEUTICALS INC
	APPY	ASPENBIO PHARMA INC
	AVTI	AVITAR INC
	BLUD	IMMUCOR INC
	CBMC	CALYPTE BIOMEDICAL CORP
	CYTO	CYTOGEN CORP
	EPIX	EPIX PHARMACUETICALS INC
	GHDX	GENOMIC HEALTH INC
	GPRO	GEN-PROBE INC
	ICCC	IMMUCELL CORP
	IMMCQ	IMMUNICON CORP/DE
	IMMU	IMMUNOMEDICS INC
	IVD	IVAX DIAGNOSTICS INC
	LXRX	LEXICON PHARMACEUTICALS INC
	MGRM	MONOGRAM BIOSCIENCES INC
	MLNM	MILLENNIUM PHARMACEUTICALS
	NNBP	NANOBAC PHARMACEUTICAL
	OSUR	ORASURE TECHNOLOGIES INC
	PTN	PALATIN TECHNOLOGIES INC
	QDEL	QUIDEL CORP

2836	3AMAR	AMARILLO BIOSCIENCES INC
	3GNTA	GENTA INC
	3HXBM	HELIX BIOMEDIX INC
	3VIONQ	VION PHARMACEUTICALS INC
	ACAD	ACADIA PHARMACEUTICALS INC
	ALTUQ	ALTUS PHARMACEUTICALS INC
	ALXN	ALEXION PHARMACEUTICALS INC
	AMGN	AMGEN INC
	ANIK	ANIKA THERAPEUTICS INC
	APHB	AMPLIPHI BIOSCIENCES CORP
	ARIA	ARIAD PHARMACEUTICALS INC
	ARQL	ARQULE INC
	ASTM	AASTROM BIOSCIENCES INC
	AVII	AVI BIOPHARMA INC
	AVRX	AVALON PHARMA INC
	AVXT	AVAX TECHNOLOGIES INC
	BCRX	BIOCRYST PHARMACEUTICALS INC
	BIIB	BIOGEN IDEC INC
	BPURQ	BIOPURE CORP
	BTX	BIOTIME INC
	CEGE	CELL GENESYS INC
	CRIS	CURIS INC
	CVM	CEL-SCI CORP
	CVTX	CV THERAPEUTICS INC
	CYTR	CYTRX CORP
	DNDN	DENDREON CORP
	DVAX	DYNAVAX TECHNOLOGIES CORP
	DYAI	DYADIC INTERNATIONAL INC
	DYAX	DYAX CORP
	ENCY	ENCYSIVE PHARMACEUTICALS INC
	GENR	GENAERA CORP
	GERN	GERON CORP
	GTCB	GTC BIOTHERAPEUTICS INC
	HEB	HEMISPHERX BIOPHARMA INC
	IDIX	IDENIX PHARMACEUTICALS INC
	IDRA	IDERA PHARMACEUTICALS INC
	IMMP	IMMTECH PHARMACEUTICALS INC
	INHX	INHIBITEX INC
	INSM	INSMED INC
	IOMI	IOMAI CORP
	ITMN	INTERMUNE INC
	LSR	LIFE SCIENCES RESEARCH INC
	MEDX	MEDAREX INC
	MNTA	MOMENTA PHARMACEUTICALS INC
	NBIX	NEUROCRINE BIOSCIENCES INC
	NCST	NUCRYST PHARMACEUTICALS CORP
	NPSP	NPS PHARMACEUTICALS INC
	NTII	NEUROBIOLOGICAL TECHN INC

	NVAX	NOVAVAX INC
	PANC	PANACOS PHARMACEUTICALS INC
	PCOP	PHARMACOPEIA INC
	PGNX	PROGENICS PHARMACEUTICAL INC
	RGBOQ	REGEN BIOLOGICS INC
	RGEN	REPLIGEN CORP
	SGEN	SEATTLE GENETICS INC
	SGMO	SANGAMO BIOSCIENCES INC
	SGXP	SGX PHARMACEUTICALS INC
	SIAL	SIGMA-ALDRICH CORP
	SIGA	SIGA TECHNOLOGIES INC
	SPPI	SPECTRUM PHARMACEUTICALS INC
	SUPG	SUPERGEN INC
	TWTI	THIRD WAVE TECHNOLOGIES INC
	URGP	URIGEN PHARMACEUTICALS INC
	VICL	VICAL INC
	XNPT	XENOPORT INC
	XOMA	XOMA LTD
	ZGEN	ZYMOGENETICS INC
2844	3EROX	HUMAN PHEROMONE SCIENCES INC
	8135A	REVLON CONSUMER PRODUCTS CP
	CAW	CCA INDUSTRIES INC
	HTEC	HYDRON TECHNOLOGIES INC
	IPAR	INTER PARFUMS INC
	RDEN	ELIZABETH ARDEN INC
	REV	REVLON INC -CL A
	SKVI	SKINVISIBLE INC
2870	3SOYL	AMERICAN SOIL TECHNOLOGIES
	AVD	AMERICAN VANGUARD CORP
	DTCT	DIATECT INTERNATIONAL CORP
	EDEN	EDEN BIOSCIENCE CORP
	TNH	TERRA NITROGEN CO -LP
2890	AROX	ALDEROX INC
	BSMD	BIOSPHERE MEDICAL INC
	CCMP	CABOT MICROELECTRONICS CORP
	LLTI	LASERLOCK TECHNOLOGIES INC
	NFTI	NOFIRE TECHNOLOGIES INC
	OTODQ	O2DIESEL CORP
	WDFC	WD-40 CO
3089	1035B	ASSOCIATED MATERIALS LLC
	3OPCO	OURPETS CO
	3SHPI	SPECIALIZED HEALTH PRODUCTS
	CGMCQ	CONGOLEUM CORP -CL A
	CHNL	CHANNELL COMMERCIAL CORP
	CMT	CORE MOLDING TECHNOLOGIES
	ENTG	ENTEGRIS INC
	GRM	GRAHAM PACKAGING CO INC
	NAMC	NORTH AMERICAN TECHNOLOGIES

	RPMM	RPM TECHNOLOGIES INC
3559	3CCEL	CRYO-CELL INTERNATIONAL INC
	ACLS	AXCELIS TECHNOLOGIES INC
	BTUI	BTU INTERNATIONAL INC
	CYMI	CYMER INC
	DDD	3D SYSTEMS CORP
	EGLSQ	ELECTROGLAS INC
	EVTN	ENVIRO VORAXIAL TECHNOLOGY
	LRCX	LAM RESEARCH CORP
	MTSN	MATTSON TECHNOLOGY INC
	QUIP	QUIPP INC
	RIMG	RIMAGE CORP
	SCNI	SCANNER TECHNOLOGIES CORP
	SMTL	SEMITOOL INC
	STHKQ	STARTECH ENVIRONMENTAL CORP
	TGALD	TEGAL CORP
	UTEK	ULTRATECH INC
	VSEA	VARIAN SEMICONDUCTOR EQUIPMT
3571	CRAY	CRAY INC
	ISWI	INTERACTIVE SYSTEMS WORLDWDE
	NDCP	NATIONAL DATACOMPUTER INC
	NWRE	NEOWARE INC
	OMCL	OMNICELL INC
	PALM	PALM INC
	SCLD	STEELCLOUD INC
	XATA	XATA CORP
3572	BCSI	BLUE COAT SYSTEMS INC
	DRAM	DATARAM CORP
	NTAP	NETAPP INC
	OVRL	OVERLAND STORAGE INC
	SNDK	SANDISK CORP
	WDC	WESTERN DIGITAL CORP
3576	3EZEN	EZENIA INC
	BRCD	BROCADE COMMUNICATIONS SYS
	CPCI	CIPRICO INC
	EFII	ELECTRONICS FOR IMAGING INC
	ELON	ECHELON CORP
	ELX	EMULEX CORP
	EXTR	EXTREME NETWORKS INC
	FDRY	FOUNDRY NETWORKS INC
	INPH	INTERPHASE CORP
	LTRX	LANTRONIX INC
	NWK	NETWORK EQUIPMENT TECH INC
	PSSR	PASSUR AEROSPACE INC
	PTIX	PERFORMANCE TECHNOLOGIES INC
	SNWL	SONICWALL INC
3577	3COPY	COPYTELE INC
	FEP.1	FRANKLIN ELECTRONIC PUBLISH

	HAUP	HAUPPAUGE DIGITAL INC
	ICAD	ICAD INC
	IOMG	I/O MAGIC CORP
	IONN.1	ION NETWORKS INC -OLD
	ISSC	INNOVATIVE SOLTNS and SUPP INC
	KTCC	KEY TRONIC CORP
	MITK	MITEK SYSTEMS INC
	NTGR	NETGEAR INC
	RSYS	RADISYS CORP
	SSYS	STRATASYS INC
	TACT	TRANSACT TECHNOLOGIES INC
3661	ATGN	ALTIGEN COMMUNICATIONS INC
	AVNX	AVANEX CORP
	ETCIA	ELECTR TELE-COMMUNCTN
	GNRD	GENERAL DATACOMM INDUSTRIES
	INTV	INTERVOICE INC
	NTFY	NOTIFY TECHNOLOGY CORP
	NVTL	NOVATEL WIRELESS INC
	OCNW	OCCAM NETWORKS INC
	SCMR	SYCAMORE NETWORKS INC
	THNKQ	THINKENGINE NETWORKS INC
	ZHNE	ZHONE TECHNOLOGIES INC
	ZOOM.1	ZOOM TECHNOLOGIES INC -OLD
3663	3ELST	ELECTRONIC SYSTEM TECH INC
	AIRO	AIRSPAN NETWORKS INC
	ANTP	PHAZAR CORP
	APSG	APPLIED SIGNAL TECHNOLOGY
	AXSI	AXCESS INTERNATIONAL INC
	AXST	AXESSTEL INC
	BDR	BLONDER TONGUE LABS INC
	CRLI	CIRCUIT RESEARCH LABS INC
	DITC	DITECH NETWORKS INC
	DSPG	DSP GROUP INC
	ENWV	ENDWAVE CORP
	LAWE	LAW ENFORCEMENT ASSOCS CORP
	LTEC	LOUD TECHNOLOGIES INC
	OPLK	OPLINK COMMUNICATIONS INC
	PRXM	PROXIM WIRELESS CORP
	RFMI	RF MONOLITHICS INC
	RWC	RELM WIRELESS CORP
	SCKT	SOCKET MOBILE INC
	TCCO	TECHNICAL COMMUNICATIONS CP
	WGNR	WEGENER CORP
	WJCI	WJ COMMUNICATIONS INC
3669	3ALRT	ALR TECHNOLOGIES INC
	3EKCS	ELECTRONIC CONTROL SECURITY
	3INSA	INVISA INC
	NIHK	VIDEO RIVER NETWORKS INC

	NSSC	NAPCO SECURITY TECH INC
	SKVY	SENTRY TECHNOLOGY CORP
	SYNX	SYNERGX SYSTEMS INC
	UUU	UNIVERSAL SECURITY INSTRUMNT
	VDSI	VASCO DATA SEC INTL INC
	VII	VICON INDUSTRIES INC
	VSTI	VERSUS TECHNOLOGY INC
	WOAM	WORLD AM INC
3672	BHE	BENCHMARK ELECTRONICS INC
	DDIC	DDI CORP
	IEC	IEC ELECTRONICS CORP
	JBL	JABIL CIRCUIT INC
	MFLX	MULTI-FINELINE ELECTRON INC
	PKE	PARK ELECTROCHEMICAL CORP
	PLXS	PLEXUS CORP
	SGMA	SIGMATRON INTERNATIONAL INC
3674	3DION	DIONICS INC
	3LOGC	LOGIC DEVICES INC
	3MPAD	MICROPAC INDUSTRIES INC
	3SODI	SOLITRON DEVICES INC
	AATI	ADVANCED ANALOGIC TECH
	ACTL	ACTEL CORP
	ADI	ANALOG DEVICES
	AFOP	ALLIANCE FIBER OPTIC PRODUCT
	ALTR	ALTERA CORP
	ANAD	ANADIGICS INC
	API	ADVANCED PHOTONIX INC -CL A
	ATHR	ATHEROS COMMUNICATIONS INC
	AVZAQ	AVIZA TECHNOLOGY INC
	AXTI	AXT INC
	CATS	CATALYST SEMICONDUCTOR INC
	CODE	SPANSION INC
	CRUS	CIRRUS LOGIC INC
	CTLM	CENTILLIUM COMMUNICATIONS
	DIOD	DIODES INC
	ENTN	ENTORIAN TECHNOLOGIES INC
	EXAR	EXAR CORP
	HIFN	HI/FN INC
	HITT	HITTITE MICROWAVE CORP
	IKAN	IKANOS COMMUNICATIONS INC
	INVX	INNOVEX INC
	ISIL	INTERSIL CORP -CL A
	ISSI	INTEGRATED SILICON SOLUTION
	IXYS	IXYS CORP
	LDIS	LEADIS TECHNOLOGY INC
	LGVN	LOGICVISION INC
	LLTC	LINEAR TECHNOLOGY CORP
	LSCC	LATTICE SEMICONDUCTOR CORP

	MATH.1	MATHSTAR INC-OLD
	MCHP	MICROCHIP TECHNOLOGY INC
	MOSY	MOSYS INC
	MPWR	MONOLITHIC POWER SYSTEMS INC
	MSCC	MICROSEMI CORP
	MSPD	MINDSPEED TECHNOLOGIES INC
	MXIM	MAXIM INTEGRATED PRODUCTS
	NETL	NETLOGIC MICROSYSTEMS INC
	NMGC	NEOMAGIC CORP
	NSCT	NATIONAL SCIENTIFIC CORP
	NVEC	NVE CORP
	OVTI	OMNIVISION TECHNOLOGIES INC
	PANL	UNIVERSAL DISPLAY CORP
	PLAB	PHOTRONICS INC
	PLXT	PLX TECHNOLOGY INC
	POWI	POWER INTEGRATIONS INC
	PSEM	PERICOM SEMICONDUCTOR CORP
	PXLW	PIXELWORKS INC
	QLGC	QLOGIC CORP
	QUIK	QUICKLOGIC CORP
	RFMD	RF MICRO DEVICES INC
	SGTL	SIGMATEL INC
	SIGM	SIGMA DESIGNS INC
	SIMG	SILICON IMAGE INC
	SLAB	SILICON LABORATORIES INC
	SMSC	STANDARD MICROSYSTEMS CORP
	SUPX	SUPERTEX INC
	SWKS	SKYWORKS SOLUTIONS INC
	TMTA	TRANSMETA CORP
	TQNT	TRIQUINT SEMICONDUCTOR INC
	TUNE	MICROTUNE INC
	TXCC	TRANSWITCH CORP
	UCTT	ULTRA CLEAN HOLDINGS INC
	VIRL	VIRAGE LOGIC CORP
	VLTR	VOLTERRA SEMICONDUCTOR CORP
	VTSS	VITESSE SEMICONDUCTOR CORP
	XLNX	XILINX INC
	ZILG	ZILOG INC
3679	3PHPG	PHOTONIC PRODUCTS GROUP INC
	AEIS	ADVANCED ENERGY INDS INC
	CHRK	CHEROKEE INTERNATIONAL CORP
	EMAN	EMAGIN CORP
	ESP	ESPEY MFG and ELECTRONICS CORP
	NSYS	NORTECH SYSTEMS INC
	PWER	POWER-ONE INC
	SPA	SPARTON CORP
	SYNA	SYNAPTICS INC
	UVUM	UVUMOBILE INC

	VPF	VALPEY-FISHER CORP
	VRTC	VERITEC INC
3690	3XDSL	MPHASE TECHNOLOGIES INC
	ESCC	EVANS and SUTHERLAND CMP CORP
	ESIO	ELECTRO SCIENTIFIC INDS INC
	MCELQ	MILLENNIUM CELL INC
	SOTK	SONO-TEK CORP
	TNRK	TNR TECHNICAL INC
	VLNC	VALENCE TECHNOLOGY INC
	XLTC	EXCEL TECHNOLOGY INC
3714	3MREO	MIRENCO INC
	3PFTI	PURADYN FILTER TECHNOLOGIES
	5149B	UNITED COMPONENTS INC
	AXL	AMERICAN AXLE and MFG HOLDINGS
	CVGI	COMMERCIAL VEHICLE GROUP INC
	DORM	DORMAN PRODUCTS INC
	STRT	STRATTEC SECURITY CORP
	WMCO	WILLIAMS CONTROLS INC
3812	3ISEC	ISECURETRAC CORP
	AIM	AEROSONIC CORP
	APLD	APPLIED SCIENCE PRODUCTS INC
	HRLY	HERLEY INDUSTRIES INC/DE
	IDSY	I D SYSTEMS INC
	KVHI	KVH INDUSTRIES INC
	LB	LA BARGE INC
	SIRF	SIRF TECHNOLOGY HOLDINGS INC
	SNSG	SENSE TECHNOLOGIES INC
3823	DNEX	DIONEX CORP
	KTII	K-TRON INTERNATIONAL INC
	MKSI	MKS INSTRUMENTS INC
	MLAB	MESA LABORATORIES INC
	MTCH	MATECH CORP
	PPTV	PPT VISION INC
	RTEC	RUDOLPH TECHNOLOGIES INC
	TCLIF	TTC TECHNOLOGY CORP
3825	3ORFR	ORBIT/FR INC
	AEHR	AEHR TEST SYSTEMS
	ATRM	AETRIUM INC
	CMOS	CREDENCE SYSTEMS CORP
	DAIO	DATA I/O CORP
	FORM	FORMFACTOR INC
	ISOOQ	ISCO INTERNATIONAL INC
	KEI	KEITHLEY INSTRUMENTS INC
	LCRY	LECROY CORP
	LTXC	LTX-CREDENCE CORP
	MCTIQ	MICRO COMPONENT TECH
	SRTI	SUNRISE TELECOM INC
	TLGD	TOLLGRADE COMMUNICATIONS INC

	WTT	WIRELESS TELECOM GROUP INC
	XXIA	IXIA
3826	CALP	CALIPER LIFE SCIENCES INC
	CPHD	CEPHEID INC
	DYXC	DIASYS CORP
	HBIO	HARVARD BIOSCIENCE INC
	ILMN	ILLUMINA INC
	MIL	MILLIPORE CORP
	OICO	O I CORP
	OMRX	ORTHOMETRIX INC
	VRML	VERMILLION INC
	WAT	WATERS CORP
3827	3INVI	INTEGRAL VISION INC
	DYSL	DYNASIL CORP OF AMERICA
	KLAC	KLA-TENCOR CORP
	MEAD	MEADE INSTRUMENTS CORP
	OPST	OPT-SCIENCES CORP
3829	3FLXT	FLEXPOINT SENSOR SYSTEMS INC
	3MKRS	MIKROS SYSTEMS CORP
	3SRMC	SIERRA MONITOR CORP
	CATT	CATAPULT COMMUNICATIONS CORP
	EDAC	EDAC TECHNOLOGIES CORP
	FARO	FARO TECHNOLOGIES INC
	MOCO	MOCON INC
	WEX	WINLAND ELECTRONICS INC
3841	3ATCS	APOGEE TECHNOLOGY INC
	3BJCT	BIOJECT MEDICAL TECHNOLOGIES
	3CMXI	CYTOMEDIX INC
	3OISI	OPHTHALMIC IMAGING SYS INC
	ABMD	ABIOMED INC
	AIS	ANTARES PHARMA INC
	ANGO	ANGIODYNAMICS INC
	ATRC	ATRICURE INC
	ATRI	ATRION CORP
	BCR	BARD (C.R.) INC
	BSX	BOSTON SCIENTIFIC CORP
	CADMQ	CARDIMA INC
	CPTS	CONCEPTUS INC
	ELGX	ENDOLOGIX INC
	ENDO	ENDOCARE INC
	HAE	HAEMONETICS CORP
	ICUI	ICU MEDICAL INC
	MMSI	MERIT MEDICAL SYSTEMS INC
	NMTI	NMT MEDICAL INC
	NURO	NEUROMETRIX INC
	NUVA	NUVASIVE INC
	POSS	POSSIS MEDICAL INC
	REPR	REPRO MEDSYSTEMS INC

	ROCM	ROCHESTER MEDICAL CORP
	RVP	RETRACTABLE TECHNOLOGIES INC
3842	3MAMM	MAMMATECH CORP
	AHPI	ALLIED HEALTHCARE PRODS INC
	AMMD	AMERICAN MEDICAL SYSTMS HLDS
	ASNB	ADVANSOURCE BIOMATERIALS CP
	ATSI	ATS MEDICAL INC
	ECTE	ECHO THERAPEUTICS INC
	EW	EDWARDS LIFESCIENCES CORP
	IART	INTEGRA LIFESCIENCES HLDGS
	IIN	INTRICON CORP
	KNSY	KENSEY NASH CORP
	LAKE	LAKELAND INDUSTRIES INC
	LIFC	LIFECELL CORP
	MDCI	MEDICAL ACTION INDUSTRIES
	MSA	MINE SAFETY APPLIANCES CO
	MTSI	MTS MEDICATION TECHNOLOGIES
	OTIX	OTIX GLOBAL INC
	RESP	RESPIRONICS INC
	RTIX	RTI BIOLOGICS INC
	SMA	SYMMETRY MEDICAL INC
	TTG	TUTOGEN MEDICAL INC
	UPI	UROPLASTY INC
	VASC	VASCULAR SOLUTIONS INC
	WMGI	WRIGHT MEDICAL GROUP INC
	ZMH	ZIMMER HOLDINGS INC
3845	3BLFS	BIOLIFE SOLUTIONS INC
	3CAMH	CAMBRIDGE HEART INC
	3IMDS	IMAGING DIAGNOSTIC SYSTEMS
	3PLCSF	PLC SYSTEMS INC
	3POSC	POSITRON CORP
	ANGN	ANGEION CORP
	ARTC	ARTHROCARE CORP
	ASPM	ASPECT MEDICAL SYSTEMS INC
	BSDM	BSD MEDICAL CORP/DE
	CASM	CAS MEDICAL SYSTEMS INC
	CGCP	CARDIOGENESIS CORP
	CMD.1	CRITICARE SYSTEMS INC
	CNMD	CONMED CORP
	CRYO	CRYOCOR INC
	CSCX	CARDIAC SCIENCE CORP
	CUTR	CUTERA INC
	CYBX	CYBERONICS INC
	CYNO	CYNOSURE INC
	DYNT	DYNATRONICS CORP
	ECI	ENCISION INC
	EPMD	EP MEDSYSTEMS INC
	HDII	HYPERTENSION DIAGNOSTICS INC

HRT	ARRHYTHMIA RESEARCH TECH
INO	INOVIO PHARMACEUTICALS INC
ISRG	INTUITIVE SURGICAL INC
NXTM	NXSTAGE MEDICAL INC
PDMI	PARADIGM MEDICAL INDS INC
PEYE	PRECISION OPTICS CORP INC
PMTI	PALOMAR MED TECHNOLOGIES INC
SMTS	SOMANETICS CORP
STXS	STEREOTAXIS INC
ULGX	UROLOGIX INC
VASO	VASOMEDICAL INC
VNUS	VNUS MEDICAL TECHNOLOGIES

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BIOGRAPHICAL INFORMATION

Carol Cagle has more than 20 years of experience managing technological developments in the aerospace, defense, and transportation industries and is well versed in the technological tools that are essential to achieving competitive advantage in today's market. She holds a Master of Science in Management of Technology from the Georgia Institute of Technology, and a Master of Science and a Bachelor of Science in Computer Science from George Washington University and the Naval Postgraduate School, respectively. She has assessed information technology resources for leaders in the simulation industry and directed operations and application development activities involving both in-house and outsourcing functions. She has held positions including Director of IT Operations for Litton PRC, Information Technology Leader for Honeywell Aerospace, Consultant for Atlantis Systems International, and Information Systems Manager for CSX Technology. She is an active member of the Institute of Electronic and Electrical Engineers and the Association of Computing Machinery.