BUSINESS STRATEGY, MANUFACTURING FLEXIBILITY, AND ORGANIZATIONAL
PERFORMANCE RELATIONSHIPS:
A PATH ANALYSIS APPROACH*

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It has been argued in the literature that business strategy and manufacturing flexibility independently affect the performance of an organization. However, no empirical examination of the interrelationship among these three constructs has been performed. In this paper, based on a field study of 269 firms in the manufacturing industry, the identified constructs have been used to test a theoretical model using path analysis techniques. Our results indicate that business strategy contributes both directly and indirectly to organizational performance. The findings provide evidence of direct effects of (i) business strategy on manufacturing flexibility and (ii) manufacturing flexibility on organizational performance.

(MANUFACTURING FLEXIBILITY; BUSINESS STRATEGY; ORGANIZATIONAL PERFORMANCE; PATH MODEL)

1. Introduction

Manufacturing flexibility is one of the most difficult goals for organizations to achieve. Concomitantly, evidence suggests that the focus of competition in global markets is shifting from quality and service toward flexibility (Ferdows and De Meyer 1989). In Europe, for example, extensive programs are being initiated to enhance manufacturing flexibility. These include implementation of advanced manufacturing technology, decrease of cycle times through lead time and setup time reductions (Giffi, Roth, and Seal 1990).

Manufacturing flexibility is a multidimensional concept (in this paper manufacturing flexibility and flexibility are used interchangeably). It ensures that the manufacturing process is both cost-efficient and effective in that it can produce customized products without sacrificing either objective. As setup time decreases, small-batch production can be as economical as large-scale manufacturing, enabling an organization to change its competitive strategy from emphasizing economies of scale to emphasizing economies of scope (Goldhar and Jelinek 1983). Flexibility can be used both as an adaptive response to environmental uncertainty and to proactively create market uncertainties for competition (Gupta and Goyal 1989; Gerwin 1993). For example, in 1981 Honda exploited

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the benefits of flexibility in inducing customers to expect more frequent changes from
the motorcycle industry. In their battle with Yamaha for supremacy in the industry, over
a period of 18 months, Honda introduced or replaced 113 models, effectively turning
over its entire product line twice. Interestingly, Yamaha managed to complete only 37
changes during the same period, thus creating the consumer perception that Yamaha
motorcycles were old, redundant, and unattractive compared to Honda’s. This forced
Yamaha to withdraw its challenge (Stalk and Hout 1990). According to Sethi and Sethi
(1990, p. 295) “manufacturing flexibility clearly has major implications for a firm’s
competitive strength. This significant role of manufacturing flexibility makes it a part of
the firm’s strategy.” Moreover, flexibility cannot be bought; it must be planned and
managed (Gustavsson 1984).

Despite the widespread acceptance of flexibility’s role in enhancing our competitive
position, the management of flexibility remains poorly understood in industry (Cox
1979; Miller and Roth 1987; Tombak and De Meyer 1988; Zammuto and O’Connor
1992). Manufacturing flexibility does not receive adequate attention at the time of
decision making for investment in manufacturing technology (Adler 1988), nor does
it receive adequate recognition in the implementation phase (Jaikumar 1986). Slack
(1987) in a study of 10 manufacturing companies observed that managers had a partial,
rather than comprehensive, view of manufacturing flexibility. Managers focused on
machine rather than system flexibility [using Buzacott’s (1982) distinction], frequently
limiting themselves to a particular type of resource. While it is very tempting to think
in this fashion, this strategy may result in a serious mistake. Machine level flexibility
alone (e.g., versatile numerical control (NC) machines) does not adequately ensure a
competitive edge and will elevate competitiveness only if the added advantage of flex-
bility in the management of the system (e.g., alternate routing policy) is present. In
the same study, Slack (1987) found that managers sought to limit the need for flexibility
by pursuing three broad strategies: (i) by limiting product range and discouraging fre-
quent product modifications; (ii) by pursuing make-to-stock rather than make-to-order;
and (iii) by matching market segmentation with segmentation of the production system,
thus reducing the product range.

On the research front, the scope of research on manufacturing flexibility has remained
quite narrow. Recent literature has focused on defining types of flexibility and identifying
systems that exhibit one or more of these (for example, see Browne et al. 1984; Chatterjee,
Cohen, Maxwell, and Miller 1984; Carter 1986; Gerwin 1987; Son and Park 1987; Brill
and Mandelbaum 1989; Hyun and Ahn 1990). Few researchers have examined measure-
ment issues for various types of flexibility (for example, see Masuyama 1983; Chung
and Chen 1990; Dixon 1992; Gupta and Goyal 1992; Gupta and Somers 1992). There
is little agreement on how to define flexibility, how to achieve flexibility, or what are the
costs and benefits of more, or less, flexibility. For example, some researchers, have viewed
flexibility primarily in terms of programmable machines and capabilities for mixing
models in production (Taymaz 1989). Others have viewed this only in terms of versatility
of people and skills (Walton and Susman 1987). Additionally, some studies treat flexibility
and flexible manufacturing systems (FMS) as equivalent concepts. In actuality, they are
not the same. FMS is one method of acquiring flexibility. Other avenues include workers
with broad skills, flexible production management techniques, and the development of
networks of dependable suppliers. Researchers have also implicitly or explicitly assumed
that more flexibility is always better (notable exceptions are Cusumano 1988; Tombak
1988). Flexibility may actually make the players worse off (for example, see Gaimon
and Singhal 1992) in some situations.

On the basis of the above discussion, it is apparent that achieving manufacturing
flexibility is a critical source of competitive advantage for many organizations. Upton
(1994) while concurring with this view highlighted that:
CEOs know this, managers know it, and shop floor operators know it. However, the exhortation heard time and time again to "go forth and be flexible" is hollow and meaningless. Managers find themselves unable to express exactly what it is that needs to be improved, without some more precise way of defining the direction of improvement. Quite often, management needs to identify multiple types of flexibility and split them up so they can be prioritized, measured and improved, each by appropriate mechanisms.

The literature on manufacturing flexibility is fragmented and does not provide answers to the basic question of manufacturing organizations: Given that flexibility is a multi-dimensional concept and that the need for each dimension may vary, under what level would a given flexibility be appropriate in improving organizational performance? As stated earlier, more flexibility in itself is not necessarily useful. The appropriate degree of flexibility depends on what a firm is aiming to achieve in terms of its products, behavior of its competitors, product-demand characteristics, and other factors (Suarez, Cusumano, and Fine 1992). We deal with the above question by investigating how business strategy and dimensions of manufacturing flexibility are related to organizational performance.

1.1. Motivation for Research

Our analysis is motivated in part by the recent work of Get-win (1993) who reviewed the literature concerning the strategic aspects of manufacturing flexibility. He established a research agenda for the area. First, research is needed to determine the extent of which manufacturing flexibility has an impact on a company's performance. A few investigators have reported relationships between specific types of flexibility and performance. Kekre and Srinivasan (1990), for example, investigated the positive and negative effects of product line breadth (in this paper we equated this to process flexibility or mix flexibility as some researchers have termed it) on firm performance. Their results provided some empirical support for the benefits of process flexibility by demonstrating that a broader product line is associated with significant market share benefits and increases in firms' profitability. We recognize that at the conceptual level, equating of product line to process flexibility and then taking the relationship between product line breadth and performance as evidence of a direct relationship between flexibility and performance may be too aggressive. At the operational level, though incomplete, breadth of product line may be an acceptable measure of process flexibility. The breadth of the product line will have positive effects on market share and profitability only to the extent that manufacturing, marketing, and engineering contribute capabilities that make the products in the broader line more desirable to the customer than the competitors' products.

Fiegenbaum and Karnani (1991) analyzed data on 83 industries to study the differences between small and large firms for volume flexibility. They concluded that small firms tend to show more volume flexibility than large firms and that small firms are able to trade cost inefficiency with volume flexibility to increase their profits. Tombak (1988) pursued the question of whether flexibility affects a firm's performance by using a sample of 1,445 business units drawn from profit impact of market strategy (PIMS) database. He examined the relationship between manufacturing flexibility and a firm's performance in the growth and mature phases of the product life cycle. He found that flexibility was an important explanatory variable for a firm's performance. Tombak and De Meyer (1988) acknowledged the multidimensional nature of flexibility by arguing that firms planning to introduce FMS should be concerned with both "mix flexibility" and the flexibility needed to accommodate the variance in inputs to the production process. Recently, Suarez, Cusumano, and Fine (1992) conducted a field study using 31 printed-circuit board (PCB) assembly organizations. They concluded that increase in mix and new product flexibility does not lead to higher costs or lower quality. These studies tend to view flexibility as a unidimensional concept. Jaikumar (1986), for example, implicitly refers to flexibility as the ability of a system to produce a wide variety of parts. Using
Browne et al.'s (1984) taxonomy, this flexibility can be termed as "mix flexibility." Yet this is merely one of the different types of flexibility available to a firm. Fiegenbaum and Karnani (1991) consider only volume flexibility. On the other hand, Suarez, Cusumano, and Fine (1992) did examine the multidimensional nature of flexibility. However, the special characteristics of the PCB industry and the relatively small size of the sample may prohibit us from generalizing their results to other industries. More specifically, these studies did not examine how other dimensions of flexibility are related to performance, nor did they consider business strategy, which in turn is hypothesized to directly affect performance (Swamidass and Newell 1987) and flexibility (Jaikumar 1986).

2. Background

In this section we review the literature relevant to each of the constructs used in this paper.

2.1. Business Strategy

Business strategy can be viewed as a part of the widely accepted hierarchy of strategy suggested by several researchers including Hofer and Schendel (1978) and Fine and Hax (1985). This hierarchy can be visualized to have three levels: corporate-level strategy, business-level strategy, and functional-level strategy. Corporate-level strategy formulation in conglomerate diversified firms is mainly characterized by the consideration of scope and resource deployments. At the business level, the scope and boundaries of each business unit (SBU) and the operational links with corporate strategy are specified. The basis on which the business unit will achieve and maintain a competitive advantage within its industry is also established. At the functional level [e.g., marketing strategy, manufacturing strategy, and research and development (R&D) strategy], the objectives are to support the desired business level strategy in a manner that will provide a competitive advantage and to determine how the functional level strategies will complement each other.

Recently, Venkatraman (1989) categorized the literature on business strategy (henceforth termed as strategy) measurement approaches into three types: (1) narrative approach, (2) classificatory approach, and (3) comparative approach.

The narrative approach is based on a premise that strategy of an organization is unique and should only be described in its holistic and contextual form (Andrews 1971). The implication of this approach is that strategy can (and should) be best described verbally. Any attempt to develop a measurement scheme will be incomplete. This view of strategy measurement may have a role in the conceptual development; it has limited use for testing theories (Venkatraman 1989).

The classificatory approach attempts to uncover underlying dimensions of strategy that are generalizable across several firms. This attempt has led to an operational definition in terms of strategy typologies based on conceptual classifications (for example, see Hofer and Schendel 1978; Miles and Snow 1978; Porter 1980) and strategy taxonomies based on empirical classifications (for example, see Hambrick 1984).

The comparative approach attempts to identify and measure key traits of strategy constructs. Consequently, the focus is less on categorization into one cell of the typology or taxonomy but on measuring the differences along a set of characteristics that collectively describe the strategy construct (for example, see Venkatraman 1989).

According to Venkatraman and Grant (1986), most of the strategy construct measures are either nominal scales with questionable measurement properties or multi-item scales whose measurement properties have not been systematically assessed. Venkatraman (1989), using the comparative approach, developed the theoretical underpinnings of the strategy construct for business strategy by proposing six dimensions of strategy: aggressiveness, analysis, defensiveness, futurity, proactiveness, and riskiness. This dimensionality...
was derived and tested by treating the individual dimensions as a building block. Venkatraman (1989) suggested that his measure for strategy could be used to test theoretical relationships. In this paper, we have used the measures of strategy provided by Venkatraman (1989). Definitions of the six strategy dimensions are as follows:

**Aggressiveness:** This dimension reflects the posture adopted by an organization in allocating its resources for improving market positions at a relatively faster rate than the competitors in its chosen market.

**Analysis:** This dimension refers to the tendency of an organization to search deeper for the roots of problems and to generate the best possible solutions alternatives. It also includes the extent to which an organization uses appropriate management systems such as information and control systems and managerial reward systems.

**Defensiveness:** This dimension captures the defensive behavior of an organization through the extent to which the organization employs cost reduction and efficiency seeking methods.

**Futurity:** This dimension reflects temporal considerations embedded in key strategic decisions, in terms of relative emphasis of effectiveness considerations versus efficiency considerations. Emphasis on basic research, for example, is most likely to have longer term focus than application-oriented research programs that reflect shorter term focus. This aspect is operationalized by emphasizing sales forecasting and customer preferences as well as tracking of environmental trends.

**Proactiveness:** This dimension reflects proactive behavior about participation in emerging industries, continuous search for market opportunities, and experimentation with potential responses to changing environmental trends.

**Riskiness:** This dimension captures the extent of riskiness in various resource allocation decisions as well as choice of products and markets.

### 2.2. Manufacturing Flexibility

A number of classifications of manufacturing flexibility and measures are given in the literature (Mandelbaum 1978; Kusiak 1985; Frazelle 1986; Upton and Barash 1988; Gupta and Goyal 1989; Hutchinson and Sinha 1989; Taymaz 1989). A most thorough classification was proposed by Sethi and Sethi (1990) who identified 11 different flexibility dimensions. Gupta and Somers (1992) developed an instrument to measure manufacturing flexibility and conducted an empirical study to validate the dimensions of flexibility identified by Sethi and Sethi (1990). Their study revealed that 11 factors of Sethi and Sethi can be collapsed into 9 measures of flexibility.

To our knowledge, no study has identified various dimensions of flexibility. Using a field study drawn from a large sample of firms, we chose to use the measures of flexibility suggested by Gupta and Somers. These measures are as follows:

**Machine flexibility** deals with the variety of operations that the machine can perform without incurring high costs or expending a prohibitive amount of time in switching from one operation to another. Machine flexibility allows small batch sizes. This yields lower inventory costs, higher machine utilizations, the ability to produce complex parts, and improved product quality.

**Material-handling flexibility** is defined as the ability of material-handling systems to move different part types effectively through the manufacturing facility. This includes loading and unloading of parts, intermachine transportation, and storage of parts under various conditions of the manufacturing facility. In the end, material-handling flexibility may increase machine availability and reduce throughput times.

**Process flexibility** is defined as the ability of a manufacturing system to produce a set of part types without major setups, something referred to as mix flexibility by Gerwin (1987) and Carter (1986). Process flexibility is useful in reducing batch sizes and, in
Routing flexibility refers to the ability of a manufacturing system to produce a part by alternate routes through the system. The purpose of routing flexibility is to continue to produce a given set of part types, albeit at a lower rate in the event of unexpected machine breakdown. It allows for efficient scheduling of parts through improved balancing of machine loads.

Volume flexibility is the ability of a manufacturing system to be operated profitably at different overall output levels, thus allowing the factory to adjust production within a wide range.

Program flexibility is the ability of the system to run virtually unattended for a long enough period. Program flexibility reduces the throughput time through reducing setup times, improving inspection and gauging, and better fixtures and tools.

Product and production flexibility is the universe of part types that the manufacturing system can produce without adding major equipment and the ease with which new parts can be added or substituted for existing parts, i.e., the ease with which the current part mix can be changed at relatively low cost in a short period. This type of flexibility is dependent on several factors: variety and versatility of available machines, flexibility of material-handling systems, and the factory information and control systems.

Market flexibility can be defined as the ease with which the manufacturing system can adapt to changing market environment. It allows the firm to respond to changes without seriously affecting the business and to enable the firm to outmaneuver its less flexible competitors in exploiting new business opportunities.

Expansion and market flexibility is the extent of overall effort needed to increase the capacity and capability of a manufacturing system when required. This flexibility may help shorten implementation time and reduce cost for new products, variations of existing products, or added capacity.

2.3. Organizational Performance

Several authors have emphasized the importance of the performance concept and have provided prescriptions for improving organizational performance (for example, see Nash 1983). Yet the debate on issues of terminology, levels of analysis, and conceptual basis for assessment of performance continues to rage in the academic community (Ford and Schellenberg 1982). Some researchers have expressed frustration with the lack of agreement on basic terminology and definition (Kanter and Brinkerhoff 1981). Venkatraman and Ramanujam (1986) suggest that business performance is a subset of the overall concept of organizational effectiveness. They argue that in its narrowest sense, business performance is associated with simple outcome based financial indicators (referred to as financial performance) “that are assumed to reflect the fulfillment of the economic goals of the firm.” The financial performance has been most widely used to determine organizational health of a firm. Typical indicators include return on investment, return on sales, and return on equity. A broader conceptualization of business performance includes emphasis on indicators of operational performance (i.e., nonfinancial) in addition to financial indicators. Under this conceptualization, measures such as market share, new product introduction, product quality, and market effectiveness might be considered within the domain of business performance. According to Venkatraman and Ramanujam (1986, p. 804) “the inclusion of performance indicators takes us beyond the black-box approach that seems to characterize the exclusive use of financial indicators and focuses on those key operational success factors that might lead to financial performance.”

The sources of data to measure financial performance, operational performance, or both can be primary (e.g., data collected directly from organizations) or secondary (e.g., data from publicly available records). However, Venkatraman and Ramanujam (1987)
in their study of 207 senior-level managers showed that managers tend to be less biased in their assessments of their organizational performance than researchers have tended to give them credit for. They argue that the perceptual data can be employed as acceptable operationalizations of organizational performance. Similarly, they demonstrate that a positive and statistically significant association exists between primary and secondary business performance data.

3. Hypotheses

In this section we justify the relationship between business strategy, manufacturing flexibility, and organizational performance. Our adaptation of Gerwin's (1993) conceptual model, shown in Figure 1, makes explicit the expected links among the three variables: business strategy, manufacturing flexibility and organizational performance. For the purpose of simplicity, the diagram shown in Figure 1 does not show all direct and indirect paths expressed by the model. In this model, business strategy is equated with various types of manufacturing flexibility and posited as a primary influence on an organization's performance. Specifically, the recursive causal chain shown in Figure 1 hypothesizes that business strategy will trigger the development and implementation of manufacturing flexibility dimensions. The introduction of manufacturing flexibility enhances the organization's performance. Gerwin's conceptual framework describes the effects of uncertainty on manufacturing strategy, flexibility, and firm performance. In this study we have used business strategy instead of manufacturing strategy. Our reasoning is based on the fact that manufacturing flexibility is not only an element of manufacturing strategy but also related to marketing and R&D strategies (Hyun and Ahn 1990; Sethi and Sethi 1990). According to Milgrom and Roberts (1990), it may be unprofitable for a firm to enhance manufacturing flexibility without changing its marketing strategy or to alter its marketing approach without adequate manufacturing flexibility, and yet, it may be highly profitable to do both together. One can, for example, think of several situations where a
firm’s manufacturing function has done a superior job of developing process, expansion, and volume dimensions of flexibility. However, the marketing function did not take advantage of the resulting opportunities, because of lack of ability or, astonishingly, because marketing remained unaware of manufacturing’s capabilities (Cleveland, Schroeder, and Anderson 1989; Vickery, Droge, and Markland 1993). This situation may result in manufacturing flexibility having a limited impact on a firm’s performance. Successful manufacturing firms exploit complementarities that exist between various functions, such as marketing, production, engineering, and organizational variables. The exploitation of complementarities among functions is usually dictated by a coherent business strategy of the firm (Milgrom and Roberts 1990). Moreover, several researchers have argued that an organization should develop a manufacturing strategy that is consistent with and linked to its business strategy (e.g., see Hayes and Wheelwright 1984).

A study by Richardson, Taylor, and Gordon (1985) provided further evidence of the need to better understand the linkage between corporate strategy and manufacturing strategy. A field study of 64 Canadian electronics companies led the researchers to conclude that companies with a strong match between their business mission and manufacturing tasks are more profitable. They argue that the way a firm competes in its markets is a key element in determining the corporate mission. Performance will be suboptimal unless a proper congruence is achieved between the corporate mission and manufacturing strategy.

Cleveland, Schroeder, and Anderson (1989) used a sample of six hard goods manufacturers to examine the relationship between business strategy, production process, production competence, and business performance. Production competence was defined as a variable rather than a fixed attribute and measured for how well manufacturing strengths and weaknesses complement the priorities of the business strategy. The study showed that production competence is linked with business performance.

Swamidass and Newell (1987), using data gathered from 35 manufacturers, studied the relationship between environmental uncertainty, manufacturing strategy, and business performance. They defined manufacturing strategy as consisting of two types of variables: (i) content variables, such as flexibility and (ii) process variables, such as the role of manufacturing managers in strategic decision making (RMMSDM). From this they concluded that: (a) greater flexibility leads to better performance; (b) RMMSDM is a function of environmental uncertainty and higher levels of RMMSDM result in improved performance; and (c) an organization may be better able to cope with high uncertainties by increasing manufacturing flexibility and maintaining and ensuring the RMMSDM.

Schroeder, Anderson, and Cleveland (1986) advocated that manufacturing strategy is a process in which business strategy determines manufacturing mission and distinctive competence. By interacting between adjacent levels of the strategy hierarchy, this process determines manufacturing objectives and leads to the formulation of manufacturing policies. Recently, Gupta and Lonial (1994), using data from 175 manufacturing firms concluded that the linkage between manufacturing strategies and business strategies is a significant predictor of organizational performance.

The above discussion indicates that manufacturing flexibility is one of the elements of manufacturing strategy. The congruence between manufacturing strategy and business strategy leads to increased organizational performance (Figure 1). Therefore, it may be appropriate to examine the relationship between business strategy and manufacturing flexibility.

3.1. Manufacturing Flexibility and Business Strategy

Hayes (1981) suggested that when organizations produce more products, they experience a higher level of demand variability. Similarly, the supply variability will be dependent on the number of unique parts sourced, the number of suppliers used, and the
introduction of new or alternate materials. An organization that operates in an industry that is facing an increasingly rapid pace of technological evolution and, consequently, a shortening product life cycle and higher product turnover would be faced with additional variability. Higher levels of labor turnover, absenteeism, and low equipment reliability are additional sources of variability. To deal with these sources of variability, the organization must increase its manufacturing flexibility.

When a firm decides to compete in the high end of markets, generally requiring more customized products, it would clearly need more process flexibility. Similarly, should a firm decide to compete in several related industries, it may require more process flexibility than when competing in a single industry.

When competitors of an organization are constantly introducing many new and improved products embracing a wide variety of features, almost all dimensions of flexibility would be required to meet competitors' challenge (Krafcik 1988; MacDuffie 1991; Suarez, Cusumano, and Fine 1992).

The above discussion suggests that:

1. H1: Business strategy has direct effects on the adoption of manufacturing flexibility dimensions.

H1 would be expected to hold whether business strategy's effect on manufacturing flexibility results from management's intention to pursue a competitive advantage or from a strategic necessity. The literature supports the position that business strategy incorporates the required flexibility (Slack 1987; Swamidass and Newell 1987).

3.2. Manufacturing Flexibility and Organizational Performance

Kekre and Srinivasan (1990) empirically examined the relationship between breadth of product line (process flexibility or mix flexibility as termed by several authors) and market success. They found that broader product lines result in larger market share and profitability and that it does not seem to be associated with higher costs.

Suarez, Cusumano, and Fine (1992), by examining the works of Stigler (1939) and Marschak and Nelson (1962), suggested that in some cases volume flexibility may be associated with higher costs and/or lower quality levels. They advocated that a plant that can shrink and expand production volume and can still keep its costs low and quality high would reap higher levels of performance.

Another dimension of flexibility that was studied by Suarez, Cusumano, and Fine (1992) is called new product flexibility (termed as product flexibility in this paper). They defined this as the ability to create new products quickly. Drawing from the works of Clark and Fujimoto (1991), Suarez, Cusumano, and Fine (1992) argued that as technology advances rapidly and customers become more sophisticated, rapid product introduction can give firms a real competitive advantage, i.e., the organizational performance could be significantly better than its competitors. Moreover, successful firms that pursue different business strategies may score higher on one performance dimension or another. Firms pursuing aggressive strategies and higher levels of flexibility, for example, may be expected to score more highly on growth performance than on financial performance. This causal logic suggests the following hypotheses:

1. H2: Manufacturing flexibility dimensions have direct effects on an organization's growth (financial) performance.

H2 provides a test of the relationship between manufacturing flexibility dimensions and an organization's performance, and similar to previous studies (Kekre and Srinivasan 1990, Fiegenbaum and Karnani 1991), the hypothesis suggests a direct association between the variables.

1. H3: Besides direct effects, business strategy also indirectly affects an organization's growth (financial) performance through its effect on manufacturing flexibility dimension.
H3 is formulated based on the recent work of Gerwin (1993) who through his conceptual model, identified the need for an applied research agenda involving manufacturing flexibility and other related variables. Specifically, research attention needs to be devoted to studying the interrelationship among business strategy, manufacturing flexibility, and organizational performance. This hypothesis proposes that business strategy's positive effect on an organization's performance can be enhanced by linking it with the appropriate manufacturing flexibility dimension. From H3 it follows that (i) if the required manufacturing flexibility dimension is inappropriate to the business strategy, the indirect effects may be negative, even when the direct effects of business strategy are positive and (ii) if the business strategy is inappropriate and direct effects on organizational performance are negative, then indirect effects through manufacturing flexibility could exaggerate or equalize business strategy's direct effects. To our knowledge, this hypothesis has not been examined in prior statistical research in manufacturing flexibility.

In this study, path analysis provides a holistic approach for evaluating H1, H2, and H3 in an integrative framework (Figure 2).

4. Method

In this section we provide an exposition of sample and data collection procedures and measurement of variables used in the study.

4.1. Sample and Data Collection

A total of 1,600 questionnaires were mailed nationwide to five types of U.S. manufacturing firms with 250 or more employees obtained from a mailing list directory: precision machinery, electrical and electronics, industrial machinery, metal products, and automobile and auto part firms. These types of firms were selected based on standard industrial codes (SIC's). We chose these types of firms (industry segments) because they have acknowledged adoption of advanced manufacturing processes.

After 2 weeks of initial mailing, a reminder letter with a fresh copy of the questionnaire was mailed to the nonrespondents. As a result of a carefully designed questionnaire, administered according to Dillman's suggestions (1978), the sample was believed to be characteristic of firms in their respective industries. A single respondent per organization, typically holding the title of CEO, President, or Vice President of Manufacturing completed the survey instrument. The manufacturing firms were located nationwide. Of 1,600 questionnaires distributed, 279 were completed and returned, representing a response rate of 17.4%. This is a typical response rate for studies of this kind (Magal, Carr, and Watson 1988). The exclusion of questionnaires with incomplete data resulted in a final sample of 269 firms. A copy of the questionnaire is available from the authors. The rationale for selecting the five types of manufacturing firms was to create a diverse sample from which it would be easier to generalize the results. We tried to sample randomly within each industry; however, nonresponse, even with follow-ups, resulted in unequal response among the firm types.

The sample is composed of large firms, with 56.4% of the firms having annual sales between 251 and 1,000 million dollars and 41.1% having 501–1,000 total employees. Table 1 presents a profile of the sample.

The extent of differences between respondents and nonrespondents can seldom be determined. Sometimes, however, one can make very limited checks for differences. In light of the low response rate, tests for nonresponse bias were considered necessary. To assess whether the firms included in the study were representative of those firms in the database, a comparison for selected demographic characteristics suggests that there were no significant differences between the groups along this set of characteristics. The similarity of respondents versus nonrespondents was assessed using the Kolmogorov-Smirnov (K-S) test. None of the test statistics were statistically significant at p < 0.05.
4.2. Operational Measures of the Variables

In this section we will describe items used in measuring the variables used in our study.

4.2.1 BUSINESS STRATEGY. A 21-item scale, extracted from the previous work on business strategies by Venkatraman (1989), was used to measure six types of manufacturing strategies: (1) aggressiveness, (2) analysis, (3) defensiveness, (4) futurity, (5) proactiveness, and (6) riskiness. Respondents were asked to indicate the extent of their agreement or disagreement with each of the items using a five-point scale ranging from 1-strongly agree to 5-strongly disagree. An overall summary measure for each of the six
 business strategies was calculated as the average of the items in their respective strategic dimension. The scale has been found to have high internal consistency reliability in prior empirical studies (Venkatraman 1989). The original group of items was subjected to reliability analysis, and five items were removed resulting in a 24-item scale. Appendix 1 provides the items that were removed. The six business strategies, represented as endogenous variables in the path model, their empirical indicators, and Cronbach's coefficient alpha are portrayed in Table 2.

4.2.2. MANUFACTURING FLEXIBILITY. In a previous study, the authors developed an instrument for measuring and analyzing manufacturing flexibility (Gupta and Somers 1992). Thirty-four items affecting manufacturing flexibility were identified from the literature, and a preliminary instrument was created to measure them (see Appendix 2 for a list of the items). Respondents were asked to indicate the extent of their agreement or disagreement with each of the items on a five-point Likert-type scale ranging from 1-strongly agree to 5-strongly disagree. The final instrument, after modification, contained 21 items and had an alpha coefficient of 0.888.

The large number of items required that they be condensed into a meaningful and manageable data set. This was accomplished using principal components factor analysis. This technique assumes that related variables describe a common underlying manufac-
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| **Aggressiveness**                                                                                                                                                                                                                                                                                                                                                                                                                                                      | We sacrifice short-term profitability to gain market share.  
We have cut prices to increase our market share.  
A strong preference for setting prices below the competition.  
Seeking market share positions at the expense of cash flow and profitability.                                                                                                                                                                                                                                                              |                   | 0.66              |
| **Analysis**                                                                                                                                                                                                                                                                                                                                                                                                                                                           | We emphasize effective coordination among functions (e.g., operations and marketing).  
When confronted with a major decision, we usually try to develop thorough analyses.  
Planning techniques (PIMS models, portfolio models).  
Regular manpower planning and performance appraisal.  
Outputs of management information and control systems.                                                                                                                                                                                                                                                                                |                   | 0.59              |
| **Defensiveness**                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Cost control systems for monitoring performance.  
Emphasis on product quality through the use of systems such as quality circles.  
Project management techniques (e.g., PERT/CPM).                                                                                                                                                                                                                                                                                                     |                   | 0.58              |
| **Futurity**                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Our criteria for resource allocation generally reflects short-term considerations.  
Forecasting key indicators of operations.  
Formal tracking of significant general trends.  
“What-if” analysis of critical issues.                                                                                                                                                                                                                                                                                                        |                   | 0.65              |
| **Proactiveness**                                                                                                                                                                                                                                                                                                                                                                                                                                                          | We constantly seek to indentify new opportunities closely related to our operation.  
We are usually the first ones to introduce new products or services in our markets.  
We are constantly on the lookout for business units we that can acquire.  
Operations in the later stages of the life cycle are strategically eliminated (i.e., liquidated, diversified).                                                                                                                                                                                                                         |                   | 0.61              |
| **Riskiness**                                                                                                                                                                                                                                                                                                                                                                                                                                                            | We adopt a rather conservative view when making major decisions.  
Approval of new projects on a “stage-by-stage” basis rather than with a “blanket approval.”  
Operations have generally followed the “tried-and-true” paths.  
A strong tendency to support projects where the expected rates of return are certain.                                                                                                                                                                                                                                          |                   | 0.54              |

turing flexibility dimension. Table 3 presents details of this analysis. As Table 3 shows, the 21 items yielded a 9 multi-item factor structure of manufacturing flexibility that explained 72% of the variance in the data. Each factor represents a unique flexibility dimension whose meaning is based on the items that make it up. These nine factors and Cronbach’s coefficient alphas are portrayed in Table 4. The reliability coefficients of each factor ranged from 0.70 to 0.89. Furthermore, the 21-item instrument had a criterion-related validity of 0.7301, which correlated significantly with a separate measure of overall flexibility. In this study, the firm’s overall manufacturing flexibility was assessed by asking respondents to rate “To what extent is your manufacturing flexible?” This criterion question employed a five-point scale: 1 = highly inflexible, 2 = generally inflexible, 3 = neutral, 4 = generally flexible, and 5 = highly flexible. The correlation of each of the nine factors with the criterion ranged from 0.55 to 0.68.
TABLE 3
Rotated Factor Matrix of 21-Item Instrument to Measure Manufacturing Flexibility

<table>
<thead>
<tr>
<th>Item</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>0.76114</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.72997</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.69472</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>0.63127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.61855</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.53061</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>0.79452</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>0.77289</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BB</td>
<td>0.32194</td>
<td>0.57358</td>
<td>0.31314</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>0.72849</td>
<td>0.72985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.82217</td>
<td>0.79851</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DD</td>
<td>0.83683</td>
<td>0.6854</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.36621</td>
<td>0.83929</td>
<td>0.52378</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>0.79581</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.532588</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>0.8613</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Note: Factor loadings provided by principal components analysis (varimax rotation) accounted for 72% of the total variance in the data. Eigenvalues exceeded 1.0 for all factors except factors 8 and 9 which were 0.999.

Nunnally (1978) suggested that Cronbach's alpha value of 0.7 is considered adequate for internal consistency reliability. For relatively new scales, however, Nunnally suggested that an alpha value of 0.6 is acceptable. Srinivasan (1985), on the other hand, argued that alpha value of 0.5 or higher should be considered sufficient in exploratory research. Moreover, alpha is a function of the number of items in the composite and tends to be conservative. On the basis of these observations, we decided those alpha values over 0.55 were acceptable.

4.2.3. ORGANIZATIONAL PERFORMANCE. An organization's performance is a multifaceted construct that defies measurement by a single number. Venkatraman (1989) used two dimensions, growth performance and financial performance, to measure organizational performance. Each dimension of performance was measured by multiple items adapted from Gupta and Govindarajan (1984) (see Table 5). Two dimensions of performance, represented as endogenous variables, were measured by asking respondents to indicate their organization's level of performance relative to their competition with respect to each of the six criteria. The response options, anchored on a five-point Likert-type scale, ranged from (1) much worse than competition to (5) much better than competition. To assess the reliability of these criteria, we calculated Cronbach's (1951) coefficient alpha. Two performance dimensions, suggested by Venkatraman (1989), were calculated for each firm by averaging the responses for their respective indicators. In Table 5, we present the performance variables.
TABLE 4  
Manufacturing Flexibility, Their Indicators, and Standardized Alpha Coefficients

<table>
<thead>
<tr>
<th>Item</th>
<th>Indicators</th>
<th>Constructs</th>
<th>Alpha Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.</td>
<td>Time that may be required to double the output of the system is likely to be extremely low.</td>
<td>Expansion/market flexibility</td>
<td>0.75</td>
</tr>
<tr>
<td>I.</td>
<td>Cost of doubling the output of the system is likely to be extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.</td>
<td>The capacity (e.g., output per unit time) of the system can be increased when needed with ease.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.</td>
<td>The capability (e.g., quality) of the system can be increased when needed with ease.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Time required to introduce new products is extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D.</td>
<td>Time required to add a unit of production capacity is extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z.</td>
<td>The ability of material-handling systems to move different part types for proper positioning and processing through the manufacturing facility is extremely high.</td>
<td>Material-handling flexibility</td>
<td>0.80</td>
</tr>
<tr>
<td>AA.</td>
<td>The ratio of number of paths the material-handling systems can support to the total number of paths is very high.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BB.</td>
<td>The material-handling system can link every machine to every other machine.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q.</td>
<td>Decrease in throughput because of a machine breakdown is extremely low.</td>
<td>Routing flexibility</td>
<td>0.79</td>
</tr>
<tr>
<td>P.</td>
<td>Cost of the production lost as a result of expediting a preemptive order is extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DD.</td>
<td>The number of different operations that a typical machine can perform without requiring a prohibitive cost in switching from one operation to another is very high.</td>
<td>Machine flexibility</td>
<td>0.85</td>
</tr>
<tr>
<td>CC.</td>
<td>The number of different operations that a typical machine can perform without requiring a prohibitive time in switching from one operation to another is very high.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E.</td>
<td>Shortage cost of finished products is extremely low.</td>
<td>Market flexibility</td>
<td>0.81</td>
</tr>
<tr>
<td>F.</td>
<td>Cost of delay in meeting customer orders is extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.</td>
<td>Number of new parts introduced per year is very high.</td>
<td>Product/production flexibility</td>
<td>0.89</td>
</tr>
<tr>
<td>G.</td>
<td>Size of the universe of parts the manufacturing system is capable of producing without adding major capital equipment is extremely large.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X.</td>
<td>Changeover cost between known production tasks within the current production program is extremely low.</td>
<td>Process flexibility</td>
<td>0.85</td>
</tr>
<tr>
<td>Y.</td>
<td>The ratio of the waiting costs of processed parts and the total output is extremely low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.</td>
<td>The manufacturing system is capable of running virtually unattended during the second and third shift.</td>
<td>Programming flexibility</td>
<td>0.70</td>
</tr>
<tr>
<td>N.</td>
<td>The range of volumes in which the firm can run profitably is extremely high.</td>
<td>Volume flexibility</td>
<td>0.75</td>
</tr>
</tbody>
</table>
5. Model Results

In this study, path analysis is the technique we use to explore our propositions about the sequential relationship among business strategy, flexibility, and organizational performance with complex direct and indirect effects, for example, such as those in H3. The most direct conversion of the conceptual model (see Figure 1) involved the specification of a path model (see Figure 2) that would allow for the examination of both the direct and indirect effects of strategy and flexibility on organizational performance. It must be pointed out that Figure 2 is simplified to show only a few of the direct and indirect strategy-organizational performance connections, and it does not show all the paths tested in accord with the effects anticipated in our hypotheses. The model is recursive insofar as it is assumed that reciprocal causation in the form of causal feedback loops does not exist (Kerlinger and Pedhazur 1973). While performance may affect future business strategy and/or flexibility adoption, these effects are best modeled by considering time lags and therefore are outside the scope of this research. Although this assumption may not be totally justified, casual feedback loops have not yet been demonstrated empirically in this literature and would require complex estimation techniques (Cohen and Cohen 1983).

In this model, our hypotheses are made more explicit through the construction of an arrow diagram depicting the expected causal sequence. The resulting diagram shows business strategy as an exogenous variable affecting the required manufacturing flexibility and organization’s performance. Manufacturing flexibility and organizational performance are endogenous variables that are explained partly by business strategy, and in the case of performance, manufacturing flexibility. Variables are classified as exogenous (independent) to the model when they only emit arrows; endogenous (dependent) variables receive arrows. Each arrow is called a path, and paths connecting the variables can be either direct or indirect. Both direct and indirect strategy and performance connections are shown in the diagram, and the paths are drawn in accordance with the effects anticipated in the hypotheses. Direct paths are those connections between variables comprised of a single pathway. A standardized path coefficient, or beta, indicates the direction (either plus or minus) and magnitude of influence between variables. For example, the standardized path coefficient between manufacturing flexibility and organization’s performance is the standardized beta weight resulting from the prediction of performance from manufacturing flexibility with business strategy already partialled out.
Indirect paths are compound pathways (with mediating variables) made up of several direct pathways. We expect there to be an indirect path from business strategy to performance that is comprised of several significant direct paths.

To test $H_1$, the regression results and the standardized path coefficients (p.c.) representing the direct effects of business strategy on manufacturing flexibility are shown in Table 6. The effects of business strategy on manufacturing flexibility are indeed quite distinguishing. Two strategies, aggressiveness and proactiveness were significant predictors of several types of flexibility. On the other hand, the strategies of a business oriented toward futurity or riskiness were not found to have any significant impact on type of manufacturing flexibility. An aggressive strategy was a significant determinant of all types of manufacturing flexibility. A proactive strategy emerged as a direct significant predictor of expansion and market, material handling, routing, machine, market, programming, and volume flexibility. Four strategies had significant direct effects on expansion and market flexibility: aggressiveness (p.c. = 0.313, $p < 0.01$); analysis (p.c. = 0.139, $p < 0.10$); defensiveness (p.c. = −0.149, $p < 0.05$); and proactiveness (p.c. = 0.133, $p < 0.05$). In fact, a defensive strategy was significantly related to only this type of flexibility (p.c. = −0.149, $p < 0.05$). The negative coefficient suggests that with increased emphasis on cost reduction and efficiency-seeking methods, the less likely the firm’s need to increase the capacity and capability of its manufacturing system. An analysis strategy was significantly associated with both expansion and market (p.c. = 0.139, $p < 0.10$) and product and production flexibility (p.c. = 0.149, $p < 0.05$). This suggests that an increase in a firm’s overall problem-solving posture is accompanied by increases in (i) capacity and capability of its manufacturing system when needed and (ii) part types that the system can produce without requiring additional major equipment.

The models differed in their ability to explain variance in type of manufacturing flexibility. An examination of the adjusted $R^2$ statistics in Table 6 indicates that a modest amount of variance in type of flexibility has been explained by business strategy. Business strategy as a whole explained from 1 to 17% of the variance in type of manufacturing flexibility. All models, except one, significantly demonstrated that business strategy has an impact on manufacturing flexibility. It would appear, however, that business strategy has no direct effect on product and production flexibility ($F = 1.38$, $p = 0.2195$) even though aggressiveness (p.c. = 0.110, $p < 0.10$) and analysis (p.c. = 0.149, $p < 0.10$) strategies approached significance at the 0.05 level. The best models were found for

### TABLE 6

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
<th>F8</th>
<th>F9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressiveness S1</td>
<td>0.313*</td>
<td>0.139**</td>
<td>0.165*</td>
<td>0.209*</td>
<td>0.158*</td>
<td>0.116***</td>
<td>0.136***</td>
<td>0.229*</td>
<td>0.136**</td>
</tr>
<tr>
<td>Analysis S2</td>
<td>0.139***</td>
<td>0.02</td>
<td>0.127</td>
<td>0.087</td>
<td>0.025</td>
<td>0.149***</td>
<td>0.012</td>
<td>0.082</td>
<td>0.002</td>
</tr>
<tr>
<td>Defensiveness S3</td>
<td>−0.149*</td>
<td>−0.028</td>
<td>−0.103</td>
<td>−0.083</td>
<td>0.004</td>
<td>0.026</td>
<td>−0.069</td>
<td>−0.064</td>
<td>−0.022</td>
</tr>
<tr>
<td>Futurity S4</td>
<td>0.066</td>
<td>0.051</td>
<td>0.058</td>
<td>0.065</td>
<td>0.02</td>
<td>−0.055</td>
<td>0.106</td>
<td>0.017</td>
<td>0.058</td>
</tr>
<tr>
<td>Proactiveness S5</td>
<td>0.133**</td>
<td>0.191*</td>
<td>0.150**</td>
<td>0.190*</td>
<td>0.159*</td>
<td>−0.015</td>
<td>0.099</td>
<td>0.158*</td>
<td>0.236*</td>
</tr>
<tr>
<td>Riskiness S6</td>
<td>0.026</td>
<td>−0.013</td>
<td>−0.006</td>
<td>−0.016</td>
<td>0.051</td>
<td>0.036</td>
<td>0.041</td>
<td>0.022</td>
<td>−0.014</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.17</td>
<td>0.06</td>
<td>0.08</td>
<td>0.11</td>
<td>0.06</td>
<td>0.01</td>
<td>0.03</td>
<td>0.1</td>
<td>0.08</td>
</tr>
<tr>
<td>F-Ratio</td>
<td>10.16*</td>
<td>3.75*</td>
<td>4.64*</td>
<td>6.45*</td>
<td>3.61*</td>
<td>1.38</td>
<td>2.24**</td>
<td>5.92*</td>
<td>4.57*</td>
</tr>
<tr>
<td>(Probability)</td>
<td>(0.0000)</td>
<td>(0.0013)</td>
<td>(0.0002)</td>
<td>(0.0000)</td>
<td>(0.0019)</td>
<td>(0.2195)</td>
<td>(0.0397)</td>
<td>(0.0000)</td>
<td>(0.0002)</td>
</tr>
</tbody>
</table>

*Note: $N = 269$; * $p < 0.01$; ** $p < 0.05$; *** $p < 0.10$.

* Values are standardized regression coefficients.
predicting expansion and market and machine flexibility. In these models, business strategy accounted for 17 and 11%, respectively, of the variance.

In a path model, the path coefficients not only identify the direct effect of each of the exogenous variables on the appropriate dependent variables, but they can also be used to calculate both the indirect and the total effects of each variable on the respective dependent variables. As seen in Table 7, the total effect is simply the sum of the direct effects and all the indirect effects that occur through intervening variables. The indirect effect of a variable is that which is traceable through its association with other variables. Estimates for indirect effects are computed by tracing in the path diagram (see Figure 2) from business strategy (S1–S6) through the nine types of manufacturing flexibility (F1–F9) to performance (growth and financial). For example, the indirect effects of aggressiveness strategy (S1) are computed according to the "tracing rule" as:

\[
0.03588 = 0.113(0.313) + 0.056(0.139) + 0.065(0.165) \\
+ 0.035(0.209) + 0.003(0.158) + -0.011(0.110) + -0.111(0.136) \\
+ -0.061(0.229) + 0.033(0.136)
\]

It has been suggested that having calculated the path coefficients for a just-identified model, path coefficients that do not meet criteria of statistical significance be deleted from the model (referred to as theory-trimming approach). Following the theory one would delete path coefficients that are not statistically significant at a prespecified level of significance. When it is desired to test whether more than one path coefficient within a given equation may be deleted, it is appropriate to test them simultaneously by using the F-test. This study, however, did not apply the theory trimming approach that would reduce the total number of variables to the smallest core of variables that could efficiently predict growth and financial performance.

To test H2 and H3, the effects of business strategy and manufacturing flexibility on growth and financial performance were decomposed into direct, indirect, and spurious. Many (5 of 6) of the business strategies were found to have an impact on the firm's financial performance. Aggressiveness (p.c. = 0.267, p < 0.01), analysis (p.c. = 0.183, p < 0.05), defensiveness (p.c. = −0.129, p < 0.10), proactiveness (p.c. = 0.191, p < 0.01) and riskiness (p.c. = −0.219, p < 0.01) have significant direct effects on financial performance. The absolute value of the standardized path coefficient allows us to determine which strategies are more important for financial performance. Thus, aggressiveness and riskiness strategies are the most important predictors of financial performance. The positive coefficients imply that financial performance increases as a firm's strategic posture increases. In contrast, a negative coefficient, for example, that found for riskiness strategy, suggests that financial performance decreases as the extent of risk taking increases.

Only one type of flexibility, process flexibility, significantly affects financial performance (p.c. = −0.111, p < 0.10), and its effect is modest, at best. Nonetheless, an increase in the capability of a manufacturing system to produce a set of part types without major setup is accompanied by a reduction in financial performance. The overall adjusted $R^2$ for the model is 0.283 (p < 0.01).

Surprisingly, when growth performance is considered as the dependent variable, several types of manufacturing flexibility significantly affect it. In contrast, we found that only one business strategy, proactiveness, appeared to be significantly related to firms' growth performance. The growth performance of a firm is influenced by expansion and market (p.c. = 0.242, p < 0.01), routing (p.c. = 0.143, p < 0.05), product and production (p.c. = −0.128, p < 0.05), process (p.c. = −0.098, p < 0.10) and volume flexibility (p.c. = 0.162, p < 0.01) as well as by a proactive business strategy (p.c. = 0.253, p < 0.01). Overall, almost 20% of the variance in growth performance is explained by the model (Figure 3).
## TABLE 7

### Direct, Indirect, and Total Effect of Business Strategy and Manufacturing Flexibility on Organizational Performance

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Direct</th>
<th>Indirect</th>
<th>Total</th>
<th>Spurious</th>
<th>$r$</th>
<th>Direct</th>
<th>Indirect</th>
<th>Total</th>
<th>Spurious</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressiveness</td>
<td>0.267**</td>
<td>0.035</td>
<td>0.302**</td>
<td>0.033</td>
<td>0.335*</td>
<td>0.090</td>
<td>0.101***</td>
<td>0.191*</td>
<td>0.056</td>
<td>0.247*</td>
</tr>
<tr>
<td>Analysis</td>
<td>0.183***</td>
<td>0.020</td>
<td>0.203*</td>
<td>-0.025</td>
<td>0.178*</td>
<td>0.027</td>
<td>0.032</td>
<td>0.059</td>
<td>0.051</td>
<td>0.110***</td>
</tr>
<tr>
<td>Defensiveness</td>
<td>-0.129***</td>
<td>-0.017</td>
<td>-0.146**</td>
<td>0.022</td>
<td>-0.124**</td>
<td>-0.073</td>
<td>-0.050</td>
<td>-0.123**</td>
<td>0.014</td>
<td>-0.109***</td>
</tr>
<tr>
<td>Futurity</td>
<td>-0.014</td>
<td>0.006</td>
<td>-0.008</td>
<td>-0.002</td>
<td>-0.010</td>
<td>0.065</td>
<td>0.033</td>
<td>0.098***</td>
<td>-0.050</td>
<td>0.048</td>
</tr>
<tr>
<td>Proactiveness</td>
<td>0.191*</td>
<td>0.029</td>
<td>0.220*</td>
<td>-0.002</td>
<td>0.218*</td>
<td>0.253*</td>
<td>0.095***</td>
<td>0.348*</td>
<td>-0.007</td>
<td>0.341*</td>
</tr>
<tr>
<td>Riskiness</td>
<td>-0.219*</td>
<td>-0.005</td>
<td>-0.224*</td>
<td>0.019</td>
<td>0.243*</td>
<td>-0.045</td>
<td>-0.003</td>
<td>-0.048</td>
<td>0.028</td>
<td>-0.020</td>
</tr>
<tr>
<td>Expansion and market flexibility</td>
<td>0.113</td>
<td>-</td>
<td>0.113***</td>
<td>0.053</td>
<td>0.166*</td>
<td>0.242*</td>
<td>-</td>
<td>0.242*</td>
<td>0.110***</td>
<td>0.352*</td>
</tr>
<tr>
<td>Material-handling flexibility</td>
<td>0.056</td>
<td>-</td>
<td>0.056</td>
<td>0.066</td>
<td>0.122**</td>
<td>0.014</td>
<td>-</td>
<td>0.014</td>
<td>0.010</td>
<td>0.074</td>
</tr>
<tr>
<td>Routing flexibility</td>
<td>0.065</td>
<td>-</td>
<td>0.065</td>
<td>0.197*</td>
<td>0.262*</td>
<td>0.143**</td>
<td>-</td>
<td>0.143**</td>
<td>0.107***</td>
<td>0.250*</td>
</tr>
<tr>
<td>Machine flexibility</td>
<td>0.035</td>
<td>-</td>
<td>0.035</td>
<td>0.069</td>
<td>0.104***</td>
<td>0.036</td>
<td>-</td>
<td>0.036</td>
<td>0.046</td>
<td>0.082</td>
</tr>
<tr>
<td>Market flexibility</td>
<td>0.003</td>
<td>-</td>
<td>0.003</td>
<td>0.058</td>
<td>0.061</td>
<td>0.069</td>
<td>-</td>
<td>0.069</td>
<td>0.028</td>
<td>0.097***</td>
</tr>
<tr>
<td>Product and Production flexibility</td>
<td>-0.011</td>
<td>-</td>
<td>-0.011</td>
<td>-0.042</td>
<td>-0.053</td>
<td>-0.128**</td>
<td>-</td>
<td>-0.128**</td>
<td>0.007</td>
<td>-0.121**</td>
</tr>
<tr>
<td>Process flexibility</td>
<td>-0.111***</td>
<td>-</td>
<td>-0.111***</td>
<td>-0.131**</td>
<td>-0.242*</td>
<td>-0.098***</td>
<td>-</td>
<td>-0.098***</td>
<td>0.044</td>
<td>-0.054</td>
</tr>
<tr>
<td>Programming flexibility</td>
<td>-0.061</td>
<td>-</td>
<td>-0.061</td>
<td>-0.066</td>
<td>-0.127**</td>
<td>-0.058</td>
<td>-</td>
<td>-0.058</td>
<td>-0.047</td>
<td>-0.105***</td>
</tr>
<tr>
<td>Volume flexibility</td>
<td>0.033</td>
<td>-</td>
<td>0.033</td>
<td>0.068</td>
<td>0.101***</td>
<td>0.162*</td>
<td>-</td>
<td>0.162*</td>
<td>0.100***</td>
<td>0.262*</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.283</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.191</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-Ratio (Probability)</td>
<td>8.062 (0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.236 (0.0000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Correlations duplicated within</td>
<td>0.10</td>
<td>13/15</td>
<td></td>
<td></td>
<td></td>
<td>12/15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: $n = 269$; * $p < 0.01$; ** $p < 0.05$; *** $p < 0.10$. 
Direct Effects of Business Strategy on Manufacturing Flexibility and Direct Effects of Business Strategy and Manufacturing Flexibility on Financial And Growth Performance:

\[ S_1, S_2, S_3, S_5, S_6 \rightarrow F_7 \]
\[ S_1, S_2, S_3, S_5 \rightarrow F_1 \]
\[ S_1, S_5 \rightarrow F_2, F_3, F_4, F_5, F_6, F_7, F_8, F_9, F_{10}, F_{11}, F_{12} \]

Business Strategy Indirect Effects on Growth Performance Through Manufacturing Flexibility:

\[ S_1 \rightarrow F_1 \rightarrow P_G \]
\[ S_5 \]

**Exogenous Variables**
- S1 - Expansion/Market Flexibility
- S2 - Material Handling Flexibility
- S3 - Routing Flexibility
- S4 - Machine Flexibility
- S5 - Market Flexibility
- S6 - Product/Production Flexibility

**Endogenous Variables**
- F1 - Expansion/Market Flexibility
- F2 - Material Handling Flexibility
- F3 - Routing Flexibility
- F4 - Machine Flexibility
- F5 - Market Flexibility
- F6 - Product/Production Flexibility
- F7 - Process Flexibility
- F8 - Programming Flexibility
- F9 - Volume Flexibility
- P9 - Financial Performance
- P10 - Growth Performance

**Figure 3.** Summary of Significant Paths from Figure 2 Based on Standardized Regression Coefficients.

It was predicted that any relations between business strategy and organizational performance would be mediated by type of manufacturing flexibility. We expect there to be an indirect path from business strategy to growth and financial performance that is comprised of two significant direct paths. The strength of an indirect path is determined by computing the product of the standardized (direct) path coefficients that make up such a compound path. The results in Table 7 demonstrate partial support for H3, which had posited that manufacturing flexibility would play a mediating role between business strategy and the organizational performance of firms. The role of manufacturing flexibility as an intervening variable is confirmed by the finding that aggressive and proactive business strategies marginally influence growth performance indirectly through their effects on manufacturing flexibility. Contrary to expectations, none of the business strategies had indirect effects on financial performance through manufacturing flexibility. Business
strategy indirect effects on financial through flexibility are quite small. These business strategies apparently have no bearing on manufacturing flexibility. It would appear then that part of the relationship between business strategy and financial performance is indirect through other variables not included in this analysis.

Billings and Wroten (1978) suggested that once path coefficients have been determined, they should be verified by attempting to recompute the correlation matrix through the calculation of the total effects between the sets of related variables. In Table 7, a comparison of the estimated correlations, found by summing the direct and indirect effects (total effect), with the original correlations \( r \) between the independent variables and dependent measures provides supporting evidence of the "goodness of fit" of these models. If we used the criterion that the absolute difference between the reproduced and original correlations should not exceed 0.10, our models can duplicate almost all (13 of 15) of the original correlations for financial performance and 12 of the 15 correlations involving growth performance (Namboodiri, Carter, and Blalock 1975). Further, the extent of the spurious effects found for both models suggests that unless business strategy is considered in these models, the direct effects of manufacturing flexibility on growth and financial performance will be underestimated. For some variables, the spurious effects and their direct effects are of opposite sign, implying that the zero-order correlation coefficient alone would provide a misleading relationship between manufacturing flexibility and firms' performance (Table 8). A summary of the results reported in this section is given in Figure 3.

6. Discussion

The objective of this paper was to determine the relationship between business strategy, manufacturing flexibility, and organizational performance. The data used to test our hypotheses and the development of flexibility measures reported by Gupta and Somers (1992) are drawn from the same database. Therefore, findings of this research put them in more of an exploratory rather than confirmatory category.

The aggressiveness dimension of business strategy is significantly related to all of the dimensions of manufacturing flexibility identified in this paper (Table 6). Since aggressive organizations tend to sacrifice profitability and set prices below competition to gain market share even at the expense of cash flow profitability and since manufacturing flexibility allows an organization to increase market share by improving its ability to produce a greater mix of products, change the volume of production, and respond to changing market conditions, it is obvious that the aggressiveness strategy should be significantly
related to manufacturing flexibility. These results are further supported by the findings reported in Table 7. In this table, the direct effect of aggressively pursuing market share (aggressiveness) on growth performance is not significant; however, aggressiveness orientation affects growth indirectly through manufacturing flexibility, suggesting that firms opting for aggressiveness strategy and aiming for an increasing growth trend must enhance manufacturing flexibility.

Proactive organizations generally seek new opportunities for business that can be acquired and are generally the first to introduce new products. Organizations pursuing this strategy seem to seek all the flexibility dimensions except process flexibility and product and production flexibility (see Table 6). In addition, the proactiveness strategy also influences growth performance indirectly through manufacturing flexibility. One possible explanation, albeit weak, for the lack of a direct relationship between proactiveness and process and product and production flexibility dimensions is that the newly acquired businesses and their associated products are generally kept independent of the current business units. Thus, the current manufacturing plant may not have a great need for process flexibility.

The path analysis results demonstrate that aggressiveness and proactiveness strategies influence growth performance indirectly through manufacturing flexibility (Table 7). These findings suggest that the linkage between strategy and growth performance is more complex than suggested by previous research and thus emphasize the need for additional studies using multivariate research designs.

It is interesting to observe that organizations pursuing a defensiveness strategy tend to seek very little manufacturing flexibility. This strategy tends to be reactive and emphasize the implementation of cost reduction and efficiency improvement methods. These characteristics generally do not require high levels of manufacturing flexibility (Giffi, Roth, and Seal 1990). The lack of a significant relationship between analysis and futurity dimensions of business strategy and dimensions of manufacturing flexibility may be attributed to the fact that defensiveness orientation in business strategy is strongly related to futurity and analysis (see Venkatraman 1989).

Our results show that the aggressiveness, analysis, defensiveness, proactiveness, and riskiness dimensions of business strategy are significantly related to the financial performance of an organization (Table 7). The directions (signs) of all these relationships, except aggressiveness and defensiveness, are consistent with those obtained by Venkatraman (1989). Our results on the association between aggressiveness and financial performance, however, are in consonance with Hambrick, Macmillan, and Day’s (1982) findings. They suggested that market share gains can be achieved without loss of current profitability. One plausible explanation could be that our study deals with the data collected exclusively from manufacturing companies, whereas Venkatraman collected data from a number of industries. In any event, the inconsistencies in results suggest the need for additional field studies in this area. The significant and positive relationship between proactiveness and growth performance is supported by previous research (Venkatraman 1989).

Our findings indicate that five dimensions of flexibility out of nine are significantly related to growth performance, whereas only one dimension significantly affects financial performance (Table 7). It is conceivable that since manufacturing flexibility is still a relatively new phenomenon, management may not yet have recognized this linkage between flexibility and financial performance. Moreover, Kekre and Srinivasan (1990) suggested that growth performance (market share) should eventually stimulate financial performance of an organization.

Expansion and market flexibility have a positive and significant impact on growth performance. This flexibility allows a firm to respond to changes in customers’ tastes, declining product life cycles, and uncertainty in sources of supplies and, thus, enables it
to become a time-based competitor. These findings are consistent with the literature, i.e.,
time-based organizations tend to perform significantly better than their competitors who
do not pursue time-based strategies (Stalk and Hout 1990). To enhance this flexibility
the process of production planning and inventory controls must be integrated with mar-
keting functions, such as product development and market forecasts. Similarly, improved
relationships with suppliers and well-developed distribution channels are essential (Sethi
and Sethi 1990).

The impact of routing flexibility on growth performance suggests that organizations
in their attempt to enhance this flexibility must employ multipurpose machines, pool
identical machines into machine groups (Stecke and Kim 1989), improve versatility of
material handling systems and system control software (Yao 1985), plan for underuti-
lization of machines, or build redundancy in machines so that the production system
can be rescheduled and maintain the overall production rate in case of a machine break-
down. This also suggests that training programs designed to increase maintenance workers’
knowledge of the production system to prevent damage and to reroute production may
be beneficial (Gerwin 1989).

It is interesting to observe that process flexibility impacts negatively on both growth
and financial performance. One plausible explanation for this result is that a large number
of organizations have implemented automated manufacturing technology with the fuzzy
notion to increase process flexibility. However, they have continued to use these tech-
ologies under mass production regimes. Thus, they do not necessarily benefit from the
potential increase in process flexibility while incurring the cost of investment in automated
technologies (see for example, Bessant 1985; Jaikumar 1986; Majchrzak 1988; Primrose
1988). Another explanation for the negative relationship between process flexibility and
performance has been put forward by Gerwin (1993) who suggested that increased product
variety (process flexibility) leads to complexity and confusion that raises overhead costs.
Contrary to expectations, product and production flexibility has a negative relationship
with growth performance. As noted by Ettlie and Penner-Hahn (1994), the true value
of this type of flexibility is not realized until the next generation of products is introduced.
It is possible that a significant number of our respondents may not have launched a new
generation of products since improving this dimension of flexibility.

The finding that volume flexibility has a significant and positive relationship with
growth performance suggests that workers must possess skills that can be used elsewhere
when production volume decreases. This, in turn, implies that management must provide
cross-functional training to their employees (Gerwin 1989). In addition, volume flexibility
can be enhanced by realizing the importance of subcontracting networks and imple-
menting just-in-time concepts.

6.1. Implications

The management of manufacturing flexibility has been cited as a critical issue for both
manufacturing executives and general managers (Upton 1994). The increasing beliefs
in the strategic role of manufacturing in general (Hayes and Wheelwright 1984), along
with the level of executive manager participation in our study, suggest that manufacturing
flexibility will continue to be a critical issue well into the 1990s.

This study was driven by a strong desire to provide empirical evidence that could form
the basis for the guidelines for managing flexibility. In this article, evidence is provided
that manufacturing managers should not increase all dimensions of flexibility in their
drive to make improvement in their organization’s performance. Some dimensions of
flexibility may have a counterproductive effect, and others may not significantly contribute
to their organizational performance goals. Consequently, the investments in flexibility-
enhancing mechanisms must be in consonance with the dimension of flexibility that
management may be attempting to improve.
Several dimensions of flexibility (for example, expansion and market and volume) allow an organization to respond to markets expeditiously. Those organizations who know their markets better may not need as much flexibility. On the other hand, less competent organizations who are unable to predict the market changes may favor flexibility. According to Ettlie and Penner-Hahn (1994) “these same organizations may have difficulty implementing flexibility and other manufacturing innovations.”

Improved expansion and market flexibility provide greater freedom to experiment with variations in product designs. This, in turn, will result in escalation in transactions between manufacturing and product design functions and “may lead to greater conflict unless the additional experimentation is prevented from interfering with regular production (Gerwin 1992, p. 215).” Senior executives of an organization must improve working relationships between these functions by implementing mechanisms that enhance communications and encourage input from manufacturing in product design process (Gupta and Somers 1993). Gerwin (1992) suggested that increased expansion and market flexibility may reduce pressure on product engineers to design the products “right” the first time because the inadequacies or defects in product design may be screened and modified when prototypes are being produced or even after, causing escalation in uncertainty for manufacturing function. The above discussion of results suggests that the most effective way to increase manufacturing flexibility is to invest heavily in flexible manufacturing capabilities, including technology, organizational systems, and worker training (worker skills are especially important). According to Fisher, Jain, and MacDuffie (1994), the companies that fail in their efforts to increase flexibility do so not because they haven’t bought the right hardware, but because they either don’t understand the importance of worker training or are hampered in their efforts to institute it.

7. Limitations and Future Research

Although this study provides interesting insights into the pattern of relationships among various dimensions of manufacturing flexibility, business strategy, and organizational performance, the results must be interpreted cautiously. It should be pointed out that although the adjusted $R^2$ statistics of 0.283 and 0.191 in Table 7 would be considered acceptable, it must also be concluded that there are other determinants of success that were not included in our model. These factors may include environmental uncertainty as measured by Swamidass and Newell (1987) or components of manufacturing strategy other than manufacturing flexibility as recognized by Miller and Roth (1994) and Gupta and Lonial (1994). It would be worthwhile to expand our model in the future studies to include these factors. Similarly, while our results support $H_1$, in that the adjusted $R^2$ statistics are significant (Table 6), not all the coefficients in each equation turned out significant. Further, all but three of the adjusted $R^2$ statistics are $<0.10$. These results indicate that there are probably a number of other factors affecting the choice of each type of flexibility. More insight on flexibility must come from subsequent studies.

Three of the six constructs of business strategy have Cronbach alpha values below 0.6, which Nunnally identified as the boundary for reliability, and three are barely above that. Although the precedents exist in the literature where alpha value of 0.5 and above was considered acceptable, the low value may be attributed to the mixing of manufacturing industries in our sample. A future study may focus on a single manufacturing industry so that the above issue may be resolved. In addition, the single-manufacturing industry study would allow researchers to control confounding market variables that may vary from industry to industry.

The study used a single respondent per organization. Seeking responses from a single informant to make judgments on complex organizational characteristics may increase the subjective propensity of single respondents to seek out consistency in their responses.
and increase random measurement error. According to Miller and Roth (1994) the random error components may result from the reporting process, knowledge deficiencies, inadequate measures, or some combination of these factors. Campbell (1955) identified two criteria for collecting information about a social system: (1) the respondents should occupy roles that make them knowledgeable about the issues being researched and (2) they should be willing and able to communicate with the researchers. In our study, the monorespondent problem may have been moderated by the fact that high-ranking respondents tend to be more reliable sources of information than their lower ranking counterparts (Phillips 1981). Moreover, we believe that such a strategy enabled us to achieve a greater and more diverse sample size. Future studies, however, should attempt to avoid this methodological pitfall by pragmatically obtaining multiple sources of information within single organizations.

This study has established the relationship between business strategy, manufacturing flexibility, and performance; it would be an important research issue to examine the impact of dimensions of flexibility on quality and productivity. Also, it would be useful to examine how various types of organization structures may have a moderating effect on the need for manufacturing flexibility.

8. Conclusions

In this study we have examined the relationship between business strategy, manufacturing flexibility and performance. Our results indicate that business strategy contributes both directly and indirectly to organizational performance. The findings provide evidence of direct effects of (i) business strategy on manufacturing flexibility, and (ii) manufacturing flexibility on organizational performance.\footnote{We acknowledge the constructive comments made by two reviewers and the associate editor on the previous version of this paper.}

\section*{Appendix 1. Business Strategy Scales}

<table>
<thead>
<tr>
<th>Item</th>
<th>Strategy Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our information systems provide support for day-to-day decision making.</td>
<td>Analysis</td>
</tr>
<tr>
<td>We have made significant modifications to our manufacturing technologies.</td>
<td>Defensiveness</td>
</tr>
<tr>
<td>We emphasize basic research to provide us with future competitive edge.</td>
<td>Futurity</td>
</tr>
<tr>
<td>Our competitors generally preempt us by expanding capacity ahead of us.</td>
<td>Proactiveness</td>
</tr>
<tr>
<td>Our mode of operations is riskier than our competitor's operations.</td>
<td>Riskiness</td>
</tr>
</tbody>
</table>

The five items above were removed based on an examination of the item-to-total correlation data, which suggested that these items could be removed from their respective scales. Low correlations for these items suggested that they may not share the core of the construct.

\section*{Appendix 2. Initial List of 34 Items Measuring Manufacturing Flexibility and Their Source}

<table>
<thead>
<tr>
<th>Code</th>
<th>Item Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Time required to introduce new products is extremely low.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>B</td>
<td>Cost required to introduce new products is extremely high.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>C</td>
<td>Time required to increase or decrease production volume by 20% is extremely low.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
</tbody>
</table>
### Appendix 2. (continued)

<table>
<thead>
<tr>
<th>Code</th>
<th>Item Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Time required to add a unit of production capacity is extremely low.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>E</td>
<td>Shortage cost of finished products is extremely low.</td>
<td>Abadie et al. (1988)</td>
</tr>
<tr>
<td>F</td>
<td>Cost of delay in meeting customer orders is extremely low.</td>
<td>Abadie et al. (1988)</td>
</tr>
<tr>
<td>G</td>
<td>Size of the universe of parts the manufacturing system is capable of producing without adding major capital equipment is extremely large.</td>
<td>Chatterjee et al. (1984)</td>
</tr>
<tr>
<td>H</td>
<td>The manufacturing system is capable of running virtually unattended during the second and third shift.</td>
<td>Jaikumar (1986)</td>
</tr>
<tr>
<td>I</td>
<td>Cost of doubling the output of the system is likely to be extremely low.</td>
<td>Carter (1986)</td>
</tr>
<tr>
<td>J</td>
<td>Time that may be required to double the output of the system is likely to be extremely low.</td>
<td>Carter (1986)</td>
</tr>
<tr>
<td>K</td>
<td>The capacity (e.g., output per unit time) of the system can be increased when needed with ease.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>L</td>
<td>The capability (e.g., quality) of the system can be increased when needed with ease.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>M</td>
<td>The per unit manufacturing cost is extremely stable over widely varying levels of total production volume.</td>
<td>Falkner (1986)</td>
</tr>
<tr>
<td>N</td>
<td>The range of volumes in which the firm can run profitably is extremely low.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>O</td>
<td>Average number of possible ways in which a part type can be processed in the system is extremely high.</td>
<td>Chatterjee et al. (1984)</td>
</tr>
<tr>
<td>P</td>
<td>Cost of the production lost as a result of expediting a preemptive order is extremely low.</td>
<td>Ball (1989)</td>
</tr>
<tr>
<td>Q</td>
<td>Decrease in throughput because of a machine breakdown is extremely low.</td>
<td>Browne el al. (1984);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Time required to switch from one part mix to another is extremely low.</td>
<td>Browne et al. (1984);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Number of new parts introduced per year is very high.</td>
<td>Jaikumar (1986)</td>
</tr>
<tr>
<td>T</td>
<td>Cost required to switch one part mix to another is extremely low.</td>
<td>Browne et al. (1984);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>Total incremental value of new products that can be fabricated within the system for a 20% additional cost in new fixtures, tools, and part programs is extremely low.</td>
<td>Jaikumar (1986)</td>
</tr>
<tr>
<td>V</td>
<td>Volume (number of different part types or range of sizes and shapes) of the set of part types that the system can produce without major setups is extremely low.</td>
<td>Gerwin (1987)</td>
</tr>
<tr>
<td>W</td>
<td>Extent to which product mix can be changed while maintaining efficient production is very narrow.</td>
<td>Carter (1986)</td>
</tr>
<tr>
<td>X</td>
<td>Changeover cost between known production tasks within the current production program is extremely low.</td>
<td>Warnecke and Stienhipler (1982)</td>
</tr>
<tr>
<td>Y</td>
<td>The ratio of the total output and the waiting cost of parts processed is extremely low.</td>
<td>Son and Park (1987)</td>
</tr>
<tr>
<td>Z</td>
<td>The ability of material handling system to move different part types for proper positioning and processing through the manufacturing facility is extremely high.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>AA</td>
<td>The ratio of the number of paths the material handling systems can support to the total number of paths is very high.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>BB</td>
<td>The material handling system can link every machine to every other machine.</td>
<td>Chatterjee et al. (1984)</td>
</tr>
<tr>
<td>CC</td>
<td>The number of different operations that a typical machine can perform without requiring a prohibitive time in switching from one operation to another is very high.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>DD</td>
<td>The number of different operations that a typical machine can perform without requiring a prohibitive cost in switching from one operation to another is very high.</td>
<td>Sethi and Sethi (1990)</td>
</tr>
</tbody>
</table>
Appendix 2. (continued)

<table>
<thead>
<tr>
<th>Code</th>
<th>Item Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE</td>
<td>The ratio of the total output and the idle cost of a typical machine for a given period is very low.</td>
<td>Son and Park (1987)</td>
</tr>
<tr>
<td>FF</td>
<td>The number of tools or the number of programs that a typical machine can use is very low.</td>
<td>Tarondeau (1982)</td>
</tr>
<tr>
<td>GG</td>
<td>The extent of variations in key dimensional and metallurgical properties of the raw input stock a typical machine can handle is very low.</td>
<td>Gerwin (1987)</td>
</tr>
<tr>
<td>HH</td>
<td>The rate at which a typical machine becomes obsolete when a new product is introduced is very high.</td>
<td>Lam (1987)</td>
</tr>
</tbody>
</table>

References


