

An Integrative Approach to Analyzing the Relationship of Business Information Systems Technology, Investment Strategy, and Operation Process

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Abstract

This study examines whether or not a congruence exists between a firm's operational process category [job shop, batch flow, repetitive and continuous] and the level of information system technology sophistication within varying business investment strategies for a cross-section of 130 firms representing 36 two digit Standard Industrial Classification (SIC) codes and 66 four digit SIC codes. Analysis of the data revealed that firms who reported implementing risk-oriented strategies of share increasing and growth employ intermittent operation processes with moderate levels of information system technology sophistication. In contrast, firms reporting the implementation of a risk-averse strategy (eg., profit) employ continuous flow operation processes with high levels of information system technology sophistication.

Introduction

Given that organizational strategy decisions influence structural and internal policy alignment (Hambrick, 1983), it is both logical and essential that strategy research examine the integrative relationship between functional strategies (eg., operations, information systems, human resources, marketing, etc.) and the effectiveness of the business level strategy. Research supporting the importance of this sys-

tematic relationship between functional activities and firm performance (Hitt, Ireland & Stadter, 1982) and the relationship between business strategy and specific functional areas (Datta, 1979; Wheelwright, 1984; Milkovich & debajar, 1987; Rockmore, 1991; Rockmore & Swinehart, 1992; Rockmore & Smith, 1993) is evident in the literature.

Research examining operation (production) strategy has also increased due to the global competitive challenge of foreign manufacturers. Researchers have stressed the need to develop production strategies consistent with business level decision making in order assure competitiveness (Wheelwright, 1984; Schroeder, Anderson, & Cleveland, 1986; Nemetz & Fry, 1988). However, research is limited in its examination of the relationship between the integration of multi-functional area strategies (eg., information systems and production/operations) and business level strategy, even though technical advances in information system technology have dramatically affected the strategic posture of production/operations (Dixon, 1991).

Information system technology has become an immediate and vital concern to senior management (Clemons, 1991). Wiseman (1988) has indicated that the linkage of an organization's competitive posture and firm goals may explain the observed differences among organizational information system technologies and practices. Rockmore and Smith's (1993) findings indicate a significant relationship between business level strategy type and the sophistication of the firm's information system technology. Moreover, information system technology may be essential to the effective implementation of other functional strategic efforts in manufacturing (operations), marketing, human resources, finance and service (Clemons, 1991)

Strategic Orientation

Bourgeois (1980) indicates that specifying the strategic level of the study clarifies its focus and increases the meaningfulness of the results. The recognition of distinct strategy levels has been documented in the literature. Recent researchers (Provan, 1987; Fahey & Narayanan, 1986; Hofer & Schendel, 1978) reference strategic levels of analysis as corporate, business and functional. The corporate level is concerned with portfolio analysis, diversification decisions, and decisions about the primary organizational structure (Hrebiniak & Joyce, 1984). The business level strategy involves analyzing the relative

competitive strength of a strategic business unit (SBU), including their distinctive competencies, market growth rates and availability of critical resources. The relationship between the corporate and business unit levels are critical in the strategic planning process since the focal point of competition is at the business unit level, not the corporate level (Hambrick 1983; Porter, 1980). Business level strategy focuses on the competitive decisions of a firm, including resource allocation or investment decisions. An SBU is a single or closely related product/service line company, or company division, product/service center responsible for a specific product/service which has its own strategies and task environment. Business strategy focuses on the distinctive and competitive decisions of a firm, allowing comparative analysis of business strategies (resource allocation decisions) within its industry product/service market, through integrating the different functional area activities (Hofer & Schendel, 1978).

Business level strategy further involves the integration of the firm's functions (ie., information system technology, operations, human resources) with one another within the business unit (Hofer & Schendel, 1978). Information system technology decisions, (eg. the type of system and amount of resources allocated to the design and implementation of a firm's information system technology), should be determined within the context of the business level strategy. Hofer and Schendel's (1978) strategic framework allows for the examination of congruence between business and functional level strategy. Their framework also permits comparative analysis across a variety of organizations in different industries.

The Operations Classification System

Hayes and Wheelwright (1979) developed a product/process matrix based on the concept of process life cycle. The process life cycle is described as an evolutionary process, beginning with a highly flexible process and moving toward increased "standardization, mechanization, and automation" (Hayes & Wheelwright,

1979, p. 134). The Hayes and Wheelwright (1979) product-process matrix compares the process life cycle -- from flexible to standardized flow (in rows) -- and -- from low volume, discrete products to high volume commodities (in columns). In addition to moving from flexibility and low volume to standardization and high volume, the movement also tends to be from low capital/high labor intensity to high capital/low labor intensity, and low cost efficiency to high cost efficiency (Taylor, Seward & Bolander, 1981).

The notion that operations processes exist on a continuum is not new (Hayes & Wheelwright, 1979; Taylor, Seward & Bolander, 1981; Fogarty, Blackstone & Hoffman, 1991; Dilworth, 1992; Schonberger & Knod, 1992), and while any attempt to establish specific classifications along such a continuum would by its very nature require arbitrary boundaries, there is substantial precedent in the previously cited literature for such classifications.

The four basic classifications of operations processes identified for this study include: job shop, batch flow, repetitive, and continuous (process) (Fogarty, Blackstone & Hoffman, 1991). Additionally, Flexible Manufacturing System (FMS), while not one of the basic classifications, is a manufacturing system designed so that the production line may be frequently rebalanced in order to quickly match output to changing demand patterns. Its primary characteristics include mixed model scheduling, cross-trained workers, standardized equipment for quick setups, a cellular production line (often U-shaped or circular) to enhance worker flexibility by allowing them to perform multiple tasks at multiple machines, and proximate cells to reduce transportation time between lines (APICS Dictionary, 1987).

Information Systems Sophistication

Most traditional literature assumes that "more is better" when addressing the characteristics of information systems. More adaptability or flexibility, higher levels of control, and a

stronger strategic orientation are all characteristics which define a superior information systems designs and which will improve system operation and maintenance. As an example Kmart Information Network (KIN II) architecture was designed specifically to bring increased flexibility to Kmart Corp (Fox, 1993). Next-generation software features include data-sharing schemes designed to provide increased flexibility (Bowen, 1993). The flexibility of Wireless Point Of Sale systems attract retailers to non-cabled point-of-sale capabilities (Robbins, 1994). Newly developed software, purports to provide consumers with both control and flexibility (Managing Office Technology, 1994), characteristics which have previously been considered as diametrically opposed. Atkinson, Kec, and Stricker (1992) provide evidence that teamwork and flexibility may be used in conjunction with a strong management commitment to enable integration of functional units within the organization, (Atkinson et. al., 1992) thus improving strategic linkages. Recent literature suggests that a firm's destiny depends on its ability to adapt its information system to create a competitive advantage and to seek the strategic advantages associated with the development of information systems and automation (Davis & Olson, 1985; Wiseman, 1988).

There currently exists a limited understanding of the nature of the linkages between various functional units and organizational strategies. Functional managers, including information systems managers, need to possess a clear vision and understanding of strategic intent to assist them in their decision-making activities. This overall strategic direction of the organization will provide functional level management with a clear understanding of their relationship to the company's goals, thus improving their ability to assist in the implementation of sound strategies for achieving these goals (Sorgenrei, 1994). Information systems managers need to understand the impact of various characteristics of their systems on the capability of the firm to successfully implement strategy in the pursuit of its goals.

There is even less literature which em-

pirically addresses the need for understanding information systems characteristics and their effects on organizational performance. Abernathy and Guthrie (1994) examined differences in the design parameters of accounting information systems in firms adopting different strategic priorities. Using a sample of 49 business unit executives, the study indicates that the effectiveness of business units is dependent on a match between the design of the information system and the firm's strategic posture. Information systems which have the characteristics of a broad scope system were found to be more effective in firms employing a strategy of continuous product/market development and innovation (Prospectors) than in firms which were protecting a comparatively narrow and stable product-market (Defenders). The results have important implications for management involved in the design and implementation of management information systems, especially in firms adopting a more innovative strategic posture (Abernathy & Guthrie, 1994).

The Operational Framework And Research Issues

Given that organizational strategy decisions influence structural and internal policy alignment (Hambrick, 1983), it is both logical and essential that strategy research examine the integrative relationship between functional strategies (e.g., operations and information systems) and the effectiveness of the business level strategy. Research supporting the importance of this systematic relationship between these functional activities and firm performance (Hitt, Ireland & Palia, 1982; Hitt, Ireland & Stadter, 1982) and the relationship between business strategy and specific functional areas (Udell, 1972; Datta, 1979; Wheelwright, 1984; Milkovich & deBajar, 1987; Rockmore, 1991; Rockmore & Swinehart, 1992; Rockmore & Smith, 1993) is evident in the literature.

Building on existing research demonstrating linkages between business level strategy and (1) operation processes (Rockmore & Swinehart, 1992) and (2) information system technol-

ogy sophistication (Rockmore & Smith, 1993; Rockmore, Smith, & Zimmerer, 1995), this study proposes a framework examining the affect of business level strategy on the relationship between operation process classification and level of information system technology sophistication. The proposed relationship between the variables of study are presented in Figure 1. The focus of this study is to empirically explore whether business level investment strategies influence the relationship between a firm's operation (production) process and the level of sophistication of its information system technology. This study explores two specific propositions:

Proposition 1: Firms pursuing risk-oriented strategies with intermittent operation processes will possess moderate to high information system technology sophistication.

Proposition 2: Firms pursuing risk-averse strategies with continuous operation processes will possess low to moderate information system technology sophistication.

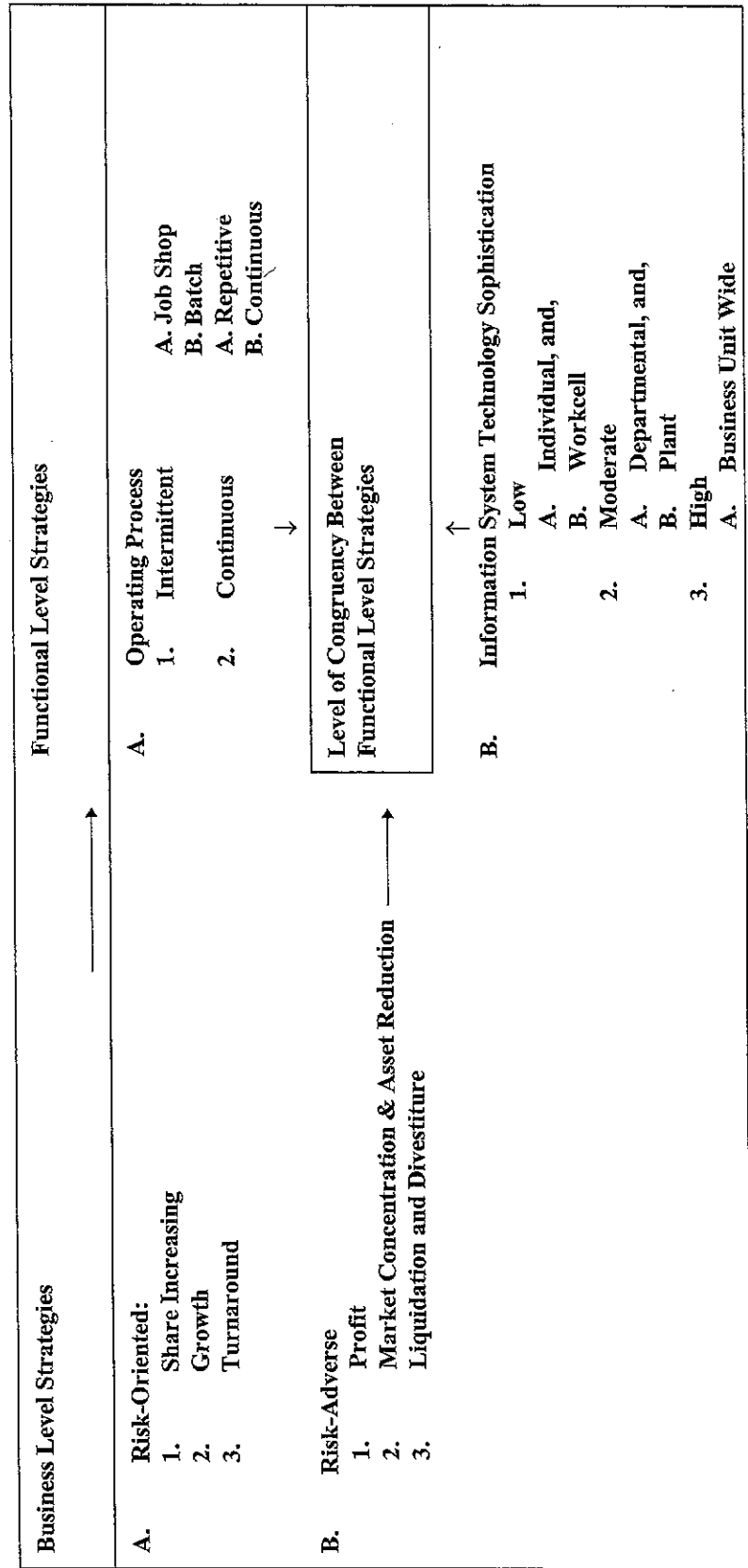
Sample

Sampling Strategy

A stratified and rational approach was used to select the business unit sample. The main concern was to ensure a cross section of geographically dispersed firms of varying size, as measured by both sales volume and number of employees, possessing varying, and operation/production process.

To ensure cross-sectional representation, the researcher consulted the following sources: (a) 1989 Standard and Poor's Register of Corporations, Directors and Executives, Volume 1, (b) 1989 Standard and Poor's Register of Corporations, Directors and Executives, Volume 1, (c) *Standard and Poor's Industry Surveys, Volumes 1 and 2* for July 1989 and January 1990, (d) *1989 Standard and Poor's Corporation Records, Volume 51*, (e) *United States Department of Commerce's 1990 U.S. Industry Outlook*, and (f) *United States Department of Commerce's 1991*

Figure 1
Framework of the Study



U.S. Industry Outlook. These sources provided the names and addresses of corporations and their subsidiaries, names and titles of the executives, brief description of their product/service market, total sales, and number of employees; marketing, financial and operational data for publicly listed business units; past and forecasted changes in market trends, economic conditions and technology by industry for the approximately 1,311 business units.

Based on the above process, 1,044 business units representing 36 two digit SIC codes and 225 four digit SIC codes were selected for the data collection.

Data Collection Procedure

Data were collected in three phases. First, two sets of questionnaires were mailed to the 1,044 selected business units. A multi-phase questionnaire was mailed to the operating heads of business units (i.e., Chief Executive Officers (CEO's), or Presidents or General Managers). The operating heads of the firm were asked to classify the nature of the firm's business investment strategy currently employed. They were also asked to have the individual responsible for operations complete the operation classification section identifying the type of operation process they currently used and the head of their information management systems complete the section identifying the degree of sophistication presently used by the firm. Each mailing included a cover letter explaining the purpose of the study, criteria for sample selection, the importance of the diverse nature of the information requested, and a guarantee of confidentiality of responses. The cover letter also informed the respondents that they would receive an *Executive Report* summarizing the results of the study's findings.

Responses

One hundred and thirty usable questionnaires were returned by the firm's executives, including the information requested from the firm's operations and information system executives, representing 12.5% response rate. These

130 business unit's represented 36 two digit Standard Industrial Classification (SIC) codes and 66 four digit SIC codes. For the sample, the total sales ranged from 2 to 7,200 million dollars. The range of employees for the total sample and the mail survey participants was 9 to 42,000. Of the total 130 participating firms, 99 (75.6%) were publicly owned firms and 31 (24.4%) firms were privately owned.

Measures

The concepts measured in the study were (1) business unit investment strategy, (2) operation process, and (3) level of information system technology.

Business Investment Strategy Classification

The responding executives were asked to indicate the nature of their business unit strategy they were presently pursuing. The response choices provided in the Appendix, consisted of Hofer and Schendel's (1978, p. 160) six business investment strategy classifications. These six business investment strategy categories were used to classify the SBU's present business strategy. The identification of a business unit's strategy was determined by the SBU's operating head (i.e., CEO, President, General Manager) selecting the most appropriate business investment strategy classification.

Production/Operation Categories

The Production/Process Matrix adapted from Hayes and Wheelwright (1979) and Taylor, Seward and Bolander (1981) was used to classify the sampled firms' production/operation technology (production process) categories: job shop, batch flow, repetitious, and continuous (Fogarty, Blackstone & Hoffman, 1991). Executives were asked to classify their firm's operation technology (production process) using Rockmore and Swinehart's (1992) Operational Process Questionnaire developed representing an adaptation of Hayes and Wheelwright (1979) and Taylor, Seward and Bolander (1981). The response choices were: job shop, batch flow, repetitious

and continuous. The description of the four operation processes are provided in the Appendix.

Classification of Information Systems Technology Sophistication

Based on a review of the information systems literature (Nolan 1974, 1979; MacIlvaine, 1991), Rockmore and Smith (1993) developed a five scale instrument which progressed from very low information system technology (eg. individual and workcell) to more sophisticated information system technology (eg., business unit wide application) to classify the degree of information system technology (IST) sophistication employed by a firm. The Appendix presents the information system technology classification scheme used in this (Rockmore & Smith, 1994) which is a modification of their five point scale to a three point scale classifying information system technology sophistication as either low, moderate, or high. The respondents were asked to indicate the degree of their information system sophistication using these three classifications. Their classification concentrates on the underlying factors flexibility, integration and control. The response choices ranged from "Level 1" the least sophisticated, flexible, or integrated information system level (control of individual machines and equipment) to "Level 3" the most sophisticated, flexible, and integrated information system level (business unit orientation). Generally, as firm's report higher use of these characteristics their classification would be classified as more sophisticated.

Data Analysis

Data analysis was conducted in two stages. Stage one involved classifying the firm's business level investment strategy, nature of its operational process, and information system technology sophistication. The three variables were classified using the respondents' classification to the survey items soliciting the business unit strategy presently employed, the type of operation process in use, and current level of information system technology sophistication.

Due to the exploratory nature of this study, stage two involved conducting multiple X^2 tests of independent samples to test the stated propositions. First, X^2 tests of independent samples was conducted to determine the congruence between the responding firm's operation process relative to its business investment strategy. Secondly, given the business investment strategy, X^2 tests of independent samples was conducted to determine the congruence between operation process and the sophistication level and the sophistication of the firm's information system technology.

Results

The distribution of the responding firms within the business investment classifications included 28 (21.5%) firms in the Share Increasing and Turnaround investment strategies, 42 (32.3%) firms pursuing Growth investment strategies, 49 (37.7%) firms employed Profit oriented business investment strategies, and 11 (8.5%) firms a Market Concentration/Asset Reduction investment strategy. This resulted in 70 (53.8%) firms pursuing risk-oriented investment strategies while 60 (46.2%) employed risk-averse investment strategies.

The distribution of the responding firms within the four operation process categories included 29 (22.3%) firms in the Job Shop classification, 29 (22.3%) firms in Batch Flow, 27 (20.8%) firms in Repetitive, and 45 (34.6%) firms in Continuous. The intermittent category included the 59 (44.6%) Job Shop and Batch firms while the continuous category included the 72 (55.4%) repetitive and continuous firms.

The responding firm's indicated that 17 (13%) currently possessed low information system technologies, 63 (48.5%) of the firms had moderate information system technologies, and 50 (38.5%) currently employed high information system technology sophistication.

Results of the X^2 tests of independent samples indicate that firms pursuing risk-oriented investment strategies employed moderate infor-

mation system technology sophistication significantly more often than either low or high information system technology and were significantly more likely to possess intermittent operation processes. Firms pursuing a share increasing strategy indicated a greater associated with intermittent operational processes [$X^2 = 10.7$, $df(1)$, $p < .01$] while firms pursuing a growth investment strategy [$X^2 = 10.29$, $df(1)$, $p < .01$] also evidenced a greater tendency toward intermittent operational process [$X^2 = 3.04$, $df(1)$, $p < .10$]. However, firms employing a risk-averse investment strategy indicated a significantly greater use of high information system technology sophistication [$X^2 = 7.38$, $df(1)$, $p < .01$] and had a significant tendency to use continuous flow operation processes.

Discussion

Generally, the results support both a relationship between the functional area strategies of operations (production) and information system technology and among business investment strategies although varying with regard to risk.

Proposition 1 suggested that firms pursuing risk-oriented strategies with intermittent operation processes would require more sophisticated information system technology. The results supported this proposition as evidenced by the association of intermittent operational processes and risk-averse strategies and their tendency toward moderate information system technology. Risk-oriented firms with had a greater tendency for an intermittent operation orientation indicated a significantly greater orientation toward less sophisticated information system technology.


However, although Proposition 2 did indicate a significantly greater use of continuous flow operations among firms employing risk-averse strategies, it did support the proposed level of information system technology sophistication. These firms indicated a significantly greater use of high rather than low to moderate information system technology sophistication. This may be explained in part by the availability

of resources of firms producing large volume. Although the flexibility and amount of integration of their information system may not be critical or add value to the organization, their resource capacity may allow them to enhance their information system technology beyond their critical needs.

Summary

In summary, business units employing risk-averse strategies are more likely to be associated with continuous flow operation process but are also more likely to have more sophisticated information system technology. Moreover, business units pursuing a risk-oriented investment strategy had implemented moderate to more sophisticated information system technology and were found to have intermittent operation processes.

Implications for Future Research

The next logical step in this stream of research would be to examine the effect that congruency between operational processes and information system technology sophistication has on firm performance. This research would provide an assessment of the "value added" provided by enhancing information system technology relative to the operational needs of the organization. Such research could also raises the question of integration versus complexity. There appears to be contradiction in the literature differentiating between integration (a true enhancement of an information system through increased application of knowledge and information) and complexity (increasing the number of application for similar existing systems). 

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2. Growth: to maintain a relative market share position in rapidly expanding markets. This strategy often requires moderately high investment in absolute terms, but not substantially above the investment average level of the industry.
 3. Profit: to maximize the business' utilization of its existing resources and skills. Investment's under this strategy are usually at maintenance level.
 4. Market Concentration and Asset Reduction: to realign resources and skills of the business to make them correspond to the (new) market segments that the business intends to serve. This strategy usually requires the sale or shutdown of some of the business' asset base and/or moderate cash investment to refocus the remaining assets.
 5. Turnaround: to reverse the declining posture of the business as rapidly as possible. These strategies may require additional capital and other resources, including self-financing.
 6. Liquidation and Divestiture: to generate as much positive cash flow as possible while usually with drawing from the business.

Appendix - Key Terms

A. Business Investment Strategy Classifications

1. Share Increasing: to significantly and permanently increase the market share of the business unit. This strategy would imply a level of investment substantially greater than the industry norm.

B. Operation Process Classifications

1. Job Shop. The job shop classification produces custom products based upon customer specifications. Volume for each product in such companies is low, and variety of products is high. The job shop layout is process oriented (by department) and the pattern of work flow tends to be random, in units or small batches of items. Such companies tend to be labor intensive, using general purpose machines and equipment along with skilled laborers to provide maximum flexibility, and the flexibility to produce many different products in low volume at high quality is generally considered to be a primary capability of the job shop.
2. Batch Flow. Like the job shop, the batch flow process is process oriented, but with sequenced departments and one or more dominant

work flow patterns. Equipment and machinery varies between general and specialized, with skilled workers and multiple products produced in batches. Often batch flow processes have a central mixing and/or reactive stage that is common to each batch (i.e., pharmaceutical, paints, etc.). Again, flexibility and low (small batch) volume is the major capability.

3. Repetitive. Perhaps the most widely recognized example of the repetitive operation is the assembly line. Unlike the job shop or batch flow, the repetitive operation is product oriented, meaning that individual flow lines are dedicated to specific products or product groups. Equipment in this environment is specialized and typically incorporates a mix of technologies. Capital intensity tends to be higher than in the job shop, with a corresponding decrease in labor intensity. The work flow pattern is continuous, rigid and linear. Labor skill requirements are low, and the primary capability of such a process is the high volume production of one or a few products at low cost.

4. Continuous. As in the repetitive environment, the continuous operation is product oriented, with flow lines dedicated to specific products or product groups. The distinguishing factor is generally considered to be the lack of discrete product units within the process, as with fluids, chemicals, and other bulk commodities. Equipment in this environment is specialized and dedicated, generally higher technology, making it an even more capital intensive environment. The work flow pattern again is continuous, rigid and linear. The primary capability of the continuous process is the high volume production at low cost.

C. Information System Technology Classifications

Level 1: (Low) Individual or Workcell Orientation. Low user control through individual machines and equipment (i.e., sensors, robots, numeric control). Some resource availability for initial training in use of machines/equipment and little to no resources for instruction for future

application or information system planning.

Level 2: (Moderate) Department or Plant Orientation. Department or workcenter control information user, higher supervisory levels of control, real time data acquisition (i.e., in process scanning, summarization and feedback). Automated plant control tasks (i.e., scheduling and tracking). Emphasis on integrating information among critical business unit departments. More emphasis on user control of information costs and information system planning.

Level 3: (High) Business Unit Orientation. Automated business unit information management (real time accounting data, electronic data transfer, on-line vendors and buyers). Focus on data administration. Resource availability for the development of strategic information systems. Emphasis on information systems that match and assist the business unit in its objectives.

Level 1: Individual. Single purpose systems with little or no flexibility. Low user control through individual machines and equipment (i.e., sensors, robots, numeric control). Some resource availability for initial training in use of machines/equipment and little to no resources for instruction for future application or information system planning.

Level 2: Workcell Orientation. Flexibility within the workcell. Information user control (i.e. programmed logic controllers, direct numeric control). Resources available to encourage machine/equipment use. Increasing concern for information system machine/equipment cost. Minimum information system planning.

Level 3: Department. Departmental flexibility and integration. Department or workcenter control information user, higher supervisory levels of control, real time data acquisition (i.e., in process scanning, summarization and feedback).

Level 4: Plant Orientation. Increasing emphasis on flexibility and adaptability of information system for all plant applications. Automated plant control tasks (i.e., scheduling and track-

ing). Emphasis on integrating information among critical business unit departments. More emphasis on user control of information costs and information system planning.

Level 5: Business Unit Orientation. Highly flexible systems integrating business unit functions. Automated business unit information management (real time accounting data, electronic data transfer, on-line vendors and buyers). Focus on data administration. Resource availability for the development of strategic information systems. Emphasis on information systems that match and assist the business unit in its objectives.