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A LONGITUDINAL STUDY OF THE UTILIZATION OF PRODUCTION MANAGEMENT TECHNIQUES BY SMALL ELECTRONICS FIRMS

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ABSTRACT

This study is a longitudinal examination of the changes that have taken place in the utilization of production management tools and techniques through the 1981-1988 time period. Results suggest that small electronic manufacturing firms are actively attempting to improve the efficiency and effectiveness of their manufacturing process. Of particular interest is the apparent emphasis on seeking to contain costs while simplifying the manufacturing process.

INTRODUCTION

During the past 20 years the world has evolved toward a globally-integrated economic system. This globalization represents one of the most important and dramatic changes in the business environment of this century and without doubt has had a tremendous impact on both the nature of industrial competition and the role of production management in securing a competitive advantage. As globalization continues, there is every reason to believe that competitive pressures will only increase, especially as new competitors possessing some economic advantage enter the competitive arena. This intensification of competitive pressure will require that today's production managers make the most effective use of available and future resources--labor, materials, equipment, facilities, energy, and capital.

Throughout the 1980s, the U.S. management practice was frequently called into question as U.S. competitiveness declined in many highly visible industries. The issues of primary interest during much of the competitiveness debate focused on how management was responding to the intensifying competitive challenge through the selection and use of management techniques designed to improve manufacturing efficiency. The objective of this paper was to attempt to better understand management's competitive response during the 1980s. Achieving the effective and productive use of the firm's resources requires that managers be aware of the different production tools and techniques available. A number of researchers have suggested that the systematic and appropriate utilization of operations/production management tools and techniques may enable a firm to enhance its competitive position in the global marketplace by improving the firm's ability to product reliable, high-quality products at competitive prices (11, 13, 27). Therefore, this research was designed to investigate the utilization patterns of many of the traditional--as well as several of the newer--production management tools and techniques. That is, the objective was to examine changes in production practices that have occurred during the 1980s, identifying the production techniques that today's manager's are emphasizing in their attempts to develop and sustain a competitive advantage based on production competence. This approachis consistent with contingency theory, which notes that management will modify its competitive strategy in response to changes in the competitive environment in order to maintain or improve the firm's competitive position.

THE STUDY

Because the mix of production tools and techniques used by a firm has the potential to improve the firm's utilization of available resources and thus lead to higher levels of productivity and quality, the authors have conducted a longitudinal study to obtain data on the comparative utilization of operations management tools and techniques. The original research project was carried out in 1981 with the follow-up study being conducted in 1988. These studies were designed to determine which management tools and techniques have been widely perceived by manufacturing managers to be the most valuable in the successful management of production activities. By focusing on changes in management practice from 1981 to 1988, insight into the competitive response of managers of small manufacturing firms can be gained.

Utililization data were collected for 40 different production management tools and techniques. The activities included in the study were selected because of their prominence in the production/operations management literature and on the basis of their ability to help a firm manage its production process. However, because of the longitudinal nature of the study, some production techniques widely used today were not generally "available" at the time the initial survey was conducted. Therefore, in addition to collecting longitudinal data for the original 40 production tools, the second survey also collected data on new production techniques that had come into popular use during the 1980s. For example, Just-In-Time manufacturing techniques have emerged as prominent production techniques during the past decade and have received considerable attention in both the popular and academic literature since the 1981 study.

Firms participating in the two studies were selected on a stratified random sample basis from Thomas and American Electronics Association (AEA) directories. Both the 1981 and the 1988 studies focused on small electronics manufacturers with 100 to 500 employees. The Vice President of Manufacturing (or equivalent) for each electronics firm was mailed a self-administered questionnaire and was asked to indicate the firm's usage experience for each of the original 40 production tools. The firms included in the 1988 study provided utilization data for the "new"

techniques that have more recently become accepted as impacting on productivity and quality. A five-point scale was used to collect data with the response alternatives as follow: 1) Never heard of it, 2) Know about, never used, 3) Used but later rejected, 4) Experimental or occasional use, 5) Continuous or routine use. Utilization totals for each technique were determined by combining the scores for experimental or occasional use and continuous or routine use (options 4 and 5). From this longitudinal data, trends in usage for each tool along with changes in rank of importance among the tools can be evaluated. Respondent firms included defense and aerospace, original equipment manufactures (OEM), industrial, and consumer goods producers. The respondents were equally distributed from the above industry groups. An overwhelming majority of the firms were batch manufacturers of average to low volume. The number of usable responses in each survey year were as follows: 1981 n = 120 and 1988 n = 100, which represent 35% and 30% response rates.

STUDY FINDINGS AND DISCUSSION

Utilization of Selected Production Techniques

The 40 selected management tools and techniques are rank ordered in Table 1 according to the percentage of firms utilizing each of the techniques as reported in the 1988 study. To facilitate comparisons, rankings and actual percentage utilizations for each technique for both 1981 and 1988 are provided in Table 1. Examination of the data reported in Table 1 indicates that seven of the operations tools listed in the top ten in 1981 also appeared among the ten most utilized tools in 1988. This observation indicates some constancy in production management practices throughout the decade despite the highly publicized need to change management practices to improve competitiveness (4, 11, 23, 24). It should be noted that the types of management technique represented by these seven tools are often considered basic to accounting for and controlling the production process.

Overall, the dominant theme presented by the ten most utilized techniques is the need for cost containment. Three of the top four ranked management tools—formal budgetary controls, capital funds justification, and formal cost reduction programs—focus explicitly on controlling or reducing expenditures. Considering the intensified competitive pressure encountered by electronics firms over the past decade, especially in the area of low-cost production, the focus on controlling or reducing costs is readily understandable. Four of the remaining top ten techniques deal with inventories or the control of physical materials. Given the emphasis placed on inventory management during the 1980s, this finding is not surprising.

The three tools that climbed into the top ten are perpetual inventories, vendor rating systems, and profit sharing in production. The inclusion of vendor rating systems and profit sharing programs in the top ten techniques is noteworthy because of the remarkable jump in ranking for each (vendor rating improved from 22 to 8 and profit sharing improved from 26 to 9). The increase in utilization of vendor rating systems reflects a recognition of the importance of purchasing practices in improving a firm's value-added performance; purchased inputs often represent from 60 to 80% of a firm's operating expenses as compared to 10 to 15% for labor (17). For the firm that has not developed high-level purchasing skills, cost reductions of 10% or greater on purchased inputs are

Table 1
Rank Order of Selected Operations Tools

1988 Ranking	Management Tool	Percentage Utilization 1988	1981	1981 Ranking
1	Formal Budgetary Controls	92.1	93.3	2
2	Inventory Obsolescence Disposition and Salvage	91.8	86.6	8
3	Capital Funds Justification	90.9	94.1	1
4	Formal Cost Reduction Program	89.9	84.9	9
5	Physical Inventories, Annual	85.7	90.8	5
6	Perpetual Inventories	85.7	81.5	12
7	Formal Systems and Procedures	84.7	87.4	7
8	Vendor Rating Systems	81.9	65.5	22
9	Profit Sharing, Production	81.6	59.7	26
10	Waste and Scrap Controls	80.8	92.4	4
11	Gantt Charts; Bar Charts	80.4	68.9	19
12	Standardization Program	78.6	76.5	14
13	Economic Lot Size (Production)	78.5	83.2	11
14	Profit Sharing, Clerical	77.5	58.8	28
15	Work Measurement, Job Standards Production	76.5	93.2	3
16	EOQ (Purchasing)	76.5	88.2	6
17	ABC Concept, Inventories	76.5	58.7	29
18	Product Line Simplification	75.6	74.8	15
19	Suggestion Systems, Production	75.5	70.6	17
20	Internal Operations Audits	74.8	79.8	13
21	Methods Study, Work Simplification	74.5	84.8	10
22	Learning Curve	70.7	63.0	23
23	Zero Defects or Quality Control Programs	70.7	58.6	30
24	Value Analysis/Engineering	68.7	61.3	24
25	Suggestion Systems, Clerical	63.2	67.1	21
26	Internal Management Audits	62.6	72.3	16
27	Pert Charts	62.6	61.2	25

Table 1 Continued
Rank Order of Selected Operations Tools

1988 Ranking	Management Tool	Percentage Utilization 1988	1981	1981 Ranking
28	Cycle Inventories, Selective Control (ABC Concept)	62.3	47.1	32
29	Cycle Inventories, A to Z	59.8	36.1	33
30	Break-Even Chart	50.0	69.8	18
31	Tool Control, Salvage, and Reclamation	49.5	67.2	20
32	Inventory and Disposal at End of Project	43.3	24.5	37
33	Wage Incentives, Production	41.8	52.1	31
34	Math or Simulation Models	40.4	33.6	35
35	Work Measurement, Clerical	36.7	59.7	27
36	ABC Concept, (non-inventory)	33.7	36.0	34
37	Wage Incentives, Clerical	27.5	23.5	39
38	Line of Balance (LOB)	25.5	20.2	40
39	Queuing, Waiting Lines	23.2	24.4	38
40	Linear Programming	19.2	33.5	36

not uncommon. Further, selecting the best possible supplier is essential to improving both quality and productivity. This change also represents a move toward the management of the total supply chain as suggested by Porter's value-added system (22). The increased utilization of profit sharing, combined with the decreased use of wage incentives, indicates a move toward the recognition of the vital role of the firm's human resource in developing a sustainable competitive advantage. These changes suggest that the small electronics firms included in the study are adopting a longer-term management perspective with respect to the production process.

The three management tools that dropped from the top ten were work measurement and job standards for production (from 3 to 15) with a decline in utilization from 93.2% in 1981 to 76.5% in 1988. Economic Order Quantity (EOQ) in purchasing (from 6 to 16) with a decline from 88.2% to 76.5%, and methods study and work simplification (from 10 to 21) with a decline from 84.8% to 74.5 %. The deadline in utilization of techniques such as work measurement and methods study, especially as they are associated with time and motion studies, suggests a partial move away from

the micro management of the production process. The decline in the use of EOQ in purchasing is consistent with the increased use of vendor rating systems, tightly-coupled buyer/supplier relationships and JIT purchasing practices, which rely more on sole sourcing, developing a partnership style relationship, and the frequent use blanket orders (16,18).

Perhaps the most surprising finding from the data in Table 1 is the absence of a quality management technique within the top ten utilized tools and techniques. Throughout the 1980s, American industry has been criticized for its increasingly tarnished reputation for producing inferior quality products. During this same period, quality has consistently been cited as the single most important factor in determining long-term competitiveness (19, 20, 21). Zero defects or quality control programs, the quality management technique found in both the 1981 and 1988 studies, received a ranking of 23 in the 1988 study with a reported utilization of 70.7%. While this utilization level is not as high as the researchers had initially expected, it does represent a substantial (and statistically significant) increase in utilization from the 1981 survey. Other quality management techniques that appeared only in the 1988 study and therefore were not included in Table 1 also failed to make the top ten listing. If they had been included, their relative rankings and percent utilizations would have been as follows: total quality control (rank = 14) is utilized by 78% of the electronics firms, statistical quality control (rank = 22) is used by 72.8%, statistical process control (rank = 30) is used by 58.6%, and quality circles (rank = 31) are used by 53%. The consistency of utilization among the more popular quality improvement techniques suggests that a reliable measure was obtained.

When the difficulties that many larger, "Fortune 500" manufacturers have had implementing quality control programs during the mid to late 1980s are considered, the utilization levels of relatively sophisticated quality control methods such as Total Quality Control (TQC) and Statistical Quality Control (SQC) reported by the survey respondents appear less troubling. Further, many small electronics firms act as suppliers to larger firms and thus respond to the incentives established by their key buyers. The change in supplier selection criteria from the long-standing emphasis on obtaining the lowest priced items to an emphasis on quality and "total" cost did not occur on a widespread basis until the middle of the 1980s. Additionally, it is increasingly common for smaller firms to participate in their major buyers' supplier certification programs. Thus, given the resource limitations-- managerial and financial--of many small firm electronics companies, they would be expected to be followers in the quality enhancement movement. From this perspective the reported utilization levels of approximately 75% as early as 1988 indicate that the firms involved in this study are responding to market incentives and are actively involved in quality improvement efforts.

Of almost equal interest to those production management tools and techniques that are most utilized is the issue of which tools are least used. The findings of the two studies are very consistent with eight of the tools receiving a ranking between 31 and 40 in 1981, remaining in similar positions in 1988. The two least used and three of the bottom ten techniques are quantitative tools that are most often classified as operations research (OR) techniques--simulation models, queuing, and linear programming. Daskin has suggested one reason these OR techniques are not used more often--the assumptions necessary to make these mathematical models tractable make them unrealistic (7). Indeed, many managers view OR techniques either as overly complex and

unwieldy or as too far from reality. Nevertheless, Daskin concludes that there is a strong need to develop models that more closely match reality (7). According to Chase, line of balance techniques are perceived by managers in much the same way--that is, as overly complicated and too difficult to implement in real world settings (5, 6). Two themes are apparent among the remaining least used techniques: the perceived ineffectiveness of wage incentives and the belief that disposal and salvage activities are relatively unimportant.

Changes and Trends in the Utilization of Production Techniques

Table 2 contains information on the change in utilization for each of the 40 management tools and techniques for the time period from 1981 to 1988. Changes in utilization are reported both in absolute terms and in percentage form. This information can be used to identify trends in utilization, that in turn provide insight into steps that have been and are being taken to improve competitiveness. For example, information in Table 2 suggests that much greater emphasis is being placed on reducing costs, controlling inventory, and improving quality. This finding is consistent with much of the literature that has appeared in the past few years (8, 12, 27, 29). By contrast, less emphasis is being placed on work measurement both in production and clerical activities, tool control, salvage and reclamation, breakeven charts, and linear programming.

Table 2
Change in Utilization Between 1981 and 1988

1988 Ranking	Management Tool	Percent Utilization 1988	Percent Utilization 1981	Change in Utilization (81 to 88) Point Change	Change in Utilization (81 to 88) % Change
29	Cycle Inventories, A to Z	59.8	36.1	+23.7	65.7
9	Profit Sharing, Production	81.6	59.7	+21.9	36.7
32	Inventory and Disposal at End of Project	43.3	24.5	+18.8	76.7
14	Profit Sharing, Clerical	77.5	58.8	+18.7	31.8
17	ABC Concept, Inventories	76.5	58.7	+17.8	30.3
8	Vendor Rating Systems	81.9	65.5	+16.4	25
28	Cycle Inventories, Selective Control	62.3	47.1	+15.2	32.3
23	Zero Defects or Quality Control Programs	70.7	58.6	+12.1	20.6
11	Gantt Charts; Bar Charts	80.4	68.9	+11.5	16.7
22	Learning Curve	70.7	63.0	+7.7	12.2
24	Value Analysis/Engineering	68.7	61.3	+7.4	12.1
34	Math or Simulation Models	40.4	33.6	+6.8	20.2
38	Line of Balance (LOB)	25.5	20.2	+5.3	26.2

Table 2 Continued
Change in Utilization Between 1981 and 1988

1988 Ranking	Management Tool	Percent Utilization 1988	1981	Change in Utilization (81 to 88) Point Change	% Change
2	Inventory Obsolescence Disposition and Salvage	91.8	86.6	+5.2	6.0
4	Formal Cost Reduction Program	89.9	84.9	+5.0	5.9
19	Suggestion Systems, Production	75.5	70.6	+4.9	6.9
6	Perpetual Inventories	85.7	81.5	+4.2	5.1
37	Wage Incentives, Clerical	27.5	23.5	+4.0	17
12	Standardization Program	78.6	76.5	+2.1	2.7
27	Pert Charts	62.6	61.2	+1.4	2.3
18	Product Line Simplification	75.6	74.8	+0.8	1.1
1	Formal Budgetary Controls	92.1	93.3	-1.2	-1.3
39	Queuing, Waiting Lines	23.2	24.4	-1.2	-4.9
36	ABC Concept, (non-inventory)	33.7	36.0	-2.3	-6.4
7	Formal Systems and Procedures	84.7	87.4	-2.7	-3.1
3	Capital Funds Justification	90.9	94.1	-3.2	-3.4
25	Suggestion Systems, Clerical	63.2	67.3	-4.1	-6.1
13	Economic Lot Size (Production)	78.5	83.2	-4.7	-5.6
20	Internal Operations Audits	74.8	79.8	-5.0	-6.3
5	Physical Inventories, Annual	85.7	90.8	-5.1	-5.6
26	Internal Management Audits	62.6	72.3	-9.7	-13.4
33	Wage Incentives, Production	41.8	52.1	-10.3	-19.8
21	Methods Study, Work Simplification	74.5	84.8	-10.3	-12.7
10	Waste and Scrap Controls	80.8	92.4	-11.6	-12.6
16	EOQ (Purchasing)	76.5	88.2	-11.7	-13.3
40	Linear Programming	19.2	33.5	-14.3	-42.7
15	Work Measurement, Job Standards	76.5	93.2	-16.7	-17.9
31	Tool Control, Salvage, and Reclamation	49.5	67.2	-17.7	-26.3
30	Break-Even Chart	50.0	69.8	-19.8	-28.36
35	Work Measurement, Clerical	36.7	59.7	-23.0	-38.5

Four of the largest jumps in utilization occurred in the area of inventory control. However, it should be noted that each of these four inventory techniques was ranked relatively low in utilization in the initial 1981 study. Even so, when the increases in utilization of these inventory activities is combined with the prominence of other inventory control techniques in the top ten used tools and techniques, as shown in Table 1, the emphasis on controlling and/or reducing inventory emerges as a major trend in management practice during the 1980s. This trend fits nicely with the emergence of Just-In-Time (JIT) manufacturing systems, which emphasize waste elimination, the synchronization of materials flow through the production process, and continual improvement (10, 26, 27).

Whereas not one quality control technique appeared in the top ten most used techniques, the use of zero defects or quality control programs increased substantially from 58.6% in 1981 to 70.7% in 1988. The rapid introduction and adoption of total quality control, statistical quality control, and statistical process control also indicate that U.S. managers are taking the charge to improve quality seriously. Further, the 11.5 percentage point increase in utilization of Gantt and bar charts can be viewed as one means of making quality increasingly visible (26). Also, the rising utilization of vendor rating systems along with an increase in value analysis/engineering points to an increasing emphasis of quality throughout the entire supply chain. That is, today's managers appear to view the acquisition of quality inputs as essential to the production of quality products.

Two additional trends that appear to be noteworthy are the increased importance of visual approaches to production and quality control and the move toward long-term considerations. First, increases in the utilization of the Pareto relationship as exemplified by the ABC concept (+ 17.8 percentage points) and in the use of Gantt and bar charts (+ 11.5 percentage points) indicate an effort by managers to make production and quality information more widely available and visible. This approach is consistent with the notion of making the production of quality products automatic by simplifying the manufacturing system and making performance visible. Second, the jumps in utilization of profit sharing in both production and clerical activities point to an increasing emphasis of long term considerations. The increased use of profit sharing also suggests an increasing effort by management to share gains in productivity and competitiveness with the employees who are most active in helping achieve them.

Utilization of Newly Introduced Production Practices

Many new production practices—in particular JIT manufacturing and automated manufacturing systems—have become popular and increasingly utilized during the 1980s. However, the nature of a longitudinal study makes retroactive collection of comparative data for these new production techniques not feasible. Yet, examining their utilization levels in the latest study does provide to revitalize their firms' production capabilities. Information on 11 of the newer or more recently empahsized production techniques is provided in Table 3. Four of these techniques relate to automated manufacturing; four relate to alternative manufacturing systems; two focus on the competitive dimension of quality; and one captures information about productivity programs.

Table 3
Utilization of Tools Introduced in the 1988 Study

Management Tool	Percentage Utilization 1988
Computer-Aided Design	89.9
Productivity Measures	88.7
Material Requirements Planning	84.7*
Statistical Quality Control	72.8
Just-In-Time Manufacturing	60.6
Just-In-Time Inventory	59.6
Statistical Process Control	58.6
Material Resource Planning (MRPII)	58.1
Computer-Aided Manufacturing	43.5
Flexible Manufacturing Systems	27.3
Computer Integrated Manufacturing	20.2

*data on MRP utilization from the 1981 study shows a 89.1 percent utilization

One area that has received a tremendous amount of attention in the past 10 years has been the area of automated manufacturing (3, 9, 14, 25, 30). Four techniques have been of particular interest: computer-aided design (CAD), computer-aided manufacturing (CAM), flexible manufacturing systems (FMS), and computer integrated manufacturing (CIM). The data in Table 3 show that of these four techniques only CAD is currently widely used with a utilizastion of 89.9%. This relatively high utilization level for CAD is reasonable since CAD is generally considered to be the least complex and most easily implemented of the automated techniques. Further, CAD can be used in isolation from other production activities and technologies, and implementation of CAD systems does not require the capital investment associated with CAM, FMS, and CIM. Nonetheless, utilizations of 43.5% for CAM, 27.3% FMS, and 20.2% for CIM demonstrate a relatively high commitment on the part of electronics manufacturers to improve their competitiveness through automated systems.

As previously noted, building high-quality, low-cost products appears to be a requisite for success in today's global marketplace. The widespread use of statistics to assure that a quality product is manufactured as indicated by the 72.8% and 58.6% utilization of statistical quality control and statistical process control, respectively, suggests that U.S. managers of small electronics firms are actively striving to improve their quality reputation. Perhaps the most significant aspect of the utilization of these two techniques is the idea that both are designed to monitor the actual production process, assuring that quality is built into the product rather than trying to

inspect quality into the product. Both techniques also play a valuable role in the process of continual improvement. An important change in manufacturing philosophy is thus manifested by the utilization of these production techniques. The 88.7% utilization rate for productivity measures indicates that managers are paying attention to the issue of cost competitiveness. Future studies should be performed to determine what types of productivity measures are being used and what impact they have on firm performance (28).

Another topic that has been discussed at length during the 1980s has been the relative merits of different manufacturing systems (1, 2, 10, 26, 31). Table 3 shows that material requirements planning (MRP), which was introduced in the early 1970s, is still widely used among electronics manufacturers. However, utilization decreased from 89.1% in 1981 to 84.7% in 1988. The more sophisticated manufacturing resource planning (MRPII) is utilized at a much lower level of 58.1%. By way of comparison, Just-In-Time manufacturing and Just-In-Time inventory systems have gained rapid acceptance during the past 10 years with approximately 60% utilizations by 1988.

Finally, because of the interest that has been generated by the perceived lack of U.S. competitiveness along with the emphasis on revitalizing manufacturing through the adiaption of JIT manufacturing systems, data were collected on those components or techniques that have appeared in the literature as comprising the JIT concept. Utilization data for the 10 prominent components of JIT are contained in Table 4. The data in TAble 4 clearly show that the various aspects of JIT have received quite diverse levels of acceptance. While cross-training employees is at the high end of the utilization spectrum at 94%, kanban control systems are utilized by a relatively few 33%. The high utilization of cross-training seems appropriate, given the high levels of interest in improving productivity and the renewed interest in making the most of the human resource. Further, small firms often rely on a flexible workforce to compensate for smaller scale operations. In contrast, the traditional dominance of other control systems, in particular MRP and EOQ based systems, helps explain the low usage of kanban. Further, the implementation of JIT systems is often seen as being incremental, with kanban one of the last elements to be implemented—only after the manufacturing environment has been simplified sufficiently through the adoption of the other JIT elements for kanban to be an effective control. An incremental approach is one that is especially well suited for the small firm manufacturer. The utilization levels for the remaining JIT components suggest that firms do indeed take an incremental approach to JIT implementation, seeking first to reduce inventory levels, inprove quality, enahnce flexibility, and in general reduce complexity. The data also indicates that some of the JIT techniques are more generally applicable to a wider set of manufacturing envrionments.

CONCLUSIONS

The results from the longitudinal study of utilization rates of traditional and relatively new production management techniques seem to suggest that small electronics firms are actively attempting to improve the efficiency and effectiveness of their manufacturing process. Of particular interest is the increasing awareness of "new" quality techniques (total quality control and statistical quality control) along with an apparent emphasis on seeking to contain costs. This trend shows that U.S. electronics firms are responding to today's competitive pressures and are indeed

Table 4
Utilization of JIT Manufacturing Techniques

Management Tool	Percentage Utilization 1988
Cross-Trained Employees	94
Total Quality Control	78
JIT Purchasing	73
Reduced Set-up Times	72
Group Technology	65
Uniform Workload	65
Focused Factory	61
Quality Circles	53
Total Preventive Maintenance	49
Kanban	33

paying greater attention to the forces that are driving competition. More specifically, techniques that are currently very widely utilized or are rapidly increasing in popularity appear to fall into four categories: general budgeting or cost containment, inventory control/reduction, quality management, and long-term human resource management.

General budgeting and/or cost containment techniques continue to be important tools utilized by small electronics firms to maintain their competitive position. Budgets, cost reduction programs, and formal systems and procedures in clerical and/or administrative activities indicate that small electronics firms are actively pursuing the containment and control of costs. These are important and beneficial results considering the competitive nature of the electronics industry and the importance of low-cost production to effective competition. Firms that do not emphasize cost containment through the use of the above techniques may find it difficult to successfully compete. Another interesting finding closely related to cost containment is the emphasis on inventory reduction. The idea that inventory is no longer viewed as an asset but rather as a liability appears to have become evident to the firms in this study. The emphasis on inventory control, vendor rating systems, and Just-In-Time inventory highlights the critical importance of inventory and its impact on the total production system. By controlling and reducing inventory in the manufacturing system, production inefficiencies are identified and can be managed or eliminated. Efforts to identify these inefficiencies may account for the incrased utilization of visual controls. The increased emphasis of zero defect programs along with the high use of newly introduced tools of statistical quality and process control embodies the realization that quality is a necessary component of a successful firm strategy. That statistical process and quality control have gained such widespread acceptance in a

relatively short period of time indicates that small businesses are in the process of implementing techniques aimed at enhancing their ability to compete on the basis of product quality. This rapid adoption of quality control methods suggests that small electronics firms are aware of and responsive to changes in the criteria used to evaluate and select suppliers.

Tying cost containment, inventory reduction, and quality control together is the increasing emphasis on human resource management. This increased recognition of the value of the human resource is identified by the rapid increase in the utilization of profit sharing (both production and clerical) and the continued use of production suggestion systems. The very high utilization of cross-trained employees is also indicative of the small electronics firm's recognition that competitive success depends on the firm's human resource. Indeed, effective human resource management is the foundation that leads to the successful implementation of cost containment, inventory reduction, and quality control tools and techniques.

Two types of techniques appear to be decreasing in popularity: those activities associated with the micro-management of production and operations research type techniques, which are perceived to lack realism and to be too complex for practical problem solving. A trend toward simplicity and the adoption of new manufacturing systems and technologies appears to be evident. This move is consistent with a suggestion by Krajewski et al. that the key to manufacturing success is improving the overall manufacturing environment (15). The bottom line is that small electronics manufacturers are responding to competitive pressures and are seeking to enhance their competitiveness through the selective use of operations management tools and techniques.

Longitudinal studies provide a basis for evaluating the evolutionary nature of the firm. Many insights and ideas can be generated from this methodology. Unfortunately, few studies have effectively explored this potential. This study has attempted through a longitudinal analysis to identify the evolving nature of the production/operations management function of the firm. This study is industry and size specific, and some of the techniques may have limited applicability to electronics firms. However, electronics firms tend to be faced with a highly competitive and dynamic environment that requires proactive management for long-term success. Thus, electronics firms are often more responseive to changes in the environment and are often on the "cutting edge" of manufacturing practice. Also, by controlling for industry and firm size, we believe that the results provide a relatively accurate representation of utilization patterns and trends over the time frame of this study. Further, the relatively stable utilization reates and technique position ranking lend support to the techniques identified in this study. The results suggest that beneficial changes have taken and are continuing to take place in this functional area within electronics manufacturing firms. While this study basically addresses the area of production/operations, the effective utilization of the various tools discussed in this paper have significant impact on the overall success of the firm. As recent experience suggests, today's organization must produce high-quality products at a competitive cost and in a timely manner. It is a basic premise of this study that the judicious use of select operations management tools and the correct management of the productive system will contribute to the long-term success of the electronics and other types of firms.

To better understand the operation of organizations, future research should emphasize the development of methodologies that document the impact of operations/management tools and

techniques on firm performance and competitiveness. Such research would be the natural follow-up to the research presented in this paper. Additional research should explore the potential of longitudinal studies in a variety of industries. Longitudinal studies provide nuances and understanding into the management of firms that traditional, cross-sectional, point-in-time studies fail to provide. They enable managers/owners to more effectively guide their companies, advisors and consultants to more effectively assist in the management of firms, and academics to better research and understand the characteristics and dynamics of successful organizations.

REFERENCES

1. Aggarwal, S.C. "MRP, JIT, OPT, FMS?" *Harvard Business Review* (Sept.-Oct., 1985), 8-16.

2. Belt, B. "MRP and Kanban--A Possible Synergy?" *Production and Inventory Management*, 28 (1987), 71-80.

3. Browne, J., J. Harhen, and J. Shivnan. *Production Management Systems: A CIM Perspective* (New York: Addison-Wesley Publishing Company, 1988).

4. Buffa, E. "Research Perspectives in Operations Management," *Journal of Operations Management* (August 1980), 1-8.

5. Chase, Richard B. "Survey of Paced Assembly Lines," *Industrial Engineering* (February, 1974), 14-18.

6. Chase, Richard B. "Strategic Considerations in Assembly-Line Selection," *California Management Review*, 18 (Fall, 1975), 17-23.

7. Daskin, M.S. "Logistics: An Overview of the State of the Art and Perspectives on Future Research," *Transportation Research*, 19A (5/6, 1985), 383-98.

8. Garvin, David A. "Quality on the Line," *Harvard Business Review* (Sept.-Oct., 1983), 65-75.

9. Gunn, T.G. *Manufacturing for Competitive Advantage: Becoming A World Class Manufacturer* (Cambridge, Mass.: Ballinger, 1987).

10. Hall, R.W. "Ten Common Problems With Just-In-Time Manufacturing," *Proceedings*, Annual Meeting of the Operations Management Association (1985).

11. Hayes, R.H. and S.C. Wheelwright. *Restoring Our Competitive Edge: Competing Through Manufacturing* (New York, 1984).

12. Hayes, R.H., S.C. Wheelwright, and K.B. Clark. *Dynamic Manufacturing: Creating the Learning Organization* (New York: The Free Press, 1988).

13. Hyer, N.L. and U. Wemmerlov. "Group Technology and Productivity," *Harvard Business Review* (1984), 140-49.

14. Jaikumar, R. "Postindustrial Manufacturing," *Harvard Business Review* (Nov.-Dec., 1986), 69-76.

15. Krajewski, L.J., B.E. King, L.P. Ritzman and D.S. Wong. "Kanban, MRP and Shaping the Manufacturing Environment," *Management Science*, 33 (1987), 39-57.

16. Landeros, R. "Buyer/Seller Relationships in U.S. Manufacturing Firms: An Empirical Study," *Proceedings*, Annual Meeting of the National Association of Purchasing Management (1986).

17. Leenders, M.R., H.E. Fearon, and W.B. England. *Purchasing and Materials Management* (Homewood, IL: Richard D. Irwin, Inc., 1989).

18. O'Neal, C.R. "The Buyer-Seller Linkage in a Just-In-Time Environment," *Journal of Purchasing and Materials Management* (Spring, 1987), 7-13.

19. Pascarella, P. "Getting a Fix on Your Competitive Position," *Industry Week* (May 14, 1984), 69-72.

20. Peters, T. "More Expensive, But Worth It," *U.S. News and World Report* (February 3, 1986), 54.

21. Port, O. "The Push for Quality," *Business Week* (June 8, 1987), 131-44.

22. Porter, M.E. *Competitive Advantage* (New York: The Free Press, 1985).

23. Reuter, V.G. "Becoming Competitive With Value Engineering/Value Analysis," *Journal of Systems Management*, 36 (1985), 17-23.

24. Ritzman, L.P., B.E. King, and L.J. Krajewski. "Manufacturing Performance—Pulling the Right Levsers," *Harvard Business Review* (March-April, 1984), 143-52.

25. Rosenthal, S.R. "Progress Toward the Factory of the Future," *Journal of Operations Management*, 4 (1984), 203-29.

26. Schonberger, R.J. *Japanese Manufacturing Techniques* (New York: The Free Press, 1982).

27. Schonberger, R.J. *World Class Manufacturing: Applying the Lessons of Simplicity* (New York: The Free Press, 1987).

28. Skinner, W. "The Productivity Paradox," *Harvard Business Review* (July-Aug., 1986), 55-59.

29. Skinner, W. "What Matters to Manufacturing," *Harvard Business Review* (Jan.-Feb., 1988), 10-16.

30. Valery, N. "Factory of The Future," *The Economist* (May 30, 1987), S1-S18.

31. Vollman, T.E., W.L. Berry, and D.C. Whybark. *Manufacturing Planning and Control Systems* (Homewood, IL: Richard D. Irwin, Inc., 1988).