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This report is one of a series under the aegis of the Productivity/ Quality project within MIT's Sloan School of Management. The Project Director is Thomas A. Barocci, Associate Professor of Management. For further information contact Ms. Carolanne Foilb, Project Administrator, Sloan School of Management, MIT, 50 Memorial Drive, E52-454, Cambridge, MA 02139.

QUALITY ASSURANCE SYSTEMS AND US MANAGEMENT IN THE 1980s: THE EXPERIENCES OF ELEVEN HIGH TECHNOLOGY COMPANIES

By
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With
Thomas A. Klein, David A. Sanford and Kirsten R. Wever

There are many reasons for the current downturn in domestic and international demand for American products; one of them -- front and center -- is their low quality, as judged by purchasers. US integrated circuits have been shown to fail between three and twenty-six times as often as those produced in Japan. (Robinson, 1980) Studies have shown that 64 percent of American-made cars, as compared to 35 percent of Japanese-made cars, suffer mechanical problems within the first six months of ownership. (Main, 1980) It is Japanese products that have gained a wide reputation for high standards of reliability and quality of workmanship.

Product quality dictates short run profits and long run survival. The type, scope and importance of quality assurance and quality control systems, and their relationship to firm efficiency, can be traced both to corporate culture and to customer demands. Quality and productivity are the flip sides of efficiency. Quality failures cannot be laid at the doorstep of low capitalization or poor worker motivation; like productivity, poor quality is a management issue.

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Quality must be built into a product from its initial design through its final packaging. These case investigations of quality assurance/control systems were prompted by widely differing opinions on the reasons for the low(er) quality of American goods. The sample of firms is taken primarily from "high technology" industries. Using a simple planning and control model, we compare quality assurance systems across companies on the basis of corporate strategy, structure, culture and environment. (Lorange and Scott Morton, 1974)

QUALITY ASSURANCE BACKGROUND

The primary function of quality control in the US has historically been the detection, rather than prevention of quality defects. The influence of the worker on quality control was all but neglected, save when piecework rates were reduced in order to account for products that failed to pass inspection. Emphasis was (maybe still is) on the quantity produced. And rapid technological progress and growing uncompetitive markets diverted attention from issues of quality, except in firms with an unusual or unique product (where price was unimportant), or in those producing primarily for the Defense establishment, where it is crucial to avoid battlefield hardware failures.

During WW II, quality pioneers like Deming and Sheward gained great influence in the US, as the War Department needed expertise in manufacturing large quantities of complex weaponry that could be maintained and repaired both easily and quickly. The allied war effort and the spirit of the times decreased organized labor's resistance to stringent quality control.

After the Allied victory, the economy of Japan had to be rebuilt completely. The transition government in Japan, under U.S. direction, was aware of the well-deserved Japanese reputation for producing low quality goods, so they called in (mostly American) consultants to aid in setting up

quality control systems that would enable Japanese firms to compete in world consumer markets. The focus on quality production in Japan has sharpened over the last 30 years. But the US did not pick up this emphasis until the 1950's when the Sputnik scare led to huge increases in the space and defense budgets. These increases were paralleled by renewed and concerted attempts to impose stringent quality standards on all products and services for the military and space efforts.

Reliability Engineering was central to the development of the Polaris Fleet Ballistic Missile System. The best known example was the "Program Evaluation and Review Technique" (PERT) (Sapolsky, 1972), which clarified the interconnections between the steps that composed the design and manufacturing processes. It identified best-, most likely- and worst-case time estimates for each production step, allowing management to find the "critical path", or shortest route through the production network. (Sapolsky, 1972) The PERT-COST model accounted for the cost and scheduling effects of task interdependencies. (Carrubba, 1975)

"Total Quality Assurance Systems" also emerged in response to the needs of the Defense Department. Among these were programs called "Zero Defects" and "Quality Control Circles", which sought to involve employees in product quality issues. (Crosby) But the impact of these systems was limited by the short life span of the defense contracts that required such strict quality controls, by the diversion of industry's attention to the competing issue of environmental regulation, and by the inability (until the mid 1970s) of US firms to see that foreign competition was increaingly a matter of quality.

Currently, many U.S. manufacturers still cling to a short-term view that leads them to focus too heavily on inspection, rather than on the detection of quality defects at every step of the production process, allowing for the identification of "chronic defects". Where Quality Control specialists exist,

they often lack the full support of high level management. In contrast to Japan, US firms generally lack a specific quality strategy.

Related Fields

When managers did develop and apply quality programs, they drew heavily on earlier developed principles of management theory. Henri Fayol's general Theory of Management and Frederick Taylor's "Principles of Scientific Management" were based on a strict division of labor between management and workers. (Carrubba, 1978) This notion became deeply ingrained in management practices in the US. As a result, US quality programs were often implemented in ways that did not involve management and workers in a joint effort to monitor production, as in Japan.

The rise of Organizational Studies led to a greater emphasis on the role of the employee in maintaining quality production. Maslow's Motivation and Personality, and McGregor's "Theory X and Theory Y" all focussed on the environmental prerequisites for job satisfaction and work effectiveness. The consensus that developed out of this field was that employees work best when in relatively close and positive contact with management, and when they are given responsibility and the opportunity to function in groups.

The application of these principles has been made difficult by the structure of the US Collective Bargaining system. Employees generally look to their employers to fulfill only certain clearly delimited needs; in Japan, the company and its employees often interact in a much more encompassing lifestyle relationship. (Deming, 1981) The relationship between management and labor is also considerably more confrontational in the US. These two factors combine to make a close working relationship around the quality issue very difficult to attain. Gainsharing plans like the Scanlon Plan, fostering employee

participation in production decisions and sharing in resultant labor cost savings, have only met with success in a very limited number of applications. (Lesieur, 1981)

Current Quality Programs

The Zero Defects program was developed during the production of the Pershing Missile System in 1960, as a response to "employees' lack of attention to their work." (Halpin, 1966) The idea was to eliminate the acceptance of human error in the production process as being inevitable by challenging and motivating the workers, and by asking for and responding to their input on problems of quality. (Juran, 1970) But the program was not entirely successful except in cases where management provided extreme clarity in its definition, structure and goals. (Juran, 1970)

"Cost of Quality" was another such program. This system used Pareto's Law to pin-point the most significant costs entailed in quality maintenance, in order to allow managers to correct the most sensitive problem areas. The greatest value of the program lay in its emphasis on the financial matters of major concern to management. It enabled quality managers to communicate with top management and manufacturing management in terms they could understand and respond to, both in the short- and in the long-run. But "Cost of Quality" was never intended to be a complete quality program.

The concept of "Quality Control Circles" was initiated in Japan, but has recently gained widespread attention in the US as well. At first, US managers believed that the success of these employee working groups depended on unique cultural traits -- that Japanese workers naturally enjoyed working in groups, while US workers did not. But McGregor's "Theory Y" concept and William Ouchi's recent book, Theory Z, have challenged this assumption. Nonetheless,

the deeply ingrained Tayloristic separation between workers and management makes it difficult for US firms to implement quality programs within many corporate cultures. (Juran, 1970) American management is still in the process of learning how hourly employees can be pulled into quality problem solving by comparing and reconciling the skill and knowledge of both management and labor. (Amsden, 1980)

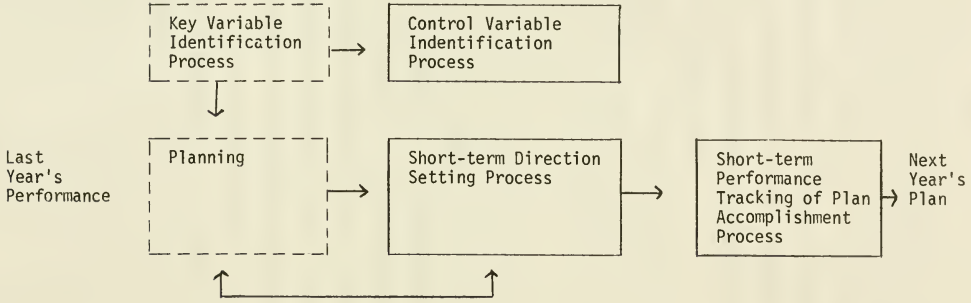
But through a combination of programs and efforts US management has begun to draw on the total potential of their employees. Quality of Worklife programs represent another recent move in this direction. As with the programs mentioned above, the primary obstacles facing management in these efforts are connected with the traditional adversarial relationship between labor and management in the US. But changing assumptions, together with an increasing willingness to learn from others, have begun to erode the deeply rooted separation between management and workers that has always permeated the US business environment.

MODEL AND METHODOLOGY

In 1974 Peter Lorange and Michael Scott Morton developed a model to analyze management planning and control systems, such as Quality Assurance systems. (Lorange and Scott Morton, 1974) The model is based on the control variables that form the basis of short-term management planning with respect to: 1) corporate goals and objectives; and 2) a firm's situational setting, including available technology, organizational structure and culture, and the external environment. (Carrubba, 1978) The specific components of the "long range management control processes" are illustrated in Figure 1. The control variables are grouped into four general categories: strategy, structure, culture, and environment.

FIGURE 1

Lorange & Scott Morton Management Control Model



Source: Lorange, Peter, and Scott Morton, Michael, "A Framework for Management Control Systems," in Sloan Management Review, Sloan School, MIT, Cambridge, MA, Fall 1974.

A firm's strategy includes short- and long-run management objectives, such as market share, technological leadership, quality levels, diversification and corporate image. This variable applies on a variety of organizational levels, which may vary in terms of factors such as the relative aggressiveness of their financial policies.

Corporate culture refers to such factors as the willingness to experiment and innovate, pride in workmanship, and the relative atmosphere of cooperation or confrontation. The general trend has been a shift from autocratic and paternalistic cultures toward a more consultative and participatory mode. But there are sharp difference across companies. The current propensity to prescribe for the US management those techniques that work well in Japan takes no account of cultural and structural differences between the two countries. The Japanese societal structure is complemented by corporate paternalism. But Japanese-style competitiveness in international markets cannot be guaranteed for the US simply by imposing managerial paternalism on the firms of a society whose structure is based on completely different principles.

A firm's structure hinges on the organization of the company itself, the product assurance system, staff and line relationships, the relative centralization of the delegation of responsibility, and the formal lines of authority and communication.

Finally, the external environment affects the firm insofar as it provides a given technology base, changing at a particular pace. Environmental factors also include the relative maturity of the industry, the basis for market competition (e.g., price, technology, quality, volume), the nature of the market (e.g., government/military, commerical/industrial, or consumer), the nature of the labor force and the type of suppliers and vendor markets involved.

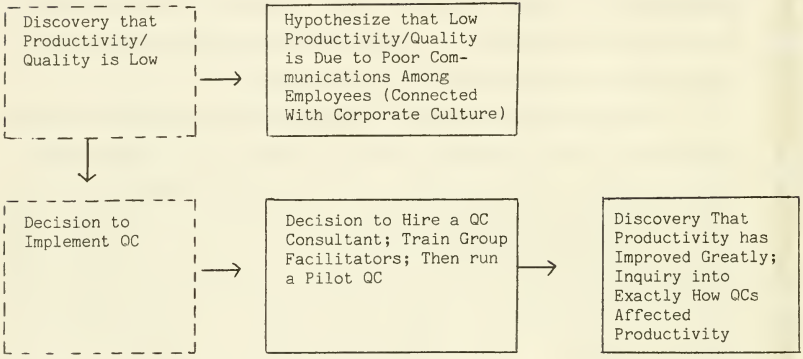
The case studies are analyzed in terms of these variables in order to allow for comparison on each of the four dimensions and across companies. Since many of the industries involved are changing rapidly, we tried to identify trends and ask the managers we interviewed to project the likely effects of these trends on the firm's quality systems. We placed particular emphasis on the role of quality assurance in the transition from product development to full-scale production, since it is during this phase that firms often incur significant costs in the maintenance of quality standards established during the product's initial development.

The case studies covered ten US technology-based firms and the American manufacturing operation of a Japanese company. We tried to interview both quality assurance and general managers at the corporate, divisional and plant levels. We typically structured about the first half of the interview around an interview guide, and the second around a more informal discussion of the planning and implementation issues that were raised. In the interest of clarity we attempted to identify specific management techniques and implementation problems with regard to a particular product. Of course the degree of detail covered varied from case to case with the level of experience of the interviewer and the relative candor of the managers interviewed.

The sequence of events that is suggested by Figure 1 is relatively self-explanatory. On the far left of the diagram, the first step is to identify "key variables", such as quality or productivity. The box is broken to indicate that it is a staff function. Following this is the staff's planning phase, and the identification on line of "control variables," or factors that affect the key variable(s). The next step is short-term direction setting, which is done in conjunction with the planning phase, and with the control variables in mind. Finally, the matter leaves the hands of staff; short-term performance is measured and the results are compared with

the initial plans to improve the key variable. This is followed by a re-evaluation, which leads to the next plan.

As a representative example, the model could be reformulated as follows:



In short, the model simply suggests the logical sequence of the different components of the implementation of a quality assurance system. While this may seem obvious, the case studies illustrate the inherent difficulties involved in implementing such programs along these lines. Their various strengths and weaknesses correspond with their relative ability to adhere to this model.

THE AGGREGATED CASE STUDIES

Product Quality and Corporate Strategy

Most of the firms we studied had explicitly stated goals to improve product quality in some way. The key variable, in other words, was clearly identified. But the methods proposed to address the problem(s) and the measures of success that were used varied widely. Figure 2 provides a brief description of the case studies. One major manufacturer of computer peripherals (firm C) had placed the objective of product reliability as a top priority on the management agenda. Other firms merely recognized the need to maintain quality in the interests of retaining market competitiveness. Where particularly sophisticated products were involved, technology development was usually the highest strategic priority. But the pressures of international competition have made it impossible to stay on the technological leading edge without simultaneously emphasizing reliability and quality. This speaks for the need to pay closer attention to the exact nature of "control variables."

Because of the importance of international competition this held particularly true for the six firms we studied that sold in the private commercial market. The government contractors generally competed only with other American firms; the managers of these companies were more concerned with meeting the stringent product quality regulations imposed by the government.

Among the eleven firms we studied the strategy of quality management was frequently couched in terms of productivity. The managers of one defense contracting firm (company F) clearly emphasized productivity in an effort to cut the costs of achieving the high levels of product quality demanded by the Defense Department. In the case of another firm, in the machine tool industry (firm I), quality control circles were introduced specifically to increase company-wide productivity. Not all the firms we studied coupled a focus on

productivity with one on quality, but some sort of management strategy of quality improvement was present in almost all of them.

FIGURE 2: QUALITY CASE STUDIES: FIRM CHARACTERISTICS

FIRM	SIZE	PRODUCTS	CUSTOMER(S)	STRUCTURE	CULTURE
A	-Semi-autonomous division of a larger firm -ca. 300-400 employees	-One product; electro-mech. assembly -High volume low cost production	-Military	-Functionally organized -Quality assurance reports to division general manager	-No attempt to motivate quality consciousness -Emphasis on job simplification
B	-Small division of a multi-billion dollar electronics corporation	-Sophisticated marine electronics systems	-World wide commerical market	-Quality assurance reports to director of manufacturing operations	-Recent strategy to change culture -Increasing communication, decentralization, training
C	-Division of a firm with ca. $100 million in annual sales	-Computer peripherals	-Commercial	-Quality Assurance Director recently made a V.P.; used to report to division general manager	-Recently acquired firm -New quality emphasis on product assurance, raising the implications of quality workmanship
D	-ca. 5,000 employees	-Naval ships -75% new construction -25% overhaul work	-U.S. Navy	-Inspection and quality assurance report to VP of Operations -Full time naval auditor -Strong Naval presence	-Tradition of pride in workmanship -Belief that quality is free -Much promotion from within
E	-Large areo-space company -Over $2.5 billion annual sales	-Sophisticated electronics systems	-80% of production for Defense Department	-Line and staff structure -ca 30 divisions -Staff director of product effectiveness reports to president and chairman of the board	-Top management supports quality emphasis -Learning from Japan -Careful not to over-institutionalize quality programs -Change is gradual because of role of military
F	-Division of a multi-billion dollar firm -ca. 20,000 division employees	-Space (satellite) and terrestrial electronics systems	-90% of production under federal contracts	-Highly matrixed along functional and product lines -Government requires that quality assurance be separate from manufacturing to to avoid conflicts of interest	-Product assurance relatively unimportant -Highly quantitative -Innovation is a function of the government -Conservative management resists change

FIGURE 2: QUALITY CASE STUDIES: FIRM CHARACTERISTICS (Continued)

FIRM	SIZE	PRODUCTS	CUSTOMER(S)	STRUCTURE	CULTURE
G	-Largest division of a major company -Divisional sales over $1 billion annually -15,000 employees	-Aerospace defense systems	-Mostly Defense Department	-Division General Manager defines scope of product assurance function -Senior manager of product assurance reports to the above -All decisions made at division level -Government constrains system	-Product Assurance relatively unimportant -Highly qualitative -Innovation is a function of the government -Conservative management resists change
H	-Small U.S. subsidiary of a Japanese firm	-Semiconductors	-Commerical market	-Simple, due to narrow product line -Functional division directors report to president -Manufacturing director is plant manager -Quality control reports to above	-Based on culture of Japanese parent -Respect for employees -Good management -Communication from bottom up -Total responsibility for work process rests with employees
I	-Annual sales over $1 billion	-Machine tools	-Commerical market	-Division structure with line and staff functions -Quality assurance is a staff function -Group director of quality assurance has wide responsibilities -Much formal, informal, horizontal and vertical communication	-Personalized -Worker-manager rapport suffered from recent growth -Quality emphasis is now recapturing team spirit and workmanship focus -Management supports changes
J	-Major firm with 50 divisions -6 product groups	-Electronic devices	-Commerical market	-Line and staff structure -Product assurance generally reports to divisional general manager -Staff product assurance function develops overall quality and reliability objectives -Decentralized, so managers have leeway	-Culture explicitly developed to emphasize quality and innovation -Comprehensive quality focus, including education
K	-Major firm	-Semiconductors	-Commerical market	-Line and staff structure -Two product groups -Group level staff includes quality assurance, reporting to group VP	-Quality emphasis relatively high now, as response to Japanese entrance and competition on quality

Product Quality and Corporate Structure

Recent changes in strategic management priorities appear to have had a significant effect on the official status of the quality assurance function within the corporate structure. This holds true across firms that were organized in a variety of different ways. Of the eleven companies studied, five were organized functionally, and six divisionally.

The functionally organized firms all produced either one or a very few products. Departments -- usually including Marketing, Engineering and Manufacturing -- almost invariably reported directly to the company president. But the structural relations among them with regard to the quality function differed.

In two of these firms the quality assurance, marketing, manufacturing and engineering functions were virtually equal. These were an electro-mechanical assembly firm with a defense contract (company A) and a manufacturer of computer peripherals (company C). In two others, a marine electronics company (firm B), and a ship-building firm (company D), quality assurance reported to an intermediate operations manager. But in none of these four cases was the quality function directly responsible to the manager of manufacturing. This is significant in its implicit distinction between the issue of quality and the actual production process.

The fifth functionally organized firm we analyzed -- a Japanese semiconductor manufacturer (firm H) -- had the Quality Assurance and Quality Control managers reporting to the Director of Manufacturing. But that director was also directly above the managers in charge of testing, assembly, production planning and plant maintenance. So the connection between manufacturing and quality in this firm is not much different from the tenuous relationship existing in the other four functionally organized firms.

All of the six divisional corporations were organized into line and staff functions. Division managers in charge of quality assurance and control reported to division general managers; in this respect all eleven firms were organized identically.

What distinguishes these six firms is the fact that they all incorporated staff quality functions. In no case did the quality staff exercise any direct control over division-level quality organization or procedures. Staff merely consulted with division quality managers and assisted in areas crossing divisional boundaries. However, staff-level quality managers were generally more open than higher-level managers to experimentation with management innovations in quality assurance. In the three firms in this group that had implemented Quality Control Circles (companies F, J and K), the programs had all originated at the staff level.

These six firms were quite similar in their organizational structure. Three of them (firms E,I and K) had the staff quality function reporting directly to the company president, while in the other three (firms F, G and J) staff reported to a manufacturing vice president. But in general this difference appeared to have little impact on their quality programs.

Product Quality and Corporate Culture

More important to the quality function than management strategy and firm organization is corporate culture. This variable appears to be critical to the type and extent of quality programs in effect. Further, a company's culture clearly has an impact on its management strategy, and quite possibly on its organization as well. In other words, corporate culture can form or deform the entire structure and sequence of the program's implementation.

Management's willingness to innovate is pivotal to a firm's development of quality assurance and control systems. This willingness appears to be closely correlated with the nature of the technology used by the firm. In

industries with highly dynamic technology bases, management practices must change alongside technological changes and innovations. This observation is borne out by the case studies. On the other hand, firms that operate with stable product technologies tend to display consistent management styles over time. Among our sampling of cases, the semiconductor firms (H and K) provide an example of the first type; the marine electronics and electro-mechanical assembly industries (B and A) represent the second.

There also seems to be a particularly relevant correlation between the type of corporate culture and management's willingness to experiment with behavioral innovations. Such innovations often require a radical redefinition of the relationship between management and workers. This redefinition must cast the relationship primarily in terms of a partnership between management and labor, rather than a confrontation between two adversary parties.

For management to recast the structure of employee-management relations in this way it must recognize three facts. First, workers have considerable control over the quality of the end product. This control can be exerted through the quality of workmanship, or through the worker's ability and knowledge, which enable him or her to suggest improvements in the design and manufacturing process to decrease defect rates.

Second, there must be a means by which an employee can communicate these ideas to management. In other words, management must create channels for upward communication, rather than relying solely on traditional management directives. Quality Control Circles provide one example of this kind of organizational restructuring. The marine electronics firm (B) was in the process of implementing a program to teach its management and supervisory staff to communicate effectively at all levels. One large aerospace company (firm G) based its productivity strategy on increased communication between its engineering and management functions. The Japanese semiconductor firm (H)

had designed even the plant facility around this notion, placing management offices near production areas, and rarely closing doors to one-person offices.

Finally, management must realize that traditional management-employee relations offer no incentives for worker input on the quality issue. The creation of more cooperative modes of dealing with employees is crucial to the involvement of the entire firm in the process of enhancing product quality.

Another component of quality assurance is sensitivity to the quality issue, as for example a longstanding commitment to excellent workmanship. The relatively old ship-building firm (D) clearly illustrated this principle in action. Pride in workmanship does exist in US firms; it need not be considered a trait unique to foreign (i.e., Japanese) cultures. (Barocci, 1982)

But corporate cultures can become extremely ingrained, and are often all but impossible to affect without some personnel changes at the management level. The manufacturer of computer peripherals (firm C) reshuffled top management after the firm's recent acquisition. The company appeared to be relatively successful in its attempts to change the corporate culture. But the marine electronics firm (B) and the machine tool manufacturer (company I) were able to implement only incremental changes, while leaving management in place.

Nevertheless, increased awareness of the significance of quality in current international competition will most likely result in changes in the culture of US firms competing in international markets. In this case, it is the environment that affects the firms and industries we have examined. And that environment is pivotal to the kind of quality programs American firms will have to adopt in the future.

Product Quality and The External Environment

A firm's market has a great impact on the type and extent of its quality system. The government and the military have played leading roles in getting companies under contract to implement stringent quality control and assurance systems. The terms of government contracts, particularly defense contracts, are extremely rigorous. Because defense contractors must comply with a priorly defined quality structure, these firms do little quality innovating. That task is more or less left to the government, since the goals of quality systems are not defined by the firms themselves.

The six firms in our study that produce for the civilian commercial market have been slower to implement quality assurance and control programs, probably because of the lack -- until recently -- of market pressures to do so. But international competition is now forcing these companies to pay more attention to the quality function. Some of them have responded by adopting systems based on those used by the government contractors. Primary among these programs are Quality Engineering, Reliability Engineering, and sophisticated statistical sampling techniques to monitor product quality. Others have implemented different systems, placing more emphasis on the behavioral approach. These are the firms that have been experimenting with ways to redefine the management-employee relationship, e.g. through the introduction of Quality Control Circles.

The critical difference between the government contracting and the private market firms is the nature of the market pressures on them. The firms in the first group have not had to innovate beyond government specifications because of the lack of international market competition; defense contracts are only awarded to domestic fims. The second group has had to step up quality programs in response to aggressive competition from abroad, and has thus had more leeway in designing system structure and scope.

But the firms producing for commercial markets have not been the only ones to innovate with product quality programs. Government regulations have required defense contractors to compete with each other in proposing the most cost-effective quality systems. Until recently, this has not been the case for American firms producing for the commerical market. The latter group of firms are only now implementing systems which have been standard for most government contractors for quite some time.

The nature of the production process also affects a firm's quality program. Companies engaged primarily in assembly operations are highly dependent on the quality of inputs. Their quality programs tend to be geared toward extensive inspection of incoming goods with numerous test stations inserted in the production line to check for subassembly integrity. One example is the government-contracting electro-mechanical assembly enterprise we studied (company A).

At the other end of the spectrum are firms heavily engaged in fabrication. Examples include the ship-builder (D) and the machine tool manufacturer (I). These companies employ highly skilled labor whose quality of workmanship is crucial to the quality of the final product. In these cases, quality systems include the human-resource-oriented programs that have gained so much recent publicity. But these programs also differ according to the type of production process. The machine tool manufacturer (I) is currently implementing Quality Control Circles with considerable success; the ship-building firm (D) has always maintained a strong management emphasis on the pride of workmanship.

SUMMARY

Of the four variables identified by Lorange and Scott Morton, corporate culture and the external environment clearly seem to be more important in affecting the nature and scope of quality assurance and control programs than

management strategy and company organization. Crucial environmental factors include the nature of the market -- governmental or private commercial -- as well as the degree of market demand for improved product quality and the measure of international quality competition. For private commercial firms the pressure for quality improvements has just emerged over the past decade. The companies serving the defense market, on the other hand, have had to meet stringent quality requirements for over thirty years. One major difference, then, is that the first group of firms has been faced only recently with the challenges of strategic reassessment. Management has not always been quick to respond to that challenge. Even where attempts have been made to develop strategies or redesign organizational structures to address the quality issue, success has been limited. In any case, the strategic and organizational differences across the firms we examined were minimal.

The role of corporate culture, on the other hand, can be gauged by obvious differences across the eleven companies. Perhaps the most important aspect of corporate culture is top management's enthusiasm about making product quality a strategic priority. This may seem absurdly self-evident. But the fact that many of the top managements of the firms we studied were <u>not</u> prepared to sacrifice manufacturing continuity, or to incur the costs of product improvement, shows that this point cannot be emphasized too strongly. The problem is that management's focus is short-term, while quality assurance and control systems most frequently address issues of long-term international competitiveness and economic viability.

Another important variable, which was not specifically identified by the Lorange and Scott Morton model, is the nature of the relevant technology. The relative dynamism of the technologies used by a given firm appears to have a noticeable effect on the nature of its corporate culture. Managers in mature industries with stable technologies are less willing to experiment with

quality systems innovations. Where technologies are continually obsolescent, management innovation on the quality dimension must parallel the firm's technological innovations.

Quality innovations have mostly to do with the redefinition of the management-labor relationship. Emphases on the quality of workmanship and on the cooperative nature of the management-employee partnership are strongest where management focusses on the human resource function. Quality Control Circles and Quality of Worklife programs most clearly illustrate this emerging aspect of the product quality issues.

Conclusion

Environmental pressure on both government contractors and firms producing for the civilian market will continue. Increasingly sophisticated weapons systems and international competition will intensify the need for American firms to enhance the quality of their goods and services. US enterprises will have to develop explicit plans for the attainment and maintenance of high quality as a central part of their corporate strategies.

Beyond developing the right strategies, management must realize how crucial corporate culture is in effecting the necessary changes. Product quality has to be a top management priority, and the rewards, duties and training of personnel must reflect it. This is not an issue only for first line supervisors and production personnel. On the contrary, it is a management problem; the consistent production of high quality goods requires that management be made the central target of the changes required.

American firms are responding to the quality challenge. Those that have had to adhere to the exacting standards of the Defense Department have an advantage in the establishment of quality assurance systems; divisions of those companies that produce for the civilian market must learn from their

divisional counterparts. Firms that do not face defense contracting constraints must let their strategies reflect the fact that modern consumers are able carefully to discern quality differences. If "buy American" campaigns are to be successful, the quality factor must be a given in our products.

Management's strategic commitment to quality must be supported by a changes in corporate cultures to reflect the understanding that a partnership between engineering, management and production workers is the only route to long term corporate survival.

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