"MANUFACTURING IN A NEW PERSPECTIVE"

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MANUFACTURING IN A NEW PERSPECTIVE

Manufacturing management has been in an uneasy transition in the last few years. It is not just that there are new pressures for survival, new technologies to learn and debug, and accelerated waves of social and government demands to accommodate. Indeed, these are sober realities all around the industrialized world. But perhaps the most disquieting new fact of life for manufacturing managers is that much of the accumulated management wisdom steadily acquired and tested in the last several decades is under question, and some of it discarded as either being obsolete or no longer trustworthy. We are caught in between an old, weakened and sometimes failing rationale for restructuring and operating production, and a new, relevant and promising book of rules.

Our purpose in this article is to present an analysis of these changes and examine their implications for the managers. In the first part of this paper we focus on the major shifts in thinking in three key areas of manufacturing management: management of production flow (or inventories), management of quality, and management of manufacturing technology. Many long-held views about the role of inventories, the cost of quality, and the versatality of process automation are currently under challenge and being gradually replaced by new notions.

The new notions demand fundamental changes in some of the values and operating policies which are deeply ingrained in the typical manufacturing organization. The complexity of having to cope with such changes in the three areas simultaneously explains why we are in an uneasy period in manufacturing management. A thorough appreciation of these developments should lead to a new perspective on the role of manufacturing in the company. That is the focus of the second (and final) part of this paper.

We build our argument on the research reported in the literature, the results of a recent survey of about 1000 manufacturers in Western Europe, North America, and Japan [Manufacturing Futures Surveys, see box], and clinical studies of twenty leading manufacturers worldwide. We will refer to the literature to show that the signals indicating the need for rethinking in many of these areas were given decades ago. We will refer to the results of the survey to show in broad terms how the new thinking is being adopted by the manufacturers in these three industrialized regions of the world. Finally, we will refer to our experience from the clinical studies to describe some of the new challenges of manufacturing management.

A NEW LOOK AT INVENTORY

Management of inventories, or alternatively production planning and scheduling, has received a great deal of attention in manufacturing management. The manufacturers in North America, Europe, and Japan who have contributed data to the 1983, 84, 85, and 86 Manufacturing Futures surveys [see box], for example, have consistently regarded their work in this area to be of critical importance. (See Exhibit 1.) What the management has been trying to do in this area, however, has been changing through the years.

When we examine the focus of attention of the managers in many manufacturing companies--and the academics who have written books and articles to help them--during the last four decades, we see three broad patterns, each prevailing during an era. We have called them "the cost optimisation era," "the requirement planning era," and "the just-in-time era." (See Exhibit 2.)

The Cost Optimisation Era

Early models for managing inventories (appearing in the literature from the late 1940's to the early 1960's) mostly focused on the buffer, or uncoupling, charateristic of inventories. Uncoupling was regarded to be both necessary and useful because it made the production system less vulnerable to both normal and unpredictable discontinuities. Different production batch sizes could be allowed at various steps, and production could continue even when an upstream operation was stopped. The unquestionable assumption was that inventories were needed to smoothen the production flow; the issue was how to balance the various costs related to keeping or not keeping them.

The rules, models, and tools which were developed to guide decision making fcr scheduling and production planning, or alternatively inventory levels, were accordingly primarily focussed on optimisation of various costs which were inherent to the manufacturing system of the firm. The famous "square-root" formula for determining the so called "economic lot size," and its many derivatives, were developed during this period. A surge of books and articles which appeared in this era essentially provided further refinements to the basic optimization model which must have been receiving attention from production scheduling and inventory managers.

The Requirement Planning Era

There were however a few signs pointing out the need for a reexamination of the role and function of inventories. One of the first signs dates back to the 1950's. Through simulation, Forrester [1], showed how the existence of buffers (inventories) can aggrevate, and not smooth, the fluctuations of the production load. The reasons are that a) inventories essentially deprive the upstream operations from timely knowledge of the changes in the downstream operations; this causes a lag in response which often creates a magnified and whiplash dynamic recovery later; and b) many of the reasonable rules which optimise inventory decision at one level (such as economic lot sizing, reorder point, "min-max") in practice accumulate the small fluctuations and release them to upstream operations in big waves.

The cheaper and more powerful computers of the late 1960's and the early 1970's came to the remedy of the first problem--i.e., the lag and inaccuracy in the flow of information. The focus became exchange of data. The idea was to maximize communications among the various steps of production, procurement, distribution, and sales by providing the details of the latest and most accurate forecast of requirements for each step, the latest projected production capacity, and the actual (not just "standard") output at each stage. A multitude of requirement planning software packages found their way into the manufacturing companies in an accelerated pace in the 70's. The systems for scheduling and control of inventories became more elaborate and sophisticated. The literature, too, reflected this shift of attention.

The principle which laid at the foundation of the thrust of the efforts during this era is that inventory and information are exchangeable commodities; if you have more of one, you need less of the other. Since generally a lot of information exists in various stages of a production chain, and through computers it has become technically feasible and rather inexpensive to communicate this information, then the road towards better inventory management system is clearly through better information systems.

For those totally committed to this principle, the road towards better management of inventories (and schedules) was through further sophistication of information systems. During the 1970's, quite a few companies went a long way on this road by installing sophisticated material requirement planning systems (or various versions of more advanced systems commonly labled under "manufacturing resource planning"); many still continue.

There were, however, signs of discontent in the early 80's. First, the sophistication of the system seemed to stifle initiatives from the shop floor. Second, the problem of inherent imbalance in suitable batches of production--mentioned above--was not being directly addressed. A new principle was needed. For most of us, the widespread recognition of this need had to wait until the late 1970's when excellent results achieved by a small number of mostly Japanese companies were publicized.

The Just-In-Time Era

Any manager who would hear that, for example, the turnover ratio of inventory assets (annual sales/average inventories) at Toyota Motor Company in 1980 was 87--i.e., their investment in inventories was equivalent to only four days of sales [2], or that Nippon Seiko, a manufacturer of bearings, had managed to improve its inventory turnover ratio from about industry average in the mid 70's, to almost three times the industry average in just four years (1977-81) [3], could not help but become very curious.

How could these be achieved? Behind the simplicity of the just-in-time and "kanban" systems used in these companies, was a profound insight: Managerial and technical talents could be channelled towards removal of the reasons for carrying inventories, rather than devising clever ways for optimizing the costs associated with inventories or installing sophisticted information systems to minimize the number of potential mistakes.

No reason for carrying inventories would be regarded as sacred in the long run: Setup times can be reduced, machine breakdowns can be prevented, operators can become multiskilled, relationships with the suppliers and customers can be substantially changed, product design can be modified, etc.

This has called for a fundamental change of mindsets. Inventory is now beginning to be seen not only as expensive and risky (as it has always been), but--because it acts as a buffer--as hiding problems, aggrevating, rather than smoothing, flows, and often totally unnecessary. Our surveys of the large manufacturers in 1986, shows that the efforts on the production planning and control systems are now more focused on JIT. (See Exhibit 3)

A NEW VIEW OF QUALITY

The importance of quality as a source of competitive advantage is beyond dispute. Our 1983-86 surveys of manufacturers in Europe, North America, Japan clearly indicate the importance that is being attached to achieving consistent quality in manufacture (See Exhibit 4). However, for many manufacturers, especially in Europe and America, there appears to be a subtle--but powerful--shift in the perception of the issues related to quality management--a shift from searching for the "economic quality level" to reaching for the "zero defect." We have called the period when the former perception has prevailed the "cost-value era," and the period of the latter perception the "diagnosis era" (Exhibit 5).

Cost-Value Era

The paradigm behind many models for quality management in the 1950's, 60's, and even most of the 70's has been that better quality comes at a cost. This was held to be true for almost any definition of "quality," and certaily for a manufacturing-based definition which is the degree of conformity to specifications. Much attention--both in the literature and in management--has therefore been paid to finding the "optimum" point in the trade-off between gains from better quality and losses due to additional costs of achieving it.

The messages of the early prophets such as Deming and Juran--dating back to the 50's--were understood as that managers should be more aware of the leverage of product quality on customer satisfaction, and that effective procedures were available to reduce the costs associated with ensuring that poor quality products would not reach the market. Powerful statistical tools and technics have since been developed and employed to provide accurate and timely data about the product and process quality at low cost.

On the value side, there seems to be a growing awareness that many manufacturers have systematically underestimated the market value of improvement in quality. Somehow the companies with outstanding quality products (such as Mercedes Benz) did not seem to go through the same difficulties which others in their industries were facing.

The net result of all these developments shifts the "optimum" point towards higher quality: costs are brought down and value is recalculted at a higher level. But the paradigm that better quality costs more still remains intact.

The Diagnosis Era

In the late 1970's, serious doubts about the nature of the trade-off between cost and quality started to appear in the literature. If the issue was to find the most economic point in this trade-off, then why did some successful companies continue their efforts to reduce rejects past this point? How can striving for "zero defects" ever be justified?

Assuming these are rational decisions, the only way to justify them is to question the paradigm of the cost of quality. The new view is that the cost of better quality (such as better tooling, training, and materials) are less than the costs of not doing the job right the first time (such as inspection, planned overruns, discontinuities in production, scrap, salvalge, and recalls).

The trade-off can now be seen as one-way, or irreversible; namely, that if low cost is the principal objective, quality will suffer, but if great quality is the goal, total costs can, in fact, be reduced! Thus "quality" becomes a means for achieving higher total productivity. The rejects, and other quality problems related to the product or the production process can then be viewed as valuable sources of information for diagnosing the specific problems which hinder the company at the given time. The endless pursuit of perfection in quality would therefore make sense.

Many Japanese manufacturers seem to have accepted this paradigm shift for some time [4]. The Europeans and Americans, too, seem to be converting at a rapid rate, especially in the last few years. IBM, Corning Glass, Ford, Hewlett Packard, Philips Electronics, General Electric, are but a few examples of the companies which have launched major quality campaigns in the last few years.

A NEW VIEW OF AUTOMATION AND PROCESS TECHNOLOGY

Since the turn of this century, investments in automation and production process technology have tended to reduce the versatility of the manufacturing systems. It is only in the last few years that new manufacturing technologies (including various components of the so called "computer integrated manufacturing") are creating radically new possibilities. We see the beginnings of a shift of view from what we have called "the standardization era," to "the versatility era." (see Exhibit 6)

The Standardisation Era

The landmark studies of Abernathy [5], and Abernathy and Utterbeck [6] provide excellent historical perspective on developments in the production process have tended to force a move towards standardisation. They show that the productive units in any industry normally go through certain "natural" phases which are marked by the degree of automation employed, the layout and pattern of product flow through the unit, the dedication of equipment to specific products, the range of tasks performed by the labor, and the planning and control systems used for managing the unit. In pursuit of better efficiency, these (and other) elements of production are modified to reduce waste and underemployment of men and machines, as well as to increase process reliability, consistency, and predictability.

However, these objectives are achieved at the expense of flexibility for volume change, customisation, introduction of new product designs, changes in product mix, varying delivery dates, and capacity utilisation. The normal profit and competitor-driven effort toward cost efficiency tends to transform a productive unit from a state of "fluidity" to a state of "rigidity"--in fact so rigid that after a point it renders uneconomic even further innovations for improvement of process efficiency.

This is a subtle and gradual process. Warnings about the existence of these long-term trade-offs had appeared in the literature in the late 1960's.[7] Later works, which number many [8], delve into the subject futher and discuss the nature of these trade-offs in more details.

But the underlying assumption--that increased capital intensity of the production process demands a move towards standardisation of the products produced--has remained unchallenged until recently.

<u>The Versatility Era</u>

In the early 1980's, we are beginning to witness major challenges to the realism of some of these trade-offs. There is talk of "economy of scope" instead of "economy of scale," mass production of very small batch sizes, and the ability to custom-make each product with a very short lead time. The basic issue under challenge is essentially: <u>Is it necessary to sacrifice versatility when efficiency, dependability, and consistency are pursued?</u>

The answer, until recently, has been "yes." Production technology for achieving efficiency, dependability, and consistency has required removal of irregularities from the shop floor--that is, allowing less variety in products produced, less changes in their designs, less variability in the rate of output, and generally less room for discretion in the production process. Moreover, the manufacturing organisation and production management systems put in place after major automation projects have often exacerbated these limitations.

But the new production technologies--driven by the computer and the microprocessor--are creating radically new technical possibilities. Flexible automation combined with computer integrated design, engineering, scheduling, procurement, material handling, manufacture, distribution, and eventually cost accounting, sales, and billing <u>can</u> change the answer. The new equipment can simply be much more versatile, quick and inexpensive to set up and change over. Furthermore, they promise reduction in overheads. Thus, even though such production systems are becoming more capital intensive, unlike the past, we may expect increased productivity as well as increased versatility.

By and large, progress in such advanced production technologies is slow. Nevertheless, there seems to be an increasing awareness of the promise of these systems. Our surveys of the European, American, and Japanese manufacturers show clearly that most manufacturers, especially in Japan, are placing a great deal of emphasis towards development of this type of production technology. Exhibit 7 shows how the Japanese are stepping up their efforts on the development of flexible manufacturing systems in the last four years.

We are witnessing major shifts in three important paradigms in manufacturing--in inventory managment, in quality management, and in management of process technology. These in turn threaten other accepted principles of manufacturing. What are the implications of all this for the management of this function?

NEW PERSPECTIVE-NEW PROSPECTS

Adjustment to any one of these new views is a difficult task; coping with the three of them, simultaneously, is a unique challenge. That is why we need to look at manufacturing from a new perspective.

The new perspective calls for acknowledging that the limits of what is achievable in manufacturing have been radically extended. Even a few years ago, who would have believed that one could rely on a multitude of suppliers to deliver parts of practically perfect quality several times a day? That the yield of certain production processes could be improved by several orders of magnitude? That the production cycle time could be reduced to a point that the firm could move from "production to stock" to "production to order," with no adverse effect on delivery?

Those who have achieved these must have challenged the traditional limits of practicality in manufacturing management. They must have persisted, since these are capabilities which are developed gradually.

For the last half-century, the practical limits of what is possible in production has been assumed to be known, rather stable, and easily measureable. The new views on inventory, quality, and process technology, imply that the capabilities in manufacturing are evolving rapidly and extending to new grounds. Since all this is happening in a rather short period, in a historical sense we are in a transition. At least for a while, the limits of what can be achieved in manufacturing are neither accurately predictable nor easily measureable.

But as we have argued in this paper, the underlying forces in this transition are identifiable: If we view the reduction of inventories and improvement of quality not just as viable ends (as we have been), but also as valuable means for diagnosis and removal of obstacles anywhere in the company, we have a whole new way of managing, which replaces the long-standing obsession with productivity. The resulting benifits would be constantly evolving. These results would be more difficult to measure, since a major part of them occur in areas other than those normally considered to be affected. Combined with the new frontiers of versatility opening up at an accelerated pace, achieving new potentials of manufacturing capability is now a fast-moving game.

Full acceptance of this new production universe would call for fresh examination of many systems, procedures, and policies in the management of manufacturing. We shall limit ourselves here to four key areas where we see opportunities for major changes:

1. Internal control of operations
2. Manufacturing investment decisions
3. Manufacturing strategy
4. Skills for manufacturing management

The changes we propose in all these areas are long term and directional in nature. Persistent work in these directions can set the organisation on a whole new course towards excellence in manufacturing.

1. Internal Control of Operations

Most of our existing manufacturing control systems are still rooted in the Taylorian view of the shop floor. These systems are most efficient when the work methods, routing, staffing, time standards, wage and production incentives schemes, inspection systems, and production mix--just to mention a few parameters--do not change frequently. For example, the successive generations of the material requirement planning systems require as input a set of values (or assumptions) about each of these parameters. Each time one of these parameters is changed, these control systems become essentially inaccurate or inefficient until the new value of the changed parameter is fed into the system. Ideally, therefore, before an operator changes one of these shop floor parameters, he (or she) ought to communicate his intention to the those who run the material requirement planning system.

The need for this forewarning becomes greater for the control systems of the more continuous flow production systems. Production control systems in a job shop generally have a larger tolerance for the (unknown) shop floor changes. So the question becomes: Can we devise a production control system which allows implementation of worker-initiated, localized changes on the shop floor without having to manage the production system as a job shop?

Answering this question is not simple. Such a control system, instead of stability, would have to assume continuous change in the production parameters on the shop floor. None of the existing production control systems known to us does that. We still do not really know how to plan production flows when at each step workers or direct supervisors may change our assumptions of the time, the amount of materials, and the tools they need to do the job. The closest we have come is to create the so called "autonomous work groups," and let them schedule and control their own work. In certain situations, the Kanban system, too, allows continuous local minor changes in a work station without the necessity of changing schedules in the upstream and downstream work stations (that is, the directly upstream and downstream operations from the changed operation do not need new instructions--from production controller or other managers--to remain efficient; management can eventually adjust the system to the new parameters, after the fact, by adding or subtracting cards). But even in these cases, some problems persist, and many remain unconvinced.

We believe that there is a challenge in this area for production management. Is there a production control system which combines, for example, "Management by Objectives" (this time applied to workers and direct supervisors the same way it is applied for more managerial and clerical staff), "Quality Circles," "Kanban," and distributed computerised shop floor information systems? Are there other tools and technics which need to be employed?

We need new and innovative production control systems which reflect the new views on inventory and quality.

2. Manufacturing Investment Decisions

If improvement in manufacturing is to be a continuous process--and not just result of step-wise changes, then the coventional methods of appraisal of manufacturing investment decisions need a re-examination. The starting point is a change of attitude--the attitude towards uncertainty and ambiguity in manufacturing.

Measurement of a continuous improvement process requires patience. Investments towards achieving greater versatility, better quality, and lower inventories require lengthy startup periods. The planning horizon, therefore, should be long enough to allow full consideration of their long-term benifits. That seems to be longer than many companies are willing to tolerate.[9] Moreover, continuous improvement is normally resulted from continuous investment; therefore, the sequence and portfolio of investment decisions become more important than the profitability of any individual project.

The problem is further confounded by the now acknowledged shortcoming of the accounting systems in measuring all the costs and benifits of these investment decisions.[10] No agreement has yet emerged on how to measure improvements in quality, delivery, or various types of production flexibility; nor is there yet a widely accepted way for considering the effects of a production investment decision on other functions (such as marketing and sales, distribution, research and development).

For these reasons, the current accounting systems and capital budgeting procedures need an overhaul to fit for the analysis of the new types of manufacturing investment decisions--those which reflect the new views on inventory, quality, and versatility. The challenge seem to have been recently taken on by the experts in these areas . But meanwhile, should we rely on faith to justify the production investment decisions?

If faith is a vision of strategy which fits the amalgamation of all the non-quantifiable, qualitative, factors of the decision, then our answer is yes. In the absence of the right numbers, it is the best we can do. The key is to let the managers make a collective judgement--a judgement which is not bound by the traditional constraints we have set for manufacturing.

Most notable among these constraints is the exactitude with which manufacturing investments usually have to be justified. In most organisations, justification of a 10 million dollars investment in production is expected to be backed by much more exact and concrete projections than justification of the same investment in advertising, sales promotion, or research and development. This is wise when improvements in manufacturing are known, stable, and measurable. But the new views on inventory, quality, and versatility, as we have said in this paper, have changed all that at least for the time being. Manufacturing capabilities are expanding beyond the conventional limits, and the new limits are not in sharp focus yet. This calls for greater tolerance of ambiguity and uncertainty in manufacturing investments, at least to the same extent as we normally do in many other functions.

The challenge here, therefore, is not only in the overhaul of the accounting and capital budgeting systems, but in bringing about a change of attitude in the organisation.

The increased tolerance for uncertainty and ambiguity should not be limited only to the initial appraisal of the investment decision. In post-investment audit, too, the performance review should incorporate more patience and focus more on the <u>rate</u> of improvement in selected key measures.

3. Manufacturing Strategy

Manufacturing strategy--simply a long-term plan for developing consistent operations policies and structures that provide facilities focused to achieve limited, but key corporate strategic objectives--will assume a greater importance in the new perspective. There are two reasons why:

First, without a long-term vision of the key operating tasks in support of chosen competitive priority, encouraging the various subgroups and professionals which comprise the manufacturing function to seek and intiate continuous improvements easily leads to conflicting production subsystems. Grassroot efforts to reduce inventories and improve quality, for example, can easily enhance or hinder versatiltiy along unintended dimensions.

The technical, mangerial, and personal talents of the manufacturing professionals in each group must of course be unleashed, but they must be channelled by a general manager into a direction which is clear to everybody. Existence of an explicit manufacturing strategy under these conditions becomes more essential.

Second, by their very natures, improvements in inventory, quality, and versatility impact other functions in the company shortly after they are intitiated in manufacturing. There will be questions and suggestions from manufacturing for procurement, distribution, cost accounting, sales and marketing, engineering, research and development, industrial relations, and human resource management. Without help from these functions, the prospects for what manufacturing can achieve are indeed limited. Agreement on a manufacturing strategy, and understanding its full implications for each function, is likely to gain their supports easier.

Furthermore, there must be a mechanism for ensuring that the other functions continuously utilize the latest capability developed in manufacturing. For example, there are many examples where flexibility of a new machine is systematically underutilized because orders from the sales department have not changed. Again an explicit manufacturing strategy can be a key part of this mechanism.

4.Skills for Manufacturing Managers

The trends in the three areas described above have direct implications for the managerial tasks in manufacturing. For the middle management in manufacturing, these trends are increasing the proportion of the project-type work, and for the senior management, they are increasing the importance of the ability to launch and monitor long-term improvement programs. Routine work, operating problems, and incremental improvements--the traditional pre-occupation of the managers in this function--are to be trusted to effective systems and well-trained operators.

These developments call for substantial changes in the operating styles, managerial foci, and career profiles for the managers in these positions. The traditional stereotype "disturbance handler," "take-charger," and "crisis manager," would need to be replaced with a new stereotype "disturbance anticipator," "team worker," and "crisis avoider."

Production managers have generally depended heavily on first-hand, detailed, and "real time" knowledge of the situation on the shop floor in order to be able to operate effectively. The new views on inventory and quality advocate a primarily "bottom up" approach not only for the improvement ideas, but also giving the workers and direct supervisors more responsibility, resources, and authority to implement their ideas.

There is a potential conflict here: The close watch by the management can hinder this bottom up approach. As more computers, electronic monitoring devices, and telecommunication lines find their way to the shop floor, the potential for this conflict increases.

The challenge for the manufacturing managers, in our view, is to develop operating styles which rely less on detailed and real time knowledge of the situation on the shop floor. Instead, they should make more time to look outside--to material suppliers, machinery suppliers, customers, competitors, system analysts, etc. These poeple are fast becoming the limiting factor in what a given production system can do. Manufacturing managers--middle as well as top--now must be more effective with such "outsiders" on a continuous basis. They need to develop both the capability and mechanism for bypassing the usual organizational "gate-keepers" between themselves and these outsiders (Purchasing for material suppliers, Engineering for machinery suppliers, MIS/EDP for system analysts, Sales for customers, etc.). Direct contacts, with proper vision, are bound to increase the rate of innovations. Programs for reduction of inventories, improvement of quality, and development of specific manufacturing versatility provide the vision for the innovations; working in project teams charged with moving along any or all of these programs provides a practical mechanism for engaging the managers in these programs.

Do these trends suggest that new kinds of managers will be coming through manufactuing? We think so. In our examination of twenty leading manufacturing companies in the United States and Europe in the last three years, we have found that the managers who were considered as high-potential candidates for important positions in manufacturing were rather different from the incumbents.[11] This was no just a question of age. Most incumbents were basically engineering oriented, had come out of first-line supervision or more technical side of operations management, and had climbed slowly to the top. They were especially strong on productivity, on standards, on mass production. They aimed for stability--in labor, schedule, product design, and generally in any element which could potentially disrupt an otherwise smooth production flow.

The new ones are moving up faster. They are coming from more varied career paths--from sales, from engineering, from marketing, from research and development; they are coming from personnel departments, computer programming; they are coming out of product management experience and program management experience. They seem to be especially effective in dealing with ambiguity and change. They become bored if there is not enough change. They are team builders and change managers. So we see a new breed emerging.

The weaknesses of the new breed, nevertheless, appear serious. They tend to be nearly as short-term-oriented as the incumbents, not much more strategic in their point of view, and weak in handling process technology and equipment. They are more architects, and less housekeeper than the incumbents.

The challenge, as we see it, is not to let the new breed be caught in the conventional wisdom of production. The new views we have described in this paper can bring out their best traites.

CONCLUSION

These are special periods for manufacturing. After six decades of relative stability, fundamental rules in three key areas of production management are suddenly under attack. These are long-estalished rules on inventory and scheduling management, on the relationship between cost and quality, and on the effects of automation and new production process technologies. The net result is that production management is fast becoming a whole new game. Adjusting to the new rules, however, is going to take some time for most of the players.

The reason for this lag (which we suspect will persist for some time) is that the changes of the rules we have described in the first part of this paper have far-reaching secondary effects on the organization as a whole. The discussion of the effects of these changes on manufacturing's control systems, investment decisions, strategy, and managers, presented in the second part of the paper, outlines the challenges which still await most organizations.

The companies which seem to have recognized that the rules of production are changing, are not picking on any one of these challenges in particular, but are working on a wide front. They are working on just-in-time, giving workers more responsibilities and tasks, vendor quality, flexible manufacturing systems, lead time reduction, and many other programs. For example, a sample of European manufacturers who in 1985 were placing a high emphasis on the development of flexible manufacturing systems, at the same time placed a high emphasis on a multitude of other improvement programs in manufacturing. (Exhibit 8)

A fundamental question in our view, is the senior management's appreciation of the depth and magnitude of the recent changes which have occured in production management. We believe that a clearer understanding of these changes will convince senior management to devote, at least in next few years, more attention, resources, and talent to the manufacturing function in their companies.

MANUFACTURING IN A NEW PERSPECTIVE

INSET BOX:

THE SURVEYS

Part of the data for this article come from the Manufacturing Futures Surveys. These are a series of annual surveys of large manufacturers in Europe, North America, and Japan which have been conducted since 1983 by INSEAD (Europe), Boston University (North America), and Waseda University (Japan). Each survey consists of a detailed questionaire which is sent to 800-1000 largest manufacturing companies in each of the three regions annually. Between 15 to 20% have responded each year. The total number of responses in the four years exceed 2000, which after accounting for responses from the same companies in more than one year, represent data from about 1000 companies in the three regions. For more information see

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FOOTNOTES

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EXHIBIT 1

FOCUS OF MANUFACTURING IMPROVEMENT PROGRAMS

(Seven Highest Rated Among 37)

EUROPE	NORTH AMERICA	JAPAN
Direct labor motivation (1,2)	Statistical process control (5,*)	Flexible manufacturing systems (1,3)
Production and inventory control systems (2,5)	Zero defects (7,*)	Quality circles (5,4)
Automating jobs (3,1)	Vendor quality (3,*)	Production and inventory control systems (4,1)
Integrating mfg. info systems (4,4)	New product introduction (NA)	Automating jobs (2,2)
Training Supervisors (6,3)	Production and inventory control systems (4,1)	Lead time reduction (10,7)
Reorganizing mfg. (10,*)	Statistical product quality control (10,*)	Developing new processes for new products (3,6)
Integrating info systems across functions (7,*)	Integrating mfg. info systems (6,3)	Reducing setup times (*,*)

Notes:

The ranks in this table are based on the degree of importance that senior manufacturing directors have placed on 37 possible plans for improvement of manufacturing performance. The seven shown for each region in this table are those with the highest average ratings in the 1986 surveys. Their ranks in the 1985 and 1984 are shown in brackets in that order; (*) indicates a rank below 10. Most ranks in this table are approximate but generally accurate within plus or minus one place (i.e., differences between non-contiguous ranks are generally statistically significant.)

Source: 1986, 1985, and 1984 Global Manufacturing Surveys

EXHIBIT 2

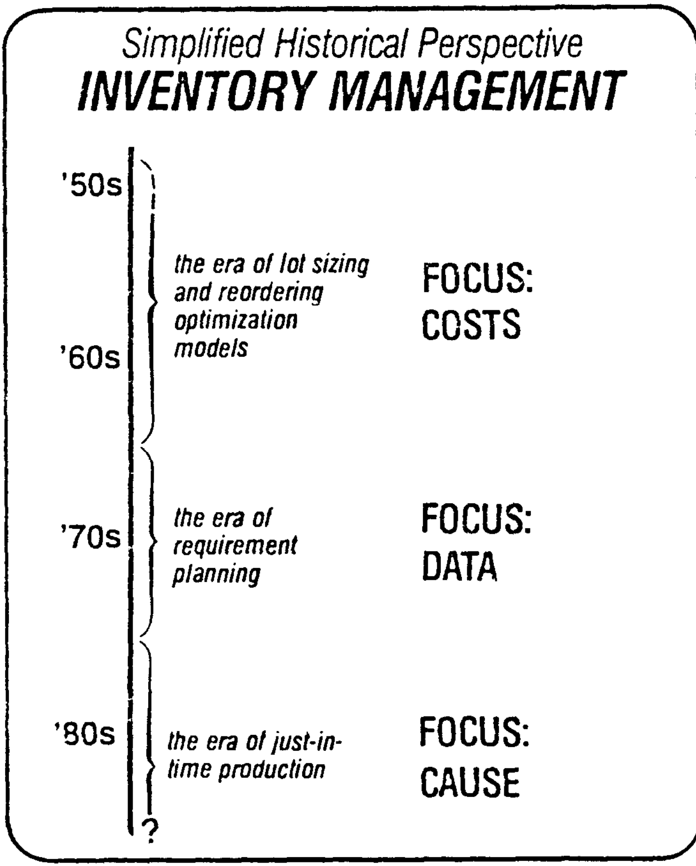
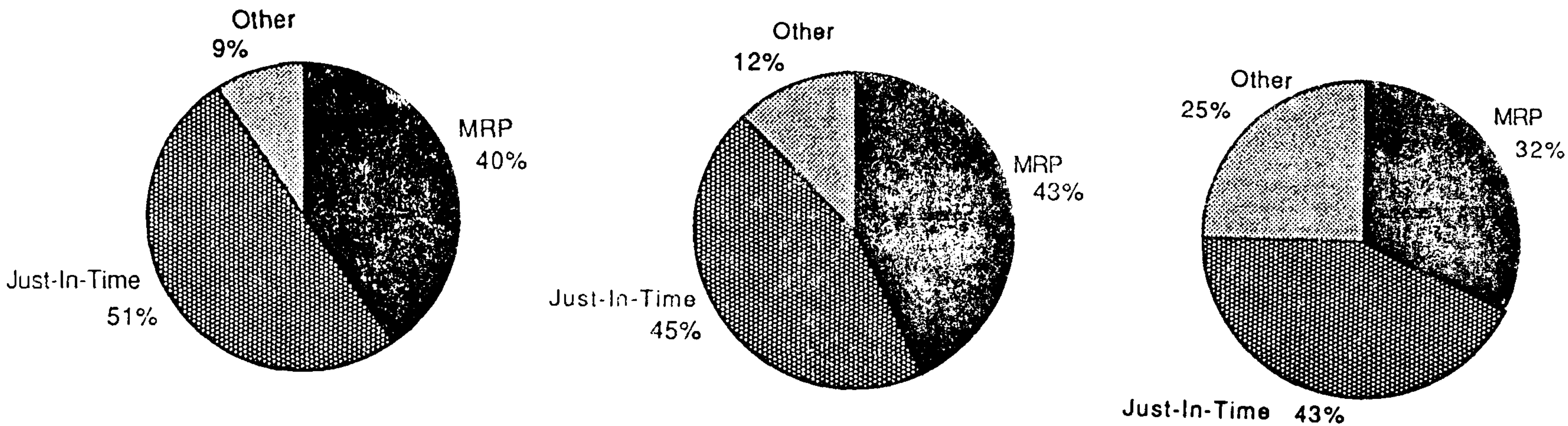

Simplified Historical Perspective
INVENTORY MANAGEMENT
'50s
'60s
the era of lot sizing and reordering optimization models
FOCUS: COSTS
'70s
the era of requirement planning
FOCUS: DATA
'80s
the era of just-in-time production
FOCUS: CAUSE
?

EXHIBIT 3

PRODUCTION AND INVENTORY CONTROL SYSTEMS EMPHASIZED

EUROPE | NORTH AMERICA | JAPAN



Sources: 1986 European, North American, and Japaneses Manufacturing Futures Surveys

EXHIBIT 4

CONCERNS IN MANUFACTURING

Seven Highest Rated Among 34

EUROPE	NORTH AMERICA	JAPAN
High overhead costs (2,2)	Producing to quality standards (1,1)	Producing to quality standards(1,1)
Producing to quality standards (1,1)	High overhead costs (2,3)	Yields, rejects (2,2)
Introducing new products on schedule (4,5)	Introducing new products on schedule (3,2)	Implementing new process technologies (NA)
High material costs (3,4)	Poor sales forecasts (4,7)	Introduce new products on schedule (3,3)
Availability of qualified supervisors (12,8)	Yields, rejects (5,5)	Falling behind in process technology (4,5)
On-time delivery (8,10)	Implementing new process technologies (NA)	Availability of qualified supervisors (5,4)
Poor sales forecasts (5,7)	High material costs (10,6)	Aging workforce (6,*)

Notes:

The ranks in this table are based on the importance of each concern to the senior manufacturing directors in each region. The seven shown in this table have received the highest weights (among a list of 34) in the 1986 survey. Their ranks in the 1985 and 1984 surveys are shown in brackets in that order. Most ranks in this table are approximate to plus or minus one place (i.e., differences between non-contiguous ranks are generally statistically significant).

Sources: 1986, 1985, and 1984 Global Manufacturing Surveys

EXHIBIT 5

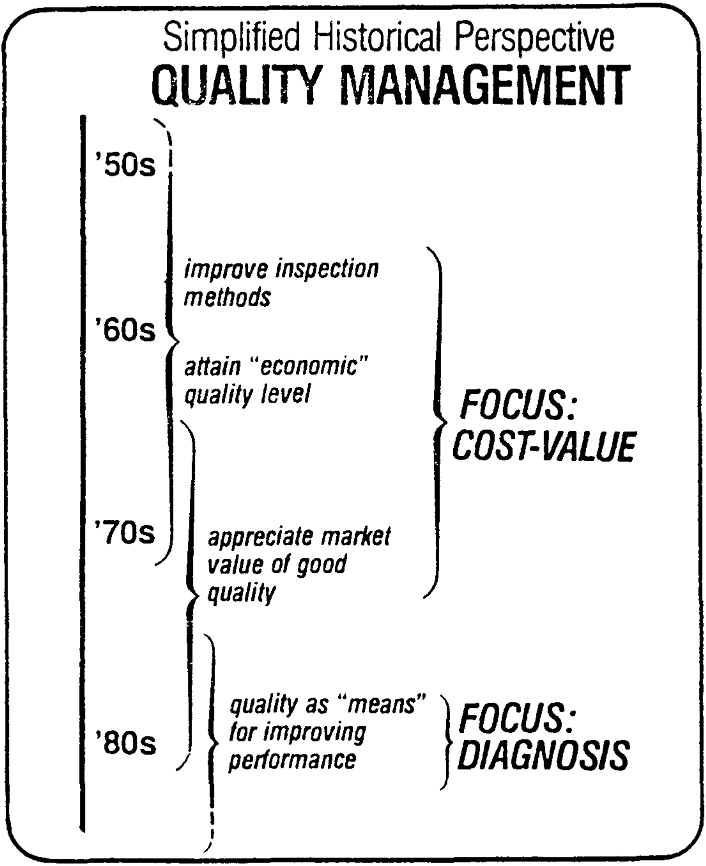

Simplified Historical Perspective
QUALITY MANAGEMENT
'50s
'60s
'70s
'80s
improve inspection methods
attain "economic" quality level
appreciate market value of good quality
quality as "means" for improving performance
FOCUS: COST-VALUE
FOCUS: DIAGNOSIS

EXHIBIT 6

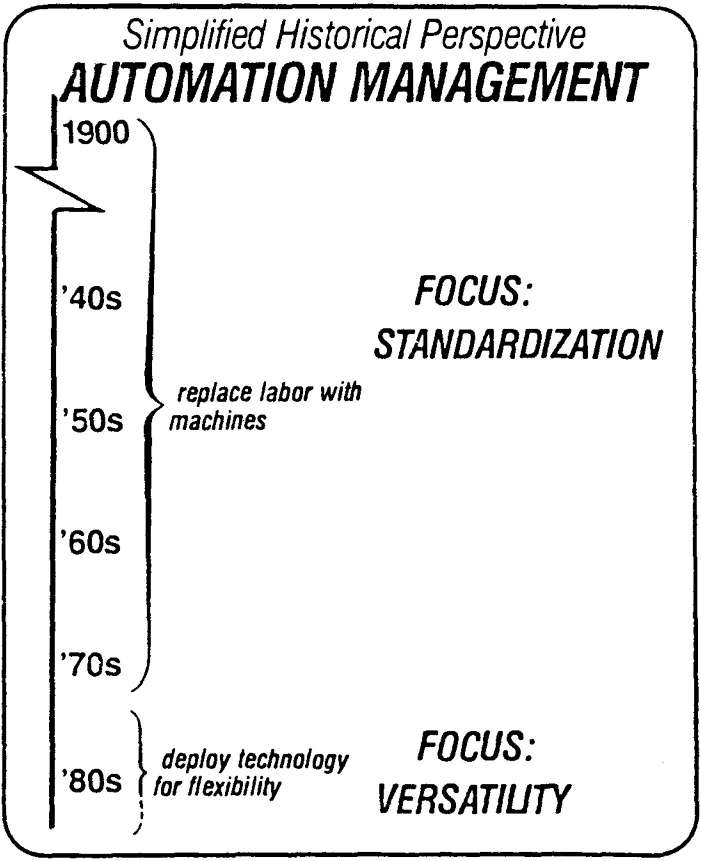
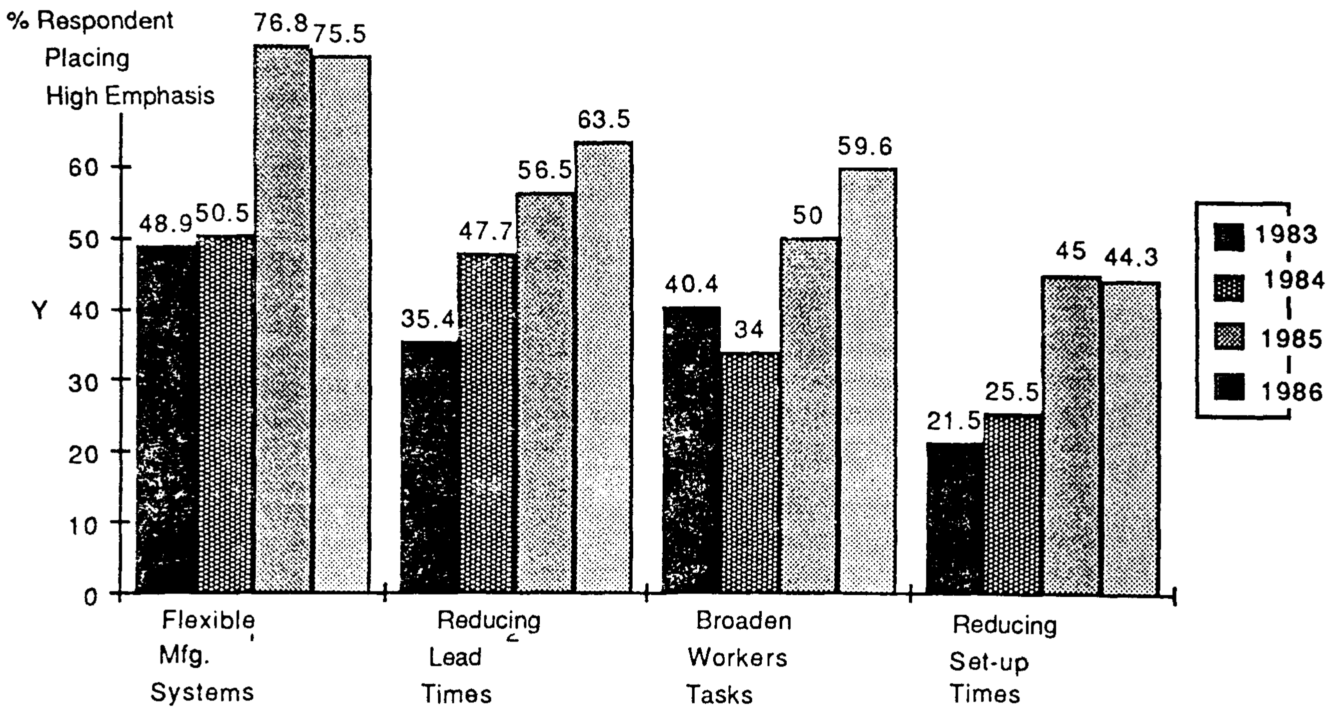

Simplified Historical Perspective
AUTOMATION MANAGEMENT
1900
'40s
'50s
'60s
'70s
'80s
replace labor with machines
FOCUS:
STANDARDIZATION
deploy technology for flexibility
FOCUS:
VERSATILITY

EXHIBIT 7

Growing Importance of Plans for Development of
MANUFACTURING FLEXIBILITY
IN JAPAN



Sources: 1983, 1984, 1985, and 1986 Japanese Manufacturing Futures Surveys

EXHIBIT 8

PROGRAMS EMPHASIZED ALONG WITH FLEXIBLE MANUFACTURING SYSTEMS

* Quality Circles
* Zero Defects
* Vendor Quality
* Changing Labor-Management Relationships
* Direct Labor Motivation
* Supervisor Training
* Reduction of Lead Times
* Reduction of Set-up Times
* Production and Inventory Control Systems
* Automating Jobs
* Computer-Aided Design (CAD)
* Computer-Aided Manufacturing (CAM)
* Developing New Processes for New Products
* Reorganizing Manufacturing
* Defining Manufacturing Strategy

<u>Note:</u>

Each program listed above shows a t-test significance of 95%--i.e., those manufacturers who have put high emphasis on the development of flexible manufacturing systems have also put high emphasis on each of these programs.

Source: 1985 European Manufacturing Futures Survey

1984

84/01	Arnoud DE MEYER	"A technological life-cycle to the organisational factors determining gatekeeper activities" , November 1983.
84/02	Jeffrey SACHS and Charles A. WYPLOSZ	"La politique budgétaire et le taux de change réel", November 1983.
84/03	Jeffrey SACHS and Charles A. WYPLOSZ	"Real exchange rate effects of fiscal policy", December 1983.
84/04	Gabriel A. HAWAWINI	"European equity markets: a review of the evidence on price behavior and efficiency", February 1984.
84/05	Charles A. WYPLOSZ	"Capital controls and balance of payments crises", February 1984.
84/06	Gabriel A. HAWAWINI	"An uncertainty model of the professional partnership", November 1983.
84/07	Gabriel A. HAWAWINI	"The geometry of risk aversion", October 1983.
84/08	Gabriel A. HAWAWINI, Pierre MICHEL and Claude J. VIALLET	"Risk, Return and equilibrium of the NYSE: update, robustness of results and extensions" December 1983.
84/09	Gabriel A. HAWAWINI, Claude J. VIALLET and Ashok VORA	"Industry influence on firm's investment in working capital: theory and evidence", January 1984.
84/10	Gabriel A. HAWAWINI and Pierre A. MICHEL	"Impact of the Belgian Financial Reporting Act of 1976 on the systematic risk of common stocks", January 1984.
84/11	Jean DERMINE	"On the measurement of the market value of a bank", April 1984.
84/12	Antonio M. BORGES	"Tax reform in Portugal: a general equilibrium analysis of the introduction of a value added tax", December 1984.
84/13	Arnoud DE MEYER and Kasra FERDOWS	"Integration of information systems in manufacturing", December 1984.

1985

85/01	Jean DERMINE	"The measurement of interest rate risk by financial intermediaries", December 1983, Revised December 1984.
85/02	Philippe A. NAERT and Els GIJSBRECHTS	"Diffusion model for new product introduction in existing markets" .
85/03	Philippe A. NAERT and Els GIJSBRECHTS	"Towards a decision support system for hierarchically allocating marketing resources across and within product groups" .
85/04	Philippe A. NAERT and Marcel WEVERBERGH	"Market share specification, estimation and validation: towards reconciling seemingly divergent views" .
85/05	Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Ira HOROWITZ	"Estimation uncertainty and optimal advertising decisions", Second draft, April 1985.
85/06	Kasra FERDOWS	"The shifting paradigms of manufacturing: inventory, quality and now versatility", March 1985.
85/07	Kasra FERDOWS, Jeffrey G. MILLER, Jinchiro NAKANE and Thomas E.VOLLMANN.	"Evolving manufacturing strategies in Europe, Japan and North-America"
85/08	Spyros MAKRIDAKIS and Robert CARBONE	"Forecasting when pattern changes occur beyond the historical data" , April 1985.
85/09	Spyros MAKRIDAKIS and Robert CARBONE	"Sampling distribution of post-sample forecasting errors" , February 1985.
85/10	Jean DERMINE	"Portfolio optimization by financial intermediaries in an asset pricing model".
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85/14	Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Douglas L. MacLACHLAN	"The advertising-sales relationship in the U.S. cigarette industry: a comparison of correlational and causality testing approaches".
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85/26	Karel O. COOL and Dan E. SCHENDEL	"Patterns of competition, strategic group formation and the performance case of the US pharmaceutical industry, 1963-1982", October 1985.
85/27	Arnoud DE MEYER	"European manufacturing: a comparative study (1985)".

1986

86/01	Arnoud DE MEYER	"The R & D/Production interface".
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2. BOISOT Max and LASSERRE Philippe (Research Paper n° 2)
The transfer of technology from European to ASEAN entreprises: strategies and practices in the chemical and pharmaceutical sectors. 1980.

3. AMAKO Tetsuo (Research Paper n° 3)
Possibilité d'un transfert à l'étranger des techniques japonaises de gestion du personnel: le cas français. 1982.

4. SCHUTTE Hellmut (Research Paper n° 8)
Wirtschaftliche Kooperation zwischen den ASEAN - Ländern und Nordrhein-Westfalen - Hemmungsfaktoren und Chancen für die deutsche Wirtschaft. 1983.

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