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Managerial Focal Points in Manufacturing Strategy

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ABSTRACT

Through analysis of specific decisions in the management of manufacturing in 163 companies, we have identified the key dimensions along which mort of the differences among manufacturing strategies can be explained. Previous research—mostly based on clinical observations—has focused on describing the typical decision categories in manufacturing strategy. Our large sample has allowed us to move beyond that and focus on the differences among manufacturing strategies. Data were collected by mailed questionnaires as a part of a large research project 'Manufacturing Futures'. The responses to a list of 35 specific current action programmes in manufacturing were reduced through a principal component analysis to eight factors. We have labeled the factors as action flexibility, changing role of workforce, quality, information systems, upkeep of existing systems, re-sizing the structure, automation, and product-process adjustments. We interpret them as the dimensions which reflect the focal points of attention of management as judged from implemented manufacturing strategies. On the basis of this analysis, we recommend explicit management attention to eight questions while formulating a manufacturing strategy.

Keywords: Manufacturing Strategy, Production Management, Operations Policy, Manufacturing Improvement Programs, Manufacturing Flexibility, Workforce, Quality, Information Systems, Automation

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1. Introduction

Since the milestone work of Skinner (1996) on the role of manufacturing in corporate strategy, a growing number of authors have made significant contributions to the understanding of the components of manufacturing strategy (Ferdows and De Meyer 1985, Ferdows and Lindberg 1987, Ferdows et al. 1986, Fine and Hax 1984, Gudnason and Riis 1984, Hayes and Wheelwright 1984, Hill 1985, Schmenner 1981, Skinner 1978, 1985). A recurring challenge in thinking strategically about manufacturing decisions has been the establishment of relationships among the widely disparate and dispersed elements of production in a firm—elements which are often riddled with technical details. Consequently, it has been difficult to provide a systematic explanation of the nature of the differences among different manufacturing strategies.

In this paper we suggest a model for doing that. Using empirical data, we identify eight dimensions along which major differences in manufacturing strategies of different companies can be explained. We suggest that these dimensions reflect the differences in the foci of attention of management. We have been able to identify these dimensions because our sample—being considerably larger than the samples in the previous research works on manufacturing strategy—allows statistical inferences. Most of the existing paradigms and concepts in manufacturing strategy have been based essentially on clinical observations in a few companies. Our model, in contrast, is based on observations in a relatively large number of companies.

2. Components of manufacturing strategy

Skinner (1978) groups the manufacturing decisions into five areas: (a) plant and equipment, (b) production planning and control, (c) labor and staffing, (d) product design/engineering, and (e) organisation and management. He identifies the trade-offs which are inherent in each of these areas, and suggests that manufacturing strategy is essentially a guide for making consistent choices on these trade-offs over time. To do that, priorities for the performance expected from manufacturing should be established (which he calls "manufacturing missions or tasks"). These priorities, in turn, are derived from corporate strategy.

Skinner's model thus implies that all decisions in manufacturing have a strategic component. To ensure that they align properly, one must start with corporate strategy, determine the "manufacturing tasks", and then examine each decision in the light of its contribution towards these tasks.

All the authors since then have essentially subscribed to this basic argument, although many of them have grouped the manufacturing decisions somewhat differently. Hayes and Wheelwright (1984) suggest eight major categories. The first four are viewed by them as "structural" in nature. They relate to (1) amount, timing, and type of capacity, (2) size, location, and specialization of facilities, (3) process technology, and (4) direction, extent and balance of vertical integration. The second groups of four decision categories are described as "infrastructural" which encompass a myriad of ongoing decisions. They are (1) skill level of the workforce, wage policies and employment security, (2) quality assurance policy, as it is reflected in prevention and monitoring of defects and intervention policies, (3) production and inventory control policies, and (4) organisation of the manufacturing function.

The same basic decisions are found in Schmenner's classification (1981). He puts them under three broad categories labeled as (1) technology and facilities (2) operating policies and (3) operations organisation. Hill (1985) and Skinner (1985) provide other useful classifications of essentially the same decisions. Buffa (1984), too, considers the same set of decisions, while posing them as questions in the context of his view that the basic manufacturing strategies vary between two polar extremes: minimum cost/high availability versus high quality/flexibility strategies.

There is, therefore, a convergence of opinions in the literature on the items which need to be decided upon when a manufacturing strategy is being formulated. Consequently, it should be possible to discern the differences in the manufacturing strategies by analyzing the pattern of decisions on these common items.

3. Research method

The underlying assumption of our study is that the specific action programs in manufacturing--under implementation or planned for the next two years—reflects the current manufacturing strategy. Stated more precisely, we assume that the differences in the actions among different companies stem from differences in their (implicit or explicit) strategies.

The data about the manufacturing plans were collected as a part of the Manufacturing Futures Surveys. The Manufacturing Futures Surveys, a collaborative effort since 1983 among three universities in Europe, North America, and Japan, consist of three annual surveys among large manufacturers in these regions towards an objective of developing an international data base for research into manufacturing management (Ferdows et al. 1986). Data used in this study are from the 1985 European survey (Ferdows and De Meyer 1985).

3.1 *The Sample*

A questionnaire survey was mailed to about 1000 of the largest manufacturing companies (based on industrial directories) in 13 West European countries (See Table 1 for the list.) One hundred and sixty three valid responses were received by our cut-off date (March 1985). Tables 1 and 2 show the distribution of the respondents by country and industry, respectively. We cannot discern a bias towards any particular industry or country in the sample. Furthermore, since we do not intend to draw any conclusions regarding the situation in

Europe in particular, we do not make any assumptions about the sample's representativeness of distribution of manufacturing output among various European countries or industries.

Table 1. Distribution of responses by country

COUNTRY	NUMBER OF RESPONDENTS
Austria	1
Belgium	11
Denmark	5
Great Britain	33
Finland	1
France	21
Germany (FRG)	31
Holland	19
Ireland	2
Italy	19
Spain	12
Sweden	3
Switzerland	5
TOTAL	163

Table 2: Distribution of responses by industry

INDUSTRY	NUMBER
Chemicals • bulk and specialty chemicals • pharmaceuticals • pesticides • petrochemicals • paper mills	36
Consumer non-durables • food products • paper products for consumer markets • tobacco	25
Electromechanical Assembly • automotive assembly • suppliers to automotive assembly • machine parts • electromechanical household appliances	34
Electronics and Instruments • communications equipment • computer hardware manufacturer • electronic components • instruments for consumer (industrial applications)	22
Machinery • machinery manufactures • materials handling equipment • machine tools • power equipment • motor	28
Others	18
TOTAL	163

The questionnaires were sent to senior manufacturing directors in the company, and over 70% of the responses received were signed by them. The rest were signed by other senior officers carrying titles of general manager, strategic planning managers, technical officer, and a variety of other titles. We also conducted face to face interviews with a number of managers of the responding companies to check the accuracy of their mailed responses. The results of this small scale audit did not indicate inconsistencies.

One section of the questionnaire asked for data on the specific action programmes which the company (or when relevant, the business unit) had either underway at the time or had firm and specific plans to launch in the following two years. A list of 35 action programmes were presented in the questionnaire. The list had been initially developed through brainstorming by the researchers and some practitioners (in 1983, when the first European and Japanese, and the second American surveys were conducted), and modified every year. As such a list can never be exhaustive the respondents had the possibility for adding more. Some of these additions were retained in later questionnaires. By 1985 our list had gone through several corrective iterations, and, on the whole, we consider the list in our 1985 questionnaire to be an extensive list of possible action programmes in manufacturing.

The respondents were asked to indicate on a continuous five-point scale the extent to which they were working or had firm plans to work on each of the 35 action programmes. The scale ranged from 1: No Emphasis, 2: Small Emphasis, 3: Moderate Emphasis, 4: Significant Emphasis, to 5: Critical Emphasis. The scale was assumed to be linear.

3.2. Results

Description of which action programme scored the highest and which the lowest is sot the objective in this paper. This has been reported elsewhere (De Meyer 1986, Ferdows and De Meyer 1985). Our focus in this paper is on the *variation* in the data. Our objective is to discern the main dimensions along which the companies differ from each other.

Principal component analysis, combined with a varimax rotation, vas used to analyse the data. This technique allows determination of the correlation between the different action plans, hence, derivation of broad families of efforts.

A principal component analysis of the data is shown in Table 3. The eight factors explain 60% of the variations in the sample. We chose eight because addition of more factors, while not changing the composition of the eight, provided little extra explanatory power. We have applied here the criteria of interpretability and invariance as indicated by Kim and Mueller (1981). To interpret the factors, we decided to consider only those components (i.e., action programmes) which had a weight of at least 0.4 on the factor. That list is presented in Table 4.

Table 3. Rotated factor matrix

ACTION PROGRAMMES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8
1) Giving workers a broader range of tasks	.01583	.72160	.10172	.01571	-0.02943	.18375	.00466	.15255
2) Giving workers more planning responsibility	.20068	.52744	.01579	.26324	-0.16283	-0.24904	-0.24275	.02801
3) Changing labour/management relationships	.03683	.75400	.10033	.13138	.17065	.04313	-0.05710	-0.05861
4) Direct labor activation	.23870	.72837	.06500	-0.02637	.08436	.07438	-0.01553	-0.00261
5) Manufacturing reorganization	.20326	.40732	-0.14293	.34388	.27885	.31938	.12042	-0.06328
6) Worker safety	.03319	-0.05607	.47558	.35948	.34150	.06742	-0.00409	.27505
7) Quality circles	.32200	.33084	.50544	.10249	-0.21551	-0.15826	.13927	-0.06554
8) Automating jobs	.12425	-0.06498	.04648	.04153	-0.00370	-0.02919	.80361	.02594
9) Supervisor training	.02816	.66329	.11169	.19724	.35440	.00381	.24604	.22358
10) Improved maintenance	-0.01882	.41955	.22692	-0.16720	.61497	-0.19406	.10326	-0.05834
11) Zero effects	.49698	.26516	.31323	.04011	.10832	-0.02166	.18228	-0.10753
12) Production/inventory control systems	.12902	.19907	.09191	.22750	.56641	-0.02790	-0.30588	-0.30676
13) Lead-time reduction	.63143	.09944	.02409	.02536	.15658	.05032	.01619	.08199
14) Purchasing management	.37661	.16672	-0.12571	.05784	.41591	.01067	-0.34577	-0.05474
15) Vendor quality	.18586	-0.15847	.11394	.26900	.28021	.01348	.08670	-0.22998
16) CAM (Computer-Aided Manufacturing	.57455	.00055	-0.06577	.31138	-0.10510	-0.02853	.33772	-0.32265
17) CAD (Computer-Aided Design)	.78354	-0.10640	.02027	.18257	-0.05362	.17814	.06399	-0.14992
18) Reducing Set-up time	.72498	.11812	.19463	-0.04511	.08925	.01904	-0.07049	.15284
19) Value analysis Product Redesign	.61199	-0.00482	-0.19389	.36009	.08289	.09648	-0.10137	.22024
20) Croup technology	.65631	.16467	.14092	.10359	-0.06645	-0.02506	.08403	.17190
21) Reducing size of manufacturing workforce	-0.10245	.06889	-0.02570	.20998	.03929	.51520	.33317	-0.40996
22) Capacity expansion	.04252	.08642	.22587	-0.07947	-0.04241	-0.11572	.05420	.67404
23) Reducing size of manufacturing units	.06519	.19752	.04485	-0.00462	-0.10834	.78051	-0.07214	-0.02054
24) Plant relocation	.27175	-0.04034	.02715	-0.06800	.12166	.69033	-0.20822	.08692
25) Developing new processes for old products	.17759	.11028	-0.12185	.01086	.25554	-0.07342	.35141	.12388
26) Developing new processes for new products	.53891	.00064	-0.01946	-0.04674	.30571	.02079	.00766	.30846
27) Narrowing product lines/standardizing	.28617	.10974	-0.19218	.27178	.08988	.13022	.10028	.60861
28) Integrating manufacturing information systems	.14771	.23738	.24168	.79226	.08855	.10364	.04356	-0.00896
29) Integration information systems across functions	.18602	.15572	.25161	.84386	-0.02396	-0.04187	.02375	.00237
30) Reconditioning physical plants	.09069	.05549	.10340	.04837	.64849	.26364	.14540	.17950
31) Introducing robots	.56957	.06481	-0.01421	.03395	-0.01825	-0.02846	.54086	-0.01893
32) Flexible manufacturing systems	.64340	.27821	.08136	.16318	.11336	.21870	.28998	-0.16989
33) Closing plants	-0.01247	-0.02284	-0.39739	.21526	.20386	.46002	.18333	-0.07179
34) Statistical quality control (Process)	.11004	.13420	.85278	.12628	.16354	-0.01975	-0.09338	.03428
35) Statistical quality control (Product)	.01512	.10197	.85713	.22408	.08857	.07028	.05027	.02948

TABLE 4. Major components of the eight factors

Factor 1 (Expanatory power: 20.4%) Action Flexibility
- Investment in computer-aided design (CAD)
- Program for reduction of set-up times
- Group Technology program
- Investment in flexible manufacturing systems (FMS)
- Program for reduction of production lead times
- Value analysis
- Investment in computer-aided manufacturing (CAM)
- Introducing robots
- Developing new production processes for new products
- Zero Defect program

Factor 2 (explanatory power: 9.0%) Changing Role of Workforce
- Changing labour-management relationships
- Programs for direct labour motivation
- Giving workers a broader range of tasks
- Supervisory training programs
- Giving workers more planning responsibilities
- Maintenance improvement programs
- Program for reorganisation of manufacturing

Factor 3 (explanatory power: 6.9%) Quality
- Statistical quality control of product
- Statistical quality control of process
- Quality circles
- Workers safety programs

Factor 4 (explanatory power: 5.9%) Information systems
- Integrating manufacturing information system
- Integrating information systems across functions

Factor 5 (explanatory power: 5.1%) Upkeeping existing systems
- Reconditioning physical plants
- Maintenance improvement programs
- Production and inventory control systems
- Programs for purchasing management
- Factor 6 (explanatory power: 4.6 X)
- Re-sizing the structure
- Reducing size of manufacturing units
- Relocating plants
- Reducing size of manufacturing workforce
- Closing plants

Factor 7 (explanatory power: 4.2%) Automation
- Automating jobs
- Introducing robots
- Developing new production processes for existing products*

Factor 8 (explanatory power: 3.9%) Product-process adjustment
- Capacity expansion
- Narrowing product lines, standardisation
- Reducing size of the workforce (negative weight)

* The weight for this component was 0.35; but this vas its largest weight on any factor.

Discussion

The interpretation of the eight factors provide rather clearly defined dimensions along which most of the differences in the collection of the action programs of the manufacturers in our sample—hence differences in their manufacturing strategies—can be described.

Dimension 1: Action Flexibility

The most powerful discriminatory dimension is what we have labeled as “action flexibility.” (explanatory power: 20.4%) Ten action programs, out of 35, load more than .4 on this factor. (See factor 1 in Table 4.) They include many of the programs which have been receiving a great deal of attention recently in manufacturing. They include programs for introduction or enhancement of computer aided design (CAD), computer-aided manufacturing (CAM), flexible manufacturing systems (FMS), robots, “group technology,” and emphasis and special attention to lead time reduction, setup reduction, value analysis, and zero-defect programs. Because so many components load high on this factor, it is difficult to suggest an all-encompassing label for this factor. However, we see a thread among these action programmes: The aim in most of them is to improve manufacturing’s capability for coping with changing demands upon it. Technology and new philosophies are deployed to do this efficiently.

Existence of so many of the “new” and recent ideas in manufacturing management on this one factor suggests a deeper and more profound interpretation for this dimension. It suggests a measure for the consciousness about the new manufacturing philosophies, tools, and technologies. Similar to the argument suggested by Ferdows and Lindberg (1987) in their study of flexible manufacturing systems, one may argue that this dimension reflects the overall attention that manufacturing is receiving in the company, and in this sense, an important indicator of the planned role of manufacturing in the competitive strategy of the company.

This is consistent with the conceptual four stages for the role of manufacturing in the competitive strategy which has been proposed by Hayes and Wheelwright (1984). The four stages—“internally neutral, externally neutral, internally supportive, and externally supportive” —are indicative of the degree to which manufacturing is hindering, supporting, or leading the business strategy of the company. Hayes and Wheelwright argue, logically, that the stage of manufacturing in a company largely explains the company’s investments in developing specific capabilities in its manufacturing function. The dimension we have identified, which happens to be the most important one in our list, supports this proposition.

Dimension 2: Changing role of workforce

The second factor clearly relates to programs directly related to workforce. (explanatory power: 9%) Programs which load high on this factor include changing labour-management relationships, direct labour motivation (educational, financial, and other programs), giving broader tasks and more planning responsibilities to workers, supervisory training—all of which indicate specific attention to the workforce. Improving maintenance, the only other program in our list under this factor (which with a weight of 0.42 just meets our 0.40 cutoff point) may appear to be less indicative of a changing role for the workforce. However, education, training, and changing assignment for the workforce are usually integral parts of maintenance improvement programs.

It is important to point out that most of these programs relate to changes in the role of the manufacturing workforce. What this dimension identifies is the extent to which the manufacturing strategy is calling for or depending on a changing role for the people who are on the shop floor.

We find this consistent with the propositions put forward by many researchers in work organization, labor relations, and quality of working life areas. A central argument in these propositions is that the commitment to the workforce is a major determinant of the strategy (Foulkes and Hirsch 1984, Walton 1985). Existence of this dimension confirms that.

Dimension 3: Quality

Most of the action programs under this factor (explanatory power 6.9%) relate to quality management. They include greater emphasis in the use of statistical techniques for control of quality of both products and production processes, and more attention to quality circles. (One may argue that even the fourth program under this factor—workers safety—relates to some aspects of quality improvement.)

We interpret this dimension as an indicator of the extent to which the company has operationalized its commitment to quality. Stated more precisely, this is a dimension which allows differentiating among companies on the basis of their action programmes on quality management. It can be a proxy measure for the strategic commitment to quality—a subject of considerable debate especially in the last few years (Garvin 1984, Juran 1981, Leonard and Sasser 1982).

Dimension 4: Information systems

This factor (explanatory power 5.9%) consists of only two significant programs, both directly related to computer-based information systems. One is the program for integration of information systems in manufacturing, and the other integration of information systems between manufacturing and other functions.

As such, this factor is simply a dimension along which the company's efforts for development of computerized information systems can be gauged. Recent authors have been advocating that deployment of information technology should play an important role in manufacturing strategy (De Meyer 1987, De Meyer and Ferdows 1985). In a sense, this dimension provides an indication—albeit an indirect one—of this role.

Dimension 5: Upkeep of existing systems

Four programs load more than 0.4 on this factor (explanatory power: 5.1%): reconditioning physical plants, maintenance improvement, production and inventory control systems, and purchasing management. A common characteristic among them, especially among the first two which are loaded with greater weights, is that they relate to upkeep of the facilities, procedures and systems which are already in place. The dimension, therefore, can be interpreted as a scale for measuring the dependence and commitment to the existing systems.

Dimension 6: Re-sizing the structure

The activities loading this factor (explanatory power 4.6%) all relate to major structural changes in the plant itself. They consist of reduction of the size of the manufacturing unit, relocation of plant(s), reducing the size of the workforce, and plant closure. This is clearly a dimension which indicates the extent of capacity shrinkage. But, more generally, it also indicates whether the company is “down-sizing” its manufacturing units.

Dimension 7: Automation

Three programs load this factor (explanatory power: 4.2%): automation of (manufacturing) jobs, introduction of robots, and development of new production processes for new products. The correlation between the first two is of course expected; one may argue that the third one gives an indication of when the first two are usually done.

The dimension identified by this factor is a familiar one (although not as explicitly shown in the literature): It provides a basis for classifying the companies according to their levels of efforts on manufacturing automation.

Dimension 8: Product-Process Adjustments

This factor (explanatory power 3.9%) cannot be clearly interpreted. Three programs load this factor: capacity expansion, narrowing of product lines standardization, and negatively, reduction of the workforce. The simplest partial interpretation would be that this dimension differentiates between those who are expanding capacity (and of course not laying off workers) and those who do not. But the move towards standardization and narrowing of the product line should also be incorporated in this dimension.

Our interpretation, therefore, is somewhat more complicated. We speculate that this is a dimension which reflects moves in the so called “product-process matrix” (Hayes and Wheelwright 1984). Standardization or narrowing of the product line implies that the productive unit is moving to the right of the matrix (i.e., along the horizontal axis); capacity expansion can also change the position of the productive unit along the vertical axis in the matrix. The combination, therefore, can be indicative of adjustments in the position of the company's productive unit on the product-process matrix.

4. Conclusions

We have identified eight dimensions along which differences in manufacturing strategies can be explained. They are:

1. Action flexibility
2. Changing role of workforce
3. Quality
4. Information systems
5. Upkeep of existing systems
6. Re-sizing the structure
7. Automation
8. Product-Process adjustments

These eight dimensions provide both a useful insight and a guide for action. The insight is in explaining the differences in manufacturing strategies of different companies. While, as we have described in this paper, there is a convergence of opinions in the literature on the decision categories in manufacturing strategy, there are almost no models which help us explain the differences in manufacturing strategies of the different firms. The only viable model so far has been that the differences in the competitive priorities set for manufacturing (or in the words of Skinner (1985), "manufacturing missions") can provide an overall explanation of the differences in manufacturing strategies being implemented through various action programs. But there is no agreed method for reducing the multitude of action programs in manufacturing to a few competitive priorities. Furthermore, even if there were a method, one had to assume that consistent and rational choices link the action programs to the competitive priorities. This is often a questionable assumption.

Our model goes beyond these limitations. First, because we have derived our dimensions from analysis of the action programs themselves, no assumptions about the link between competitive priorities and action plans need to be made. Second, our dimensions provide a more detailed and specific explanation of the differences in manufacturing strategies. Our dimensions are more directly related to specific action programs in manufacturing, and as such provide more accurate and specific explanation for the differences among the manufacturing strategies of different companies. They provide a framework for identifying the focal points of attention of the management—even if they may not have been conscious of them or made them explicit. This point is perhaps better understood as we describe (below) the usefulness of our model as a guideline for formulation of manufacturing strategy.

Explicit attention to these dimensions provide a useful guideline for manufacturing strategy formulation. The usefulness comes from allowing discussion at an intermediary level in the long chain between competitive priorities and specific decisions and action programs. Specifically, we suggest that the company can benefit from holding a discussion and reaching an agreement on the following eight questions:

1. How flexible is manufacturing in the company? To what extent is this function capable of coping with changing conditions? How ready is it for adopting new approaches, concepts, and technologies?
2. Is there a new role for the production workforce?
3. What is the commitment to quality in practical terms?
4. To what extent manufacturing should rely on computerized information systems?
5. How much attention should be paid to the upkeep and maintenance of existing systems?
6. Is there a policy for changing the overall size of the manufacturing units of the company?
7. How aggressively should production be automated?
8. Is there a need to adjust the focus of the production facilities?

The answers to these questions determine the position which the firm has chosen along each of the eight dimensions we have identified. In this paper we have shown that these are the major dimensions along which senior manufacturing directors differ from each other; hence we suggest that, among the multitude of questions which one might raise in the process of formulating a manufacturing strategy, these are the ones which deserve more management attention. And among the eight, the most important one by far is the first question, then the second one; the rest are of about the same importance with only small differences in the order presented.

The first question is in fact more profound than what is stated above. A deeper look into the first dimension turns the question into “To what extent is the company willing to bank on its manufacturing function to enhance or lead its competitive strategy?” Our data shows that, in spite of the myriad of action programs being implemented in manufacturing at any time, the answer to this question is the most powerful determinant of the manufacturing strategy. This is intriguing and deserves further research.

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