"FACTORIES OF THE FUTURE: EXECUTIVE SUMMARY OF THE 1990 INTERNATIONAL MANUFACTURING FUTURES SURVEY"

by

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1990 International Manufacturing Futures Survey

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Factories of the Future

Synopsis

The phrase "factory of the future" describes a vision of the organization, technology, and culture that manufacturing firms aspire to create. The 1990 International Manufacturing Futures Survey shows that this vision is quite different among manufacturing executives of the large successful firms based in Europe, America, and Japan. The factories of the future envisioned for these three regions of the world are different not only in terms of what they are designed to do, but also in terms of the key tasks required to create them.

This report on the 1990 International Manufacturing Futures Survey reviews the current status of key regionally-based participants in the race for competitive superiority. It outlines the visions of the factory of the future that dominate in each region, the progress of manufacturers in each region working towards manifestation of that vision, the investments that are proving to be most worthwhile in each region, and future barriers that must be surmounted. The survey, initiated in 1981 at Boston University, has been administered in Japan by Waseda University and Europe by INSEAD since 1983. The 1990 survey of over 500 large successful manufacturing businesses in these three regions provides the following specific insights:

• A common thrust in all three regions is strategic integration. American firms continue the heavy emphasis on the integration of manufacturing strategies with business strategies started in the late 1980s. The 1990 survey shows that European and Japanese firms joining the Americans in emphasizing integration of manufacturing

and business strategies. We believe this finding signifies global acceptance of the proposition that competitive manufacturing firms must tightly integrate the activities and goals of the manufacturing function with those of other functions, and with the mission of the business unit as a whole.

• A second thrust which is common to all three regions is quality. The Japanese initiated the "quality revolution" in the 1970s, and have achieved worldwide recognition for their accomplishments. The Americans joined the revolution in the mid 1980s and have made rapid advances. More recently the Europeans have launched a concerted effort to improve quality. Manufacturers in all three regions plan to continue to emphasize this competitive variable.

• Japanese companies are in the process of creating a *design factory of the future;* one which can make fast design changes and provide a variety of products individualized for each customer. They are placing primary emphasis on fundamental process development, as well as better integrated computer systems, in order to achieve this vision.

• American manufacturers are building a *value factory of the future.* The emphasis here is on creating responsive organizations that can produce quality goods at a reasonable price. Critical investments are being made in building cross functional teams, empowering and training workers, and statistical process control.

• The Europeans are most heavily focused on building the *borderless factory of the future.* Their efforts are concentrated by the remarkable changes inherent in *Europe of 1992.* But, the borderless factory implies more than just a factory for which continental, geo-political have been eliminated, it also implies a factory which can

remove internal barriers to communication with the rest of the organization. This vision has led them to a fundamental restructuring of manufacturing operations in order to realign them with new market definitions, in addition to major investments in training, computer integrated manufacturing, and quality function deployment.

• Across the broad spectrum of industries surveyed, there are few performance measures on which the large successful firms in each region perceive themselves to have clear superiority. After correcting for the normal tendency of individuals to overrate their own performance, critical differences showed up in four areas. Europe and the United States believe they are ahead in terms of their capability to design and to build high performance products, but Japan believes that it excels in making rapid design changes and in introducing new products quickly. Firms in the United States perceive significant advantage in their ability to distribute across a broad range of channels and customers. Japanese firms say they have better abilities, in general, to handle volume surges.

• No one is standing still. The rates of improvement in competitive variables are rapidly changing in all three regions. The United States is gaining most rapidly in quality and inventory turnover, the Japanese in flexibility, and the Europeans in customer service, delivery, and set-up and lead-time reductions. The greatest rates of improvement in each region are on those variables which are most closely associated with its vision of the factory of the future.

• Training and development of employees is universally seen to be highly advantageous. In all three regions, these activities were identified as high-payoff investments for firms over the past two years, and are projected to be critical in the future as well. Other high-payoff activities differed substantially by region. In Japan,

computer-aided design (CAD), quality function deployment (QFD), value analysis, computer-integrated manufacturing (CIM), and process development scored high. In contrast, the Europeans saw greater payoff from reorganization, the development of new strategies, and reconditioning facilities. The United States firms in the sample were highly rewarded for their efforts in statistical process control (SPC), just-in-time (JIT), cross-functional teams, and developing manufacturing strategies. Design for manufacturing (DFM) and activity-based costing (ABC) programs were low payoff activities in all three regions in the opinion of the manufacturing executives surveyed.

• Competitors from all three regions expect to increase their market share and to expand global markets. The Americans, in particular, are looking at offshore markets as the basis for future growth. The Europeans are more preoccupied with events in Europe, while the Japanese are concentrating on meeting their internal needs brought on by increasing domestic consumption.

• Strategies are becoming more diverse within each of the three regions, yet more alike between regions. Over time, according to survey data, the Europeans display the widest range of strategies, with the Americans a close second. The Japanese firms have historically shown a strong tendency to approach manufacturing in the same way. However, this unified paradigm appears to be breaking down as Japanese manufacturers employ a wider range of strategies. The diversity of strategies across all regions means that although each region reflects a unique central paradigm in its collective vision of the factory of the future, there is a great deal of cross fertilization. That is, the Japanese vision of the factory of the future is held by some Americans and Europeans, and vice versa.

- Each factory of the future represents a viable option for competitors within the region. However, there are risks associated with adopting each version. Moreover, we see that competitors holding each separate vision will influence each other over time as they already have. The end result at some distant time in the future may be a unified vision of the factory of the future.

This report is divided into four parts. In the first part, we look into the future. After a description of the competitive priorities which shape the factories of the future in each region, we look at the improvement plans to implement those strategies. In the second part, we examine recent performance achievements in each region. Given the composition of our sample, we believe the analysis of these achievements provides important clues to new competitive benchmarks for manufacturers worldwide. In the third part, we examine the action programs that were behind those achievements. Particularly, we look into the experience of the manufacturers in each region with specific improvement programs – which programs have had a high payoff and which have had little payoff. In the final section, we examine the implications of the trends for manufacturers in each region, and summarize the insights we infer from our data.

Project History

The International Manufacturing Futures Project was initiated in 1981 at Boston University by Professor Jeffrey G. Miller. In 1983, he was joined in the survey effort by faculty from INSEAD and Waseda University in order to provide a global scope to the work. The informal relationships between faculty which guided the survey efforts in its early years were replaced by a formal agreement between the three schools in 1990 which ensures the continuation of this work. In 1991, The Manufacturing Futures Survey is one of the longest running international research projects on manufacturing and competitiveness. The three schools which first allied to make this

international survey possible have since been joined by faculty who administer the survey from other countries, including Australia, Korea, Mexico, Singapore, and New Zealand.

Part One

FACTORIES OF THE FUTURE

The race for national competitiveness continues at a fast pace. Supported by significant improvements in the past, and faced with rapidly changing worldwide business environments, companies around the world are looking into the future with new competitive priorities and visions. The results from the 1990 International Manufacturing Futures Survey provide a picture of how global competition will shape manufacturing in Europe, the United States and Japan in the last decade of the 20th century.

Dominant visions of the factory of the future are emerging in each region. Manufacturers in the United States, Japan, and Europe are all pursuing a more integrated factory that can yield higher quality goods. However each of these factories of the future is being designed to achieve different objectives. United States manufacturers are moving toward what we have called the *value factory of the future.* That is, a factory designed to build high quality products at a reasonable price. European companies are moving toward what we have called the *borderless factory of the future.* The borderless factory is one which is equipped to do business in the newly forming pan-European market, as well as non-European countries. In Japan, manufacturers are working steadily to build the *design factory of the future.* The design factory is oriented toward producing not just products in volume, but a continuing stream of new designs that are highly customized for individual use.

Our conclusions about the factory of the future in each region were shaped by our analysis of the dominant competitive priorities exhibited by the manufacturers in each

region, and of the investments they plan to make in the early 1990s. Competitive priorities indicate the most important capabilities that a firm bases its ability to compete on. To get information on competitive priorities, we put the question directly to the manufacturing executives of a sample of 500 large successful companies in all three regions. We provided the respondents with a list of 15 possible competitive priorities, and asked them to indicate the importance of each in competing through 1995. Table 1 shows the list of the top five competitive priorities from each region.

Table 1
Top Five Competitive Priorities in the Next Five Years

EUROPE	*JAPAN*	*UNITED STATES*
conformance quality	reliable products	conformance quality
dependable delivery	dependable delivery	dependable delivery
reliable products	rapid design changes	reliable products
high performance	conformance quality	high performance
fast delivery	product customization	price competition

The similarity of the average rankings between Americans and Europeans is striking although not new. We have observed this similarity in every year since 1983. The lists of the top five priorities from the two regions include providing consistently low defect rates, dependable deliveries, product reliability, and high performance products (that is, products with advanced features and functionality). Defect rates, reliability, and performance are different dimensions of what is commonly viewed as "quality". The importance of high performance products to both the Americans and Europeans, but not the Japanese, indicates the Western focus on highly developed *product technologies* to provide the basis for advances in product performance.

The Americans are distinguishable from the Europeans by their greater emphasis on the ability to compete on price. Hence, we conclude that they are focused on competing more on the basis of price-adjusted value. In contrast, the priorities of the European manufacturers reflects a focus on quality and delivery to their customers (in a Europe without borders). Hence, we conclude, they are focused on building the borderless factory of the future.

More striking differences are found from the comparison between the Japanese manufacturers and their counterparts of the other two regions. While Japanese firms also place a strong emphasis on quality and delivery related priorities, they assign much higher priorities to the ability to make rapid design changes in highly customized products. Hence the design factory, built to be flexible enough to build an ever changing stream of products. In addition, the Japanese focus more heavily on reliability and consistency as aspects of quality, and less on product performance. This is consistent with the Oriental focus on *process technology* and simplicity reported by many other researchers.

In the report of our survey four years ago entitled, *Flexibility: the Next Competitive Battle,* we first identified the focus of the Japanese on the design factory with its inherent demands for manufacturing flexibility. We also noted that this strategy provides the Japanese with a powerful and new approach to competition. We still believe that this approach has certain unique advantages, which will require a response from competitors elsewhere in the world in the future.

Even clearer indications of the visions of manufacturers in each region for the factory of the future are provided by the investments they plan to make in the early 1990s. Using an identical set of 26 investment areas in the surveys in each region, we asked

the respondents to indicate the improvement programs in which they planned significant investments of time, managerial effort, and money in the next two years (1990-1992). Table 2 shows the top five responses in each region in rank order of importance.

Table 2
Most Important Improvement Programs in the Next Two Years

UNITED STATES

1. Linking manufacturing strategy to business strategy
2. Giving workers broader tasks and more responsibilities
3. Statistical process control
4. Worker and supervisor training
5. Interfunctional work teams

EUROPE

1. Linking manufacturing strategy to business strategy
2. Integrating information systems in manufacturing
3. Quality function deployment
4. Training of supervisors, workers and managers
5. Integrating information systems across functions

JAPAN

1. Integration of information systems in manufacturing and across functions
2. Developing new processes for new products
3. Production and inventory control systems
4. Developing new processes for old products
5. Linking manufacturing strategy to business strategy

From Table 2, we notice a remarkable difference in the investments being made to improve manufacturing by the United States manufacturers compared to their competitors in the other two regions. United States improvement programs are

heavily focused on workers and teams of workers. We interpret this finding to indicate the acceptance in America of the idea that the greatest advances in quality and cost will come by positioning the workforce to make a greater contribution to improvement, and by breaking functional boundaries. Our surveys also show that United States firms carry the largest percentage of their costs as overhead among the three regions. By reallocating effort to individuals lower in the organizational pyramid, and breaking bureaucracies with direct interfunctional teams, the Americans can improve their ability to create the *value factory of the future* at lower cost than before.

In contrast, the Japanese manufacturers place a strong emphasis on the development and improvement of fundamental process technologies. Along with information systems integration, this strong orientation toward process development supports their thrust toward factories which can make reliable, rapid design changes in customized products. The Japanese *design factory of the future* is fundamentally based on new processes that can overcome the enormous complexity involved in delivering large numbers of new and custom products with high quality in a short leadtime.

European manufacturers are investing in a variety of programs and activities which hint at the major restructuring their organizations are going through to adapt to the newly forming pan-European market. Restructuring implies a simultaneous change in the culture, coordination techniques, and configuration of a firm. Europe's investment in integrated information systems is designed to enhance its ability to coordinate its activities across borders. Quality function deployment enhances its ability to design products that are acceptable to the new European market, and training is necessary to build new skills and a new culture for competing with their vision of the *borderless factory of the future*.

Whether they are based on a vision of a value factory, a design factory, or a borderless factory, the factories of the future in each region are all focused on the development of businesses in which manufacturing strategy is tightly linked with the business strategy. All three regions report a high emphasis on the linkage between their manufacturing's functional strategy and their overall business direction. This result signifies the strategic importance of the manufacturing function in the increasingly competitive global marketplace.

Part Two

CHANGING PERFORMANCE BENCHMARKS

While each emerging vision of the factories of the future is designed to perform well on a particular set of dimensions, no competitor can afford to perform on any dimension at an unacceptable level. In this race, there are no non-competitive dimensions. For this reason, performance benchmarks have become increasingly important to manufacturers around the globe.

The 1990 International Manufacturing Futures Survey does not provide direct evidence on absolute performance levels. However, it does provide data on how competitors in each region perceive themselves to be performing in comparison to other world class competitors, and the rates at which improvement on each dimension is occurring. Overall, our international survey indicates that large Japanese manufacturers perceive themselves to be the performance leaders on many key measures; United States manufacturers have been fighting back and gaining ground and European performance has begun to improve dramatically.

While statistical analysis shows few differences in perceived competitiveness across regions on such critical variables as conformance quality, product reliability, cost, and delivery dependability, regional differences do show up in other dimensions as seen in Table 3. European and American companies see themselves as leaders in designing high-performance products. American firms also believe they have significant advantages in their ability to distribute products across a broad range of channels and customers. Japan considers itself a leader in flexible manufacturing, that is, making rapid design changes, introducing new products quickly, and handling volume surges.

TABLE 3
1990 Competitiveness Index*

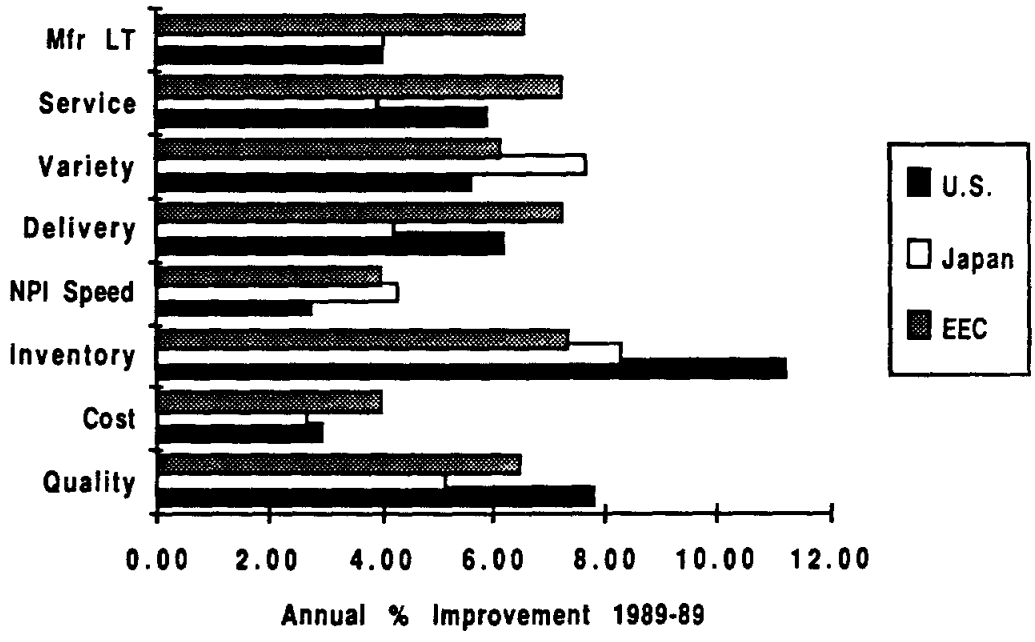
	U.S.	*Japan*	*Europe*
Price	3.98	4.11	4.14
Design Change	3.89	**4.32***	4.25
Volume Change	4.31	**4.61***	4.34
Product Mix Change	4.43	4.62	4.41
Broad Product Line	4.59	4.44	4.60
Conformance Quality	4.94	4.91	5.03
Performance Quality	**4.92***	4.43	**5.01***
Product Reliability	5.23	5.02	5.17
Delivery Speed	4.61	4.46	4.52
On-time Delivery	4.82	4.79	4.67
After-sales Services	4.86	4.62	4.67
Product Support	4.85	4.59	4.67
Broad Distribution	**4.81***	4.51	4.49
Product Customization	4.56	4.70	4.63

*The table shows the normalized mean scores of the respondents from each part of the world on a question which asked them to rate their perception of their capabilities on each of the performance measures in comparison to their competitors. A 7-point scale was used where 1 was weak and 7 was strong. All respondents have a tendency to overrate their competitiveness. Therefore, we have normalized the scores by each region's tendency to overrate. Bold numbers indicate scores which are significantly different among regions.

The fact that no region's leading manufacturers believe they dominate on more than one or two performance criteria underscores the importance of rates of improvement in the competitive race through the 1990s. The manufacturers in our sample reported significant improvements in several performance measures in 1988 and 1989. The average annual rates of improvement on eight critical performance dimensions in each region are shown in Figure 1. Table 4 shows the annual rates of improvements in each region on these and other less significant variables.

The most notable feature of Figure 1 is the overall high rate of improvement for Europe. In past surveys (1985-87 time frame), Europe's rates of improvement were significantly lower than those for the United States and Japan. During the mid-80s, quality, on-time deliveries, and delivery speed were improving at a lackluster 2.5% per year among the European firms. In contrast, the rate of quality improvement in Europe during 1988-89 nearly tripled to 6.1% per year, suggesting that the European firms have finally joined the Japanese and American competitors in the quality revolution which has been sweeping the industrial world. Rates of improvement in delivery reliability and speed also increased concomitantly.

Figure 1
Performance Improvements 1988-1989



The improvement we observe in the key variables is the result of catch-up efforts on the part of some companies, and major advances on the frontiers for others. The

benchmarks for the following four areas are the fastest changing and so deserve special attention:

TABLE 4
Annual Rates of Improvement (%) 1988-89

	U. S.	*Japan*	*Europe*
Overall Quality	7.8	5.2	6.5
Manufacturing Cost	3.0	2.7	4.0
Inventory Turnover	11.3	8.3	7.4
New Product Development Speed	2.8	4.3	4.0
Delivery Reliability	6.2	4.3	7.3
Product Variety	5.6	7.7	6.2
Customer Services	5.9	4.0	7.2
Manufacturing Leadtime	4.1	4.1	6.6
Procurement Leadtime	2.3	2.8	3.8
Delivery Leadtime	2.4	4.3	5.1
Setup Time	5.9	6.3	5.8

Inventory Turnover: All three regions report significant improvements in inventory turnover: American firms improved at an annual rate of 11.3% per year, the Japanese at 8.3%, and the Europeans at 7.4%. There is no statistical difference between the rates of the Europeans and Japanese, but the United States rate was significantly faster than for the others, as it was in 1985-87.

Table 4 shows that set up time has been reduced by about 6% per year in each region over the 1988-89 time period, and this explains some of the improvement in inventory turnover. Procurement and manufacturing leadtimes have also shown persistent rates

of reduction, and reveal another cause for inventory reduction. The rates of decline in manufacturing leadtime for European manufacturers were significantly greater than those of the American and Japanese.

Quality and Customer Service: The relentless drive towards better quality around the world continues. We have seen in previous surveys that substantial attention has been paid to quality improvements over the last eight years. The 1990 survey confirms that this trend continues in Japan and the United States, and shows that Europe has embraced it as well. The Americans report 7.8% annual rates of improvement in overall quality, while European and Japanese firms improved quality by 6.5% and 5.2% respectively. More than ever, product quality has become a given in industrial competition qualifying the players in the game, rather than separating the winners and losers.

A firm's perception of their performance in the area of customer service was measured for the first time in the 1990 survey. The high rates of improvement in customer service show that increasing attention is being paid to non-product quality as well; it is the area of quality in which the Europeans have shown the most improvement, with the Americans close behind.

Time Based Competition: Time continues to be a key element of competition for all three regions as shown by the high rates of improvement in delivery reliability and speed. The Americans and Europeans report 6-7% annual rates of improvement in the reliability of delivery promises; the Japanese 4.3% per year. Table 4 shows that the Europeans and Japanese are improving delivery speed at faster rates than their counterparts in the United States.

As mentioned before, this improved reliability of delivery has not been accomplished at the expense of higher inventories. This suggests that the manufacturers in all regions, particularly in Europe and the United States, have been increasingly successful in their efforts to overcome the inherent variability and uncertainty in the order filling process. Figure 1 provides further clues on this critical competitive dimension: manufacturing lead times have been reduced at an annual rate of 6.6% in Europe, and 4.1% in America in Japan. At the same time, delivery and procurement lead times were shortened considerably.

Reduction in the time required for new product development has received much attention recently. The rates of improvement reported by our sample of manufacturers are fairly modest – 4.3% by the Japanese, 4.0% by the Europeans, and 2.8% by the Americans. The Japanese exhibited a similar rate of improvement on this dimension over the 1985-87 time period, according to our previous surveys. However, the Europeans and Americans have doubled their rate of improvement on this dimension in 88-89 compared to 85-87. Given the long cycle times associated with many new product introductions in the United States and Europe, it will be several years before substantial reductions can actually be realized.

Flexibility: Table 3 provides evidence that overall, the Japanese manufacturers excel in their ability to change product designs and respond to changes in volume or product mix. For the first time in the 1990 survey, we measured the rate of improvement in the variety of products producible by manufacturing as an overall measure of flexibility. Figure 1 shows that the Japanese are also substantially ahead of the Europeans and Americans in terms of their rate of improvement on this variable. Flexibility provides competitors with the ability to respond better to individual customer needs. Therefore greater flexibility is an advantage for the competitor who is globally diversifying their

operations, and allows the manufacturers to serve local markets with a wide variety of individually tailored products.

It is notable that the fastest rates of improvement in each region have occurred on the measures that are most closely associated with each region's vision of its factory of the future. The United States has improved the fastest on two dimensions that add to their ability to deliver value: quality and inventory. The Europeans have improved the most on those dimensions that allow them to serve broader continental markets better; delivery reliability, customer service, and shorter lead times. The Japanese have improved the fastest in their ability to change product designs and to deliver a broader variety of products from their factories.

Part Three

EFFECTIVENESS OF IMPROVEMENT PROGRAMS

How did the manufacturers in each region achieve the improvements in performance they reported? We looked into what they had done in the recent past by providing a list of 26 specific improvement programs and asking the respondents to indicate which ones they had emphasized in the last two years (1988-89). We also asked them to indicate the relative payoffs of the programs which they had emphasized. Our list of 26 programs is of course not exhaustive, but contains our collected observations from the three regions over the last eight years. Table 5 shows the programs with the highest and lowest payoffs in each region.

Though manufacturers in the three regions have grown towards each other in performance, the way they did this was quite different. The similarities and differences among regions are intriguing. In broad terms, the Americans and Europeans have benefited from structural changes in manufacturing— reorganization of the manufacturing function, redeploying workers, linking manufacturing more closely to the business strategy. The Japanese, on the other hand, seem to find the most benefit from fundamental process development, as well as in quality function deployment and quality circles.

Training of workers, supervisors and managers has paid off handsomely in all three regions— making it to the top of the list for the Europeans, and in the top tier of the American and Japanese lists. For the Americans, the investments in statistical process control and just-in-time are starting to pay off. The Japanese continue to benefit from quality circles (but, interestingly, not the Europeans) and from the constant search for new production processes for old and new products.

TABLE 5

Payoff From Activities 1988-1989

EUROPE

	1.	Training of supervisors, management, and workers
Highest	2.	Manufacturing reorganization
Payoff	3.	Linking manufacturing to business strategy
	4.	Quality function deployment
	5.	Developing new processes for new products
	<	
	22.	Quality circles
Lowest	23.	Activity based costing
Payoff	24.	Design for manufacture
	25.	Closing/relocating plants
	26.	Robotics

UNITED STATES

	1.	Inter-functional work teams
Highest	2.	Manufacturing reorganization
Payoff	3.	Statistical process control
	4.	Linking manufacturing to business strategy
	5.	Just in time
	<	
	22.	Flexible manufacturing system
Lowest	23.	Integrating info systems across functions
Payoff	24.	Integrating info systems in manufacturing
	25.	Activity based costing
	26.	Robotics

JAPAN

	1.	Developing new processes for old products
Highest	2.	Developing new processes for new products
Payoff	3.	Quality circles
	4.	Computer-aided design
	5.	Quality function deployment
	<	
	22.	Computer-aided manufacturing/Flexible manufacturing system
Lowest	23.	Integrating info systems across functions
Payoff	24.	Hiring new skills from outside
	25.	Activity based costing
	26.	Closing/relocating plants

By comparing the lists of high payoff items in the 1990 survey with those of previous surveys, we find at least one relatively new item on each of the three lists. In the American list it is inter-functional work teams. The shorter lines of communications, reduced bureaucracy, freer flow of information, mutual trust, and other benefits from this approach are evidently proving to be worthwhile. On the European list, the new item is quality function deployment (QFD) : a set of techniques for determining and communicating customer needs and translating them into product and service design specifications and manufacturing methods. QFD is also on the Japanese list of high payoff programs.

For the Japanese, another new item on the high payoff list which deserves attention is computer-aided design (CAD). It is interesting that CAD has started to pay off, while other computerization programs such as computer-aided manufacturing (CAM), integration of information systems between manufacturing and other functions, and even flexible manufacturing systems (FMS) are all in the bottom of the payoff list in Table 5. The focus on CAD is symptomatic of the Japanese focus on the *design factory of the future.*

One surprising result was the low payoff showing for activity based costing (ABC) in all three regions. Many manufacturers in our sample had not started an ABC program. However, even among those who had, the response was poor. We believe that the low payoff scores for ABC reflect a lack of fundamental yet important changes in some of the most entrenched control practices in companies attempting it. Such changes are difficult and take time. Moreover, we do not believe that ABC alone has the potential for a positive impact of the same magnitude as other more fundamental investments. ABC may be helpful in steering and measuring the course of continuous improvement,

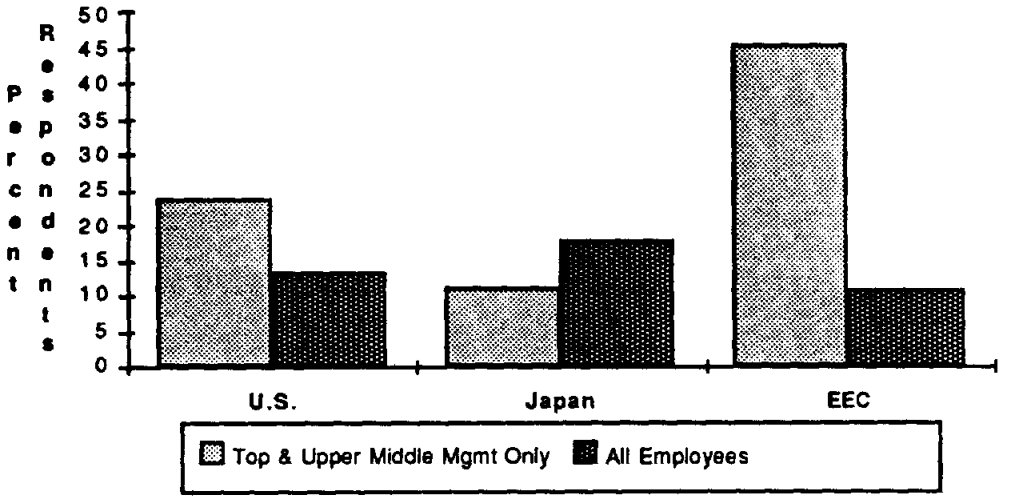
but it cannot provide the punch and impact that other quality and process improvement programs can provide.

Finally, we note the low payoff given to efforts to improve design for manufacturing (DFM). The Europeans put it near the bottom of the list, and the Americans and the Japanese in the lower third. We believe that while the focus of DFM (improving engineering/manufacturing communication) is fundamentally right, it is losing ground in popularity because it places the focus for design improvements on manufacturing and engineering issues, and not the customer's needs. Quality function deployment achieves many of the same aims as DFM, but puts the emphasis on integrating the customer, marketing, *and* engineering and manufacturing.

Behind the programs for improving manufacturing effectiveness is a fundamental issue of strategy implementation. Who in the organization has knowledge of its goals and plans, and is called upon to deliver them? Figure 2 shows that Japanese and United States firms have the widest involvement of their employees, and that European firms remain the most hierarchical in their management approach. Employee participation has not been a hallmark of American manufacturing for long however. The 1984 United States survey showed that only two percent of the firms in the sample made all employees aware of goals and plans. In 1990, nearly 14% of the United States respondents reported awareness on the part of all employees. Examination of the detailed data shows that, in those firms where all employees have not been made aware of goals and plans, there is a greater tendency to share this information with middle management.

Figure 2

Respondents Who Share Knowledge of Goals and Plans (%) 1990



Part Four

FACTORIES OF THE FUTURE AND THE GLOBAL MANUFACTURING RACE

The Americans are building a value factory of the future, the Japanese a design factory of the future, and the Europeans a borderless factory for the future. The strategic intent of the majority of manufacturers in each region is clear. But why does each vision make sense for one region and not for another? What are the risks inherent in their pursuit?

The argument for the Japanese factory of the future is that Japanese firms operate in a country whose internal customers are demanding many more sophisticated new products. At the same time, the decade-long high value of the yen to the dollar makes them less able to export low-valued products, or to compete on price. This combination of forces creates an environment in which the ability to rapidly introduce, change or modify new products provides a substantial advantage. With a design factory, the Japanese firm can meet the explosive growth in internal demand for newer, more sophisticated and more individualized products, and compete for offshore markets by providing a continuing stream of highly differentiated products that are less susceptible to price competition. It also allows the Japanese to exploit one of their national assets: a large pool of well trained, and (comparatively) low cost engineers.

In contrast to Japan, demographic and economic forces predict relatively low rates of consumption growth in the United States. However, improved quality and a favorable exchange rate offer American producers an opening to complete globally on the basis

of value, that is good quality for the price. At the same time, the U.S remains (and will remain even after 1992) the largest homogeneous market in the world, offering advantages to manufacturers who can exploit economies of scale. Though product development is also important for the Americans, especially in high tech industries such as electronics, it does not provide a fundamental driving force across industries as it does in Japan. An emphasis on the *value factory* of the future calls for actions which will simultaneously increase quality and reduce costs, and that is what we see the Americans doing. This strategy also exploits a previously untapped resource, the American production worker. Historically, the American factory worker has not been employed to think about ways to improve quality and reduce costs. Those tasks have been performed by more highly paid "overhead" employees who design and direct factory worker's activities. Use of these lower cost workers as a source of continuous improvement is a relatively inexpensive way for United States firms to deliver more value.

The *borderless factory* of the Europeans responds to their needs to adapt to the new Europe of 1992. They are driven less by demographics and exchange rates than by new political and market realities; they are responding to much more fundamental and enduring changes than the Japanese and Americans. The massive restructuring in information systems, organizations, and corporate cultures leads to a factory of the future that is designed to do the same things as the factory of old— excel at quality and delivery. But it will be able to deliver on these dimensions on a pan-European, rather than a country-by-country basis.

Some evidence for these interpretations as well as further insights into the strategies is provided in the following three figures. Figure 3 shows that manufacturers in each region have aggressive intentions with respect to market share. The high percentage

of American and European manufacturers' intent on building market share is consistent with the American's opportunity to grow in export markets, and the European's opportunity to build new pan European markets. We believe that the large percentage of Japanese firms with a "maintain" posture reflects two factors. The first is the pressure put on these firms to keep up with the high growth rate of the Japanese domestic economy, and the second is the impact of trade pressure from America and Europe.

Figure 3

Future Market Strategies

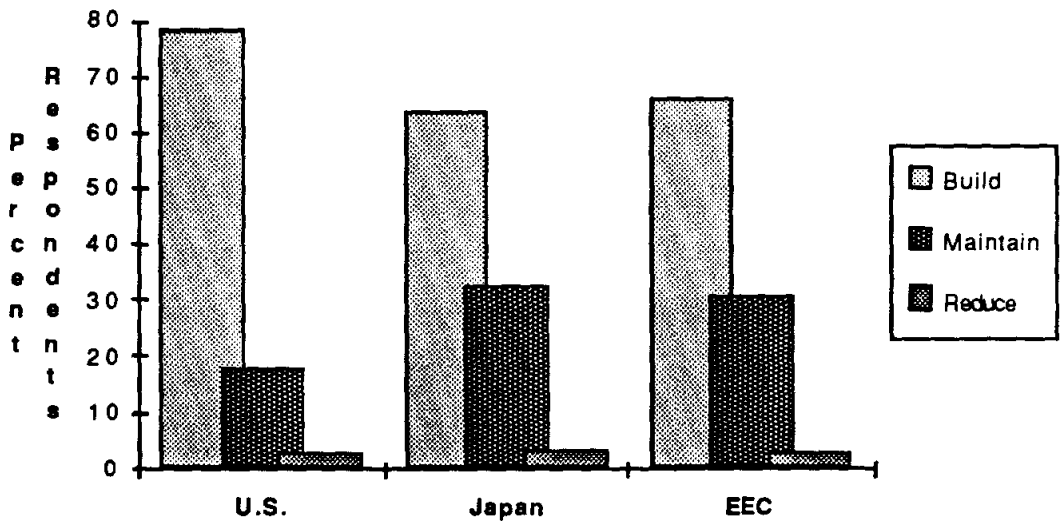
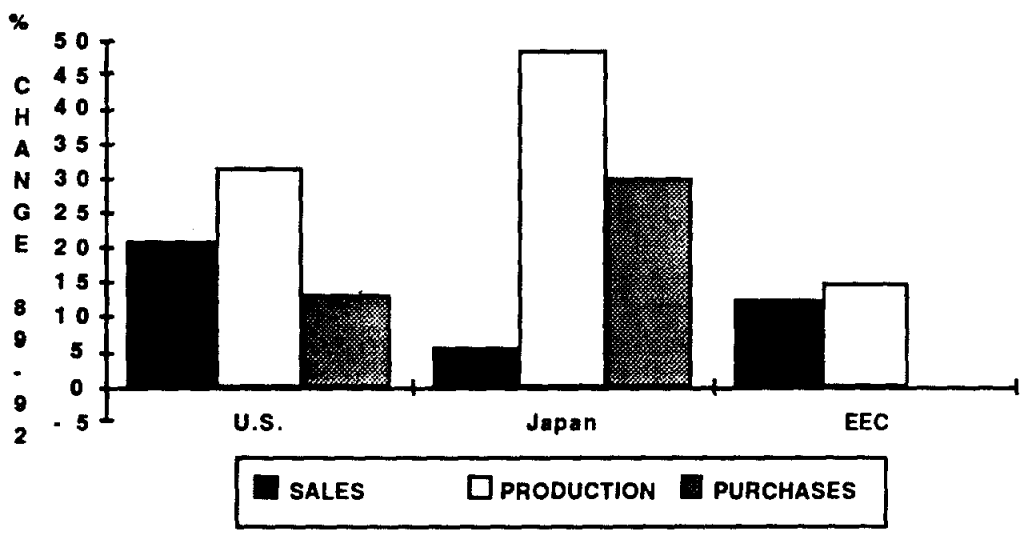


Figure 4 shows the planned rate of increase in the offshore portion of sales, production, and purchasing by producers in the sample. It shows the Americans are following an aggressive program of exports that is already appearing in economic statistics, and this aggressiveness is consistent with the priorities we have seen. We believe the increases in offshore production and purchasing by the Americans

reflect their intention to become more global, to produce locally in the offshore markets, and to balance procurement patterns in accordance with local requirements and counter-trade issues. The Europeans are substantially less aggressive in their plans to export from the EEC, and to produce offshore. We believe that this is an indication of their focus on EEC changes in anticipation of the creation of the unified market by 1992, as well as the challenge posed by the opening of Eastern European markets. The Japanese, as is already apparent in the United States and Europe, are reacting to trade pressure by increasing production in these regions with a consequent reduction in the growth rate of exports.

Figure 4: Changes in Offshore Activities



The disadvantages and risks associated with the pursuit of these factories of the future are significant. The Americans are following a strategy of "doing better what

we already do." An analysis of their action plans shows that the top five priority items are limited to activities that are also on the "high payoff" list. The question for the Americans is whether they can and should move "beyond the quality revolution" as have the Japanese, in order to meet the competitive challenge they present, and to adapt to the opportunities of the 21st century.

The Europeans are clearly building a factory of the future that is capable of "doing new things" in a borderless Europe. They are taking the most risks by investing in those activities which have had either low payoff for them historically, such as computer integrated manufacturing (CIM), or other activities which are new to them. The question is whether they can be successful while defending against the Americans and the Japanese. Are the fundamental aims of their factories of the future ambitious enough even if they do succeed in building the borderless factory? The quality priorities of the Europeans are very similar to those of the Americans, but if their quality is merely equivalent, and their prices are not competitive, they will lose. Their current strategy also leaves them vulnerable to the design/development strategy of the Japanese.

The Japanese portfolio of action plans is intermediate in risk in comparison to the Americans and Europeans. They are attempting to do some new things, and some things that have not paid off well for them in the past. At the same time that they are focused on doing the same old thing better— process development. They are also hedging their bets by moving large parts of their industrial base to America and Europe, while they learn how to do the new things at home.

Each factory of the future represents a viable option for competitors within the region. However, there are risks associated with adopting each version. Moreover, we see

that competitors holding each separate vision will influence each other over time as they already have. The end result at some distant time in the future may be a unified vision of the factory of the future.

Definitions for
1990 Manufacturing Futures Survey

Activity Based Costing: The use of cost accounting tools which attempt to allocate indirect or overhead costs on the basis of related activities rather than using surrogate allocation bases such as direct labor or machine hours, floor space, or material costs.

After Sale Service: Service provided after the sale such as repair or warranty service, customer problem solving, or follow-up to ensure the customer is satisfied.

CAD: Computer Aided Design. The use of computers in interactive engineering drawing and the storage and retrieval of designs.

CAM: Computer Aided Manufacturing. The use of computers to program, direct and control production equipment.

Design for Manufacture: A general approach to designing products which can be more effectively manufactured. Often used in conjunction with data bases. Includes such concepts as design for assembly, design for servicability, or design for test.

Direct Labor: Labor expended in directly adding value to the product. Often called "touch" labor since direct-labor employees usually physically touch the product or its parts

High Performance Products: Products with clearly superior attributes such as taste, styling, speed, comfort, capacity, etc..

Indirect Labor: Any labor, including supervision and management, that is not direct labor. Overhead activities such as material handling, stockroom, inspection, manufacturing engineering, maintenance, supervision, cost accounting, personnel, etc. are usually included.

Interfunctional Communication: Communications and understandings between manufacturing and other functional areas in a business. For example, between manufacturing and marketing, or manufacturing and finance.

Just In Time: Applies both to a philosophy of eliminating waste, and to a toolset for pacing and controlling production and vendor deliveries on time, with short notice, and with little or no inventory.

Manufacturing Lead Time: The cumulative time from the beginning of the production cycle until an item is finally finished. Time spent in inventory as work in process, setup times, move times, inspection, and order preparation time are included.

Manufacturing Overhead Costs: The manufacturing overhead costs that are allocated to unit product costs. It includes the cost of indirect labor as well as

indirect purchased services and supplies. It excludes unallocated period costs such as sales and marketing, R&D, etc..

Procurement Lead Time: The cumulative time from the beginning of the procurement order cycle (order commitment) until the procured item is delivered. Includes vendor lead time, transportation, receiving and inspection time.

Product Amenities: Extra product features that enhance the basic product and make it easier to use or more enjoyable. For example, a car radio.

Product Support: Activities which support the customer in the use of a product, such as customer education, information about related products or services, information hotlines, etc..

Quality Circles: The use of teams of employees to diagnose and solve quality problems. Also includes the use of the work team concept for solving other problems related to productivity improvement, safety, etc..

Quality Function Deployment: A set of techniques for determining and communicating customer needs and translating them into product and service design specifications and manufacturing methods.

Statistical Quality Control: The use of statistical techniques for process control or product inspection. Also includes the use of experimental design techniques for process improvement.

Value Analysis: A systematic approach to simplification and standardization of products so that they provide needed value at minimum cost. Usually applied to existing products to reduce part-counts and simplify designs.

The International Manufacturing Futures Survey

This report is based on the joint research of faculty at the following institutions. Details on survey findings in the U.S., Europe, and Japan can be acquired by contacting the appropriate institution.

Boston University

Boston University is the fifth largest private university in the United States. The Manufacturing Roundtable, a consortium of 14 leading manufacturers and the Boston University School of Management have sponsored the Manufacturing Futures Survey in the U.S. since its inception. For further information, or for a copy of the 1990 U.S. Manufacturing Futures Survey Report entitled, "Beyond the Quality Revolution," contact the Boston University Manufacturing Roundtable
621 Commonwealth Ave., Boston, MA. 02215.
Tel: 617/353-5077.

INSEAD

INSEAD, the European Institute for Business Administration, was recently recognized by *Fortune* magazine as the leading International Business School in Europe. Its Management of Technology and Innovation Program has sponsored the European Manufacturing Futures Survey since 1983. For further information, or for a copy of the 1990 European Manufacturing Futures Survey Report entitled, "Removing the Barriers In Manufacturing,"
contact INSEAD
Boulevard de Constance, F-77305 Fontainebleau Cedex, France.
Tel: (1) 60 72 40 00.

Waseda University

Waseda University, one of the leading private universities in Japan, was founded to uphold the independence of learning and to promote the practical utilization of knowledge. Its Systems Science Institute was founded as the Institute for Research in Productivity in 1956, and has sponsored the Japanese Manufacturing Futures Project since 1983. For further information, or for a copy of the 1990 Japan Manufacturing Futures Survey Report contact the Waseda University Systems Science Institute
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90/25 FIN/EP	Lars Tyge NIELSEN	"Existence of Equilibrium in CAPM", January 1990.
90/26 OB/BP	Charles KADUSHIN and Michael BRIMM	"Why networking Fails: Double Binds and the Limitations of Shadow Networks", February 1990.
90/27 TM	Abbas FOROUGHI and Tawfik JELASSI	"NSS Solutions to Major Negotiation Stumbling Blocks", February 1990.
90/28 TM	Arnoud DE MEYER	"The Manufacturing Contribution to Innovation", February 1990.

90/29 FIN/AC	Nathalie DIERKENS	**"A Discussion of Correct Measures of Information Asymmetry"**, January 1990.
90/30 FIN/EP	Lars Tyge NIELSEN	**"The Expected Utility of Portfolios of Assets"**, March 1990.
90/31 MKT/EP	David GAUTSCHI and Roger BETANCOURT	**"What Determines U.S. Retail Margins?"**, February 1990.
90/32 SM	Srinivasan BALAK-RISHNAN and Mitchell KOZA	**"Information Asymmetry, Adverse Selection and Joint-Ventures: Theory and Evidence"**, Revised, January 1990.
90/33 OB	Caren SIEHL, David BOWEN and Christine PEARSON	**"The Role of Rites of Integration in Service Delivery"**, March 1990.
90/34 FIN/EP	Jean DERMINE	**"The Gains from European Banking Integration, a Call for a Pro-Active Competition Policy"**, April 1990.
90/35 EP	Jae Won PARK	**"Changing Uncertainty and the Time-Varying Risk Premia in the Term Structure of Nominal Interest Rates"**, December 1988, Revised March 1990.
90/36 TM	Arnoud DE MEYER	**"An Empirical Investigation of Manufacturing Strategies in European Industry"**, April 1990.
90/37 TM/OB/SM	William CATS-BARIL	**"Executive Information Systems: Developing an Approach to Open the Possibles"**, April 1990.
90/38 MKT	Wilfried VANHONACKER	**"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models"**, (Revised February 1990).
90/39 TM	Louis LE BLANC and Tawfik JELASSI	**"An Evaluation and Selection Methodology for Expert System Shells"**, May 1990.
90/40 OB	Manfred KETS DE VRIES	**"Leaders on the Couch: The case of Roberto Calvi"**, April 1990.
90/41 FIN/EP	Gabriel HAWAWINI, Itzhak SWARY and Ik HWAN JANG	**"Capital Market Reaction to the Announcement of Interstate Banking Legislation"**, March 1990.
90/42 MKT	Joel STECKEL and Wilfried VANHONACKER	**"Cross-Validating Regression Models in Marketing Research"**, (Revised April 1990).
90/43 FIN	Robert KORAJCZYK and Claude VIALLET	**"Equity Risk Premia and the Pricing of Foreign Exchange Risk"**, May 1990.
90/44 OB	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Organisational Change and Cultural Realities: Franco-American Contrasts"**, April 1990.
90/45 TM	Soumitra DUTTA and Piero BONISSONE	**"Integrating Case Based and Rule Based Reasoning: The Possibilistic Connection"**, May 1990.
90/46 TM	Spyros MAKRIDAKIS and Michèle HIBON	**"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy"**.
90/47 MKT	Lydia PRICE and Wilfried VANHONACKER	**"Improper Sampling in Natural Experiments: Limitations on the Use of Meta-Analysis Results in Bayesian Updating"**, Revised May 1990.
90/48 EP	Jae WON PARK	**"The Information in the Term Structure of Interest Rates: Out-of-Sample Forecasting Performance"**, June 1990.
90/49 TM	Soumitra DUTTA	**"Approximate Reasoning by Analogy to Answer Null Queries"**, June 1990.
90/50 EP	Daniel COHEN and Charles WYPLOSZ	**"Price and Trade Effects of Exchange Rates Fluctuations and the Design of Policy Coordination"**, April 1990.

90/51 EP	Michael BURDA and Charles WYPLOSZ	"Gross Labour Market Flows in Europe: Some Stylized Facts", June 1990.
90/52 FIN	Lars Tyge NIELSEN	"The Utility of Infinite Menus", June 1990.
90/53 EP	Michael Burda	"The Consequences of German Economic and Monetary Union", June 1990.
90/54 EP	Damien NEVEN and Colin MEYER	"European Financial Regulation: A Framework for Policy Analysis", (Revised May 1990).
90/55 EP	Michael BURDA and Stefan GERLACH	"Intertemporal Prices and the US Trade Balance", (Revised July 1990).
90/56 EP	Damien NEVEN and Lars-Hendrik RÖLLER	"The Structure and Determinants of East-West Trade: A Preliminary Analysis of the Manufacturing Sector", July 1990
90/57 FIN/EP/ TM	Lars Tyge NIELSEN	Common Knowledge of a Multivariate Aggregate Statistic", July 1990
90/58 FIN/EP/TM	Lars Tyge NIELSEN	"Common Knowledge of Price and Expected Cost in an Oligopolistic Market", August 1990
90/59 FIN	Jean DERMINE and Lars-Hendrik RÖLLER	"Economies of Scale and Scope in the French Mutual Funds (SICAV) Industry", August 1990
90/60 TM	Peri IZ and Tawfik JELASSI	"An Interactive Group Decision Aid for Multiobjective Problems: An Empirical Assessment", September 1990
90/61 TM	Pankaj CHANDRA and Mihkel TOMBAK	"Models for the Evlauation of Manufacturing Flexibility", August 1990
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90/65 EP	Charles WYPLOSZ	"A Note on the Real Exchange Rate Effect of German Unification", August 1990
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90/67 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Integrating Prior Cases and Expert Knowledge In a Mergers and Acquisitions Reasoning System", September 1990
90/68 TM/SE	Soumitra DUTTA	"A Framework and Methodology for Enhancing the Business Impact of Artificial Intelligence Applications", September 1990
90/69 TM	Soumitra DUTTA	"A Model for Temporal Reasoning in Medical Expert Systems", September 1990
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90/75 MKT	Roger BETANCOURT and David GAUTSCHI	"The Outputs of Retail Activities: Concepts, Measurement and Evidence", October 1990
90/76 MKT	Wilfried VANHONACKER	"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models", Revised October 1990
90/77 MKT	Wilfried VANHONACKER	"Testing the Koyck Scheme of Sales Response to Advertising: An Aggregation-Independent Autocorrelation Test", October 1990
90/78 EP	Michael BURDA and Stefan GERLACH	"Exchange Rate Dynamics and Currency Unification: The Ostmark - DM Rate", October 1990
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90/80 TM	Anil GABA and Robert WINKLER	"Using Survey Data in Inferences about Purchase Behaviour", October 1990
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90/87 FIN/EP	Lars Tyge NIELSEN	"Existence of Equilibrium in CAPM: Further Results", December 1990
90/88 OB/MKT	Susan C. SCHNEIDER and Reinhard ANGELMAR	"Cognition in Organisational Analysis: Who's Minding the Store?" Revised, December 1990
90/89 OB	Manfred F.R. KETS DE VRIES	"The CEO Who Couldn't Talk Straight and Other Tales from the Board Room," December 1990
90/90 MKT	Philip PARKER	"Price Elasticity Dynamics over the Adoption Lifecycle: An Empirical Study," December 1990

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91/01 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research Can Do More for Managers Than They Think!," January 1991
91/02 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research and Environment," January 1991
91/03 FIN	Pekka HIETALA and Timo LÖYTTYNIEMI	"An Implicit Dividend Increase in Rights Issues: Theory and Evidence," January 1991
91/04 FIN	Lars Tyge NIELSEN	"Two-Fund Separation, Factor Structure and Robustness," January 1991
91/05 OB	Susan SCHNEIDER	"Managing Boundaries in Organisations," January 1991
91/06 OB	Manfred KETS DE VRIES, Danny MILLER and Alain NOEL	"Understanding the Leader-Strategy Interface: Application of the Strategic Relationship Interview Method," January 1990 (89/11, revised April 1990)

91/07 EP	Olivier CADOT	**"Lending to Insolvent Countries: A Paradoxical Story,"** January 1991
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