"HOW GREEN IS YOUR MANUFACTURING STRATEGY?"

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How Green Is Your Manufacturing Strategy?

(Exploring the impact of environmental issues on manufacturing strategy)

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Abstract

In this paper, we illustrate the impact of environmental issues on manufacturing strategy. We use a well-known framework for manufacturing strategy, and show, by means of examples, that environmental issues may significantly affect each component of that framework. We conclude that all levels within manufacturing management will soon be confronted with environmental issues and that these issues are sufficiently important to be taken seriously. We suggest a simple framework to distinguish between various ways of responding to environmental issues. The main goal of this article is to create a certain extent of awareness.

1 Introduction

In this article we use a simple framework with which we show how the factor "environment" can be integrated in existing manufacturing strategy literature. The framework is only intended as an illustration, and does not pretend to be complete or better than others.

Let the strategy process of a firm begin with an *industry analysis*, e.g. using an approach as developed by Porter (1980). He distinguishes 5 competitive forces: buyers' and suppliers' bargaining power, threat of new entrants and substitutes, and internal rivalry in the industry. An industry analysis enables the firm to formulate a *business strategy*, with which it expects to be able to confront the competitive forces as well as possible. Porter distinguishes competition on the basis of price or differentiation, both either industrywide or for a specific market segment. The business strategy is then translated into 5 specific *competitive priorities* (Skinner, 1969; Hill, 1989):

- *cost,*
- *quality,*
- *dependability,*
- *flexibility,*
- *innovation.*

While each of these competitive priorities is important for long-term survival and growth of a firm, it is not considered possible to compete successfully on all five dimensions simultaneously. In general, firms will choose to focus on a specific market segment by assigning different weights to each of the competitive priorities. These weights then represent the firm's *manufacturing mission*, defining the task which manufacturing must fulfill. Manufacturing must then develop a *manufacturing strategy* which is consistent with the given relative ranking of the competitive priorities. This requires making decisions with respect to a number of structural and infrastructural decision areas (Hayes & Wheelwright, 1984; Hayes, Wheelwright & Clark, 1988). The *structural decision areas*, the so-called "hardware" of a firm, are:

- *aggregate capacity strategy* (total capacity, utilisation, follow or lead demand);
- *facilities strategy* (number of plants, size of plants, location of plants, focus of plants);

- *technology strategy* (degree of automation, flexibility, product design);
- *vertical integration strategy* (make or buy decisions, supplier control, buyer control, relation between vertically linked stages).

The *infrastuctural components*, the so-called "software" of a firm are:

- *human resource management* (management selection policies, management training policies, worker training, reward systems);
- *quality assurance and control systems* (choosing quality levels, process design and control to assure quality);
- *production planning and inventory control systems* (demand forecasting, assigning production to facilities/processes, production scheduling, order policies, size and location of inventories);
- *information management*;
- *performance measurement and capital allocation systems* (what to measure, setting standards and goals, investment policies);
- *organisational structure and design.*

The above is briefly summarised in Figure 1. Hayes & Wheelwright (1984) distinguish 4 stages of interaction between manufacturing strategy and business strategy: "Stage 1", where manufacturing does nothing more than meet minimum requirements; "Stage 2", manufacturing is not doing any worse than the competition; "Stage 3", manufacturing supports business strategy; and "Stage 4", where manufacturing leads to a competitive advantage. The above, simplified discussion does of course not represent a comprehensive review of manufacturing strategy literature, but it is sufficient for our purposes.

The literature on environmental issues is growing at an exponential rate. It demonstrates the seriousness of the present environmental situation, and shows how much worse things can become if environmental concerns are not taken into consideration in all aspects of life: at home, in government, and in industry. An International Labour Office (1990) report states that in the Netherlands the cost of air pollution is estimated at 2% of GNP; "environmental costs" are estimated to be as high as 2% of sales for some sectors of Dutch industry. A report by the Dutch

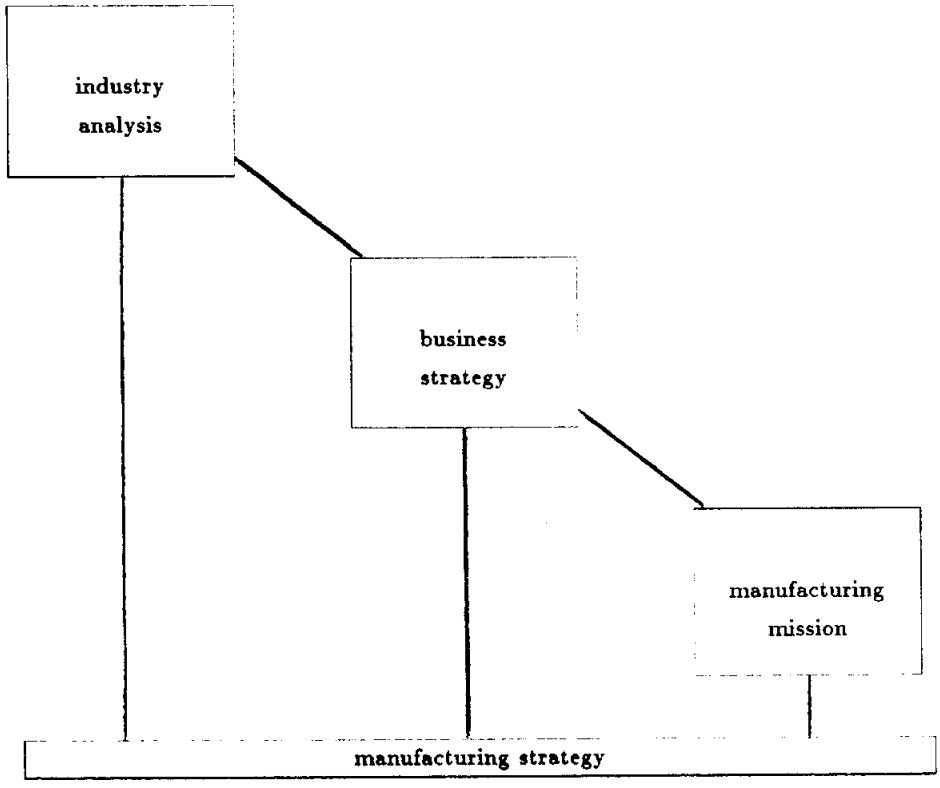

Figure 1: Strategic framework

Institute for Health and Environment (RIVM, 1988) discusses the consequences of a collection of suggested measures in the Netherlands. E.g., the current policy with respect to CFCs will lead to the ozone layer becoming 5 to 10% thinner, resulting in 4 to 15% more fatal cases of skin cancer; even this policy will cost approximately $f270$ million per year already in 2010. The number of houses suffering from bad smells caused by nearby industry will rise from 1,0 million in 1985 to 1,1 million in 2010; the measures to be taken by metal, chemical, and food industries and in cattle sheds in or surrounding built-up areas, to prevent this number from rising further, cost $f25$ million in 1990, and $f260$ million in 2010. Reducing emissions into water will cost over $f2500$ million per year in 2010 under the current policy. The report by the Brundtland Commission *Our*

Common Future (World Commission on Environment and Development (WCED), 1987) estimates the cost of soil cleaning in the Netherlands to be *f*3000 million. Environmental awareness among consumers is also strongly on the rise: a survey in the USA shows that 27% of consumers has already boycotted a product due to the environmentally unfriendly image of the producer (Levin, 1990), and in Europe "green consumerism" has already developed considerably further (Stuller, 1990).

Surprisingly, environmental issues are very rarely considered in manufacturing literature. We consider this a serious omission, and this paper aims to demonstrate why.[1] To do so, we will revisit the manufacturing strategy framework discussed above, and review the competitive priorities (Section 2) as well as the structural and infrastructural components (Sections 3 and 4 respectively) of manufacturing strategy in the context of environmental issues. Finally, in Section 5, some of the examples are placed in a strategic framework, and some possible reaction patterns are discussed. Note that "environment" cannot be considered in isolation from health and safety, which is illustrated by the widespread existence of "health, safety and environment managers". Many of the issues discussed in this article also apply to problems such as using animals in product development, bioindustry, or other problems where ethical factors occur.

2 Environmental issues and competitive priorities

In this section we review the five competitive priorities (cost, quality, dependability, flexibility and innovativeness) in the context of environmental issues. Many of the examples discussed here naturally apply also to structural and infrastructural decision areas of manufacturing strategy.

The *cost* of environmental aspects of manufacturing is perhaps one of the first issues that comes to mind. However, a great deal of misunderstanding exists in this field, as many firms automatically equate protection of the environment or pollution prevention with cost increases. Consider, for example, CFCs: considerably cheaper than replacements less damaging to the ozone layer found

[1] By starting the *Management of Environmental Resources* Programme, INSEAD has decided to give priority to research into the impact of environmental issues on business. In this context the authors of this article are performing theoretical and applied research into the ways in which environmental regulation affects manufacturing decisions. They are primarily interested in modelling the effects illustrated by the examples in this article.

so far. This has a large impact on the cost of blown foams, as CFCs account for 20% of the raw material costs. By contrast, a refrigerator costing $800 might contain only half a pound of CFC's, costing $0.60 per pound (National Wildlife Foundation, 1989).

There are firms that have achieved a cost reduction due to an improvement in their environmental performance, e.g. by recycling waste or recovering energy. The slogan *Pollution Prevention Pays* (first introduced by 3M) and the *Zero Waste* concept had already been adopted in some businesses. The *zero waste* concept is derived from an existing, highly successful concept: that of zero defects. Although it is practically impossible to produce with no defects at all, zero defects has proved to be a target well worth aiming at. This form of total quality control involves a high degree of control of the entire production process and strongly reduces the number of defective products coming out of the process, and is often cited as one of the main reasons for the success of Japanese manufacturers. Zero waste is a similar concept: it is generally not possible to eliminate all waste. However, a process causing less waste clearly uses fewer raw materials, and in practice low waste and high quality frequently go hand in hand. Already in 1984 Japanese firms used 40% less raw materials per unit industrial production than in 1973 (WCED, 1987).

Because firms generally introduce the cheapest environmental protection measures first, they will find it increasingly difficult to make pollution prevention pay, even though further reduction of pollution is needed to achieve sustainable development. By introducing pollution taxes governments provide a more lasting incentive to introduce cleaner technologies. The duties on waste water have reduced industrial use of water by 85% on average between 1970 and 1985 (RIVM, 1988). Higher duties, such as the increase of the duty on petrol on July 6, 1991 in the Netherlands, have consequences for international competitive relations, but need not mean a deterioration of competitiveness. The possibly coming EEC legislation on CO_2-producing fuel will seriously undermine competitiveness in the European steel industry. On the other hand, strict environmental legislation and a high degree of environmental awareness in Sweden and Germany have forced innovation, so that their industries lead the world in environmental products and services (Porter, 1990).

Increased pollution liability has sometimes led to firms paying huge sums of money: Union Carbide, e.g., paid at least $200 million after the Bhopal disaster (Case Research Association, 1985). Exxon has already spent $2 billion cleaning up the Alaskan oil spill, which has led many American

shipowners to raise their liability insurance from around $100 million to $750 million or so. The difficulty of finding insurers to cover pollution risks of over $1 billion has already led Shell to cease shipping oil to many American ports (The Economist, 8 Sep. 1990; p. 15). Even more terrifying has been the impact of the "Superfund" legislation, introduced in the USA to tackle the problem of toxic-waste sites (see, e.g., Bloom & Scott Morton (1991)). Under this act, liability for the costs of cleaning up toxic-waste sites may fall on almost anybody, sometimes even including the bankers of the firm that deposited the waste. Moreover, this liability is "strict", that is, regardless of fault or negligence on the part of the firm. It is also "joint and several", which means that the government can pick on any single firm and require it to pay all cleanup costs, regardless of the amount of waste that particular firm actually dumped; that firm then has the right to sue other firms involved to achieve a "fair" division of the costs. In addition, the law is retroactive, so that companies can be held liable for dumping that was perfectly legal at the time when it occurred (The Economist, 8 Sep. 1990; p. 15).

The next competitive dimension is *quality*. The importance of quality as an essential competitive priority is frequently recognised by firms; for this reason it would be beneficial to incorporate environmental issues into quality. This is enabled by using the definition of quality recently proposed by Taguchi (1986; p. 1): *quality is about minimising the loss a product causes to society after being shipped, other than any losses caused by its intrinsic functions.* What is new here is that societal loss is explicitly considered as a quality problem. Taguchi restricts loss to two classes: loss caused by variability of function (when a product does not perform as well as it should, like clothes losing their colour after being washed), and loss caused by harmful side effects (e.g. in medicine, an excellent sedative can sometimes produce terrible side-effects). Not all loss is considered a quality problem: the problems caused by drunks are not due to a quality problem in alcohol, but to the ethical choice made by society in allowing the use of alcohol. Bread knives are another example of this: they are intended for slicing bread, and the fact that they can be used as lethal weapons does not affect their quality. Reconsider the CFC example: making holes in the ozone layer is not the primary function of CFC's but an inevitable consequence of their use, therefore, according to Taguchi, this is a harmful side effect and hence a quality problem. Automobiles are another example: when their economic life is over, their life as waste begins. The huge scrapyards seen everywhere clearly illustrate that in this respect all cars are of extremely poor quality. The difference between alcohol and knives on the one hand and CFC's and cars on

the other is that the first only become damaging through abuse by human beings, whereas the other two are inherently damaging. By considering environmental concerns as part of the quality of a product, one can use the existing and accepted infrastructure in many firms which is geared at improving quality. People who improve quality are rewarded, so adopting Taguchi's definition allows them to also be rewarded for improving a product's environmental performance.

A new concept being introduced in industry is that of "*design for disposability*", which carries an existing concept a step further: design for manufacturability involves designing products in such a way that they are easy to manufacture; this concept was introduced to prevent firms from being unable to economically manufacture the products which the research and development department had designed. As firms will be required to dispose of their own products themselves, they should now also incorporate disposability into the design of their products. The German car manufacturer BMW has recently set up a research centre, in cooperation with other manufacturers, to study design for disposability. Existing examples are coffee cups made of edible paper and easily degradable hamburger containers. In fact, as Prof. D. Huisingh of the Erasmus Studiecentrum voor Milieukunde has remarked, a better expression would be *design for reusability*, reflecting that reuse of products is more desirable than disposal.

On an entirely different level, being environmentally sound can be part of performance quality and perceived quality (two of the eight dimensions of quality distinguished by Garvin (1987)) of a product, thereby enhancing its value to consumers. This brings us to the subject of *green marketing*. It is not yet clear whether and when a higher price can be charged for green products. Consumers are then asked to pay for a public good: a cleaner environment. They will only do this if the specific product only accounts for a small part of their total budget; this is the reason why unleaded petrol is not popular if there is no price advantage, even though it is cleaner than leaded petrol, when used in combination with a catalytic converter. Use of green marketing also can have adverse effects, particularly through the extra attention and scrutiny it causes: Procter & Gamble introduced a concentrated form of the popular laundry detergent Ariel Ultra, claiming that this would lead to less washing powder and less packaging ending up in the environment. A British newspaper rewarded this by carrying the headline "Animals Die for Green Soapsuds", maintaining that animal testing had been used during the development of the product (Rolfes, 1990).

To remedy the confusion caused among consumers by green marketing, governments are increasingly introducing *eco-labelling* schemes. The West German scheme has been the prototype; various other European governments are considering introduction of a similar scheme, as is the European Commission. These schemes are to be much more advanced than simply labelling an aerosol as CFC-free. The schemes presently being developed will probably take the "cradle-to-grave" approach, so that the entire life of a product (from its manufacturing cradle via its life with the consumer to its waste grave) will be considered when awarding green labels. (To emphasise the desirability of reuse Huisingh prefers the expression "from preconception to reincarnation" over "cradle to grave".)

Dependability represents the ability of a firm to deliver the right product to the right place at the agreed time. This dependability can be endangered by environmental circumstances. A concentration of heavy industry can often be found in strategically attractive locations, so that the air pollution in such areas sometimes reaches such worrying levels that local authorities order temporary closedown of local heavy industry. Unless the firms have large and costly (and sometimes hazardous) inventories, such partial or complete closing down of plants may seriously affect dependability. Firms using a Just-In-Time system will particularly suffer in this case. Other firms may also be paralysed via a ripple effect. An isolated location may therefore be much more attractive as a site for a new plant than was generally considered before.

Another way in which dependability can be endangered is due to varying quality of environmental inputs. Some firms rely on water from the local river for use in their process, but if that water itself is occasionally polluted they will find themselves confronted with an uncontrollable source of variability. Trucks belonging to a transport company with a poor safety reputation will be more frequently stopped and checked by police: another source of unreliability. The increasing public awareness and fear of the potential dangers of toxic substances (Erikson, 1990) may well cause shutdowns to be ordered much more frequently by authorities if the firm does not permanently improve its safety management.

Flexibility comes in many forms. Let us consider the flexibility to change over between products on the same line, i.e. similar but not identical products. An example could be a product which is sold in different colours, where changing over from one colour to another involves thoroughly cleaning the machines to remove all traces of the previous colour. Every time a changeover occurs, large

quantities of paint and detergents may be lost. Another form of flexibility is volume flexibility, the ability to quickly react to changes in quantities. This can be achieved by providing excess capacity, thereby reducing average capacity utilisation. However, many of the costs involved in using capacity do not depend on the utilisation rate; a conveyor belt consumes the same amount of energy whether it is transporting 10 or 100 bottles a minute. The whole plant needs to be lighted and heated, regardless of capacity utilisation. There are many examples of manufacturing and service companies with large excess capacities in order to be able to cope with peak periods.

The last competitive priority is *innovation*, which can be slowed down by increasingly strict environmental legislation. In the pesticide market, for example, it can take up to 10 years for a new pesticide to be approved (Rich, 1988). Considering that a patent for a new pesticide expires after some 20 years, we see that by the time a new pesticide enters the market, half of its economically interesting life for the inventing firm has passed. Innovation can also be stimulated by environmental concerns, e.g. in the form of introducing new, environmentally sound products to replace polluting products. This is presently happening in the pesticide market, where huge sums of money are being spent on research to find biological replacements for the current chemically based pesticides. Simultaneously, researchers are working on genetic engineering, with the intention of changing the characteristics of crops and making them more resistant to all kinds of diseases, thereby reducing the need for pesticides. The replacements for CFCs mentioned above are another example, as is the development of lean-burn engines for automobiles. In the chemical industry, where products are often inherently environmentally damaging, innovation into environmentally safe products is recognised as essential for competitive success, thereby justifying the often huge costs of developing such products.

There is also another side to the innovation story. Rapidly introducing new products or replacing old ones is becoming a new source of competitive advantage (Stalk, 1988); product life cycles are continuously shrinking. Consumers replace products long before their economic life is over; refrigerators, washing machines, hifi equipment etc. are often replaced just because a newly introduced product has some relatively small additional features, not because they no longer function properly.

3 Environmental issues and structural manufacturing strategy components

Here we illustrate the influence of environmental issues on the structural manufacturing strategy components mentioned in the Introduction.

For an extreme example of the impact of the environmental concern on *aggregate capacity* decisions, let us reconsider the CFC example. In 1978, the Environmental Protection Agency in the USA banned certain "non-essential" uses of CFC's, such as aerosol uses. This caused several firms to either leave the market altogether or to rationalise their CFC manufacturing operations by closing plants. In the pesticide market, many products are only sold during a relatively short period each year, leaving manufacturers no choice but to lead demand and build inventories over the year to cope with the sudden peak in demand. This implies keeping large inventories of pesticides. It is continuously becoming more costly to meet the increasingly tight safety regulations for such large inventories of hazardous products. A trade-off must be made here between the size of the capacity and the amount of inventory: with sufficient capacity, the need for inventories would no longer exist, but this capacity would only be used a few weeks per year.

Decisions concerning *facility location and size* are clearly influenced by environmental issues. One environmental aspect of plant location has already been noted above, in the discussion on dependability. Increasingly tight environmental standards in highly developed countries can be a reason for firms to establish their operations abroad, possibly in developing countries. A survey in the Netherlands[2] reveals that tighter environmental legislation would cause some 30% of the affected firms to seriously consider moving their manufacturing operations abroad. These firms will however find it increasingly difficult to sell their products in countries with strict environmental legislation.

Waste disposal requirements can cause economies of scale to become more pronounced. The list of chemicals, compiled by the United Nations, considered too hazardous to be transported, is constantly growing. Waste consisting of such chemicals must be disposed of at the production site. This can involve the need for costly waste disposal units; these can be so costly that spreading

[2]NRC Handelsblad, 12/9/1990

production over several plants, each with its own waste disposal unit, is no longer economically feasible. This would lead to an industry consisting of large production plants at a few carefully chosen locations.

Technology decisions have recently been affected by waste reduction and pollution prevention programs. Royston (1980) mentions numerous examples of this occurring. Dow Corning, e.g., realised a 33% annual return on investment by recovering two substances previously considered waste. By 1976, 3M had realised that the sharply rising cost of pollution control was threatening its profitability, and introduced its 3P program: "Pollution Prevention Pays". It certainly has paid: in the first nine months, 3P programs within 3M had eliminated 70,000 tons of air pollution and 500 million gallons of waste water, while saving the company over $20 million. Many other examples can be found.

Environmental standards are continually being tightened, and changes in environmental legislation are sometimes unpredictable due to the emotional element involved. This makes it important to consider possible future environmental concerns and legislation when investing in new technology now, in order to prevent having to make costly adjustments when legislation unexpectedly becomes tighter. Such tightening of legislation can also stem from an unexpected cause. Some firms already have to meet a zero emission standard for some particularly hazardous substances, but as governments continually introduce more sensitive measuring equipment, firms can find themselves suddenly breaking the law without having changed their production process when their previously undetectable emissions become detectable.

Decisions concerning *vertical integration* are nowadays viewed in an entirely different light, due to the introduction of environmental legislation. In the USA, "Superfund" holds firms retroactively liable for all environmental damage they have caused in the past, even if their activities were considered legal at the time. Taking over another firm has become a risky affair: if that firm has, at some time in the past, indulged in practices presently considered environmentally harmful, the buying firm can be held responsible for all damage following from those practices. The costs involved in cleaning up can be stupendous. On the other hand, a firm desiring to adhere to environmentalist principles will also expect its suppliers to do so, and may want to increase its control over the process used and the product made by its suppliers. Such a firm would desire a greater degree of vertical integration.

A modern alternative to vertical integration is a value-added partnership, in which buyers, suppliers and transporters cooperate closely to improve each others' competitiveness, without actually merging (Bowersox, 1990). Such firms will also have to take the environmental aspects of their partners' production processes into account. Due to a ripple effect, temporary closing down of one plant can cause several other firms to be paralysed. The extent to which buyers and suppliers work together and are legally linked may also determine the extent to which they are jointly responsible for environmental damage caused by any single firm in the value-added partnership.

4 Environmental issues and infrastructural manufacturing strategy components

Finally, we discuss each of the infrastructural manufacturing strategy components distinguished in the Introduction in the context of environmental issues.

Perhaps the most crucial part in introducing an environmentalist approach in business is *human resource management.* If the employees are not convinced and motivated to act in an environmentally sound way, the firm will never be environmentally sound either. At present, many plant managers are discouraged from taking any environmentalist action such as introducing cleaner technology, because of the reward systems in use. The plant manager is often evaluated solely in terms of the short-term profit made by the plant, while delaying introduction of environmentally sound technology may prove to be fatal to the firm in the long run. It can therefore happen that although top management is convinced of the need for an environmentalist approach to business, this need is not properly communicated to middle and lower management, preventing top management's green feelings from being turned into action. Environmental actions taken by the plant manager, such as requesting an environmental audit on his own initiative, should be incorporated into the reward system. A generally recognised point is that managers and employees will have to be trained if they are to follow environmentalist guidelines in their work. Young staff have entirely different views than 20 years ago, and are much more critical in examining their company's environmental performance (Rickelmann & Bürgi, 1989). Union Carbide has spent a large amount of effort after the Bhopal disaster to raise employee morale.

The influence of environmental issues on *quality control systems* has already been discussed under quality. Possible liability for all "loss caused to society after being shipped" means that environmental aspects must be carefully considered in defining appropriate quality levels, and that the quality control system must function properly. It may also require quality monitoring systems to extend far beyond the factory walls. This is common in e.g. the chemical industry, where *product stewardship* is part of the industry's environmental policy. This involves showing (though not actually accepting legal) responsibility for the product after it has been sold, among others by informing and training buyers in the use and handling of the product.

A *production planning and inventory control system* based on Just-In-Time is particularly vulnerable to temporary but frequent plant closures due to smog-alarms. Frequent changeovers may involve extra waste, encouraging production in large batches. An example of an environmental restriction on production is given in Bodily & Gabel (1982). They describe the situation of a steel mill in the USA (Armco's Middletown plant) in 1980. The Environmental Protection Agency had proposed that Armco install hoods and baghouses to control particulates in its blast furnaces, open-hearth furnaces, and basic oxygen furnaces. This would cost $14 million to install, and also significantly raise annual operating costs. Armco was required either to install this equipment or achieve an equivalent reduction of particulate emissions in some other way, e.g. by limiting production. Armco already used a linear programming model to find the best combination of products and processes under the constraints of a fixed production capacity so as to maximise net revenue. They now faced an additional constraint, this time on the amount of pollution they were allowed to cause. Using the linear programming model with the extra constraint on pollution revealed that installing the EPA equipment was only slightly less expensive than limiting production. Now, in 1990, the steel industry is still going to have a hard time coping with the forthcoming legislation concerning e.g. CO_2 emissions, despite their efforts so far to reduce pollution. In fact, had the "bubble policy" already been introduced at that time, Armco could have saved a lot more. The bubble policy treats entire firms as being enclosed in a bubble and allocates each firm (each bubble) a specific total pollution limit. This allows firms to decide for themselves how to cut back pollution. Armco could have decided to clean and treat roads and limit traffic, which would have led to a reduction in particulates four times as high as with EPA's hoods and baghouses at a cost of only 6% of EPA's proposals.

The direct cause of the Bhopal disaster (Case Research Association, 1985) was the presence of a large inventory of the raw material methyl isocyanate (MIC). The plant was designed in such a way that large inventories of raw materials and intermediate products were necessary, the dangers of which have now become clear. A Just-In-Time approach, which minimizes inventories at all stages of the production process, can be highly preferable for this reason. CIBA-GEIGY have reduced stocks of potentially dangerous substances, and in some cases store no more than the amount required for processing at any given time (CIBA-GEIGY, 1988).

Information management becomes even more complex with all the environmental information becoming available. All the issues discussed in this paper involve information being collected, given to the right person, processed and acted upon, generating new information in the process. For example, in process control it is important that machine operators are given the correct amount of information at the correct time. Machines can be equipped to monitor the quality of the products being produced, the same can be done for their environmental performance, checking, e.g., whether a chemical reaction is behaving normally and not about to drift out of control. A control system should try to predict when a process will get out of control (so-called condition monitoring), and not only observe after the fact. The question then is, when should the control system issue a warning? If a wide tolerance interval is chosen, the system will be too late in issueing a warning, but when the tolerance interval is too narrow, it will issue too many false warnings and not be taken seriously by the operators.

This was one of the causes of the Bhopal disaster (Case Research Association, 1985): around midnight several workers noticed that their eyes had begun to water and sting, a signal that indicated an MIC leak. The leak, a small but continuous drip, was soon found. As minor leaks were a common occurrence, the operators were still not concerned and resolved to see to the problem after the tea-break. By then, it was too late. The leak could not be stopped, and a cloud of the highly toxic MIC was already drifting towards the town of Bhopal, leaving 2,000 dead, more than 100,000 injured and forcing 500,000 (half of the town's total population) to flee. Medical personnel generally had no idea what this invisible enemy was that they were fighting due to the closed information policy Union Carbide had followed. A system of corporate risk disclosure is itself an effective risk management tool (Baram & Partan, 1990), as repeated reports of near accidents will increase public concern enough to (legally) enforce appropriate measures. In the

USA, Dow only became aware of the extent of environmental damage they were causing when forced by law to gather and publish information on pollution (Kleiner, 1991). An open information policy sets an example for other firms and leads to more credibility with authorities and pressure groups, which can be important during negotiations over future legislation. Norsk Hydro and the South African energy company ESKOM published extensive reports on their environmental performance.

How disastrous the effects of an incorrect *performance measurement* system can be is illustrated by the extremely poor environmental state of Eastern Europe. Apparently,[3] Eastern European governments had found, using "advanced econometric techniques", a fixed relationship between input and output of plants. The input used by a plant was taken as the measure of a plant's performance, as it was easier to measure than output. This provided plant managers with a very strong incentive to maximise input per unit output, leading to the highly inefficient manufacturing practices currently encountered in Eastern Europe: the amount of energy and other inputs required by an Eastern European plant per unit value of output is 2 to 3 times higher than that in the West. One way to counter such problems is by introducing internal cost accounting systems reflecting the *Polluter Pays Principle*, such as done by e.g. CIBA-GEIGY (Eigenmann, 1985).

Managers need to be aware of not only their firm's financial performance, but also its environmental performance. Financial auditing has long been used to assess a firm's economic viability. Such a financial audit consists of a detailed and comprehensive analysis of all financial aspects of a plant's operations, and is intended to provide a clear picture of how well the plant has been doing in the recent past and what resources it has to function in the future. The potentially dramatic impact of environmental legislation, some examples of which have been mentioned above, demonstrate that considering only financial aspects of a firm's operations no longer provides a complete picture of the firm's overall viability. The environmental side of a firm's operations is monitored using *environmental auditing*. A widely accepted definition of environmental auditing is given by the International Chamber of Commerce (1988):

"Environmental auditing is a management tool comprising a systematic, documented,

[3] As stated by Dr. T. Zylicz, Director of Planning in the Polish Ministry of Environmental Protection, in a lecture held at INSEAD, November 19, 1990

periodic and objective evaluation of how well environmental organisation, management and equipment are performing with the aim of helping to safeguard the environment by:

- facilitating management control of environmental practices;
- assessing compliance with company policies, which would include meeting regulatory requirements."

Controversial issues at the moment are whether environmental audits should become compulsory for firms, and whether the results of the audits should be made available to the general public. It is felt that disclosure of the results of an audit, which are currently strictly internal, would reduce the cooperation of the people whose operations are being audited. This cooperation is essential for an environmental audit to succeed.

How to evaluate the environmental impact of investments in the *capital allocation* process is a difficult question. Current accounting principles will certainly not encourage investments in environmentally sound production technologies, if there is no direct economic motive for doing so (see Kaplan, 1984), so that firms are not capable to calculate correct costs of their products and evaluate their investments properly. On the other hand, firms with a good environmental reputation have an advantage in attracting capital (ICC, 1990; p. 130). A particularly controversial aspect of capital allocation is use of a discount rate. Using a discount rate reflects the fact that a given quantity now is valued higher than that same quantity in the future. For capital, this is not unreasonable. For environmental resources, however, it could be considered highly unethical to use a discount factor, as this would mean that the present generation do not find it necessary to leave behind the same amount of environmental resources as they were given by their predecessors. It will by no means be easy to incorporate environmental resources in a firm's accounting system. If it is not done, however, firms will not be able to price their products and evaluate investments correctly.

Finally, the *organisational structure* must be designed in such a way that environmental issues are firmly built into the firm. This requires creating environmental awareness in all employees, but this alone is not enough. An expert in the field of environmental auditing illustrated this, with the example of a firm for which he had performed an environmental audit. The firm had

a number of tanks containing some hazardous chemical, which should have been inspected on a regular basis. This was recognised by top management, who considered it the responsibility of the department using the chemical. That department realised that inspections were necessary, but held the opinion that the site engineering department was responsible. They, in turn, held the purchasing department who had bought the tanks responsible for keeping them up. Purchasing also realised the need for inspections, but thought that the suppliers would carry them out. During the environmental audit, the contracts concerning the purchase of the tanks were studied, and the suppliers were found not to be responsible for the tanks. Having observed this, the tanks were inspected and indeed found to be leaking. This illustrates that awareness alone is not sufficient; environmental responsibility must be built into the firm's organisational structure.

Another firm got itself into serious organisational trouble by changing its organisational structure. The firm produced several kinds of beverage containers for all Western European countries: aluminium, glass, tin, plastic, PVC, and others. The firm had traditionally been organised by country. Just as various European countries started introducing different laws on disposability of beverage containers and return systems, the firm reorganised itself by container material, creating separate divisions for glass containers, for aluminium containers, etc. As each country was contemplating different kinds of legislation, the "glass manager" found himself fighting the "plastic manager" as they now had highly conflicting interests. While "glass" was advocating a compulsory return system, "plastic" was pointing out the immense logistical problems involved with such a system, while yet another division was telling everybody how much better it would be to use an environmentally friendly one-way container...

5 Strategic framework

Let us return to the strategic framework outlined in the Introduction and see how the factor "environment" fits in.

In an *industry analysis*, environmental forces can come from three sources: through legislation, the market, and from internal pressure in the firm. Examples of pressure through *legislation* are taxes and limits on emissions, gradual abolition of CFCs, liability legislation such as Superfund,

stricter requirements for storage of hazardous goods, and enforced publishing of environmental data. *Market forces* come into action when buyers demand CFC-free products, even before CFCs are actually banned, a situation described by Boons (1991). These market forces are comparable to Porter's (1980) 5 competitive forces. *Internal pressure in a firm* causes the firm to go further than required by law or demanded by the market, such as DuPont does with their internal safety standards. Mintzberg (1989) calls such a gradual establishment of behavioural patterns "emergent strategy". Pressure groups are no force in themselves, but operate through one of the three ways mentioned above.

Following this line, firms can integrate environment in their manufacturing strategy in three ways: adopting a follower strategy, a market-oriented strategy, or by turning environmental performance into a key factor. A *follower strategy* involves complying with all legal requirements and is comparable to Hayes & Wheelwright's (1984) "Stage 1" and "Stage 2". In a *market-oriented strategy* market considerations (of a relatively short-term nature) dominate; environment is subordinate to but supports the fulfilling of the business strategy, as in "Stage 3". When *environment is seen as a key factor*, it becomes a fully integrated part of business strategy, as in "Stage 4". A fourth strategy, which we do not discuss here, could be an evasive or non-compliance strategy.

In Table 1 we show what each of these three strategies could mean for the examples just mentioned.

6 Conclusion

We have seen that environmental issues affect all possible aspects of manufacturing strategy in some way or another. In Table 1 we have distinguished three response patterns. None of these three patterns is superior under all circumstances; further research, both conceptual and empirical, is needed in order to better understand each of the three strategies with their advantages and disadvantages. It is of course possible that for a specific firm a mix of response patterns is the best choice, e.g., a highly proactive strategy focussing on environment as key factor in much publicised, sensitive issues, and a follower strategy in less visible situations.

With this paper, we hope to have created some awareness, both among managers and academics, of the challenges posed by the environment.

example	follower strategy	market-oriented strategy	environment as key factor
taxes and limits	pay taxes, meet requirements	reduce emissions if this improves sales or reduces cost	*zero waste*: less sensitive to stricter legislation, better negotiation position
quality, e.g. CFC problem	only stop producing CFCs when legally required	replace CFCs or develop concentrated laundry detergent if buyers demand that	integrate environment and quality; *design for disposability*; be the first to develop substitutes for CFCs in order to establish standards
vertical integration	cooperate with anyone	only cooperate with firms with a good environmental reputation	cooperation or takeover only after *environmental audit* of the candidate
human resource management	do nothing special	do nothing more than needed to prevent surprises	include environmental awareness as factor in training and selection; this facilitates attracting new employees
production planning and inventory control	ensure that storage facilities meet requirements	let storage facilities meet internal, possibly stricter requirements, but let customer service dominate	eliminate hazardous stocks by changing to JIT production
disclosure	disclose no more than required	disclose extra information selectively if that will help sales	full or nearly full disclosure to create internal pressure and external credibility

Table 1: Examples of strategies for environmental problems

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90/21 FIN	Roy SMITH and Ingo WALTER	"Reconfiguration of the Global Securities Industry in the 1990's", February 1990.
90/22 FIN	Ingo WALTER	"European Financial Integration and Its Implications for the United States", February 1990.
90/23 EP/SM	Damien NEVEN	"EEC Integration towards 1992: Some Distributional Aspects", Revised December 1989
90/24 FIN/EP	Lars Tyge NIELSEN	"Positive Prices in CAPM", January 1990.
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
90/62 EP	Damien NEVEN and Menno VAN DIJK	"Public Policy Towards TV Broadcasting in the Netherlands", August 1990
90/63 SM	Sumantra GHOSHAL and Eleanor WESTNEY	"Organising Competitor Analysis Systems", August 1990
90/64 SM	Sumantra GHOSHAL	"Internal Differentiation and Corporate Performance: Case of the Multinational Corporation", August 1990
90/65 EP	Charles WYPLOSZ	"A Note on the Real Exchange Rate Effect of German Unification", August 1990
90/66 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Computer Support for Strategic and Tactical Planning in Mergers and Acquisitions", September 1990
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
90/70 TM	Albert ANGEHRN	"'Triple C': A Visual Interactive MCDSS", September 1990
90/71 MKT	Philip PARKER and Hubert GATIGNON	"Competitive Effects in Diffusion Models: An Empirical Analysis", September 1990
90/72 TM	Enver YÜCESAN	"Analysis of Markov Chains Using Simulation Graph Models", October 1990
90/73 TM	Arnoud DE MEYER and Kasra FERDOWS	"Removing the Barriers in Manufacturing", October 1990
90/74 SM	Sumantra GHOSHAL and Nitin NOHRIA	"Requisite Complexity: Organising Headquarters-Subsidiary Relations in MNCs", October 1990

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
90/79 TM	Anil GABA	"Inferences with an Unknown Noise Level in a Bernoulli Process", October 1990
90/80 TM	Anil GABA and Robert WINKLER	"Using Survey Data in Inferences about Purchase Behaviour", October 1990
90/81 TM	Tawfik JELASSI	"Du Présent au Futur: Bilan et Orientations des Systèmes Interactifs d'Aide à la Décision," October 1990
90/82 EP	Charles WYPLOSZ	"Monetary Union and Fiscal Policy Discipline," November 1990
90/83 FIN/TM	Nathalie DIERKENS and Bernard SINCLAIR-DESGAGNE	"Information Asymmetry and Corporate Communication: Results of a Pilot Study", November 1990
90/84 MKT	Philip M. PARKER	"The Effect of Advertising on Price and Quality: The Optometric Industry Revisited," December 1990
90/85 MKT	Avijit GHOSH and Vikas TIBREWALA	"Optimal Timing and Location in Competitive Markets," November 1990
90/86 EP/TM	Olivier CADOT and Bernard SINCLAIR-DESGAGNE	"Prudence and Success in Politics," November 1990
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
91/08 EP	Charles WYPLOSZ	"Post-Reform East and West: Capital Accumulation and the Labour Mobility Constraint," January 1991
91/09 TM	Spyros MAKRIDAKIS	"What can we Learn from Failure?", February 1991
91/10 TM	Luc Van WASSENHOVE and C. N. POTTS	"Integrating Scheduling with Batching and Lot-Sizing: A Review of Algorithms and Complexity", February 1991
91/11 TM	Luc VAN WASSENHOVE et al.	"Multi-Item Lotsizing in Capacitated Multi-Stage Serial Systems", February 1991
91/12 TM	Albert ANGEHRN	"Interpretative Computer Intelligence: A Link between Users, Models and Methods in DSS", February 1991
91/13 EP	Michael BURDA	"Labor and Product Markets in Czechoslovakia and the Ex-GDR: A Twin Study", February 1991
91/14 MKT	Roger BETANCOURT and David GAUTSCHI	"The Output of Retail Activities: French Evidence", February 1991
91/15 OB	Manfred F.R. KETS DE VRIES	"Exploding the Myth about Rational Organisations and Executives", March 1991
91/16 TM	Arnoud DE MEYER and Kasra FERDOWS et.al.	"Factories of the Future: Executive Summary of the 1990 International Manufacturing Futures Survey", March 1991
91/17 TM	Dirk CATTRYSSE, Roelof KUIK, Marc SALOMON and Luk VAN WASSENHOVE	"Heuristics for the Discrete Lotsizing and Scheduling Problem with Setup Times", March 1991
91/18 TM	C.N. POTTS and Luk VAN WASSENHOVE	"Approximation Algorithms for Scheduling a Single Machine to Minimize Total Late Work", March 1991
91/19 MKT	Vikas TIBREWALA and Bruce BUCHANAN	"An Aggregate Test of Purchase Regularity", March 1991
91/20 MKT	Darius SABAVALA and Vikas TIBREWALA	"Monitoring Short-Run Changes in Purchasing Behaviour", March 1991
91/21 SM	Sumantra GHOSHAL, Harry KORINE and Gabriel SZULANSKI	"Interunit Communication within MNCs: The Influence of Formal Structure Versus Integrative Processes", April 1991
91/22 EP	David GOOD, Lars-Hendrik RÖLLER and Robin SICKLES	"EC Integration and the Structure of the Franco-American Airline Industries: Implications for Efficiency and Welfare", April 1991
91/23 TM	Spyros MAKRIDAKIS and Michèle HIBON	"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy", April 1991 (Revision of 90/46)
91/24 TM	Louis LE BLANC and Tawfik JELASSI	"An Empirical Assessment of Choice Models for Software Evaluation and Selection", May 1991
91/25 SM/TM	Luk N. VAN WASSENHOVE and Charles J. CORBETT	"Trade-Offs? What Trade-Offs?" April 1991
91/26 TM	Luk N. VAN WASSENHOVE and C.N. POTTS	"Single Machine Scheduling to Minimize Total Late Work", April 1991
91/27 FIN	Nathalie DIERKENS	"A Discussion of Correct Measures of Information Asymmetry: The Example of Myers and Majluf's Model or the Importance of the Asset Structure of the Firm", May 1991
91/28 MKT	Philip M. PARKER	"A Note on: 'Advertising and the Price and Quality of Optometric Services', June 1991
91/29 TM	Tawfik JELASSI and Abbas FOROUGHI	"An Empirical Study of an Interactive, Session-Oriented Computerised Negotiation Support System (NSS)", June 1991

91/30 MKT	Wilfried R. VANHONACKER and Lydia J. PRICE	**"Using Meta-Analysis Results in Bayesian Updating: The Empty Cell Problem"**, June 1991
91/31 FIN	Rezaul KABIR and Theo VERMAELEN	**"Insider Trading Restrictions and the Stock Market"**, June 1991
91/32 OB	Susan C. SCHNEIDER	**"Organisational Sensemaking: 1992"**, June 1991
91/33 EP	Michael C. BURDA and Michael FUNKE	**"German Trade Unions after Unification - Third Degree Wage Discriminating Monopolists?"**, June 1991
91/34 FIN	Jean DERMINE	**"The BIS Proposal for the Measurement of Interest Rate Risk, Some Pitfalls"**, June 1991
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91/36 TM	Albert ANGEHRN	**"Supporting Multicriteria Decision Making: New Perspectives and New Systems"**, August 1991
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91/40 TM	Luk VAN WASSENHOVE, Dirk CATTRYSSE and Marc SALOMON	**"A Set Partitioning Heuristic for the Generalized Assignment Problem"**, August 1991
91/41 TM	Luk VAN WASSENHOVE, M.Y. KOVALYOU and C.N. POTTS	**"A Fully Polynomial Approximation Scheme for Scheduling a Single Machine to Minimize Total Weighted Late Work"**, August 1991
91/42 TM	Rob R. WEITZ and Tawfik JELASSI	**"Solving A Multi-Criteria Allocation Problem: A Decision Support System Approach"**, August 1991
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91/45 MKT	Philip M. PARKER	**"The Effect of Advertising on Price and Quality: An Empirical Study of Eye Examinations, Sweet Lemons and Self-Deceivers"**, September 1991
91/46 MKT	Philip M. PARKER	**"Pricing Strategies in Markets with Dynamic Elasticities"**, October 1991
91/47 MKT	Philip M. PARKER	**"A Study of Price Elasticity Dynamics Using Parsimonious Replacement/Multiple Purchase Diffusion Models"**, October 1991
91/48 EP/TM	H. Landis GABEL and Bernard SINCLAIR-DESGAGNE	**"Managerial Incentives and Environmental Compliance"**, October 1991
91/49 TM	Bernard SINCLAIR-DESGAGNE	**"The First-Order Approach to Multi-Task Principal-Agent Problems"**, October 1991