"STRATEGIES FOR INTERNATIONAL MANUFACTURING"

by

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Abstract

In the literature on production and operations management, little has been written about the international aspects of the field. How a company with operations in several countries should structure its operations is a question which still, to a large extent, remains unanswered in literature. It is nevertheless an important question nowadays, as many companies become more global in their operations, and as even domestic companies are faced with global competitors.

Managers have identified the lack of an adequate manufacturing strategy as one of the main barriers to the effective management of their international manufacturing operations. How to set up and manage an effective and efficient network of plants is a key issue here.

In this we will give an overview of what we believe are key issues in the manufacturing strategy of a company with operations in several countries. We will first explore the main elements of the international network of plants. We will analyse the benefits of having one or more plants abroad, and discuss the number of plants in the international network and their optimal size. The selection of the plant location is a key decision in the process of building a network of international operations, and will therefore also be explored. We will pay attention to the allocation of manufacturing competence to the distinct plants in the network, and more specifically to the advantages and disadvantages of centralizing the manufacturing functions in the company.

Each plant is just a building block which has to fit in the overall 'architecture' of the international network. Therefore, two theoretical models will be described that provide insights for designing this network 'architecture' of the multinational company.

Next, we will explore some of the managerial issues that arise in the operations of such an international plant network: how to improve the overall productivity of the network; how to optimize the flow of information and the flow of goods within the network; and finally how to transform each plant in the network into a 'virtual' plant.

1. Introduction

Several models have been developed which describe the internationalization strategy options for a company. We have adopted the model developed by Bartlett and Ghoshal as the frame of reference. This model describes how, during the 1980s, many companies have been faced with a growing complexity of their businesses. Whereas traditionally companies had to respond to pressures for global integration or local differentiation, increasingly now they have to respond to both (Bartlett and Ghoshal 1989). Consequently we see today that many multinational companies develop capabilities to respond to diverse national demands, while at the same time they integrate and co-ordinate their activities to reduce costs and improve productivity. Examples are the auto or the telecommunication industry. This trend is clearly visible in Europe: the evolution towards a single market has increased the benefits that can be gained from global, or at least Pan-European integration. At the same time local aspects remain important: customer preferences may vary in different countries, or distribution channels may remain nationally oriented. Examples are the white-goods and the detergents industry: in some countries top-loading washing machines are preferred over front-loading machines; also, the spin-speed and the temperature requirements differ from country to country. The resulting diversity in washing machines creates a similar effect in the washing detergents business. (Baden-Fuller and Stopford 1991)

2. Rethinking the manufacturing strategy

These changes force multinational companies to rethink their global strategy in general, and to rethink their manufacturing strategy more specifically. The same task is challenging domestic companies, as they may face global competitors in the near future. In order to effectively compete with those giant global companies, a small domestic company may decide to go for foreign markets, and eventually to establish plants abroad, to obtain a cost reduction through economies of scale.
Designing a global manufacturing strategy is not an easy task, as there are no straightforward answers that fit any business context. At the same time it is a critical task, as has been shown in a recent study by Klassen and Whybark, in which they identified the barriers to the effective management of international manufacturing operations (Klassen and Whybark 1993). Lack of a global view and manufacturing strategy appeared to be the two most important barriers to effective international operations. The lack of a global view refers to the difficulties managers face when exploring and evaluating opportunities in global markets, and assessing their global competitors. In this paper we focus on the second barrier, the manufacturing strategy, and we highlight some ideas that will help companies to reformulate their manufacturing strategy in the light of the international operations.

Some of the manufacturing issues which will be discussed in this paper are similar to the ones that arise in companies with multiple plants within a single country. As such, the framework which will be developed is to some extent also valid for these domestic companies. Some of these issues become more important in the international context, such as the interplant distance. Others are uniquely applicable in companies operating in multiple countries, such as the importance of government incentives and differences in tax systems for the selection of a plant location.

3. Key decisions of the international manufacturing strategy

Whether a multinational company in expansion is in search of new opportunities to operate abroad, or it faces a rationalization and restructuring of its foreign operations, the key decisions that have to be made are of the same nature. In both cases a manufacturing strategy

plan is needed which focuses on the plant configuration. This plan should answer questions such as: How many plants should the company have ideally? Why should the company operate abroad? Where should these plants be located? What level of competence should each plant have? Which strategic role should be attributed to each plant? Which products should be produced in which plant?

For each of these questions we will describe some concepts and models that will be helpful to the managers who are responsible for setting up the plant configuration. It is obvious though that these topics are interdependent and should be discussed jointly on the strategic level of the company. This strategic exercise will result in a coherent set of plants, in which each plant will contribute to the corporate strategy of the company.

3.1. Why should the company exploit plants abroad?

Multi-site companies may theoretically consist of several plants, located in a single region or country. There are however benefits to be gained from locating the plants on a larger distance, abroad. It is therefore useful to examine in detail what drives a company to locate a plant abroad.
Usually, a company will have a combination of several good reasons for setting up or acquiring a plant abroad. The primary reason to go abroad, which is the main factor that convinces management to go for it, basically falls into one of the following three classes (Ferdows 1989):

<u>the access to low cost production input factors</u> (labour, materials, energy and capital)

The exploitation of production facilities in countries in which wages are low, can be an important cost advantage, especially for labour intensive industries. There are many examples of companies which for this reason have plants in the Far-East or in Eastern Europe.

The proximity of cheaper raw materials or energy may also be a reason for going abroad. This factor explains for example the location of production plants in Saudi Arabia, close to the oil fields, or the location of food processors near the agricultural suppliers of fresh fruits or vegetables.

The next production factor, capital, may be a factor in choosing among alternative plant locations. A company may for example obtain a cheaper loan for capital invested in a certain country. This will however seldom be a primary reason or driver to go abroad, but may become important in subsequent iterations for determining the location of the plant.

<u>the proximity to the market</u>

The establishment of a production plant in an important market or close to an important customer may have a direct cost influence through a reduction in transport costs.

But even more important than these cost effects are the less tangible effects of this decision. Proximity to the customers allows for more rapid and more reliable delivery, which obviously has a positive impact on the service level towards the customers. Plants producing perishable goods for example may have to be located near their market. Being close to the customer also facilitates the establishment of a Just-in-Time relation, which enhances the competitive position of both the producer and the customer. It also encourages customer involvement in product design and development, which is especially important for products that require a high degree of customization. This is for example the case for Bekaert, a Belgian steel cord producer, which has established plants close to some of its large customers, mainly multinational producers of tyres, in order to allow for co-operation in technological developments.

the proximity to sources of technological knowledge

Proximity to universities, research centres, or sophisticated suppliers, competitors and customers makes it possible for the company to absorb know-how and to learn from the experts in these places. This factor explains to a large extent the location of subcontractors near IBM plants, or the location of LEGO plants in Denmark, Switzerland and Japan, three countries with a sophisticated knowledge base on plastics.

Apart from technological product or process know-how, a plant may also learn about sophisticated administrative systems of suppliers, customers or competitors. Plants located in Japan for example, may have the opportunity to learn about the concepts and the philosophy of Just-in-Time applied in the Japanese plants.

The exploitation of a plant in a region with qualified engineers, scientists or technicians, or with highly skilled workers, also makes it more easy to attract these talented people into the company, thus incorporating knowledge into the company through these people.

Plants established in the proximity of technological know-how are an important source of knowledge for the company as a whole. They are at the basis of the learning capability of the company. As we will see later, it is important to link these plants tightly with the other plants of the company, to allow for the diffusion of the knowledge across the whole network of plants (De Meyer 1993).

3.2. How many plants should the company have ideally?

Theoretically it is possible to calculate the economically optimal number of plants a company should have. If one can estimate the aggregate capacity required to meet market demand, and calculate the optimal plant size, the optimal number of plants is found by dividing the required capacity by the optimal plant size. But how to calculate the optimal plant size?

As its size increases, the plant can exploit more 'economies of scale': The fixed costs are spread over a larger production volume, which makes the cost per unit go down. But at the same time the plant may be subject to 'diseconomies of scale'. As the production output grows, the plant usually has to distribute its products over a larger geographic area, which affects the distribution costs. There may also be a tendency to increase the level of co-ordination and control more than proportionally, by creating a more bureaucratic organization. Managerial costs per unit of production will therefore go up as well. These few examples of diseconomies of scale illustrate that there clearly may be disadvantages to the increase of plant size. If we can identify and quantify the economies and diseconomies of scale, it becomes possible to calculate the optimal plant size. (Hayes and Wheelwright, 1984)

In practice however, it may be extremely difficult to estimate the parameters required to calculate the optimal plant size. Moreover, as we have described in the previous section, a company may have several reasons for exploiting a plant, other than the purely economical, quantifiable reasons. A plant with an economically sub optimal size may therefore very well be justified. The European market for example traditionally was a fragmented market, which may have forced companies to produce locally in multiple countries, with relatively small plants. The removal of trade barriers however has decreased the need for some companies to produce locally in a certain country. This change favours the concentration of production in larger plants, thus allowing the company to approach the optimal plant size.

As the calculated plant size can only be a rough estimate of the optimal size, and as many qualitative factors should also be taken into account, we conclude that the calculated size only gives us an indication of the ideal plant size, and correspondingly of the number of plants a company should establish. It should not be considered as a strict guideline.

The economically optimal plant size may change over time. The growing degree of automation for example, which has taken place in many plants, has changed the cost structure of these production facilities: the proportion of direct labour cost decreases, whereas the proportion of indirect labour and capital cost increases. As a result, the optimal plant size increases. In stagnating or declining markets, this trend towards larger plants inevitably implies a reduction in the number of plants.

A possible disadvantage of an increase in the production volume of the plant might be a loss of flexibility. Traditional production systems often call for a trade-off between production volume on the one hand and product variety on the other hand (Hayes and Wheelwright 1984). The more recent, automated production systems however, such as FMS, CAD/CAM or CIM, combine speed and flexibility, thus allowing the company to produce a high variety of products in high volumes (Lei and Goldhar 1991).

3.3. Where should these plants be located?

The decision to exploit a plant abroad is only a starting point. Where exactly to locate the plant is the next question. Although the primary reason to go abroad, as described above, gives some direction, it usually leaves several alternatives open. A company may for example decide to locate a plant in the USA, in order to reduce transport costs by being closer to the US market. Or it may want to invest in Eastern Europe to take advantage of low cost labour. But it may still be undecided about which US state or Eastern European country would be most appropriate. Although some location criteria will be strongly linked with the drive to locate the plant abroad, some others can as well become important now, such as environmental issues, expatriate issues, etc.
The main issues that may be important in determining the plant location are listed in Table 1: We will discuss three of them in more detail: the access to markets, the government incentives and the environment.

Access to markets.

Peripherality, which means that the plant is located on a large distance from the important markets, can be a serious disadvantage, as has already been discussed. 'Distance' should not be viewed strictly in terms of miles or kilometres only. The time to transfer goods from producer to customer is in some circumstances more meaningful to define the distance. If for example goods can be transported economically by air plane, the 'distance' between Japan and Europe may be pretty short. Customs are another element of 'distance' in this broader sense. The idea of time rather than mileage as a measure of distance is nicely illustrated in an analogy described by Eric Friberg (Friberg 1988) :

> 'If, for example, a commercial truck driver who left New York and drove the 5000 or so kilometres to Los Angeles respected all the applicable work and rest rules, he could drive that entire distance at an average speed of 60 kilometres per hour. If that same rule-obeying driver in the same lorry were to leave the Midlands in the United Kingdom, pass by London, and drive down to Athens, also a distance of some 5000 kilometres, he would be able to average only 12 kilometres per hour. It is worth noting that 12 kilometres per hour happens to be the speed of a horse and cart.'

In the meanwhile, the elimination of customs in the unified Europe has definitely shortened this 'time distance' between the Midlands and Athens.

Labour	labour cost productivity absenteeism labour availability (the possibility to find skilled workers) social regulations strength of the unions
Raw materials	cost of raw materials availability of raw materials quality of raw materials reliability of the supply
Access to the market	distance (time) to customer customs tariff barriers
Property costs	property or rental costs of land, plants and offices
Transport	cost of transport availability and quality of transport infrastructure (air, road, rail or ship transport) availability and quality of transport organizations
Telecommunication	telecommunication cost availability and quality of the communication network
Energy	cost of energy availability of electricity, gas, oil or coal
Government incentives	financial incentives to encourage manufacturing investment
Taxes	structure of the tax system tax rates
Environment	state of the environment (water, air, noise, land, climate) environmental regulations
Expatriate issues	personal tax systems cost of accommodation, cost of living work permit requirements availability and quality of international schools crime rate quality of life

Table 1
Location criteria
(Haigh 1990; Ernst&Young 1992)

Government incentives

Especially in the case of developing regions or regions with high unemployment, national government sometimes offers financial incentives to encourage manufacturing investment in the region. Within Europe, incentives are also provided by the EC for some of its regions.

Among the criteria which are regularly used to decide upon the attribution of a government grant are the number of jobs created in the region, the degree of export orientation, the technological content of the product or process, and the degree of use of local suppliers and local raw material. (Ernst&Young 1992)

The environment

In recent years there has been a growing awareness about the impact of industrial activities on the environment (Ernst&Young 1992). There is severe pressure on business to invest in the protection, and even improvement, of the environment. Research has shown that within Europe the nature and the size of the environmental problems vary from one country to the next, and so does the country's capability to solve these problems. This shows that the environment is clearly an issue which should be taken into account when choosing a plant location.

Many aspects of the environment may influence the working conditions and the productivity of the workers. Poor air quality for example appears to reduce human and plant activity.

Perhaps even more important is the fact that environmental regulations restrict the location choice of the company. If for example regulations concerning waste disposal vary across countries - as is the case in Europe - it may happen that a plant would get an exploitation permission in one country but not in another.

3.4. What level of competence should each plant have?

The previous discussions have brought us now to the point where we have a set of plants in different countries, which have been chosen on a rational basis. The question remains how to organize and co-ordinate this set of plants.

In order to manage the manufacturing function in the company, some level of competence is required in several managerial tasks, such as planning, procurement, product and process development, maintenance and production. One possible option is to centralize these tasks in headquarters or in a central plant. This clearly has the advantage that corporate management has full control over the operations in the plants. Centralization also avoids duplication of effort. With decentralized product development for example there is a risk of having multiple development teams working on a similar product. Another advantage of the centralized approach is that it creates more uniformity among the plants. Finally, centralization makes it more easy to obtain a critical mass in the manufacturing function, such as product and process development, or procurement, where centralization increases the bargaining power of the company as larger volumes may be purchased from a single supplier.
But the loss of control and efficiency which is inherent to decentralization may be counterbalanced by the advantages of decentralizing managerial tasks. Decentralized planning, procurement and product development for example increase the ability of the plants to respond to market needs more flexibly and rapidly. It allows the plants to be innovative, and to develop new or improved products in co-operation with the customers.

It is clear that each company should attempt to achieve the delicate balance of centralization and decentralization of the manufacturing tasks. This balance should not necessarily be the same for each manufacturing function, nor should it be the same for each plant in the company. A company may have good reasons to limit the investment in managerial competence in one plant, which will then produce products developed elsewhere, according to a planning imposed on the plant, and at the same time to provide room for an ample manufacturing staff in another plant, which will then be the designer plant for new products or which will take the lead in for example quality management or Just in Time for the company as a whole.

The four key decisions which we have described up to this point are to some extent decisions concerning each plant separately. They provide the building blocks, the components, of the company's plant network. In order to make sure that 'the whole is more than the sum of its

parts' these building blocks must be assembled into a well-considered architecture. In the following two sections we will describe two theoretical models which provide insights for designing the network architecture of the multinational company.

3.5. Network architecture: The strategic role of the plants

The two characteristics of a plant which we have described above - the primary reason for its existence and exploitation. and the extent of manufacturing tasks allocated to the plant - in combination determine the 'strategic role' or 'charter' of the plant. This strategic role in fact gives us an idea of how and to what extent the plant may contribute to the strategic mission of the company as a whole, ranging from plants that merely act as implementors of plans developed outside of the plant, to plants that are key players in the attempt of the company to outperform its competitors.
The model describing the strategic roles of plants has been developed by Ferdows, and is shown in Figure 1 (Ferdows 1989).

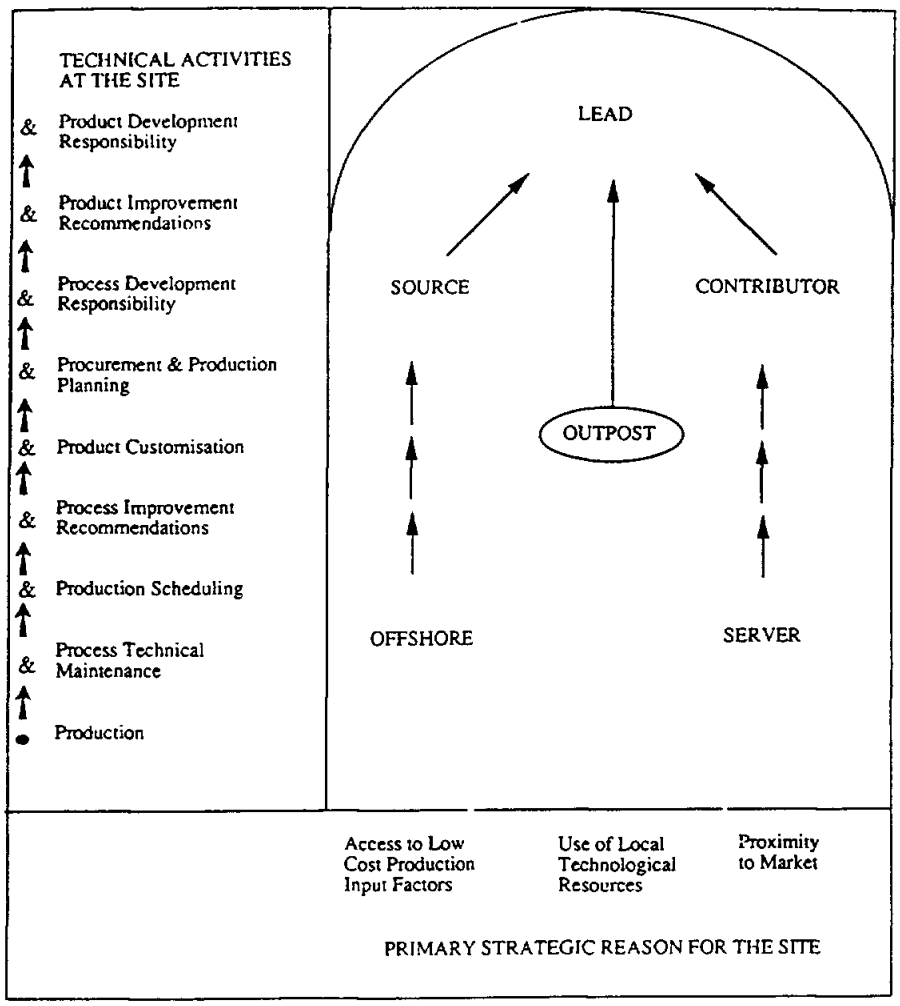


Figure 1
The strategic role of plants
(Ferdows 1989)

Ferdows distinguishes six different types of plants:

The off-shore plant

The plant has been established essentially to utilise local cheap production input factors. Managerial investment in the plant is kept to the minimum essential to run the production efficiently.

The source plant

As the off-shore plant, the source plant has been established essentially to utilise local cheap production input factors, but it has more managerial assets, and a lot more autonomy than the off-shore plant. The strategic role of the source plant is more substantial, as it may become a focal point for the development and/or production of specific components or products and for the design or improvement of specific production processes.

The server plant

The server plant is established for serving a national or regional market, with a minimum level of managerial investment, sufficient to run the production efficiently. Its role is essentially limited to the production of the products for the market.

The contributor plant

As the server plant, the contributor also serves a specific national or regional market, but its strategic role goes beyond just supplying products. It is comparable to the source plant in that it develops know-how for the company, and as such contributes to the competitive advantage of the company.

The outpost plant

The outpost collects useful information from universities or research centres, or from technologically advanced competitors, suppliers or customers, and it transfers this information to headquarters or other plants in the company. It has been set up though with relatively little local competence.

Empirical studies have prevailed very little examples of outpost plants. We assume that it is extremely difficult for a plant to tap into local technological know-how, without giving any know-how in return to the technologically advanced partners in the region. It may therefore be unrealistic to collect information through a plant without investing in the expertise within the plant.

The lead plant

The lead plant is located in a technologically advanced region, and has developed a large competence base in manufacturing. Its role is to tap into local technological resources but, unlike the outpost plant, the lead plant has the ability to use this information effectively. The lead plant acts as a partner of headquarters in developing manufacturing capabilities within the company. It is often the 'centre of excellence', where products are developed and produced for the global market.

The advantage of this model is that it allows the management team of a company to 'map' the set of plants according to their strategic roles. This map clearly shows eventual unbalances in the set of plants and highlights opportunities for further development of plants. A possible conclusion may be for example that a company is not as customer oriented as it claims to be, if the classification shows a lack of contributor of server plants. Or vice versa, if the clasification shows a relatively large number of servers and contributors, one may realise that cutting costs may require a restructuring and reorientation of the set of plants of the company.

As figure 1 shows, this model is not static. There seems to be an evolution of the plants 'upward' in the model. Plants abroad usually start as off-shore or server plants. But over the

years, if these plants stay in their original role, which implies that there will be relatively little local competence, the plant may fall behind in productivity, as there are few manufacturing managers capable of maintaining a high rate of improvement. Secondly, those plants contribute very little to the company as a whole, or otherwise stated, the company as a whole might be missing an opportunity to benefit from local expertise and market know-how. And thirdly, by treating the plant merely as a supplier of products, the company certainly does not create a challenging environment for the local management team. In the long run, this may demotivate the local managers, and at the same time make it more difficult to convince talented people to join the plant.

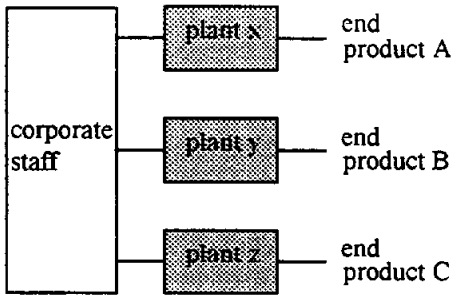
These observations explain why it is desirable for a company to invest in its plants competence, in order to allow the plants to fulfil a more substantial strategic role. But even without an explicit, top-down decision to develop local competence some plants seem to follow a natural way upwards in the model. The pressure to reduce time-to-market or to increase customer service for example may stimulate local management to develop the local competence base. Similarly, one may argue that managers will spontaneously seek for the control of a growing amount of competencies and assets, as this increases their status and prestige within the company. So there is a bottom-up pressure of the plants as well, which makes them grow into source or contributor plants. For those plants located in a technologically advanced region a move further up towards the lead role is possible.

Other, usually less successful plants may disappear from the 'map', as the company closes down the plant or sells it to another company. Reasons for this can be the competitive pressure to reduce costs, which may call for a concentration of the production in a smaller number of plants, as described earlier, or the appearance of new opportunities. The fall of the Iron Curtain for example has made many companies move part of their production facilities to Eastern Europe, thus decreasing their production in Western Europe: Eastern Europe offers the opportunity to benefit from low wages; at the same time the distance between the plant and the mother company is small compared to a plant in the Far-East, so that transportation costs are reasonable and communication with the local management team is not hampered.

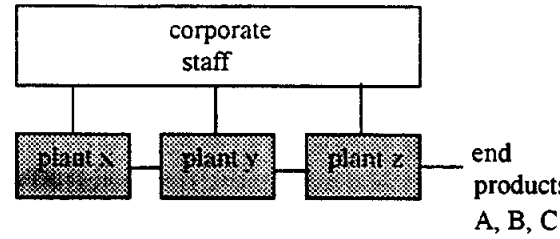
3.6. Network architecture: The focus of the plants

We have discussed the fact that a plant is located in a certain region, mainly for reasons of cost, market or technology. We have argued that some manufacturing functions may be run on a centralized basis, whereas others may better be delegated to the plants. But up to now we have no criterion that may help us decide which products or components to produce in which plant. From the point of view of the company there is a whole portfolio of products which have to be allocated to the plants.
An interesting approach for this problem has been described by Hayes and Schmenner (1978). They argue that a company has the choice between two - polar - organizing principles, the product focus and the process focus. Figure 2 clarifies the two approaches through a simplified example.

In the product-focused company each plant is responsible for the production of a product or a product group which consists of similar products in terms of market needs and manufacturing requirements. In the process-focused company each plant concentrates on a distinct stage of the production process. As such, each plant is just another link in the production chain.



PRODUCT FOCUS
Figure 2a



PROCESS FOCUS
Figure 2b

The choice between the product and process focus has strong implications for the range of tasks of the corporate manufacturing staff and the plant management. The plants in a process-focused company in general operate less autonomously than the plants in a product-focused company. The reason is obvious: by spreading the distinct stages of a production process over more than one production unit, co-ordination is required to get a product out of the process-focused organization. Usually decisions concerning capital, technology and product development will be made locally in the product-focused company, whereas they will be centralized in corporate staff for the process-focused company. The production plan of the process-focused company is usually more complicated, as it should be an integrated plan for the plants, whereas the production plan for a product-focused plant is relatively independent of the plan for other plants in the company. The higher level of co-ordination required in the process-focused company implies that, in general, this type of company has a lower degree of flexibility: it is more difficult to introduce new products rapidly or to change the output level of the plants. But on the other hand, it offers opportunities for cost reduction through economies of scale. (Hayes and Schmenner 1978)

Up to here we have presented the product/process focus issue as if any company can go for either one or the other. In reality it is not that simple. The factors influencing the choice between the two options may be different for distinct product lines or business segments of one company. The message here is not that the two options should not co-exist within one company, but rather that if they co-exist, they should be separated managerially as much as possible. We have argued before that the two options place different demands on the corporate staff and the plant managers. Adopting the two approaches within the same organization, under the same managerial structure, will create confusion and conflicts of interest. This implies that the transfer of products between a plant in the process-focused part of the company and a plant in the product-focused part should not be co-ordinated by the corporate staff, but should rather happen through negotiation between the plants (Hayes and Schmenner 1978).

Research has shown that within Europe many multinational companies, anticipating the shift of the European market from a fragmented towards a more integrated market, have moved towards a clear product or process focus (Collins, Schmenner et al. 1989). Their plants have been specialized in a more limited number of product lines, or in a more limited stage of the production process. As a result of this plant focus, the number of technologies to be mastered by the manufacturing staff of the plant has decreased, and the planning and control task has been simplified.

Both models - the strategic roles model and the product/process focus model - approach the issue of designing the architecture of the multinational network of plants from a different angle. As such they will provide complementary insights to the manager who is in charge of the

international operations of the company. These models are not fully independent however. We expect that a process-focused company will locate its plants - each of them dedicated to a particular stage of the production process - in a country or region which has a considerable knowledge base in this particular process stage, or in a country or region which provides low cost production input factors to the process. We have argued that the process focus requires a relatively high level of co-ordination, and therefore we expect a relatively high degree of centralization of manufacturing tasks. We may conclude that the process-focused company is more likely to have a network of predominantly off-shore and outpost plants, and to some extent source and lead plants.
In the product-focused company on the other hand, each plant is dedicated to a limited number of products or product lines. It is therefore reasonable to expect a relatively high degree of autonomy in these plants for manufacturing tasks such as product and process design, and production planning. We expect that the product-focused company is more likely to have a network of predominantly source, lead or contributor plants.

4. Major managerial concerns

In this final section we will explore some of the major managerial issues that arise in the operations of a multinational plant network.

4.1. Managing the network productivity

The overall productivity of the network is determined by the productivity of the individual plants. A study carried out bu Chew, Bresnahan and Clark (1990) has shown that the productivity of a plant within a multinational company may vary substantially among the distinct plants. Performance differences between the best and the worst plant were shown to be on the order of magnitude of 2:1. Although these performance differences may occur in any multi-plant network, they are probably more pronounced in a multinational network, because of the longer interplant distances and the possibility of cultural differences and of differences in the performance measurement systems.

We may wonder why it is that some plants perform considerably less good than their colleague plants within the same company. The researchers have concluded that these companies have missed the opportunity to increase the productivity of the weakest plants, especially because they fail to optimize the transfer of know-how from the more productive plants to the weaker ones. As such, the overall company performance remains below the level which could be obtained.

In order to create the possibility of transferring know-how, we believe that three conditions should be fulfilled.

First, some plants in the network must have the capability to transfer, and therefore to develop know-how valuable for the other plants. By definition this implies that there must be a number of source plants, contributors and/or lead plants in the set of plants.

Secondly, the managers in these plants must be motivated to share their know-how with other plants. The transfer will not happen unless the corporate culture and the performance measurement system stress the importance of sharing know-how. If the corporate culture is characterized for example by the belief that each plant is unique, and that each plant has a unique set of customers, it is more likely that managers are not motivated to learn from one another. This type of culture breads the 'not-invented-here' attitude, rather than an openness to the new ideas developed in other plants. The performance measurement system should provide uniform productivity measures for all the plants in the network. Differences in the age and size of the plants, their technologies, and their location for example are factors which may influence the productivity of the plant. As these factors are beyond the control of plant management, they should be filtered out of the productivity measure used for plant comparison. We refer to Chew et

al. (1990) for details on the construction of a uniform plant productivity measure. The performance measurement system should be the basis for the incentives awarded to the plant managers, in order to motivate them to transfer their know-how to other plants, and vice versa, to adopt know-how developed at other plants, and unless performance measures on the plant level and management incentives stimulate the exchange of ideas.

A final condition is that the manufacturing staff in the plants must be trained to recognize opportunities to transfer know-how. First of all that the staff must become well aware of the know-how developed in one or more plants. And secondly it must become aware of the possibility to apply this know-how in another plant.

4.2. Managing the communication network

In the previous section we discussed the importance of the transfer of know-how between plants. The effectiveness and efficiency of this transfer of information depends heavily on the quality of the communication between the plants. Research on R&D centres has highlighted several elements that have an important impact on the communication between the centres (De Meyer 1993). The conclusions from this study may be helpful to understand the communication efforts between production plants as well.

- An important element is the 'socialization' effort; Companies may attempt to create a 'family' atmosphere, which may favour formal and informal exchange of information. Socialization can be accomplished by temporary assignments of managers to a foreign plant, or by the stimulation of travelling between the plants.
- Many companies use rules and procedures to stimulate formal communication. There may be a policy that innovations must be carefully reported and documented, and there may be a formal channel to distribute these documents to all the plants. Or a strict planning process may force the plants to exchange information.
- The plants may have a 'gatekeeper', a person who is very familiar with the internal organization of the plant, and who - at the same time - has many contacts with people in other plants.
- A fourth element which came up in the study are the organizational mechanisms. We have already discussed several advantages and disadvantages of centralization. An issue which in this respect has not been discussed yet is the centralization of information. It is clear that having a central staff who collects and distributes relevant information has its advantages. On the other hand, direct communication between the plants may be faster and more reliable than this rather bureaucratic centralized mechanism.
- A fifth element is the importance of electronic communication media, such as computer networks, electronic mail systems, and video conferencing. But although electronic communication facilitates communication all over the world, it can not be the sole source of communication a company relies upon: it appears that the level of confidence between people decreases continuously if they communicate solely through electronic media, without any direct contact. This has been described as the 'half-life effect of electronic communication', in analogy with the decay of for example nuclear radiation. However, a certain amount of confidence between people is crucial if these people have to work together effectively. As such, periodic face-to-face contact seems necessary to re-establish the confidence required for effective co-operation. (De Meyer 1991)

4.3. Managing the flow of goods

The choice between the product and process focus has major logistical implications for the company, as it determines to a large extent the flow of goods in the network. The process focus by definition implies the transportation of semi-finished products from one plant to another. The interplant distance is therefore an important decision parameter, as well as the quality of the available transportation infrastructure. Some characteristics of the product may

have important logistical consequences which must be taken into account when deciding to adopt a product or process focus. It is for instance more appropriate to adopt a product focus for products which would be very costly or haphazard to transport between two production stages. The case of a soft drink company illustrates this point. One of the bottling plants in the company has vertically integrated into the business of blowing plastic bottles. Instead of having two production stages - blowing and filling bottles - spread over two plants, the company has now integrated the process under one roof. This new approach eliminates the transportation of the empty bottles, which is predominantly a (costly) transportation of air!
Another characteristic of the product which comes into play is the perishability of the raw materials or the semi-finished products. Food processors may have to locate a plant near the suppliers of raw material and adopt a product focus. if the raw material and the semi-finished product would perish during transport to a distant plant. On the other hand the company may adopt a process focus if the raw material is perishable, but the semi-finished product is not. Fruit Juice for example may be squeezed near the supplier of fruit, transported in bulk, and packaged anywhere else in the world. This example illustrates at the same time the importance of the location of the supplier(s) of raw materials or components in the choice of the plant configuration.

Having established a tight network of plants which support the strategy of the company as a whole, with clear strategic roles and a clear-cut focus, the manager now has to rethink the allocation of products so that the combination of total logistical cost, delivery reliability and customer service is optimized.

This task is of course extremely difficult, as multiple factors have to be taken into account, such as the number of distribution centres, the transportation costs and transportation facilities and infrastructure, the capacity and capabilities of the plants, the distance between the plants and suppliers, the distance between the plants and distribution centres, and the interplant distances. Another important aspect of this task is the make-or-buy decision: It may be more desirable to outsource part of the logistical chain, rather than to own the whole transportation and distribution network.

It is also a task which asks for frequent revision. As the parameters of the decision change, the decision should be re-evaluated.

4.4. Creating the virtual plant

Is it sufficient that a company has established a clear and rational network of its international plant configuration, and then optimized the allocation of manufacturing tasks to compete effectively in tomorrow's market? The answer is probably no!
Its next challenge is to integrate manufacturing with other the functions, rather than to maintain manufacturing as a separate and isolated function (De Meyer and Wittenberg-Cox 1992). Manufacturing is more than just the physical process of building a product on the basis of some components and materials; it is an integral part of one long value-creating chain which finally leads to a product that will satisfy the customer needs.

Manufacturing should, therefore, be integrated with other functions within the company such as marketing, product development and process development. 'Quality Function Deployment' and 'Design for Manufacturing' are two examples that stress precisely the need for this integration. But these two examples go beyond the mere internal integration of functions. The plant of the future will also integrate externally with its customers, suppliers and environment. Companies profit by treating suppliers as long-term partners: delivery reliability of raw materials or components may increase; inventories can be reduced; quality inspection of incoming goods can be eliminated; and co-operation in product development becomes feasible. A partnership with the customer may be just as valuable. Information about customer needs is an important input for the product design process, and integration with the customer's planning

system provides useful information for the company's own production planning. The environment has also become an important player in the competitive game. A company that does not produce environmentally friendly products or use an environmentally friendly production process may very well be the losing company tomorrow.

This interaction with external partners enables the company to transform raw materials and components into value, rather than mere products, for the customer. We would call this future plant a 'virtual' plant (De Meyer 1992).

The process of internal integration with the other functions and external integration with the suppliers, customers and environment is more complex for the multinational than it is for the domestic company, as it requires a co-ordination of several partners across national borders.

5. Conclusion

We have argued that the effective management of the international operations of a company requires first of all a clear-cut manufacturing strategy. The multinational company should be viewed as a network of plants, each with a clear strategic role and a clear focus, that support the strategy of the company as a whole. The number and size of the plants, their location, and the level of competence in each plant, are issues that require thorough analysis.

Secondly, we have shown that the management of an international network of plants is in fact the management of flows: flows of know-how between the plants; flows of information between the managers in the network; flows of goods between the plants. Managing these flows should lead to a productive network of 'virtual' plants.

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