A NETWORK TYPOLOGY OF PLANTS IN GLOBAL MANUFACTURING NETWORKS

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ABSTRACT

The paper describes a typology of plants in multinational manufacturing companies. Four clusters of plants are identified, each with a distinct position in the multinational manufacturing network. It is shown that plants with different network roles also differ in terms of some plant characteristics, such as their strategic role, their focus and their degree of autonomy, and in terms of the stability of their position.

The international environment in which the MNE is operating exerts pressures on the manufacturing configuration of the MNE. On the one hand, these pressures create a need for global integration, on the other hand they push the MNE towards responsiveness to local market needs. (Bartlett & Ghoshal, 1989) The manufacturing strategy of the MNE has to respond to these -sometimes conflicting- pressures. A manufacturing configuration has to be designed that provides the capabilities needed for improving the MNE's competitive position. A major assignment for the manufacturing manager in the MNE is therefore the creation of an international network of production facilities that develops these capabilities. In this network, each production facility needs to "play" its specific role. This network role of the plant has been the focus of our research. Through empirical research, four types of network role have been identified. It has been shown that plants with different network roles also differ in terms of some plant characteristics, such as their strategic role, their focus and their degree of autonomy, and in terms of the stability of their position

A NETWORK PERSPECTIVE

Research on the structure and organization of the multinational company has shifted from a focus on the one-to-one headquarters-subsidiaries relationships towards the problem of managing a network of foreign subsidiaries. (Kogut, 1989). Doz, for example, states that differences in the mission of subsidiaries are reflected in the "pattern and intensity of information flows" (Doz & Prahalad, 1991 p.160). The information flow is only one type of network relationship between the subsidiaries and headquarters, and among the subsidiaries. The physical flow of components, semi-finished goods or end products, financial flows, and "flows" of people moving around in the network are other types of network relationships that merit our attention (Bartlett et al., 1989).

This trend towards depicting the MNE as a heterogeneous network of units can also be observed in the *manufacturing strategy* literature. Work has been done, for example, in the description of the benefits and methods of the transfer of best practices across the manufacturing network. See for example Flaherty (1996), Chew (1990), Hayes (1986), Schmenner (1990)

From the *metaphor* of the MNE as a networked set of plants, each with its distinct strategy and goals, it is only a small step to the network perspective as a *research methodology*.

Ghoshal and Bartlett have claimed that the network approach "is particularly suited for the investigation of such differences in internal roles, relations, and tasks of different affiliated units (...) and of how internal co-ordination mechanisms might be differentiated to match the variety of subunit contexts." (Ghoshal & Bartlett, 1990, p620)

Not only is network analysis a useful tool, it is also a necessity, according to Nohria, who claims that "If we are to take a network perspective seriously, it means adopting a different intellectual lens and discipline, gathering different kinds of data, learning new analytical and methodological techniques, and seeking explanations that are quite different from conventional ones" (Nohria, 1992, p.8)

In our research, network theory has been used not only as a theoretical metaphor to describe the plants network in the MNE, but also as a methodological tool to describe and understand the structure of this network.

RESEARCH METHODOLOGY

Since the purpose of our research was to understand the "*how*" and *"why"* of the international plant network, the research is exploratory, and case study research has been preferred over other research methodologies. (Yin, 1984)

Case study research is not a very frequently used methodology in POM research. A common argument against the use of case research is based on the misconception that case research would be based on qualitative data only, and would therefore lack precision and rigor. However, several methodological papers and books are available that help the researcher to design a rigorous, precise and objective research instrument. Examples are Eisenhardt (1989), Miles (1994) and Yin (1984). To the extent possible and where appropriate, these methodological guidelines have been followed in our research. Both qualitative and quantitative data has been collected, in a rigorous and structured way, and it is analyzed in a systematic way.

Several variables have been measured through multiple item measures. The reliability of these measures has been assessed by calculating the Cronbach alpha, and factor analysis has been used to reject or confirm the assumption that some theoretical constructs underlie the items. (Carmines & Zeller, 1979; DeVellis, 1991)

One of the tactics that have been used to enhance the construct validity of the research, is the use of multiple raters. This tactic is still fairly uncommon in manufacturing strategy research; Speier and Swink have highlighted this as one of the shortcomings in current Operations Management research. They argue that research based on a single respondent may be subject to the "lone wolf syndrome", the risk that this single respondent has a biased view on the organization unit being studied, or has limited access to information. (Boyer & Verma, 1996; Speier & Swink, 1995).

The ICC or “Intra-Class Correlation” method has been used to assess the inter-rater reliability of the variables. The ICC index measures the variance of the scores of the raters within a plant, relative to the between-plant variance. (Boyer et al., 1996)

Data Collection

The case research has been carried out in eight companies headquartered in Western Europe, each having between 4 and 10 manufacturing plants. In total data has been collected on 58 manufacturing plants. Forty-four of these plants are located in Europe, the fourteen other plants are spread globally. Data has been gathered at two levels of analysis: the plant and the company. Quantitative as well as qualitative data has been gathered, through multiple data collection methods:

- Interviews have been conducted with the general manager and with manufacturing managers at headquarters of the companies. In total, 110 hours of interview have been conducted, with 37 managers. The number of interviews varied between 2 and 6 per case. A highly structured questionnaire, with closed and open-ended questions, has been used as a guide through the interviews.
- A questionnaire has been sent to the plant managers and/or the manufacturing managers in the distinct production plants. In total, 148 questionnaires have been sent to managers in the plants (82% of which have been returned). The number of questionnaires returned from the plants varied between 1 and 5 per plant.
- Information has also been obtained from company brochures and publications, company archives, and plant visits.

THE NETWORK POSITION OF THE PLANTS

Bartlett and Ghoshal recognize four types of relationships between subsidiaries: physical goods, information, people and financial resources (Bartlett et al., 1989). The flow of resources in the strict sense of providing capital to subsidiaries is of lesser importance in our study of network relationships between plants, and will therefore not be discussed here. The three other types of relationships - goods, information and people- differ in the degree of tangibility of the network flows. Our interest lies primarily in the intangible knowledge network of the MNE, since we are exploring how the network of production facilities of the MNE may enhance the creation of strategic capabilities. The logistics organization of the MNE, which is reflected in the tangible transfer of goods through the network, has been of secondary interest.

A plant typology has been developed by clustering the sample of plants (N = 58), based on the extent to which they are embedded in the intangible network of information and people.

The information network

Two types of information flows can be distinguished: the administrative information flow, and the knowledge flow (Gupta & Govindarajan, 1991). In a manufacturing context, the *administrative information flows* consist of information on inventory levels, purchasing requirements, forecasts, production plans, …. These information flows depend to a large extent on the degree of centralization of manufacturing tasks, such as planning, inventory management and procurement. More interesting from a manufacturing strategy perspective are the *knowledge flows*. Our attention goes primarily to the flows of knowledge embedded in innovations, since this relates closely to a manufacturing context. Product, process as well as managerial innovations have been studied.

The people network

An important means of managing the interdependence between the operating units of the network is the "sharing" of managers. This not only contributes to the exchange of information, but in addition creates commitment to the overall manufacturing strategy in the distinct operating units. We distinguish three types of "sharing" of managers.

A typical example is the position of a manager having line or staff *responsibility in two or more plants*. This can be at the level of the plant manager, as well as the functional levels reporting to the plant manager. This type of relationship can be called "interlocking management" (by analogy with the interlocking directorship, i.e. one person being member of the board of directors of two or more companies - see Gerlach (1992))

Of equal importance are the "dispatched managers” (by analogy with the dispatched director - see Gerlach (1992)), i.e. the managers who have been *transferred from one operating unit to another*, on a permanent or a temporary basis.

A third aspect of the flow of people refers to the day-to-day operations of the network. These relations between units are realized through *"coordinators", managers traveling frequently between operating units*, visiting two or more operating units in order to share information and to accomplish co-operation between the units. The role of such “coordinators” has received a lot of attention in the organization literature. They are specific examples of what Galbraith and Mintzberg have defined as the “liaison devices” of an organization. (Galbraith, 1977; Mintzberg, 1979).

A major advantage of these liaison devices is the opportunity they create for personal contact between people in the organization. Ghoshal et al have shown that the relationship among subsidiary managers and the relationship between managers of subsidiaries and managers of headquarters have a significant influence on the frequency of the inter-subsidiary communication, and on the frequency of communication between the subsidiaries and headquarters. (Ghoshal, Korine, & Szulanski, 1991; Ghoshal, Korine, & Szulanski, 1994)

Other papers demonstrate the importance of communication as a facilitator of the transfer of innovations in multinationals. (Ghoshal & Bartlett, 1988; Gupta et al., 1991)

When we bring these two observations together, it appears that there is a strong relationship between flows of innovations, flows of people, and communication "channels" in the multinational plant network.

Operationalization of the Network Position of the Plants

transfer of innovations

We have followed Ghoshal and Bartlett in their classification of innovations into three categories: the development and production of a new *product,* the development and introduction of a new *production process,* and the implementation of a new *management system.* The innovation transfers have been measured by asking managers in the plants and in headquarters to enumerate and describe the transfers of innovations they know of, over the past three years. A similar operationalization has been used by Ghoshal and Bartlett. (Ghoshal et al., 1988) An example of the questionnaire is provided in APPENDIX A. The information from these different sources was combined into a large matrix. This matrix has been checked, complemented and eventually corrected by at least one manager in headquarters.

Flow of people

Data on the extent to which people are traveling from one unit to another has been collected through a questionnaire, which was based on the tool used in the research by Ghoshal (1986). This questionnaire can be found in APPENDIX B.

Communication

Communication between the managers in the plants and in headquarters has also been measured through questionnaires. However, such self-report questionnaires may suffer from recollection problems. This problem is severe if the data collection method consists of an interview or questionnaire asking the respondent to name the persons he/she communicates with frequently. This approach has been followed by (amongst others) Allen in his early studies of communication networks in R&D laboratories. (Allen, 1977) An alternative approach is to provide a list of people, and to ask the respondent with whom on this list he/she has communicated, rather than letting the respondent name the people he communicated with. (Knoke & Kuklinski, 1982) This approach has been followed in our research. An example of the questionnaire has been provided in APPENDIX C.

In network analysis, the consequences of missing data are severe, since the lack of data from a single actor implies the lack of data on the N-1 possible relationships of this actor with the other actors in the network. Estimates such as centrality and density can therefore be distorted if data are missing. Therefore, great care has been taken so as to maximize the response rate.

The primary network measure used in our research is the *centrality* of the plant in the plant configuration. If network relations are mutual (as is the case for the communication network), we measure centrality of the actor through its “degree”. If network relations are not mutual (as is the case for the flows of goods, people and innovations), two degree measures are used: the actor’s “indegree” and “outdegree”.

The *indegree of an actor* is defined as the proportion of relations received by the actor from all other actors. The *outdegree of an actor* is defined as the proportion of relations from that actor to all other actors. The *degree of an actor* is defined as the proportion of other actors with which an actor has a direct relationship, which is equal to the average of the indegree and outdegree of the actor. (Knoke et al., 1982)

The following network variables have been defined:

- the communication centrality of plant i estimates the frequency of communication of the manufacturing staff of plant i with the manufacturing staff in the other units in the network
- the innovation indegree of the plant i captures the intensity of the innovation flow transferred (and implemented) from the other units to plant i
- the innovation outdegree captures the intensity of the innovation flow transferred (and implemented) from plant i to the other units
- the people indegree of the plant captures the number of days plant i has received visitors from manufacturing staff people of the other plants
- the people outdegree of plant i captures the number of days manufacturing staff people of plant i have been visiting other plants in the plant configuration

K-means clustering, with Euclidian distance measure, has been carried out on these network variables. The number of clusters has been set equal to 4, on the basis of the hierarchical Ward’s method of clustering: Upon visual inspection of the dendogram, we recognized a structure with four clusters. K-means clustering was preferred over the hierarchical cluster methods for the actual development of the typology, since it is an iterative partitioning method, and thus is compensating for a poor initial partitioning of the cases. The variables have been standardized prior to the clustering. (Aldenderfer & Blashfield, 1984)

EMPIRICAL RESULTS

The typology of plants resulting from this cluster analysis is depicted in Figure 1.

In this chart, we have represented the plants as ovals. The width of the gray band in the oval indicates the communication centrality of the plant. The arrows on the left hand side of the ovals represent the inflow and outflow of innovations. The arrows on the right hand side of the ovals represent the inflow and outflow of manufacturing staff people. The thickness of the arrows gives an indication of the average level of innovation and people flows. A wide band or a thick arrow indicates an average centrality above 1; a narrow band or a thin arrow represents an average centrality between 0 and 1; the absence of a band or arrow represents an average level below 0. These cut-off values are defined on the standardized variables.

Network Typology of Plants

The first type of plants (labeled as type A) occupies an "*isolated*" position in the plant network. Few innovations reach the plant, few innovations are transferred to other units, few manufacturing staff people come to visit such a plant, few manufacturing staff people from this plant go visit other plants, and there is little communication between the manufacturing staff people of this plant and the other manufacturing managers in the network.

The second type of plant (type B) picks up innovations from the network, but it returns hardly any innovations to the other units. The intake of innovations is not accompanied by a high inflow or outflow of people or by extensive communication with the manufacturing managers in the network. It looks like such a plant carries out innovations on the basis of a "*blueprint"* developed elsewhere, without much interference with the developing unit.

These two clusters thus consist of plants that are only weakly embedded in the production network. They represent the majority of plants in the sample: 11 plants were assigned to cluster A, and 26 plants to cluster B.

The other two clusters, clusters C and D, consist of plants that are true network players. Cluster C contains 8 networked plants only. A type C plant frequently exchanges innovations, both ways, with the other units. The picture that emerges is one of a "*host plant"*, since the manufacturing staff of the plant communicates fairly extensively with the other manufacturing managers, and the plant receives a lot of visitors from other plants.

The fourth type of plant is a strong network player. Its manufacturing staff communicates extensively with the other manufacturing managers. Many innovations "travel" in and out this plant. And the manufacturing staff of this plant pays a lot of visits to the other plants. Manufacturing staff people from other plants visit this fourth type of plant, but not as extensively as is the case for the third type of plant. The emerging picture for this fourth type of plants is one of providing the "*glue for the network*". Only 4 plants were found in this cluster.

Cluster Validation

Aldenderfer recommends the use of statistical tests on external variables (i.e. variables not used to generate the cluster solution, and yet relevant) as a validation of the cluster solution. (Aldenderfer et al., 1984). A concept that is strongly related to the typology discussed here, is the concept of the “strategic role” of the plant. Building on the work done by Ferdows, we define the strategic role of the plant as the extent to which the plant contributes to the other units in the manufacturing network (Ferdows, 1989). We have measured the strategic role of the plant on a 9-point Likert scale, describing plants which have as their main goal "to *get the products produced*" at the one extreme, to plants that are a "center of excellence, and serve as a *partner of headquarters in building strategic capabilities* in the manufacturing function” at the other extreme. The average level of strategic role of the plants in each of the clusters is indicated in Figure 1.

Insert Figure 1 about here

Since we have defined the strategic role as the extent to which the plant contributes to the other plants in the network, the strategic role of cluster D should be high. The strategic role of the plants in clusters A and B, on the other hand, should be low, since these plants make little contributions to the plant network. The Kruskal-Wallis and Median Test[1] confirm that *cluster D rates higher in strategic role than clusters A and B* (p=0.07). This confirmation provides validation to the network typology of plants.

[1] Tests have indicated that, for most of the variables in our research, the assumption of normality is violated. For those variables the non-parametric alternatives to the ANOVA have been used.

Cluster Characteristics

The four types of plants have been compared on a set of plant characteristics. The variables that have been studied are

- the age of the plant (the number of years the plant has been part of the company)
- the autonomy of the plant. Both strategic autonomy and operational autonomy have been measured. A similar approach has been followed by Ghoshal for studying subsidiary autonomy (Bartlett et al., 1989; Ghoshal, 1986). Ghoshal has based his approach on the instrument developed and used by De Bodinat (De Bodinat, 1975). The wording of the questions and the description of the scale that have been used in the questionnaire are to a large extent based on the questions used by Ghoshal (Ghoshal, 1986). They have been adapted to the specific decisions and functions in or closely related to manufacturing, and to the context of a plant rather than a subsidiary.

  Two dimensions of strategic autonomy have been identified, using factor analysis:

  - strategic autonomy in decisions concerning the operations of the plant (eg. the decision to develop a new product or to introduce a new planning system, the selection of a new supplier);
  - strategic autonomy in decisions concerning the design of the plant (eg. the decision to develop a new production process, the choice of a new technology);

  Two dimensions of operational autonomy have been identified, using factor analysis:

  - operational logistics autonomy (eg. developing a production plan, placing purchasing orders, managing inventories);
  - operational autonomy in design and engineering (developing new products and processes).

- size of the plants (expressed in number of employees)
- the focus of the plant (Collins, Schmenner, & Whybark, 1989; Hayes & Schmenner, 1978):
  - product focus: the extent to which the plant focuses on a narrow portion of the company's product range
  - market focus: the extent to which the plant focuses on a narrow portion of the geographical market served by the company
  - the supplier/user relationship with other plants in the network, measured as the centrality of the plant in the physical network of goods, which is defined as the extent to which components or semi-finished goods are transferred to or from other plants
- the level of investment: four types of investment have been identified, using factor analysis:
  - investments in the *production process* (eg. setup time reduction, plant automation, process analysis, productivity improvement, throughput time reduction)
  - investments in *planning* (eg. material and/or capacity planning, just in time systems)
  - investments in *managerial improvement* programs (statistical process control, supplier partnerships, total quality management, employee participation programs)
  - investments in *new product development*
- the level of capabilities in the plant
- the performance of the plant, relative to the target set for the plant. Two dimensions of performance have been identified, using factor analysis:.
  - performance on time measures (performance relative to the target set for manufacturing throughput time, delivery lead time and on-time delivery to customers)

- performance on cost and quality measures (performance relative to the target set for unit production cost, productivity of direct workers, defect rates, and overall product quality)

The results of the (mostly non-parametric) comparisons of the four clusters on these variables have been summarized in Figure 2. Only those results have been mentioned that are statistically significant at the 0.05 and 0.10 (shown between brackets) confidence level.

Insert Figure 2 about here

Age of the plant. The number of years the plant has been part of the company differs significantly across the clusters. The average age of the plants in cluster C is over 30 years, whereas the average age of the plants in clusters A and B is 17 and 11 years respectively. The difference between cluster C on the one hand, and clusters A and B on the other hand, is significant ($p < 0.05$). The average age of the plants in cluster D lies in between: it is approximately 20 years. This observation suggests that networking is built over a long period of time.

Size of the plant. We have expressed size in terms of the number of employees. We have analyzed the effects of the total number of employees in the plant, the number of workers, the number of salaried employees, and the number of people in manufacturing staff functions. None of these differ significantly across the clusters.

Focus of the plant. On the basis of the results of the Kruskal-Wallis ANOVA and the median test, we conclude that the plants in cluster A are, on average, market focused, whereas the plants in cluster C, on average, supply a broad market. The plants in cluster A have little inflow and outflow of components and semi-finished goods. On the other hand, the inflow of these goods is high in cluster C, whereas the outflow is high in cluster D. Significance levels are at $p<0.05$.

Investments and capabilities in the plant. The investments in managerial improvement programs are higher in cluster A than in cluster C and B. The difference in managerial investment between clusters A and D is not significant. The level of capabilities is lowest in cluster B (significantly lower than the other clusters at $p<0.10$); it is highest in cluster D, although not all differences are significant.

The level of process investment in cluster D exceeds the process investment level in the three other cases significantly. Plants in cluster D also invest more in planning systems than plants in cluster A (at $p<0.10$ significance). Their level of investment in planning systems also exceeds the level in clusters B and C, although with low significance ($p=0.12$).

Autonomy. There is a significant difference across the clusters in only one of the four autonomy factors: the level of strategic autonomy in decisions concerning the design of the plant ($p<0.05$). It is lowest in cluster A. Cluster D has the highest level of autonomy (although not significantly different from the level of autonomy in cluster C).

Performance of the plant. Although the Kruskal-Wallis test shows no significant difference in cost/quality target performance across the clusters, the Median test suggests (with $p=0.08$ significance) that the cost/quality target performance of the average plant in cluster C is low, whereas it is high in cluster A. We should note, however, that the difference in median is small.

Future Strategic Role of the Plant

We have discussed the relationship between the network position of the plant and the level of strategic role played by the plant. Our research also provides information on the expected changes in the strategic role of the plant. The interviewees were asked to estimate the strategic role of the plant as they expect it to be in 5 years, on the 9-point Likert scale described above.

Figure 3 shows the histogram of the expected change in strategic role, for each of the four clusters. We can see that in each of the clusters positive as well as negative changes are expected, which explains why, on average, little change is observed. However, what strikes in these histograms is that

- whereas in clusters C and D only marginal increases are expected (up to +1, with one exception), large changes are expected in clusters A and B. Increases up to +4,0 (on a 9-point scale) are expected.
- whereas in clusters B, C and D marginal decreases are expected (up to -1 on a 9-point scale), expectations for some of the plants in cluster A are fairly dramatic: decreases are expected up to -5,5.

Insert Figure 3 about here

This suggests that the plants which occupy an integrated position in the network (clusters C and D) are fairly stable in terms of the level of strategic role they play in the company. Some of the A and B plants are expected to experience an important increase in strategic role. Given the relationship that we observed between the role of the plant and its network position, it is fair to expect that these plants will probably be moving from clusters A or B towards cluster C or D. Some of the other plants in clusters A and B, on the other hand, are expected to experience a decrease in strategic role (the expected decrease is very large for a couple of plants in cluster A). It is clear that these two clusters of non-integrated plants are less stable than the two clusters of integrated plants.

An example illustrates our point. One of the plants in the sample has been closed since we started our case research. This plant was one of the “blueprint receivers”. We don’t want to infer here the plants in the "isolated" or "blueprint" clusters are on the waiting list for closure. The examples of plants with a positive expectation in strategic role would certainly contradict this point. Our hypothesis is that the plants in these two clusters are in a variable position, and that this variability may lead towards an increase as well as a decrease in terms of the role the plant plays in tomorrow's network.

DISCUSSION

There is a strong link between the position of the plant in the intangible network of ideas and in the tangible network of goods. The "isolated" plant, which is not actively taking part in the network of ideas is also isolated in a physical sense: it doesn't depend on other plants for its components or semi-finished goods, nor does it provide such goods to the other plants. The network players (type C and D) on the other hand are typically suppliers to the other plants (in the case of cluster D) or customers of the other plants (in the case of cluster C), for components or semi-finished goods.

Secondly, we conclude that the two types of network players, ie. the plants in clusters C and D, have a very different character. The plants in cluster C are typically fairly old, they supply a broad market, and they are characterized by a low level of investment and a fairly low performance. The comments given throughout the interviews add some more elements to these characteristics: these plants were claimed to be characterized by technical competence and product know-how, by complexity, and by a broad product range. It is striking that out of the eight C-plants, four are the "mother plant", the earliest plant in the network, located close to headquarters. The description of the D-plants shown in Figure 2 mentions investments, capabilities, and autonomy. Only one of the D-plants is a “mother plant”. These observations suggest that there are two different scenario’s for the development of plants operating as network players in the international plant configuration. The first scenario builds on the heritage of the plant. The network relationships exist because the plant has been in the network for a very long time; in some cases it even was the very first plant in the company. We hypothesize that, because of its age and because of the broad market it supplies, the plant has gained a lot of experience, which explains why the plant is seen as an important source of innovative ideas by other plants. The plant seems to *undergo* this scenario as the network evolves over time. The scenario that emerges from the characteristics of the type D-plants is more dynamic. These plants build capabilities through investments, under a relatively high level of autonomy. Such plants are actively building network relationships by sending manufacturing staff to other plants and through extensive communication.

Finally, the data suggests that the future perspectives of the plant depend on the plant’s network position. Plants which are strongly embedded in the production network, are expected to maintain the high level of strategic role they are playing in the network. The future of plants in rather isolated positions has been predicted to be in two opposite directions: some plants are expected to grow in strategic importance, and are assumed to develop network relationships; others are expected to become less important, and may even disappear from the manufacturing network. Given the small number of plants in each of the clusters, this conclusion requires verification on a larger sample.

CONCLUSION

In the research, network analysis has been used as a methodology for understanding the position of plants in international manufacturing networks. The focus has been primarily on the intangible know-how network, and secondarily on the physical, logistic network. A typology of plants in a manufacturing network has resulted from the research. Four types of plants, with a different strategic role, different characteristics, and different perspectives for the future have emerged.

The current research suggests that two scenarios for attaining an integrated network position exist: a scenario built on heritage, and a dynamic, bottom-up scenario. Future research should bring more insights into the dynamics of the network position of plants.

REFERENCES

Aldenderfer, M. S. & Blashfield, R. K. 1984. Cluster Analysis: SAGE Publications.

Allen, T. J. 1977. Managing the Flow of Technology: MIT Press.

Bartlett, C. A. & Ghoshal, S. 1989. Managing across borders: The transnational solution: Hutchinson Business Books.

Boyer, K. K. & Verma, R. 1996. A note on the use of multiple raters in survey-based operations strategy research. Paper presented at the Decision Sciences Annual Meeting, Orlando.

Carmines, E. G. & Zeller, R. A. 1979. Reliability and validity assessment: Sage Publications.

Chew, B. W., Bresnahan, T. F., & Clark, K. B. 1990. Measurement, coordination and learning in a multiplant network. In R. S. Kaplan (Ed.), Measures for manufacturing excellence: 129-162: Harvard Business School Press.

Collins, R. S., Schmenner, R. W., & Whybark, D. C. 1989. Pan-European manufacturing: the road to 1992. European Business Journal, 1(4): 43-51.

De Bodinat, H. 1975. Influence in the multinational corporation: The case of manufacturing. Unpublished Unpublished doctoral dissertation, Harvard University, Graduate School of Business Administration.

DeVellis, R. F. 1991. Scale development. Newbury Park: Sage Publications.

Doz, Y. L. & Prahalad, C. K. 1991. Managing DMNCs: A search for a new paradigm. Strategic Management Journal, 12: 145-164.

Eisenhardt, K. M. 1989. Building theories from case study research. Academy of Management Review, 14(4): 532-550.

Ferdows, K. 1989. Mapping international factory networks. In K. Ferdows (Ed.), Managing International Manufacturing: 3-21: Elsevier Science Publishers.

Flaherty, M. T. 1996. Global Operations Management: McGraw Hill.

Galbraith, J. R. 1977. Organization Design: Addison-Wesley.

Gerlach, M. L. 1992. The Japanese corporate network: a blockmodel analysis. Administrative Science Quarterly, 37: 105-139.

Ghoshal, S. 1986. The innovative multinational: A differentiated network of organizational roles and management processes. Unpublished Unpublished doctoral dissertation, Harvard Business School.

Ghoshal, S. & Bartlett, C. A. 1988. Creation, adoption, and diffusion of innovations by subsidiaries of multinatinal companies. Journal of International Business Studies(Fall): 365-388.

Ghoshal, S. & Bartlett, C. A. 1990. The multinational corporation as an interorganizational network. Academy of Management Review, 15(4): 603-625.

Ghoshal, S., Korine, H., & Szulanski, G. 1991. Interunit communication within MNCs: The influence of formal structure versus integrative processes: INSEAD (Fontainebleau).

Ghoshal, S., Korine, H., & Szulanski, G. 1994. Interunit communication in Multinational Corporations. Management Science, 40(1): 96-110.

Gupta, A. K. & Govindarajan, V. 1991. Knowledge flows and the structure of control within multinational corporations. Academy of Management Review, 16(4): 768-792.

Hayes, R. H. & Schmenner, R. W. 1978. How should you organize manufacturing? Harvard Business Review(January-February): 105-119.

Hayes, R. H. & Clark, K. B. 1986. Why some factories are more productive than others. Harvard Business Review, 64(September-October): 66-73.

Knoke, D. & Kuklinski, J. H. 1982. Network analysis. Newbury Park: Sage Publications.

Kogut, B. 1989. Research notes and communications: A note on global strategies. Strategic Management Journal, 10: 383-389.

Miles, M. B. & Huberman, A. M. 1994. Qualitative Data Analysis (2nd edition ed.): SAGE Publications.

Mintzberg, H. 1979. The structuring of organizations: A synthesis of the research: Prentice Hall Inc.

Nohria, N. 1992. Is a network perspective a useful way of studying organizations ? In N. Nohria & R. G. Eccles (Eds.), Networks and Organizations: 1-22: Harvard Business School Press.

Schmenner, R. & Rho, B. H. 1990. An international comparison of factory productivity. International Journal of Operations and Production Management, 10(4): 16-31.

Speier, C. & Swink, M. 1995. Manufacturing strategy research: An examination of research methods and analytical techniques: University of Oklahoma, College of Business Administration.

Yin, R. K. 1984. Case study research: Design and methods. Beverly Hills: Sage Publications.

APPENDIX A

Questionnaire item for flow of innovations

We define innovation here as the development and introduction of something new that is developed for the first time in your company. It need not be new for the world, but only for your company. We will consider three types of innovations:

- the development and production of a new *product* (this may be an important change to an existing product, the creation of a new product within an existing product family, or the creation of a whole new product family)
- the development and introduction of a new *production process* (for example, investment in new machinery or equipment, automation of part of the production process, introduction of an FMS)
- the implementation of a new *managerial system* (for example, the implementation of a JIT-system, a new planning system, a new quality management procedure, a BPR-project, a throughput time reduction program, a setup time reduction program)

Do you know of any innovations (product, process or administrative) that have been developed at a certain plant, and have been adopted in other plants of your company ? Focus on the past 3 years only.

Please indicate in the table below which plants have benefited from innovations developed at these plants. Specify each of these innovations by giving a brief description.

		PRODUCT INNOVATION				
		and adopted at plant				
innovation		HQ	plant a	plant b	plant c	…
developed	HQ	-				
at plant	plant a		-			
	plant b			-		
	…					-

(An identical table was inserted for production process innovations and for managerial innovations)

APPENDIX B

Questionnaire item for flow of people (traveling)

During the past 12 months, you may have spent some time in headquarters, or in other plants of your company.

In the table below, indicate how much time, in full day equivalents, you spent in headquarters and in the other plants.

Time spent in headquarters and/or other plants during past 12 months (IN DAYS)	
in headquarters	
in plant a	
in plant b	
in plant c	
…	

APPENDIX C

Questionnaire item for communication

Please indicate for each of the colleagues listed on the facing page *how frequently you personally communicate* with the person.

This communication may be formal or informal; it may be on business or non-business issues; it may be face-to-face, over the phone, through fax or e-mail.

FREQUENCY OF COMMUNICATION WITH COLLEAGUES	DAILY	WEEKLY	MONTHLY	A COUPLE OF TIMES A YEAR	ONCE A YEAR	LESS THAN ONCE A YEAR	NEVER
person x HQ							
person y HQ							
person z HQ							
person u plant a							
person v plant a							
person w plant a							
… plant b							
… …							

FIGURE 1

Network typology of plants: a graphical representation

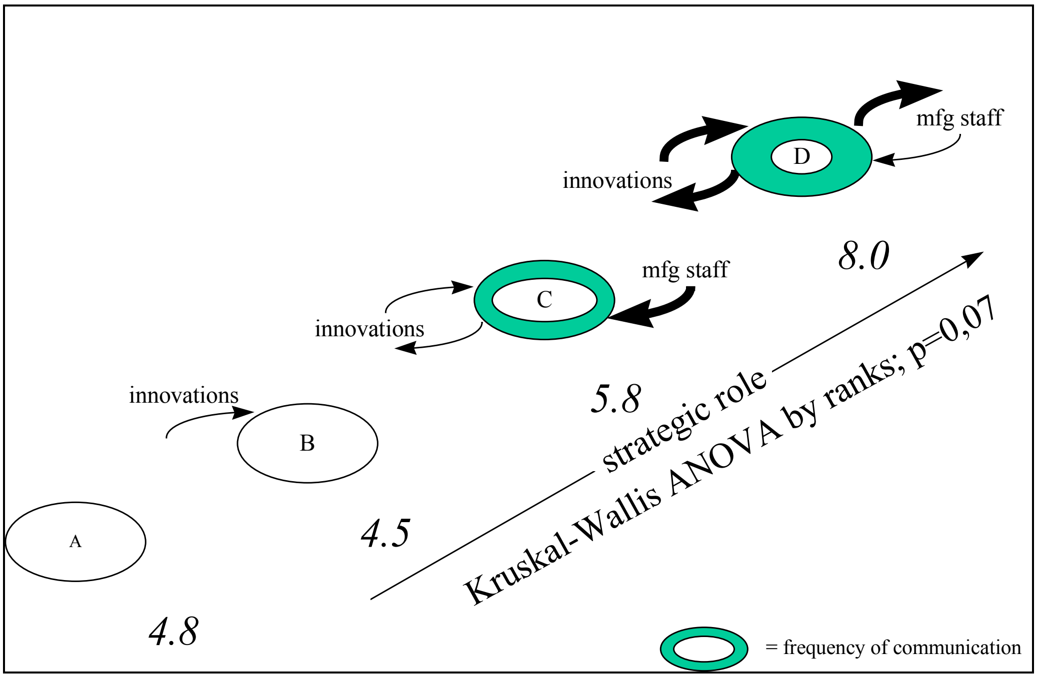


FIGURE 2

Cluster characteristics

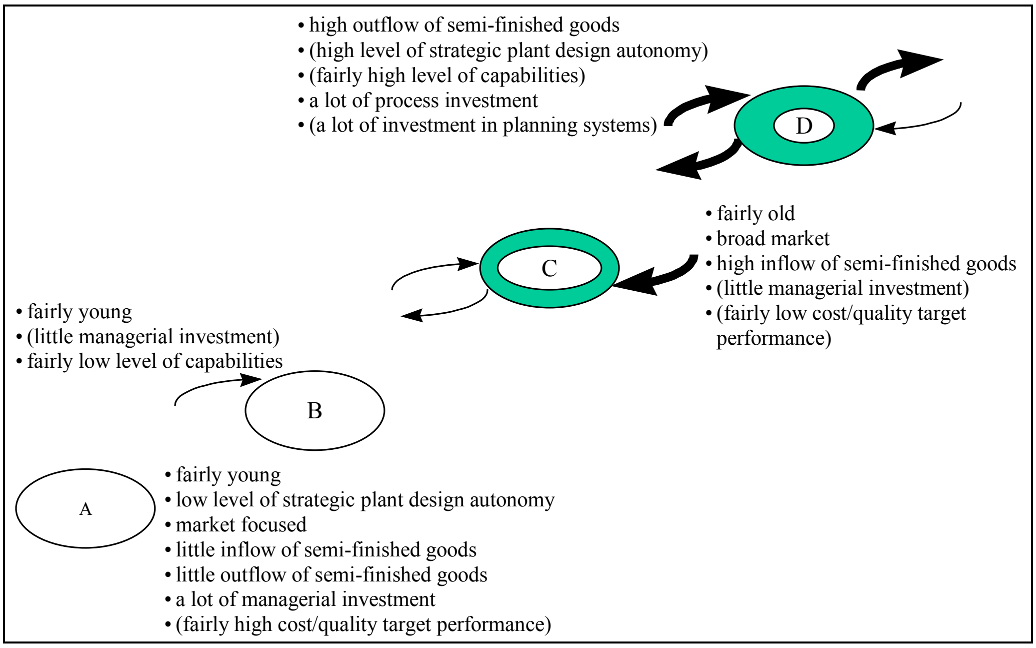
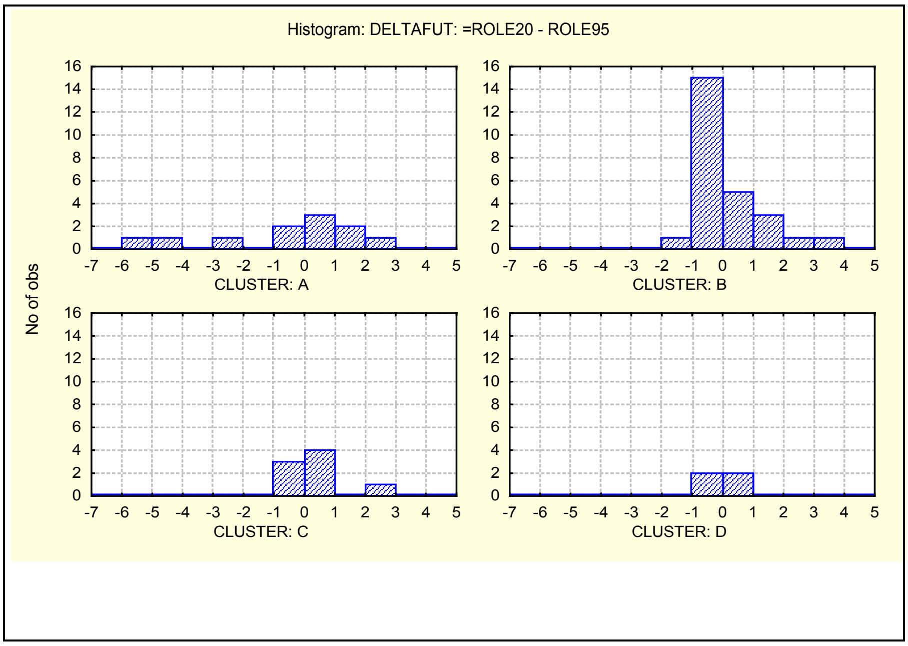


FIGURE 3

Expected change in strategic role by network type



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