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Vlerick Leuven Gent Management School

the Autonomous Management School of
Ghent University and Katholieke Universiteit Leuven

RESEARCH REPORT

THE POSITION OF PLANTS IN FLANDERS WITHIN GLOBAL MANUFACTURING NETWORKS: BENCHMARKING TOOL

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July 2009

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- **Creativity Class** for young high-potentials
- **Flanders DC Fellows**, inspiring role models in business creativity
- **Creativity Talks**, monthly seminars on business creativity and innovation
- **Innovix,** online innovation management game
- **Flanders DC Academic Seminars:** research seminars on business creativity and innovation
- **TeamScan**, online tool

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TABLE OF CONTENT

LIST OF FIGURES

TABLE OF CONTENT

The purpose of this report was to develop a benchmarking tool that makes it possible to classify plants according to their role in the international innovation and knowledge manufacturing network. Research for this report included the creation of the tool based on previous research and a pilot study in 5 Flemish plants.

The findings of the pilot study indicate that there is a need for a benchmarking tool since the respondents, plant managers, have no clear vision about the current network position of their plant. Both suppliers and customers are important network actors besides the headquarters, sister and partner plants in a global manufacturing network. The results of the validity tests and pilot study prove the value of the tool.

We can conclude that our tool is able to take a “picture” of a plant by surveying one manager in this single plant. In such a way, the tool provides insight into the network position of the plant by asking detailed questions on innovation transfer, communication and plant visits.

As competition is globalizing and the environment in which companies operate becomes increasingly complex, managing an integrated international network is a crucial task for manufacturing managers. It is commonly accepted that one of the main reasons for the existence of multinationals is the possibility to acquire, create, and transfer technological assets across national boundaries (Collinson, 2009; Dunning, 1993). Networking can therefore be seen as highly important for the future competitiveness of production plants (Collinson & Morgan, 2009) in Flanders. A global manufacturing network consists of different types of plants. Those plants play a different strategic role in the company, have their own focus, and differ in age, autonomy, and level of resources and investments. The evolution of the plant depends to some extent on the network role of the plant. One earlier research has shown that plants that play the role of 'lead plants', which means they innovate and actively share their innovations with the other plants in their network, are likely to survive. In contrast, plants that occupy a more isolated position are more likely to disappear (Vereecke, Van Dierdonck, & De Meyer, 2006). Moreover, coordination with suppliers and customers helps to improve the performance of the plant (Vereecke & Muylle, 2006).

In this report we will describe the development of a benchmarking tool that allows us to measure the network position of production plants.

A. Research scope

The research project builds on some earlier research studies:

1 PhD study of Ann Vereecke (1997) in eight multinational companies. In this case-based research, a typology of plants has been developed classifying plants according to their position in the manufacturing network of their multinational company. The typology has been derived from data collected in 1995-1996.
2 Research project conducted by Ann Vereecke, for FDC, showing the impact the network role of plants in multinational companies has on their future growth, or alternatively, on their chances for survival (see FDC research report July 2007, Ann Vereecke, "Network relations in multinational manufacturing companies"). These conclusions have been drawn from a comparison over a ten year period (1995-1996 and 2005-2006) of the manufacturing network of the eight multinational companies.
3 Research carried out by Ann Vereecke and Steve Muylle on the IMSS database, showing the impact of networking with suppliers and customers on firm performance (Vereecke & Muylle, 2006).

The conceptual model underlying the tool is to a large extent based on the model of Ferdows (1997), describing the strategic role of plants and on the typology of the position of plants in global manufacturing networks developed in our previous case-based, empirical research (Vereecke, 1997).

The eight multinationals that have been studied in 1995-1996 and again, in 2005-2006 had gone through major changes over this 10-year period. Four of them agreed to participate in the pilot study of our current research project.

1 **Case A:** Company A was a manufacturer of steel products, with headquarters in Belgium, and with manufacturing units all over the world. Over a period of ten years this company had become an even more global player, by establishing plants in Eastern Europe, China, India, Indonesia, Russia and Brazil.
2 **Case B:** Company B was a family owned textile company, with headquarters in Belgium. When participating to the 1995-1996 study, the manufacturing units were mainly concentrated in Belgium, although two units were located abroad, namely in Ireland and in the USA. The major change in Company B came from closing down some of its factories, ten years later. By now, only two plants are left, one in Belgium and one in the USA. Changing the business model, Company B has strong relations with partner plants in India, China and Pakistan. Those three plants are no official sister plants, but they are included in the global manufacturing network as partner plants.
3 **Case C:** Company C was headquartered in the USA. It was divided into three divisions: the USA, Mexico and Europe. The research in 1995-1996 focused on the European division only, which had its local headquarters in Belgium. This division had manufacturing units spread over Europe. For part of its business, Company E had established strong partnerships with some East

European manufacturers. Although these suppliers were not legally part of company E, they were included in the research, since operationally they were tightly linked to the company. Over time, the partnerships with subcontractors in Eastern Europe stopped, and company E now has its own manufacturing facilities in China and India.

4 **Case D:** Company D was headquartered in the USA. The company produced plastic products. The European division had its operations headquarters in Belgium. The division produced in five European countries, and supplied the European market. This European division was also responsible for the plant in South Africa. The major change in Company D for the period 2005-2006 had been in rationalizing the plants network, which had resulted in the closure of one of the plants. Today, part of the volume is sourced through subcontractors. In 2009, the division contains a total of 13 plants around the world. Four of them are located in Europe.

B. Objective of the project

The purpose of the research project is to develop a tool that makes it possible to classify the plants according to their role in the international innovation and knowledge manufacturing network. This classification is based on several variables. First, the degree to which plants share innovations (in product, processes and systems) with sister/partner plants, suppliers and customers. Second, the degree to which manufacturing staff people are travelling through their network. Third, the degree of communication between the managers in the plants, in headquarters, suppliers and customers (Vereecke et al., 2006).

The tool (see Exhibit 1) is web-based and can be used as a self-assessment by any plant in Flanders, to benchmark the plant against the 'typical' plant in Flanders. Moreover, the tool can be used to benchmark the plants located in Flanders against plants located in other regions in the world.

The development of the benchmarking tool included the following steps:

1 A questionnaire has been developed, based on the above mentioned IMSS questionnaire and on the questionnaire that had been developed for the above mentioned FDC research project. To make this "new" questionnaire useful for benchmarking purposes, we faced the challenge to measure the network position of the individual plant, without the need for input from all other plants in the network.

   The validity of the newly developed questionnaire has been tested by simulating the use of the "new" questionnaire on the old data (1995-1996) and comparing the results with the results obtained on the same data using the "old" way of data collection.

2 Interviews with a selection of 5 plants in Flanders which are part of multinational groups, to fill out the questionnaire. This provided us with a first database of 5 plants in Flanders. (The initial proposal described the ambition to test the questionnaire on 30 plants. However, obtaining access to the plants turned out to be more sufficient than anticipated, leaving us with 5 useful cases).

3 Footprint of the plants in Flanders: data analysis to conclude on the position and role of the "typical" plant in Flanders in its global network of sister plants and in its supply chain (preliminary results at this stage).

4 Development of a web-based tool to offer the survey as an assessment tool to interested companies on an ongoing basis.

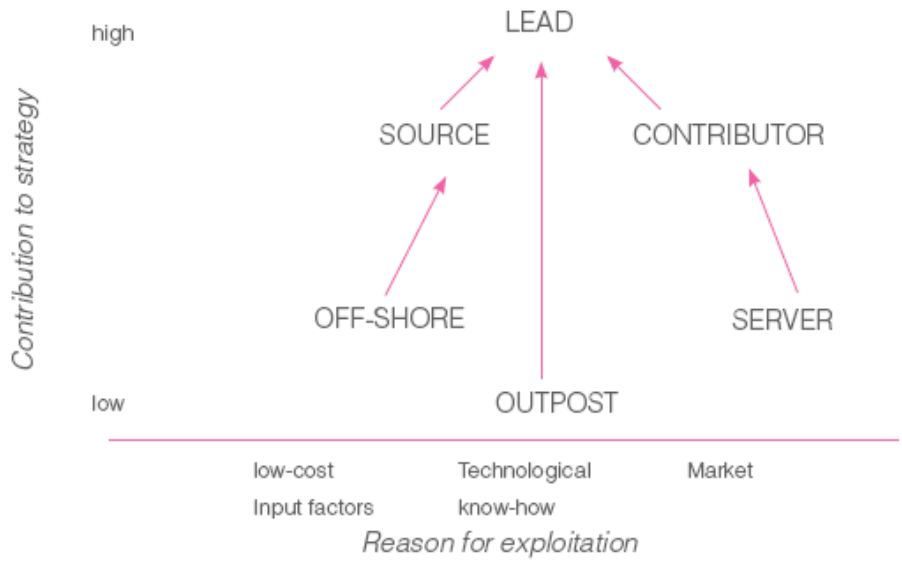
The purpose of the tool that has been developed has been to assess the position of the plant in its network. The scope of this network is the sister plants of the plant under study, as well as its key suppliers and customers. As mentioned earlier, the position of the plant in the network is described with respect to two existing frameworks: The first one is the conceptual framework developed by Kasra Ferdows, describing the strategic role of the plant (Ferdows, 1997). The second one is the typology that has been derived empirically in our own research (Vereecke et al., 2006). Both models are discussed briefly here.

A. The strategic role of the plant – Kasra Ferdows

Ferdows' framework describes six possible types of factories, based on two dimensions (see Figure 1):

- The primary advantage for exploiting the plant, that is, market proximity, availability of low-cost input factors, and the availability of skills or know-how.
- The degree of contribution of the plant to the company's strategy, ranging from "low" for factories that have as their sole role to get products produced, but are also important "developers and providers of know-how" for the other plants in the network. Another way of defining this second dimension is by referring to the plant's competence, which may include, next to production, also process technical maintenance, procurement, local logistics, production planning, product and process technical maintenance, procurement, local logistics, production planning, product and process development and improvement, development of suppliers, the supply of global markets, and a global hub role for product and process knowledge (Ferdows, 1997). This vertical axis is labelled as the "level of strategic role" (Vereecke, 2007).

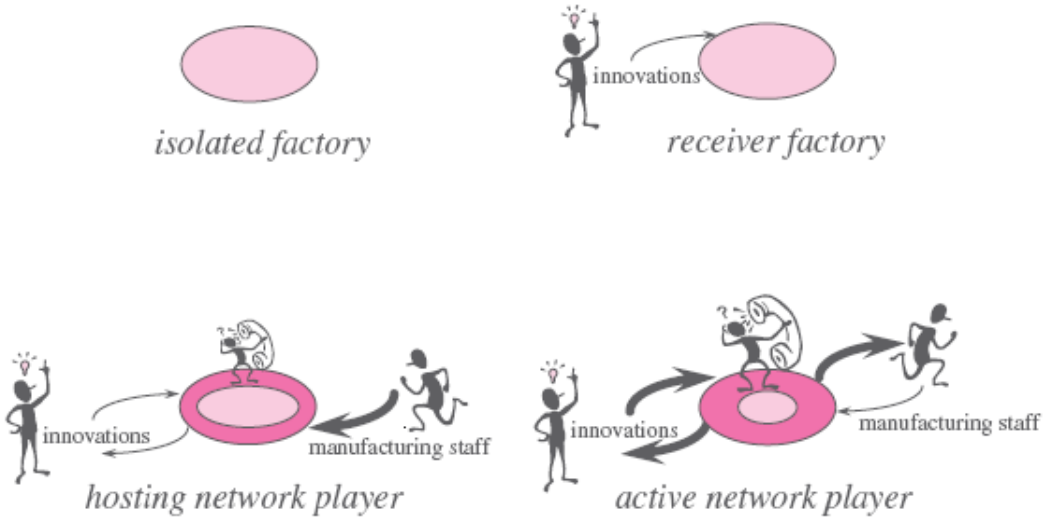
Figure 1 Strategic role of the plant (Ferdows, 1997)



1 The network position of plants – empirical classification

The second typology (see Figure 2) is derived from initial research results in 1995-1996. The plants were classified into categories by using cluster analysis, based on the data collected in 1995-1996. Four types of plants have been identified, ranging from very isolated plants, to highly integrated plants (Vereecke et al., 2006). These four types differ in terms of the extent to which the plants have established network relationships with other plants in the network and/or with headquarters. The knowledge flows in the manufacturing network can be seen as the primary focus in this typology. These knowledge flows have different formats. A first important one is the transfer of innovations in the network. An explicit flow of knowledge takes place whenever innovations developed in a site are transferred to and implemented in a plant that belongs to the network. A second and informal flow of knowledge occurs when managers of different sites talk to each other, or visit one another's site. Therefore, the level of communication between managers across plants has been measured, as well as the number of days manufacturing staff people from each plant have visited the other plants in the network.

Figure 2 Network position of plants – typology (Vereecke, De Meyer, Van Dierdonck, 2006)



1 The first category consists of the "isolated" plants. Few innovations are transferred from the isolated plant to other units and few innovations reach this plant. Moreover, there is little communication between the manufacturing staff people of this plant and the other manufacturing managers in the network. The plant receives few visits from sister plants or headquarters, in addition the plant visits rarely other plants or headquarters in the network.
2 Similar to the isolated factories are the "receiver" plants. They differ from the isolated factories on one aspect only: they receive quite a few innovations from other factories in the network and/or from headquarters.
3 The third category of plants consists of the "hosting network players". Those plants have established strong network relationships. There is a high level of communication with other units in the network and the hosting network players exchange a lot of innovations with the other

units. They do not only transfer innovations to the other plants, they also benefit from innovations developed elsewhere. Typical is that they are frequently hosting visitors from other plants in the network and from headquarters.

4 The fourth category encloses the “active network players”. The main difference with the previous category lies in the intensity of communication and of innovation transfers, and the dominant direction of the flows of visitors. These plants communicate intensively with other units in the network. They share very actively innovations and they are not only hosting visitors from other factories, they also pay lots of visits to the other plants.

Part of the benchmarking tool is using an adaptation of the questionnaire used in 1995-1996. In developing the benchmarking tool, we had to take into account that the level of detail in data collection in 1995-1996 would not be feasible in the use of the benchmarking tool. The data collection was very detailed, and followed a two-step approach: data was gathered at two levels of analysis, the plant and the company.
The main suppliers and customers have been added as units in the network for the benchmarking tool. Moreover, this will allow us to assess not only the intensity of the network relationships with sister plants, but also with the main external partners in the supply chain.

1 Interviews were conducted with the general manager and with manufacturing managers at headquarters. In total data has been collected on 59 manufacturing plants, through 37 interviews. The number of interviews varied between 2 and 6 per case. A structured questionnaire with closed and open-ended questions was used as a guide through the interviews.
2 A second questionnaire was sent to the plant managers and/or the manufacturing managers in the distinct production plants. The number of questionnaires returned from the plants varied between 1 and 5 per plant.

More information on the initial research methodology can be found in Vereecke, Van Dierdonck and De Meyer (2006).

As mentioned before, the goals of the research project reported here has been to develop a benchmarking tool, using a revised version of (part of) the questionnaire that has been used in 1995-1996. The revisions/modifications to the initial approach were needed for the following reason:

1. Whereas the initial questionnaires have been sent to a manager in both headquarters and the plant, our intension in the benchmarking tool has been to rely only on the perception of the plant management (for practical reasons).
2. In the initial approach the questionnaire was sent to all plants in the network, which gave us a complete view on the entire network. In the new study, data will be collected on a single plant in the network, which will give a partial view only. This asked for rephrasing some of the questions.
3. The initial study relied on multiple respondents per plant. The new study relies on single respondents.
4. Not only does this require some modifications to the questionnaire, it also asks for a validity check. We checked the validity of the assessment tool by comparing the old method of data collection (1995-1996 study) with a simulation of the new method of data collection (2009) on the old data of 1995-1996. After the validation of the tool, we conducted a pilot study in four of the multinationals that participated in the previous network studies. Initially all eight multinational companies were contacted. They all provided us with the necessary information concerning the plant managers in Flanders. Eventually five plant managers were willing to participate. The pilot study thus contained five plants located in Flanders. We visited each plant and provided the plant manager with the questionnaire on hard-copy, since there was not yet a web-based tool available. They completed the questionnaire in our presence. The duration was about 30 minutes. Afterwards they had the opportunity to give some comments. This information allowed us to optimise the tool before implementing it as a web-based benchmarking instrument. The web-based tool will be available online as of the 14th of July.

The following variables are measured in the assessment tool:
1 Main advantages of the plant's location (see Exhibit 1, p34)
2 The level of strategic role of the plant (see Exhibit 1, p35)
3 The intensity of the flow of goods between the plants (see Exhibit 1, p36)
4 The intensity of communication with headquarters, sister plants, suppliers and customers (see Exhibit 1, p38)
5 The degree of innovativeness of the plant (see Exhibit 1, p41)
6 The intensity of transfer of innovations to and from the plant (see Exhibit 1, p42)
7 The intensity of flow of people to and from the plant (see Exhibit 1, p44)
8 The current network position of the plant (see Exhibit 1, p46)

These variables will be explained in the next section. The interviews with the plant managers in the pilot cases were used to improve and refine the questionnaire. Exhibit 2 summarizes the modifications based on the remarks of the pilot study respondents.

1 Level of strategic role of the plant

As in the 1995-1996 study, we measure the level of the strategic role of the plant on a 9-point Likert scale. Therefore, we ask the respondents to score their plant on this scale. The following descriptions have been attached to the scores:
1 The main goal of the plant is "to get the products produced". Managerial investment in the plant is focused on running the plant efficiently.
3 The plant has sufficient internal capabilities to develop and improve its own components, products and production processes.
5 The plant is a focal point for the company for the development of specific important components, products or production processes.
7 The plant develops and contributes know-how for the company.
9 The plant is a "centre of excellence", and serves as a partner of headquarters in building strategic capabilities in the manufacturing function.
The current strategic role of the plants is measured, as well as the level of strategic role five and ten years ago, and the expected level five years ahead.

2 Main reason for exploitation

We ask the respondents to indicate on a list of potential reasons for exploitation the three main advantages that the plant's location provides today.
The advantages should be scored as 1, 2, 3. A score of 1 reflects the most important main advantage, whereas a 3 refers to the third most important main advantage.

3 Network position of the plant

In the 1995-1996 study, the network units considered in the manufacturing network of the multinational company were all the plants and the managers in headquarters responsible for manufacturing. The network relations considered in the assessment tool were the flows of innovation, the use of coordinators and the communication between the units in the network.
The network position of the plant was studied in a detailed and rigorous way.

1 The flow of goods (components and semi-finished goods) between the plants was measured by asking the volume of transfers.
2 The innovation transfers were measured by asking plant managers (through the mail questionnaires) and headquarters (through the interviews) to enumerate and describe the transfers of product, process, and managerial innovations they knew of over the previous three years. The information that had been gathered was checked, complemented and corrected by at least one manager in headquarters, in the course of the in-depth interviews.
3 The presence of coordinators was operationalized as the extent to which people were travelling from one unit to another. This information on people flows had been collected through the mail questionnaire to the plants. The respondents had to report the number of days they had spent, over the previous year, in headquarters and in each of the plants in the company's network.
4 The communication between the plant managers and headquarters was measured by one of the questionnaire items. The respondents had a list of all manufacturing staff people, and were asked with whom on this list he/she had communicated daily, weekly, monthly and less then monthly. By providing a list we tried to diminish the data validity problem of recollection.

Cluster analysis was used to identify different types of plants, according to their position in the know-how network of their company.

In the 2009 benchmarking tool, the network position of the plant is measured in a similar way. Nevertheless, an important difference exists in the fact that the assessment tool relies on one respondent, i.e. the plant manager, for each plant that participates through the tool. Also, because of the importance of customers and suppliers, those two network actors are now added to the questionnaire items.

1 The respondents have to indicate whether their plant receives components or semi-finished goods from other plants (sister plants and partner plants). In addition, they should also be indicated if the plant transfers components or semi-finished goods to other plants in the network. (see Exhibit 1, p36)
2 The plant managers are asked to enumerate the transfers of product, process, and managerial innovations they know of over the past three years. The main customers and main suppliers are also included in the transfer of innovations. Before enumerating the innovation transfers, the respondent should rate the level of innovativeness for his/her plant on a scale from 1 (not innovative) to 9 (highly innovative). A distinction is made between three types of innovations: new product development, new production process development and new managerial systems. The questionnaire contains an item that focuses on innovations developed by other units in the network and adopted by the plant of the respondent, while a second item asks to enumerate innovations developed in the respondent's plant and transferred to other units. (see Exhibit 1, p 41)

3 Furthermore, the respondents have to report the number of days they spent, over the previous year, in headquarters, in each of the plants in the company's network and with the main customers and main suppliers. Moreover, the tool asks the number of days the concerning plant was visited by those network actors. (see Exhibit 1, p44)
4 The communication on management level between the plants and headquarters is measured by a questionnaire item that consists of a list of all sister plants, partner plants, headquarters, main customers and main suppliers in the global manufacturing network. The respondent is asked with whom on this list he/she has communicated daily, weekly, monthly and less than monthly. Contrary to the 1995-1996 questionnaire, we could not provide the names of all manufacturing staff people in the questionnaire list. The questionnaire item refers to the manufacturing staff people as a whole without differentiation between individuals. (see Exhibit 1, p38)

In addition to the questionnaire items used in the 1995-1996 study, we add a question that asks for an estimation of the current network position based on the network position of plants typology (Vereecke et al., 2006). The respondents have a short description of each type and they are asked to identify the plant type that best describes his/her plant. (see Exhibit 1, p46)
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The goal of the benchmarking tool is to provide managers an insight into the network position of their plant based on their own perception/knowledge of the role of their plant, through a self-administered questionnaire, with a reasonable effort and time needed to fill out the questionnaire. This, naturally, puts an important constraint on the design of the questionnaire. It is important for us to understand to what extent the "picture" taken of a plant by surveying one manager in this single plant, corresponds to the "picture" we would obtain by surveying several managers in all plants in the network (including headquarters). This validity test is explained in this section.
Validity has been tested using the 1995-1996 data on flows of communication, innovation, and people. We constructed a new dataset, by selecting the responses of a single respondent, the plant manager, and by calculating the network measures for his/her plant using this data. These network measures were then compared to the network measures that were obtained using the data from all respondents.

Our primary network measure has been the centrality of the plant in the network. If network relations are mutual, we measure centrality of a unit through its degree (as is the case for communication). The degree of a unit is defined as the proportion of other units with which a unit has a direct relationship. If network relations are not mutual, two degree measures are used: the unit's indegree and outdegree (as is the case for the flows of people and innovations). The indegree of a unit is defined as the proportion of relations received by the unit from all other units. The outdegree of a unit is defined as the proportion of relations from that unit to all other units (Knoke & Kuklinski, 1982).
The following network variables were defined for examining the validity of the instrument:

1 The *communication centrality* of plant i captures the frequency of communication of the manufacturing staff of plant i with the manufacturing staff of the other units in the network.
2 The *innovation indegree* of plant *i* captures the intensity of the innovation flow transferred (and implemented) from other units to plant *i*.
3 The *innovation outdegree* captures the intensity of the innovation flow transferred and implemented from plant *i* to the other units.
4 The *people indegree* of the plant captures the number of days plant *i* has received visitors from the manufacturing staff team of the other plants.
5 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.

First, we checked the validity of the questionnaire item that measures the communication between the managers in the plants and the headquarters. The total number of 49 plants for which data was available were included. We have simulated that a single respondent, the plant manager, fills out the survey. We then calculated the communication centralities of each plant. In order to determine how this single respondent would have scored the intensity of the communication by his plant management team with the plant management team in the sister plants, we selected the highest frequency of communication with the different colleagues in each plant. An example will explain this method. Plant X had four respondents (managers) in the 1995-1996 questionnaire. The first respondent indicated a weekly based communication with one of the managers from sister plant Y. The second respondent from plant X claimed to have daily communication with one of the managers of sister plant Y, while the third respondent communicated almost never with the plant management team of plant Y. The simulation method used in the 2009 survey focuses solely on the highest

frequency of communication, indicated by one respondent. By that, the frequency of communication between plant X and Y is measured as daily. The respondent should automatically provide us the highest frequency of communication when taking into account the communication of his entire plant management team with the other network units.

We calculated the centralities based on the highest frequency of communication for each plant with their sister plants and headquarters. The obtained variable has been standardized prior to the clustering. Three levels were distinguished: “low” for average value below 0; “medium” for average level between 0 and 1; and “high” for average value above 1.
Exhibit 3 lists the plants with their communication centralities for both methods.
The validity test results are summarized in Tables 1, 2 and 3.

Table 1 Communication Centrality 1995-1996

	Communication centrality			
	LOW	MEDIUM	HIGH	Total
Number of plants	37	8	4	49

Table 2 Communication Centrality 2009

	Communication centrality			
	LOW	MEDIUM	HIGH	Total
Number of plants	32	9	8	49

Table 3 Communication Centrality

	Number of plants correctly classified	Number of plants incorrectly classified
LOW	29	3
MEDIUM	4	5
HIGH	3	5
Total	36	13

A total number of 36 plants (that is 73%) were correctly assigned to the “low”, “medium” or “high” category. 3 out of the 8 companies had a perfect match on their communication centrality, compared with the results of 1995-1996. Another three companies have solely one plant that was categorized differently. Finally we noticed that two companies have an almost completely different communication centrality outcome if we take into account the highest frequency in the 1995-1996 data. This is caused by strong variation in communication frequency, dependent on the individual members from the plant management team. For example, manager A from plant Z communicates daily with sister plant X. The other managers from plant Z communicate monthly with sister plant X. Our tool solely calculates the centrality based on the highest frequency. In contrast, the 1995-1996 study took an average from the individual communication frequencies for each plant. As a consequence, this plant will be categorized differently when using the tool, compared to the approach used in the 1995-1996 study.

We observe that for 9 of the 13 incorrectly classified plants, the error was modest. By that we mean a class mistake of 1, for example classified as medium while it should be low.
The objective of attaining a perfectly valid indicator is unachievable. Instead, validity is a matter of degree, not an all-or-none property (Carmines & Zeller, 1990). In conclusion we can say that most of the plants have a similar communication centrality like in the 1995-1996 study. Thus, one plant manager is fairly well able to provide the frequency of communication on management level between his/her plant and the sister plants, headquarters in the global manufacturing network.

Second, the validity of the transfer of innovations by simulating the responses we would obtain with the 2009 tool on the 1995-1996 data for 49 plants and comparing this to the classification that resulted from the 1995-1996 questionnaire. Whereas the 1995-1996 measurement consisted of interview data from headquarter managers completed with mail questionnaire data from plant managers, the 2009 survey measurement will collect data from the plant managers only.

We calculated the innovation indegree and outdegree of each plant, according to the method used in the assessment tool. That is, the respondent has to indicate whether there are innovation transfers between his/her plant and the plants that are part of the global manufacturing network (see page 42). The respondent should respond on three different zero/one variables (one for each type of innovation, without giving a description). We made a sum of the three innovation types to achieve a measure of the intensity of the total transfer of innovations. Next, the indegree and outdegree were calculated. The obtained variables have been standardized prior to the clustering. Three levels were distinguished: “low” for average value below 0; “medium” for average level between 0 and 1; and “high” for average value above 1. This way of working is therefore identical to the way of working in 1995-1996, with the only difference that the question is now asked to a single respondent in a single plant, instead of a list of respondents from all plants and headquarters.
Exhibit 3 lists the plants with their innovation centralities for both methods. The test results are summarized in Tables 4 to 7.

Table 4 Innovation Degrees 1995-1996

	Innovation indegree				Innovation outdegree			
	LOW	MEDIUM	HIGH	Total	LOW	MEDIUM	HIGH	Total
Number of plants	11	3	4	49	37	8	4	49

Table 5 Innovation Degrees 2009

	Innovation indegree				Innovation outdegree			
	LOW	MEDIUM	HIGH	Total	LOW	MEDIUM	HIGH	Total
Number of plants	27	15	7	49	33	6	10	49

Table 6 Innovation Indegree

	Number of plants correctly classified	Number of plants incorrectly classified
LOW	11	16
MEDIUM	14	1
HIGH	1	6
Total	26	23

Table 7 Innovation Outdegree

	Number of plants correctly classified	Number of plants incorrectly classified
LOW	30	3
MEDIUM	2	4
HIGH	3	7
Total	35	14

The innovation indegree level is correctly assigned to 26 of the 49 plants or 53%, whereas the outdegree level was right for 35 plants of the total number of 49 or 71%. The classification error measures 1 class for 22 of the 23 incorrectly classified plants concerning the innovation indegree. This is also true for the innovation outdegree for 11 of the 14 plants.

The relative high number of false clustering on this item is caused by the fact that we did not take into account the innovation transfer information provided by the headquarter managers. Our tool relies on the answers of one respondent without the input of headquarter managers or additional managers in the plant management team. The observed difference is explained by the fact that single respondents fail to list all transferred innovations that would be listed by a group of respondents, simply because of not knowing or not recollecting all innovation transfers.
The recollection problem can be reduced by providing a list of examples of innovation transfers in the questionnaire.

1 PRODUCT INNOVATIONS
design of a product, design of the collection, product improvements, new specifications, development of prototype, etc
2 PRODUCTION PROCESS INNOVATIONS
new machinery, design of new processes, production process modifications, etc
3 MANAGERIAL INNOVATIONS
quality management (ISO, Six Sigma, etc), organisation of human resources, rewards and incentives system, organization of the production shifts, lean manufacturing concepts, etc

The lack of knowledge on transfers will remain. With a sufficiently large number of plants, we can use this new data to recalculate the cut-off levels to distinguish between low, medium and high innovation transfer intensity. For the moment, we have to accept that the innovation degree measures are somewhat underestimating reality.

Finally, we studied the validity of the centrality measures concerning the flow of people in the network. The people indegree and outdegree were computed for each plant by using the method of the assessment tool. In the 2009 tool, the single respondent is asked to estimate the number of days his plant management team visits the other units in the network (and vice versa). It is fair to assume that this respondent will report the number of days on which there have been visits, irrespective of the number of visitors.

An example will illustrate the difference between the 1995-1996 method and the new method. Suppose that plant X had three respondents (managers) in the 1995-1996 questionnaire. The first respondent indicated that he spent 20 days in plant Y. The second respondent from plant X visited plant Y during 14 days, while the third respondent only visited plant Y for 1 day. In total, according to the 1995-1996 analysis method, this gave us 35 days of visit of the management team of plant X to plant Y. Since we do not know whether the three managers were visiting the plant together or separately, all we know is that the 2009 benchmark tool will give us a response that lies between 20 and 35. In our simulation of the 2009 survey on the 1995-1996 data, we selected the highest frequency of flow of people, indicated by one respondent. By that, the frequency of visits, between plant X and Y in our example is measured as 20 days. The largest discrepancy between the old and the new method would occur if all visits are done together, in which case the new method would give us 20 days as the intensity of visits. In our simulation, we have therefore used the worst case as the basis of our validity test.

We calculated the degrees based on the highest number of visiting/hosting days for each plant in their global manufacturing network. The obtained variable has been standardized prior to the clustering. Three levels were distinguished: “low” for average value below 0; “medium” for average level between 0 and 1; and “high” for average value above 1. Given that the data has been standardized, it is fair to expect that the impact of measuring a lower number of days of visits will be minor on the estimation of the centralities.
Exhibit 3 lists the plants with their flow of people centralities for both methods. The test results are summarized in Tables 8 to 11.

Table 8 Flow of People Degrees 1995-1996

	People indegree				People outdegree			
	LOW	MEDIUM	HIGH	Total	LOW	MEDIUM	HIGH	Total
Number of plants	37	4	8	49	37	8	4	49

Table 9 Flow of People Degrees 2009

	People indegree				People outdegree			
	LOW	MEDIUM	HIGH	Total	LOW	MEDIUM	HIGH	Total
Number of plants	32	9	8	49	29	11	9	49

Table 10 People Indegree

	Number of plants correctly classified	Number of plants incorrectly classified
LOW	32	0
MEDIUM	3	6
HIGH	7	1
Total	42	7

Table 11 People Outdegree

	Number of plants correctly classified	Number of plants incorrectly classified
LOW	27	2
MEDIUM	8	3
HIGH	5	4
Total	40	9

Our analysis showed a highly correct total number of plants for both the indegree and outdegree. 42 plants or 86% were assigned to the right level of people indegree. In addition, 40 plants or 82% were correctly classified to the level of people outdegree. We can conclude that the questionnaire item in our assessment tool has a strong validity for determining the network position of the plants.

As mentioned earlier, Exhibit 3 lists the results of the 1995-1996 measurement and the simulation of the 2009 survey measurement for the 49 plants. Firstly, an overview of the absolute values is provided (Exhibit 3A). Secondly, a table with the variable levels low-medium-high is presented (Exhibit 3B). Based on the scores on the five variables in Exhibit 2, we have now classified the plants in the typology of network positions. That is, we have classified them as isolated plants (A), receiver plants (B), hosting network players (C) and active network players (D) (see Figure 2).

For 11 plants, the combination of their scores on all five variables matches the combination for one of the four predefined types of position (which was the result of a cluster analysis). Another 12 plants matched the characteristics of one of the clusters on 4 out of 5 variables. A total of 10 plants came close to their initial cluster value by 3 out of the 5 correct variable levels. Another 7 plants had a deviation on three variables but were still approximate to their original cluster. A new cluster value was estimated for 9 plants. We can conclude that a correct cluster value is estimated for 82% or 40 plants. Finally, 9 plants or 18% approached a different cluster value in the simulation of the 2009 measurement. An important remark should be made on the classification results of the 2009 measurement. We noticed that the wrong classifications are situated between cluster C and D or A and B, except for one plant. This implies a modest difference between the isolated and receiver plant or between the hosting and active network player. By that, we can conclude that if there is a mistake made in classifying the plants, it is obviously not crucial.

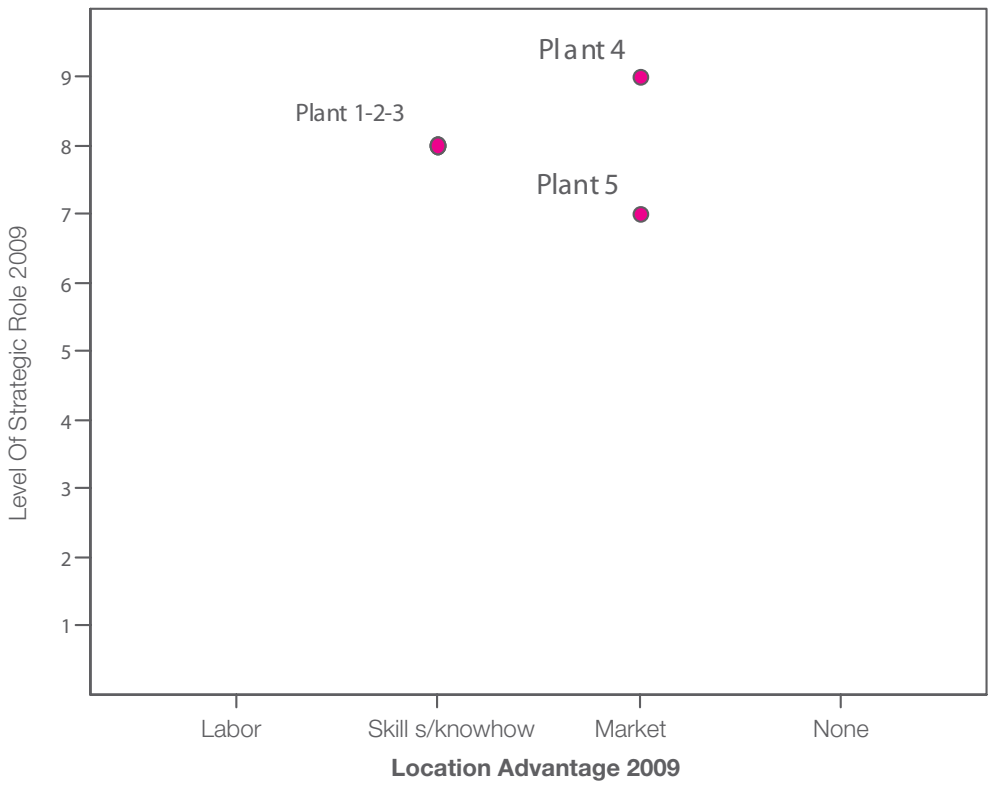
In this section, we present the current network position of the five Flemish plants that have been surveyed using the 2009 benchmark tool. The results are based on the questionnaire data collected through the plant manager interviews.

Strategic role of the plant

The level of strategic role is implicitly assumed in the vertical axis of Ferdows' model, since the plant's competence is a measure for the importance of the plant for the company's strategy. Ferdows' typology combines the level of strategic role and the primary location driver.

Figure 3 describes the primary reasons for exploitation and the current strategic role level of the five pilot study cases.

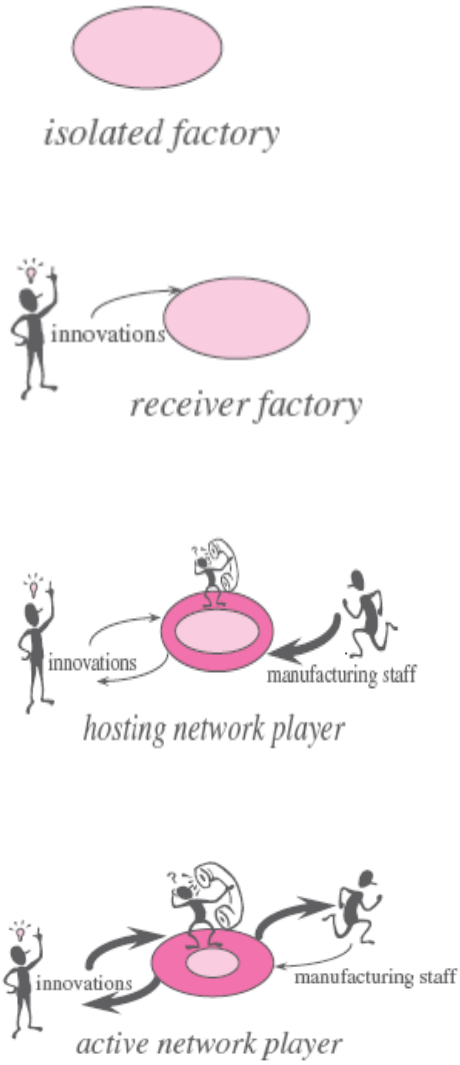
Figure 3 Strategic role of plants in Flanders



The network position of the plant

The network position is determined by five network variables: communication centrality, innovation indegree, innovation outdegree, people indegree, people outdegree. After the calculation of each variable value for the five plants, we classified them into the best fitting cluster.
Figure 4 shows the position of the plants in their network. Two plants are positioned as an isolated plant with a relatively high level of strategic role. Furthermore, we identified one receiver plant, one hosting network player and one active network player. The active network player has the highest level of strategic role. Interesting to mention is that the plant manager of one of the isolated plants announced that his plant will be shut down in the near future. The reason for the planned shut-down is the transfer of business to other sister plants in the global manufacturing network.

Figure 4 Network position 2009



The respondents were asked in the final questionnaire item to estimate their current network position, taking the definitions of the four types into consideration. Two plant managers were able to make a correct estimation, namely “active network player” and “hosting network player”. The remaining three respondents made a wrong assessment of their plant position. They overestimated the network position of their plant by indicating “active network player” or “hosting network player” while the plant is in fact a receiver plant or an isolated plant according to the questionnaire data.

The relation with suppliers and customers

Table 12 provides the relation intensity with the main suppliers and main customers on each of the five network variables. It is interesting to observe that plant 4, which was classified as an active network player in its own network of sister and partner plants, also scores high on the intensity of its relations with suppliers and customers. Plant 2 which has an isolated position in the network of sister plants and partner plants also reports a weak relation intensity with its main suppliers and main customers. We repeat that this very isolated plant will soon be closed. Although anecdotal at this stage, these observations highlight the relevance the benchmarking tool can have in the future, for practitioners and policy makers.

Table 12 Intensity of the relation with suppliers and customers

	2009 data 2009 survey measurement				
Plants	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree
1.	Low	Low	Medium	Medium	Low
2.	Low	Low	Medium	Low	Low
3.	Medium	Low	Low	Low	High
4.	High	High	High	Medium	Medium
5.	Low	Medium	Low	High	Low

This chapter summarizes the main conclusions of the research.

1 The goal of the benchmarking tool is to provide managers an insight into the network position of their plant based on their own perception/knowledge of the role of their plants, through a self-administered questionnaire, with a reasonable effort and time to fill out the questionnaire. The validity test results show that 82% of the 49 plants were correctly classified according to the simulation method for the 2009 survey measurement. We can conclude that our benchmarking tool is able to take a "picture" of a plant by surveying one manager in this single plant that corresponds to the "picture" we would obtain by surveying several managers in all plants in the network (including headquarters).

2 Although there were only five cases involved, the pilot study revealed some interesting insights concerning plants in Flanders. One of the plants has made space for plants abroad in the network. The plants that remain in Flanders are here because of the availability of skills and know-how, or because of market proximity. We remarked that three plant managers made a wrong estimation about their plant position when we asked them to apply the network position typology on their current plant situation. This emphasizes the need for a benchmarking tool that provides insight into the network position of the plant by asking the detailed questions on innovation transfer, communication and plant visits, as presented in this report. We conclude (from our preliminary data) that most of the plants in our pilot study have medium till high intensive relations with their main suppliers and main customers. It is obvious that both suppliers and customers are important network actors besides the sister/partner plants and headquarters in a global manufacturing network.

X IMPLEMENTATION AND FUTURE PLANS

The benchmarking tool is now being constructed as a web-based tool, by a subcontractor. The tool will be available online as of July 14th, 2009. Some extra work still needs to be done on the automotive generation of the output reports towards the respondent. The promotion of the tool will be started after summer, in co-operation with FDC.

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Plant position assessment tool

The purpose of this tool is to assess the position of your plant relative to its sister plants in your company (If your company consists of several business units or divisions, the scope of the assessment is the position of your plant relative to the sister plant within the business unit or division).
This tool guides you through a set of questions in two steps.

1 In step 1 we will identify the manufacturing network by asking for the list of plants in your company (or business unit or division).
2 In step 2 we will ask for information on the relationship of your plant with your sister plants in your division, your main suppliers and your main customers.
3 In step 3 we will ask you to indicate your current network position according to four types or categories of plants.

After completion of the questionnaire, you will soon receive a benchmark report, positioning of your plant, relative to many other manufacturing plants.

For more information, please contact
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All data obtained through the tool will remain strictly confidential. Publications based on this data will content aggregate data. Individual cases will not be revealed.

STEP 1: IDENTIFICATION OF YOUR PLANT AND ITS SISTER PLANTS

1. GENERAL INFORMATION

Name of your company: .....

Name of your plant: .....

Address of your plant: .....

Street + number .....

City.....

Zipcode.....

Country .....

Year: .....

What is the name of the business unit or division where your plant belongs to?

.....

How many **sister plants** do you have? This means how many plants are part of this business unit or division in your company? (including your plant)

.....

How many **partner plants** do you have? This means how many plants act as a partner (subcontractor) in the supply of end products?

.....

What % of the total production costs goes to labour?

.....

A. Concerning the sister plants

What is the name and location of each of these sister plants.

NAME OF THE SISTER PLANT	COUNTRY	CITY
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		

B. Concerning the partner plants

What is the name and location of each of these partner plants?

NAME OF THE PARTNER PLANT	COUNTRY	CITY
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		

C. Concerning the main suppliers and main customers

Think about your three main suppliers and three main customers. We don't need you to write down the real name of each of your main suppliers and customers. A description of the type of supplier or customer can be sufficient. For example: chemical factory, wholesaler, etc.
We need to distinguish between the three main suppliers and customers in the interest of the following questions of this assessment tool

What is the name of your three main suppliers?

.....

.....

.....

What is the name of your three main customers?

.....

.....

.....

2. MAIN ADVANTAGES OF THE PLANT'S LOCATION

In the following list, some reasons for exploiting manufacturing facilities have been identified. Please indicate, for your plant, the three main advantages that the plant's location provides today.
Give the main advantages a score of 1, 2 or 3. A score of 1 implies the most important main advantage, whereas a 3 refers to the third most important main advantage.

		Main advantage of plant's location *today*
SUPPLY		
	to be close to low cost suppliers	
	to have access to a source of raw materials	
LABOR/SKILLS	to take advantage of low-cost labor	
	to take advantage of qualified workers	
	to take advantage of skilled engineers	
	to take advantage of managerial/organizational skills	
MARKET		
	to provide fast service or technical support to customers	
SOCIO-POLITICAL	to benefit from tax breaks and/or investment incentives	
	to overcome trade barriers	
COMPETITION	to be close to major competitors	
ENERGY	to take advantage of low-cost energy	
OTHER		
	to create a high quality of life for employees	
	to capture/maintain market share	
NONE	the plant is here for historical reasons only, the location has no clear competitive advantage anymore	

3. ROLE OF THE PLANT

Typically, the plants in a company may have different roles. Some plants for example, have a clear focus on the production function only; other plants may be the development and production centre for specific product groups or components, or may be the specialized plant for specific processes; other plants have become a partner of headquarters for certain manufacturing capabilities that are important for the whole company.
This "role" of the plants is described below on a 1 to 9 scale. On this scale, indicate for your plant where it is positioned vis-à-vis the other plants in your company, that is indicate which role your plant plays in your company today.
Please estimate also the position of your plant 5 and 10 years ago.
Finally, indicate the role that your plant should play -according to your opinion- 5 years from now.

ROLE OF YOUR PLANT	The main goal of the plant is "to *get the products produced"*. Managerial investment in the plant is focused on running the plant *efficiently.*		The plant has sufficient internal *capabilities to develop and improve* its own components, products and production processes		The plant is a *focal point* for the company for the development of *specific important components, products or production processes.*		The plant *develops and contributes know-how* for the company		The plant is a "centre of excellence", and serves as a partner of headquarters in building strategic capabilities in the manufacturing function
TODAY	1	2	3	4	5	6	7	8	9
PAST 10 YEARS AGO	1	2	3	4	5	6	7	8	9
5 YEARS AGO	1	2	3	4	5	6	7	8	9
FUTURE IN 5 YEARS	1	2	3	4	5	6	7	8	9

STEP 2: THE RELATIONSHIP OF YOUR PLANT WITH YOUR SISTER PLANTS, YOUR MAIN SUPPLIERS AND YOUR MAIN CUSTOMERS

1. THE FLOW OF GOODS BETWEEN THE PLANTS

This question deals with the flow of components or semi-finished goods between the plants. It excludes end products.

Please indicate by 'X' if your plant receives components or semi-finished goods from other plants (sister plants and partner plants).

Plants		
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	15.	
	16.	
	17.	
	18.	
	19.	
	20.	
	21.	
	22.	
	23.	

Please indicate by ‘X’ if your plant supplies other plants (sister plants and partner plants) with components or semi-finished goods.

Headquarters		
Plants		
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	15.	
	16.	
	17.	
	18.	
	19.	
	20.	
	21.	
	22.	
	23.	

2. COMMUNICATION

The following question deals with the frequency of communication with sister plants, suppliers and customers.
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 email.

How frequently do you and your plant management team communicate with colleagues in the sister plants, partner plants and headquarters?

		Frequency			
		Daily	Weekly	Monthly	Less then monthly
Headquarters					
Plants	1.				
	2.				
	3.				
	4.				
	5.				
	6.				
	7.				
	8.				
	9.				
	10.				
	11.				
	12.				
	13.				
	14.				
	15.				
	16.				
	17.				
	18.				
	19.				
	20.				
	21.				
	22.				
	23.				

Please think about your three main suppliers. How often do you and your plant management team communicate with at least one of their employees?

		Frequency			
		Daily	Weekly	Monthly	Less then monthly
Supplier	1.				
	2.				
	3.				

Please think about your three main customers. How often do you communicate with at least one of their employees?

		Frequency			
		Daily	Weekly	Monthly	Less then monthly
Customer	1.				
	2.				
	3.				

3. CREATION, ADOPTION and TRANSFER OF INNOVATIONS

We define innovation as the development and introduction of something new that is developed for the first time in your company.
It needs not to 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 of a new production process
(for example, investment in new machinery or equipment, the automation of part of the production process, the introduction of an FMS)

the implementation of a new management system
(for example, the implementation of a JIT or lean-system, a new planning system, a new quality or continuous improvement programme, a process redesign and improvement programme, a new HRM system)

3.1. Creation of innovations

On a scale from 1 (not innovative) to 9 (highly innovative), rate the level of innovativeness for your plant, for each of the three types of innovations described above.

	DEGREE OF INNOVATIVENESS OF YOUR PLANT								
	not innovative				moderately innovative				highly innovative
New Product Development and Introduction	1	2	3	4	5	6	7	8	9
New Production Process Development and Introduction	1	2	3	4	5	6	7	8	9
New Managerial Systems	1	2	3	4	5	6	7	8	9

3.2. Innovations developed by other units and adopted by your plant

It may be that over the past 3 years, some innovations have been implemented in your plant that were not developed by your plant, but rather by headquarters, sister plants or partner plants or even by external parties (suppliers or customers).
In the table below, indicate whether your plant did adopt innovations that have originally been developed by headquarters, sister plants, partner plants or external parties.

Innovations Innovations adopted by your plant that have originally been developed by Headquarters		PRODUCT INNOVATIONS	PRODUCTION PROCESS INNOVATIONS	INNOVATIONS IN MANAGERIAL SYSTEMS
Plants				
	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
	7.			
	8.			
	9.			
	10.			
	11.			
	12.			
	13.			
	14.			
	15.			
	16.			
	17.			
	18.			
	19.			
	20.			
	21.			
	22.			
	23.			
Main Suppliers				
	1.			
	2.			
	3.			
	1.			
	2.			
	3.			

3.3. Innovations developed in your plant and transferred to other units

It may be that other plants (or headquarters and external parties) benefit from the innovations that have been developed in your plant.
In the table below, indicate whether an innovation developed in your plant was implemented in headquarters, sister plants, partner plants or external parties.

Innovations Innovations developed in your plant and implemented in Headquarters		PRODUCT INNOVATIONS	PRODUCTION PROCESS INNOVATIONS	INNOVATIONS IN MANAGERIAL SYSTEMS
Plants				
	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
	7.			
	8.			
	9.			
	10.			
	11.			
	12.			
	13.			
	14.			
	15.			
	16.			
	17.			
	18.			
	19.			
	20.			
	21.			
	22.			
	23.			
Main Suppliers	1.			
	2.			
	3.			
Main Customers	1.			
	2.			
	3.			

3.4. Flow of people

What is the number of days colleagues from headquarters, from the plant management team of sister plants, partner plants, from main suppliers or customers have been visiting your plant during the past 12 months?

Visitors coming from		Number of days with visitors during the past 12 months
Headquarters		
Plants		
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	15.	
	16.	
	17.	
	18.	
	19.	
	20.	
	21.	
	22.	
	23.	
Main Suppliers	1.	
	2.	
	3.	
Main Customers	1.	
	2.	
	3.	

What is the number of days you or your colleagues in your plant management team have been visiting headquarters, sister plants, partner plants, main suppliers or customers?

Visitors coming from		Number of days spent elsewhere during the past 12 months
Headquarters		
Plants		
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	15.	
	16.	
	17.	
	18.	
	19.	
	20.	
	21.	
	22.	
	23.	
Main Suppliers	1.	
	2.	
	3.	
Main Customers	1.	
	2.	
	3.	

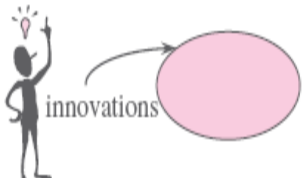
STEP 3: CURRENT NETWORK POSITION

Based on previous research we distinguish four types or categories of plants.
Please read the descriptions carefully, and check the one that best describes your plant.

ISOLATED PLANT

☐

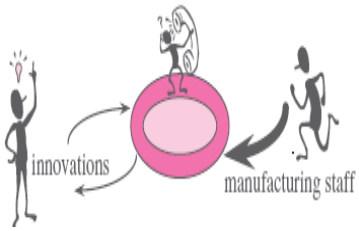
Few innovations are transferred from here to other units and few innovations reach the plant.
There is little communication between this plant and the other units in the company.
The plant receives few visits from sister plants or headquarters, in addition the plant visits rarely other plants or headquarters.
The plant relies on its own capabilities to improve its manufacturing processes.



RECEIVER PLANT

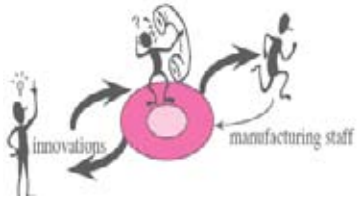
☐

Few innovations are transferred from here to sister plants, but the plant receives quite a lot of innovations from its sister plants in the network and/or from headquarters.
There is little communication between this plant and the other units in the company.
The plant relies on its own capabilities to improve its manufacturing processes.



HOSTING NETWORK
PLAYER

The plant has established strong network relationships. There is a lot of communication with other units in the network.
The plant frequently hosts visitors from other plants and from headquarters.
There is also a high level of innovation transfer to and from the sister plants and headquarters.
The plant actively visits sister plants rather then being the host for visitors from sister plants.



ACTIVE NETWORK
PLAYER

The plant communicates intensively with other units in the network.
The plant shares very actively innovations with other units.

Tool modifications based on interviews in pilot study

1 The tool differentiates between sister plants and partner plants in the global manufacturing network. Originally we included headquarters, main suppliers and customers and the actual sister plants in the manufacturing network of the respondents. During the pilot study it became clear that plants can have strong relations with subcontractors who act as a partner in the supply of end products, while they have much weaker relations with the actual sister plants. It is even possible that a plant has few or no sister plants but instead has several partner plants. One of our respondent plants acts currently according to a business model based on sourcing and has no real sister plants anymore in the manufacturing network. The pilot study thus revealed the importance of partner plants. Therefore, our assessment tool had to focus on both sister plants and partner plants.

2 The assessment tool examines the relationship of the plant with its three main suppliers and main customers. Therefore the respondents have to identify those suppliers and customers. During our pilot study we noticed that some plant managers were reluctant to reveal the name of the suppliers and customers. One plant manager told us that this questionnaire item can be quite confidential for the company. Because we do not need the real name of the suppliers and customers, we have decided to rephrase this item in a way that it is clear for the respondents that a one-word description of each main supplier and customer is sufficient.

3 A lay-out change was performed on the item ‘main advantages of the plant’s location’ because of confusion about how to answer this questionnaire item.

4 Two plant managers told us that the plant’s location advantage is historically determined. This implies that the plant is there for historical reasons which can not be seen as a clear advantage of the plant’s location today. So we categorized this answer as ‘no advantage’.

5 The questionnaire item that focuses on communication in the network was not well defined in the original tool version. We rephrased the question so it would be clear for the respondent that he/she has to answer in the name of the plant management team.

Comparison 1995-1996 measurement and simulation of 2009 survey measurement

A. Absolute Values

	1995-1996 data 1995-1996 measurement						1995-1996 data simulation of 2009 survey measurement					
Plants	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster
1.	0,05	0,37	0,30	25	2	B	0,27	0,33	0,30	12	2	B**1
2.	0,05	0,37	0,53	17	14	B	0,27	0,30	0,43	16	9	B**
3.	0,03	0,43	0,10	18	50	B	0,23	0,33	0,07	13	48	B**
4.	0,03	0,40	0,40	53	7	C	0,23	0,40	0,20	52	6	C***
5.	0,02	0,40	0,40	29	23	C	0,17	0,33	0,40	22	17	D**
6.	0,02	0,33	0,33	11	16	B	0,10	0,23	0,50	8	10	B*
7.	0,01	0,30	0,30	15	1	B	0,10	0,23	0,03	15	1	B*
8.	0,01	0,30	0,30	1	33	B	0,07	0,20	0,07	1	30	B*
9.	0,01	0,17	0,17	0	2	A	0,07	0,07	0,00	0	2	A
10.	0,00	0,33	0,33	0	21	B	0,00	0,30	0,03	0	20	B*
11.	0,15	0,33	0,58	9	5	B	0,42	0,08	0,58	7	5	B***
12.	0,11	0,58	0,17	6	10	B	0,33	0,58	0,08	6	9	B**
13.	0,22	0,33	0,33	21	58	D	0,33	0,33	0,42	21	31	D*
14.	0,19	0,50	0,58	56	19	C	0,25	0,50	0,33	31	20	C***
15.	0,06	0,33	0,00	17	0	B	0,25	0,25	0,00	17	0	B*
16.	0,08	0,33	0,13	6	11	B	0,21	0,29	0,04	6	10	B
17.	0,06	0,25	0,21	12	21	B	0,17	0,00	0,08	9	21	B**
18.	0,07	0,25	0,25	0	1	A	0,29	0,13	0,17	0	1	A*
19.	0,09	0,21	0,04	5	0	A	0,29	0,04	0,04	5	0	A
20.	0,07	0,13	0,00	2	16	A	0,29	0,08	0,00	2	10	A
21.	0,07	0,13	0,13	7	3	A	0,29	0,08	0,00	5	2	A
22.	0,16	0,42	0,63	56	33	C	0,38	0,21	0,25	54	24	C
23.	0,11	0,25	0,08	23	42	B	0,21	0,13	0,08	21	40	B***

	1995-1996 data 1995-1996 measurement						1995-1996 data simulation of 2009 survey measurement					
	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster
Plants												
24.	0,07	0,29	0,21	4	16	B	0,25	0,13	0,04	4	13	A
25.	0,00	0,25	0,00	0	4	A	0,00	0,04	0,00	0	4	A
26.	0,08	0,33	0,21	6	4	B	0,21	0,13	0,13	6	4	A
27.	0,21	0,29	0,33	57	22	C	0,44	0,00	0,13	57	22	C**
28.	0,34	0,50	1,00	15	40	D	0,56	0,17	0,67	15	40	D*
29.	0,18	0,29	0,25	25	32	B	0,39	0,20	0,07	25	32	B***
30.	0,13	0,29	0,25	0	0	B	0,17	0,13	0,00	0	0	A
31.	0,15	0,17	0,17	0	0	A	0,22	0,10	0,00	0	0	A
32.	0,12	0,25	0,21	12	15	B	0,22	0,17	0,17	12	15	B***
33.	0,38	0,72	0,83	34	90	C	0,67	0,11	0,44	33	35	D**
34.	0,17	0,39	0,17	0	7	B	0,4	0,11	0,00	0	7	A*
35.	0,20	0,44	0,28	36	7	C	0,47	0,06	0,11	26	6	A**
36.	0,10	0,44	0,11	0	5	B	0,27	0,00	0,00	0	5	A
37.	0,13	0,44	0,28	10	23	B	0,2	0,22	0,00	10	16	B**
38.	0,27	0,22	0,83	92	24	C	0,83	0,17	0,39	54	20	C***
39.	0,23	0,33	0,83	44	76	D	0,89	0,28	0,44	36	51	D*
40.	0,12	0,44	0,06	6	8	B	0,83	0,28	0,06	6	8	B*
41.	0,18	0,39	0,00	11	26	B	0,89	0,22	0,00	7	14	B*
42.	0,15	0,39	0,17	15	13	B	0,78	0,22	0,17	13	9	B**
43.	0,13	0,44	0,00	10	31	B	0,56	0,22	0,00	10	24	B**
44.	0,06	0,11	0,22	3,5	0,5	A	0,22	0,06	0,06	3	0,5	A
45.	0,17	0,33	0,22	72	25	C	0,50	0,11	0,00	54	18	C**
46.	0,06	0,06	0,17	7,5	7	A	0,11	0,00	0,06	7,5	7	A
47.	0,05	0,33	0,00	2	5,5	B	0,28	0,11	0,00	2	4	A
48.	0,02	0,28	0,00	3	2	A	0,11	0,06	0,00	3	2	A
49.	0,12	0,00	0,17	19	67	A	0,28	0,00	0,11	12	50	A*

B. Level Cluster Variables

Plants	1995-1996 data 1995-1996 measurement						1995-1996 data simulation of 2009 survey measurement					
	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster	Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster
1.	Low	Medium	Low	Low	Low	B	Low	High	Medium	Low	Low	B**
2.	Low	Medium	Low	Low	Low	B	Low	Medium	High	Medium	Low	B**
3.	Low	Medium	Low	Low	Low	B	Low	High	Low	Low	High	B**
4.	Medium	Medium	Medium	High	Medium	C	Low	High	Medium	High	Low	C***
5.	Medium	Medium	Medium	High	Medium	C	Low	High	High	Medium	Medium	D**
6.	Low	Medium	Low	Low	Low	B	Low	Medium	High	Low	Low	B*
7.	Low	Medium	Low	Low	Low	B	Low	Medium	Low	Medium	Low	B*
8.	Low	Medium	Low	Low	Low	B	Low	Medium	Low	Low	High	B*
9.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
10.	Low	Medium	Low	Low	Low	B	Low	Medium	Low	Low	Medium	B*
11.	Low	Medium	Low	Low	Low	B	Medium	Low	High	Low	Low	B***
12.	Low	Medium	Low	Low	Low	B	Medium	High	Low	Low	Low	B**
13.	High	High	High	Medium	High	D	Medium	High	High	Medium	High	D*
14.	Medium	Medium	Medium	High	Medium	C	Low	High	High	High	Medium	C***
15.	Low	Medium	Low	Low	Low	B	Low	Medium	Low	Medium	Low	B*
16.	Low	Medium	Low	Low	Low	B	Low	Medium	Low	Low	Low	B
17.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Medium	B**
18.	Low	Low	Low	Low	Low	A	Low	Low	Medium	Low	Low	A*
19.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
20.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
21.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
22.	Medium	Medium	Medium	High	Medium	C	Medium	Medium	Medium	High	Medium	C
23.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Medium	High	B***

Plants	1995-1996 data 1995-1996 measurement Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster	1995-1996 data simulation of 2009 survey measurement Comm. centrality	Innovation indegree	Innovation outdegree	People indegree	People outdegree	Cluster
24.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Low	A
25.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
26.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Low	A
27.	Medium	Medium	Medium	High	Medium	C	Medium	Low	Low	High	Medium	C**
28.	High	High	High	Medium	High	D	High	Low	High	Medium	High	D*
29.	Low	Medium	Low	Low	Low	B	Medium	Medium	Low	Medium	High	B***
30.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Low	A
31.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
32.	Low	Medium	Low	Low	Low	B	Low	Low	Medium	Low	Medium	B***
33.	Medium	Medium	Medium	High	Medium	C	High	Low	High	High	High	D**
34.	Low	Medium	Low	Low	Low	B	Medium	Low	Low	Low	Low	A*
35.	Medium	Medium	Medium	High	Medium	C	Medium	Low	Low	Medium	Low	A**
36.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Low	A
37.	Low	Medium	Low	Low	Low	B	Low	Medium	High	Low	Medium	B**
38.	Medium	Medium	Medium	High	Medium	C	High	Low	High	High	Medium	C***
39.	High	High	High	Medium	High	D	High	Medium	High	High	High	D*
40.	Low	Medium	Low	Low	Low	B	High	Medium	Low	Low	Low	B*
41.	Low	Medium	Low	Low	Low	B	High	Medium	Low	Low	Low	B*
42.	Low	Medium	Low	Low	Low	B	High	Medium	Medium	Low	Low	B**
43.	Low	Medium	Low	Low	Low	B	High	Medium	Low	Low	Medium	B**
44.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
45.	Medium	Medium	Medium	High	Medium	C	Medium	Low	Low	High	Medium	C**
46.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
47.	Low	Medium	Low	Low	Low	B	Low	Low	Low	Low	Low	A
48.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	Low	A
49.	Low	Low	Low	Low	Low	A	Low	Low	Low	Low	High	A*

The total number of * indicates the deviation of the simulated classification. For example: B** indicates that the plant is classified as a receiver plant, based on the data for this plant, but there is a minor deviation on two variables.

Color Key

Blue correct level
Yellow deviation of one level
Red deviation of two levels

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ISBN-NUMMER : 978907885????
D/2009/???