The Influence of Intangible Factors in the Strategic Network Configuration on Operations Performance

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Abstract

The configuration of global production networks is influenced by numerous tangibles (e.g. wage and transportation costs) as well as intangibles (e.g. employee qualification and political stability). However, due to the difficulty of quantifying intangibles, they are often neglected in decision-making resulting in not optimal configuration decisions. For this reason, this paper examines the role of intangibles in strategic network configuration in relation to corporate performance. 13 influencing factors are analyzed regarding their perceived relevance and consideration as well as the corporate network and competitive capabilities. The results show statistically significant relationships between intangibles and performance.

Keywords: Strategic network configuration, Global production networks, Strategic fit

Introduction

Large corporations, as well as medium-sized companies, organize their value creation in globally distributed production sites. The sites can pursue a wide variety of motives, such as access to sales markets, the development of knowledge clusters, or the exploitation of labor cost advantages (Ferdows, 2014) resulting in hierarchically grown, complex, and interwoven global production networks (GPN). Designing the GPN in accordance with the production strategy is the main task of network configuration.

In practice, however, the creation and preservation of strategic alignment are complex and challenging. Reasons for this are the multitude, difficult quantifiability, and limited comparability of influencing factors. While factors such as labor and transport costs are clearly quantifiable in monetary terms, factors such as access to qualified personnel or reliability of infrastructure are difficult to quantify but influence the competitiveness within the network significantly (Lanza et al., 2019). Due to these difficulties, intangible factors are often prioritized lower and are, at best, implicitly considered in decision-making through managerial judgment. As a result, network decisions are made on insufficient and incomplete premises and thus not optimally supporting the production strategy.

This suggests that by taking more intangibles into account, the strategic fit in the network can be increased, and thus the competitiveness of the network can be improved. Therefore, the aim of this paper is to investigate this assumption through an empirical-quantitative study. Hence, the study examines the relationship between the incorporation of intangibles in decision-making and the company´s performance as a result of network configuration.

Theoretical Background

Strategic network configuration includes all decisions related to the geographic distribution of production sites, the allocation of capacity between sites, the allocation of products and competencies, and the determination of material flow relationships between sites and with customers as well as suppliers (Lanza et al., 2019).

The overriding goal of the configuration is to design the network in such a way that it supports the corporate strategy optimally. This relationship is referred to as strategic fit (Friedli et al., 2014). Often, several strategic goals are pursued simultaneously in a corporate strategy. Scientific literature offers a whole plethora of different goals, which are constantly growing over time. Frequently cited strategic goals are time, costs, and quality. Now, the focus is increasingly shifting to adaptability and sustainability (Netland and Frick, 2017). Furthermore, interactions between goals can also occur. These relationships can be classified into conflicting, complementary, or neutral goal relationships (Laux et al., 2014). Research in operations management also focusing on these dependencies resulting in models such as the Trade-Off model from (Boyer and Lewis, 2002) and the sandcone model from (Ferdows and Meyer, 1990).

All configuration decisions are subject to the influence of the internal and external corporate environment. Internal influencing factors are for example the product structure or the packing density of the products. Among other things, the product structure influences the required resources and capacities that need to be allocated in the network configuration. With a high proportion of common parts, there is a higher degree of freedom to allocate products in the network. The packing density influences the cost efficiency of transport (Abele et al., 2008). External influencing factors include market development, logistics infrastructure, cost factors, political, legal, and cultural factors (Lanza et al., 2019). For example, prohibitive trade agreements may encourage companies to produce on-site. In contrast, cultural hurdles can lead to the cannibalization of labor cost advantages in low-wage countries. (Verhaelen et al., 2021) These examples show that, in addition to the sheer number of influences to be taken into account, the factors also vary in how well they can be quantified. Wage and transport costs, for example, can be explicitly assessed in monetary terms. However, cultural difficulties or the availability of qualified personnel are more difficult to grasp. This makes it difficult to evaluate influencing factors objectively and comparably and thus represents a major challenge for both production managers and scientists (Lanza et al., 2019).

Decision-Making Approaches and Hypotheses Development

The variety and ambiguity of influencing factors, strategic goals and interactions make network configuration a highly complex decision area. For this purpose, decision support models exist to help decision-maker in finding the optimal choice according to their goals (Clark and Scott, 1995). In the operations management a large number of models already exist, which can be divided into graphical and mathematical models (Laux et al., 2014). Graphical models visualize the relationship between goals and decision alternatives and thus contribute to a high degree of clarity. The frameworks commonly used in practice also belong to these. Well-known representatives are from to (Christodoulou et al., 2019; Miltenburg, 2009; Shi and Gregory, 1995). However, such models fail already with a small number of parameters. Mathematical models can handle much more complex problems. Such models are defined by decision variables with an acceptable range of values. These are mathematically related to the target variables. Approaches from simulation (Auberger et al., 2021; Lanza and Ude, 2009) and from mathematical optimization (Lanza and Moser, 2012; Moser et al., 2016) are based on such models.

Graphical models are often used in practice because of their simplicity and comprehensibility. Mathematical models, in contrast, can handle more complex problems, but they are often limited to cost factors only. Intangible factors are disregarded as they are difficult to quantify. Instead, they are considered implicitly by manager's gut feeling. These observations could also be proven in preliminary studies.

However, this bears the risk that intangible factors are underrepresented in decision-making, even though they may significantly influence the advantageousness of a strategic alternative (Lanza et al., 2019). This can lead to a GPN configuration that does not optimally support the strategy and thus incurring losses in company performance. In turn, this leads to the assumption that companies that incorporate intangible factors more strongly and systematically in their decision-making will achieve a better strategic fit in the network and therefore higher performance. Based on this assumption, four research-guiding hypotheses can be derived, which are depicted in Figure 1:

(H1) With the increasing perceived relevance of intangible influencing factors, a company's network capabilities are higher

(H2) Companies that systematically consider intangible influencing factors reach higher network capabilities.

(H3) With the increasing perceived relevance of intangible influencing factors, the performance improves more strongly

(H4) Companies that systematically take intangible influencing factors into account improve their performance.

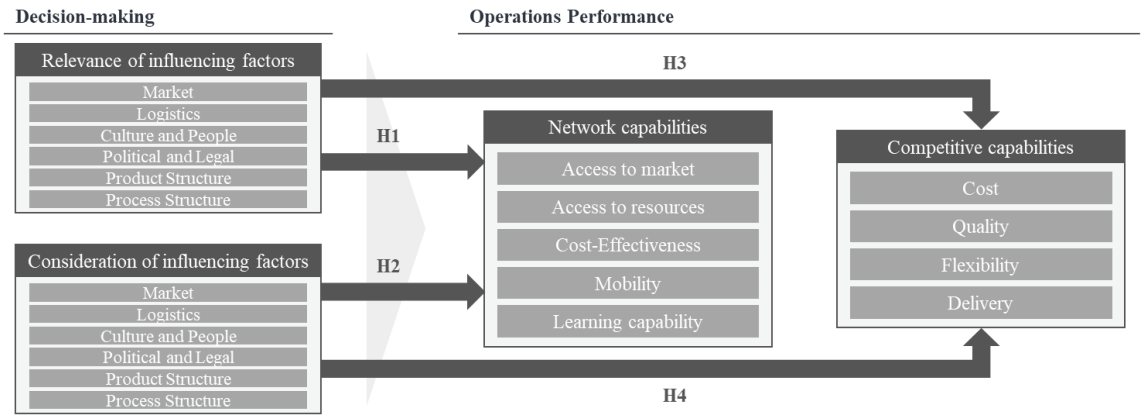

Figure 1 – Hypotheses and Research Structure

Research Design

To achieve the aim of the paper, an empirical study is conducted. The study follows a hypothetical-deductive method to test the four previously defined hypotheses. The analysis is based on primary data collected with a quantitative questionnaire.

The data collection took place from June to December 2021. 29 companies from the manufacturing sector participated, whereas most of them are large enterprises with a globally distributed footprint. To ensure high content validity, the questionnaire was addressed to positions such as Head of Global Production.

The research design is shown in figure 1 consists of the handling of intangible influencing factors in decision-making and the performance of the network. Decision-making, in turn, can be characterized by the perceived relevance as well as by the systematics of consideration in the decision-making approach. Relevance describes the weighting that decision-makers assign to an influencing factor. However, this does not describe how influencing factors are included in the decision-making process. Nevertheless, the relevance of influencing factors often correlates with systematics, as a high perceived importance encourages decision makers to put more effort into the analysis of the corresponding factor. Relevance is operationalized by a 7-point Likert scale and is thus metrically scaled. To capture the systematics of consideration, a nominal scale with the following levels is used: not at all, implicit, explicit with utility analysis, explicit in business case and explicit in analytical model. The analyzed influencing factors are visualized in Table 1.

Table 1 –Intangible Influencing Factors

External environment constructs	Items
Market	Proximity to market Opportunity of learning in local ecosystem
Logistics	Availability of reliable infrastructure Availability of supplier Climate
Culture and people	Availability of qualified people Employee fluctuation Language barrier Different mentality
Political and legal	Political stability Trade barriers
Internal environment constructs	Items
Product	Product structure
Process	Availability of mature technologies

To assess the impact of decision-making approaches on network performance, the concept of differentiation factors according to (Friedli et al., 2014) is adapted in order to measure the performance. (Friedli et al., 2014) divides the global production strategy into the strategic levels of production strategy and network strategy. The production strategy is described by the constructs competitive performance and represent the characteristics a company differentiates itself from the competition. These differentiation factors are in turn operationalized by the network strategy and the underlying network capabilities. Tables 2 and 3 show the constructs and associated items of network capabilities and competitive performance, respectively. All items are measured with a 7-point Likert scale and are thus metrically scaled.

Table 2 – Network Capabilities

Constructs	Items
Access to market	Network's dispersion provides geographical closeness to all target markets Actively adjust our global footprint to be near to our core customers
Access to resources	Our global footprint provides access to regions with cost-efficient production factors Actively seek to establish factories in regions with low production costs
Cost-effectiveness	Cost savings through volumes of production (economies of scale) Mass production to reduce overall production costs Aggregate production volumes across factories to reduce overall production costs
Mobility	Shift production volumes from one factory to another factory Shift orders between our factories to handle demand peaks
Learning	Process improvements are shared with other factories Our factories actively seek to provide production-related skills and knowledge

Table 3 – Competitive Performance

Constructs	Items
Costs	Unit manufacturing cost Ordering cost Materials, water and / or energy consumption
Quality	Conformance quality Product quality and reliability Product assistance / support Customer service quality (e.g. training, information, help-desk) Workers' motivation and satisfaction Health and safety conditions Pollution emissions and waste production levels
Flexibility	Volume flexibility Product mix flexibility Product customization ability New product introduction ability
Delivery	Delivery speed Delivery reliability Manufacturing lead time Procurement lead time

Findings

To examine the role of intangibles in strategic network configuration in relation to network capabilities and corporate performance, various descriptive and statistical analysis were conducted based on the results of the empirical study. The 13 intangible influencing factors are analyzed regarding the perceived relevance and the systematics of consideration in the decision-making approach to further investigate their influence on the company's network capabilities and competitive performance. The findings aim to assess the four previously defined research hypotheses.

Influence of Intangible Factors on Network Capabilities (H1 & H2)

First, the influence of intangibles in strategic decision-making on network capabilities was examined. To test the first hypothesis with the aim to prove, that with the increasing perceived relevance of intangible factors, a company has higher network capabilities, a regression analysis was conducted. The relevance is used as independent variable and network capabilities as dependent variable. A scatterplot of the mean perceived relevance and the mean network capabilities of a company can be seen in Figure 2.

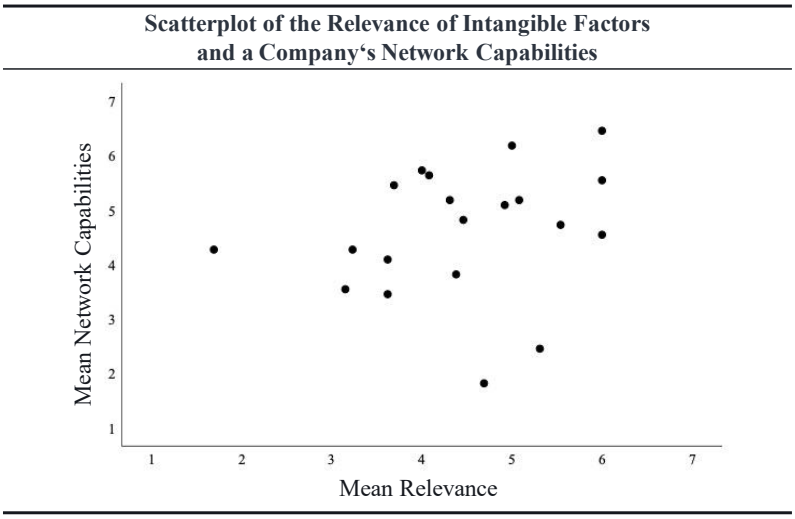

Figure 2 – Scatterplot of Mean Relevance and Mean Network Capabilities

Even though it seems like there should be a positive correlation, this could not be statistically confirmed (p-value = 0.321). However, looking at the individual influencing factor groups defined in the research design, significant dependencies to network capabilities can be found. Hence, correlations between the mean relevance of the factor group logistics and the network capability learning (p-value = 0.011) as well as between political and legal with the capability learning (p-value = 0.033) and process and learning (p-value = 0.012) can be observed. All of them are significant at the significance level of 5%. Using a significance level of 10%, an additional correlation between the relevance of the influencing factor group product and the network capability access to resources can be statistically proven (p-value = 0.068). Regarding the first hypothesis, the study shows that there are some statistically significant correlations between the perceived relevance of specific intangible influencing factors and certain network capabilities.

Furthermore, the influence of the systematically consideration of intangibles in decision-making and its effect on network capabilities is analyzed. This investigation is based on the second research hypothesis and conducted using a variance analysis. In this case, the independent variable is the allocation into one of the two groups of companies that explicit consider intangible factors by using a case study or analytical model and on the other side companies that implicit consider intangible factors. The dependent variables are the different available network capabilities of a GPN introduced in the research design and measured with a Likert-scale. The results are displayed in Figure 3.

It can be observed that the group of companies that systematically take intangibles into account have better network capabilities. The largest difference can be seen within the group *mobility*, followed by *access to resources* and *learning*. Although the descriptive analysis provides the impression of a relationship between consideration and network capabilities, this could not be statistically proven. Therefore, the second hypothesis, that companies that systematically consider intangible influencing factors reach higher network capabilities, cannot be confirmed even though the descriptive results indicate a difference between the two groups of consideration in decision-making.

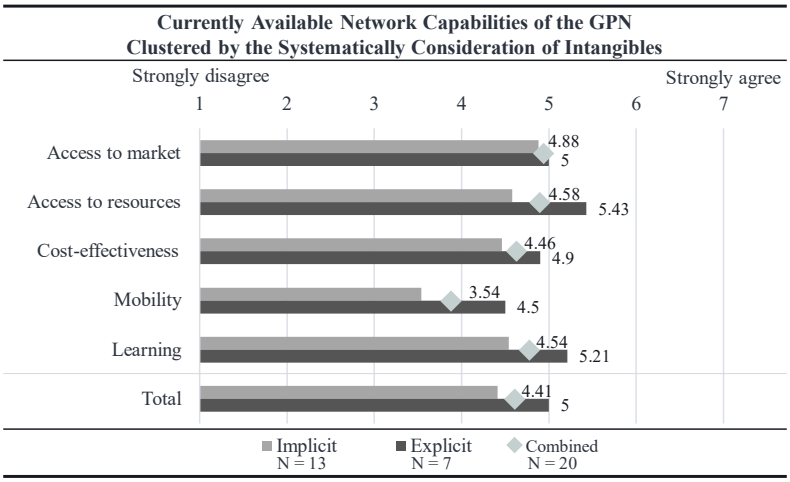

Figure 3 – Available Network Capabilities Clustered by the Systematically Consideration

In conclusion it can be said that the perceived relevance and systematics of consideration of intangible influencing factors in strategic decision-making have an impact on a company's network capabilities and thus influence the network configuration and strategic fit in the GPN. Additionally, as network capabilities operationalize the differentiation factors of the production strategy, which is described by the competitive performance, it may indirectly influence the performance of a company. This construct is analyzed in further detail.

Influence of Intangible Factors on Corporate Performance (H3 & H4)

To examine the dependencies between the incorporation of intangibles in decision-making and the company's performance as a result of network configuration, a regression and variance analysis were conducted. A regression analysis confirmed H3 with a p-value of 0.091 at a significance level of 10%. The scatterplot in Figure 4 displays the correlation between the mean perceived relevance of intangibles and the mean performance development during the last three years. It can be observed that the highest improvement of a company's performance correlates with the highest rated mean relevance of intangible influencing factors.

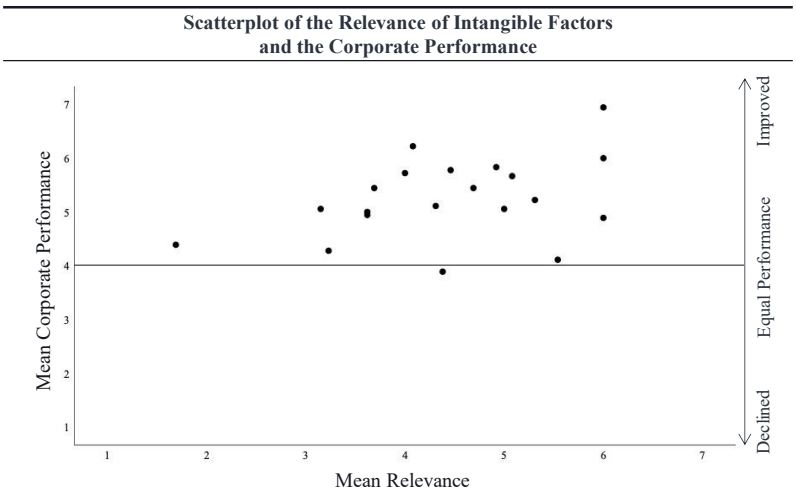

Figure 4 – Scatterplot of Mean Relevance and Corporate Performance

Looking at the individual constructs, a relationship with a significance level of 5% can

also be confirmed for the competitive priorities quality (p-value = 0.017) and flexibility (p-value = 0.019). An additional significant correlation is proven for the construct costs (p-value = 0.061) at a significance level of 10%. All significant relations between the clustered relevance groups and the individual competitive priorities are visualized in Figure 5. As a result of the regression analysis, the study confirms the positive influence of the perceived relevance and the development of a company's performance.

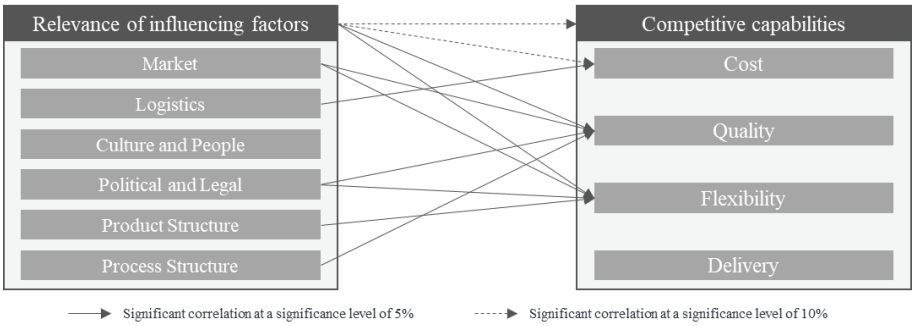

Figure 5 – Linear Regression Analysis of Relevance and Performance

The last research hypothesis of this paper addresses the influence of the systematically consideration of intangible influencing factors on the improvement of corporate performance. To investigate this relationship, a descriptive analysis and a variance analysis were performed.

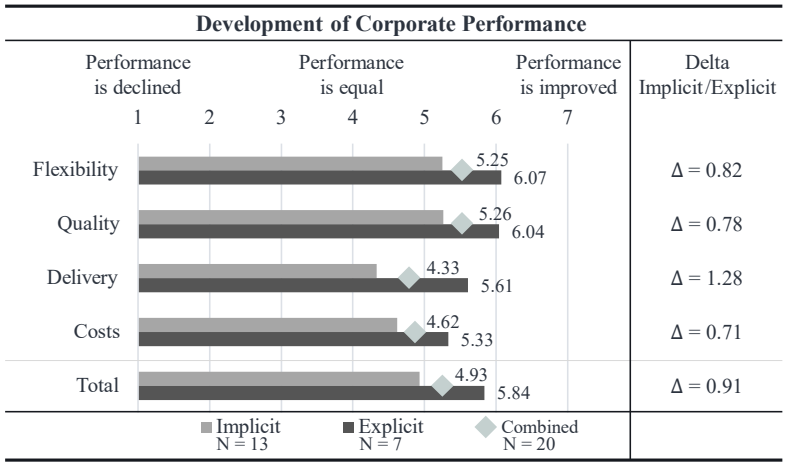

Figure 6 – Development of Corporate Performance

Figure 6 displays the development of the performance clustered by the individual competitive priorities and the groups implicit and explicit. It can be seen that the group of explicit consideration has a better performance in every performance construct. The largest difference occurs in the competitive performance construct delivery, followed by flexibility, quality and costs.

To statistically evaluate the hypothesis, a T-test for equality of means as part of the variance analysis, with the systematics of consideration as independent and the performance as dependent variable, was conducted. With a p-value of 0.006, a significant relationship between consideration and competitive performance can be found at a significance level of 5%. Thus, the null hypothesis, that the mean performance is the same, regardless of the consideration of intangibles, can be rejected. This proves, that the development of a company's performance varies depending on how they take intangible

influencing factors into account during the decision-making process. To further analyze this statement, a one-sample T-test was conducted. Based on the test value of four, what equals an improvement of the corporate performance, it can be statistically evaluated that companies that explicitly consider intangible factors improve their performance (p-value < 0.001). The results of the two statistical tests as well as the group statistics are shown in Table 4. Based on the findings of the study regarding the influence of intangibles on operations performance, it can be said that the perceived relevance as well as the systematically consideration in decision-making have an impact on the development of the corporate performance. Especially the competitive priorities quality and flexibility significantly correlate with the relevance and consideration of intangibles.

Table 4 – T-Test for Equality of Means and One-Sample T-Test

Group Statistics					
	Consideration	N	Mean	Std. Deviation	Std. Error
Relevance	Implicit	13	4.93	0.65	0.18
	Explicit	7	5.84	0.55	0.21
T-Test for Equality of Means					
One-sided p		Two-sided p	Mean Difference		Std. Error Difference
0,003		0.006	-0.91		0.29
One-Sample T-Test (Test Value = 4)					
One-sided p		Two-sided p	Mean Difference		N
<0,001		<0.001	1.84		7

Discussion and Conclusion

The configuration of GPNs is overlaid by a multitude of strategic motives and influencing factors. Factors such as wage costs can be directly evaluated in monetary terms, while other factors such as employee qualifications are difficult to grasp, even though they have a substantial influence on competitiveness. This evaluation uncertainty leads to the fact that intangible factors are often neglected in decision-making. For this reason, this paper uses four hypotheses to investigate the relationship between the influence of intangible factors in decision-making and the resulting operations performance. It can be shown that there is a positive correlation between the incorporation of intangible influencing factors in strategic GPN configuration and the resulting corporate performance. Within the hypotheses H1 and H2 the influence on network capabilities was investigated. Thereby the group of explicit consideration shows considerable differences in the capabilities *access to resources*, *mobility* and *learning*. It can be argued that by systematically considering intangible factors, imminent resource bottlenecks are captured as well as possible countermeasures such as the relocation of resources are assessed. (Prinz and Bauernhansl, 2013) include such factors in the evaluation through so-called success and risk positions. In terms of relevance, there is also a positive correlation between *process* and *learning* as well as *product* and *access to resources* These results indicate that product and process complexity also influence GPN configuration, confirming the findings of (Ferdows et al., 2016; Schuh et al., 2013). In terms of corporate performance, positive dependencies are also shown (H3 & H4). The regression analysis implies significant improvements in *quality* and *flexibility* at a higher assigned relevance by the decision maker. This result confirms hypothesis by (Lanza et al., 2019). They argue that with greater incorporation of intangible local advantages, foreign production sites become more resilient to disruptions, which are consistent with increases in *quality*, *flexibility*, and *mobility*.

The results thus imply that production managers should emphasize intangible influencing factors in strategic GPN decision-making. Practitioners are encouraged to revise their own decision-making process and to incorporate intangible factors more profoundly, e.g. through analytical approaches. The proven influence on a company's performance justifies a thoroughly more elaborate decision preparation by quantifying less tangible influencing factors. Also, for application-oriented research, the contribution represents a motivation for the development of further decision support models, which can deal with the myriad and polymorphism of the influencing factors and extend the spectrum of so far operations research coined methods. Conceivable approaches may be fuzzy logic, statistical models, or expert systems. The inclusion of intangible factors can ultimately promote the harmonization of production strategy and network configuration.

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