The diversity of European manufacturing plant roles in international manufacturing networks*

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It is generally assumed that Western European (WE) plants belonging to multinational companies are more developed and have higher competence levels than their Central and Eastern European (CEE) counterparts. Nevertheless, empirical evidence on the plant level is very scarce. Thus, a sample of 291 manufacturing subsidiaries from 14 European countries is used to test this general statement. We argue that the clear distinction between the two regions is gradually changing with diverse plant roles coexisting in both European regions that reflect different development paths or strategies. Our results show that while less competent plants based on low cost factors are still more prevalent in CEE, a considerable group of highly competent plants is also emerging in the region that use their access to local skills and knowledge to become knowledge hubs within their networks. Nevertheless, highly competent WE plants still preserve a unique position within the multinational's network.

Key words: multinational company, manufacturing plant, plant role, competence, location advantage (JEL codes: F23, M11, M16)

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Introduction

There have been significant changes in the world economy due to the processes of globalization in the last few decades. More and more companies discover the advantages of establishing subsidiaries abroad, new countries are becoming targets of FDI, and the division of labour between countries is in a continuous change. Meanwhile, subsidiaries themselves evolve over time, as they build knowledge and develop capabilities. As international manufacturing networks (IMNs), i.e. networks of plants belonging to the same company, become more fragmented along the value chain, it is getting increasingly difficult to find general recipes for success, and to give advice to plant managers and policy makers.

In this paper we first search for empirical evidence for the general statement that manufacturing plants in Western Europe (WE) have higher competence levels than those in Central and Eastern Europe (CEE). Second, we intend to go beyond the general level and investigate whether there are subgroups in the two regions which are different from each other and, thus, mirror different development paths or strategies, which can provide useful information for decision makers to develop businesses and ensure a stimulating environment for these businesses. We approach the issue from the subsidiary point of view as opposed to the more prevalent IMN perspective.

First, we provide an overview of the literature on IMNs, including the unique characteristics of plants operating within a network. Next, we develop our hypotheses, introduce research methodology, analyse and discuss the results, and finally present the conclusions of this study.

Literature review

The paper focuses on multinational manufacturing companies. These companies coordinate the operations carried out by a network of globally dispersed manufacturing plants (IMN). Plants operating as members of IMNs have several unique features compared to single-plant companies. For example, they can play different roles within the network (Ferdows 1997), interact with other network members (Vereecke/Van Dierdonck/De Meyer 2006), benefit from being part of the network (Shi/Gregory 1998), and contribute with specific advantages to the whole company (Cheng/Farooq/Johansen 2011; Feldmannn/Olhager/Fleet/Shi 2013). Literature offers a substantial body of knowledge related to plant roles. It is generally acknowledged that location issues are important determinants of the decision on what roles various plants have to play within an IMN (Ferdows 1997). Several studies relate location with plant competences: the general assumption is that less developed countries serve as offshore sites from where they supply plants or markets located in more developed regions with parts, components and/or products (Mudambi 2008). But does location really imply the competences a plant possesses? Do plants in less developed countries always remain simple manufacturing sites, leaving their counterparts in more developed countries to control all the high value adding activities? To what extent does location and site competence determine the role of the plant within the network? These are the questions that constitute the starting point of our paper. Consequently, aspects of site competence and location provide the basis of our literature review.

Site competences

When defining different plant roles the type and level of *site competence* is one of the most important factors used by authors to classify manufacturing plants within a network. *Type* refers to the scope of activities/areas plants are responsible for, while *level* indicates the depth of knowledge in various activities/areas. These two dimensions (scope and depth) are usually considered simultaneously in the literature.

Koufteros, Vonderembse, and Doll (2002) define manufacturing competence as inwardly focused skills that are attained through the successful implementation of programs and plans. It is assumed that the more programs a plant implements the more competent it becomes. These programs can cover new areas (scope) but can also deepen previous knowledge (depth). In Ferdows' (1997) seminal paper, site competence refers to the scope of current activities performed by the plant. Competence at the lower edge starts from assuming responsibility for production and technical processes. Then it can be extended by such steps as assuming responsibility for procurement and logistics, making process or product related improvement recommendations, taking a role in the development of suppliers, assuming responsibility for process and/or product development, supplying global markets, and, at the highest competence level, becoming a global hub within the network for product and process knowledge. Vereecke and Van Dierdonck (2002) measure site competence similarly. According to their scale, at the lower edge of the spectrum plants have the main goal to "get the products produced", while at the higher end the plant becomes a "center of excellence, serving as a partner of headquarters in building strategic capabilities" (Vereecke/Van Dierdonck 2002: 500) for the whole network. Meijboom and Vos (2004) add production scheduling and production planning to the competence building stages provided by Ferdows (1997). Adding these items clearly indicates the depth of production competence: some plants just receive materials, technologies and even production plans from outside, while others take the responsibility for production planning and/or improving production processes, indicating a much higher level of the same production competence.

Besides Ferdows' (1997) developmental stages, there are several similar approaches in the literature that provide an evolutionary view on the level of plant competences. In a case based research on cross border activities between WE and CEE companies Reiner et al. (2008) found that subsidiaries in CEE build up development competence only after they possess the required production and supply chain competence. Feldmannn and Olhager (2013) investigate the level of local responsibility of the plant for several activities. Using factor analysis they conclude that site competence factors can be grouped into three categories: 1) *production competence* (including production, technical maintenance, and process improvement), 2) *supply chain competence* (including logistics, procurement, and supplier development), and 3) *development competence* (including the introduction of new product technologies, product improvement, and introduction of new process technologies). In a complex description of evolving plant roles and networks Cheng et al. (2011) aggregate existing plant role categorizations to define three levels of site competence based on the scope of activities they are responsible for (i.e., plants with low, medium, and high competence). Then, they investigate how manufacturing plants improve their competences, striving towards higher roles within the network.

Researchers cited above argue that there is a natural scope enlargement process as plants develop in time, from production competences, through logistics and supply chain activities, to designing and developing products and processes. Feldmann and Olhager (2013) show empirically that this sequence of competence building is valid for all manufacturing plants in their sample. Furthermore, it is also argued that the extension of scope (types of competences) and depth (gaining more experience and knowledge related to the same type of activities) happens simultaneously.

In conclusion, to differentiate between high and low competence levels, the following definitions are used. Based on the literature review we define a low competence plant as a plant that is at a significantly lower stage of the production – supply chain – development competence sequence (e.g. high production, medium supply chain, and no development competence), while high competence is described by a more advanced position in this path (e.g. high production, high supply chain, and medium development competence).

Plant location

The other important aspect of plant roles in IMNs is the *advantage provided by the location* of the manufacturing plant. Ferdows (1997) identifies three potential factors: low cost production, access to market, and access to skills and knowledge. The three location factors have been confirmed or used in several subsequent studies, including Vereecke and Van Dierdonck (2002), Maritan, Brush, and Karnani (2004), Jensen and Pedersen (2011), Feldmann and Olhager (2013). Reiner, Demeter, Poiger, and Jenei (2008) provide examples for low cost and access to market. They find that capacity problems or uncertain demand can represent further important reasons to locate subsidiaries in CEE countries. Moreover, they identify cases where the particularities of the existing supply network (e.g. the problem of material availability, breaking out from standard, mature product portfolio) have pushed companies to establish new subsidiaries. Although Reiner et al. (2008) show complex combinations of potential location factors, researchers usually provide more simplistic approaches. For example, Mudambi (2008) argues that low value-added activities (such as assembly manufacturing) are performed in emerging countries, and high value-added activities in developed countries. Other authors (Demeter/Gelei/Jenei 2006; Lewin/Massini/Peeters 2009; Cheng et al. 2011; Jensen/Pedersen 2011), however, find that in some cases offshoring to emerging countries can be motivated by other reasons than simply low costs, such as the availability of skilled labour or the size of the market (e.g. China).

Altogether, there seems to be an agreement in the literature on the main location factors identified by Ferdows (1997), but decision on plant locations is complex, so generalizations can sometimes be misleading. Our assumptions regarding the complexity of location decisions in case of WE and CEE are presented in detail in the hypothesis development section.

Other relevant plant characteristics in IMNs

Beside location, literature identifies several other characteristics which can be related to the competence level of plants. These factors provide relevant information in characterizing the role of plants within IMNs. Flow of knowledge, plant age, global orientation, plant autonomy, and physical embeddedness are among the most relevant of these factors.

In discussing plant roles within IMNs Vereecke et al. (2006) propose to take into consideration the *flow of knowledge*, namely flow of innovation, flow of people, and communication between plants. Clearly, more competent plants can become hubs of knowledge being able to share useful knowledge with less competent plants through these flows (Frost/Birkinshaw/Ensign 2002). However, as argued in the previous sections, competence building requires time. Thus, it is plausible to assume that *plant age* is associated with the knowledge accumulated by companies. Vereecke et al. (2006) offer some evidence for this relationship: in their research sample hosting network players, who play an important role in the exchange of knowledge between plants are much older (30 years on average) than any other plant type (the next group had an average age under 20).

The extent of *global orientation* of a plant is another important feature. Enright and Subramanian (2007) argue that “geographic scope can affect both the development and use of capabilities” (p. 910). One plant can serve the local market with its product line, or grow through regional responsibilities to a global mandate (Birkinshaw/Morrison 1995), requiring entirely different competences.

Plant *autonomy* is also regarded as a competence related feature. Meijboom and Vos (2004) find that having the competence of production planning is already a kind of knowledge that not all plants possess, which then hinders them to make autonomous planning decisions. Vereecke et al. (2006) explicitly examine strategic and operational autonomy. They find no difference among their plant types in respect of operational autonomy, but find significant differences in strategic autonomy, which is higher as the level of knowledge of plants increases. Reiner et al. (2008) conclude that the level of control of headquarters over subsidiaries is one important aspect which urges WE companies to find target location closer, i.e., in CEE instead of the Far East.

Lastly, the *physical embeddedness* of the plant in the intra-network flow of goods is considered. The more embedded a plant in the IMN, the more decisions have to be made on the network level, which directly influence the individual plant (Rudberg/Olhager 2003). Thus, higher embeddedness leaves less room for autonomous decisions, and thereby for competence development.

Hypothesis development

In an attempt to connect geographic location with the type of activities performed by IMN plants, Mudambi (2008) argues that low value-added activities are mainly performed in emerging countries, while knowledge-intensive, high value-added activities are generally located in developed economies. The global pattern of distribution of manufacturing activities is applicable in the case of the two European regions as well. In an empirical investigation of offshoring activities of 207 Danish firms, Jensen and Pedersen (2011) find that, in general, CEE attracts less-advanced manufacturing activities compared to WE, while research and development processes are more frequently offshored to developed regions. Focusing explicitly on European manufacturing industries, Dachs, Ebersberger, Kinkel, and Waser (2006) summarize the empirical results of the European Manufacturing Survey of 2249 companies located mainly in WE. Their study concludes that CEE countries represent one of the most attractive target regions for cost driven offshoring activities. On the other hand, offshoring to other WE countries is generally driven by the possibility to compensate for capacity bottlenecks in the home country, and to perform research and development activities. From a historical perspective the CEE region became attractive for WE manufacturers from the beginning of the 1990s, right after the fall of the communist regimes. Outsourcing to this region witnessed an unprecedented growth in the first decade (Guerreri 1998; Geishecker 2005), which has quickly led to the formation of a new division of labour, where the low value-added, repetitive manufacturing activities were performed by CEE plants (Marin 2006). The enlargement of the European Union in 2004, followed by the accession of two new CEE countries in 2007 further strengthened this process (Garmel/Maliar/Maliar 2005; Filippov/Duysters 2011). Moreover, in a survey study of CEE manufacturing subsidiaries, Filippov and Duysters (2011) find that during 2003-2008 manufacturing plants were able to increase their competences in activities related to production and sales, but achieved only little improvement in respect of supply chain and, notably, research and development competences. In an earlier case study of four CEE plants Meijboom and Vos (2004) also report a slow rate of progression in terms of site competence.

Thus, based on the historical evolution of CEE manufacturing in the last more than two decades, we presume that, on a general level, the division of labour between the two European regions still exists.

> *H1. Manufacturing plants in CEE, belonging to multinational companies, have lower competences than their WE counterparts.*

However, as Mudambi (2008) argues, manufacturing plants "to which these lower value-added activities are outsourced view them as stepping stones in the course of moving into higher value-added activities" (p. 708). Literature suggests that low competence plants should strive to acquire competences in higher value-added activities, thereby "catching-up" with other, more developed plants. Vereecke et al. (2006), for example, find that plants with higher competences and, thus, a deeper embeddedness in the network can better stabilize and secure their future. Several other case studies imply that plants should aim to develop their competences in time (Birkinshaw 1996; Meijboom/Vos 2004; Feldmannn et al. 2013). Not only that site competence improvement is beneficial for the respective plant, but it also impacts the whole network (Cheng et al. 2011; Feldmannn et al. 2013). As Ferdows (1997) puts it, the challenges, but also the rewards of upgrading the competences of a plant are substantial: "these plants ultimately provide their companies with a formidable strategic advantage" (p. 79). Indeed, in a survey of 263 WE manufacturers Linares-Navarro et al. (2014) find that offshoring involves a significant share of more advanced and knowledge-based activities (like product design or research and development) as well. Cheng et al. (2011) provide a description of the longitudinal evolution of three IMNs, in which some CEE plants (particularly those from Estonia, Poland, and Hungary) were able to upgrade their competences by accumulating experience with low value-added operations and making specific investments in technology and equipment. The improvement of plant capabilities was also supported by the headquarters of the respective companies. Thus, we expect that, beside low competence plants, a clearly definable group of CEE high competence plants also exists.

> *H2. A group of CEE plants has already developed higher competence levels relative to other plants in the same region.*

Next, going into the details of WE manufacturing, we argue that the whole picture is more nuanced than described on aggregate level (H1). Dachs et al. (2006), for example, find that several WE multinationals offshore their production activities to other WE countries simply because they need to expand production capacities. They argue that the geographical vicinity and controllable logistics expenses make these locations ideal targets for offshoring simple manufacturing activities. Cheng et al. (2011) also provide a case study example of a Denmark based IMN in which German, Swiss, and Austrian subsidiaries take the role of Server and Outpost factories, i.e., plants with low site competences according to the Ferdows (1997) model. In conclusion, we hypothesize that, beside the general pattern, there is a group of WE plants that (need to) have only lower competences.

> *H3. A group of WE plants have reached only a lower level of competences relative to other plants in the same region.*

In summary, H1 refers to the general distinction between WE and CEE manufacturing plants, while H2 and H3 fine-slices the relationship by going deeper into the competence levels of IMN member plants of the two regions. Besides testing the three hypotheses, we also propose to investigate the characteristics of different plant types in the two regions (in terms of location advantage, knowledge flows, plant age, global orientation, plant autonomy, physical embeddedness) to gain a deeper insight into the role different groups of European plants play in manufacturing networks.

Research sample and methodology

Research design

For the empirical analysis we use the sixth edition of the International Manufacturing Strategy Survey (IMSS VI). Launched in 1992 by the London Business School and the Chalmers University of Technology, the IMSS is carried out by an international network of researchers every 4-5 years focusing on plant-level manufacturing strategies, practices and performances of companies from all around the world (www.manufacturingstrategy.net). The IMSS VI was carried out in 2013-2014 using an e-mail/online survey sent to production/operations managers of manufacturing plants. The data collection process was administered in each country by local coordinators. Wherever needed, English language questionnaires were translated into local language by manufacturing strategy academics. Targeted plants belonging to the ISIC Divisions 25-30 (manufacture of fabricated metal products, machinery and equipment) were selected from official databases of manufacturing organizations in each country. Returned questionnaires were centrally controlled for missing and incorrect data, which were generally handled on a case-by-case basis by contacting the respondent again.

The final version of the IMSS VI database contains 931 responses from 21 countries, among which 114 responses from 3 CEE, and 384 responses from 11 WE countries. However, in concordance with the purpose of this study, we only use manufacturing plants that are members of an IMN. The IMSS questionnaire enquired about the configuration of the manufacturing network the respondent plant belongs to, more specifically whether the plant is: 1) stand-alone (single plant within the company), 2) member of a domestic network, 3) member of a regional network, or 4) member of a global network. Consequently, only plants that selected option 3 or 4 were considered in this study. Ultimately, we ended up with 291 usable answers, among which 245 WE and 46 CEE manufacturing plants. The distribution of the sample is presented in Table 1.

Table 1: The composition of the research sample by countries

CEE				WE			
No.	**Country**	**Total no. of plants**	**No. of IMN member plants**	**No.**	**Country**	**Total no. of plants**	**No. of IMN member plants**
1.	Hungary	57	**25**	1.	Belgium	30	**27**
2.	Romania	40	**12**	2.	Denmark	39	**24**
3.	Slovenia	17	**9**	3.	Finland	34	**12**
				4.	Germany	24	**11**
				5.	Italy	53	**29**
				6.	Netherlands	49	**28**
				7.	Norway	29	**21**
				8.	Portugal	34	**20**
				9.	Spain	30	**19**
				10.	Sweden	32	**29**
				11.	Switzerland	30	**25**
TOTAL		114	**46**	**TOTAL**		384	**245**

SPSS 21.0 software is used to apply cluster analysis and analysis of variance (ANOVA) with post-hoc tests to investigate the hypotheses and offer a deeper insight into the role of European manufacturing plants in IMNs. Questionnaire items used in this study are described in detail in the next subsection.

Questionnaire items

To assess the *competence levels* of manufacturing plants a questionnaire item is used which enquires about the extent the manufacturing plant is responsible for different types of activities. The activities considered are the three major categories put forward by Feldmannn and Olhager (2013), namely production, supply chain and product/process development. Each competence type is measured on a 1-5 Likert scale. The exact wording of the question is presented in Appendix 1.

To offer a better understanding of various plant types, additional plant characteristics are involved in the analysis. The exact wording of these items is presented in Appendix 2.

First, to assess the *location advantage* of the plant, three categories are considered, based on Ferdows (1997):

- access to low cost resources (labour, materials, energy);
- proximity to market (rapid/reliable delivery, customization, fast service and support);
- access to knowledge and skills (skilled workers and managers, technological know-how).

Each advantage is assessed on a 1-5 Likert scale, from “Strongly disagree” (1) to “Strongly agree” (5).

Second, respondents were asked to rate the extent to which their plant is responsible to serve as a hub of knowledge within the network (Frost et al. 2002; Deflorin/Dietl/Lang/Scherrer-Rathje 2012). Responses were recorded on a 1-5 Likert scale, ranging from “No responsibility” (1) to “Full responsibility” (5). Additionally, since the accumulation and creation of knowledge takes time (Veerecke et al. 2006), the year of plant foundation, a proxy for *plant age* is also taken into consideration.

Third, the extent of *global orientation* of plants (e.g. Enright/Subramanian 2007) is measured using a 1-5 Likert-scale item ranging from “The plant serves a specific geographic area/market” (1) to “The plant serves the whole world/global market” (5).

Fourth, in terms of *plant autonomy* both strategic and operational autonomy is assessed (Meijboom/Vos 2004; Veerecke et al. 2006). In terms of strategic autonomy the IMSS questionnaire measures on a 1-5 Likert scale whether “the plant can make its own strategic decisions” (1) or “The strategy is set by another plant in the network or an international division”. On an operational level, it enquires about whether “The plant is autonomous in defining the production plan” (1) or “Production plans are coordinated by another plant or an international division” (5).

Fifth, the *embeddedness of the plant* is also evaluated in terms of the extent to which the plant is involved in the physical flow of goods within the network. The physical embeddedness is assessed both on the supply and demand side. Respondents were asked to specify the percentage of input and output goods supplied by/to other plants in the network relative to the total amount of inputs/outputs handled.

Response bias

Van de Vijver and Leung (1997) argue that three types of biases have to be taken into consideration when doing comparative research: construct bias, method bias and item bias.

Construct bias refers to the case when a construct measuring the same concept has a different structure (i.e. different items) across different groups (Van de Vijver/Leung 1997). Our study uses cluster analysis on the competence variables (instead of factor analysis) to arrive at different competence level groups without creating constructs. Thus, construct bias is not an issue in this paper.

Method bias "is a generic name for all sources of bias emanating from methodological-procedural aspects of a study" (Van de Vijver 1998: 45). This type of bias can be further divided in three subtypes (Van de Vijver/Leung 1997). The first one is *sample bias* which arises due to differences in sampling approaches across different groups. The IMSS requires a standard sampling procedure from all participant countries, uniformly defining population characteristics and sampling methods for each country. Thus, we argue that sampling bias does not present a significant problem in our case. The second subtype is *instrument bias* which is due to the fact that respondents from different cultural groups might react to the same instrument in a consistently dissimilar way. For example, studies in psychology have shown that some non-Western respondents tend to increase their answers more than Western groups (Kendall/Verster/Von Mollendorf 1988; Van de Vijver/Daal/Van Zonneveld 1986). Instrument bias could be a potential influencing factor in the present study as well. Therefore, it is taken into account when drawing conclusions from the analysis. The last subtype of method bias is *administration bias* which might arise due to differences in the procedural aspects of the data collection. Data collection procedure being centrally designed and controlled, we believe that administration bias does not significantly influence our results.

Item bias refers generally to poor translations. IMSS uses a reliable method for translating the questionnaires to local languages. Researchers use either double parallel translation carried out by manufacturing strategy scholars or back-translation (Hult/Ketchen/Griffith/Finnegan/Gonzalez-Padron/Harmancioglu/Huang/Talay/Cavusgil 2008) to ensure consistency of items across different languages. Additionally, Likert-scale items have anchors attached to the endpoints of the scales (e.g. 1 – "no responsibility", 5 – "full responsibility") which are easily understood in each country (Rungtusanatham/Forza/Koka/Salvador/Nie 2005).

Thus, instrument bias could be the only potential biasing factor in the present study. This case, however, applies only when directly comparing the two regions, i.e. WE and CEE, and has to be only taken into consideration in testing H1.

Data analysis

Hypothesis testing

To test the first hypothesis the three major competence categories are used, namely production, supply chain and development. ANOVA is applied to compare the average competence levels of CEE and WE plants. Results are summarized in Table 2.

Table 2. Comparison of competences of CEE and WE manufacturing plants

Region / Competence	CEE Mean (St. Dev)	WE Mean (St. Dev)	F-value	Sig.
Production	4.67 (.668)	4.74 (.597)	F(1,287)=.526	.469
Supply chain***	3.65 (1.178)	4.19 (.968)	F(1,286)=11.266	.001
Development***	3.04 (1.364)	3.86 (1.177)	F(1,285)=17.101	.000

*Difference between the two regions is significant at the *** p=.001, **p=.01, *p=.05 level*

Results indicate that, on average, CEE plants have a significantly lower responsibility for carrying out supply chain or development related activities. On the other hand, production competence is at a similarly high level in both regions. This is, however, not surprising, given that the research was targeted at manufacturing plants, which most probably have a primary responsibility for production. Thus, we conclude by accepting H1. Furthermore, it is also evident that in both regions production competence has the highest level, followed by supply chain, and lastly by development competence. This clear order of competences points toward the cumulative, successive nature of competence development (Feldmann/Olhager 2013).

Next, to test H2 and H3, and get a more refined picture on the role of CEE and WE manufacturing plants in IMNs, a two stage cluster analysis procedure is used. First, a hierarchical cluster analysis with Ward's method is applied to determine the most suitable number of clusters based on both the agglomeration schedule and the dendogram. Then, this number is used as parameter in the non-hierarchical k-means clustering method involving the three competence variables.

For the classification process of CEE plants (H2), hierarchical cluster analysis clearly indicates that a two-cluster solution should be used. Then, k-means clustering is used to classify each case into one of the clusters and compute average competence values. Results are illustrated in Figure 1.

As a result, a *high competence* (N=22) and a *low competence* (N=23) cluster emerges. Both clusters have a similarly high production competence (F(1, 43)=.544, p=.465). The difference between the two groups is clearly made in terms of supply chain (F(1, 43)=10.389, p=.002) and, notably, development competence (F(1, 43)=120.139, p=.000). To offer a deeper insight into how individual cases form the two clusters a 3-dimensional coordinate system is created to illustrate the exact characteristics of the two clusters in terms of the three competence factors (i.e., production, supply chain and development).

Figure 1: Two clusters of CEE manufacturing plants based on competence levels

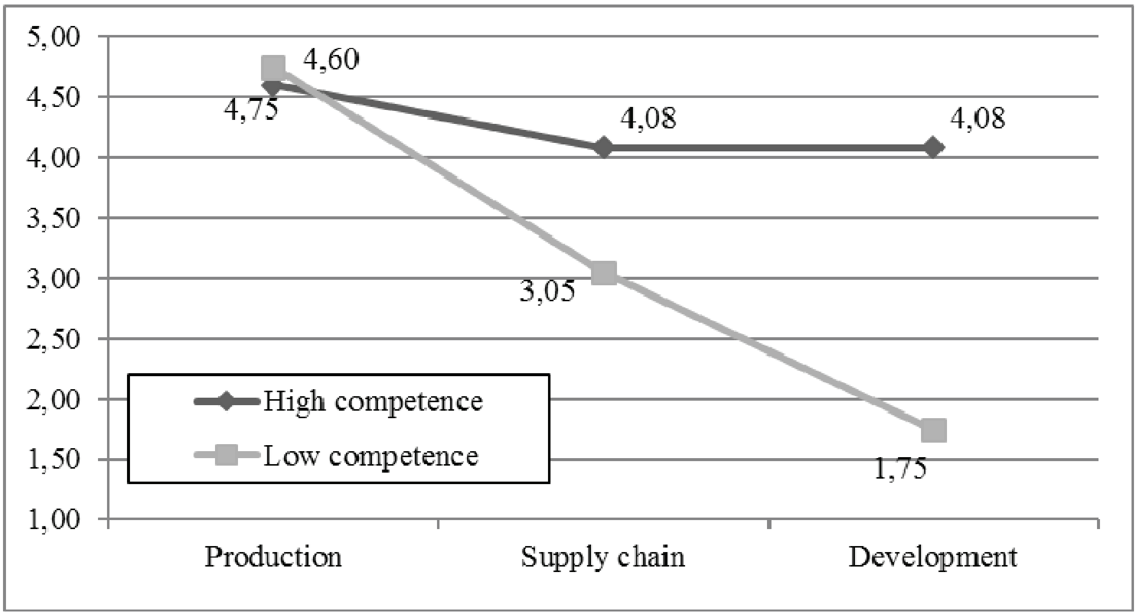


Figure 2: The distinguishing factors of the two CEE clusters of manufacturing plants

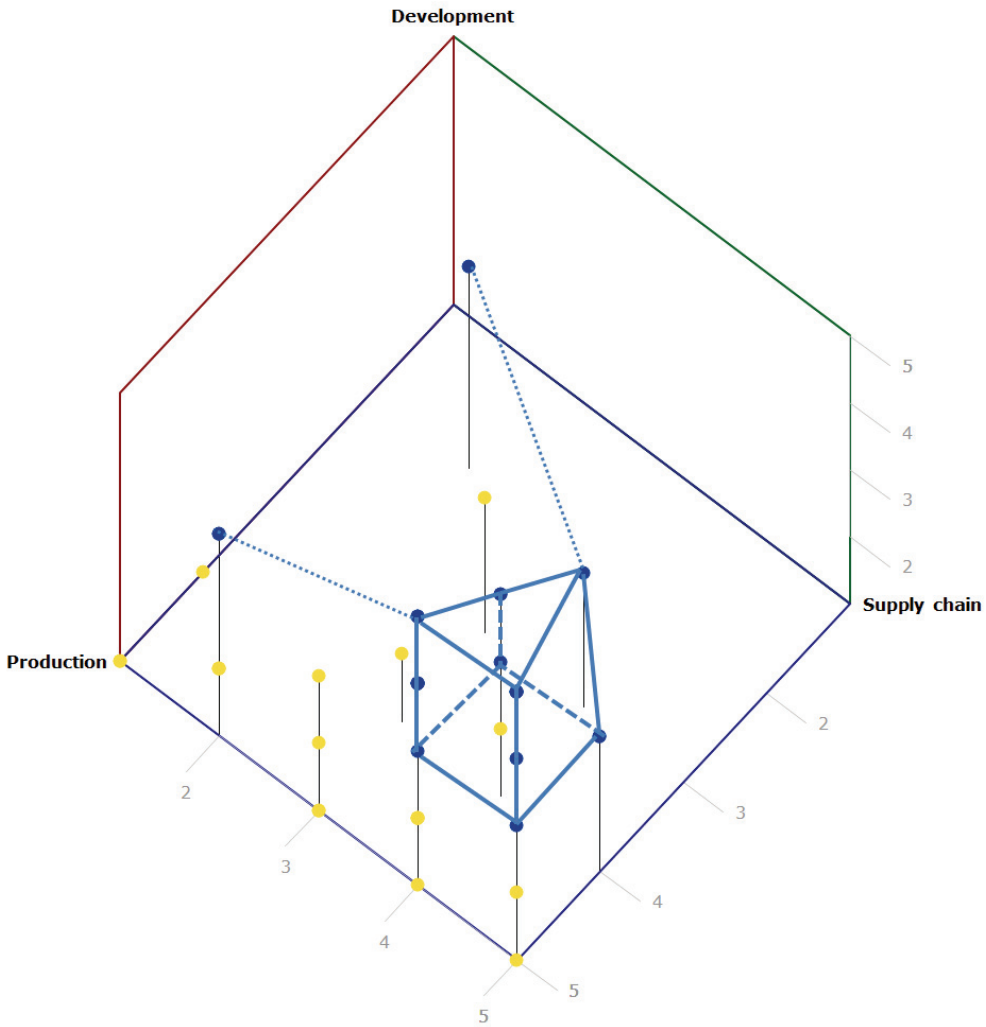
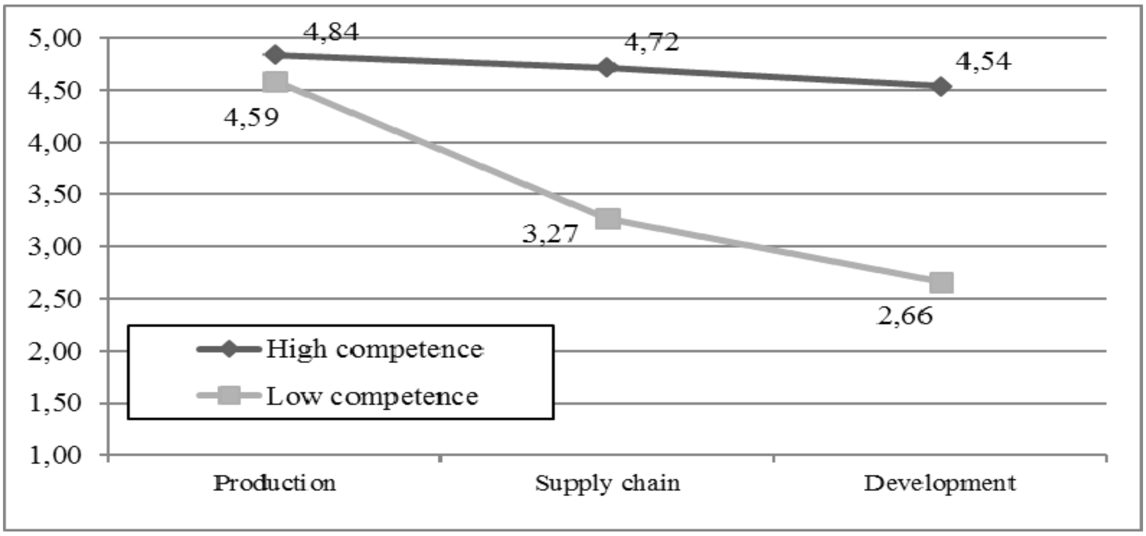


Figure 2 shows each individual case based on the three competence variables. The 3D shape marked with bold outlines contains all high competence plants: it shows that each individual manufacturing plant from this cluster has at least high production and supply chain competences (>=4), and at least medium development competences (>=3). There are only 2 exceptions with lower production and supply chain competence, respectively, but both score high on the development competence. Thus, in contrast with the general findings related to H1, in CEE there is a clearly definable cluster of manufacturing plants with (medium-to-)high competence levels. In conclusion, H2 can be accepted.

Next, to classify WE manufacturing plants (H3), an identical approach is used. Hierarchical cluster analysis suggests that the two-cluster solution is the most suitable. Results of the k-means clustering process are illustrated in Figure 3.

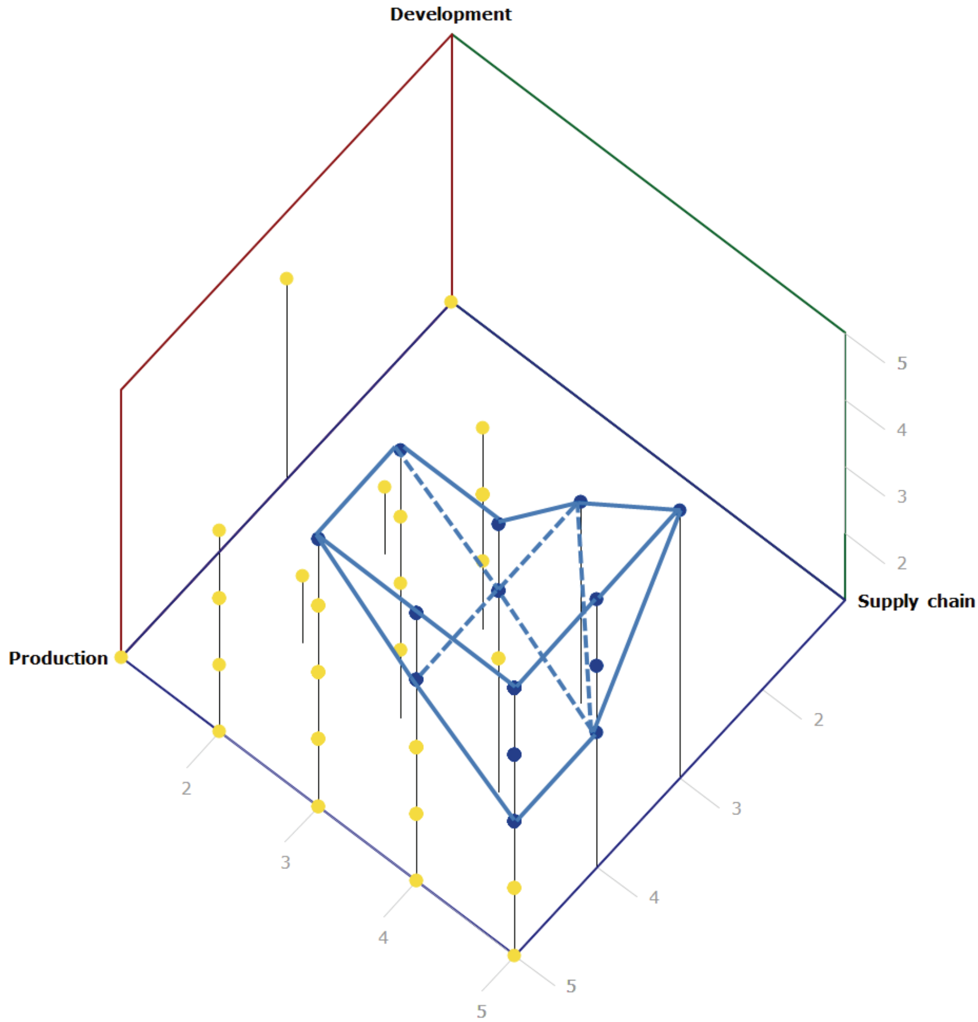
Figure 3: Two clusters of WE manufacturing plants based on competence levels



Similarly to the CEE case, in WE two clusters of *high competence* (N=131) and *low competence* (N=109) manufacturing plants emerge. There is a small, but significant difference in terms of production competence between the two clusters ($F(1, 239)=9.807$, $p=.002$), while supply chain ($F(1, 239)=257.704$, $p=.000$) and development competences ($F(1, 239)=348.906$, $p=.000$) show substantial differences. To investigate individual cases in more detail, another 3-dimensional coordinate system is created (Figure 4).

While the 3D shape marked with outlines contains manufacturing plants that have at least medium scores on all three competence dimensions, there are several other cases which score quite low on one, two or even all three factors. Thus, these findings show that, besides high competence plants, there is a clearly definable group of relatively low competence plants in WE. Thus, H3 can be accepted.

Figure 4: The distinguishing factors of the two WE clusters of manufacturing plants



In conclusion, the generally accepted regional contrast – that the more competent plants of manufacturing networks are located in WE, while the less competent ones in CEE –is only true on an aggregate level (H1). The cluster analyses show that in CEE a clearly distinguishable group of highly competent plants (H2) also exists, similar to the high competence cluster in WE. In the same time plants with a limited set of competences (in several cases restricted only to production competence) are also present in WE (H3).

Description of clusters

In order to offer a deeper insight into the different roles of CEE and WE manufacturing plants in IMNs, relevant descriptors of manufacturing plants within networks are involved in the analysis.

Using the items presented in the Research sample and methodology section (location advantage, hub of knowledge, plant age, global orientation, plant autonomy, physical embeddedness), ANOVA with Scheffe and LSD post-hoc test is applied to discover the differences between each pair of the four clusters of manufacturing plants developed in the previous section. The three competence measures are also involved in the comparisons to confirm the results of the cluster analysis. Fisher's LSD (least significant difference) is one of the most commonly used post-hoc test, being however the most permissive one in discovering significant pairwise differences, while the Scheffe test is the most conservative option (Hair/Black/Babin/Anderson 2010). We propose to use both approaches to shed light on any possible difference (LSD), while offering strong statistical support for the most obvious ones (Scheffe). The four clusters used in pairwise comparisons are: high competence plants in CEE (*CE-HI*), low competence plants in CEE (*CE-LO*), high competence plants in WE (*W-HI*), and low competence plants in WE (*W-LO*). Additionally, to check whether regional effects play a significant role, CEE and WE is also compared on an aggregate level. Detailed results are presented in Appendix 3. Due to the complexity of pairwise comparisons, a textual summary of the results is provided in Table 3.

Table 3: Comparison of clusters on plant specific variables

	CE-HI	CE-LO	W-HI	W-LO
Competences	**High** production, **relatively high** supply chain and development competence	**High** production, **medium** supply chain, **low** development competence	**High** production, supply chain and development competence	**Relatively high** production, **medium** supply chain and development competence
Location advantage	**Low cost** is important, but **access to market** and to **knowledge and skills** even more	Mainly **low cost** advantage	Low cost is not important, only **proximity to market**, and, notably, **knowledge and skills**	**Proximity to market** is relatively more important
Hub of knowledge	**High** responsibility for hub of knowledge	**Low** responsibility for hub of knowledge	**High** responsibility for hub of knowledge	**Medium** responsibility for hub of knowledge
Plant age	**Younger** plants	**Younger** plants	**Mature** plants	**Mature** plants
Global orientation	Not significant: medium global orientation	Not significant: medium global orientation	**Higher** relative global orientation	**Lower** relative global orientation
Plant autonomy	Medium strategic and operational autonomy	Medium strategic and operational autonomy	**High** strategic and operational autonomy	Medium strategic and operational autonomy
Physical embeddedness (ratio of flows within the network)	**High ratio** of outputs. Not significant: **medium** ratio of inputs.	**High ratio** of outputs. Not significant: **medium** ratio of inputs.	**Low** ratio of outputs. **Lower** relative ratio of inputs in the network.	**High ratio** of outputs. **Higher** relative ratio of inputs in the network.

Descriptive summary of post-hoc test results

CE-HI = Central and Eastern Europe, high competence; CE-LO = Central and Eastern Europe, low competence; W-HI = Western Europe, high competence; W-LO = Western Europe, low competence.

Based on the significant differences, a detailed description of the four clusters of manufacturing plants is provided below.

CEE high competence plants: all three competence levels are high. While low cost is an important location factor, proximity to market and access to knowledge and skills play an even higher role which is an atypical result for the CEE region. Possessing high competence levels, these plants have an equally high responsibility for knowledge dissemination as WE high competence plants. Plants are relatively young. These plants show an average level of global orientation and autonomy. Embeddedness in the physical flows within the network is relatively high, especially on the output side. In other words, they produce inputs for other IMN members.

CEE low competence plants: besides high production competence, supply chain has a medium, and development only a very low level. Low cost is the primary advantage of location, while proximity to market and access to knowledge and skills play significantly less important role compared to other clusters. As opposed to the CEE high competence group, possessing low competences makes these plants significantly less responsible for knowledge sharing within the network. These plants are relatively young, and similarly to CEE high competence plants they also show an average level of global orientation and autonomy. Embeddedness in the physical flows within the network is relatively high, especially on the output side. In other words, they also produce inputs for other IMN members.

WE high competence plants: all three competence levels are very high. Access to knowledge and skills seems to be the most important location factor. These plants take high levels of responsibility in assuming the role of knowledge hub within the network. Plants are relatively older and are highly globally oriented. They are both strategically and operationally highly autonomous. In concordance, they are the least embedded in the flow of goods within the network, especially on output side, selling their products mostly to external customers.

WE low competence plants: production competence is high, while supply chain and development competence has a medium level, but still significantly lower than any of the high competence clusters. Proximity to market seems to be an important location factor, while access to skills and knowledge has average importance. They rarely assume the role of knowledge hub within the network, which however is still somewhat higher compared to CEE low competence plants. Plants are relatively older. These plants show an average level of global orientation and autonomy, which are significantly lower than in the case of WE high competence plants. Embeddedness in the physical flows within the network is relatively high, both on the input and output side.

Discussion

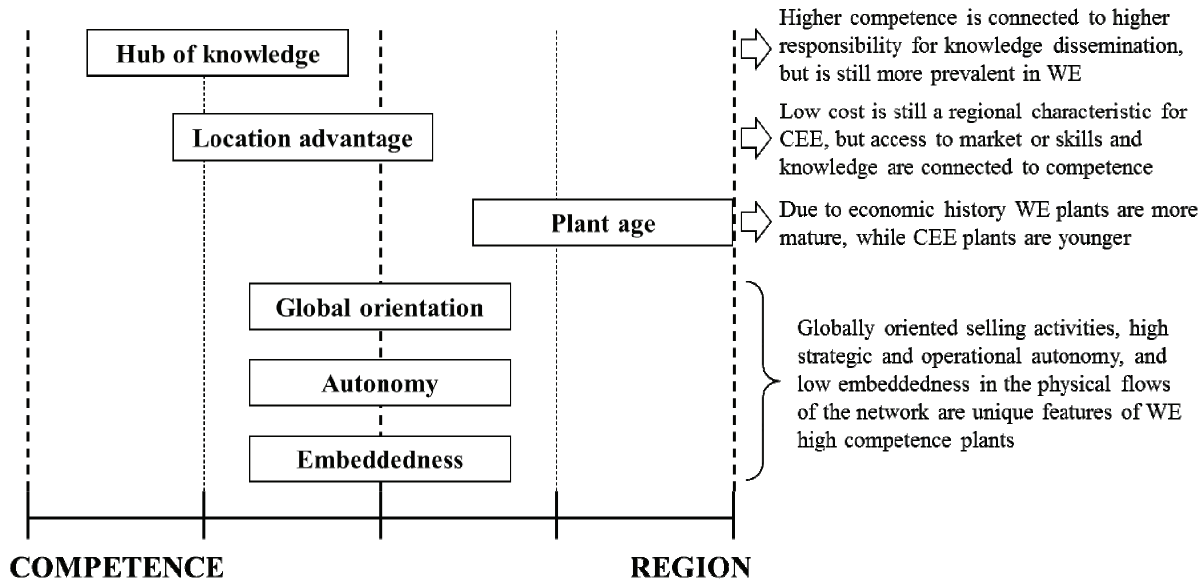
On an aggregate level, subsidiaries in CEE have lower supply chain and development competences than their counterparts in WE (H1, Table 2). That alone can explain why these plants are also less frequently serving as a hub of knowledge in the IMN: they have to accumulate knowledge before they can start sharing it (Vereecke et al. 2006; Deflorin et al. 2012). This accumulation takes time (Veerecke/Van Dierdonck 2002). Looking at their age, plants in CEE are, on average, younger. Being younger might have a strong association with the level of competence of a plant due to the shorter timeframe to accumulate knowledge and experience. The association between the average competence levels of WE and CEE plants, on one hand, and hub of knowledge and plant age, on the other hand, is supported by our post-hoc analysis (Appendix 3): responsibility for hub of knowledge, and year of plant foundation are the only group of variables that clearly and significantly differ between the two regions.

The relatively high standard deviations of competence levels in both regions, notably in terms of supply chain and development competence, indicate that it was a meaningful approach to further dissect the two samples, and examine different plant roles within each region. Furthermore, several plant-level characteristics show a strong association with the differentiation of clusters within each region. For example, hub of knowledge, while different on a regional level, it shows clear differences along high and low competence clusters in both regions as well. Thus, the possibility of becoming a centre of knowledge for the whole network is clearly in connection with the level of competences acquired by the plant. Another important implication of handling high and low competence plants separately is connected to location advantage: while low cost advantage is still determined on a regional level (i.e. higher in CEE), proximity to market and to knowledge and skills is a clear advantage of CEE high competence plants relative to CEE low competence plants. Similarly, proximity to market seems to be a more important location factor for WE low competence plants than for WE high competence plants. Thus, location advantage is not only a given geographical circumstance: it also depends on the mandate of the plant to choose which location factors to take advantage of.

On the other hand, there is a set of plant characteristics which seem to be a distinctive feature of WE high competence plants. This cluster is uniquely described by relatively high global orientation, high degree of strategic and operational autonomy, and low embeddedness in the intra-network flow of goods, especially on the output side, meaning that these plants deliver their products mainly to external customers. All these features point toward the role of lead factories within networks (Ferdows 1997; Enright/Subramanian 2007), which – according to our findings – are most frequently taken by WE high competence plants. Whether CEE high competence plants can also develop to this role in the future remains a question for future research. Our findings show that they are more integrated in the intra-network flow of goods: linking plant operations results in more synchronized operations and control in the network, and thus in a lower operational autonomy (Reiner et al. 2008), which is also confirmed by our results. Thus, the operations of CEE high competence plants are still under the control of headquarters or lead plants, but due to the accumulated competences they have become important centres of knowledge for other plants in the network. Sass and Szalavetz (2009) also arrive to similar conclusions on the basis of case studies carried out in the Hungarian automotive and electronics sectors. They find that even if some companies managed to upgrade their competences considerably, "top quality levels (…) [the highest capabilities/decisions] are hardly attainable for peripheral, local subsidiaries" (p. 15). The performance of such CEE subsidiaries is still highly dependent on their linkages with other units (including the headquarter) within the network (Golebiowski/Lewandowska 2015).

Figure 5 offers a summary on the association between plant characteristics, on one hand, and region (CEE versus WE) and competence (high versus low), on the other hand.

Figure 5: The connection between plant characteristics and competence/region



From a managerial point of view it is an important question, whether the evolution of plants throughout the years that ultimately leads to higher competences, also changes the location advantages perceived by these plants. This question is particularly important for CEE plants. As they become responsible for more functional areas due to increasing competences, the number of operational links with other network members might reduce, and they might start to search much more for skills and knowledge, and less for lower costs. This is a crucial point for less developed countries, which still try to attract foreign companies with the comparative advantage of lower costs. But as more and more highly competent plants emerge in these countries, they will require highly educated labour instead, which will definitely cost more, reducing to some extent the comparative advantage of less developed countries. Since education takes a long time, policy makers have to be prepared for this change.

Conclusions

Summary and implications

Using an international survey, this paper examined the role CEE and WE plants play in their international manufacturing networks. The main contributions of our research are twofold: 1) it supports empirically at plant level the difference in competence levels between CEE and WE plants, and 2) it gives a deeper insight into both regions by characterizing more and less competent clusters, showing that there is a great diversity of plant roles in both regions.

On an aggregate level, our results demonstrate that WE plants have higher competence levels than CEE plants, which can be in close relation with their age, since WE plants in our sample are, on average, more than 20 years older. Throughout these years, WE plants have accumulated more knowledge on supply chain management and product/process development, and therefore serve more frequently as a hub of knowledge.

In terms of location advantages, the uniqueness of CEE compared to WE is still the low cost production. However, there is a tendency that the increasing competence level of plants in this region, as observed in the case of CEE high competence plants, could eliminate this driver in the future, or at least reduce its role compared to access to knowledge and skills.

Besides investigating plant characteristics on a regional level, our study suggests that the picture within each region is more nuanced: in both WE and CEE plants exhibit a great diversity in terms of competence levels. There is a clearly definable high competence cluster in CEE, and a low competence cluster in WE as well. Regardless of the region, competence clusters show a clear association with the responsibility of the plant to become a centre of knowledge, but also with location factors (except for low cost which is more regionally determined). Similarly, global orientation, autonomy and low network embeddedness seem to be exclusively associated with high competence plants in WE.

Limitations and further research

One important limitation of this study is that the research sample is neither on country nor on regional level statistically representative. However, we argue that the careful selection of targeted manufacturing plants, the centrally controlled, rigorous data collection and validation process, and the use of regions as the main grouping variable in this research (Disdier/Mayer 2004) allow us to formulate more general conclusions. Nevertheless, future studies should test our findings on a more encompassing European sample to investigate the diversity of development paths of manufacturing plants.

Although research and questionnaire design strived to minimize response bias, relativities in the usage of scales due to national or cultural differences can not be entirely eliminated.

Another limitation is the cross-sectional nature of this research. Longitudinal analysis could be applied to investigate the accumulation of capabilities, and to show whether this has an effect on perceived location advantages, leading ultimately to a complete change of plant roles and characteristics.

This study focuses on Europe. Nevertheless, it is highly probable that similar relationships exist on other parts of the world, where the level of development is different in two adjacent regions. Such regions represent another bountiful opportunity for further research.

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Appendix 1

To what extent is your plant responsible for the following activities?

	No responsi-bility				**Full respon-sibility**
Production (e.g., production, process improvement, technical mainte-nance)	1	2	3	4	5
Supply Chain (e.g., procurement, logistics, supplier development)	1	2	3	4	5
Development (e.g., Product improvement, Introduction of new product or process technologies)	1	2	3	4	5

Appendix 2

To what extent do you agree with the following statements about the current advantages of your plant's location?

	Strongly disagree				Strongly agree
Your current advantage is to access low cost resources (labour, materials, energy)	1	2	3	4	5
Your current advantage is the proximity to market (rapid/reliable delivery, customization, fast service and support)	1	2	3	4	5
Your current advantage is to access to knowledge and skills (skilled workers and managers, technological know-how)	1	2	3	4	5

To what extent is your plant responsible for the following activities?

	No responsibility				Full responsibility
Serving as a hub for product / process knowledge (e.g. showroom for good practice, sending out experts to share knowledge)	1	2	3	4	5

In what year was the plant established ______________________________

What is the role of your plant according to the following dimensions?

Your plant serves just a specified surrounding geographic area/market	1	2	3	4	5	Your plant serves the whole world / global market

How do you coordinate with other plants in the network?

You can make your own strategic decisions	1	2	3	4	5	The strategy is set by another plant in the network or an international division
This plant is autonomous in defining the production plan	1	2	3	4	5	Production plans are coordinated by another plant or an international division

Please provide an estimate of the distribution of value of inputs (materials, components, sub-assemblies products) and outputs exchanged with other partners:

Inputs (materials, components, sub-assemblies)		**Outputs (components, sub-assemblies, products)**	
From other plants/units in the network	_______ %	To other plants/units in the network	_______ %
From external suppliers	_______ %	To external customers	_______ %
Total	**100 %**	**Total**	**100 %**

Appendix 3 - comparison of regions and clusters on plant specific variables

	CEE	WE	Sig.	*CE-HI*	*CE-LO*	*W-HI*	*W-LO*
Competences							
Production competence	4.67	4.74	.469	4.60	4.75	**4.84** (W-LO)	**4.59** (W-HI)
Supply chain competence	3.65	4.19	**.001**	**4.08** *(CE-LO, W-HI, W-LO)*	**3.05** *(CE-HI, W-HI)*	**4.72** *(CE-HI, CE-LO, W-LO)*	**3.27** *(CE-HI, W-HI)*
Development competence	3.04	3.86	**.000**	**4.08** *(CE-LO, W-HI, W-LO)*	**1.75** *(CE-HI, W-HI, W-LO)*	**4.54** *(CE-HI, CE-LO, W-LO)*	**2.66** *(CE-HI, CE-LO, W-HI)*
Location advantage							
Low cost resources	3.61	2.31	**.000**	**3.40** *(W-HI, W-LO)*	**3.90** *(W-HI, W-LO)*	**2.17** *(CE-HI, CE-LO, W-LO)*	**2.55** *(CE-HI, CE-LO, W-HI)*
Proximity to market	3.82	3.71	.530	**4.32** *(CE-LO, W-HI)*	**3.21** *(CE-HI, W-LO)*	**3.59** *(CE-HI, W-LO)*	**3.91** *(CE-LO, W-HI)*
Access to knowledge and skills	3.96	4.09	.357	**4.20** *(CE-LO)*	**3.70** *(CE-HI, W-HI)*	**4.14** *(CE-LO)*	3.99
Hub of knowledge							
Hub for product/process knowledge	3.07	3.66	**.002**	**3.72** *(CE-LO,W-LO)*	**2.35** *(CE-HI, W-HI, W-LO)*	**3.98** *(CE-LO,W-LO)*	**3.10** *(CE-HI, CE-LO, W-HI)*
Plant age							
Year of plant foundation	1988.3	1967.4	**.000**	**1983.2** *(W-HI)*	**1994.9** *(W-HI, W-LO)*	**1964.6** *(CE-HI, CE-LO)*	**1972.2** *(CE-LO)*
Global orientation							
Plant serves specific region (1) / whole world (5)	3.82	3.92	.637	3.63	4.00	**4.14** (W-LO)	**3.53** (W-HI)
Plant autonomy							
Own strategy (1) / set by another plant, division (5)	3.11	2.90	.316	3.00	**3.39** *(W-HI)*	**2.57** *(CE-LO,W-LO)*	**3.45** *(W-HI)*
Own production plan (1) / another plant, division (5)	2.91	2.31	**.012**	**2.80** *(W-HI)*	**3.16** *(W-HI)*	**2.08** *(CE-HI, CE-LO, W-LO)*	**2.68** *(W-HI)*
Physical embeddedness							
Inputs from other plants in the network (% of total)	23.02	24.23	.785	23.13	22.50	**20.77** *(W-LO)*	**29.95** *(W-HI)*
Output sold to other plants in the network (% of total)	33.95	22.12	**.018**	**32.79** *(W-HI)*	**35.50** *(W-HI)*	**17.34** *(CE-HI, CE-LO, W-LO)*	**29.79** *(W-HI)*

Bold values = significantly different from at least one other cluster
Cluster name(s) in parentheses = significant difference between the cluster in column and the cluster(s) in parentheses
Italic = LSD post-hoc test (p<.05), Underlined = Scheffe post-hoc test (p<.05), *Italic and underlined* = significant difference according to both post-hoc tests used