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Coordination within International Manufacturing Networks: A Comparative Study of Three Industrial Practices

Farhad Norouzilame[1,2], Magnus Wiktorsson[1]

[1]School of Innovation, Design and Engineering, Mälardalen University, Eskilstuna, Sweden
[2]LEAX Group, Köping, Sweden
Email: farhad.noruzi@leax.com, magnus.wiktorsson@mdh.se

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Abstract

The globalisation of manufacturing activities has led to the emergence of internationally dispersed manufacturing plants. Coordination of such networks is a complex task and entails several management challenges. The purpose of this paper is to increase the understanding regarding the coordination issues and how they could be managed in IMN environment. Using a multiple case study approach, data from three multi-plant manufacturing businesses were collected and analysed. The results include discussions on coordination aspects such as autonomy and mechanisms to conduct coordination. Furthermore, a model for assigning autonomy level to the plant in an IMN is suggested as well as mechanisms to conduct the coordination work.

Keywords

International Manufacturing Network, Coordination, Case Study

1. Introduction

The internationalisation of business is indisputable [1]. During the last decades, many companies have expanded their manufacturing network on a global scale, either organically or through acquisitions [2]. In 2013 only, foreign affiliates of multinational corporations (MNCs), employed 71 million people and showed \$35 trillion in sales and \$97 trillion in assets [3]. The globalisation of manufacturing activities has led to the emergence of internationally dispersed manufacturing plants, a phenomenon termed an "international manufacturing network (IMN)" within the literature. An IMN is an intrafirm network of internationally dispersed factories with matrix connections, in which the individual factories affect each other and cannot be managed in isolation [4] [5]. As opposed to a supply chain that includes several plants and several companies, an IMN includes multiple plants within a single organisation [6].

In the course of the aforementioned trend, the focus in production/operation management research (P/OM) has moved from plant management to managing a network of geographically dispersed plants (see e.g. Colotla, Shi, and Gregory 2003; Cheng and Johansen 2014; Rudberg and West 2008). Consequently, different facets of IMN management have emerged. Examples include plant roles and the locations of production plants [5] [7] [8], network topologies [9], studies on IMNs from an strategic perspective [10] [11], balancing the configuration and coordination of manufacturing networks [12], learning and distribution processes within manufacturing networks [13].

Similar to any other operating system, management of an IMN includes two distinguished types of decisions: 1) decisions regarding its configuration and 2) decision regarding its coordination [14]. The decisions concerning "configuration" address structural decisions to design a network, and those related to "coordination" address infrastructural links among plants [15]. Maritan, Brush [16] conclude that for strategic management of an IMN, it is insufficient to only understand the strategic role of each plant within a network. Cheng [17] demonstrates that organizations that outperform their competitors tend to better coordinate their existing interdependence. A proficient coordination among IMN's plants improves cost, delivery performance, and learning ability in a network [18].

Coordination itself is not a new research topic. It is an interdisciplinary field of research that has been studied in diverse context such as computer science, organization theory, operations research, economics, and psychology [19]. However, within IMN-related literature, coordination is one of a few under-investigated topics/issues [1]. Apart from the research of a few scholars in IMN management area (e.g. [2] [12] [20] [21] [22]), studies have seldom addressed the coordination of manufacturing specifically.

Nevertheless, studying coordination, due to the need for interdisciplinary teams of specialists and distributed operations [23] and being one of the two main issues concerning the management of manufacturing networks [22], is significant. In fact, since configuration and coordination aspects are closely related [24], even a successful configuration of an IMN is dependent on its coordination. Kinkel and Maloca [25] show that underestimated coordination needs are among the top five reasons for a site's being back sourced. A proficient coordination that includes the establishment of procedures to link or integrate factories in a network is necessary in order to orchestrate the plants of an IMN to achieve the strategic objectives of a business of a manufacturing network (Cheng *et al.*, 2011).

Three streams of studies on IMN coordination are identified as: 1) the introduction of practices related to IMN coordination, 2) the transfer of production technologies and knowledge, and 3) the optimisation of physical distribution [1]. In a multi-plant context, both knowledge transfer and coordination of physical have been sufficiently studied (see e.g. [26]-[31]). Nevertheless, the body of knowledge in global manufacturing still lacks documented cases of good practice on how international manufacturing companies should be managed and coordinated [22] [32]. Studying such practices will allow understanding of current issues and the used concepts and methods. Consequently, the purpose of this paper is to increase the understanding regarding the coordination and how it is conducted in IMN environment by investigating three industrial practices. This was pursued in line with the following research question. "How is IMN coordination conducted and realised in the operation network of MNCs?" Studying the industrial practice on IMN coordination can provide useful insight to expand the currently limited IMN coordination theories.

This research is based on a qualitative multiple case study method [33]. The literature review is founded in the fields of global manufacturing in particular IMN management. The case studies are descriptive in nature [33], with data being collected during various periods for each case. The structure of the article is as follows. First, a review of related literature on IMNs and their coordination is provided. Then, the research method and data collection method are explained followed by the findings from the cases studies. Next, discussions on coordination issue and suggested mechanisms are provided. The final section concludes the paper and highlights future research possibilities.

The contribution of this research is bilateral. First, to contribute to the existing theories, a short summary of theories on IMN management and coordination was provided. Then, the coordination practices of three MNCs and the autonomy of plants in those companies were explored. Studying the coordination practices in other companies allows practitioners to rethink and improve their network coordination. A model was presented in this regard in which three classes were introduced in regards to the coordination role of a plant in an IMN. Besides, mechanisms were introduced that are needed to conduct the coordination work.

2. Literature Review

2.1. Management of International Manufacturing Networks

Traditionally, research on P/OM has concentrated on individual, isolated production plants [34]. While structural decisions manage the physical layout of the resources in a plant [35], infrastructural decisions deal with activities that take place within the plant [36]. Owing to the explosive growth in international trade and appearance of dispersed operations [21], there was a new wave of studies regarding the management of IMNs (see e.g. [4] [15] [22] [24]). By reviewing 107 articles from 41 journals, Cheng, Farooq [1] provide a thorough analysis of the development of research on IMNs. They classify network-level literature around IMN management into two main categories: 1) configuration aspect that relates to plant roles and location criteria, such as the placement and number of plants for each activity in a network and 2) coordination aspect which deals with questions on how to organise, link, and integrate linked activities in plants [15] [37].

The configuration aspect of IMN management covers two structural decision areas: 1) the geographical location of plants and the inter-facility allocation of production resources, and 2) the strategic roles of the plants in the network [12]. Regarding the role of a plant in an IMN, Ferdows [8] assigned six strategic roles to plants in an IMN, based on two criteria: 1) the primary reason for establishing a plant, and 2) the competence scope of a plant [8]. In another study, Schmenner [38] identified four generic strategies with regard to the structure of an IMN: 1) *product plants* with plant focusing on certain products, 2) *process plants* where each plant is responsible for part of the overall production process, 3) *market area plants* in which plants produce multiple products to serve a particular region, and finally 4) *general purpose plants* that include plants with responsibility for products, process and market.

2.2. Coordination in International Manufacturing Networks

Coordination is defined as 'the process of managing dependencies among activities' [19]. Literature around coordination spans a wide context among them computer science, organization theory, operations research, economics, and psychology [19]. Cheng [17] studied 127 research units from 33 organizations to investigate the implications of interdependence on coordination and its effect on organizational performance. Not surprisingly, their results indicated that interdependence not only relates significantly to coordination, but it also moderates the relationships between coordination and performance of an organization [17].

The emergence of dispersed manufacturing as multi-plant complex systems seeded the study of coordination in IMN context. Within an IMN, there are two types of flows *i.e.* physical, such as products and material flows, or non-physical, such as information and knowledge flows [39]. Coordination of interactions among the plants of an IMN allows full exploitation of network advantages [40]. It reduces costs and enhances the effectiveness of a network, while preserving some diversity in products and in the location of manufacturing ([18] p. 83). Two main infrastructural issues in coordination are: 1) autonomy of production plants and network governance and 2) management of flows among the plants [15] [41].

The autonomy issue concerns institutional rules on the two aspects of centralisation and standardisation. Feldmann [20] defines the centralisation of decision-making as the distribution of decision-making authority for manufacturing decisions and divides decision-making strategies into: centralised at the headquarters, decentralised at the plant level, and integrated between the headquarters and local plants [42].

In an early study, Mascaren has [43], by analysing the relationships and increasing manufacturing interdependence in 25 multinational companies, suggested four coordination modes *i.e.* impersonal methods, system-sensitivity, compensation system, and personal communication. In another study, Mintzberg [44] introduces three methods for coordination in inter-firm type of organisation: direct supervision, standardisation and mutual adjustment.

As previously mentioned, prior research does not reflect much about coordination of IMNs. One exception is the research of Rudberg and West [22], who present a coordination model developed originally at Ericsson Radio System. They examined how recent research on manufacturing networks was incorporated in their global operation strategy. The model provides tools for transforming a global operation strategy into a set of guidelines and directives for management. It includes three main elements: 1) the model factory (plant), which is regarded as a virtual factory that establishes a framework for the design and operation of plants in the network, 2) the network organisation, which includes plants with certain responsibilities to the company as a whole, and to the other plants in the IMN, in the form of master or clone plants[1], and 3) the competence groups, which are groups that revise and update the standards of manufacturing [22]. Rudberg and West [22] provide a good starting point to understand the key areas of coordination. However, regarding the autonomy of plants, their model does not go beyond the "master-clone" concept. Neither does their model discuss exact mechanisms to be conducted within their proposed framework. Nevertheless, in order to consistently manage the cooperation between the plants in an IMN, coordination mechanisms need to be set in place ([2] p. 11).

2.3. Existing Coordination Literature

The previous studies on IMN management have had a great emphasis on the strategy-related areas [45]. In this area, the long term fortune of operations through the achievement of unique competitive advantages has been thoroughly studied [11] [46] [47] [48] [49]. Furthermore, literature around the configuration aspect of IMN management provides a rich domain of studies on number and role of the plants in a network of operations [5] [8] [50].

However, in comparison to the other aspects of IMN management, literature around coordination of IMNs has still great potential to get improved. Some of challenging areas in regard to the coordination of an IMN are: establishing an autonomy balance among the network plants, transferring the culture and core values of a company to the network plants, exchange of information and knowledge among the plants of an IMN, and re-organisation and re-allocation of the resources [32]. Regarding the management of physical flows within a network of plants, different approaches are suggested for optimised production and distribution of a manufacturing and distribution network (See e.g. [26]

[1]The "master-clone", or alternatively called "core and hub" concept, refers to a classification of plants into two main categories with different levels of autonomy on transfer of production know-how.

[27]). Therefore, in this study, we tried to focus on the less studied aspect of coordination *i.e.* coordination of non-physical flows in an IMN.

3. Research Methodology

3.1. Research Approach

The purpose of this paper is to increase the understanding regarding IMN coordination by studying three industrial practices. We chose case study approach as it allowed investigating rich, empirical description of particular instances of the phenomenon (coordination in this case), based on a variety of data sources [33] [51]. Furthermore, since case studies are typically carried out in close interaction with practitioners, they represent a methodology that is ideally suited to studying managerially relevant issues [52]. To increase the quality of emergent theory [53] and the explanatory power of the data collection process ([54] p. 172]), a multiple setting was selected.

The research was conducted in a multi-plant intra-firm (single ownership) setting (IMN context). The data were collected from the plants that produced discrete components for automotive and construction equipment sector. All of the companies were headquartered in Sweden. Therefore the interviews took place mainly at those premises. That said, three participants from a company's plant in Brazil and two from a plant in Germany were involved in the data collection phase.

3.2. Case Selection

Three case companies (A, B, and C) were selected for analysis (see **Table 1**), each representing a case (also labelled A, B, and C). The criteria for choosing the companies were: 1) to be in an international multi-plant setting under a single company ownership (IMN context) and 2) to have a relevant history of performing coordination activities between their plants (hereby set to be more than ten years) and 3) to grant the possibility to access to in-depth data from relevant people and documents regarding coordination in those organisations.

The selected companies fulfilled all of the mentioned criteria. Furthermore, as recommended by Pettigrew [55] the cases were chosen from diverse types (hereby from centralisation and plant strategy point of view) to achieve a wider domain of data. The respondents were informed in advance about the scope of the study and the interviews.

3.3. Data Collection and Analysis

The data collection involved multiple rounds of participation, interviews, and document studies over various periods for each case company. The data collection took about nine months for Company A, six months for Company B, and three months for Company C. This was because the authors of this paper was, to various degrees, employed, or engaged in Company A and Company B. This provided an opportunity to gather richer data in those companies and therefore,

Table 1. Key characteristics of the case companies.

Company	Company A	Company B	Company C
Size (employees)	Ca. 1200	Ca. 40,000	Ca. 15,000
Industry sector	Automotive, mining, etc.	Automotive	Mining and construction
	Diverse	Commercial vehicles	Construction equipment
Product	High	Medium	High
Product variety	Medium	High	High
Process complexity	11 plants,	15 plants,	17 plants,
Manufacturing footprint	6 countries	7 countries	10 countries

data collection took intentionally a longer time in these companies.

Data was collected through three sources. First, workshops were conducted in order to grasp a general picture of IMN coordination in each case, as well as to anchor the related theories. Second, semi-structured interviews were conducted with two to three senior managers in each company, such as the head of a business unit, head of global industrial development, global supply chain manager, plant manager, and network quality and environment manager. The purpose of the interviews was to obtain in-depth insight into how coordination was perceived and implemented at those companies. The interview questions revolved around: 1) the plants' autonomy and the centralisation policy, 2) transfer of knowledge, and the specific production system (XPS[2]) [56] of a company, 3) resources assignment to coordination activities, and 4) coordination routines. The third source for the data collection was archival data that allowed triangulation of data [57].

The large data set was initially described per case to obtain a holistic view of each IMN and its coordination. Then, the data were reduced into case reports that were anchored to the case companies in order to obtain their verification and feedback. Finally, the data were analysed in a cross-case analysis by addressing similarities and differences between the coordination methods in each case [53].

4. Case Study Results

4.1. Case Company A: The Global Contract Manufacturer

This company was a global contract manufacturer headquartered in Sweden. It produced a wide range of products in automotive, mining, and construction and was also involved in the telecommunications and general industry. Since its establishment in 1982, the network of this company grew from a single plant to 11 plants in six countries. The IMN of the company was relatively new, and most of its plants were established after 2010. Figure 1 provides an overview on the IMN

[2]XPS is a tailored corporate-wide improvement program and operation performance model that reflects the management philosophy of a company.

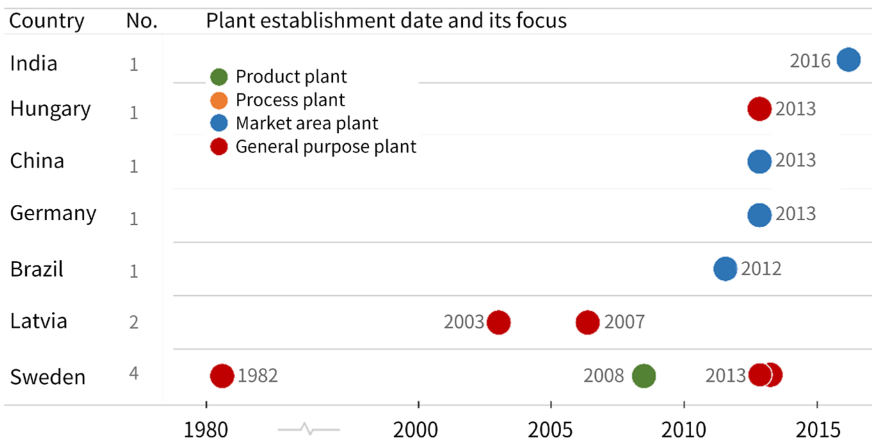


Figure 1. Overview of the IMN of Company A. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

including: number of plants, the established year, geographical location, and focus.

With regard to autonomy, there was no documented model on the responsibility span of a plant with regard to network activities. The plants adopted varying roles and, therefore, had different levels of decision autonomy, depending on the projects they were involved in. For instance, a plant that was acquired in 2008 in Sweden produced a strategic product and had the highest competence level in the network for that specific component. This plant supported a plant in Brazil that was established later in 2012 regarding the production of the same product. However, owing to a lack of clarity regarding the autonomy level of the plants, the expectations in a project were not met that led to irreparable loss for the company. In an interview, the plant manager of the Chinese plant and the global quality and environment (Q & E) manager working at the headquarters emphasised on the need for having clear definition and introduction of responsibilities for plants as they interact. They stressed the significance of transparency on what is being handled centrally and what is being handled locally in the subsidiary plants.

Since Company A had expanded considerably during the last decade, several plants were added to the network in a relatively short period. This resulted in multiple 'micro cultures' in the company derived from the culture of the location or from former organisations. For instance, three plants (in Sweden and Germany and Brazil) that recently joined the network had different (and sometimes conflicting) cultures compared with that of the parent company. That being said, some global customers placed orders on multiple plants in different countries at the same time. In this regard, the global Q & E manager mentioned, "*it is significant to ensure that customers get somewhat the same level of quality, service, and delivery performance from all of the plants*".

Concerning the coordination of non-physical flows, the company did not have a specific system for their coordinating. Having said that, the intranet of the company had gone through major changes, with the aim of "*…making the standards and working methods more universal, available and usable for the plants*", as mentioned by the global quality coordinator. In addition, instructions have been prepared for the plants, and they have been informed about the latest global and local news. A database of ongoing projects and the status of each had been also created. In addition, a number of cross-plant teams were formed, focusing on critical competence areas, such as heat treatment, gear cutting processes, and project management. The manager of the Chinese plant referred to the need for continuous communication between the subsidiary plants and the central management, as well as communication among subsidiaries in order to stay informed about the latest developments in the network. He also stressed the importance of the transfer of the culture, core values, and XPS. The company's XPS was coordinated by a central team at the headquarters, as well as local responsible persons at all plants. Monthly virtual meetings with quality managers of all of sites were held. The agenda covered issues on the quality within the network, the performance of each site, trends, and best practices. Apart from these virtual meetings, a physical meeting was also held annually.

4.2. Case Company B: The Global Truck Manufacturer

Company B was among the top five leading companies in the world within its product segment, with more than a century of manufacturing experience. The company was headquartered in Sweden and had 15 plants in seven countries across Europe and South America, employing approximately 40,000 people. The network of the company was quite mature, with most of its plants being established between 1950 and 2000 (see **Figure 2**). The Company B's network included plants with different focuses that produced sub-systems of the end product, which were then assembled at certain plants.

The company had a centralisation ambition, in the sense that they tried to have multiple steps in the value chain, R & D, purchasing, and market activities as geographically close to the headquarters as possible. Nevertheless, in order to have access to various global markets, the manufacturing network was built in a handful of end-product assembly plants around the world. With regard to the autonomy of the plants, some plants had specific manufacturing processes linked to the product they produce (e.g. casting, welding, and painting). However, in general, most of the plants shared an interest in manufacturing processes that were relevant to multiple products (e.g. machining, heat treatment, and assembly). For the first type of manufacturing process, the relevant sites could be relatively autonomous in terms of specific process development. For the second, and more general type of processes, each plant had process engineers and a centrally staffed organisation with process experts who benchmarked the plants based on the best-practice plant in the network. Hence, the coordination ambitions needed to be realised by network-organised *competence groups* that shared requirements, experiences, and solutions from the network plants. Those

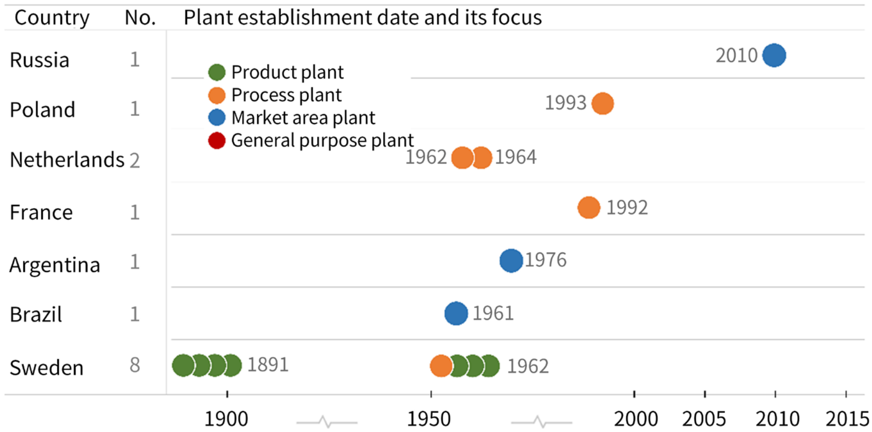


Figure 2. Overview of the IMN of Company B. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

groups were coordinated by a centralised group of staff for industrial development at the headquarters. The coordination of specific manufacturing process development allowed for pilot implementations of new manufacturing processes to be jointly tested and monitored, equipment suppliers to be evaluated, and investment budgets to be discussed at several sites simultaneously.

The company also had a well-established centralised organisation within its headquarters that coordinated the work related to XPS and its continuous improvement. The company had a standardised process to develop its XPS. The XPS-related central organisation led the production system development process and coordinated pilot implementations of new working processes at different plants, together with sub-groups and steering groups from each plant. The same organisation also held a wider role of coordinating organisation standards and the continuous improvement of processes.

Among Company B's process-focused plants, where different plants supplied to other sites internally, there was strong coordination in the order-to-delivery process during operations. Sourcing, production planning, and inventory planning were centralised via common infrastructural platforms. The final assembly was, to some extent, done in different markets. Hence, at the final product level, there was a coordination among the assembly plants to level and synchronise production volumes between assembly sites in different markets.

In addition, Company B built its knowledge capital on key central IT systems used to share and document standards, pilot implementations, and shared experiences.

4.3. Case Company C: The Global Construction Equipment OEM

Company C was a multinational company headquartered in central Europe that designed and manufactured equipment for construction and related industries, with about 15,000 employees. The company's global footprint included 17 plants in 10 countries worldwide, including Europe, Asia, North America, and South

America. The first plant of the company was established in 1832 in Sweden. Since then, the company grew its network, with the majority of the plants focusing on specific markets (**Figure 3**).

With regard to autonomy, Company C's headquarters had full control over large investments. Each end-product in the company was designed at a specific site and produced in several plants with related competences (core and hub concept). In terms of how production was developed, the 'core' plants (not necessarily the headquarters) gave instructions on the manufacturing processes and the intended production system for that product. The hub plants could not develop products. Nonetheless, they could do continuous improvement processes in their sites.

In terms of XPS coordination, tools and concepts was developed centrally. However, the implementation of XPS was up to each plant. The central XPS development organisation included five people who were connected to the local organisation in each plant to implement and further develop the company's XPS.

Company C conducted a long-term project to identify the competence networks within the larger manufacturing network, with the goal of identifying specific production methods and technologies (e.g. welding, painting, maintenance) as well as the experts in each plant in each area. Thus, it was clear which plant was a core plant *i.e.* the plant that conducted development projects (both product and production development) where the production systems for certain products were initially designed and developed. The core-hub plant sub-networks on common areas met virtually once per month. The director of global manufacturing technology noted that "*… the core plants explain the most recent product changes and the related production systems to the hub plants*". He mentioned sub-networks met physically approximately once per year, or

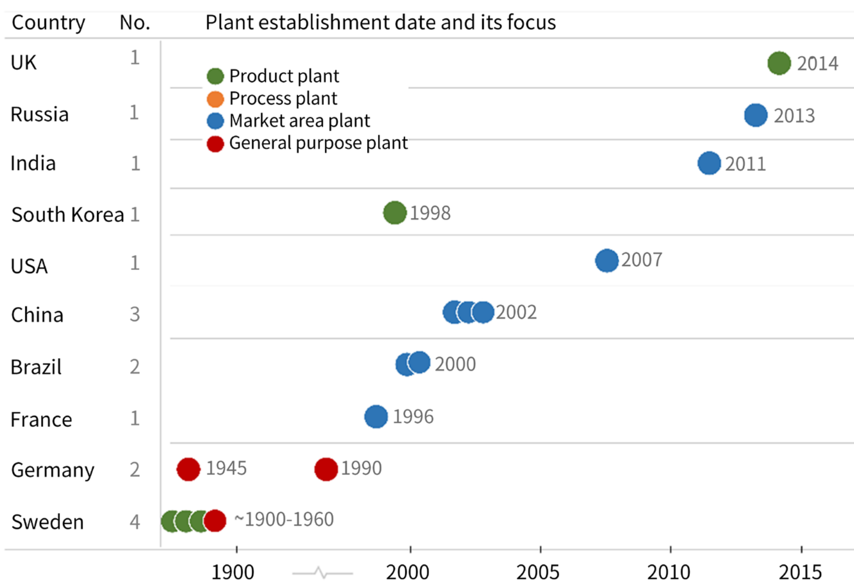


Figure 3. Overview of the IMN of Company C. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

when a new generation of a specific product was introduced. The director also referred to the risks of not having transparency in communication, adding "*… each plant may try to boastfully present its achievements that prevents real problems to surface and impedes discussing the more relevant challenges and solutions during common meetings*".

5. Analysis and Discussion

Based on the three industrial cases and their corresponding case reports, the dataset on coordination practices were analysed in relation to key issues of coordination such as discussions on the autonomy/centralisation aspect and conducted mechanisms in order to conduct coordination.

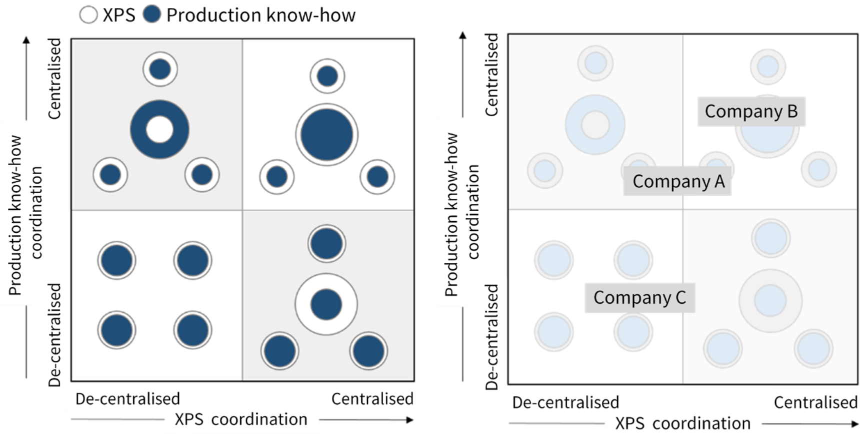
5.1. Autonomy, Centralisation, and Coordination Responsibility

The companies were aware of the significance of coordinating their IMNs. Each company had therefore ongoing coordination activities with unique approach due to its context. Company A for example that had transformed from a few plants to an international network of plants, did not have a clear routine or a documented model regarding of its centralisation policy. In contrast, companies B and C had already classified their plants into "core" or "hub" plants that had a "sender" and "receiver" role the transfer of a certain type of knowledge respectively.

One general finding, in line with the results of Cheng [17], was that the more interdependencies in an IMN, the more the need for coordination. Also, the type of interdependencies affected the coordination itself in the sense that the more process plant in the network, the more the need for coordination of the physical flows. In contrary, the increase in the number of other type of plants in the network demanded better coordination of the non-physical flows.

According to the data from the cases, two main streams of knowledge flows that were coordinated within those IMNs were: 1) the knowledge regarding the culture and XPS of a company and 2) the production know-how. As illustrated in **Figure 4(a)**, four strategies could be hypothetically assumed regarding how centralised/decentralised the coordination of XPS and production know-how is conducted. Those strategies and the general positioning of three cases are depicted in **Figure 4(a)** and **Figure 4(b)**, respectively. For example the upper-right quadrant represents a situation where XPS and the production know-how are centrally coordinated. In other words, the central management is more involved in XPS coordination as well as coordination of production know-how.

Those strategies come with inherent advantages and disadvantages. Based on the findings of the performed interviews in this study, a centralised approach consumes more resources from the CMT that usually have high cost. This makes a centralised coordination a costly solution. For instance, Company B with ambitions for a more centralised coordination was recently challenged by market developments and a need for a global network of end-product plants. However,



(a) (b)

Figure 4. Centralization of XPS and production know-how. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.(a) Hypothetical strategies; (b) Case positioning.

the task congestion regarding the coordination of those plants in the CMT made their coordination work a costly activity. On the other hand, a centralised coordination is prone to lesser risk as it relies on the contribution of headquarters that are usually more experienced and have usually better understanding of a company's culture. Besides, a centralised structure expedites the decision-making process [58], while providing more control than in a decentralised coordination.

Our results do not include enough evidence about the long-term consequence of either of the above-mentioned approaches. Nor does it claim that reality fits perfectly into one of the explained strategies. In fact, centralisation policy is based upon a spectrum of centralised versus decentralised structures on a multitude of decision areas [59] [60]. The evolution of an IMN [21] and the changing role of the plants [61] demands more dynamic models to assign the right decision-making power in an IMN. As observed in the findings of this study, in practice, each plant in an IMN, due to factors such as location, competence level, distance from the headquarters, and home country culture, may have a unique autonomy level (see Figure 5).

Despite the emphasis on the need for clear guidelines on how autonomy is assigned in a network [12], this matter has not been sufficiently addressed. In contrast to the configurational roles of the plants of an IMN that been studied in several studies (see e.g. Ferdows, 1997), the role of the plants in an IMN in regard to their coordinative role has not received enough attention. Based on the analysis of the findings of the cases, three patterns could be identified regarding the autonomy of plants in coordination activities here by labelled as: Class A, Class B, and Class C plants (see Figure 6).

Class A plants: are the ones that lead the coordination activities and have full degree of autonomy. Plants in this class usually have both dedicated and flexible

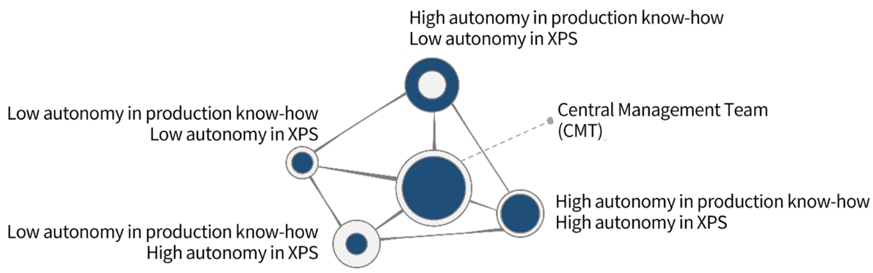


Figure 5. The variation of autonomy level in plants of an IMN. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

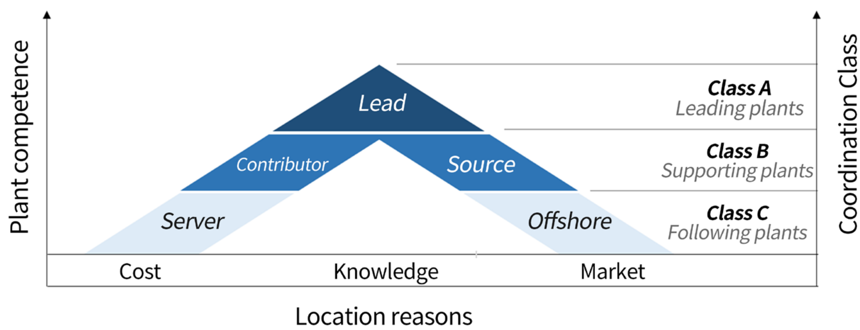


Figure 6. Three classes of plants in an IMN with regard to network coordination. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

resources for coordination activities. They take the main responsibility of supporting other plants in network-level projects. In addition, they ensure effective production development by being actively involved in managing projects and transferring the knowledge with regard to both XPS and production know-how. According to the data, all the plants in the three companies that could certify as Class A plants had the configurational role of *lead*. Apparently, in practice, it should be specifically mentioned in what specific 'area' a plant is a lead factory (configurational role) or a Class A plant (coordinative role).

Class B plants: play a supporting role and assist plants in Class A to perform coordination activities. According to the data, plants that could be placed in this class had obtained considerable knowledge in production and maintenance, as well as in market and supply chain activities and could be considered in the same level as Ferdows's (1997) *contributor* or *source* plants. Class B plants coordination role is to assist Class A plants in development projects at other Class B plants or class C plants. Their contribution to coordination activities becomes more crucial when Class A plants are involved in several projects simultaneously. Apart from freeing up time for resources at Class A, the support from class B plants in such situations therefore decreases coordination costs by fairly economic expert resources to the project. In Company A for instance, a plant in Latvia contributed to a project at a production unit in Brazil by assigning specific process experts to the project that was coordinated centrally from the headquarters. Similarly, in Company B, a plant in Brazil gained considerable knowledge on XPS of the company, could be used as back up in XPS coordination.

Class C plants: have a minor role in coordination activities and their role is only limited to following coordination activities. Class C plants competence level is at the lowest level and thereby place in the same grade as *server* and *offshore* plants. Since plants in this class play an important role in the expansion of an IMN, they need to increase their absorptive capacity [62] when receiving knowledge from class A and B plants. An example of such plant was a recently established plant of Company A in China that received support from the headquarters to implement its XPS, improve its business, and develop its production plant. Another example was a plant of Company C in USA that had a server role and received a lot of knowledge from a lead plant in Sweden regarding both production know-how and XPS of the company.

5.2. Mechanisms for IMN Coordination

Once there are rules on place, to conduct the coordination work and manage the interdependencies among plants in an IMN, mechanisms needed to get implemented [2]. A mechanism for coordination is any tool for achieving integration among different units of an organisation [63]. Among the suggested mechanisms for coordination of an organisation are programming the behaviour [43], communication and socialisation [63]. Their proposed mechanisms include both information (communication) as well as behavioural change that is a result of learning [64]. Also, Mascaren has [43] refers to mutual adjustment as a coordination method. Furthermore, shaping and grouping the organisation, cross-departmental relations, planning, and budgeting have been also listed as coordination mechanisms that are preparatory work for the actual coordination work [63].

Based on the findings of this study and the previous studies regarding the requirements of coordination activities, three coordination mechanisms were postulated (see **Figure 7**).

1) Dissemination[3]: to continuously feed an IMN's plants with relevant information. Research has been done on the type, quality, and tools of headquarter-subsidiary information exchange [65] [66] and its effect on the evolution of a subsidiary plant [67]. Examples of the types of information that need to be circulated within the network are the latest developments in the network and its management principals, recent technological developments, market trends, operational outputs, changes in the organisation, success stories, and best practices. Dissemination of information in the IMN of all cases were mainly realised through informal communications or through IT solutions in the form of intranet of the company, direct emails, newsletters, and etc. Company A for example

[3]The term "disseminate" in this thesis is used consciously instead of the term "inform" in order to imply a directional spread of information i.e. information that involves motivation and progression.

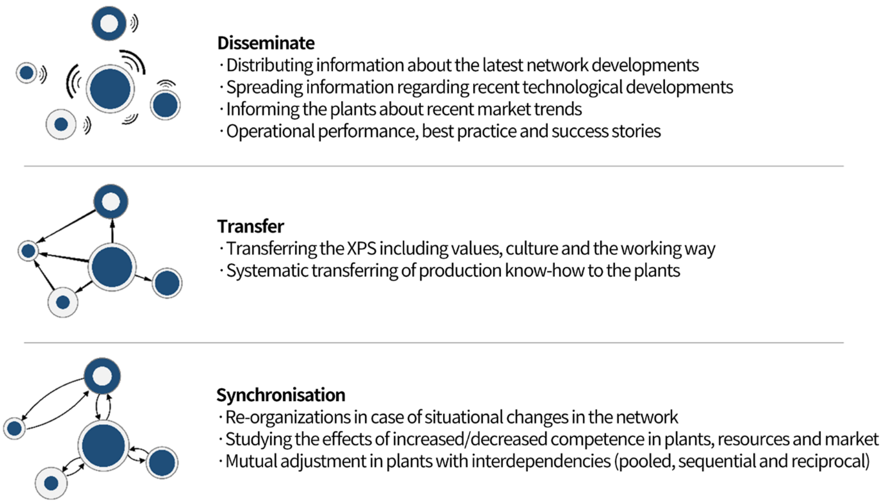


Figure 7. Suggested mechanisms for IMN coordination. The figure is drawn by the authors of this paper with the data source coming from the analysis of collected data in this study.

had become aware of the significance of such mechanism and began to improve their intranet in order to disseminate the relevant information to their IMN plants.

2) Transfer: an effective and efficient method for transferring knowledge among the plants within an IMN regarding production know-how as well as a company's XPS. Apparently, identification of the knowledge gaps in the overall network and its constituent plants are a prerequisite for this mechanism. For example company C had started a long-term project in order to identify the available knowledge and competence in their network. The knowledge discussed here is the tacit type of knowledge and therefore its transfer happens through physical meetings rather than virtual communication.

3) Synchronise: a mechanism that allows analysing the consequences of different changes within an IMN. Such a mechanism is required to adjust the network especially the mutually interdependent resources as a result of changes in the network. For instance, the developed production processes in a plant of company B in Sweden affected the plants that had that specific process.

Hereby, we put a distinction between dissemination and transfer mechanisms. Dissemination refers to spreading and circulating *information* within an IMN whereas the purpose of the latter is the inter-plant transfer of *knowledge* including production know-how and XPS of a company. Such a differentiation is essential due to the inherent difference between information and knowledge [28]. Information is data that has been given meaning by way of relational connection while knowledge is the appropriate collection of information, such that its intent is to be useful and applicable [68].

The chief financial officer (CFO) of Company A emphasised on recurrent use of information mechanisms and added that "*sometimes a key account manager not having a simple piece of information, which could have been shared either* *formally or informally, may deprive our company of a great opportunity*". In addition, as the ability inter-plant transfer of knowledge within an organizational has been mentioned as a main reason for the existence of MNCs [69], there is always a need for a continuous transfer of knowledge between plants within the IMN.

Finally, synchronisation mechanism is required to provide useful input to configuration of a network. Continuous investigation of the changes to the plant along with their effect on the network seems to be necessary. The after-effect of the synchronisation mechanism could be reallocation of production resources such as people and production equipment and change in the products in the plants of a network.

6. Conclusions

The purpose of this study was to increase the understanding regarding IMN coordination and how it is practiced in IMN environment. The results of this research include a review of coordination practice from three global manufacturing companies. Further analysis of the results led to proposal of two models on autonomy categorisation of plants in an IMN as well as introduction of three mechanisms for conducting the coordination activities in an IMN.

Nonetheless, the findings of this study are derived from three industrial cases and therefore of limited generalizability. The application of the developed models and theories must be taken with much care. As for future research, the following is recommended:

1) To investigate the rationale behind different centralisation policies and their consequences on coordination routines, and vice versa;

2) To study the capabilities derived from conducting the coordination mechanisms and implementing their right combination to achieve desired capabilities;

3) To consolidate the models developed here and existing theories to develop a comprehensive IMN coordination framework.

Based on the findings of this study, in order to manage better the IMNs, the managers of MNCs that operate a disperse network of operation should design and communicate the right autonomy to the plants and effectively transfer the required knowledge in their network. Sophisticated models are required for systematic coordination of IMNs. Future research on IMN coordination in a wider range of plants and a higher number of cases can enable this by testing the current methods and expanding them.

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