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# Exploring the content of company-specific plant role models in international manufacturing networks

Jens Kaiser and Thomas Friedli
*Institute of Technology Management, University of St. Gallen, St. Gallen, Switzerland*

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## Abstract

**Purpose** – This study explores the phenomenon of company-specific plant role models. Following the establishment of distinct lead factories, recent studies imply that multinational companies are now using more detailed plant roles to manage manufacturing networks. While multiple plant role typologies can be found in literature, this is, to our knowledge, the first article to systematically analyze the content of such company-specific plant roles.

**Design/methodology/approach** – We rely on a multiple-case study design of 29 plant role models primarily belonging to multinational companies headquartered in German-speaking countries. Coding is performed to analyze the models for similarities and differences.

**Findings** – The content of company-specific plant role models seems highly dependent on a company's context; hence, there is no one best way to build them. Companies appear to be pursuing different priorities with the application of plant roles, for example, the reorganization of manufacturing networks, the systematic allocation of products or the definition of decision-making autonomy. Compared to the primarily two-dimensional models from theory, companies rely on more dimensions to make their plant roles practical. Similar to models from literature, competence bandwidth, inter-plant knowledge/information flow and location advantage are the most relevant dimensions to differentiate plants from a headquarters' perspective.

**Practical implications** – Plant role models are a powerful management tool that enables delayering the complexity and allows for proactive management of manufacturing networks. Managers fit the content of their plant role models to their company-specific context and the intended application for manufacturing networks. Managers aiming to build company-specific plant roles can use the conceptual framework based on the empirical findings as a benchmark.

**Originality/value** – This study complements prior research on plant roles by acknowledging that companies might develop their own version of plant role models rather than copying the ones from the literature. By doing so, we explore how plant roles look like in a real-world setting.

**Keywords** Plant roles, International manufacturing network, Company-specific, Empirical research

**Paper type** Research paper

## Quick value overview

*Interesting because:* Manufacturers are increasingly operating networks of globally distributed factories, yet managers often lack straightforward tools to effectively manage these networks, which can prevent them from fully harnessing their potential. The concept of plant roles offers a promising management tool in this context. While previous studies have either focused on the prominent role of the "lead factory" or generalized plant-level data from various companies into broad typologies, this study takes a different approach. It examines 29 manufacturers that have developed a tailored model of distinct plant roles at the headquarters level to strategically guide their manufacturing networks. This showcases the company-specificity of plant roles.

*Theoretical value:* In contrast to previous research, this study provides a new perspective on how headquarters managers strategize plant roles to drive their manufacturing networks. Our findings show that multinational companies typically develop three to four distinct roles that are differentiated by several key dimensions. These dimensions include the scope of

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plant competencies, the definition of the flow of knowledge between plants, and location-specific advantages such as cost advantages.

*Practical value:* The insights gained are of significant value to companies looking to restructure their manufacturing networks or make strategic decisions about product allocation, for example. Our conceptual framework integrates typical structural elements and differentiating dimensions of plant roles. Hence, it becomes to a practical guide for managers aiming to design plant roles that fit their company's context. These roles can then be used to align on the strategic development of the manufacturing network between headquarters and local plant management.

## 1. Introduction

Motives such as providing access to emerging markets or exploiting favorable factor costs have caused the internationalization of manufacturing in recent decades (Abele *et al.*, 2008; Shi and Gregory, 1998). Today, multinational companies (MNCs) operate international manufacturing networks (IMNs) (Olhager and Feldmann, 2022), i.e. aggregations of intra-firm plants dispersed in different geographical locations (Cheng *et al.*, 2015). Managing such manufacturing networks has become critical for an MNC's competitive advantage in global markets (Miltenburg, 2015a; Olhager and Feldmann, 2022; Shi and Gregory, 1998). However, manufacturing network managers are often overwhelmed with this task as they are confronted with an "arduous list of variables to consider" (Ferdows, 2018, p. 394) when making decisions.

The concept of plant roles, first introduced by Ferdows (1989, 1997), is a suitable way to "delayer" (Ferdows, 2018) the complexity of IMNs and make decisions about it discussable. Moreover, it enables network managers to bridge the critical gap between central headquarters functions and local plant management regarding roles and responsibilities. The concept of plant roles holds that not all plants in a manufacturing network should pursue the same strategy (Olhager and Feldmann, 2022). Instead, plants should be differentiated based on specific dimensions such as capabilities, products, or markets so that the plants collectively contribute to the overall manufacturing network's success.

One of Ferdows's (1997) six proposed roles, the "lead factory", has received notable attention in the literature (see, e.g. Deflorin *et al.*, 2012) and industry. As a factory that develops new processes, products, and technologies for the entire company (Ferdows, 1997, p. 76), this type of factory is particularly suitable as a target for high-wage locations. Under the terms "competence center" (e.g. BASF, Continental), "lighthouse factory" (e.g. LG, Unilever), or "lead factory" (e.g. Bosch, Siemens), such lead factories can be found at many large MNCs today. However, the formulation of additional roles – complementary to the already established lead factories – has hardly been addressed by MNCs so far.

More recently, several MNCs have started to define and manage such additional plant roles. Formalizing the roles and responsibilities of the remaining plants seems a logical evolution of the lead-plant concept since it enables the companies to assign a distinct role to more of their IMN's plants than just some selected lead plants. Companies often describe the composition of the different plant roles, their interactions, and governance in a formal model. In this article, we coin such a model a "company-specific plant role model".

Recent benchmarking studies conducted in German-speaking countries suggest that companies using plant roles as a management tool are no longer an exceptional phenomenon: In a 2016 study, more than 75% of all participating companies stated that they use plant roles ($n = 57$) (Schuh *et al.*, 2016). In a later study from 2020, the figure is still 65% ($n = 83$) (Friedli *et al.*, 2020). Yet almost none of such company-specific models can be found publicly. Even more disappointing is that such models have so far been completely ignored in research as a unit of analysis. Instead, empirically derived plant role models tend to merge plant-level data from multiple companies to categorize plants based on dimensions chosen by the respective scholars (see, e.g. Cheng and Farooq, 2018; Vereecke and van Dierdonck, 2002). However, plant roles proactively defined by MNCs have not yet been investigated in the literature. To fill this gap, we pose the following research question: *What do plant role models look like in the industry?* We answer it by exploring the content of 29 company-specific plant role models from practice.

The remainder of this paper is structured as follows: the next section summarizes the literature on plant roles and raises respective concerns. Section 3 outlines the conducted research methodology. Section 4 presents empirical data from 29 company-specific plant role models and discusses them related to previous literature. Finally, we present our conclusions in chapter 5.

## 2. Related literature

### *2.1 Origins of plant roles*

The origins of plant roles can be traced back to the concept of the *focused factory* by Skinner (1974). The author proposed that focusing a plant on a dedicated manufacturing task would increase its competitiveness. In contrast, giving them too many conflicting targets would result in poor compromises. Further early contributions linked to plant roles can be found in Hayes and Schmenner (1978) and Schmenner (1979, 1982). The authors proposed different plant types – the product, the market, the process, and the general purpose plant – based on a study of Fortune 500 companies. While the literature on international business discussed strategic roles of subsidiaries since the 1980s (e.g. Bartlett and Ghoshal, 1986, 1989; Jarillo and Martíanez, 1990; Roth and Morrison, 1992), Ferdows (1989, 1997) was the first researcher to explicitly translate them into roles of manufacturing entities (i.e. plant roles). He proposed differentiating plant roles on two dimensions: *plant competence* and *strategic site reasons*. Plant competence describes the range of activities carried out by a plant – from "production only" to "being a global hub for product and process development". The strategic site reason, in contrast, is the primary reason to establish or exploit a plant (Ferdows, 1997). Combining the two dimensions constitutes six distinct plant roles: each with differing levels of competencies and each focusing on one of three site reasons.

### *2.2 Overview of articles related to plant roles*

Over the past decades, a considerable number of articles evolved around Ferdows's (1989, 1997) plant role model. Three strands of articles can be distinguished (Cheng and Farooq, 2018; Lohmer *et al.*, 2021).

First, those that use Ferdows's model to *describe and categorize* existing plant configurations mostly using case research (e.g. Blomqvist and Turkulainen, 2019; Cheng *et al.*, 2011; e.g. Fusco and Spring, 2003; Kim *et al.*, 2011; Mediavilla *et al.*, 2015; Meijboom and Vos, 2004; Miltenburg, 2015a, b). Second, mostly empirical articles that centered around testing and further understanding Ferdows's model (Demeter *et al.*, 2017; Feldmann and Olhager, 2013; Maritan *et al.*, 2004; Olhager and Feldmann, 2022; Vereecke and van Dierdonck, 2002). The third strand of articles, of particular interest for this study, focused on complementing and extending Ferdows's model. These articles derived adapted or new plant roles based on various dimensions. Table 1 summarizes the characteristics and key contributions of relevant plant role models from IMN literature sorted by year of publication.

In contrast to Ferdows's model with six plant roles, the majority of subsequent articles shown in Table 1 either contain three roles (Norouzilame and Wiktorsson, 2018; Vokurka and Davis, 2004) or four roles (Cheng and Farooq, 2018; Szász *et al.*, 2019; Vereecke *et al.*, 2006). A clear hierarchy between the roles can be identified in many of these models. The *lead factory concept*, already described in earlier publications (Deflorin *et al.*, 2012), can also be found in

| Article | Plant roles | Dimensions | Empirical base | Key contribution |
|---|---|---|---|---|
| Vokurka and Davis (2004) | (1) Standardizer plant (2) Customer plant (3) Automator plant | (1) Product volume (2) Product variety (3) Process flexibility (4) Process complexity (5) Material availability (6) Material variety (7) Customer variety (8) Scheduling flexibility (9) Labor complexity (10) Plant size | Questionnaire with 305 plants | Derivation of key dimensions and to differentiate plants and three basic plant roles with performance links |
| Vereecke *et al.* (2006) | (1) Isolated plant (2) Receiver plant (3) Hosting network player (4) Active network player | (1) Communication centrality (2) Innovation indegree (3) Innovation outdegree (4) People indegree (5) People outdegree | Case studies of 8 firms with 4–10 plants (59 plants in total) | Classification of plants based on knowledge and physical flows and analysis of dependance on plant characteristics such as age and autonomy |
| Cheng and Farooq (2018) | (1) Star plant (2) Old school plant (3) Expert plant (4) Replaceable plant | (1) Plant competence (2) Location advantage | Questionnaires with 606 plants | Empirically derived four plant roles and link to management practices |
| Norouzilame and Wiktorsson (2018) | (1) Leading plant (2) Supporting plant (3) Following plant | (1) Production know-how coordination (2) Production system coordination | Case studies of 3 firms with 11, 15, and 17 plants | Link of plant roles to coordination mechanisms and a new model for assigning autonomy to plants |
| Szász *et al.* (2019) | (1) Net receiver plant (2) Active receiver plant (3) Balanced actor plant (4) Net sender plant | (1) Information sending (2) Information receiving (3) Innovation sending (4) Innovation receiving (5) Offering training (6) Receiving training | Case studies with 13 plants in 4 countries | Classification of plants in the knowledge network and identification of capabilities needed to become a knowledge-sending plant role |
| Feldmann and Olhager (2019) | (1) Component plant (2) Assembly plant (3) Integrated plant (4) Strategic feeder (5) Full lead | (1) Material flow (2) Plant competence | Case studies of 20 product subnetworks of 5 firms (49 plants in total) | Identification of four network types (i.e. linear, divergent, convergent, and mixed) and classification of plant roles along the material flow |
| Blomqvist and Turkulainen (2019) | (1) Lead plant (2) Dependent plant (3) Generalist plant (4) Special task plant | (1) Site competence (2) Dependence of plants in network (3) Scope of activities and responsibilities | Case studies of 5 firms with 2–8 plants | More detailed framework based on Ferdows's roles with 4 main role types and 11 plant roles |

**Source(s):** Authors' own work

**Table 1.**
Characteristics and contribution of plant role models from literature

the names of more recent plant role models such as the "leading plant" in Norouzilame and Wiktorsson (2018), the "star plant" in Cheng and Farooq (2018) or the "full lead" in Feldmann and Olhager (2019) (see Table 1).

In their article about plant missions, Khurana and Talbot (1999) named six dimensions to differentiate plants. Namely, products, market/geography, process/technology, volume, location rationale, and capabilities/competencies. The last two dimensions reflect the dimensions used in Ferdows's model and can also be found in many other models (e.g. Blomqvist and Turkulainen, 2019; e.g. Cheng and Farooq, 2018) shown in Table 1. Other relevant dimensions, not listed by Khurana and Talbot (1999), emerge through classifying plant roles with flows. For example, material flows (Feldmann and Olhager, 2019) or knowledge flows (Vereecke *et al.*, 2006). As can be seen in Table 1, in principle, any number (up to 10 in Vokurka and Davis, 2004) and type of dimension can be used to categorize plants. There does not seem to be an agreement between the authors on either the type or the number of dimensions most useful.

### *2.3 Conclusions on previous plant role models*

The plant role models presented above offer an important perspective on the strategic management of plants. The models use various dimensions such as coordinational (e.g. Szász *et al.*, 2019; Vereecke *et al.*, 2006) or configurational aspects (e.g. Feldmann and Olhager, 2019; Vokurka and Davis, 2004) of an IMN. Moreover, the classification of plants is strongly rooted in empirical data from various industries, not least with the aim of empirically validating Ferdows's model (e.g. Cheng and Farooq, 2018; Vereecke and van Dierdonck, 2002).

However, some concerns can be formulated on the previous models. First, scholars tend to merge plant-level data from various companies (e.g. Cheng and Farooq, 2018; Vereecke *et al.*, 2006; Vokurka and Davis, 2004) to organize plants into generic plant roles. This approach is helpful to break down the complexity of reality for further analysis. However, it does not investigate the headquarters perspective, i.e. what plant roles from an MNC's perspective look like to design and manage their IMN.

A related second concern comes with the disregard of the "company-specific" part of plant roles – the oversimplification of the models. Typically, models from the literature only incorporate two dimensions to differentiate plants (Thomas *et al.*, 2015). The key strength of plant roles in literature – the precise characterization of plants – also reveals a major weakness of the concept for managers: the lack of variety in describing the roles (Cheng and Farooq, 2018; Vereecke and van Dierdonck, 2002). This makes them hardly operational in real-world settings (Mediavilla *et al.*, 2015).

A third concern is related to the choice of the dimensions used. Theoretically, dozens of dimensions could be used for the strategic differentiation of plants. However, there is little systematic justification for the specific choice of dimensions, such as location advantage in Ferdows (1989, 1997) or material flow in Feldmann and Olhager (2019). This means that the classifications of plants in the reviewed articles depend heavily on the perspective of the respective authors, and it is difficult to say how useful the classifications are in a corporate context.

To address the aforementioned concerns, we base our empirical analysis on real-world plant role models of 29 industrial companies. The underlying methodology used is outlined in the next section.

## 3. Methodology

As mentioned, this paper aims to elaborate on the established concept of plant roles by shedding light on the company-contingent perspective of plant roles. Voss *et al.* (2002) and Yin (2018) suggest a case study approach in such a contingency-rich setting since it allows the investigation of phenomena in its "real-world context" (Yin, 2018, p. 286). We chose a multiple-case design to enable the comparison between cases and, therefore, increase the generalizability (Voss *et al*., 2002; Yin, 2018).

### 3.1 Database of 29 company-specific plant role models

We built a database of relevant cases to explore the phenomenon of company-specific plant role models. For such a new phenomenon, convenience (Lewis, 1998) and purposive sampling (Bryman, 2015) based on available cases is an acknowledged strategy. Convenience sampling of companies we already knew before this study allowed us to gather a high number of potential cases mostly from German-speaking countries, in a relatively short period of time. However, to answer our research question – *What do plant role models look like in the industry?* – we selected only those case companies that already had a plant role model (i.e. purposive sampling). While we could not measure how widespread plant roles are in the industry in general, this gave us direct access to companies that were using them. We received the data from informants such as the VP of Manufacturing or Head of Global Operations, who have a good overview of their respective IMN. This ensures that the documentation delivered is representative of their respective plant role models.

The collection of models followed two main strategies. First, we searched our institute's database for former research collaborations in which either a plant role model was created or we were given access to the company's model. With this first strategy, we gathered 17 cases. To increase our database and hence the external validity of this study, we started an additional inquiry (September to November 2022) in a second step. We mainly contacted firms that our institute had prior contact with. As a benefit of sending us their documentation, the firms were granted access to the results in the form of a draft report. Contacting 65 firms yielded 18 additional plant role model documentations (i.e. response rate of 28%), out of which we excluded six based on the criteria described above. Twenty-two firms declined, mainly because they did not have a plant role model or could not provide them due to confidentiality concerns. The rest remained silent.

To enable a meaningful comparison between the cases, we primarily analyzed the case company's formal model describing the composition of the different plant roles – mostly in the form of slides or text files. Since this article focuses on the content, not the governance process of plant roles, we consider such documentations an appropriate source of evidence. They have the strength of containing exact names and details so that they can be reviewed repeatedly (Yin, 2018). To ensure that we understood the content of the models correctly, we additionally engaged with the companies (see Table 2). In 13 cases, directly via participation in workshops, and in a further three cases via personal, informal contact. In all other cases, information on the content of the plant role model was obtained via brief e-mail contact or in the context of online calls or interviews.

To increase the *reliability* of our research, we established a research database that was continuously updated throughout the two data collection steps. The final sample of 29 plant role models and their characteristics are presented in Table 2. All plant role models belong to large MNCs headquartered in high-cost manufacturing countries in the understanding of Ketokivi *et al.* (2017), i.e. countries with high Gross Domestic Products (GDP). Except for three models (two in the US, one in Japan), all headquarters are in German-speaking countries. All major industries are represented in the sample. While the majority of the models cover all plants of the case companies, eight only apply to one business unit.

### 3.2 Analysis of plant role models

To analyze the content of the collected company-specific plant role models for similarities and differences, we distinguish between three categories: first, the overarching architecture

| No. | Plant role model name | Plant role unit | No. of roles | Coverage | No. of plants | HQ | Main industry | Model documentation year | Additional exchange to clarify plant role model content |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Individual Production Center | Production unit | 4 | BU | 5 | GER | Optoelectronics | 2020 | Interview |
| 2 | Plant Profiles and Modular Operating Units | Production unit | 4 | Company | 16 | GER | Automation | 2022 | Personal exchange during a site visit |
| 3 | Plant Types | Production site | 3 | Company | 40 | CH | Plastics | 2012 | Workshop participation |
| 4 | Pharma Network Site Roles | Production site | 3 | BU | 18 | GER | Pharma | 2021 | Workshop participation |
| 5 | Site Role Framework | Production site | 3 | Company | 12 | US | Medical Devices | 2022 | Online call |
| 6 | Network Site Roles | Production site | 3 | Company | 18 | CH | Medical Devices | 2022 | Workshop participation |
| 7 | Plant Types | Production site | 3 | Company | >100 | GER | Automotive | 2022 | Personal exchange during a site visit |
| 8 | Strategic Site Roles | Production site | 4 | Company | 18 | CH | Military | 2022 | Workshop participation |
| 9 | Manufacturing Level Model Structures Freedom and Duties of Plants | Production site | 4 | Company | 23 | GER | Automotive | 2017 | Workshop participation |
| 10 | Site Roles | Production site | 3 | Company | 9 | AUT | Aerospace | 2021 | Workshop participation |
| 11 | Supply Chain Site Categories | Production site | 2 | Company | 48 | GER | Security | 2018 | E-mail contact |
| 12 | Site Role Responsibilities and Autonomy | Production unit | 3 | BU | 12 | GER | Chemicals | 2018 | Workshop participation |
| 13 | Site Roles | Production site | 4 | Company | 8 | GER | Semiconductor | 2022 | E-mail contact |
| 14 | Definition Organizational Roles | Production site | 3 | Company | 6 | CH | Drive Technology | 2022 | E-mail contact |

(*continued*)

**Table 2.** Database of 29 company-specific plant role models

Table 2.

| No. | Plant role model name | Plant role unit | No. of roles | Coverage | No. of plants | HQ | Main industry | Model documentation year | Additional exchange to clarify plant role model content |
|---|---|---|---|---|---|---|---|---|---|
| 15 | Roles of Production Plants | Production site | 6 | Company | 50 | GER | Automotive | 2022 | Interview |
| 16 | Factory Roles | Production site | 3 | Company | 22 | GER | White Goods | 2014 | Workshop participation |
| 17 | Plant Role Concept | Production site | 3 | Company | 32 | US | Automotive | 2022 | E-mail contact |
| 18 | Concept for the Definition of Site Roles | Production site | 6 | Company | 32 | CH | Machinery | 2015 | Workshop participation |
| 19 | Specialization – Site | Production site | 4 | Company | 18 | GER | Sealing components | 2010 | Workshop participation |
| 20 | Unknown | Production site | 2 | Company | 8 | CH | Electrical | 2012 | Workshop participation |
| 21 | Responsibilities and tasks of a center of competence | Production site | 4 | Company | 8 | CH | Food | 2012 | Workshop participation |
| 22 | Lead Factory Concept | Production unit | 2 | BU | 5 | GER | Traffic technology | 2014 | Workshop participation |
| 23 | Design principles to arbitrate between locations' production purpose | Production site | 3 | BU | 18 | GER | Electrical | 2020 | Phone call |
| 24 | Site Role in the Production Network | Production site | 5 | BU | 5 | GER | Electrical | 2018 | Online call |
| 25 | Roles, tasks, and responsibilities of master and secondary plants | Production site | 2 | Company | 22 | GER | Machinery | 2016 | Personal exchange during a conference |
| 26 | Lead Factory Concept | Production site | 3 | Company | 38 | GER | Automotive | 2022 | E-mail contact |
| 27 | Manufacturing Set Up | Production site | 4 | BU | 7 | GER | Optoelectronics | 2022 | Online call |
| 28 | Plant Roles | Production site | 3 | BU | 53 | GER | Automotive | 2022 | Online call |
| 29 | Technology Site Roles | Production site | 4 | Company | 29 | JP | Pharma | 2022 | E-mail contact |

**Source(s):** Authors' own work

of the models; second, their constituting elements; and last, the dimensions used to differentiate the plant roles within the models. The explorative analysis of the *architecture* of the plant role models served to foster the fundamental understanding of the models as a management tool.

With the analysis of the *elements*, we wanted to investigate the composition of the models. In literature, authors typically use role names (e.g. "lead plant" in Ferdows's model) and frameworks (e.g. bar chart in Ferdows's model) to compose their models. In our analysis, we inductively assigned descriptive codes (Saldaña, 2021) to the models, resulting in a list of eight structural elements – *Role names, Textual descriptions, Frameworks/diagrams, Allocation of plants, Plant mission statement, KPIs, Evolution path of plant (roles), and Link to manufacturing strategy*.

Besides the overarching structure, we analyzed the models for their used *dimensions* to differentiate plants. To enable a meaningful comparison across the models from practice, we thoroughly reviewed the literature for potential dimensions. Subsequently, we generated a long list of potential dimensions from screening the articles for their used dimensions. We clustered the dimensions and removed redundancies (e.g. the *number of SKUs* as a specification of the dimension *product variety*). Table 3 shows the result of this process, i.e. 28 distinct plant role model dimensions clustered in four categories, which we used as a pre-defined list of codes to analyze the models from practice. We then deductively (Miles *et al.*, 2014) assigned the plant role models' content to these codes. This strategy helped generalize the plant role dimensions' relevance across the cases (Eisenhardt, 1989). Dimensions that were not covered by the initial literature review were added. The coding was performed and checked several times to increase the reliability of this subjective process.

In the next step, we compared the outcomes with existing literature as recommended by Eisenhardt (1989). The comparison with conflicting and similar literature increases the internal and external validity (Eisenhardt, 1989) and is critical to addressing the purpose of this study – the elaboration of the concept of plant role models' content. Finally, we controlled the results for the *type of industry*, whether the model is *external or internal*, the *number of covered plants*, and whether the model covers only a *BU*.

### *3.3 Validity and reliability*

As with any case study research, ours is also subject to methodological limitations. To assess the quality of qualitative research, four tests have been well-established in most social sciences – internal validity, external validity, construct validity, and reliability (Yin, 2018).

As this study is not designed to establish causal relationships, *internal validity* has not been relevant to this research (compare Yin, 2018). Consequently, we focused on meeting the remaining three tests for qualitative research. First, we addressed *external validity* by including a comparably high number of cases from various contexts (i.e. industry, size). We embedded the results in existing literature as proposed by Eisenhardt (1989). Additionally, a draft report containing the results, discussion, and conclusion sections was sent to the informants. Besides briefly stated consensus, we received detailed feedback from seven informants from the headquarters level, such as VP Manufacturing or Head of Global Operations. The comments essentially confirmed the information provided in the report and helped contextualize the conclusions, which increased the face validity of the study.

Second, to address *construct validity*, we based our primary construct – the dimensions to differentiate plants – on a literature review. Multiple peer researchers reviewed the intermediate results of our study. Moreover, the draft report described above helped ensure the constructs' validity.

Last, to meet *reliability requirements*, we used a continuously updated case study database to ensure transparency regarding data collection and analysis. Moreover, we coded the data, which enabled reviews of peer researchers.

| Category | Dimension | Exemplary operationalization | Exemplary articles |
|---|---|---|---|
| External Factors (EXTERN) | 1.1 Location advantage | Proximity to market, Access to low-cost, Access to skills and knowledge | Ferdows (1997) |
| | 1.2 Geographic location | Europe, Americas, Asia-Pacific | Demeter and Szász (2016) |
| Plant mandates from HQ (HQ) | 2.1 Plant focus/specialization | Product plant, Market Area Plant, Process Plant, General Purpose Plant | Khurana and Talbot (1999), Schmenner (1982) |
| | 2.2 Plant competence bandwidth | Production, Technical maintenance, Process improvement, etc. | Ferdows (1997) |
| | 2.3 Network competence reach | Activity performed for plant alone, Selected plants, Network | Ferdows (1997), Scherrer-Rathje *et al.*, (2014) |
| | 2.4 Plant competitive priorities/performance | Cost efficiency, Quality, On-time delivery, Delivery speed, etc. | Feldmann and Olhager (2013) |
| | 2.5 Market scope | Domestic, International, Global markets | Miltenburg (2009), Poynter and White (1984) |
| | 2.6 Plant decision autonomy | Planning decisions, Production decisions, Control decisions | Maritan *et al.* (2004) |
| | 2.7 Incentivization basis of plant | Individual for each plant, for a group, identical for all plants | Friedli *et al.*, (2014), Gupta and Govindarajan, 1991 |
| | 2.8 Products produced by plant | Product A, Product B, etc. | Vokurka and Davis (2004) |
| | 2.9 Processes/technologies held by plant | Process/technology A, Process/technology B, etc. | Cheng and Farooq (2018) |
| Level of plant embeddedness (EMBEDD) | 3.1 Inter-plant people flow | Intensity of people in-/outflow (e.g. travels of managers) | Vereecke *et al.* (2006) |
| | 3.2 Inter-plant knowledge/information flow | Frequency of communication (e.g. best-practice sharing) | Vereecke *et al.* (2006) |
| | 3.3 Inter-plant flow of physical goods | Intensity of goods in-/outflow (e.g. components) | Feldmann and Olhager (2019), Vereecke *et al.*, (2006) |
| | 3.4 Internal integration with R&D department | Organizational integration, Communication technologies, etc. | Cheng and Farooq (2018) |
| | 3.5 Internal integration with purchasing and sales departments | Information sharing, Joint decision-making, etc. | Cheng and Farooq (2018) |
| | 3.6 Supplier integration | Information sharing, Joint decision-making, etc. | Cheng and Farooq (2018) |
| | 3.7 Customer integration | Information sharing, Joint decision-making, etc. | Cheng and Farooq (2018) |
| | 3.8 University and research integration | Collaboration with universities, Research centers, etc. | Corti *et al.* (2014) |

**Table 3.**
Dimensions to differentiate plants in literature

(*continued*)

| Category | Dimension | Exemplary operationalization | Exemplary articles |
|---|---|---|---|
| Plant characteristics (PLANT) | 4.1 Plant size | Sales volume, Number of employees | Taggart (1997) |
| | 4.2 Plant age | Young plant, Mature plant | Taggart (1997) |
| | 4.3 Product supply chain position | Component manufacturing, Assembly, etc. | Feldmann and Olhager (2013) |
| | 4.4 Product uniqueness in network | Products produced by one or multiple plant(s) | Cheng and Farooq (2018) |
| | 4.5 Product volume | One-of-a-kind, Low volume, Higher volume, etc. | Khurana and Talbot (1999) |
| | 4.6 Product variety | Number of SKUs, Number of setups required | Taggart (1998) |
| | 4.7 End-product maturity | Organizational experience with the product in years | Arndt *et al.* (2019) |
| | 4.9 Product customization | Engineer-to-order, Make-to-order, Assemble-to-order, etc. | Jarillo and Martíanez (1990) |
| | 4.9 Automation level | Manual with low automation, Machine assistance, etc. | Feldmann and Olhager (2019) |

**Source(s):** Authors' own work

**Table 3.**

## 4. Results and discussion

### *4.1 The architecture of plant role models*

*4.1.1 Context of the models.* This article argues that MNCs build plant role models that fit their company-specific context. Nevertheless, one could also argue that companies base their plant roles on the work of external consultants without properly fitting them to their context.

None of the models examined is alike. Although most models incorporate a similar number of roles, i.e. three or four (22, 76%), the role definitions differ significantly. The various contexts and resulting pressures that affect our diverse sample of case companies are also reflected in the companies' plant roles. One example is the model of a Tier 1 automotive supplier (case 15). As usual in the supplier industry, the manufacturing network is strongly influenced by the OEMs to be supplied. The case company has reflected this dependency in the role definition by introducing a "delivery perspective". While the "Customer Specific Plant" only has one customer (less than 30 kilometers away), the "Regional Plant" has a large number of customers, which can be over 500 kilometers away from the plant. Another example of the influence of context is provided by case 5 from the medical technology industry. The case company's network is subject to constant change through mergers and acquisitions (M&As). The company regularly acquires new technologies and, hence, new plants. Consequently, the company has defined an "M&A Site" as a plant role. This role sets strategic guidelines on how and whether the acquired plant can be transferred to one of the other prescribed plant roles. Finally, a pharmaceutical company (case 29) distinguishes its four roles within the technologies commonly used in the pharmaceutical industry: biologics, plasma, small molecules, and mixed. To conclude, although the models are similar in terms of their outer composition (see chapter 4.2), the content of the various roles depends heavily on the respective conditions, such as industry, supplier position, and other company-specific contingencies.

*4.1.2 Level of detail of the models.* Major differences in the level of detail are evident from the analysis of the 29 models. 6 of the 29 models are more of a descriptive nature. The rather generic role definitions indicate that the case companies prefer to use these models as purely conceptual models to delayer the complexity of their manufacturing networks into units that are easier to comprehend. The remaining models have more of a prescriptive character for managing the manufacturing network. This is indicated by the analytical structure of these models. For example, these models break down specific KPIs into various roles; they assign the actual plants to their roles and define how plants can change their roles.

A further difference in the level of detail emerges in the unit of analysis of a plant's role. Although authors such as Ferdows (1997) or Vereecke and van Dierdonck (2002) describe the possibility that a plant can take on multiple roles, this has not been specifically investigated in the literature. In our sample, the case companies apply their defined plant roles to two dedicated units of analysis: either individual production units (4, 14%) or production plants (25, 86%), which represent an entire geographical location. Although the case companies with production units as a unit of analysis tend to operate smaller networks (i.e. two cases with only five plants), the choice also appears to depend heavily on how the models are applied.

In summary, the analysis of the models reveals a trade-off between a high and low level of detail. While the former can be better used for analytical purposes (e.g. IMN reorganization), the latter allows a quicker categorization of roles for further analysis.

*4.1.3 Application of the models.* The analysis of the 29 models reveals their different intended use as management tools, which can be divided into the two decision-making categories of manufacturing networks: coordination and configuration. As illustrated in Figure 1, about half of the models (15) focus only on the configuration of networks, while about the other half (14) also define coordination mechanisms in addition to the configuration.

The majority of companies (12) appear to use their model to implement their strategy or reorganize their manufacturing networks. These models typically use various information, such as KPIs or present plant capabilities, to justify expanding or closing plants. An example is case 4, which uses the model to explore possible scenarios for the plants in a reorganized network in 2027. An additional eight case companies appear to use their models to enable a systematic allocation of their products and technologies to the plants. Most of these models focus on configurative aspects such as the capacities of the plants and, in some cases, define product ownership. In six other cases, companies appear to use their models more as a conceptual framework to reduce the complexity of their networks by clustering their distinct types of production (see previous chapter). Two

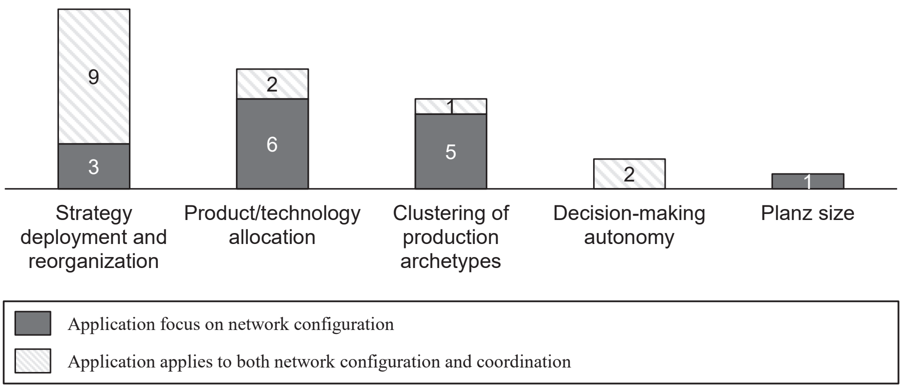



**Figure 1.**
Application focus of the 29 plant role models

**Source(s):** Authors' own work

models focus on the distribution of decision-making autonomy between the plants, and one focuses on the definition of plant sizes to be achieved.

To conclude, the case companies pursue very different objectives through their models. Although most of the models clearly focus on configurative aspects, about half of the companies use the models holistically to address both the coordination and configuration of manufacturing networks.

*4.2 Elements composing plant role models [1]*

We identified eight relevant elements from the analysis of the 29 plant role models' content. They are listed in decreasing order of their occurrence in Table 4.

*4.2.1 Role names.* The plant role names seem to be the most essential element of the plant role models as they appear in almost all analyzed models (27). One of the remaining models uses manufacturing regions (East Europe, West Europe, Asia-Pacific), and the other uses actual plant names in a matrix instead of abstracted role names.

In total, we found 92 plant roles in the 29 models. The case companies make partial use of labels, which is also discussed in the literature. For example, "Lead" and "Contributor" Plant from Ferdows (1989, 1997) or "Assembly" from Feldmann and Olhager (2019). However, the dominating part of the names such as "Cost-Focused Plant", "Production Center", or "Regional Plant" does not originate from literature. This supports the contingency perspective in company-specific, i.e. that companies develop their own company-specific versions of plant roles. As opposed to certain hardly applicable role labels in literature (e.g. "replaceable plant" in Cheng and Farooq (2018) or "isolated plant" in Vereecke *et al.* (2006)), managers use the role names sensibly so that they can be communicated to the plants and enable the plants to identify with their roles.

*4.2.2 Textual descriptions.* Seventeen models (59%) use textual descriptions, primarily in the form of (half-) sentences. Out of the 12 remaining models, nine contain frameworks/diagrams. Hence, the case companies seem to decide either way when developing their models. Most textual descriptions are visualized in tables (10 out of 17) as bullet points, whereas four models use text only with complete sentences. The high usage of textual descriptions enables the companies to fit the plant roles to their company-specific context and describe each role in depth. A description and visualization based on two dimensions, as usual in most conceptual articles (e.g. Bartlett and Ghoshal, 1986; Ferdows, 1989, 1997; Jarillo and Martíanez, 1990) seem hence not sufficient to make them useable in real-world applications.

*4.2.3 Frameworks/diagrams.* Out of the 13 models that use frameworks/diagrams for better visualization, four use matrices along several axes, three radar charts (with dimensions at the edges), two relationship diagrams, and two process diagrams.

| Rank | Element | No. | % |
|---|---|---|---|
| 1 | Role names | 27 | 93% |
| 2 | Textual descriptions | 17 | 59% |
| 3 | Frameworks/diagrams | 13 | 45% |
| 3 | Allocation of plants | 13 | 45% |
| 5 | Plant mission statement | 7 | 24% |
| 6 | KPIs | 6 | 21% |
| 7 | Evolution path of plant (roles) | 5 | 17% |
| 8 | Link to manufacturing strategy | 3 | 10% |

**Source(s):** Authors' own work

**Table 4.** Elements covered by 29 plant role models

Compared to the primarily two-dimensional matrices from the literature, the analyzed company-specific ones tend to incorporate more dimensions. Besides Friedli *et al.*'s (2014) plant role portfolio, such a matrix can be found in Thomas *et al.* (2015). It allows mapping an IMN's plants along multiple dimensions and comparing them with their aspired target levels. Own versions of such a visualization were also found in our sample.

*4.2.4 Allocation of plants.* Thirteen plant role models assign the as-is position of their multiple plants, including names to the different plant roles. Ten cases out of this sub-sample have multi-plant networks of less than 30 plants. Two of the remaining models only list exemplary plants in each role. One model uses a table to present the number of plants in each defined role (case 28). Seven models use visual elements to present some characteristics of the plants, e.g. the production volume, the product portfolio, or functions present at the plant. Similar visual elements of plants can be found in case studies presented by Friedli *et al.* (2014, pp. 197–251) or in the most recent version of the textbook (Friedli *et al.*, 2021).

The allocation of plants to the company-specific defined roles allows managers strategic considerations in managing their IMNs. Like Ferdows *et al.*'s (2016) framework for gauging plant subnetworks, such consideration may include spotting anomalies in allocating products or competencies to plants, the fit of current and future missions, etc. The allocation of actual plants to the defined roles helps hence bringing the manufacturing and network strategy to the plant level.

*4.2.5 Plant mission statement.* The notion of plant missions has been discussed in literature from different angles. Schmenner (1982) mainly stresses structural elements (e.g. assignment of products, processes, etc.) in his description of plant "charters", while Khurana and Talbot (1999) define the mission in terms of the competitive priorities assigned by senior management. The plant missions in the seven plant role models include various of the above-mentioned elements. They are mostly formalized in a one-liner. The following examples show two typical plant missions:

(1) "Fulfill orders for products for a defined market w/o engineering" (case 1)

(2) "Focus on high volume, low complexity at the lowest possible cost" (case 28)

*4.2.6 KPIs.* As noted by Cheng and Farooq (2018), companies should not only understand the role of each plant but also differentiate their management practices individually to ensure that the plants can achieve their desired role. Plant-role-specific KPIs may be such a management practice. Interestingly, only six models in our sample (21%) use KPIs. The number of KPIs per model ranges between one and five. They mainly measure structural elements of the plant role, such as the hourly labor rate or the capacity utilization, while "softer" KPIs, e.g. to measure the knowledge exchange of plants, are missing.

*4.2.7 Evolution path of plant.* Analogously to the allocation of plants, mapping the evolution path in the plant role model helps to address the "interaction" between the network and plant level, which is a significant component of a successful IMN (Colotla *et al.*, 2003; Olhager and Feldmann, 2022). Five models (17%) include evolution paths in their models. These models use two different units to describe the evolution.

Three models use the plant role itself. They contain an explicit hierarchy of roles. For example, case 3 prescribes the development of any start-up plant into a standard within a period of three to five years. The idea that plants with growing company affiliation take on a higher strategic importance in the network has already been observed by Ferdows (1989) and tested by Vereecke and van Dierdonck (2002, p. 506) who found that "Newcomers have a low level of strategic role, compared to the 'seniors' in the plant configurations." Our results imply that the higher strategic importance of plants is not necessarily only driven by the efforts of local plant management but may also be centrally intended.

The remaining two models use the actual plants of their multi-plant networks as the unit of analysis. Similar to the visualizations in Cheng *et al.* (2011) and Thomas *et al.* (2015), they use arrows to indicate the (potential) future position of each plant in several years.

*4.2.8 Link to manufacturing strategy.* The link to manufacturing strategy is the least often covered structural element found in the sample of 29 plant role models. In our sample, only three models contain an explicit link to the manufacturing strategy. Concepts such as network capabilities (Shi and Gregory, 1998) or production priorities (see, e.g. Slack and Lewis, 2002) are used to formalize the manufacturing strategy. The plant roles are linked with their contribution to elements of either the network capabilities (e.g. thriftiness ability, manufacturing mobility) or the production priorities (e.g. price, quality, delivery).

### *4.3 Dimensions used to differentiate plant roles*

Table 5 presents the occurrence of dimensions from the pre-defined list of codes introduced in the data analysis section.

*4.3.1 Overall integration and dominating dimensions.* Most of the 202 dimensions found across the 29 analyzed plant role models fit into the list of dimensions from the literature. Two dimensions are covered one time (i.e. *customer integration* and *plant age*), and *product uniqueness in the network* was not part of any model at all. Twelve dimensions emerged additionally from the analysis that could not be assigned to the original dimensions of the reference framework. They were hence newly added to Table 5 (indicated by asterisks (*)).

| Rank | Dimension | # | % | Rank | Dimension | # | % |
|---|---|---|---|---|---|---|---|
| 1 | Plant competence bandwidth | 23 | 79% | 21 | Inter-plant people flow | 3 | 10% |
| 2 | Inter-plant knowledge/ information flow | 17 | 59% | | Inter-plant flow of physical goods | 3 | 10% |
| 3 | Location advantage | 16 | 55% | | Internal integration with purchasing and sales departments | 3 | 10% |
| 4 | Network competence reach | 13 | 45% | | Degree of HQ-investment* | 3 | 10% |
| 5 | Market scope | 12 | 41% | | Equipment flexibility* | 3 | 10% |
| 6 | Plant competitive priorities/performance | 11 | 38% | | Processes/technologies held by plant | 3 | 10% |
| 7 | Product variety | 10 | 34% | 27 | Incentivization of plant | 2 | 7% |
| 8 | Plant focus/specialization | 9 | 31% | | Supplier integration | 2 | 7% |
| | Plant decision autonomy | 9 | 31% | | University and research integration | 2 | 7% |
| | Product volume | 9 | 31% | | Digitalization/industry 4.0 level* | 2 | 7% |
| 11 | End-product maturity | 8 | 28% | 31 | Customer integration | 1 | 3% |
| | Product supply chain position | 8 | 28% | | Plant age | 1 | 3% |
| 13 | Plant size | 7 | 24% | | Plant organizational structure* | 1 | 3% |
| 14 | Product customization | 6 | 21% | | Strategic plant importance* | 1 | 3% |
| | Automation level | 6 | 21% | | Number of divisions/BU's supported* | 1 | 3% |
| 16 | Products produced by plant | 5 | 17% | | Integration with logistics* | 1 | 3% |
| | Internal integration with R&D department | 5 | 17% | | Shift system* | 1 | 3% |
| 18 | End-product complexity* | 4 | 14% | | Production experience* | 1 | 3% |
| | Value-added scope* | 4 | 14% | | Process/technology complexity* | 1 | 3% |
| | Geographic location | 4 | 14% | 40 | Product uniqueness in the network | 0 | 0% |

**Note(s):** * Dimension not listed in Table 3
**Source(s):** Authors' own work

**Table 5.** Dimensions covered by company-specific plant role models

The dimensions of *plant competence bandwidth*, *inter-plant knowledge/information flow,* and *location advantage* seem to be the most relevant, as they are covered in more than half of the analyzed models. Overall, this empirical finding supports the proposed dimensions in two of the literature's most influential plant role models. On the one hand, differentiating plant roles based on external factors and competence in Ferdows (1989, 1997). On the other hand, to differentiate them based on knowledge/information flows as proposed by Vereecke *et al.* (2006). The high importance of differentiated levels of competence throughout the IMN can also be observed in literature as not only Ferdows (1989, 1997) uses this dimension (see, e.g. Khurana and Talbot, 1999; Cheng and Farooq, 2018; Feldmann and Olhager, 2019; Blomqvist and Turkulainen, 2019).

The analysis of the dominating dimension of each model – mostly identified by analyzing the models' role names, frameworks/diagrams, etc. – results in a diverse picture. While *plant competence bandwidth* and *plant focus/specialization* account for around half of the dominating dimensions (both 45%), there is a wide variety of dominating dimensions across the remaining models. For example, one model defines its three roles along the *plant locations* West Europe, East Europe, and Asia (case 23). In contrast, model 5 defines its criteria along the *plant sizes* in the three roles "standard site", "large site", and "XL site". The diversity in the dominating plant role dimensions fits the contingency aspect in the "company-specific" of plant role models again.

The analysis of the *number of dimensions* per model results in a similar variance. While on average, 7.6 dimensions are integrated into the models; four models only integrate four dimensions or less. Eight models integrate ten dimensions or more. The multi-dimensionality in our empirical sample is in contrast with the often (over-) simplified models in the literature using two dimensions only (e.g. Bartlett and Ghoshal, 1986; Ferdows, 1989, 1997; Jarillo and Martíanez, 1990). None of our analyzed models only incorporates two dimensions. The high average of dimensions is hence in line with the call to incorporate multiple dimensions by IMN scholars (e.g. Thomas *et al.*, 2015; Enright and Subramanian, 2007; Granlund *et al.*, 2019; Cheng and Farooq, 2018). At the same time, it gives important evidence on how to make the theoretical models from literature operational, as demanded by Mediavilla *et al.* (2015).

*4.3.2 External factors.* Out of the category of external factors, *location advantage* ranks number three across the analyzed models. The *geographic location*, in contrast, is only incorporated by four models. Most of the analyzed models' operationalization of *location advantage* fits into one of Ferdows's (1989, 1997) or Vereecke and van Dierdonck's (2002, pp. 513–514) list of location advantages. Compared to the other location advantages, access to low-cost production is disproportionately named in the models. Besides its importance, this may be because it is easier to operationalize (e.g. through the hourly rates) than most other location advantages. It hence seems that plant roles with access to low-cost production as *location advantage* are more explicitly defined than others as they are easier to measure.

*4.3.3 Plant mandates from HQ.* The most often occurring dimension to differentiate plant roles (79%) is the *plant competence bandwidth.* The operationalization of this dimension across the models largely resembles the one in Ferdows's model. However, two additional competence categories emerged, i.e. *ramp-up* or *launch competence for new products* and *continuous improvement and lean competence*. Regarding the latter dimension, some MNCs hence prescribe a different lean maturity. This finding from points in a similar direction as Demeter *et al.*'s (2017) survey results: The authors find that only certain plant roles (i.e. lead and source plants in Ferdows's (1989, 1997) model) use lean management with a positive impact on specific performance dimensions.

*Market scope* as a dimension to differentiate plant roles can be found in 12 models (i.e. 41%). The models' operationalization mainly fits the one proposed in the literature (e.g. in Poynter and White, 1984; Cheng and Farooq, 2018). A common differentiation across the models is the “local-for-local” or “for the market plant” versus the “global market plant”, similarly already described in Poynter and White’s (1984) early article about foreign subsidiaries.

Both the dimensions of *plant competitive priorities and performance* (38%) and *plant focus/specialization* (31%) are mainly operationalized as proposed in the literature (i.e. quality, cost, etc. for the former and market area, technology, etc. for the latter). Out of the nine models (31%) that incorporate *plant decision autonomy*, case 24 stands out: It uses a matrix along 27 decision categories (e.g. location strategy, organization development, etc.) and the degree of autonomy (i.e. none, supportive and reactive, prescriptive and proactive, and responsible) to categorize its five plant roles. A similar matrix along “manufacturing decision-making categories” and degree of centralization from a plant’s perspective can be found in a study by Olhager and Feldmann (2018).

*4.3.4 Level of plant embeddedness.* As outlined in chapter 4.1, plant role models influence both decision layers of IMNs, i.e. configuration and coordination (Feldmann and Olhager, 2013). However, the configurational dimensions dominate across our analyzed sample. The low integration of dimensions in the category of plant embeddedness reflects this. Only the dimension of *inter-plant knowledge/information flow* appears under the top 10 dimensions (compare Table 5). Most of the models either formalize the sharing of best practices or define lead-recipient plant relationships for products and/or technologies.

*4.3.5 Plant characteristics.* The two most important dimensions in the plant characteristics category are *product variety* (34%) and *product volume* (31%). As one would expect, the models stress the opposing direction of the two dimensions. That is, plant roles with high volumes tend to have a limited product range and vice versa.

Although used by less than 30% overall, the dimension of *end-product maturity* and *plant size* are the dominating dimensions for one model each. The former is used by case 7, which differentiates plant roles for innovative, mature, and cost-focused products – the latter by case 5, with a distinction into standard, large, and XL sites. Although categorized as plant characteristics in our reference model, these case companies seem to use the aforementioned dimensions as plant mandates explicitly given by HQ.

*4.3.6 Occurrence of additional dimensions.* Twelve dimensions emerged from the analysis, which could not be assigned to the dimensions of the literature review. Only five of these principles occurred more than once (compare Table 5).

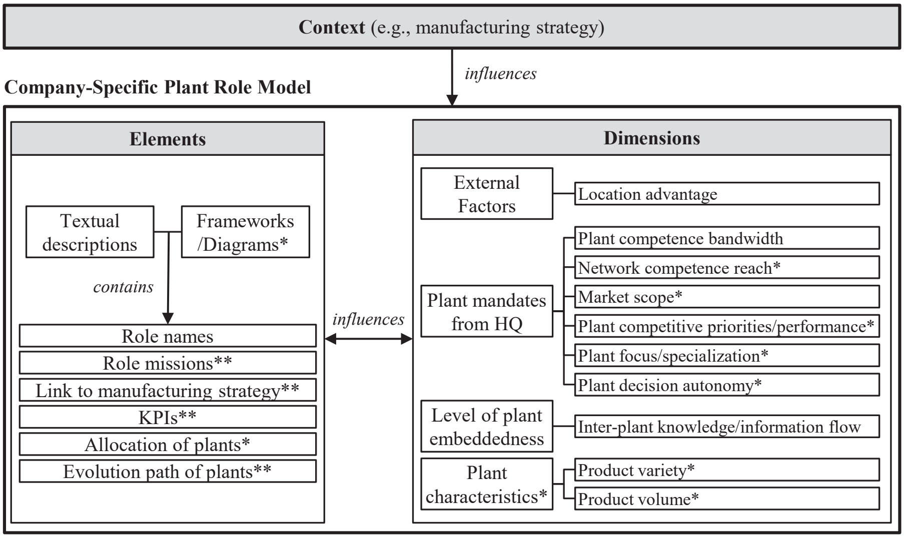
An interesting dimension is the *value-added scope* contained in four models. Some of these models put the product value creation in proportion to their material cost. This proportion can be used to indicate the right choice of a location’s average hourly rates. Another interesting dimension is the *digitalization/industry 4.0 level* contained in two models. Like the observation about the lean maturity above, we can conclude that a few case companies intentionally differentiate the expected digitalization/industry 4.0 level based on their plants’ roles.

We controlled the sample for differences in the additional dimensions across the case companies’ main industries. However, we did not detect any major variances.

### *4.4 Conceptual framework of plant role model content*

Figure 2 summarizes the results of the analysis of the 29 plant role models in a conceptual framework and thus enables a comprehensive answer to our research question: *What do plant role models look like in the industry?* By looking at plant roles from an industry and headquarters perspective, the model complements existing models from the literature, such as that of Vereecke *et al.* (2006), Cheng and Farooq (2018), or Blomqvist and Turkulainen (2019).

First, our model places the company-specific plant roles in the corporate context (see Figure 2 at the top). Even though our study was not explicitly designed to investigate the




**Note(s):** * in 30 to 50% of plant role models covered; ** in less than 30% of plant role models covered
**Source(s):** Authors' own work

**Figure 2.** Conceptual model of plant role model content

dependency between plant roles and their contingency factors, we could clearly demonstrate that, for example, the role definition of a supplier is strongly influenced by the OEM to be supplied. On the left side, Figure 2 shows the eight elements prevalent in the models' content and, on the right side, the dimensions MNCs primarily use for differentiation across their plant roles.

Elements and dimensions that are used by less than 50% of the case companies are marked with one asterisk (*). The ones used by less than 30% by two asterisks (**). Besides visually answering our research questions, the conceptual framework can be used by managers as a guiding framework, e.g. like a checklist, when defining the company-specific content of a new plant role model.

## 5. Conclusions

Multinationals recently started defining plant roles to complement their often-existing lead plant concept. We chose a multiple-case study design to explore how these companies define their company-specific plant roles as a management tool to support the design and management of their related manufacturing networks.

We found that MNCs tend to define three or four plant roles – often summarized in a formal model consisting of elements such as plant missions, KPIs, frameworks, diagrams, and simple textual descriptions. The case companies seem to differ in the priorities they pursue with their models. Some companies appear to use the models to implement and reorganize their manufacturing networks. Other applications include the allocation of products and technologies to plants, the definition of decision-making autonomy, or simply the reduction of the complexity of their networks. Compared to most models from the literature, MNCs in our sample typically use multiple dimensions (seven to eight) to operationalize differentiation across their company-specific plant roles. Plant competence bandwidth is the most important dimension for differentiating plants, followed by inter-plant knowledge/information flow and location advantage. Although the outer structure of the models is similar, the prioritized dimensions are highly different, which hints at the unique context in which the analyzed MNCs operate.



*5.1 Contribution to literature*

This study contributes to the literature by elaborating on the concept of plant roles. To our knowledge, this is the first study that systematically analyzes the "company-specific" aspect of plant role models from a contingency perspective. With that, we enable the analysis of plant role models and how they are practically used in a "real-world context" (Yin, 2018). In addition, we contribute to understanding plant roles from a headquarters perspective, as demanded by various IMN researchers (Blomqvist and Turkulainen, 2019; Cheng and Farooq, 2018; Feldmann and Olhager, 2013). More specifically, we could empirically confirm that differentiating plants based on location advantages, competencies, and knowledge flows, as proposed in two early publications on plant roles (i.e. Ferdows, 1997; Vereecke *et al.*, 2006), is also an industrial practice. Moreover, in our sample, we observed a high level of detail in plant role description that was applied analytically to managing and designing manufacturing networks. This observation relates to Mediavilla *et al.*'s (2015) and Thomas *et al.*'s (2015) suggestions that plant roles must provide enough variety to be practical for managing manufacturing networks. Last, we increased the understanding of how plant roles relate to "the manufacturing network as a whole", as Cheng and Farooq (2018, p. 27) demanded.

*5.2 Managerial implications*

Managers in charge of manufacturing networks need tools that help them deal with such networks' high complexity levels (Ferdows *et al.*, 2016). Our research shows that plant roles are a powerful tool for actively managing an IMN by combining its two main decision layers (i.e. configuration and coordination) and condensing the implications to the plant level. Managers aiming to use plant roles for managing their IMNs seem to fit them to their company context, such as the overarching manufacturing strategy in which the company operates. Depending on the objective and the context of the plant role model, managers need to carefully select the right elements (e.g. KPIs or evolution path of plants) and dimensions (e.g. plant competence bandwidth or market scope) for plant differentiation. The list of sorted dimensions for plant role differentiation (Table 5) and the conceptual model (Figure 2) can be used as a benchmark in the development of the plant role model.

*5.3 Limitations and future research*

As with any case-based study, our's also comes with several limitations (Yin, 2018). While we took care in meeting established best practices of qualitative research such as *accuracy checks*, a *strong theoretical foundation,* and *transparent methods analysis* (Bluhm *et al.*, 2011), the primary usage of documentations poses a major limitation to this study, especially the construct validity. A second limitation of the used data source comes with the limited ability to capture *dynamic aspects* such as the creation or change process of the plant role models' content. For example, we could not address the process related to plant roles or organizations' "cultural readiness" to deploy plant roles. Future case-based research designs could shed light on the creation and deployment process of plant role models to identify patterns of success. Moreover, our study has taken a headquarters perspective on plant roles. Consequently, our study could not address possible perception gaps between plant and headquarters managers related to the roles as investigated by Vereecke and van Dierdonck

(2002). We encourage future studies based on combined plant and network-level data to investigate related perception gaps.

Next, as for most case study-based research designs, a limitation comes with the *number of cases* and the underlying *selection procedure*. Our sample consists of 29 plant role models based on convenience and purposive rather than statistical sampling logic with case companies headquartered in high-cost countries. Although most models belong to companies headquartered in German-speaking countries, the sample also contains three outside of these countries (two in the US, one in Japan), however, with no notable differences. Future research using sampling logic (i.e. large-scale surveys) might incorporate models from low-cost countries and more industries to test our findings. This would enable the comparison of cultures, industries, company sizes, and other factors. In this context, it would also be interesting to examine which plant roles and which plants can be found in which specific countries, such as high- or low-cost countries.

Last, like most articles on plant roles, our article was not designed to analyze the performance effects of applying plant roles in a corporate context. Consequently, we encourage such studies investigating how plant roles affect and potentially improve organizational performance. Overall, we think that the phenomenon of company-specific plant role models offers multiple exciting research directions that are also of high interest to managers [1].

## Note

1. A previous version of Sections 4.2 to 4.4 has initially been published in Kaiser (2024).

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## About the authors

Dr Jens Kaiser studied industrial engineering at RWTH Aachen University and Tsinghua University in Beijing and completed his doctorate about plant roles at the University of St. Gallen. After completing his doctorate, he joined the consultancy business, where he leads projects on strategic issues for manufacturing companies. Jens Kaiser is the corresponding author and can be contacted at: jens.kaiser@rwth-aachen.de

Prof. Dr Thomas Friedli is Professor of Business Administration in the field of Production Management and Director of the Institute of Technology Management at the University of St. Gallen. In addition to international manufacturing networks, the topics of operational excellence and smart services are among the main areas of research in the department he heads.