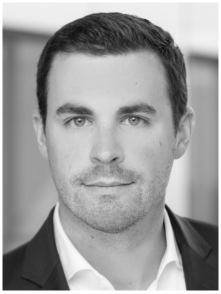
Framework for determining the degree of centralization in global production networks

Günther Schuh, Andreas Gützlaff, Julian Ays, Tino X. Schlosser

Abstract: Over the last decades, global production networks have developed to high complex systems. To adapt quickly the dynamic environmental conditions, an active network management is required. The network management and the associated distribution of responsibilities in the production network is mostly grown historically. Further, the issue is only commonly considered in current approaches. Therefore, this paper presents a framework for determining the degree of centralization in global production networks under the aspect of increasing efficiency. Beyond the theoretical framework, a workshop procedure is presented in which the framework can be tested.

Keywords: Global production, production network, network coordination, network management, degree of centralization

Gestaltungsrahmen zur Bestimmung des Zentralisierungsgrads globaler Produktionsnetzwerke

Zusammenfassung: In den letzten Jahrzehnten haben sich globale Produktionsnetzwerke zu immer komplexeren Systemen entwickelt. Um sich schnellstmöglich an die dynamischen Bedingungen des Marktumfeldes anzupassen ist ein aktives Netzwerkmanagement erforderlich. Das Netzwerkmanagement und die damit einhergehende Verteilung von Verantwortlichkeiten im Produktionsnetzwerk ist meist historisch gewachsen und wird in der Wissenschaft teils nur nebenläufig betrachtet. Daher stellt der Beitrag einen Gestaltungsrahmen zur Bestimmung des Zentralisierungsgrads in globalen Produktionsnetzwerken unter dem Aspekt der Wirtschaftlichkeitssteigerung dar. Über den theoretischen Gestaltungsrahmen hinaus wird ein Workshop Vorgehen beschrieben, in dem die Aspekte des Gestaltungsrahmens erprobt werden können.

Stichwörter: Globale Produktion, Produktionsnetzwerk, Netzwerkkoordination, Netzwerkmanagement, Zentralisierungsgrad

1. Introduction

1.1. Motivation

Global manufacturing companies find themselves in an increasingly volatile environment due to the rapid development of world trade and the increasing internationalization of value chains in recent decades (*Sager* 2018). Past crises, developments of new technologies, and political tensions have led to high uncertainties and increased competitive pressure. Global manufacturing companies are facing new challenges while advancing digitalization: On the one side, they have to meet new requirements for the transformation of international value chains; on the other side the former focus on production processes is displaced by new processes of data processing and breaks up traditional industry patterns. Nevertheless, the impact of digitalization on global manufacturing companies is still not clear, because most trends do not show a clear future vision for the design of production networks yet (*Krzywdzinski* 2019). This results in increased complexity and dynamics in the environment of global production networks. Accordingly, a high adaptability of the networks is required to be able to react to new circumstances as quick as possible (*Friedli et al.* 2013). The ongoing Covid-19 crisis highlights the compelling need to remain responsive and agile (*Görg* 2020*; McKinsey* 2020). In addition to agility in network design and structure, an active network management is essential to make complexity manageable and to align production networks in a targeted way (*Lanza et al.* 2019). In the course of network management, the question of the appropriate degree of centralization and the associated optimal distribution of responsibilities is not trivial. Most structures have grown historically and are based on subjective decisions by management (*Mack* 2003). In addition, most approaches deal only superficially with network management and its associated implications, thus it is not assigned the necessary importance (*Cheng et al.* 2019). As an important lever on the performance and related profitability of production networks, the orientation of network management should be approached actively and objectively (*Blomqvist/Turkulainen* 2019). Considering the degree of centralization is worthwhile in this regard, as it reveals the allocation of functions in the network of the company and includes influences on the economic efficiency. However, existing approaches to determine the degree of centralization still show some serious deficiencies, as those only include individual functions of the production network. The influence of the degree of centralization on the economic efficiency of the network management is neglected and a systematic approach missing.

In order to meet today's challenges of an active network management and the associated distribution of responsibilities in the course of designing the degree of centralization, the following requirements for a holistic approach must be met:

- A delineation of functions, which have to be considered in the distribution of responsibilities and the design of the degree of centralization in the network
- Description of relevant factors that have an impact on the design of the degree of centralization in terms of barriers and enablers
- A systematic procedure for determining the targeted degree of centralization, regarding the relevant network properties and the factors previously determined, by considering the impact on the economic efficiency

1.2. Existing Approaches

Existing approaches for the design and coordination of global production networks focus primarily on the support of the network design, network structuring, and the evaluation of performance and efficiency. For the selection of the approaches considered a systematic literature review was carried out. The corresponding factor terms were analyzed and qualitatively evaluated by applying formal and substantive quality criteria. As a result, a total of eleven approaches emerged which deal with relevant topics. In the following, these approaches are considered in detail with regard to the previous defined requirements:

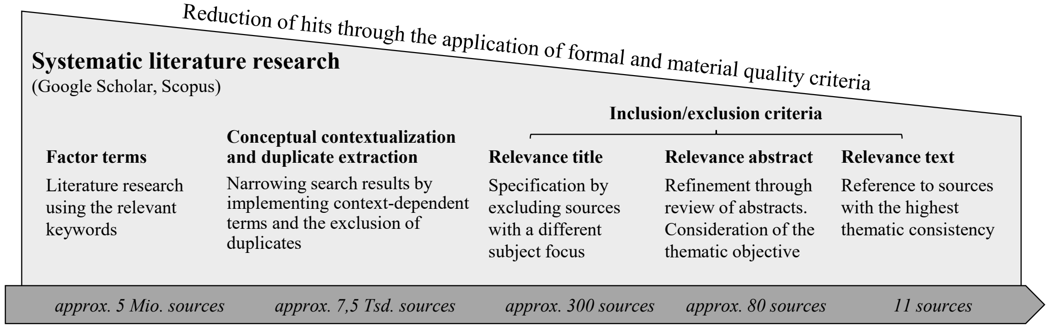


Figure 1: Systematic literature research to find relevant approach

The site-role model of *Ferdows* (1997) analyzes the strategic importance of individual production sites based on their strategic goal and location competences. The categorization of the sites leads to a reduction in the complexity of the production network and improves the decision-making competencies of the company. By the approach, the network complexity can be reduced and a framework for strategic decisions in global production network is formed. (*Ferdows* 1997).

The analysis approach of *Maritan et al.* (2004) bases on this site-role model and deals with the relationship between production sites and their decision autonomy. Sites are categorized and determined for their degree of autonomy based on twelve essential management decisions. The correlation between site and decision autonomy is proofed by a study, but the interdependencies of influencing factors in global networks are usually more complex than presented (*Maritan et al.* 2004).

In *Mourtzis et al.* (2012), the transition from classical to individualized mass production results in a simulation model that enables the evaluation of centralized and decentralized production networks in a particularly customer-oriented environment. The approach examines centralization in production networks in terms of their configuration. The simulation of the performance of centralized and decentralized network configurations shows that decentralized network alternatives are more efficient compared to centralized production networks. However, the design field of network coordination and management is not addressed in further detail (*Mourtzis et al.* 2012).

Another approach to the centralization of decision-making authority in global production networks is presented by *Gurcaylilar-Yenidogan and Windsperger* (2013). The aim is to identify determinants of the degree of centralization for the decision-making responsibility. The approach enables conclusions of the influence between individual determinants and the centralization in the network. However, the impact of centralization on network performance is neglected (*Gurcaylilar-Yenidogan/Windsperger* 2013).

The approach on centralization and standardization of production networks developed by *Friedli et al.* (2013) presents an aggregated perspective on the degree of autonomy in production networks. The framework uncovers inconsistencies in the network structure and coordination and provides a starting point for developing towards the target state. Furthermore, it is suitable for mapping the current degree of centralization. However, the impact on the profitability and overall efficiency of the network is not considered (*Friedli et al.* 2013).

Lanza et al.'s (2013) approach provides a way to assess global network effectiveness. The network is subdivided into subsystems and evaluated based on their effectiveness in the overall network (*Lanza et al.* 2013). The methodology can support network management by identifying optimization potentials in the network. However, due to the focus on the effectiveness of the subsystems, important aspects such as flexibility and mutability of the network structures cannot be addressed.

The semi-centralized model according to *Liu and Song* (2017) is based on the insight that global production networks are usually semi-centralized. Network coordination is carried out by a central planning authority, with subunits acting autonomously in certain areas. The model exhibits the success of various supply chain coordination strategies but addresses a specific coordination problem in the context of a consulting project (*Liu/Song* 2017).

The framework of *Ferdows et al.* (2016) on sub-networks addresses the increasing complexity of global production networks. In order to simplify this, the overall network is structured into smaller sub-networks. The resulting reduction in complexity and strategic focus on these sub-networks enables a simpler design and management of the production network (*Ferdows et al.* 2016).

The site-role model of *Arndt et al.* (2017) combines a realistic depiction and dynamic design measures for complex production networks. Individual target dimensions are derived depending on the site-role. By aggregating site-specific processes on the value chain level, a holistic assessment of network performance is performed by aggregating site performance using averaging. A dynamic evaluation of different network configurations is enabled by embedding them in an agent-based simulation model (*Arndt et al.* 2017).

The approach of *Scherrer and Deflorin* (2017) examines the influence of the production site and its perspective in the production network on the fulfillment of the corporate strategy. The relationship between site and network capacity is examined as well as the influence of the coordination, configuration, and strategy of the production network. The approach examines the influencing factors of cost, mobility, availability and learning ability. The research area was set up broadly and includes the essential considerations of interdependencies in production networks. However, the influence of strategic decisions on the network management has not been addressed in detail (*Scherrer/Deflorin* 2017).

The approach of *Olhager and Feldmann* (2018) models a structure for strategic production decisions. The results are based on survey data from 107 production sites on the location of decision authority at the network or site level. The approach proves the existence of three alternative structures of responsibility allocation for strategic decisions. A differentiation in the allocation of responsibility could not be empirically proven. The results of the study focus on the views of a single production site and do not allow an analysis of the simultaneous coordination of several sites (*Olhager/Feldmann* 2018).

	Delimitation of relevant functions	Consideration of barriers regarding centralization	Systematic approach regarding the increase of the economic efficiency
Ferdows (1997)	largely fulfilled	barely fulfilled	not fulfilled
Maritan et al. (2004)	barely fulfilled	partly fulfilled	barely fulfilled
Mourtzis et al. (2012)	barely fulfilled	barely fulfilled	partly fulfilled
Gurcaylilar-Yenidogan & *Windsperger* (2013)	barely fulfilled	barely fulfilled	not fulfilled
Friedli et al. (2013)	largely fulfilled	partly fulfilled	not fulfilled
Lanza et al. (2013)	partly fulfilled	largely fulfilled	barely fulfilled
Liu und *Song* (2017)	barely fulfilled	barely fulfilled	barely fulfilled
Ferdows et al. (2016)	partly fulfilled	barely fulfilled	partly fulfilled
Arndt et al. (2017)	barely fulfilled	barely fulfilled	partly fulfilled
Scherer & Deflorin (2016)	partly fulfilled	barely fulfilled	barely fulfilled
Olhager & *Feldmann* (2018)	partly fulfilled	barely fulfilled	barely fulfilled

not fulfilled · barely fulfilled · partly fulfilled · largely fulfilled · completely fulfilled

Figure 2: Critical comparison of existing approaches

The consideration of relevant approaches shows, that existing approaches do not sufficiently address the necessary requirements of a targeted design of the degree of centralization. Most approaches address the distribution of competencies via site-roles in the network configuration. The actual transfer to network coordination, which considers the inter-operational relationships, remains unconsidered. The economic component is mentioned only marginally; mostly general performance considerations are made, but the impact of the network management on the economic efficiency is not described in more detail. Most approaches focus on the mapping of the current situation. This already increases transparency in the network, but does not support the deviation of conclusions regarding the targeted degree of centralization. Thus, a holistic design approach that maps the systematic design of the degree of centralization and the associated distribution of responsibilities in the network is missing.

2. Presentation of the framework

2.1. Degree of centralization and decision-making levels

In the following, a framework is presented which describes in more detail the various aspects for determining a suitable degree of centralization and the associated distribution of responsibilities. The degree of centralization is not to be comprehended as a key figure, but rather as a gradual classification of the extent to which functions are located either on a centralized or decentralized decision-making level (*Figure 3*).

Accordingly, a high degree of centralization means that functions are clustered centrally, e.g. at network level, and thus apply to all production sites. A low degree of centralization describes instead a decentralized orientation. Accordingly, sites can act very autonomously and independently since the functions and decision-making powers are held by them. Decentralized network decisions lead to increased complexity and reduced transparency in the network control. However, the susceptibility of production systems to faults can be reduced by decentralized control (*Jahn 2016*). In this case, network control is made more flexible and adapted to local subsystems. There can be various gradations between the two extremes, which vary depending on the considered company and production network.

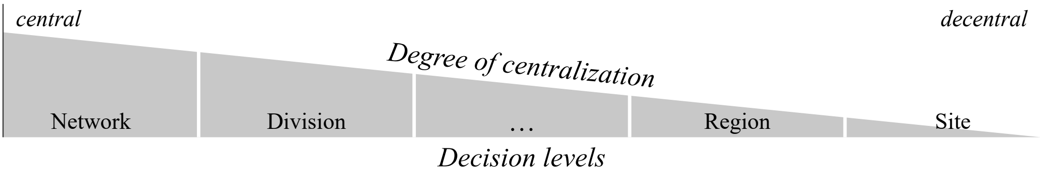


Figure 3: Description of the degree of centralization in global production networks

The below described framework is divided into a Top-Down and a Bottom-Up perspective (*Figure 4*). The Top-Down perspective describes a generic ideal approach, depending on the considered functions and the general characteristics of the production network. Instead, the Bottom-Up perspective analyzes the factors influencing directly the production network, which support or inhibit the achievement of a corresponding degree of centralization.

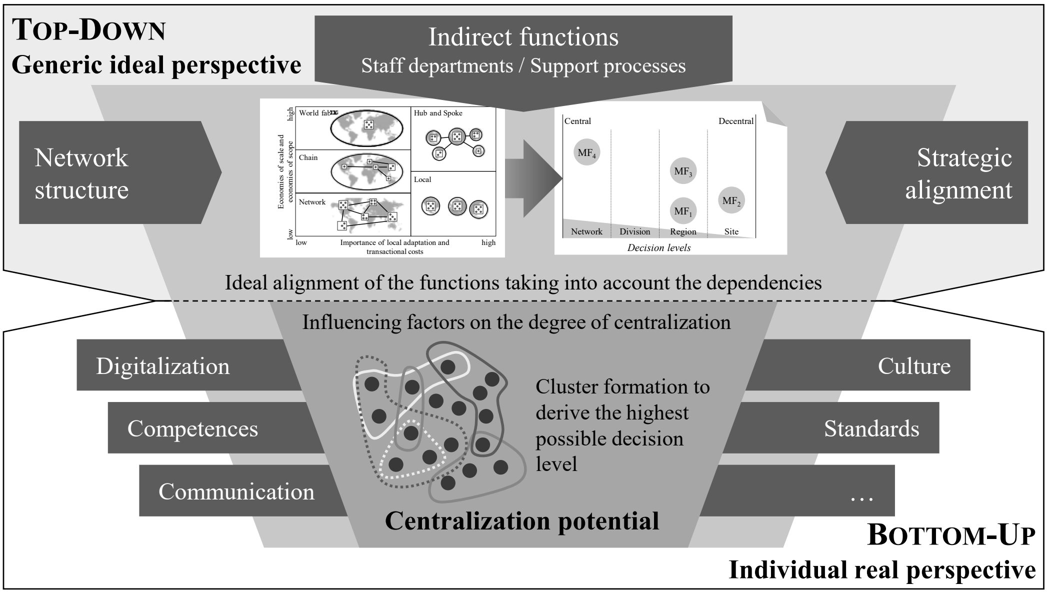


Figure 4: Framework for determining the degree of centralization of global production networks

2.1. Top-Down perspective

In the top-down perspective, the scope and the characteristics of the production network as well as the followed strategic orientation are classified. First, the scope and considered functions which can be centralized potentially must be defined in more detail. A distinction between direct and indirect functions of a manufacturing company is made. Direct areas are characterized by a direct allocation to the provision of services or the production of goods (*Westkämper/Decker* 2006). They are therefore also referred to directly value-adding, primary or performance-oriented functions. Instead, indirect function are referred to indirect value-adding, secondary or resource-oriented areas (*Jost* 2000; *Magenheimer* 2013). The indirect areas are less directly related to physical production and can be considered separately from it to a large extent. Often described as support functions, they include tasks such as planning, organizing, and informing. The change in the boundary conditions of manufacturing companies that has become apparent in recent years indicates increasing interdependence between direct and indirect activities, with process-related activities such as control, troubleshooting, and monitoring increasingly falling within the scope of indirect tasks (*Bauer/Schlund* 2018). To increase the value creation processes in those areas, it is recommended to make the production process as transparent as possible and to ensure a high level of system understanding by the users (*Lock* 2020). Indirect functions also represent an important component in the decision-making process of more complex issues (*Nyhuis/Wiendahl* 2014). The focus of the framework presented here is on indirect function, since their definition means that they require only a low level of direct proximity to the production processes and can therefore also be detached from them in terms of location. It is therefore possible to bundle these functions more centrally. Typical function are e.g. finance and controlling, procurement and production planning and control. Due to the shift in the spectrum of indirect activities toward more knowledge-intensive activities and the increasing interdependence of production, product development and product creation, as well as order processing, a new examination of the indirect functions is necessary (*Bauer* 2018). In this context, it is important to identify the functions that are directly interdependent and thus must be located at the same decision-making level. Thus, certain clusters of functions can be formed, and the scope of consideration can be further narrowed down.

In addition to the delimitation of the considered functions, the strategic orientation and structure of the production network is an important component of the top-down perspective. The strategic orientation of the network is reflected in the network strategy. While operational decisions are made primarily in the short term on subsidiary level, strategic decisions depend increasingly on the external circumstances of the network (*Birkinshaw/Morrison* 1995). Strategic decisions are aimed at the long-term development and reduction of capacities, which can then be used at the operational decision-making level. Network strategies can be divided into certain differentiation factors. In addition to access to markets and resources, strategies are differentiated according to efficiency, mobility, and learning (*Friedli et al.* 2013). In most cases, not only one differentiation factor is decisive for the targeted strategy, but a prioritization among them. Accordingly, characteristic groups can be identified. A distinction is made between market producers and specialists, competence specialists and network experts (*Thomas* 2013).

According to *Abele* (2006) network structures can be classified in the dimensions of *Importance of local adaptation* and *Economies of scale*. Based on these dimension five ideal network structures are derived: world factory, chain, network, hub & spoke, and local (*Abele* 2006). The different network structures are also characterized by their centralized or decentralized orientation. While the world factory, with a location that serves the whole global demand, represents the most centralized structure, the local form describes the precisely contrary orientation, decentralized production sites that can adapt to local conditions directly (*Lanza* 2019). The orientations of the other structures move between these two forms. The network structure and pursued network strategy cannot be considered independently of each other. The targeted network structure results from the strategy pursued; conversely, the given network structure can limit the possible network strategies.

The final step in the top-down perspective is to determine the most economic efficient degree of centralization for the considered functions, considering the network structure and strategy. *Nyhuis and Wiendahl* (2014) have shown that, depending on the form of organization, there are economic advantages to combining indirect functions (*Nyhuis/Wiendahl* 2014). In general, the highest degree of centralization should be aimed for the considered functions based on the existing network structure and aimed network targets, in order to achieve a positive impact on the economic efficiency. The processes of these functions are characterized particular by the use of digital media, a low degree of standardization, and a high lack of transparency and complexity (*Magenheimer* 2014). Due to this fact, it is not easy to quantify the economic efficiency of them. Still, the positive impact on the economic efficiency can be described by taking a detailed look on the potential decrease of waste due to a targeted centralization. Waste describes repeated and superfluous activities in the value chain, which do not contribute to the increase in value of the product and the customer. Therefore, the elimination of waste along the whole value chain has to be aimed (*Ohno* et al.2013; *Herlmold* 2021). A large part of the waste in the indirect areas is due to unused or incorrect information, a lack of standards and, in some cases, a lack of communication. This leads to waste in the form of inventories, errors, and movements. Furthermore, waste occurs in the form of an inefficient resource usage, interfaces, and idle power. These result from a high degree of task sharing, countless systems, and duplicate activities as well as the parallel development of competencies (*Magenheimer* 2014). A targeted centralization of functions counteracts these wastes and leads to a more economic efficient result. Synergy effects occur in the form of a steeper learning curve and the exchange of best practices can be carried out in a more targeted manner (*Hirzel et al.* 2019). A centralized organization can actively design the communication between relevant resources. Due to an overall central perspective, targeted solutions can be developed and applied (*Weitzel et al. 2006*). It can reduce the lack of information and promote best-practice sharing approaches and supports the establishment of certain standards (*Treber et al.* 2019). Through the transparency, oversizing or wrong requirements can be identified as well as overlaps in the network, whereby the usage of resources can be planted in an efficient way and parallel idle power be reduced. Another important aspect is the increased transparency for the decisions making process. A well-known example from microeconomics is the prisoner's dilemma. This involves the lack of transparency in the decision-making process of two self-interested actors whose decisions have an equal impact on the outcome. Since they do not receive information about each other's decisions, they choose the best alternative from an individual perspective. However, this leads to a less favorable outcome in the overall perspective (*Bardmann*

2020). This problem can be applied analogously to a global production network. If each production site acts only for itself and tries to maximize its own benefit, the result will not be Pareto-optimal for the network. This is mainly since the scope of consideration and information of the sites is not large enough (*Hens/Pamini* 2008). A centralized position, which has an overview on all participants regarding their characteristics and preferred alignments, can use relevant information right away for finding the optimal setting and therefore reduce the occurrence of waste. The goal must be to move the sites from the individual goal of maximizing benefits to a collective goal of maximizing benefits for the entire network. This can be achieved through a targeted centralization of functions, as it significantly expands the scope of consideration. Besides the positive impact on the decrease of waste due to a centralized clustering of indirect function, new waste can occur, especially waiting times due to longer communication ways. Therefore, an individual consideration for each production network has to be executed in order to analyze the impact of the degree of centralization on the waste.

2.2. Bottom-Up perspective

After the centralization potentials have been determined based on the network structure and strategy in the top-down perspective, the bottom-up perspective is about refining the degree of centralization to individual real conditions. In addition to strategy and structure, other factors effecting a production network to achieve the highest possible degree of centralization. Beside changes in the general conditions of production networks and the trend of process automation, the establishment of standardized processes is considered future-oriented. Fundamental factors that are considered in the formation of centralized structures are company characteristics, the entrepreneurial objectives as well as internal and external changes (*Asbach/Haselhorst* 2018). Increasingly relevant centralization factors, which have been emerged due to technological- and digital changes, are presented in the following:

An important factor is the degree of digitalization and the associated transparency in the network (*Fleischmann et al.* 2018). The ability to access the necessary information and data from anywhere at any time is an important prerequisite for being able to make valid decisions remotely. This also includes the implementation of appropriate systems and interfaces (*Buchholz/Knorre* 2019).

In addition to the degree of digitalization, standards are an important factor for centralization. Uniform standards allow an advantageous combination of decision-making processes and the associated competencies. It creates greater process transparency, which further has a positive effect on the productivity management (*Dorner* 2014). The establishment of standards improves the exchange of network-relevant information, special knowledge and resources. In addition, the potential of possible synergies is exploited, and a more uniform management structure sought (*Friedli et al.* 2013).

Existing competencies regarding processes and products must also be considered. Core competencies include methodological- and system competencies for increasing productivity as well as competencies for project organization and problem solving (*Dorner* 2014). In the indirect areas, product-dependent competencies must be considered. Depending on the diversity of the existing product portfolio, the indirect areas can have different orientations or focuses, which results in difficulties regarding the implementation of a central bundling of them (*Dorner* 2014).

Especially in the topic of network management, the aspects of communication and culture have an important role (*Cristofoli et al.* 2020). It has to be evaluated to what extent certain decisions can be communicated and delegated over longer distances with appropriate media or whether direct communication between the different areas is necessary and therefore a different location would not be feasible. The cultural aspect refers to the acceptance of central decisions and specifications (*Ehrenmann* 2015). It must be considered that acceptance varies depending on the regional affiliation of the decision-making level and the locations. To avoid conflict potential and inefficiencies, a more decentralized strategy should be sought in selected cases (*Buchholz* 2019).

In addition to the factors presented here, further influencing factors from the environment of production networks must be considered. In summary, these factors can be described as PESTEL factors (political, economic, social, technological, environmental, legal) (*Theobald* 2016). Further restrictions can be derived out of them, which have an influence on the degree of centralization. For example, due to serious differences in the education systems in some regions, it can be extremely difficult to find appropriate skilled personnel. This would favor the centralization of tasks at another location. Furthermore, a targeted location of more expensive functions, such as indirect functions (*Magenheimer* 2014), can bring financial advantages, and thus have a positive effect on the economic efficiency.

The relevant influencing factors have to be determined individually for a specific production network. Once these are identified, the different characteristics of each factor are evaluated for each production sites of the network. Based on this evaluation production sites with corresponding characteristics are bundled to clusters for the various influencing factors. For example, a digitalization cluster describes a sum of production sites, which have the same IT architecture or the same degree of digitalization. Analogous, further clusters describe the same competencies profile, the same implemented standards, etc. After deriving the different clusters, the intersections of these are to be examined in more detail. The aim is to identify the largest possible overlap between different clusters. In this case, an overlap describes a set of production sites with coherent characteristics for various influencing factors. Accordingly, a large overlap describes a bundle of production sites with similar characteristics for various influencing factors. Due to the same characteristics, this represents a high centralization potential since the different functions can be centralized across the involved production sites (*Asbach/Haselhorst* 2020). Depending on the complexity of the production network, the amount of overlaps can vary. The largest possible overlaps are to be identified and prioritized for further consideration, in order to have the greatest possible positive impact on the economic efficiency via the realizable centralization potential.

3. Initial implementations in a practical workshop

The theoretical framework has been translated into a project approach to gather initial insights and experience with the targeted design of the degree of centralization. The approach describes a five-stage procedure (*Figure 5*).

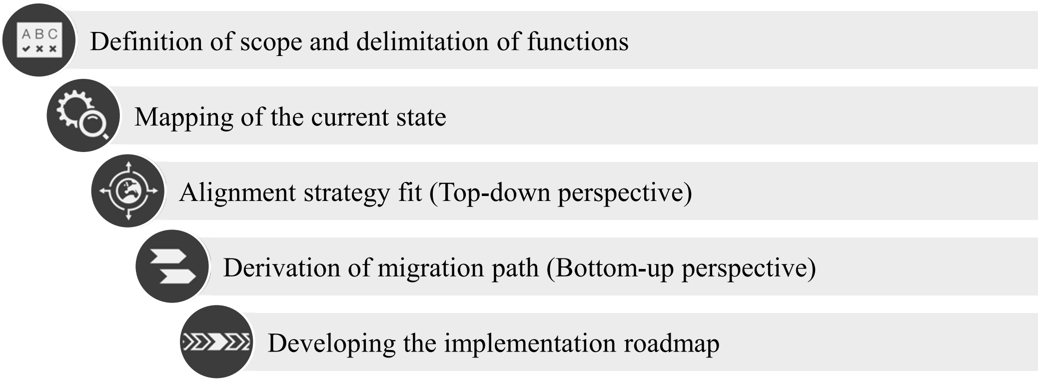


Figure 5: Project procedure for determining the optimal degree of centralization

In the *Definition of scope and delimitation of functions*, the company business unit to be examined is defined together with the project partner. It is defined which indirect functions and associated decisions are to be considered. Finally, this results in a longlist of company-specific functions, which originate from the internal areas as described in section 2.2. Further, existing restrictions have to be recorded for being considered in the assignment of responsibilities. In particular, this includes interdependencies between considered functions as well as restrictions, which affect an unrestricted centralization of functions. In addition, another focus is on the delineation of possible decision-making levels in the network. This can be based on the given organizational structures and the existing network structure.

The following *Mapping of the current state* is divided into three phases to obtain an accurate as possible mapping of the current situation. For this purpose, the mapping of the previously defined functions of consideration are first conducted from the perspective of management (centralized) and then from the perspective of the production sites (decentralized). Afterwards, both perspectives are matched. The independent mapping of both perspectives, guarantees a realistic as possible mapping of the current state. While the management likely describes how the distribution of responsibilities should be, the production sites describe how it is conducted in practice. The two perspectives are compared to identify deviations and make appropriate adjustments to achieve a uniform current state. The "Centralization & Standardization Framework" by *Friedli et al.* (2013) is particularly suitable for this recording, as it is a practical approach.

The next step, *Alignment strategy fit*, derives the desired target state by including the pursued network strategy and the existing network structure. Thereby, the pursued medium- and long-term target state of the production network is also to be considered. This step is analogous to the *Top-down perspective* in the presented framework. While the network structure is usually given, the prioritization of the pursued network strategies is to be prepared and derived workshop based within the project team. Based on these information and the previous defined functions, the aimed degree of centralization is derived. As described in the Top-down perspective, the aim is to find the highest degree of centralization in order to decrease waste. Therefore, the aim is to find the optimal concentration of functions at a certain network level and to evaluate the improvement regarding the different waste categories. The elaborated result is transferred into the standardization-centralization matrix. This mapping presents the target state to be aimed for.

In the *Derivation of migration path*, the current and target state are superimposed to identify necessary adjustments. In addition, analogous to the *Bottom-up perspective*, influencing factors, which might have an impact on the implementation of the desired target state, are identified. Workshop based the factors are identified, analyzed, and corresponding clusters of different production sites formed. Parallel, existing barriers, which have an influence on the aimed degree of centralization, are discussed and how they can be reduced by targeted measures in order to realize larger clusters as well as larger overlaps. The resulting overlaps represent the basis for the future orientation of the network to be implemented. Subsequently, it is necessary to transfer the identified measures and further necessary adjustments into a migration plan to achieve the desired state. Attention must be paid on how the migration steps depend on each other so that they can be proceeded in a logical sequence. Since there can be an extremely large number of migration steps, a cost-benefit analysis is helpful for prioritizing them.

Finally, the identified and prioritized steps are to be transferred into an *Implementation roadmap*. In addition to the implementation schedule, a project organization for the implementation has to be established. Responsibilities and milestones must be defined, as well as cost estimates and criteria for measuring the success of the project.

4. Conclusion and outlook

This paper presents a framework for determining the appropriate degree of centralization, considering the increase in economic efficiency, as well as an initial procedure for testing the design framework in practice. On a qualitative level, first correlations between the degree of centralization and economic efficiency are shown, which must be considered during network management and the distribution of responsibilities. The presented design framework represents a first approach to close the scientific gap of a holistic approach to determine the degree of centralization and the distribution of responsibilities in the network. Therefore, the approach is divided in two perspectives. The top-down perspective derives the centralization potential for defined functions based on the network structure and strategy. Resulting, the optimal concentration of functions is described. The subsequent bottom-up perspective enables an individual transferability of the framework by analyzing different factors and identifying certain clusters in an individual production network and leads to the under current conditions feasible degree of centralization. The spread between both perspectives describes further improvement potentials. Further, a first idea for analyzing the influence of the degree of centralization on the economic efficiency was presented in a qualitatively way. The workshop procedure that emerges from the design framework enables applicability under real conditions and finally leads to the determination of the optimal degree of centralization for a specific production network. The focus of further work is on the detailing the influence of economic efficiency in a quantitative way. Further, the approach has to be validated through appropriate data collection and modeling in order to operationalize the approach.

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Günther Schuh, Prof. Dr.-Ing. Dipl. Wirt.-Ing., is Director of the Chair of Production Engineering at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Address: WZL of RWTH Aachen University, Chair of Production Engineering, Campus-Boulevard 30, DE-52074 Aachen, +49 (0) 241 80–27404, g.schuh@wzl.rwth-aachen.de

Andreas Gützlaff, M.Sc. RWTH, is Chief Engineer of the Production Management department at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Address: WZL of RWTH Aachen University, Chair of Production Engineering,
Campus-Boulevard 30, DE-52074 Aachen, +49 (0) 241 80–27375,
a.guetzlaff@wzl.rwth-aachen.de

Julian Ays, M.Sc. RWTH, M.Sc., is Group Leader of the Global Production group at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Address: WZL of RWTH Aachen University, Chair of Production Engineering, Campus-Boulevard 30, DE-52074 Aachen, +49 (0) 241 80–28344, j.ays@wzl.rwth-aachen.de

Tino X. Schlosser, M.Sc. RWTH, M.Sc., is Research Assistant of the Global Production group at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Address: WZL of RWTH Aachen University, Chair of Production Engineering,
Campus-Boulevard 30, DE-52074 Aachen, +49 (0) 241 80–28367,
t.schlosser@wzl.rwth-aachen.de