A TAXONOMY FOR INTERORGANIZATIONAL PRODUCTION NETWORKS

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Abstract

Manufacturing industries are facing increasing customer demands, dynamic markets, and high cost pressure. Digital innovations increasingly empower the implementation of interorganizational production networks that contribute to achieving goals, such as reducing order risks and maintaining flexibility as well as speed of reaction by utilizing synergy potentials. Additionally, trends like Industry 4.0 or Sharing Economy require innovative, adaptive, and resilient institutional arrangements. The description and design of these networks represent a significant challenge, since production networks in and between many companies have been established over the last decades, in most instances historically grown without being explicitly planned. We aim to develop a classification using a conceptual approach based on a structured literature analysis with an initial focus on interorganizational production networks. Within a hierarchical framework, we first classify types of collaboration between organizations. We analyze the purpose as well as the structure of interorganizational production networks by developing a taxonomy. To exemplary show the successful application, a typology is developed by assigning selected dimensions to the most common types of interorganizational networks. This study's results are a first step towards supporting companies in planning new production networks when evaluating a suitable form of collaboration. Within further research, the taxonomy should be evaluated with real-world scenarios. The robustness of the taxonomy should be tested in a broader range of industries. Based on this taxonomy, it could be examined whether there are similarities in the strategies for adopting specific structural forms to achieve certain purposes. By using the taxonomy, concrete recommendations for action regarding digital innovations to support and enhance production networks, e. g. platforms for sharing manufacturing capacities, can be derived.

Keywords: production networks, interorganizational networks, corporate collaboration, taxonomy

1. INTRODUCTION

The structure of companies was relatively distinct prior to the first industrial revolution. Individual production sites characterized the corporate landscape (Ke & Wu, 2011). Automation followed mechanization and mass production (Liu, 2017). By entering the latest revolution, Industry 4.0, driven by the Internet of Things (IoT), digital services are linked to manufacturing processes and have the potential to reshape collaboration between companies (Hakanen et al., 2017). Cyber-physical systems form the basis for operational excellence and creating a competitive advantage. Therefore, it is essential for companies to further develop organizational structures and processes.

While the organization of individual manufacturing plants consisting of Industry 4.0 components is demanding already, new questions of organization and resource allocation arise concerning more complex production networks (Bender et al., 2019). In recent years, such production networks have emerged within and between manufacturing companies. Designing and operating these networks represents a major management challenge (Schuh et al., 2017). Key questions are how to connect and integrate production entities and how to manage and support the span of control from normal business relationships via different forms of collaboration to corporate structures within networks. For example, Freichel et al. (2019) propose to realize an interorganizational production network by using a digital platform to distribute manufacturing capacities. This approach is also researched by Stein et al. (2019) and Freitag et al. (2015). Connected production processes and planning of collaboration partners could permanently be integrated within networks of enterprises. Such concepts impact stakeholder performance and, therefore, the dynamics of the production network (Freitag et al., 2015). As a basis for developing a comprehensive platform-based approach, an in-depth analysis of dimensions and characteristics of modern production networks becomes evident. Many authors target the description and evaluation of production networks, e.g., regarding configuration or strategy (Friedli et al., 2011), which are often based on the status quo and do not include future concepts (Abele et al., 2007).

This work seeks to address this issue and provides a starting point for future research concerning the design of interorganizational production networks driven by digital innovations. The following research questions guide the present work:

RQ1: *Which dimensions and characteristics can be used to describe production networks?*

RQ2: *How can characteristics be categorized within a taxonomy to distinguish production networks with a specific focus on interorganizational collaboration?*

We structure our study as follows: First, we describe the theoretical basics in the following Section 2. Subsequently, the methodical procedure is addressed in Section 3. The procedure is applied to answer our research question in Sections 4 and 5. A conclusion and future research approaches concludes this work in Section 6.

2. FOUNDATIONS

Value creation networks have been shaping discussions on the corporate organization for a long time. Until today, research has not succeeded in providing an adequate theoretical framework for the conceptual description and explanation of networks. The complexity of the topic as well as the different fields of application (Grandori & Soda, 1995) almost rules out a uniform definition of the term also in the future. In the following, we refer to the definitions according to Sydow (1992). He describes business networks as a form of organization of economic activities aiming to realize competitive advantages. They are characterized by complex-reciprocal, rather cooperative than competitive, and relatively stable relations between legally independent enterprises.

In the context of value creation networks, the term *collaboration* is defined as a contractually regulated voluntary cooperation between legally and economically independent companies to increase their efficiency (Nieschlag et al., 1997). Collaboration can be of varying intensity, duration, and direction. In the context of this study, collaboration is also referred to as interorganizational cooperation.

As most companies are faced with volatile markets and intense competition within a dynamic environment, one way of dealing with these challenges is to create smart *production networks*. Complex production networks have developed within and between production companies over the past decades. How companies or business segments of companies are able to link and interact manufacturing resources within and across organizations are increasingly important success factors (Schuh et al., 2017).

As shown in Figure 1, four types of production networks can be classified according to the number of production sites per organization and the number of organizations in the network. In this context, manufacturing sites are the most basic type as the sole location of an enterprise. As the main objective of this work, interorganizational networks often combine several manufacturing sites, supply chains, or internal networks of different companies as single entities.

Figure 1. Network Types

number of organizations ↑		
	Supply Chain (one site, multiple organizations)	**Interorganizational Network** (mulitple sites, multiple organizations)
	Manufacturing Site (one site, one organization)	**Intraorganizational Network** (mulitple sites, one organization)

number of manufacturing sites per organization →

Source: based on Rudberg & Olhager, 2003

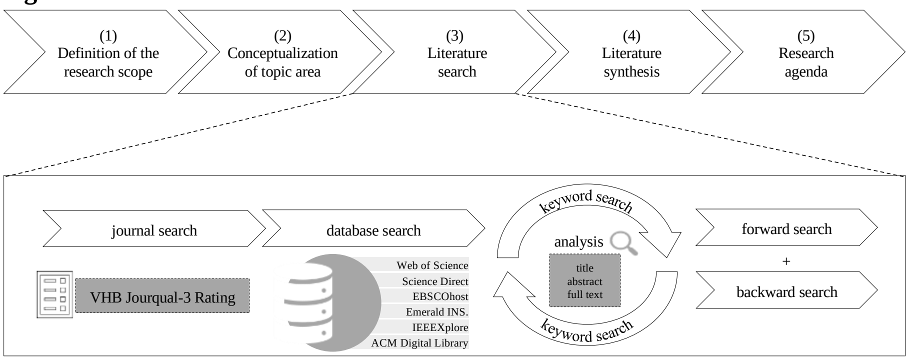
Since this study develops a taxonomy for production networks, the term production and production network are considered in a generous framework. Carvalho & de Campos (1997) consider a production network as the entirety of facilities, suppliers, customers, products, technologies, and distribution methods to supply the final customer. We follow Sturgeon (2002) who complements this and defines production networks as representation of the various inter-company relationships that connect a group of firms into larger business units.

3. METHODOLOGY

We chose two methods for this work which we shortly present in the following: a structured literature analysis as well as taxonomy development including an exemplary typology.

The results of our study are based on the structured *literature research framework* developed by vom Brocke et al. (2009) shown in Figure 2. The procedure model consists of five phases: Definition of the research framework, conceptualization of the topic area, literature research with keyword search, analysis and synthesis of the search results and reflection of the research results, and establishment of a research agenda.

Figure 2. Literature research framework



Source: based on vom Brocke, 2009

To define the scope of the research, we applied the taxonomy according to Cooper (1988) (see Table 1). The chosen characteristics for this study are shown in bold letters. Research outcomes, theories, and applications are the focus, whereas the goal of the research is the integration of the research area of production networks. Besides, a neutral presentation specifies the perspective, and the research area is defined as exhaustive and selective. The results are organized conceptually to answer the research question. The research audience includes experts in the subject areas: Company networks, production networks, and entrepreneurial cooperation. Managers or management consultants, who can be classified as users, are also included in the target group.

Table 1. Defining our Research Scope within the Taxonomy of Literature Reviews

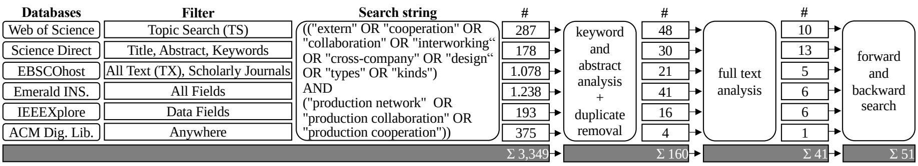
Dimension	Characteristics			
Focus	**Research Outcomes**	Research Methods	**Theories**	**Applications**
Goal	**Integration**	Criticism	Central Issues	
Perspective	**Neutral Representation**	Espousal of Position		
Coverage	Exhaustive	**Exhaustive and Selective**	Representative	Central
Organization	Historical	**Conceptual**	Methodological	
Audience	**Specialized Scholars**	General Scholars	**Practitioners**	General Public

Source: Cooper, 1988

According to vom Brocke et al. (2009), a literature search consists of the phases shown in Figure 2 and Figure 3. To obtain high-quality search results with the desired complete and selective coverage, we used journals and proceedings of renowned conferences (Webster & Watson, 2002). The publication quality was ensured as far as possible by the VHB-Jourqual 3 (VHB, 2021) or by cross-references between the publications. In the literature search, the six databases named in Figure 3 were searched. The search was carried out with two keyword groups connected by an AND link (see Figure 3).

Figure 3 summarizes the numbers of search results during the literature search process. We reviewed a total of 3,349 papers during the literature search process. Based on titles, keywords, and abstracts, 160 were classified as relevant to the defined research question. The number decreased to 41 titles according to the full-text analysis. In the forward and backward search process, ten further relevant works were identified. The search resulted in 51 relevant papers.

Figure 3. Literature Search Process



Source: own illustration

Based on the literature analysis, we developed a *taxonomy* for interorganizational production networks following the definition and methodology of Nickerson et al. (2013), which has been applied in various taxonomy development projects and is therefore accepted in research. A taxonomy generally consists of a structure (hierarchy) based on the technical terms of a subject area (Nickerson et al., 2013). Nickerson et al. (2013) state that a variety of terms, such as classification or categorization, are used interchangeably for this specific type of classification system. Taxonomies are of particular importance in several disciplines because the classification of objects helps researchers and practitioners to understand and analyze complex areas. A taxonomy contains a set of n dimensions, each consisting of at least two mutually exclusive and exhaustive characteristics so that each object considered has only one characteristic for each dimension. According to Nickerson et al. (2013), taxonomies can be developed empirical or conceptual. This work follows a conceptual, deductive approach.

Furthermore, we have adopted the taxonomy to present a *typology* for exemplary characteristics. According to Nickerson et al. (2013) and Bailey (1994), a typology is usually multidimensional and "restricted to a system of conceptually derived groupings" (Nickerson et al., 2013).

4. LITERATURE SYNTHESIS

The 51 relevant articles identified cover a broad and heterogeneous spectrum in collaboration between enterprises within production networks. In the following, we present an overview of the literature obtained and discuss key aspects. For a comprehensive overview of the search results, we implemented a concept map according to Webster & Watson (2002) in Table 2. We added an "x" if the dimension is completely covered, whereby an "o" is added if the article indirectly or partially covers the dimension.

Table 2. Concept Map of Search Results

		Range		Main Focus		Further Perspectives						
No.	Reference	Internal	External	Production Network	Network Management	Collaboration	Global Production Management	Virtual Company	Supply Chain	vertical	horizontal	Production Process
1	Barnes et al., 2012		x	o	o	x						
2	Behnamian & Fatemi Ghomi, 2015		x	x	x						x	
3	Bender et al., 2019	x		x					x			x
4	Carneiro et al., 2013		x		x	x		x				
5	Carvalho & de Campos, 1997		x	x	o	x	o					x
6	Dicken, 1994	x			o	o						
7	Fengru & Guitang, 2019		x	x	x	x	x			x	x	
8	Freitag et al., 2015	x		x					o			o
9	Grandori & Soda, 1995		x		x	x				x	x	
10	Grossman & Rossi-Hansberg, 2008	x					o					x
11	Gualdi & Mandel, 2019		x	x								
12	Hochdörffer et al., 2018	x		x	x	x						x
13	Huang et al., 2008	x		x	x	x			x			
14	Karlsson & Sköld, 2007	x		x	x		x			x	x	x
15	Ke & Wu, 2011		x	x		x				x		
16	Kogut, 1988		x	o								
17	Kuhn, 2006		x	o	x							
18	Lanza et al., 2019		x	x	x		x					
19	Leng et al., 2017		x	o	x				o			
20	Leng & Jiang, 2018		x	x	o	x						o
21	Maropoulos et al., 2006		x	x	o							
22	Matt & Rauch, 2012		x	x		x						
23	Matt & Rauch, 2013	x	o	o	o		o					
24	Meier et al., 2006		x	x	x	x						
25	Mladineo et al., 2018	x	o	x		x		x				
26	Monauni, 2014		x	x	x		o					
27	Mourtzis et al., 2012	x		x	o							o
28	Mugurusi & de Boer, 2013			x			x					
29	Ngniatedema et al., 2015	x		x					x	x		x
30	Nigro et al., 2003		x	x	x			x	x			x
31	Nowak, 2017		x	x	x	x						
32	Olhager & Feldmann, 2018		x	x	o							x
33	Peng & Zong, 2009		x	x	x	x						
34	Pfohl & Buse, 2000		x	x	x	x		x	x			
35	Poocharoen & Ting, 2015		x		x	x						
36	Redlich et al., 2014		x	x	x	x						
37	Rudberg & Olhager, 2003		x	x	x				x	x		
38	Rupp & Ristic, 2004	x		x			o		x	o	o	
39	Saniuk et al., 2014		x	x	x			x				
40	Saunders et al., 2004		x		o	x		x	x			
41	Schuh et al., 2013		x	x	x							
42	Schuh et al, 2017		x	x			x					
43	Schuh et al., 2018		x	x	x							
44	Sturgeon, 2002		x	x					o	o	o	
45	Sun et al., 2020	x		x					x		x	x
46	Teich et al., 2001	x		x	x	o		o				x
47	Todeva & Knoke, 2005	o	x		x	x						
48	Tuma, 1998		x	x	x	x		x				x
49	Veza et al., 2015		x	x	x			x		x	x	
50	Wiendahl et al., 1998		x	x	x	o		x	x			
51	Wu & Shou, 2010		x	x	x	x	x					

Source: own illustration

Only six articles were published prior to the year 2000. In the meantime, the topic had lost importance in the literature. Up to and including the publications from 2014, only two relevant contributions were found on average per year. However, these reports indicate a changing view on production networks. From 2015 onward, we observed a significant increase in papers of relevance.

The earlier papers covered topics such as just-in-time production (Carvalho & de Campos, 1997), which was a current research approach at that time. Some authors, however, were already broadening their perspective and predicted a high relevance of cross-company production networks for the future (Teich et al., 2001; Grandori & Soda, 1995). The characteristics and possibilities of virtual companies were also discussed (Tuma, 1998). However, new results in connection with production networks were mostly lacking. One reason for this is the lack of clarity regarding the terms used, making it difficult to get a comprehensive overview of previous literature and prepare further studies based on it. For example, Hochdörffer et al. (2018) defines production networks as the internal production facilities of a production company. This view, however, contradicts almost all other sources included in this work. The contributions published up to 2015 were characterized by the use of specific design algorithms or mathematical calculations to optimize production networks (Nigro et al., 2003; Maropoulos et al., 2006; Huang et al., 2008; Peng & Zong, 2009; Ngniatedema et al., 2015).

To conclude the synthesis of the literature, we consider cyber-physical systems, where products and machines act independently within their environment, while the smart factory encompasses this vision by mainly self-organizing manufacturing plants and logistics systems (Bender et al., 2019; Mladineo et al., 2018; Sun et al., 2020; Freitag et al., 2015; Veza et al., 2015). This form of production represents the future and is gaining importance but has not yet reached the real production environment. Hence it will not be included in this work.

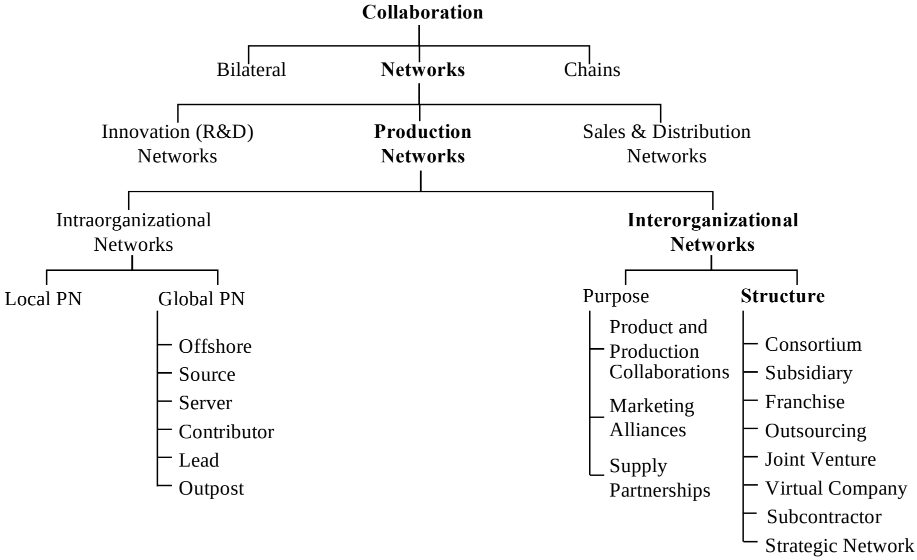
5. A TAXONOMY FOR INTERORGANIZATIONAL PRODUCTION NETWORKS

In this section, we will first conduct a hierarchical classification of collaboration types, followed by a taxonomy for interorganizational production networks and a typology for selected dimensions to exemplary show applicability.

5.1. Hierarchical Classification

For a precise categorization, hierarchical levels above the production network are also included, starting with types of collaboration between organizations. We summarized the classification in Figure 4 and highlighted the types focused on this work using bold letters. We but did not go into further detail regarding the analysis of the alternative types as this would exceed the scope of this work' s objective.

Figure 4. Hierarchical Classification of Collaboration Types and Interorganizational Networks



Source: own illustration

Corporate collaboration is located at the highest level of the hierarchy. Collaboration can be subdivided into three types according to the number of partners. First, collaborations may occur in the form of supply chains. In this case, supply chains can be seen merely as a chain, in which a company maintains relations only with one upstream supplier or downstream customer (Pfohl & Buse, 2000; Rudberg & Olhager, 2003). Second, bilateral agreements allow collaboration between two companies. Those two types of collaboration will not be considered in the following. The third form of corporate collaboration consists of networks that have three or more different links.

Within our framework, we classified networks into three types: Innovation networks in research and development, distribution networks, and production networks. Different characteristic attributes can be assigned to production networks. The geographical dimension ranges from local to regional or national to international collaboration (Wegehaupt, 2004). Alternatively, a distinction could be made between global and local production networks. Thereby local networks also include collaborations distributed both regionally and nationally (Wu & Shou, 2010). Capacities and competencies can be assumed to be complementary, redundant, or complementary-redundant in their characteristics (Wegehaupt, 2004).

The hierarchy level below the production networks differentiates between intra- and interorganizational networks. Intraorganizational production networks are increasingly differentiated according to their geographical dimension. The decisive factor in this regard is the distribution of manufacturing sites. These can be located within national, regional, or local boundaries. Technological improvements in the transportation business enable faster and more cost-effective distribution of products

(Grossman & Rossi-Hansberg, 2008), which in turn allows companies to expand internationally (Lanza et al., 2019). Consequently, more global production networks are being established over time, as companies seek to exploit the advantages outlined by Ferdows (1997). The author identifies cost savings, including direct and indirect costs, capital costs, and taxes, as key benefits. Besides, logistics costs could be reduced significantly for some companies. Advantages also include the potential for further learning from local suppliers, customers, or competitors. Better customer service, development of alternative supply sources, and worldwide recruitment of talent are mentioned in this context. In order to fully exploit the advantages mentioned above, Ferdows (1997) identifies six types of international factories distinguished by their level of competence and strategic reason (location advantage): Offshore, source, server, contributor, lead, outpost. We will not explain these intraorganizational production networks in detail, and instead focus on interorganizational networking as the main subject of this work.

Interorganizational production networks can be classified according to their purpose and structure. The purpose a company wants to achieve through collaborating, is the decisive factor for creating networks. Todeva & Knoke (2005) point out that, even though the choice of collaboration forms is determined to a certain extent by the partners' resources, the main focus lies on the purpose for which the collaboration is necessary. After the purpose of a network has been defined in the planning/development stage, managers consider which structure is best suited to fulfill it. It is essential to determine whether the chosen structure makes collaboration operationally feasible. Companies form production networks for a variety of reasons: To increase their production capacities or achieve economies of scale, to reduce uncertainties in their internal structures and external environment, to gain competitive advantages that enable them to increase their profits, or to realize future business opportunities that guarantee higher market values for their products. Furthermore, restructuring or performance improvement, as well as cost-sharing or risk reduction, are intentions to cooperate (Todeva & Knoke, 2005). Partners choose a particular form of collaboration to achieve greater control, higher operational flexibility, and realization of market potential. The strategic intentions for organizations to participate in alliance formation vary depending on company-specific characteristics and the various environmental factors.

The different purposes lead to area-specific implementation possibilities, where three main activity areas emerge. In addition to product and production collaborations, marketing alliances and supply partnerships, as well as possible sub-categories, are distinguished. The motivation for including forms of collaboration is based on their economic importance relating to these forms (Barnes et al., 2012; Contractor & Lorange, 1988). Given the complexity of modern companies, it is likely that there is an inherent overlap between these categories; for example, joint marketing activities do not necessarily imply a marketing alliance. In the case of a joint venture established for the production of goods in partnership, the marketing activity is only a secondary purpose. Since the categorization cannot take into account all the many and varied permutations that occur in reality, it should be considered as a tool to draw attention to the primary purpose of the collaboration.

The main purpose should determine the choice of an appropriate collaborative structure (Barnes et al., 2012). In this study, only two ways of product and production collaboration will be examined in detail. A comprehensive list is provided by Barnes et al. (2012). *Parallel production* involves an agreement to produce the same or similar products in manufacturing sites in two or more locations. In this type of collaboration, one partner usually takes the lead in the development of production equipment and brings the new product to the market first. *Joint production* describes collaboration between two or more companies to produce separate elements of a complete product. Partners produce intermediate products in support of one of the partners, which carries out a following step in the production process. All partners share risks and benefits resulting from the partnership (Barnes et al., 2012).

5.2. Taxonomy

Interorganizational production networks can be differentiated according to their structure, wherefore the literature offers different classification possibilities. Sydow (2010) provides characteristics linked with a morphology of enterprise associations as well as the extension according to Wegehaupt (2004). In the following, we outline the structure of interorganizational production networks, which we summarized in the form of a taxonomy with categories (bold) and dimensions as well as characteristics in Table 3. We will subsequently classify the most distinctive forms of collaboration in academic and business environments by using selected typographical characteristics. Based on the most common interpretations, we will then compare and evaluate these characteristics.

Table 3. Taxonomy of Interorganizational Production Networks

Categories & Dimensions	**Characteristics**		
Configuration			
Number of network participants	simple (3)	complex (4-6)	highly complex (>6)
Type of origin	planned	emergent	
Decision structure	central (monocentric)	integrated	decentral (polycentric)
Decision range	=1 stakeholder	>1 stakeholders	
Decision direction	horizontal	vertical	diagonal (lateral)
Control			
Control type	hierarchical (focal)	heterarchical (polycentric)	
Control location	internally managed	externally managed	
Management structure	explicitly guided	implicitly unguided	
Intensity			
Formality	informal (agreement)	formal, no capital participation	formal, capital participation
Stability	stable	dynamic	
Legal binding force	voluntary	mandatory	
Binding alternatives	open	closed	
Binding hierarchy	primary	secondary	
Binding period	solely project-related	scheduled	unlimited

Source: own illustration

First of all, production networks can be categorized according to the category *configuration*. The area within the life cycle of a product has to be defined. According to the definition of production networks in this paper, we separate procurement, production, and assembly/installation. The configuration of production networks can also be differentiated according to the number of network participants. With three participants, they are considered simple, with four to six partners they are defined as complex, and with more than six participants they are considered highly complex (Sydow, 2010). Another dimension is the way production networks are established: the type of origin. In some cases, they are conceptually designed or planned, but in other cases, there is no continuous and integrated planning of the production network, although decisions concerning the design of production networks have long-term effects on manufacturing companies (Schuh et al., 2017). The category configuration, furthermore, includes the dimension decision structure, which evaluates the degree of centrality (Poocharoen & Ting, 2015). Configuration authorities can be distributed between the partners of the network on the one hand and the cooperation, on the other hand, either centralized (monocentric) or decentralized (polycentric). Olhager and Feldmann (2018) elaborate a third form in their study, which is called "integrated" and is positioned between centrality and decentrality. Subordinate to the structure is the range of decision-making, which indicates the scope of influence of the coordinating functions. This delimits the direct effect on one or more participants in a network. The decision direction completes this dimension. A distinction is made between horizontal, vertical, and diagonal (lateral) connections of production networks. Horizontal connections include partners of the same value-added stage, while vertical connections are to be located at different, successive production stages (Karlsson & Sköld, 2007). On the other hand, diagonal production networks are characterized by cross-sectoral links and usually vary in the value-added steps.

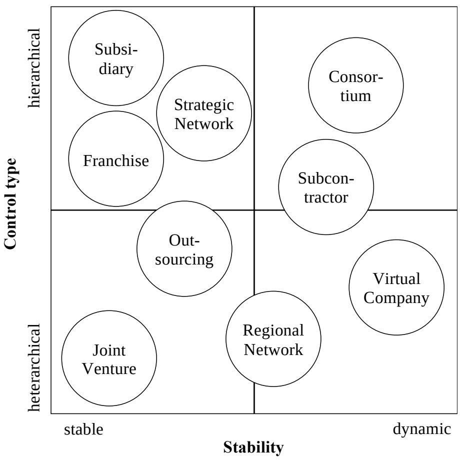
A further category is *control*, which can be differentiated according to type and location. Considering formal orientation, the control type can be hierarchical (focal) and justify an asymmetrical distribution of control possibilities (Karlsson & Sköld, 2007). Here, one company (the focal company) dominates the other partners. In contrast, we see heterarchical (polycentric) production networks in which all partners have similar control possibilities (Meier et al., 2006). If the type of control is considered according to location, internal and external controlled networks are separated. The latter form can be performed by third parties or network management organizations. In addition, management and thus, control are classified according to the management structure, divided into two fundamentally different paradigms. Explicitly guided production networks integrate an institutional coordinating instance into the collaborative system. Implicitly unguided coordination is based on self-organization with a limited range of decision-making effects. Alternatively, control can be subdivided into strategic and regional. Perspectives of other authors differ here, and should, therefore, be accompanied by a context check.

The *intensity* of a production network forms another category to define the degree of autonomy or freedom of decision. In this context, the term *formality of a network* is partly used. Collaborations can be entered into by verbal agreements (informal) or contracts (formal). The agreements made should be implemented by the partners regardless of their form (Nowak, 2017). Equity investments create a particularly intensive commitment. The temporal stability of bonds in network relationships can be regarded as stable or dynamic. The legal binding force can foster stability. In some countries, individual companies are forced by the government to cooperate under certain boundary conditions, which in turn reduces productivity, since decisions on cooperation should be made consciously (Nowak, 2017). In most cases, however, the contrary can be observed, and cooperation is based on voluntary action. The intensity of commitment can be influenced not only for a network but also for individual companies within a network by the possibility of entering or exiting. In this context, binding alternatives are referred to, which promote the dynamics of open networks (Leng & Jiang, 2018). If a company is located in several networks, primary and secondary networks can be differentiated. This hierarchy of bonds is particularly crucial in focal companies. The duration of the collaboration in production networks can also be used to determine the type. The duration/period of the cooperation or the temporality of the existence can be exclusively project-related or subject to time limits. If no temporal or otherwise defined goal is set, the cooperation is considered to be of unlimited duration.

5.3. Typology

Using the developed taxonomy shown in Table 3, production networks can be classified in detail. To exemplary show the successful application, we developed a typology by assigning selected dimensions to the most common types of interorganizational networks, which we already introduced in Figure 4. The following Figure 5 compares these types of cooperation in a four-field matrix based on the two dimensions stability and control type.

Figure 5. Typology of Interorganizational Network Forms by Selected Dimensions



Source: own illustration

Consortia are used to manage temporary and contract-based projects; thus, they are also called project networks. The partners' collaboration is temporary, but the relationships usually remain latent after the end of the project. Consortia are, therefore, mostly not completely dynamic. Project networks are formally handled without capital participation and are predominantly managed by a focal company (Sydow, 2010). If the projects require it, consortia are open production networks.

Subsidiaries are founded by the parent company, which controls the subsidiaries since it is the main shareholder or even the sole shareholder. The parent company uses formal systems to control the subsidiaries, whereby the form of control is hierarchical. Accordingly, a subsidiary is a new company with its management board, formally founded with capital participation. Consequently, the network of parent company and subsidiaries is generally very stable and only open to participation by other market participants to a limited extent (Dicken, 1994; Todeva & Knoke, 2005).

Franchise is a cooperation between a franchiser and several franchisees who are organized as independent companies. The distribution of goods or services is realized under a uniform brand identity through extensive formal contractual regulations. Clear framework conditions ensure the stability and permanence of the network. The franchisees are hierarchically subordinated to the focal companies but can offer additional product concepts of their own depending on the contract. Several franchisees usually develop these in regional cooperation. A heterarchical form of control can be observed (Matt & Rauch, 2013; Matt & Rauch, 2012; Todeva & Knoke, 2005).

Outsourcing describes the permanent transfer of non-core competences of a company to external parties. The modular production networks described are mostly based on outsourcing strategies of large companies (Peng & Zong, 2009). Outsourcing involves a long-term, unlimited relationship and is therefore temporarily stable. Outsourcing partners tend to be on an equal level, so no hierarchical instruments are formally available to the outsourcing company. Nevertheless, the mutual dependency implies a certain degree of influence by the outsourcing company. Generally, this type of production network is open (Mugurusi & de Boer, 2013; Leng et al., 2017).

Joint Venture is a legal organization established by two or more companies with equal capital participation and joint management. Due to the joint equity participation, the management form is heterarchical. As a registered organization, a joint venture is closed concerning the bonding alternatives and represents an unlimited type of collaboration, which makes the company extremely stable (Kogut, 1988; Barnes et al., 2012).

Virtual Companies or virtual production networks are a particular form of collaboration. For a given order, the network only includes companies required, hence the virtual company is classified as dynamic. The network is primarily organized in a heterarchical way, in which each company has to fulfill an individual task based on respective core competencies (Tuma, 1998; Wiendahl et al., 1998; Leimeister et al., 2001; Saniuk et al., 2014; Behnamian & Fatemi Ghomi, 2015).

Subcontractors are companies providing partial or complete services covered by a contract between a leading company and its customer. Passing orders to a subcontractor depends on the market, so the stability can be assumed to be dynamic and hierarchical.

Strategic Networks are operated by a key company, mainly a supplier of finished products and therefore organized hierarchical (Wiendahl et al., 1998). Most of the other partners are contractually linked to the key company, but also offer their services to other customers outside the network to remain competitive. These networks are mostly opened, but very stable due to the internal secret knowledge (Rupp & Ristic, 2004).

Regional Networks, on the other hand, are based on a special conglomerate of highly specialized small and medium-sized enterprises. These enterprises usually have latent links to a large number of other companies in the region and therefore organized heterarchical. If necessary, the companies are activated by involving different partners, depending on the current demand situation. Exemplary advantages can be greater flexibility and lower management costs (Wiendahl et al., 1998).

6. CONCLUSION

Production networks in and between many companies have been established over the last decades, in some instances historically grown without being explicitly planned. Well-established companies have been forced to adapt over time. Accordingly, trends like Industry 4.0, the Internet of Things or Sharing Economy require innovative, adaptive, and resilient institutional arrangements. The classification of interorganizational production networks as the primary objective developed in this study can help to improve understanding and further development regarding technical support of production networks. A taxonomy helps to classify production networks and to restructure or optimize them according to the purpose. When joining together the two perspectives of structure and purpose, it reflects the complex reality of actual partnerships. Furthermore, this study's results are a first step towards supporting companies in planning new production networks when evaluating a suitable form of collaboration.

To answer the research questions, we developed a comprehensive overview of production networks and collaboration according to the following steps. For data collection, a structured literature search and analysis (1) was carried out, whereby 51 relevant contributions were examined. A comprehensive overview of characteristics for describing interorganizational production networks could not be found. Based on this, a hierarchical classification framework (2) for the classification of production networks could be created. Besides structural aspects, the purpose of establishing interorganizational production networks was addressed. Therefore, companies could reconcile their purpose with the cooperation structures. Subsequently, a taxonomy (3) was created specifically for interorganizational production networks with the categories *configuration*, *control* and *intensity* as well as a number of dimensions and corresponding characteristics.

Using a typology (4), it was possible to classify different real-life cooperation structures concerning their productive function. The typology has been equipped with a precisely selected set of forms of collaboration based on the selected typological dimensions *control type* and *stability*.

We suggest the following starting points for future research: First, an extension of the literature search should be carried out with a revised keyword search using the classification and taxonomy identified. Additionally, the taxonomy should be evaluated with real-world scenarios. The robustness of the taxonomy should be tested in a broader range of industries. Based on this taxonomy, it could be examined whether there are similarities in the strategies for adopting specific structural forms to achieve certain purposes. Furthermore, the temporal development of relationships between collaboration partners should be examined for predictable patterns in the structural forms adopted at each development stage. By using the taxonomy, concrete recommendations for action regarding digital innovations to support and enhance production networks, e.g. platforms for sharing manufacturing capacities, can be derived.

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