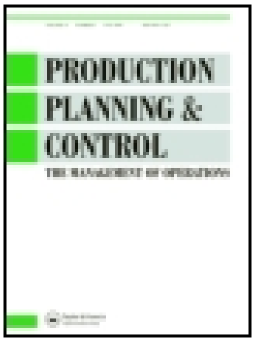

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Network-based factory planning for small and medium-sized enterprises

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ABSTRACT

Many industrial sectors are currently being challenged with regard to the flexibility and adaptability of their production and control processes, which can, inter alia, be attributed to macroeconomic trends such as digitisation. These trends not only shorten product lifecycles but also lead to a greater need for redesign and transformation of production systems within factories. Since this field of *factory planning* tends to play a subordinate role in SMEs anyway, the above-mentioned factors impede an efficient execution of corresponding projects even more. While large companies are more likely to have a factory planning department, SMEs often do not have sufficient resources to meet the aforementioned challenges through independent factory planning projects. Although network-based structures could be a realistic and practical way to meet the challenges of factory planning as they generally provide possibilities for resource and risk sharing, SMEs often manifest resentments towards network collaborations. This paper aims to validate these resentments. For this purpose, a profound expert study explores whether network cooperations could overcome companies' challenges. It derives implications towards a model that enables network cooperations in factory planning.

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1. Introduction

Network cooperations are frequently implemented in the business landscape to exploit resource synergies, share knowledge inter-organisationally and increase the capability to innovate. These features could be beneficial to planning fields that are characterised by an interdisciplinary nature and a lack of individual expertise. Factory planning with its multiple planning disciplines is one of those fields.

Hence, the present paper sets its research focus to the area of factory planning. Since factory planning is a research field mainly pursued in Germany, the elements *factory* and *planning* constituting this research area may be described in further detail. Planning can be described as a systematic information-processing procedure for the target-oriented solution of a specific task and generally refers to the development of a plan. The goal is to define an optimal way, derived from a comparison of alternatives, which leads to the achievement of jointly defined objectives within a decided time frame and in a binding manner (Hayes-Roth and Hayes-Roth 1979, 275–276; Mumford, Schultz, and Osburn 2015).

This definition already shows that planning processes are always subject to certain conditions. Thus, there is no set of predefined planning processes that can be applied to whatever problem that may arise. They are rather to be understood as certain tools and measures whose use must vary depending on circumstance and field of application (Christensen 1985). In order to transfer this to the special form of factory planning, some basic facts about this planning field must be explained beforehand.

The term *factory* originates from the Latin word 'fabrica' and can be translated as workroom. This understanding has not changed fundamentally in modern times: The Association of German Engineers (VDI) defines the factory as a place where value is added by the division of labour in the production of industrial goods under the use of production factors (VDI 2011). The composition of the two words factory and planning to the composition of the term *factory planning* thus describes the future-oriented design, layout and determination process for an industrial production site as well as its transformation of production factors into end products. This understanding is also shared by the Association of German Engineers (VDI). It describes factory planning as a systematic and target-oriented approach that is structured into phases covering the entire value stream from the determination of objectives until the ramp-up of production.

Following this definition, factory planning plays a crucial role in the competitiveness and success of companies.

Though, factory planning projects have an interdisciplinary and complex nature (Kampker et al. 2015). Many different fields of expertise are required and to be coordinated during the planning and realisation phases of a factory (Hawer et al.

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2017; Kampker et al. 2013; Schuh, Kampker, and Wesch-Potente 2011). Furthermore, required shortening of the realisation time of factories triggers the need for parallelisation of planning tasks (Kampker et al. 2013; Schuh, Kampker, and Wesch-Potente 2011). This leads to the fact that factory planning is becoming a major challenge for producing companies. At the same time, companies underlie multiple change factors. Shortening of product lifecycles, dynamism of markets, cost pressure and digitisation are only a few challenges to face (Ackermann et al. 2013; Jeon and Kim 2016). Besides these external impulses, the management imposes internal requirements such as operational efficiency and adaptability of production systems to new product variants (Schuh, Kampker, and Wesch-Potente 2011). In a consequence, these change factors lead to increasing demand for factory planning projects within various industries (Hawer et al. 2017; Kampker et al. 2015; Schuh, Kampker, and Wesch-Potente 2011).

The outlined complexity and interdisciplinarity of factory planning projects, as well as internal and external change factors, especially challenge small and medium-sized enterprises (SME) due to their inherent organisational structure (Aguilar et al. 1997; Burggräf, Krunke, and Voet 2015; Kampker et al. 2015). Factory planning projects in SMEs do not follow a strategic process but are more often initiated by the owner (Burggräf, Krunke, and Voet 2015). Also, a lack of resources as well as a limited division of labour and separation of functions lead to factory planning being characterised as a special task that is undertaken by persons without expert knowledge (Lelah et al. 2012). In fact, most of the small and medium-sized companies do not have an organisational department for factory planning compared to bigger companies (Burggräf, Krunke, and Voet 2015). This goes along with the fact that SMEs do not follow a standardised factory planning procedure but rather a pragmatic, unstructured approach (Burggräf, Krunke, and Voet 2015; Levy and Powell 2005).

Yet, SMEs are of great importance for the German economy: 99.6% (3.6 million) of all private companies have ranked among small and medium-sized enterprises and the corresponding 16 million employees have generated 55% of the entire net value-added of German companies (IfM Bonn 2017). Throughout the EU, SMEs also mark an important role with a share of 99% of all businesses and 36% of the entire net value-added in 2017 (European Commission 2018).

Hence, an innovative conceptual approach is needed that enables these companies to develop expertise in the field of factory planning and to increase planning outputs and efficiency in realised projects.

Observing other fields than factory planning, the aforementioned challenges are often faced through value-adding networks. Risk spread, joint competencies and resources as well as planning synergies in networks indicate that network-based structures could be a solution approach for SMEs' factory planning (Antonelli et al. 2015; Lelah et al. 2012). In other areas than factory planning, the cooperation potentials in networks are utilised already: in the automotive industry, for instance, it can be observed that companies cooperate in heterarchic value-adding networks successfully for the production of electric mobility components (Kampker, Burggräf, and Nee 2014; Kampker et al. 2015). According to Villa and Antonelli, SMEs aggregate in order to promote flexibility and productivity through a division of labour. This is seen to be reasonable given the highly specialised and yet scarce resources of SMEs. (Villa and Antonelli 2009, 3–5) Koporcic and Törnroos emphasise that especially in strategy-related activities – which factory planning most certainly is – SMEs should not isolate from each other but act together and create joint activities to gain value as a network. To that end, SMEs in a network should consider a reasonable balance of mutual investments into the network and avoid lock-in situations through learning and idea sharing inside the network (Koporcic and Törnroos 2020, 27). While this argumentation appears to be promising, it remains questionable whether network effects constitute a realistic and practical possibility in order to face the current challenges in factory planning projects. Hence, the following research question shall be raised:

Is the structure of a network capable of empowering SMEs to plan their factories jointly with other SMEs and yet independently and in a self-determined way? Each research process begins with the definition of the research problem (Kothari 2009, 10–12). Since little research has been done in the above-outlined field of factory planning with regard to network-based structures and since no existing database can be referred to yet, the main goal of the presented paper is to dissect the underlying SME-related problems and to achieve new insights into challenges of this type of companies in the field of factory planning. Further, the value of network-based structures in the context of factory planning shall be explored. For this purpose, a qualitative, explorative approach in terms of an expert study was chosen that is described in more detail in the following sections. To this extent, a brief case study of an industrial knowledge network in the context of factory planning as one exemplary network type is presented in the last section, giving implications for future research based on the findings of this paper.

This specific network deals with the SMEs' lack of individual expertise by sharing knowledge in factory planning related matters. This is done by inter-organisationally developing joint planning methods and standards from which all network members can benefit.

To this end, the following objectives for the study at hand can be formulated:

1. Explore the challenges and obstacles of companies in the field of factory planning, especially with regard to SMEs.
2. Explore and outline the value of network-based structures in the context of factory planning for SMEs.

The structure of the paper follows the research process according to Kothari (Kothari 2009, 10–12). Section 1 introduced the underlying research field and outlined the research problem based on literature review and observations from industry projects of the Laboratory of Machine

Tools and Production Engineering of RWTH Aachen University. In conclusion, the research question for the presented expert study as well as its specific objectives were stated.

Section 2 thereupon describes the applied research methods along with a critical review of methods in the field of qualitative research. The primary part of this paper consists of the conducted expert study, the design of which is described in detail throughout the following sections. The study consisted of a preceding questionnaire for the preparation of in-depth interviews with experts in the field of factory planning and, moreover, of the interviews itself.

The study's hypotheses as well as its results are presented in Section 3. Herein, the aforementioned challenges are validated together with representatives of both SME and the research field factory planning. In addition, specific conditions mentioned by the experts with regard to a network's design are stated as well.

The findings are summarised in Section 4, accompanied by an outlook for further research. Here, a brief industry case study is described that shows how –based on the results of this paper – a possible network in factory planning could be designed and which collaborative tasks are therein pursued.

2. Research method

The above-mentioned research question has been formulated based on literature review and explicit observations from industry projects of the Laboratory of Machine Tools and Production Engineering of RWTH Aachen University. This has given rise to assumptions regarding the underlying causes of the problem as well as to first approaches for solution hypotheses.

With regard to the research process according to Kothari (2009), it can be seen that the research proposal at hand finds itself in an early stage (Kothari 2009, 10–12). Therefore, the unconfirmed assumptions described in the above have to be validated in a first step. For that purpose, questionnaires are used (which is further discussed below). However, this alone would still be too limited a gain of knowledge as this research field combining factory planning, SMEs and network structures has so far been scarcely researched (see Section 1). The authors hence intend to employ an explorative, open approach to further dissect the problem and explore fundamental requirements for a solution concept. In the end, this approach enables the creation of new hypotheses and theories.

In explorative studies, qualitative data collection methods are commonly applied as they allow an open perspective on the subject matter (Kothari 2009, 95–97). The qualitative data collection methods have evolved from the area of humanities and focus primarily on hermeneutics, i.e. they systematically interpret text material (e.g. observation protocols and interview transcripts). Typically, the corresponding research process is deliberately unstructured or less structured, enabling unexpected findings to be made. Moreover, one usually concentrates on a very detailed and comprehensive analysis of a few cases that are investigated (Kothari 2009, 95–97). Within a qualitative research approach, it can be chosen from a variety of methods, each of which has its own benefits and area of application.

In general, three popular data collection types can be differentiated: questionnaires, individual interviews and focus group interviews. Questionnaires are used very frequently for the purpose of data acquisition. A great database can be generated in a short period of time and respondents are very flexible regarding the timing of conducting the study and are not influenced by the interviewer. Unlike an interview, it is not possible to dig deeper into specific content and ask detailed, complex follow-up questions. Due to the anonymous and impersonal nature of a questionnaire, one gains little impressions of the participant itself and whether the questionnaire was taken seriously (Kothari 2009, 97–99). Individual and focus group interviews are widely used to collect information first hand. They offer a more detailed approach as they cover more specific questions that are not suitable for questionnaires. On the downside, they require a greater level of workload since interviews must be transcribed, organised and analysed. As group interviews tend to repress opinions expressed by rather restrained participants and do not provide a deep understanding of each individual's opinion and experience they are not taken into consideration (Kothari 2009, 97–99; Williamson 2018, 395–396). Additionally, focus group interviews do not cover as much depth as individual interviews since the majority of participants are not able to present their ideas in a highly detailed way (Williamson 2018, 395–396). In this particular case, it would have been impossible to meet up with all experts as they tend to have very busy schedules and are located in various regions. During in-depth interviews, however, interviewers are able to ask follow-up questions and can focus on topics that are more detailed as well as pursue questions with a high level of complexity (Kothari 2009, 97–99).

In this particular case, no extensive database can be accessed and data must be collected first hand. For this purpose, in-depth interviews with experts from the designated field were conducted. In order to validate initial assumptions – based on literature and observation in practice – and for preparation of the interviews, a questionnaire was designed and sent out to the selected experts for the study.

The initial validation through the questionnaire laid the foundation for the expert interviews. By querying the assumptions in advance, it was possible to obtain an initial assessment of the reliability of the assumptions through the experts. Furthermore, the preparation of the in-depth interviews could be done individually for each interview, based on the answers from the questionnaire.

The questionnaire contained the predefined answer options: 'correct,' 'incorrect,' 'not assessable'. This triple scale was chosen in order to limit the effort of the respondents and to obtain as pointed and unambiguous answers as possible.

The content and the development of the questionnaire's questions, or rather hypotheses, that were derived from literature and observation from practice will be explained in detail in section 3.

Interviews, especially one-on-one in-depth interviews, demand a comparably high amount of time for the execution of the study. Well-trained or at least non-biased interviewers and interviewees have to be matched in order for the study to be rigour. However, an interview enables an individual reaction of the interviewer to every answer of the interviewee and therefore ensures an explorative character by spontaneously digging deeper into certain statements. Based on the above, the method of (expert) interviews was chosen as an adequate qualitative data collection method.

Although expert interviews have an open character, they need to follow a certain structure. For this reason, a specific interview approach has been introduced, which is shown in Figure 1. The in-depth interviews were conducted orally. The next characteristic, 'standardisation', describes the degree of a predefined structure regarding content, order and response options of questions. For instance, a highly standardised study is characterised by a strict order of questions with fixed response options. This, in fact, does not meet the requirements of a qualitative interview as the interviewer loses any flexibility to react to the interviewee's statements. A non-standardised interview, however, has no guidelines other than the field of topic (Kothari 2009, 97–99). The study at hand is hence to be classified as partly standardised since the abovementioned assumptions regarding the problematic nature of the research topic at least formed a guideline for the interviews but still left a lot of room for the interviewer to deviate in a particular direction. Another distinction of the approach can be made through the degree of the author's authority claim. Whereas the soft interview is based on a psychotherapeutic approach, the hard interview is characterised by aggressive and continuously challenging connotation. The study in this paper follows the neutral way by granting both interlocutors equal rights. (Bortz and Döring 2016, 365–368)

Furthermore, according to Figure 1, the nature of a study can be determined by the number of interviewers and interviewees. The interviews for this article were performed with 8 experts from the areas of factory planning, SMEs and network structures. Due to the interviewees' expertise from different areas, group interviews were omitted and one-on-one-interviews were conducted instead.

Depending on the particular research interest, the status of an expert should be considered relational and with regard to the determined problem. As a generally applicable definition, it can be stated that an expert has privileged access to relevant expertise, decision processes or groups of people (Meuser and Nagel 2009). In the context of the present paper, the status of an expert refers therefore to skills and competencies in the research field of factory and network planning as well as the interaction with small and medium-sized enterprises.

A total of eight data sets were obtained during the expert interviews. For reasons of anonymity, the results of the individual surveys are not published but rather presented as a whole in Section 3. The geographical origin of the experts can be limited to Germany. The experts covered, inter alia, the automotive industry, the public research sector and the branch of machine construction. The interviews took place in person or by telephone in August 2017 and each interview lasted approximately one hour.

3. Expert study

The following section describes the expert study underlying hypotheses followed by the study results. As stated in the introduction, factory planning projects become more and more a crucial challenge for companies due to its interdisciplinary and complex nature, many different fields of expertise that need to be coordinated as well as the need for parallelisation of planning tasks. Hypotheses based on literature review and explicit observations in industry projects by the authors shall be derived in the following and set the basis for the conducted study.

Rationale of the expert study

Figure 2 shows a selection of factors that drive the discrepancy between status quo and transformed requirements that need to be met by the factory, respectively its planning (Ackermann et al. 2013; Hawer et al. 2017; Schenk, Wirth, and Müller 2010; Wiendahl, Reichardt, and Nyhuis 2015). These change factors can be divided in internal and external impulses. The external drivers comprise dimensions, which affect the company from the outside, such as social, political and ecological influences. In contrast, the term 'internal impulse' describes areas like company strategy or operational measures.

The presented factors influence the research field *factory planning* and corresponding projects entirely and therefore have an impact on change drivers of lower levels. The internationalisation of production networks consequently results in a higher dynamic of markets. Thus, the available time for reacting to changes decreases and product lifecycles are shortened (Burggräf, Krunke, and Voet 2015; Hawer et al. 2017; Kampker et al. 2015). Moreover, companies have to cope with the antagonistic challenge of meeting demands of high quality and of simultaneously responding to high cost pressure. In this context, companies increasingly orientate their product and production strategy towards their customers and hence individualise the products on a scalable basis. Furthermore, industrial revolution, through digitisation and connectivity, is leading to communication between machinery and equipment by means of the internet of things. Regarding the related technological edge in Europe, a trend of relocation can be observed causing high factory planning demand as well. In order to measure up to the above-mentioned challenges, changeability as a response to internal or external triggers as well as operational efficiency should be improved. It is evident that changes within the periphery of factory planning are appearing more frequently which results in continuously changing requirements (Agyapong-Kodua, Haraszkó, and Németh 2014; Kampker et al. 2015).

These dynamics also lead to the fact that information required for the planning projects need to be refined throughout the planning process itself. This particular

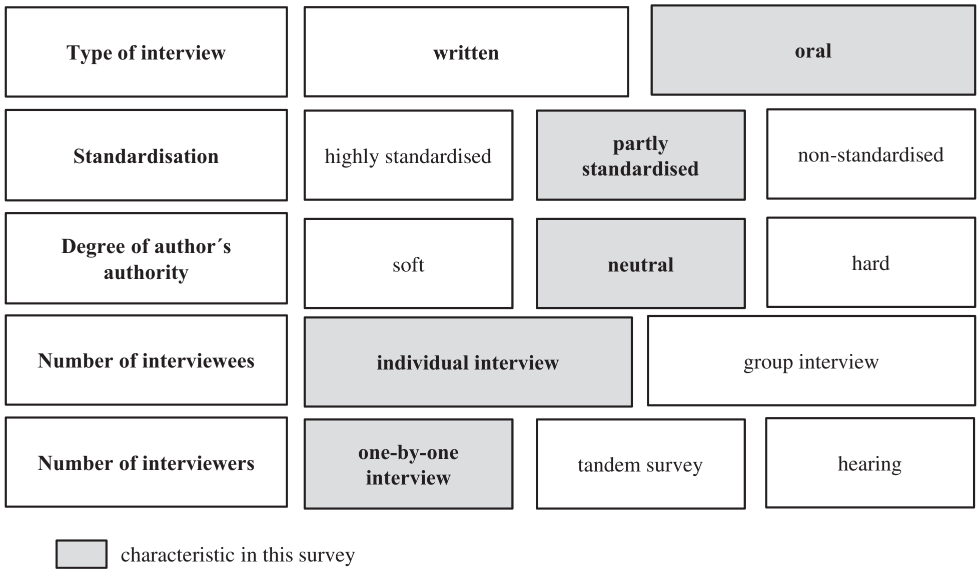

Figure 1. Interview approach (Bortz and Döring 2016, 360–363)

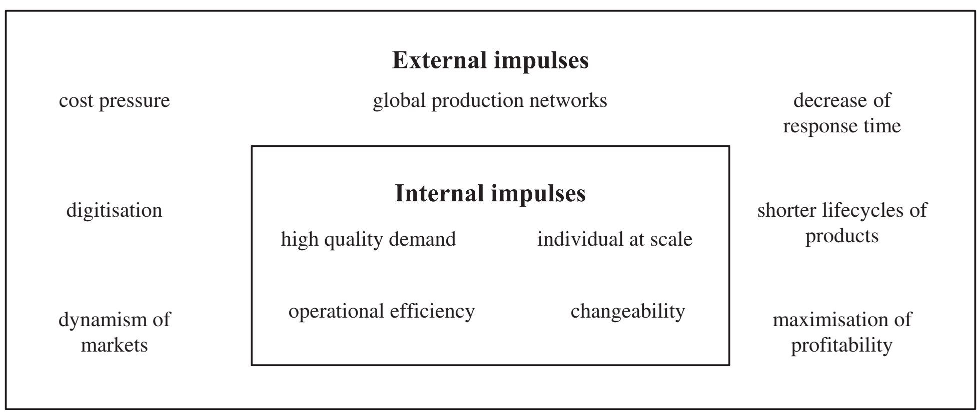

Figure 2. Change factors for factory planning

development had posed a dilemma for the classic way of factory planning: A classic approach divides the planning process into temporally consecutive phases at an early stage of the project and insinuates immutability of the predefined planning target. Due to changing requirements, however, factory planning is subject to high interdependencies, strong dynamism with regard to planning activities and planning targets as well as to not fully predictable subjectiveness of the involved parties (Schuh et al., 2011). From the aforementioned challenges and change factors influencing the performance and efficiency in factory planning projects, the first hypothesis can be derived:

H1: High complexity and strong dynamism in the market and technology environment of companies lead to a more frequent need for factory planning and higher factory planning costs.

Compared to major companies, SMEs show a lower degree of product and service diversification (Agyapong-Kodua, Haraszkó, and Németh 2014; Stevenson 2009). Particularly due to highly specialised expertise, this leads to a significant competitive advantage but simultaneously yields a not negligible business risk on account of strong dependencies on certain suppliers and customers. Moreover, against the background of owner-manager-identity, business success and failure do often depend directly on the company's owner and his or her entrepreneurial skills (Lelah et al. 2012; Levy and Powell 2005). Low throughput capacity and relatively higher business risk frequently result in weak bargaining positions on financial and supplier markets (Lanninger 2009; Levy and Powell 2005). Hence, the following hypothesis can be formulated:

H2: SMEs have a weaker bargaining position on procurement and capital markets compared to larger competitors.

The organisation of small and medium-sized enterprises is often characterised by limited division of labour and separation of functions (Antonelli et al. 2015). This low organisational depth leads to activities being defined rather person-related than value-focused. In consequence, one person might take over several tasks for which he or she does not possess the necessary expertise and know-how (Levy and Powell 2005; Stevenson 2009). Due to the described limited resources and person-oriented task allocation, factory planning is perceived as a rather special task that is undertaken by, for instance, production managers or production planners. In fact, in only 30% of all cases, factory planning ranks among the main tasks of the persons responsible (Hennersdorf 2011).

Following these SME-specific characteristics, the hypotheses three and four can be defined:

H3: SMEs do not possess specific factory planning know-how.

H4: Factory planning tasks in SMEs are not carried out by internal specialists, but by management as a secondary task in addition to their day-to-day business.

SMEs often do not show a standardised factory planning procedure but rather follow a pragmatic, unstructured approach that is generally based on intuition and experience as those companies have limited resources, little factory planning expertise and a low frequency of factory planning projects (Burggräf, Krunke, and Voet 2015; Nöcker 2012; Schuh et al., 2011). Regarding this, Hennersdorf (2011) points out that 59% of all German SME have been at the same location for over 30 years. Conflating these characteristics, it can be noted that factory planning itself is usually not represented by an established and efficient process within SMEs. This fact becomes even reinforced against the described background of higher parallelism and interdisciplinary nature as well as increasing absolute demand for planning processes. Especially the lack of resources and planning-specific expertise leads to factory planning projects becoming a core challenge for SMEs (Lelah et al. 2012). Hence, the following hypothesis can be derived:

H5: Factory planning tends to be an extraordinary challenge for SMEs that cannot be compensated by their organisational structures.

It has been frequently observed that by bundling expertise, the collaboration of several small and medium-sized companies can result in product innovations (Antonelli et al. 2015; Wurche 1994). This concentration of expertise, however, is not necessarily limited to product development but might also cover the enhancement of production and therefore of factory planning. As a consequence, the following hypothesis can be derived:

H6: In networks, SMEs can benefit from learning effects through knowledge exchange.

Value-adding networks are commonly created for the sake of risk spread and amalgamation of competencies and resources (Antonelli et al. 2015; Sydow 2010, 237–238). In fact, the above-mentioned learning effects could even be facilitated further through cooperative provision and utilisation of mutual resources. In this context, the assertion is made that such a synergy could also relate to planning resources (Lelah et al. 2012). As these processes become harmonised, transaction costs drop, especially with regard to information gathering, control costs, and adaption costs (Sydow 2010, 237–238). Therefore, the following hypothesis can be derived:

H7: In networks, SMEs can benefit from planning synergies through joint planning.

The best-known form of networks are sourcing networks. The merger of several SMEs increases the total volume purchased by suppliers. Along with a joint market presence, a network-based approach can yield more optimal bargaining positions and therefore more adequate procurement costs (Jarimo and Kulmala 2008; Lelah et al. 2012; Wurche 1994). Hence, the following hypothesis can be derived:

H8: In networks, SMEs can benefit from economies of scale through joint purchasing.

SMEs often own specialised expertise. On this account, employees of SMEs usually act within a framework of strong obligation to secrecy. Especially in the context of network cooperation, this way of competitiveness restrains required collaborative working environments (Antonelli et al. 2015; Käfer 2016; Lelah et al. 2012). The underlying distrust regarding other companies also results in a significant portion of resources being allocated to the minimisation of business risk instead of expediting a network's cooperation processes. Moreover, SMEs seem to see networks as a limitation of their entrepreneurial flexibility leading to them not being able to potentially defend themselves appropriately against a potential rival (Gausdal, Svare, and Möllering 2016; Wurche 1994). Along with that, they tend to fear the endangerment of their traditional independence when being bound by the network's activities (Käfer 2016; Gausdal, Svare, and Möllering 2016). The previously described strong need for secrecy leads to SMEs hesitating to run the risk of losing their expertise to a competitor who might be able to implement their knowledge immediately (BDU_Studie 2014; Jarimo and Kulmala 2008). Lastly, SMEs appear to see a high effort associated with the integration of network processes into their own enterprise. Therefore, they often claim that their resources would not be sufficient for selecting and evaluating the performance and risk potential of prospective cooperation partners (BDU_Studie 2014; Gausdal, Svare, and Möllering 2016). Based on these considerations, the following hypothesis can be derived:

H9: SMEs are resentful towards networks due to the restriction of their entrepreneurial independence, strong distrust, higher perceived entrepreneurial risk or strong coordination effort.

Results of the expert study

The following will describe the results that have been gained from the conducted expert study. The interviewees have been asked whether recent changes within the market and technology environment would lead to higher factory planning demand and effort *(H1)*. All respondents fully agreed with this statement. Relating thereto, all interviewees confirmed that SME often have weak bargaining positions on both procurement and capital market and do not possess expertise in terms of factory planning leading to factory planning projects being conducted in an unstructured and inefficient way *(H2, H3)*.

In the further course of the questionnaire, the hypothesis was proposed that planning tasks are hardly ever executed by internal specialists but rather pooled in one person like, for instance, management. As the challenge of factory planning can allegedly not be met by the SMEs' organisational structures, the aforementioned person carries out factory planning tasks as a secondary duty in addition to his or her day-to-day business *(H4, H5)*. These hypotheses have been confirmed by all SME-representatives. However, representatives of the research field *factory planning* stressed the limitation of this hypothesis to management alone.

The survey also resulted in a positive response regarding planning synergies, procurement synergies and learning effects induced by network processes and collaboration *(H6, H7, H8)*. As an additional factor of the research problem, especially SME-representatives emphasised their restraint towards network collaborations as these were apprehensive of jeopardising their independence and exposure to high entrepreneurial risk and coordination effort *(H9)*. The existence of the postulated research problem has hence been validated.

The second part of the expert study comprised individual, personal conversations with the intention to create and discuss first solution approaches and to consider additional requirements for the further course of the research project. The underlying framework of these interviews has already been described in the previous section. The following therefore focuses on the study's key findings.

A major insight from these interviews is the explicit need for a collaboration model that clearly defines which benefits and which specific services are offered to the potential network members. This is seen as crucial by the experts since resentments of SMEs towards networks pose a significant hurdle to the successful creation and operation of an SME network. Consequently, from the perspective of an SME, not the revenue structure of a potential network operator but a clear benefit promise should be the first structural aspect to be designed in the network.

However, the idea of a central coordinator has been perceived as highly beneficial by the interviewees since the effort of coordinating the network is estimated as a major obstacle for SMEs when initiating network collaboration. In this context, the discussion with the experts led to two essential design elements to be considered for the network creation: Firstly, a 'member model' that sets clear rules and requirements for companies to be allowed to join the network; secondly, a culture-related model that lays down basic principles of collaboration and shared values by which the individual SME has to abide within the network. These elements were seen as highly relevant in terms of preventing both internal network conflicts and potential resentments that SME show towards networks. In light of this, it was emphasised by the interviewees that a sensible balance is needed between contractual safety and social control based on the above-described common values and behavioural fundamentals in order to establish and maintain a trusting cooperation atmosphere.

Figure 3 visually summarises the results of the expert study: numerous SMEs set up a network that is coordinated by one central coordinator. For the purpose of a specific factory planning task, certain SMEs collaborate and act jointly as a consortium towards other entities like financial institutes or suppliers. The coordinator is both responsible for the inclusion of new companies to the network and for organising the collaboration among different SMEs. To this end, the coordinator maintains rules and regulations that have to be

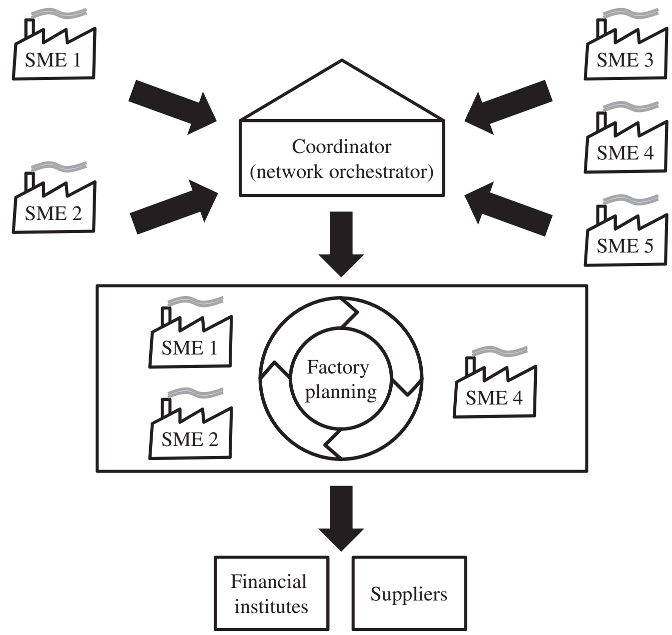

Figure 3. Solution model.

created in agreement with the network-SMEs. Moreover, the coordinator should relieve the companies of all support processes within the network, such as the organisation of meetings, preparation of protocols or providing necessary infrastructure for collaboration. In order to response in particular to the lack of factory planning expertise highlighted in the expert study, the coordinator should either himself be an adequate expert or at least have access to experts from the factory planning community.

4. Summary and outlook

Factory planning is a highly interdisciplinary task that has a long-term impact on a company's future value creation. Due to resource bottlenecks and gaps in expertise, however, especially SMEs are not in a position to deal intensively with this topic although it is crucial for their future business development. Leveraging resources and pooling knowledge, in turn, are properties that are often attributed to the benefits of network structures. The authors of the present paper hence raised the question whether a network structure could be a solution approach to the described challenges of SMEs.

In order to follow a systematic and transparent research process, the above-described problem was described and delimited from other areas. To this end, an explorative approach had been chosen by conducting an expert study with the means of a hypothesis-based questionnaire and subsequent in-depth interviews. This procedure enabled the authors to not only validate the hypotheses underpinning the research problem but also to gather first requirements for a potential solution to the problem. Figure 3 thereupon summarised the main outcomes of this expert study. The central structural element is a network coordinator taking over all support processes in order for the SMEs to concentrate on purely value-adding processes. The coordinator should be able to equip the network with factory planning knowledge and, moreover, set common rules of network collaboration and admission to membership.

The following will describe a brief industry case study conducted by the authors. The goal of this case study was to make the proposed network approach more tangible and, simultaneously, to validate the approach. For this purpose, a permanent working group of factory planning at WZL of RWTH Aachen University was chosen as the research object. Its members can therefore be considerated as network participants. This working group consists of 16 members of 10 different companies from different industries (automotive OEM, automotive supplier, consumer goods, pharmaceutical, life science and print). The general objective is to exchange knowledge, experiences, and best practices in the context of factory planning. For this purpose, the working group meets several times a year for two days at different production facilities of the members. This working group can therefore be characterised as an inter-organisational knowledge network. It is coordinated centrally by the WZL of RWTH Aachen University which functions as the network's orchestrator. Each member company faces certain challenges in factory-related projects. Most companies, especially SMEs, do not have an organisationally established factory planning department. Planning tasks are therefore often taken over by project managers as a secondary task in addition to their day-to-day business. This leads to a lack of expertise in factory planning activities. To tackle these challenges, joint planning methods and standards are developed within this network by sharing knowledge and best practices among the network members and bringing in external expertise from the university field as well as external experts. This way, the know-how in the companies can be improved, and ultimately enables them to pursue factory planning projects autonomously, more successfully, and efficiently. Observing the working group over a period of three meetings showed the great potential of this network type in building expertise, especially for SMEs. During this time a toolbox for logistics planning methods in production was developed and standard procedures for planning logistical value streams and scaling storage space in a factory were derived. It showed that the hypotheses 3–7 from the expert study (see Section 3) could be validated within this inter-organisational network. Nevertheless, it could also be observed that not all participants shared their experiences and knowledge very openly, but were resentful from time to time. Certain well-known resentments from network management literature and industry practice could be observed, such as network members fearing to loose sensitive knowledge and therefore not willing to give detailed insights into project experiences. Therefore, further research needs to be done on resentments that appear in network collaboration – especially in the context of factory planning – since they prevent the network to share know-how openly and to grow expertise.

As a next step within the research process, the authors intend to carry out an empirical study to validate the current research problem, which has been specified in the present paper, with a specific focus on resentments within network collaboration in factory planning. An explorative approach shall provide insights into empirically validated implications regarding the solution approach of network-based factory planning.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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