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Critical Conditions For Factory Ramp-Up Planning In SMEs

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Abstract

Companies experiencing rapid sales growth need to ramp-up operations and production facilities to meet the increased customer demand. Exporting small and medium sized companies (SMEs) offering new technology in new markets often have to deal with high uncertainty and risk and the ramp up plan needs to be continuously adjusted to changing sales forecasts. Factory planning is a complex task, and includes a wide range of critical decisions. The literature is mainly dominated by research seeking to develop theoretical models and methods for planning support. There is limited empirical research addressing issues related to the actual planning process. Existing methods are mainly developed based on general theoretical terms without taking specific conditions into account. Further research is therefore needed to better adapt current models and methods to specific contexts. This study seeks to bring further understanding of critical conditions for the planning process, by exploring the conditions of the planning process in a real-life context of an SME. The findings are expected to contribute to improved insights to the factory ramp-up planning process in SMEs and better understanding of critical factors that need to be considered.

Keywords

Planning context; Factory planning; SME; Production ramp-up; Case study

1. Introduction

Factory planning is a critical process for companies experiencing sales growth and increasing production volumes. Due to dynamic world market conditions, manufacturing companies that participate in global trade often face challenges when making decisions related to factory expansion and production ramp-up. Factory planning may be a complex task, especially for fast growing small and medium sized enterprises (SMEs), which often have limited financial resources and competence. This is because factory planning often involves a wide range of critical decisions, where multiple factors need to be considered making the decision process complex [1]. Market uncertainty, related to the timing and rate of sales growth for instance, may add to the complexity of the planning situation.

A significant amount of models and frameworks providing decision support in factory planning are available in existing literature, see literature reviews by [2], [3] and [4]. Structured and systematic approaches are proposed as well as sophisticated methods that are adjusted to specific decisions, e.g. investment in capacity expansion [5]. The factory planning literature is mainly dominated by research seeking to develop theoretical models and methods for planning support. There is limited research addressing issues related to the planning process and empirical studies. Further research is therefore needed to better adapt current models and methods to specific contexts [1]. Also, researchers especially call for further case study investigations in a variety of situations for a better understanding of application of models in industry [5].

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The importance of context for the factory planning process and adoption of planning methods and models is widely recognized in current literature. For example, Glock and Grosse [3] emphasize the need to take specific characteristics of ramp up situations into consideration, including factors such as interruptions, uncertainty, defects, learning and demand growth. Traditional factory planning approaches are further criticized for providing limited support in terms of process adaptability and flexibility, which is required to handle changes during planning projects, nor consider specific requirements of factory planning projects [6]. More dynamic approaches such as condition based factory planning (CBFP) are developed to meet the need for more flexible and adaptable planning processes [7]. Factory planning in an SME context is considered to be especially challenging, since these companies do not typically follow a standardised factory planning procedure but rather a pragmatic, unstructured approach [8].

Even though the importance of context and external conditions are recognized in previous research, studies addressing factory planning issues rarely take contextual factors into account. Therefore, this study seeks to bring further understanding of critical conditions of factory planning, by highlighting detailed insights from a real-life SME context.

2. Methodology

The study is based on an explorative case study research design with one case company [9]. The manufacturing company develops and produces technological equipment with one specific industry sector as the main target, and with a wide range of additional application opportunities in other industry segments. Machines primarily serve a global market and are exported to customers all over the world. The company has about 130 employees and it represents a typical Norwegian SME in several ways. Yet, the high part of export sales combined with large degree of market uncertainty, due to the novelty of their machine combined with a wide range of possibilities in various markets and segments, constitutes a specific feature of this company. The company's planning situation is characterized by high uncertainty regarding the developments of markets and sales volumes, rapidly changing conditions, and high financial risk. Investments in new technology development over the past ten years combined with an increased focus on sustainability and reducing greenhouse gas emissions in the main target sector, have led to a rapidly increasing demand. This has implied a need to plan for increased production volumes in the factory.

The study is part of two research projects where the company collaborates with an external research institute. The research addresses major issues related to the development of production activities and the factory in view of the specific export growth situation of the company. A team with external researchers and company representatives have held workshops and meetings to discuss issues and solutions related to the company's production and factory planning.

A literature search is carried out to identify relevant previous works within factory planning and production ramp-up planning. Rather than providing a comprehensive and in-depth literature review on the topic, this literature search seeks to provide a brief overview of relevant works. The search approach is based on the guidelines by Thomé et al. [10]. Literature is identified through searches in Google Scholar and Scopus, using relevant keywords including "factory planning", "ramp-up planning", "SME", "planning process", "conditions", "factors", and so on. The relevance of identified papers was determined based on their abstracts. The literature search also included forward and backward searches.

Since previous research of factory planning has mainly been concentrated on providing systematic and structured models and approaches, and studies investigating the planning process and critical conditions are lacking, an explorative approach is adopted in this study. It means that empirical data from the case company are used to add a rich and detailed picture of critical conditions.

3. Theoretical background

A challenge of factory planning is to design production systems that, on one hand, last for decades but, on the other hand, are adaptable to changing requirements of the dynamic market environment [7]. Also, important questions for process, resources and layout design can often not be answered systematically due to uncertain information and changes in requirements. Since factories have to be designed to adapt to changing, situation specific requirements, factory planning needs to combine the initial factory design and continuous reorganisation of the production system [7].

A factory planning reference model has been developed by Hawer et al. [1] based upon a set of planning tasks. Typical tasks include defining the manufacturing program and manufacturing system structuring, selection and determining quantity of manufacturing equipment, determining space requirements (rough and detailed), material flow analysis (between blocks and detailed), building and facility design, rough planning of block layout, technology planning, ideal and real layout planning (detailed). Each planning task together with input and output data constitutes a module. The reference model aims to give general guidance and a starting point to gain awareness about how the planning tasks in a project depend on each other and should be adapted to each company's specific settings in order to be applied by users.

Facility layout planning, which is considered one of the most important design decisions, involves the process of physically arranging all the production factors that make up the production system [2]. The layout planning problem encompasses two process related criteria; the planning approach and phase [2]. Layout planning approaches can be defined as either static or dynamic depending on the variability of the material flow intensity during the planning horizon. Also, layout planning phases include the layout as a whole (block layout) which represents the phase when departments are arranged in buildings by considering if one relevant objective is met, while in the detailed layout phase elements making up the production system in the physical space inside each department are arranged.

Schuh et al [7] criticise traditional sequential planning approaches for failing to support factory planning projects in practice as they overlook the interactions and dynamics in the planning project as well as the stakeholder subjectivity. In addition, unconsidered interactions, conflicting motives and inflexible project structure lead to time-consuming, expensive and late adaptations. Insufficient synchronisation and coordination may also imply local optimisation and deviations from the overall objectives. In order to deal with these issues, the authors [7] propose the condition based factory planning. This is a modular, parallel approach that can be reconfigured according to the specific conditions of the planning project and company.

4. Empirical findings

This chapter presents critical conditions of the factory planning process that are identified in the case company. An overview of conditions is shown in Table 1, followed by a further description of conditions.

Table 1: Overview of case findings

Condition	Description based on examples from the case company
Market information reliability	Limited reliability of available market information and expected demand growth rate
	Uncertainty in sales and growth forecasts
Interdependencies between planning tasks	Several tasks related to for example production capacity, product variety and factory construction, depend upon other running planning tasks
	Multiple tasks are carried out in parallel, rather than in a sequential order
Access to necessary resources and expertise	Limited availability of dedicated resources with specific factory planning expertise
	Team of employees from various functions representing a mix of skills and competences
	Involvement of the management team and external researchers
	Gain strong and wide support in the organization

Balance of multiple objectives	Decisions are based on combined objectives, influenced by changing conditions and uncertainties related to e.g. markets, customer behaviour and product development
	Iterative approach where solution options are developed and evaluated by several iterations
	Alignment of rough overall plans with more detailed ones
Definition of project structure	Frequent changes of external conditions
	Continuous development process to find the best alternative
	Handling multiple updates of assumptions, forecasts, and plans
Knowledge and data on current production	Decisions on capacity expansion need to be taken based on uncertain production process information
	Uncertainty regarding lead times and quality in current processes
	Limited availability to detailed production process data and limited application of quantitative models and methods in planning
Decision-making culture	Ability of management and employees to deal with uncertainty and risk in markets and technology development
	Decisions based on limited information and rough analyses
Ramp-up in line with sales growth	Step-by-step approach to match stepwise production capacity expansion with anticipated sales growth
	Phase in of new technology while running normal production
	Significant investments in new technology may imply excess capacity
Planning of new investments	Decisions on major investments in new production technology and in infrastructure based on highly uncertain market information and demand forecasts
	Prioritizing investments that contribute to capacity expansion
	Investments combined with performance improvements
	Balancing short-term planning and long-term commitment of new investments

The company has identified significant market opportunities, both across multiple market locations, with worldwide customers and sales activities, and multiple industries e.g. agriculture and waste sectors. Due to its limited resources to provide detailed analyses and insights into market opportunities, the **reliability of market information** is considered to be low. Uncertainty in growth scenarios and sales forecasts is a specifically critical condition, that affects the entire planning process.

The company's factory planning process involves several **interdependent planning tasks** that run simultaneously, including for instance determining space requirements, material flow analysis, physical building and facility design, rough planning of block layout, technology planning, and so on. The planning process mainly concerns up-scaling existing capacities in the factory and extending the existing building, in parallel with running operations. Also, the ramp-up on a short-term involves the production of the same machines that are produced in the factory today, while on a longer term the product range may be extended. A dynamic planning approach, facilitating multiple tasks, is needed to ensure alignment of plans for future production capacity, product variety and the development of production facilities.

Due to limited resources, the company has difficulties in allocating **specific internal planning resources and expertise** to ramp-up planning tasks. A dedicated multidisciplinary team with employees representing various relevant skills and competences related to manufacturing and assembly processes, testing, inventory and logistics, production development and technology, and so on, is defined to carry out planning tasks in a joint manner. For the company, it is important that the process has broad support in the organization, involving employees representing multiple functions and facilitate a democratic process taking several perspectives into consideration and support solutions and decisions. The management team of the company is also involved in discussions and decision-making together with the planning team. A team of researchers have been involved, providing support to the factory planning team by adopting a systematic approach and evaluating relevant options.

The planning tasks seek to find optimal solutions where several **planning objectives are balanced**. The planning situation is influenced by uncertainty and frequent changes related to product development, customer behaviour, markets and so on. Thus, planning involves several iterations of developing and evaluating possible solutions. Also, tasks involve the alignment of overall rough plans and detailed planning, as well as adjustment of plans to changing conditions.

The factory planning project is mainly structured as an integrated continuous development process, involving a wide range of relevant considerations. The planning tasks are coordinated in the planning team and evolves in line with changing conditions. Tasks are not defined or planned in a typical **project structure** with a project plan including activities and a timeline with milestones, and so on. The chosen approach allows flexibility and continuous adjustments, taking into consideration frequent changes in underlying assumptions such as sales forecasts and production volumes, due to major uncertainty and frequently changing conditions.

With limited **knowledge of production process performance**, such as lead time and quality performance, the company is forced to make planning decisions based on incomplete information on their own operations. Detailed data on operational performance is also limited. Qualitative planning methods are thus primarily applied, while quantitative methods are used only to a limited extent to support the company's planning process.

The new machines that the company has developed constitute a radical innovation. This implies that the market introduction of the machines is related to major uncertainty. With an environment characterized with high uncertainty related to market adoption and technology development, the organization has developed a flexible **decision-making culture**. This means that in decision-making, employees are used deal with uncertainty and risk, adapting to changing conditions and make decisions based upon imperfect information and rough analyses.

The factory planning process in the company encompasses major investments in facilities and infrastructure, as well as in specific manufacturing technology and equipment and material handling systems, to ensure necessary capacity expansion. It is important for the company that the capacity **ramp-up plan is in line with sales forecasts**. The necessary capacity expansion is thus planned to be carried out in steps, where investment plans and production capacity plans are frequently aligned with up-to-date sales forecasts. When replacing old equipment, expansion plans consider the introduction of new equipment without disruptions in operations. To ensure sufficient long-term capacity, the company also needs to plan investments that may imply excess capacity on short-term.

Decisions regarding major investments in new production technology and in infrastructure need to be taken based on highly uncertain market information and demand forecasts. With limited funding, the company plans to make several major investments e.g. in the factory building and in manufacturing technology and equipment. The **planning of new investments** constitutes an essential part of the company's factory planning process, where priority is given to investments that directly contribute to capacity expansion. An example is the expansion of the existing factory building to include new offices for the administration. The investment in new offices has lower priority than the investment in the new production hall that is expected to contribute to increase capacity in final assembly, testing and shipping. In order to ensure financial pay-off of investments in production facilities and buildings, which are not expected to have a direct effect on performance, the company also seeks to combine new investments in capacity expansion with improvements in operations. Overall, the company meets challenges related to that the long-term commitment of several investments in necessary production facilities and technologies leads to reduced planning flexibility on a short term. Therefore, the company seeks to ensure high flexibility also in their long-term investments. An example is the construction of a new factory building, which constitutes a major investment. The building is constructed so that it can be easily adapted to various types of operations, as space needs may change in the future, with changing locations of departments and functions.

5. Discussion and conclusion

This study highlights a set of critical conditions for factory ramp-up planning in an SME setting. Findings suggest that companies have various needs of decision support in terms of systematic methods and advanced tools. This supports previous research emphasizing the need for condition-based approaches. In terms of applicability of sophisticated decision support, SMEs typically have limited resources. While SMEs may experience high complexity in their factory planning processes, a typical challenge among SMEs is related to limited access to data and quantitative facts that are important input in decision-making. The applicability of existing advanced models and methods available in literature in SMEs may thus be questioned. There are major opportunities to enable data driven decision support and promote further advancement of current planning methods by utilizing digital technologies, such as sensors, RFID and Internet of things.

The study contributes with detailed empirical insights into critical conditions for the planning process, emphasising the importance of contextual settings. Being based upon one single case of an SME with a high degree of export to multiple market segments with major uncertainty, findings are expected to be particularly relevant for exporting SMEs, targeting multiple markets. However, since the single case in several ways represent a typical SME, findings are also expected to be relevant for SMEs in more general terms.

Suggested further research includes studies addressing how the planning context influences the adoption of tools and methods as decision support in factory planning. The conditions identified in this study can serve as a starting point investigating empirical contexts and planning processes in real life settings, comparing various contexts, by adopting a multiple case study approach. The findings may also be valuable for practitioners in manufacturing SMEs, e.g. production managers, that aim to further understand and develop their factory ramp-up planning processes.

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Biography

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