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PRODUCT DEVELOPMENT PROCESSES IN SMALL AND MIDDLE-SIZED ENTERPRISES – IDENTIFICATION AND ELIMINATION OF INEFFICIENCY CAUSED BY PRODUCT VARIETY

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ABSTRACT
As SMEs face a limitation of their resources, it is crucial to monitor the strategy of product variety management and the interplay of project work and day-to-day business. Competiveness of small and middle-sized enterprises (SME) correlates with recognizing customer needs and being able to efficiently react to it. This paper aims to achieve the former by identifying and eliminating inefficiencies in product development processes. Thus, a procedure is introduced to reduce development effort by successfully handling the necessary product variety. Further goals are to avoid sources of inefficiency – to improve the interplay between development process and everyday work – and to gain consciousness about how the processes are lived within the enterprise and how product variety impacts on the day-to-day-business.

Keywords: SMEs, product variety, development process improvement, Lean Development

1 INTRODUCTION
Competiveness of small and middle-sized enterprises (SMEs) is due to recognizing customer needs and being able to efficiently react to it, as SMEs face a limitation of their resources. The customer orientation primarily drives product variety growth. Other causes may be a lack of documentation of existing product variants or the growth of a company. A multitude of strategies to manage product variety exist, which affect the overall product development process in different ways. This includes not only the performance of the development process of a single product, but also the ability to react to change orders. Thus product variety affects – aside from product design – the day-to-day business, often bringing along a multi-project environment. It is crucial to monitor the strategies of product variety management – chosen by SMEs – and the interplay of project work and day-to-day business.

This paper focuses on the identification and elimination of inefficiency in product development processes of SMEs. Starting with an analysis to identify the symptoms of inefficiency, the sources or drivers of these symptoms are found. Finally, measures to eliminate these drivers are suggested. The analysis of inefficiency focuses on the day-to-day business in SMEs, with the project work competing with the demands of daily business. The identified sources of inefficiency are characterized by their dependency to the prevalent strategy of product variety management. Based on that the latter is monitored and methods to adapt and to improve the product development process are suggested.
The described tasks are captured within a procedure proposed in this paper. The intended effect of the application of the procedure for identifying and eliminating inefficiency caused by product variety in SMEs is on the one hand the reduction of development effort by successfully handling the necessary product variety. On the other hand avoiding the sources of inefficiency improves the interplay between development process and everyday work. Additionally, consciousness arises about how the processes are lived within the enterprise and how product variety impacts on the day-to-day-business.
The following research questions from the basis for the design of the procedure:

1. How do single product variants evolve in and how is product variety handled within a SME?
2. What is the impact of the strategy of product variety management on the development processes in a SME? (especially regarding day-to-day-business and a multi-project environment)
3. How can inefficiencies be identified in product development processes of a SME?

4. Is the management of product variety feasible?
5. How can the sources of inefficiency be eliminated?
6. How can the development process be improved?
7. How can an optimal interplay between project work and day-to-day business be achieved?

The following section presents related work, while section 3 covers the authors' current research project which forms the basis for the procedure proposed in section 4. The paper ends with a discussion of the procedure and an outlook on future research.

2 RELATED WORK

2.1 Small and Middle-sized Enterprises

Several authors name an abundance of advantages of SMEs. An important aspect is their flexibility and a low degree of bureaucracy, as there are fewer hierarchical levels [1] than in large companies. Furthermore, fast and informal communication is possible, as are rapid decision making and focused customer orientation in SMEs [2]. Additionally, the willingness to take risks, the often motivated and committed management, motivated labour, fast reaction to changing market requirements and the ability of SMEs to dominate narrow market niches are named [1].

But although this empowers SMEs to play an important role in the market, there are disadvantages they have to face. Not only are their resources limited, but also their environment is rather uncertain [2], as markets and customer wishes are rapidly changing. To maintain or improve their competitive market position, the strategy of a SME needs to be planned carefully. Thus, business and product strategy regarding customer wishes and necessary product variety should be aligned with the available resources. But in reality, the strategy is often not planned, as resources are scarce and e.g. no staff position for strategy planning can be afforded [3]. This is also emphasized by Vossen [1] who describes the lack of attention for marketing and financial planning and Schmidt-Kretschmer et al. [4] who criticize the lack of a holistic approach of requirements management.

2.2 Product Variety

Product variety management is tackled rather differently in literature. Apart from the handling of variants by the design of product platforms and various approaches of modularity or product families [5], configurable [6] and customised products [7] are used to react to the customer's wishes.

According to Scavarda et al. [8] it is important for a company to determine the optimal or appropriate level of variety, in order to maintain its position in the market and to be able to compensate for the increasing operational effort induced by additional product variants.

Da Silveira [9] emphasises the strategic importance of product variety, which faces the two aspects of meeting market requirements and maintain an operational performance in regards to manufacturing processes and supply chain management. Thus, he adds that product and part variety should be managed with adaptive and flexibility strategies. The impact of product variety on manufacturing and supply chains [5] is mentioned by several authors. Appelqvist [6] answers the question of how to manage trade-offs between offering a broad portfolio and high operational efficiency from an engineering perspective with the need to limit the external variety, make use of customisation, design for supply chain, use of pre-defined configurations and form postponement, as well as focused and flexible manufacturing. But no specific conclusions on product modularity or the impact of product variety on product development processes are drawn [6]. According to Ramdas [10], while the impact of the strategy of product variety management on manufacturing and the supply chain has been well researched, the impact of the strategy on the design productivity – for example whether a modular architecture is feasible in certain circumstances – lacks attention in literature.

2.3 Process Performance

Standard processes are widely used as a basis for project planning and organizational learning and it is often assumed that all product development tasks are known from the start in process modelling [11]. There are growing research activities on tailoring and scaling a standard process for a particular project, although the existing frameworks and models do not provide much guidance for process tailoring and scaling [11]. Current approaches name e. g. flexible product development processes [12] or the design of individual processes e. g. for adapting of customised products [7]. Although these

approaches to adapt the development process for current situations, they do not explicitly take into account the needs of SMEs.
Thus, processes can be adapted in order to increase their efficiency and performance. By monitoring the process performance or the project problems can be identified and corrected before they affect the commercial success of a product [13]. Syamil et al. [13] name three dimensions of effective process performance: teamwork, team productivity, and engineering change time – i.e. completing change orders on schedule. According to them, process performance has a direct relationship with customer satisfaction, as well as an indirect relationship to customer satisfaction through reducing product development time [13]. Thus, e. g. concurrent engineering impacts the overall project development performance. Syamil et al. [13] further state that process performance has a direct relationship with product cost and manufacturing cost.
Liao [14] focuses on engineering productivity. He mentions several aspects, which impact engineering productivity cost, deviation of schedule and change costs. These are the size of a development project and its nature – as in an adaptation or new product development – and the priority of the project and the work involvement – design-only versus design-and-construct projects. He also states that modularisation correlates with higher engineering productivity.
Although there is much research on process performance, only a few authors have contributed to the question of how the strategy of product variety impacts the performance of the development process. The interplay of project work and day-to-day business has not been examined in this context.

2.4 Lean Product Development

Lean Development (LD) focuses on the efficiency of processes and its main directive is value orientation [15-17]. The definition of value is essential in order to be able to guide improvement processes [16]. Thereby, processes are improved by eliminating waste – i. e. unnecessary tasks, activities or time loss – and thus shortening cycle time of process steps and the lead time of the overall process [16]. Methods – so called lean enablers – are used to eliminate waste [18], structured along the lean principles of value, value stream, flow, pull and perfection [15]. According to Oehmen and Rebentisch [18] different categories of waste (waste sources) are highly linked, impact each other and cause other wastes. Thus, waste sources cause other waste symptoms. In order to successfully eliminate the waste, it is important to identify their root causes [19] and apply the lean tools to them. Additionally, there are possibilities to prioritize waste for its elimination by mapping wastes to its sources and calculate their coupling [20] to deduce a ranking of the occurring waste causes.
Due to their value orientation and their focus on process efficiency the lean tools can be of use in order to monitor and improve development processes, although current research does not focus on SMEs in particular. Lean Development has evolved from being applied in large companies e. g. in the automotive or aerospace industry.

2.4 Implications from Related Work

Product variety management is well researched, as an abundance of approaches exists as product platforms, different approaches of modularity, product families or customised products. But there have been no investigations on how product variety management impacts on the interplay of project and day-to-day work. Although methods have been provided to adapt and improve processes to an upcoming situation in the development process, there are no tools to improve the product development process and its productivity taking into account the special needs of SMEs.
As it had been mentioned above it is important to monitor the performance of development processes. But current research lacks insights on how product variety impacts process performance, which is of special importance for SMEs due to their limited resources and lacking staff positions for strategy development and implementation. Thus, in this paper a procedure for identifying and eliminating inefficiency caused by product variety in SMEs is proposed. By the use of tools in Lean Development problems and drawbacks in product development processes are identified, as these tools allow monitoring the processes and the interplay of day-to-day business with project work. Hence, the proposed procedure fills the gaps described above by borrowing tools from lean development.

3 DESCRIPTION OF THE CURRENT RESEARCH

The authors' current research project is conducted together with three German companies. The project focuses on the implementation of Lean Development (within this paper it will be abbreviated by IoLD) within these companies and is structured in three phases.

Within the first phase, the development processes of the three middle-sized enterprises have been analysed in order to identify the waste occurring in the processes. During the second phase the philosophy of lean development is to be implemented within the companies by eliminating the previously identified wastes. Thus, the advantages of lean procedures can be revealed to the stakeholders within the partner firms. The last phase focuses on securing the permanent establishment of LD within the companies.

Table 1 shows the most important differences between the cooperating companies. Although they all develop and produce premium products, their industry branches, types of good and distribution channels vary, as does the company size. The most prominent differences can be seen with the number of employees in product development. In figure 1 the main problematic influences on the product development processes observed within these companies.

Table 1: Differences of companies in IoLD

	Company 1	**Company 2**	**Company 3**
Employees	600	200	200
Employees in product development	100	6	12
Product segment	Premium	Premium	Premium
Type of good	Consumer	Investment goods	Investment goods
Distribution Channel	Direct selling / specialized trade	open bidding	Direct selling / specialized trade

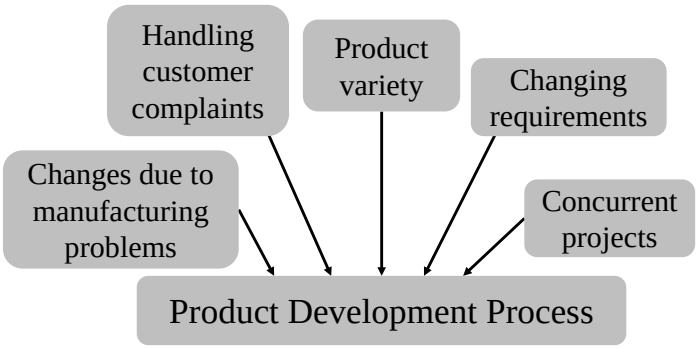

Figure 1: Main problematic influences on product development processes identified in IoLD

As has been shown in section 2 that there are no means to monitor the influence of product variety on the interplay of day-to-day business, comprising the work on change orders, customer complaints and conflicting concurrent projects, and project work in SMEs. Further, a lack of approaches to adapt and improve the development processes in SMEs regarding the strategy of product variety management is obvious.

Hence, based on the results from IoLD, a procedure has been developed in order to enable the identification and elimination of inefficiency caused by product variety in the development process of SMEs. By applying the procedure – focusing on problems specific to SMEs – insights can be gained on the actual effects of product variety on a company specific development process and how these effects are interconnected. Thus, the procedure allows for the improvement of development processes, the interplay with everyday business and the process performance using of tools from LD.

4 PROPOSED PROCEDURE – DEALING WITH INEFFICIENCY IN PRODUCT DEVELOPMENT PROCESSES CAUSED BY PRODUCT VARIETY

This section covers the procedure, which has been developed based on the research described above. It focuses on the specific problems in SMEs and offers guidance for the identification of and choice of measures to avoid process inefficiency in the interplay of product development and daily activities.

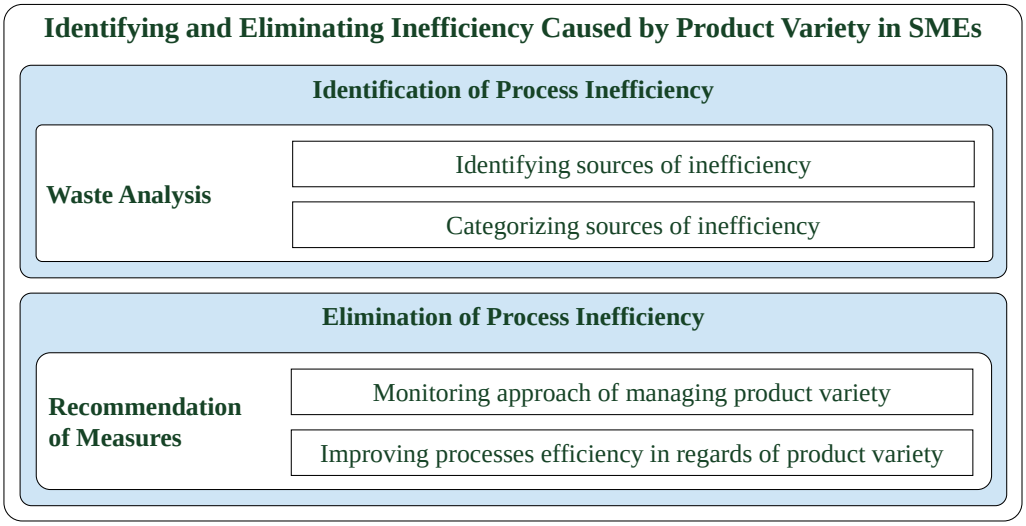

Figure 2: Proposed procedure – dealing with Inefficiency in product development processes

Figure 2 depicts the two stages of the procedure. In order to identify process inefficiency in an enterprise, a waste analysis – taken from Lean Development – is suggested. Thereby the sources of inefficiency are gathered. Subsequently, these sources are categorized regarding the strength of their dependency on product variety. Hence, the first stage aims to answer the first three research questions presented in section 1.

The second stage focuses on the elimination of inefficiency. First, it is to be assessed whether the current approach of handling product variety of a company is feasible concerning the amount of waste caused by it (see research question 4). Second, measures to eliminate the single waste sources are proposed (see research question 5 to 7). Thus, SMEs can easily gain recommendations and support for a mutual improvement of their development and daily activities by applying the procedure.

4.1 Identification of Necessary Improvement – Identifying and Categorising Inefficiency

In Lean Development the analysis and elimination of waste is an important task in order to create a development process fulfilling the lean principles of value, value stream, flow, pull and perfection [15] as named above. Tools which can be used for the identification of waste are semi-structured interviews, workshops and techniques to model and visualise processes as for example product Development Value Stream Mapping (PDVSM) [16]. According to Pessôa et al. [20] common types of waste can be summarized in the categories waiting, transport or handoffs, movement, over processing, Inventory, overproduction or unsynchronized processes, defects, re-invention, lack of system discipline and limited IT resources. These categories comprise several subtypes of waste, which influence and cause each other [20].

Within IoLD various interdependent instances of these waste types have been observed. During further discussion, differences between the witnessed problems and their actual causes emerged. While Pessôa et al. [20] state, that the waste types are caused by others, it became evident that the observed waste has to be regarded as a symptom of inefficiency, while it is caused by a different source. In order to ensure the elimination of the observed negative effects, it is crucial to focus on their sources. The waste sources – as observed in the current research – often cause several waste symptoms and can be summarized by the categories shown in figure 3: setting objections, process management, internal and external customers, information flow, data management and documentation, employees and testing. Figure 3 shows which instances of sources of inefficiency have been found to cause which symptoms. These categories of waste sources occurring in SMEs can serve as a guideline or checklist within

waste analysis. Thereby, the product development process can be analysed by the review of past projects, the company's standard product development process, the information flow between departments, the processes of daily matters as well as the interplay of the latter and the development process. Finally, the company's approach to handle product variety has to be regarded and the actual reasons for the evolution of product variety have to be gathered. It is important to visualize the results of the waste analysis, e. g. using PDVSM or a matrix-format similar to figure 3, but more detailed. As a result knowledge about problems, inefficiency and the actual execution of the development and daily processes of the SME can be created.

Sources of inefficiency \ Symptoms of inefficiency	Waiting	Movement	Over-processing	Inventory	Over-production	Defects	Re-invention	Lack of system discipline	Limited IT resources
Setting of objections	X		X	X	X	X		X	
Process management	X	X	X	X	X	X	X	X	X
Internal and external customers					X	X			
Information flow	X	X	X		X			X	X
Data management and documentation	X	X			X		X	X	
Employees	X	X	X	X	X		X	X	
Testing			X	X	X				

Figure 3: Symptoms of inefficiency and their sources

The categories of sources of inefficiency in SMEs comprise of several instances. An overview of the sources shows table 2. All sources have a specific impact on the activities of an enterprise, which is listed in the second column. These impacts differ in the strength of their relation to product variety.
Hence, three levels of the dependence between product variety, everyday activities and inefficiency in the product development have been observed in IoLD (see right column in table 2). Level 1 represents a direct and strong connection between the source of inefficiency and product variety or its management. Level 2 stands for an indirect link, e. g. no benefit can be gained from synergies between similar development processes and activities, and the interplay with daily business. Sources on level 3 are independent from daily operations and product variety, but should be regarded nevertheless, in order to allow for a thorough process improvement.
Within IoLD the authors observed and defined the three dependency levels of the waste sources. In order to enable SMEs to categorise the sources of inefficiency without external support, methodological support has to be provided. The approach guiding the assessment of inefficiency is part of future research and therefore not covered within this paper.

Table 2: Sources of inefficiency caused by product variety

Sources of inefficiency		**Impact of source of inefficiency – based on results from current research project**	**Level**
Setting of objections	Planning of business and product strategy planning (Priorities of company)	Without a defined business and product strategy, i. e. prioritization of products, product variety cannot be handled effectively.	1
	Definition of project goals (Priorities of project)	The lacking or frequently changing goals within a development project cause unnecessary variety.	1
	Requirements management	Without a holistic and continuous requirements management, the optimal degree of product variety cannot be reached.	1

Process management	Workload leveling	A disadvantageous management of variety can lead to an uneven use of resources by development projects.	1
	Tracing fulfillment of work packages	A lack of tracing the fulfillment of work packages prevents monitoring the current status of a project.	3
	Process analysis	Without a continuous process analysis no identification of waste is possible. No knowledge exists about currently used or available resources, in order to allow for flexibility for the interplay of project work and day-to-day business.	2
	Identification / Documentation of boundary conditions	Lacking knowledge of boundary conditions (within a project, for day-to-day work, integration of several departments) causes ineffective communication and increases probability of defects.	3
	Process standardization	Without standard processes for identical or similar activities in the development process, e. g. for the development of similar product variants, processes are always planned from scratch, which increases the probability of inefficient alignment of process steps or lacking steps.	2
	Performance measuring	Without regular measurement of process performance inefficiency cannot be identified, no insights can be gained how unplanned activities in day-to-day business affect the project work.	2
	Use of Resources	If the use of resources is not monitored the flexibility to react to unplanned activities cannot be guaranteed.	2
	Bureaucracy and Decisions	Long decision chains cause unnecessary stagnation of processes.	3
Internal and external customers	Maturity of development results	The communication and use of immature results causes defects.	3
Information flow	Documentation of information flow	A lacking documentation of necessary information flow, e. g. for activities recurring for specific product variants, increases the probability of defects.	2
	Lacking coordination and communication	Without sufficient coordination and communication within the development department and to other departments the probability of defects increases.	3
Data management and documentation	Data management	Insufficient data management increases the probability of unnecessary product variants, e. g. lacking knowledge of already existing variants, and the probability of defects, e. g. unavailability of information.	2
	Documentation	Without documentation of product variants, specific problem solutions, procedures to fulfill change orders etc. this knowledge – i. e. synergy effects – cannot be reused.	2
Employees	Specialization of employees	If employees work on several specific topics additional time for switching between activities is necessary.	3
	Training (technical, methodological)	A lack of methodological and technical training of employees increases the probability of inefficiency and defects.	2
	Awareness of responsibilities	Without being aware of one's responsibilities, their role in the development process and everyday work, employees cannot see the impact of their actions.	3
Testing	Test specification	A lack of or disadvantageous test specifications (virtual or physical testing) do not deliver results to be used to concretize product design. Without standardized test specifications the testing for similar product variants causes additional effort instead the possibility of combining tests.	2

4.2 Elimination of Inefficiency Caused by Product Variety

By means of the recognised and analysed sources of inefficiency a SME's strategy to manage product variety can be evaluated. Subsequently, approaches – suggested in this subsection – can be applied to eliminate the waste causes. By the application of both steps, which are described in detail below, development processes and their interplay with daily operations can become more efficient and affording less effort, while knowledge about how processes are actually lived arises.

4.2.1 Monitoring the strategy to deal with product variety

The waste analysis, which is conducted in the first stage of the procedure, results in a certain amount of causes of inefficiency. These represent the degree of inefficiency within the development and daily processes of a SME. It is important to define – specifically for each company – the degree up to which it is more profitable to eliminate the waste sources and maintain the strategy of product variety management instead of changing the latter.

To accomplish this, the amount of sources of inefficiency – directly dependent from product variety (level 1, see sec. 4.1) – has to be assessed as has their influence on the remaining sources with levels 2 and 3. Thereby, the need to establish a new way of handling variety becomes evident, if waste caused by management of product variety outweighs its benefits. In other words, the strategy should be changed, if the transformation of variety management avoids the sources of inefficiency on level 1 and entails the improvement of the interplay of development and everyday processes (level 2 and 3).

If in contrast only a low degree of inefficiency is due to the current management of product variety, the improvement of the development process and the interplay with everyday work has to be emphasized.

As a short example, the current approach to handle product variety may be to offer customized products without a standardized product design. This may cause a considerable amount of waste, as synergies between different development projects are not optimally used. It may also lead to the decision to change the strategy of variety management.

In contrast, modularized products aim for a reduced development effort. Thus, with this strategy it is more likely that inefficiencies are mainly identified in the context of a multi-project environment and the interplay with daily operations.

In order, provide the means to improve the process efficiency, while a certain approach of product variety management is given, measures are suggested in the following subsection to overcome problems directly linked to product variety (level 1) and to eliminate sources of inefficiency with level 2 and 3.

4.2.2 Improving process efficiency

In Lean Development (LD) several tools are recommended to achieve efficient processes. E. g. Hoppmann [21] proposes to implement LD consisting of eleven tools – so called lean enablers. In literature lean tools strive mainly for the realisation of the lean principles [15]. Thus, in order to transform a company into a lean organisation the principles have to be fulfilled and waste has to be avoided and eliminated. Although the need to prevent waste is emphasized in literature, only in few specific cases tools or methods are recommended to be applied to certain waste causes [16]. Hence, so far there is no methodological support to choose methods to eliminate certain sources of inefficiency in SMEs.

Within the current research, measures have been taken from the context of LD and process improvement, in order to examine their feasibility to eliminate sources of inefficiency. These measures have been linked to the identified categories of waste sources (see table 2) and the levels of dependence between product variety, everyday activities and inefficiency in product development (see section 4.1).

One the one hand, the measures address sources of inefficiency directly linked to product variety (level 1), in order to support the current strategy of variety management. On the other hand, approaches focusing on the improvement development process in general and its interplay with daily business further promote the optimal use of synergies between development processes of similar product variants (level 2 and 3).

In order to attain optimal effects by the application of measures, the latter to be adapted for a specific company in regard to its constraints.

In table 3 procedures are proposed for the elimination of specific sources of inefficiency in the product development process of SMEs for each level of dependence between inefficiency, product variety and daily operations. Within each row of table 3 a measure is described shortly and the sources of inefficiency it focuses on is named.

Table 3: Measures to avoid or eliminate causes inefficiency

Measures to avoid or eliminate sources of inefficiency – description of approaches as characterized by several authors [15-17, 21-27] – Source of inefficiency
Level of dependence 1
Formalized requirements management Requirements management as the basis of successful product development with continuous monitoring and refining of requirements – tools e. g. Quality function Deployment, Design Structure Matrix **Source of inefficiency - Setting of objections**
Product strategy driven by business strategy Consistent value system – in the sense of the overall goals for product development as well the entire company – in order to align product strategy and business strategy as prerequisite for the holistic success of company **Source of inefficiency – Setting of objections**
Level of dependence 1 and 2
Testing Testing (physical, virtual) in early phases of product development in order to gain insights for further specification of product concept or design **Sources of inefficiency – Setting of objections, testing**
Level of dependence 2 and 3
Continuous waste analysis Continuous analysis of inefficiency by the use of workshops, interviews, value stream mapping, Design Structure Matrix or Multiple-Domain Matrix **Source of inefficiency – Process management**
Continuous analysis and improvement of processes Enabler for monitoring processes to improve efficiency and flexibility with the effect of awareness of the current state of processes and day-to-day business **Source of inefficiency – Process management**
Decisions Short of decision chains, decision on the lowest possible level of hierarchy to avoid unnecessary stagnation of process **Source of inefficiency – Process management**
Efficient and effective communication Support of communication by focusing on essential aspects using semi structured forms for documentation of solutions for defects, meetings etc. **Sources of inefficiency – Process management; information flow; employees**
Flow and Pull Lean principle Flow as the availability of the appropriate amount of the right information at the right time by the use of regular scheduled milestones in order to allow for monitoring results, coordination and adaption of processes Lean principle Pull as affordance of the awareness of every stakeholder in the process who is his customer who needs which information when, people have to pull the information by identifying necessary information flow according to (standardized) processes **Sources of inefficiency – Process management; internal and external customers; employees**
Involving suppliers Early integration of suppliers or manufacturers with the effect to gain insights for the concretization of product specification in early phases and to lower the probability of defects **Source of inefficiency – Internal and external customers**
Knowledge management, Best practices, Documentation Documentation of solutions for defects, customer complaints and best practices by the use of checklists, semi-structured forms or databases **Sources of inefficiency – Process management; data management and documentation**

Performance measurement and visualization Support of continuous monitoring and analysis of processes, visualization and performance measurement (awareness of the current state of processes and daily business) **Source of inefficiency – Process management**
Pull of Information – Realization of optimal information flow and pull, physical environment (paper-based communication) and digital environment (design of databases, structure of data storage) with the goal of explicit, reliable supply of information **Sources of inefficiency – Information flow; employees**
Self-reliant planning of work packages by employees to enhance their motivation Self-reliant planning of activities by employees in between predefined milestones, serving for monitoring the project and the results of single work packages with the effects to gain the employees' awareness of current status of each stakeholder and the increment of their motivation **Sources of inefficiency – Process management; employees**
Set-Based Design and Simultaneous Engineering Set-based design (in order to increase the probability to gain an optimal solution development of various alternative product solutions, elimination only if requirements cannot be met) supported by the parallel alignment of design activities in concurrent engineering **Source of inefficiency – Process management**
Specialist career path Employees as specialists for specific topics to building of profound expertise in the context of a continuous improvement of the company **Source of inefficiency – Employees**
Standardized processes Standardized processes for specific phases of the development process according to type of project (new product development, design adaption etc.) for activities recurring in each development project with the effect of supporting efficient communication, information flow and a lower probability of defects **Sources of inefficiency – Process management; employees**
Strong Project Manager Strong project manager with high technical expertise to drive the project by defining value and goals, being responsible for the product architecture and monitoring of the development process **Sources of inefficiency – Process management; employees**
Workload leveling Planning of even use of resources over all projects of the company and within single projects to gain the flexibility to react to unplanned circumstances **Sources of inefficiency – Process management; employees**

5 DISCUSSION AND CONLUSION

Small and middle-sized enterprises face the challenge to maintain and improve their market position with limited resources. Thus, it is of importance to give SMEs not only the means to monitor their strategy of product variety management and the performance of their development processes, but also to improve the latter and its interplay with day-to-day business.

This paper introduces a procedure for identifying and eliminating inefficiency in the product development process of SMEs caused by product variety. The procedure has been developed based on a current research project carried out with three middle-sized companies. Therefore, the procedure specifically focuses on causes of inefficiency that can be observed in SMEs, which forms its distinction to existing approaches.

The procedure comprises a procedure using waste analysis – taken from Lean Product Development – to identify causes of inefficiency in the product development process and in daily business. Further, measures to eliminate these causes are proposed.

As positive effects of applying the procedure the product variety can be handled successfully and thus the product development effort can be reduced, the development process can be improvement - as its interplay with day-to-day-business – and awareness about how these processes are lived within the enterprise and impacted by of product variety can be gained.

So far the procedure is based on the observations made within the three cooperating companies. But as the boundary conditions and the situation within a SME differs strongly according to the type of product, the industry branch and the internal organisation, further research is necessary to broaden the results. Thereby, support for the identification, assessment and elimination of inefficiency in the development processes of SMEs given by this procedure has to be further extended and validated. Moreover, there is the need to evaluate further methods regarding their feasibility concerning waste elimination in different case studies, in order to encompass other conditions than observed in the current project. And approach to enable the user of the procedure to categorise the sources of inefficiency is part of future research.

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