CHANGEABILITY IN VALUE NETWORKS – IDENTIFICATION OF CRITICAL OBJECTS

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Abstract
Due to continuous deviations in long-term plans, small and medium-sized enterprises (SME) have to adapt to frequent changes beyond the range of flexibility. Within a value network of SME, long-term processes of adapting to change have to be in accordance to the company's strategic direction as well as its network partners. Precondition for the implementation of changeability is structured information about critical objects within the network. This paper describes an approach for the analysis of network connections and their dependence on the company's own adding-value as a function of time. In connection with the companies structural and operational organization the approach allows to identify critical objects throughout the company and its network. Implemented in a digital tool, the approach supports yearly business planning through structured information about critical objects regarding capacity demands for a well-defined capability.

Keywords:
Changeability, Value Networks, Business Planning

1 INTRODUCTION

The environment of small and medium-sized enterprises with make-to-order production and small-lot manufacturing can be characterized as turbulent 'because of shorter delivery times, logistical accuracy including maximum delivery reliability and increasing product variety' (1). Base data for yearly business planning processes becomes increasingly vague. Scientific approaches and methods that enable SME to absorb turbulences beyond flexibility use the term "changeability".

Supposing that the concentration of capabilities on core competences is selected as strategic guide line in this environment, the cooperation in networks becomes unavoidable and concerns all departments of value-adding. Networks are used for workload balancing of well-defined capabilities (2) (3). The needed capacity for the amount of workload balancing is measured in time per period or piece.

Research on changeability focuses on intra-organizational objects and ignores the evolution towards value-adding in networks of SME – the so-called value networks (3; 4). Especially when it comes to deviations in capacity demands with long-term forecast, changeability within networks is a new option (see Figure 1: possible reactions to fluctuations in capacity demand) when focusing on core competencies.

Precondition for implementing changeability is to identify relevant objects of change on all levels of production (3). This paper addresses the network level and connects long-term forecasts through scenarios and yearly business planning with focus on SME.

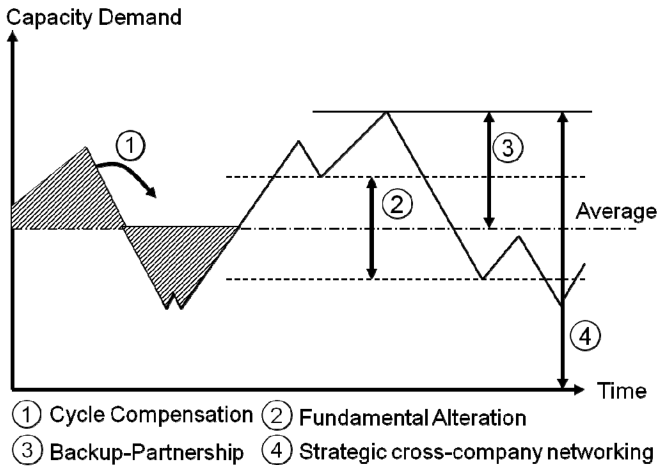

Figure 1: possible reactions to fluctuations in capacity demand

First, the addressed problem is described in more detail. After the description of the state of the art, an approach for solving this problem is presented as well as a first prototypical implementation.

2 LONG-TERM CAPACITY PLANNING IN VALUE NETWORKS

This section describes the underlying problem of the presented approach and consists of two parts. The first part describes the problem on a theoretical basis, the second part discusses the practical relevance of the problem by example of a German SME.

2.1 Scientific view

Figure 1 shows different cases of how SME can handle turbulences in planning of capacity demand. A small amount of workload balancing can be achieved through cycle compensation and exploiting flexibilities – see case 1. Alternatively, the company can try to raise or lower its average capacity offer in order to meet the demand.

Changeability within affected departments simplifies this process – see case 2. When the internal changeability comes to its limits, backup capacities in networked companies can be used (case 3). This is done short-term and through subcontracting or other well researched methods.

In cases where backup capacities are exhausted or do not exist for a well-defined competence, a new cooperation has to be initiated – see case 4. Usually, this is prepared, planned and documented in the yearly business planning as they have impact on investment planning and other yearly plans through make-or-buy decisions. However, the forth case – the strategic cross-company networking – for absorbing turbulences is found only rarely.

Several factors influence operation in networks. The two most time-consuming prerequisites for cooperation are a consistent strategy among all partners as well as confidence and especially trust (1). A new cooperation can result in economical losses due to a late identification or an incorrect set-up, supposing that the fulfillment of these conditions takes longer than the identification of turbulences. If the time span between identification and fulfillment is too short, there might not be time to set up a new cooperation.

Transferring the idea of changeability to the network level a company facing this problem should enable critical 'objects of change' to face possible future turbulences that cannot or hardly be foreseen. Two prerequisites are needed to identify critical objects of change: In the first place, the company needs to have an idea about multiple futures – e.g. by using scenario management – to identify long-term deviations in capacity demands. Secondly, a capacity planning tool for middle and long term is needed that can use multiple futures to identify, how these affect the capacity usage throughout the company, the yearly business planning and the network partners. Thus, multiple futures result in multiple business cases and the connection between yearly and long-term planning ensures the viability of new and existing network connections (2).

This paper proposes an approach to link scenario management and long-term capacity planning to be able to identify critical objects of change. This way, it is possible to identify the capacities that are definitely needed and prepare network connections that – if needed – can be activated or disconnected within a short time. This is useful for bilateral workload balancing of well-defined capabilities.

2.2 Practical relevance

The practical relevance of the problem will be explained and verified with a typical medium-sized German company acting on international markets with highly innovative and customized products. At first, the planning process for long, middle and short-term planning will be explained. Secondly, the necessity for the presented approach will be derived by showing a gap in the long-term planning.

In this company, there are a few planning instruments for different purposes. Two categories can be used to divide them into groups: focus on specific time periods and planning objects. In the following, the planning instruments will be listed according to their focus on specific time periods (see Figure 2).

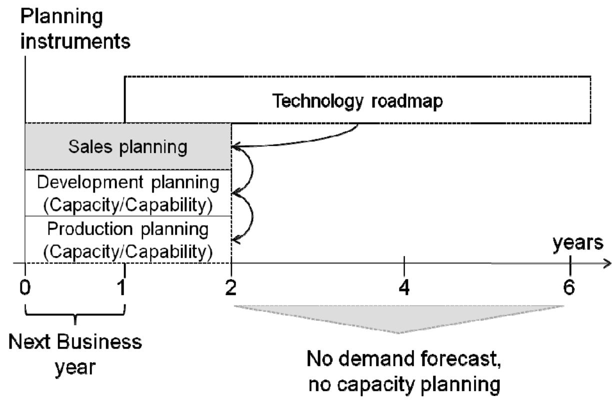

Figure 2: Example of planning instruments at a medium-sized German company

Long-term planning: The company uses a technology roadmap for long-term planning. This roadmap contains information about future technologies relevant for the company (e.g. new production technologies or new product technologies) and, more importantly, information about planned future products. Depending on the product divisions, this roadmap has a five to eight year focus and uses years as planning steps. It is the major source of information for long-term planning.

Short and middle-term planning: The development planning has a one to two year focus and is directly connected to the technology roadmap. Firstly, it gives information about which products from the technology roadmap have to be developed within the next one or two years. Secondly, it allocates product development resources to these products. If necessary, a search for external capacities is triggered. The sales-planning has a one to two year focus and is detailed in the course of one year by a rolling forecast. It gives an estimation about future sales based on probabilities (certain, 80%-orders and uncertain). The production planning has a one to two year focus and is detailed also in the course of one year. It allocates the capacities of production and assembly with the sales planning and – if necessary – gets back on or triggers the search for external (production) capacities or resources (e.g. buy rather than produce).

Identified problem: The company matches its resources in production and development continuously with the market development in a short term period of up to two years. If a mismatch arises it tries to use external resources if possible. This is done rather reactive since the narrow timeframe does not leave many options.

The long-term planning, however, cannot solve the problem: Firstly, there is no structured information about market development and other important factors influencing future markets. Hence, there is no information about future product quantities in the long-term. Most forecasting is done by the management without specific methods. Secondly, the influence of future products on resources of the company is not being measured.

In conclusion, the company responds to change regarding its resources reactively rather than proactively. This is because today the company cannot identify, how future change will influence company resources and which of the resources are likely to be critical in terms of capacity. This paper proposes an approach to fill this gap.

3 CHANGEABILITY IN NETWORKS

First of all, this paragraph gives an overview on changeability. In connection with a characterization of networks, the last subparagraph describes the addressed research topics.

3.1 Changeability

Today, companies have to compete in turbulent environments (1). Market demands, competitor's actions, shorter life cycles and new technologies often change or arise quickly. Changeability helps companies to compete successfully in such an environment. A system (e.g. company) can be described as changeable, if its structures and resources can permanently adapt towards changing conditions and customer demand within a short, middle and long term (5). Changeability can also be described as the ability of a system to change beyond a planned corridor of flexibility (see figure 3). If the existing flexibility corridor is not capable of absorbing turbulences any more, a company can use changeability to get to a new flexibility corridor.

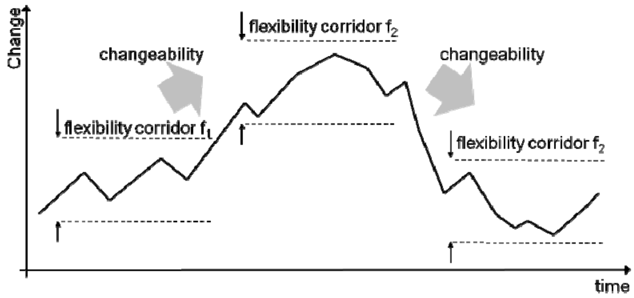

Figure 3: the concept of changeability and flexibility (5)

To use the concept of changeability, a system is further divided into 'change objects'. This can be done by using two dimensions (6): the 'planning level' and the 'form of transformability'. The planning level can e.g. be divided into network, site, factory, cell and workstation. The form of transformability can e.g. be structured into technical, organizational and spatial. Therefore, a change object is a technical, organizational or spatial object on a certain planning level. An object on a higher planning level can – but does not have to – consist of one or more change objects of lower planning levels.

Change can occur on all levels of a company, from network to work station or even machine level. So far, much research has gone into developing concepts of how to enable change objects on a site, factory, cell and workstation level by using transformation enablers such as universality, mobility, scalability, modularity and compatibility (7). However, there are only a few concepts dealing with changeability on a network level (5) (4). The objects that can change on these different levels are described as 'objects of change'.

This paper focuses on changeability on a network level. That is, it helps companies in a network to first identify change objects on a network level that should be enabled towards transformability (see 'critical objects' in section 4). Second, it helps to identify change objects on a factory (or lower) level that should and can be enabled towards transformability with existing concepts. Therefore, the focus of this approach is rather long-term.

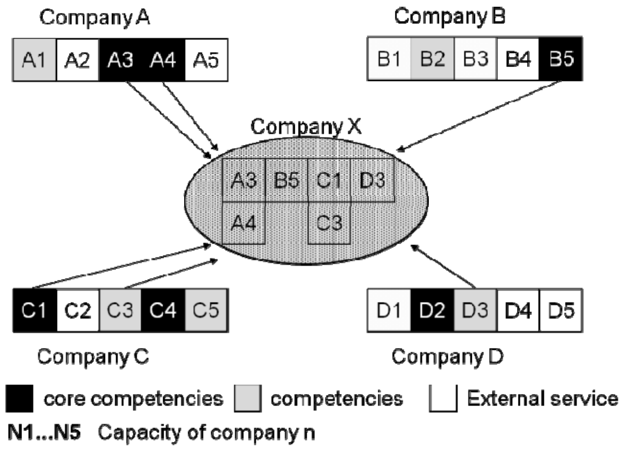

Figure 4: Capacity exchange in value networks (based on (6))

3.2 Inter-organizational value-adding

Value networks can be differentiated by their main capabilities in research and development, production or marketing and sales networks. In the context of this paper, a network connection is used to obtain or to provide capacities in a certain capability and period, supposing, that all capabilities can be measured in amount of time per period, e.g. production capacities for grinding are measured in hours per period or piece. 'The typical problem in capacity planning is to decide on the timing and amount of investment as well as the selection of resources (equipment, facilities, systems, and people) to use in a manufacturing site at any time. (7)'

The cooperation life cycle can be subdivided in initiation, formation, leadership and termination (2). While the main value-adding takes place in the phase of leadership, a structured initiation and formation are a fundamental condition for a successful cooperation. Main part of the initiation has to be the analysis of core competencies in order to find the right partner.

The complexity of value-adding within the cooperation determines the duration of the initiation as well as the formation phase. Supposing that these phases are a loss-making business, explains why new cooperation has to be well decided. Especially the development of new technologies in a new cooperation takes time, due to building trust and getting used to one another.

3.3 Changeability in value networks

The description and the advantages of collaboration in networks are well documented. When it comes to application research, short time flexibility and troubleshooting within networks is done using keywords like bullwhip-effect or supply chain management. Here, the focus lies on existing cooperation.

A network connection, used in the sense of changeability, is activated and running before its existence, is urgently required and it is terminated in the moment when it becomes valueless. This way, the network connection is used similarly to insurance. By identifying critical objects, the presented approach is a first step to establish changeability within networks.

4 IDENTIFYING CRITICAL OBJECTS IN NETWORKS

Critical objects are understood as objects that are identified to be critical regarding their capacity of a well-defined capability. In the sense of changeability, these critical objects might be transformed into change objects.

The decision about this transformation is made during yearly business planning. Due to the long-term aspect and the network as level for changeability, these objects find themselves at the top end of the organizational structure of the company, e.g. departments.

4.1 Structuring forecasts

In order to identify critical objects, the view on multiple futures is divided into three sequenced time spans and three fields of forecasts. The first two time spans cover the next business year and the following year. The third time span ends at 5-10 years. The three fields of forecast cover technologies, product development and production planning. The overall structure is based on a technology calendar (8).

Technology roadmap

Within a technology roadmap, new technologies and other long-term aims with impact on the product development are described. This can be innovations or the renewal of existing products. Divided into technical categories, they have to be described as detailed as possible with dependencies and supplemented with an expected or advised date of their realization within specific products. In addition, the estimated amount of workforce for their realization is recorded in the roadmap. This is done based on implicit knowledge of the involved engineers, experiences of the past or inter-organizational comparison. The workforce is measured in persons per month.

Product development plan

The product development plan describes the transfer of elements within the technology roadmap into products ready for production. This is supposed to be a decision taken by the management and is based on market research or specific requirements of customers. The transfer is realized by an engineering process described by amount of workforce and investments for the involved departments of product development. The departments are described through their capacity for a well-defined capability as a function of time. E.g. the development of control engineering has a monthly average capacity of 200h in the next business year.

Production planning

The production planning cares about the preparation of the production departments for expected modifications. This is done based on the types of products, described within a working plan, and the expected quantity of sales over time. Results of this planning are investment plans and expected amount of needed workforce as a function of time for each production department. Similar to the product development, the production departments are described through their capacity for a well-defined capability. E.g. milling has an average capacity of 300h per month in the next business year.

4.2 Preprocessing information

Existing information about the actual and future state of the company are used to fill up the three time spans and fields of forecasts. The collection and analysis of information is done decentralized or in interdisciplinary workshops. All information is specified more precisely during a rolling process. The granularity of the information corresponds to the yearly business planning.

Average values from the past can be gained from Enterprise Resource Planning or Manufacturing Execution Systems and are use to describe the actual state. Through an interdisciplinary process and in connection with implicit knowledge of the involved people, the expected development of these values during the three time spans is described.

Network connections during product development are identified through mismatch of existing and needed capabilities and capacity. During product planning this is done by make-or-buy decisions. In order to integrate the network connections into the presented structure, every connection is represented by a virtual department described by an amount of capacity for a well-defined capability.

4.3 Business cases through scenarios

In connection with scenarios for the external market development and expected turbulences, the technology roadmap becomes dynamic regarding starting dates of innovations and expected amount of capacity.

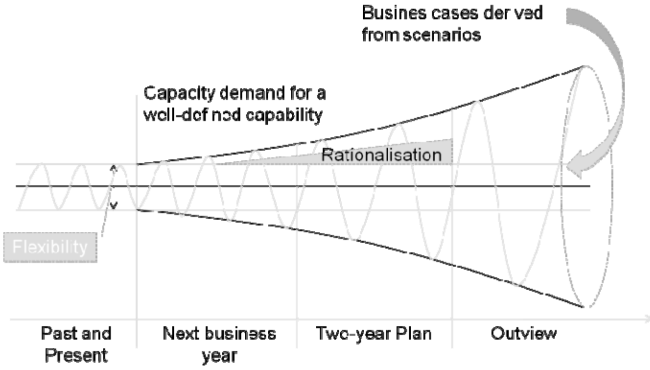

Figure 5: Impact of multiple futures on yearly planning

A connection between technology roadmap and product development as well as production planning allows identifying the departments affected by this technology within the company. Every single scenario for external environment creates a business case that is used for planning the next business year. In other words a business case corresponds to one possible manifestation of the future.

Through an implemented connection between the technology roadmap and the product development plan, the amount of needed capacities of a well-defined capability becomes more precise regarding starting date and duration of capacity usage.

The production planning depends not only on the type of products but also on the expected amount of sales. By multiplying the amount of time per piece with the amount of sales, the needed capacities can be calculated. The simulation of different sales scenarios can be used as a ‘stress test’ for the robustness of the planning.

This way the impact of new technologies on the own as well as the virtual departments in network connections for product development and production planning can be identified. By the comparison with the actual state and analysis of different business cases, action fields for rationalization, investments or network connections can be identified.

4.4 Identifying critical objects

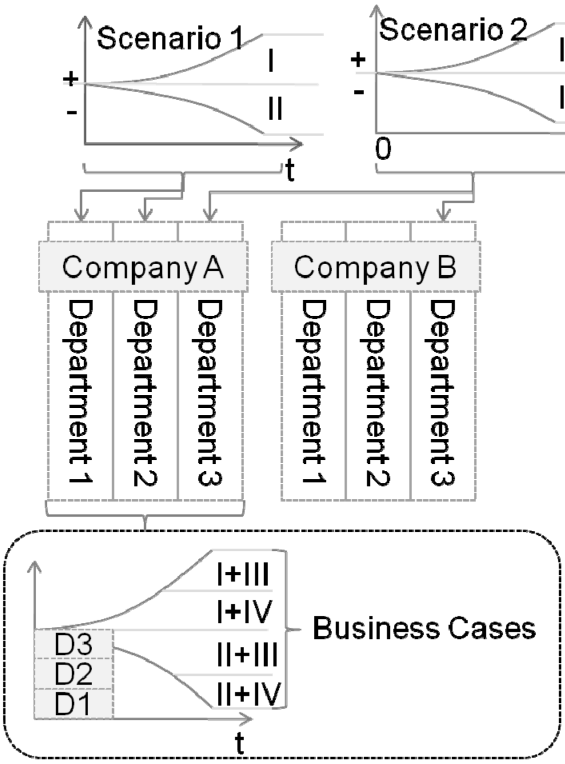

Figure 6: Business cases derived from scenarios

The identification of critical objects starts with a comparison of the business cases and the actions that are derived from these in order to fulfill capacity demands for a well-defined capability. Two basic results for this comparison are possible (Figure 6):

- At least two business cases describe an opposed capacity demand for one single department
- At least two business cases describe a conformable capacity demand

The comparison shows if these impacts on departments reinforce each other, happen in a similar time span and what time is left to adapt to the business cases.

Objects become critical when they cannot adapt to the capacity demand identified by the comparison of the business cases due to economical reasons or missing time. The decision about the implementation of changeable objects is done within the yearly business planning. The impact of actions planned by the management can be analyzed by integrating their capacity demand within the structure for the forecast as well. This way a recursive what-if-analysis is possible. As the network partners are represented as virtual departments, the impact of the different business cases can be identified as well as possible constraints for new network connections.

5 IMPLEMENTATION OF A DIGITAL SUPPORT TOOL

The consideration of multiple futures during yearly business planning demands for a digital tool that supports the handling of information and numerous business cases. At the moment, several functions are prototypically implemented in separate software modules for validation. The following subparagraph will describe, how this prototype is built up.

The collected data and information is a mixture of qualified and quantified data. Data from the past and the near future about the number of sold products or the needed production capacities are by a majority quantifiable and stored in digital tools. A common tool used in SME is spreadsheet software. Many planning or controlling tasks are done in specialized spreadsheets and already used to support long-term planning without concrete orders.

The following main requirements haven been identified for a support tool:

- Decentralized gathering of information
- Individual privacy for gathered information
- Intuitive visualization and usage
- Single-point of truth for the information

For the implementation of the presented approach Microsoft Excel has been chosen as it is highly customizable and well known by SME. The collaboration platform Microsoft Sharepoint Server 2010 in connection with Performance Point Server has been chosen as main data storage. It is able to connect various Microsoft Excel spreadsheets, establish individual privacy and create analysis dashboards within one platform. Figure 7Figure 7: ICT-architecture of shows the overall architecture of the support tool.

Data from Excel-Sheets are extracted and connected to Key Performance Indicators (KPI) and visualized on dashboards. Every change within the sheets can be propagated to the Microsoft Sharepoint Server 2010 and immediately changes the KPI and allows a continuous data analysis. The scenario management allows creating different Business cases. Through optional connectors to ERP or MES software, information and data can be imported automatically. Communication can be realized through SQL-commands. Also optional is the connection to network partners and the import of information.

The usage of this platform is intended to be in SME, that aim to support their planning processes or within a business game in order to learn about changeability in networks.

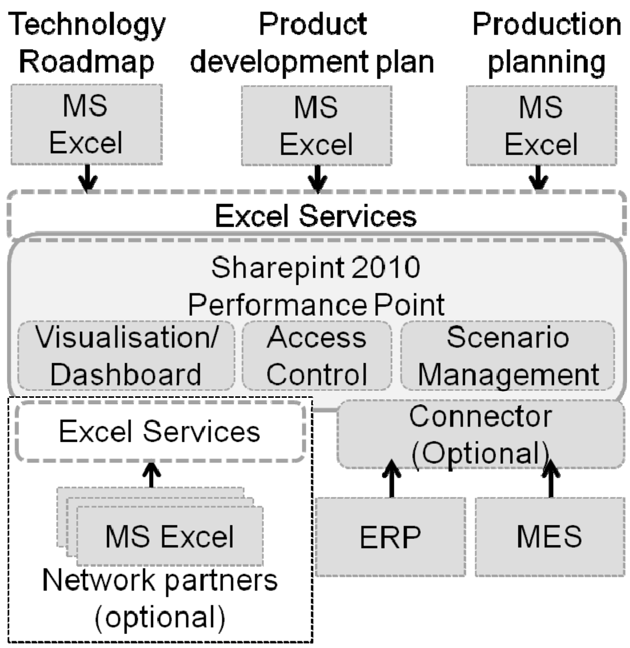

Figure 7: ICT-architecture of support tool

6 VALIDATION

The approach and the digital support tool presented in this paper are validated in different SME and their corresponding value network. So far, several software modules are prototypically implemented as there is the production planning module and the stress test module.

Basic analysis with the Microsoft Sharepoint platform is available. Real data from SME was not integrated yet due to a missing implementation of individual privacy parameters.

However, the actual development already allows some interesting conclusions:

- The integration of a scenario-based long-term market view into the technology roadmap is a giant leap ahead for the SME in a peer group and turns out to be of help, already today. This is because the impact of different market scenarios on the ‘future’ products–- planned within the technology roadmap – on the company and network can be displayed.
- It is possible to identify ‘critical’ objects. That is, critical objects of change show great deviations in capacity demands for a well-defined capability. However, to this point it is not possible to predict whether these objects are more likely to be critical than others, since there is no long-term data on the outcome.
- Conflicts arise, since companies do not want to share ‘strategic’ information and show tendencies to hold back information. This is an organizational problem of the principal-agent and cost-benefit-sharing type and will be addressed.

To conclude the validation paragraph: There are some promising results already. Some mainly organizational problems emerged. However, for a full validation the tool needs to be further developed and “go live” so that real-time test data can be analyzed.

The research project presented in this paper will address these aspects.

7 CONCLUSION AND OUTLOOK

This paper presents an approach enabling SME to detect critical objects on the network level that are more likely to be affected by future turbulences then others. This is done by using different business cases derived from market scenarios. Those objects that are highly affected are critical and should be enabled for changeability.

A digital support tool enables SME to detect and locate uncertainties in their yearly business plans by connecting long-term scenarios with planning parameters . Through identifying and visualizing the variability scale of these parameters, the management is supported during the planning process. Furthermore, through focusing on the network, the management of existing and the initiation of new cooperations is strengthened.

Further research will be done on the scenario-based forecast and the enabling of network connections towards changeability. For this, it is necessary to define limit values and introduce a new economical calculation method. The implementation and validation phase of digital tools will be forwarded as well as the development of business games addressing this topic.

8 ACKNOWLEDGMENT

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