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Sustainability in Model-based Planning and Control of Global Value Creation Networks

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Abstract

Manufacturing companies are affected by an increasing complexity driven thru fast changing requirements in the global market. To meet the large catalogue of requirements, enterprises are forming global value creation networks and provide services jointly. The existing time pressure and the involvement of many stakeholders results in a demand of methods and tools for a quick configuration of such networks. Beside the management of material, information and money flows the quest of a sustainable corporate development poses a further challenge for the decision makers. The consideration of sustainability in business process management is one approach to take also social, economic and environmental aspects within global value creation networks into account. Reviewing existing modelling techniques shows that the requirements for a fast configuration and an adequate management of sustainability are just insufficiently addressed or are raising the complexity further. This paper will explore capabilities of an enterprise modelling technique which supports an integrated handling of network configuration and sustainability management in a fast and efficient manner.

Keywords: enterprise modelling technique; sustainability; planning and control; complexity

1. Introduction

There has been a massive transformation in the framework conditions for production over the last decade. The market situation is in constant change, the pace of innovation has increased significantly. Market participants have

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to be extremely flexible and willing to develop to fulfil increased customer requirements in a global marketplace. To cope with such requirements companies are establishing value creation networks, to remain competitive and get flexible. Today the partners of such networks are more and more spread around the globe, so that they are considered as global value creation networks (GVCN) in this contribution. Furthermore, sustainability has changed from an idealistic theory to an active topic in society. Enterprises are confronted with a growing number of national and international regulations and standards regarding sustainability. A growing active consumer demand and a surcharge capability for sustainable products are observed as well [1].

These factors make it necessary e.g. to realize an efficient use and recycling of all materials through a coordinated interaction of producers, consumers and recyclers. The resulting expansion of the system boundaries leads to a further increase of relevant actors and thus to a further increase in complexity of the systems to be coordinated [2].

To meet the challenges of sustainability holistically in GVCN complex problems in the design and control of partner relations for an economic, environmental and social evaluation of products, services and value chains have to be solved.

1.1. Global Value Creation Networks

In general, a value creation network can be described as a network of relationships that generates value [3]. If the perspective is broadening to the global market, they can be introduced as global value creation networks. The network actors can be suppliers, manufacturers, customers and other stakeholders.

Taking into account the development of Parolini, value creating systems, such as global value creation networks are "sets of activities that are jointly involved in the creation of value". In his definition these activities are carried out by using a set of human, tangible and intangible resources. Furthermore, Parolini already emphasizes that companies should not only concentrate on themselves. Otherwise they are just optimizing their own work and fail to see that their problems are located somewhere else in the network. The effort for improving operation might be wasted by failing in the entire system [4].

Adapting these statements to the concept of sustainability, the importance of an efficient management of information, material and financial flows increases and requires methods and instruments for closing geographical, information, communication and compliance or implementation gaps.

1.2. Management Challenges of Sustainability in GVCN

Concentrating on sustainability the above mentioned challenges need to be addressed on a company level as well as on a network level. In a first step every individual actor of GVCN must have an overview about the impact of their own products and activities to enable the evaluation of preceding and following process steps through integration [5]. Beside an agreed sustainability strategy in line with the company's philosophy this includes an adequate evaluation system, a selected pool of sustainability measures and an explicit internal communication concept. So, instruments for covering this demand should be able to connect the perspectives of strategic, tactical and operational planning and control. Scaling up this demand to GVCN many actors are involved in the planning procedure to ensure the functionality of the GVCN after implementation in its operational phase [6]. The complex cause-effect mechanisms of product, process and sustainability are often not fully known, nor can be predicted. Information flows and exchange processes have to be planned and controlled in an adequate way within a whole value creation network. The distribution of resources, objectives, stakeholders and limitations of the network must be continuously reflected and coordinated. In addition further uncertainties like growing international competition, shorter innovation cycles and an increasing competitive pressure require mechanisms to handle the increasing number of influencing factors within global value creation networks. To manage the occurring dynamic, integrated flexible mechanisms and instruments with low-effort are required to support the development of global value creation networks within all phases.

In this paper, we will explore capabilities of an integrated modelling platform for network models, which enables the stakeholders of GVCNs for collaboration and supports the planning and control from a sustainability perspective. Based on an integrated enterprise model the demand of network planning and control are depicted in a multi-perspective modelling concept [7], [8]. The presented approach is a development out of the Collaborative

Research Centre SFB 1026 – "Sustainable Manufacturing – Shaping Global Value Creation" funded by the DFG. It illustrates how network objectives, pools of indicators and visualization components can interact based on an integrated enterprise model and how it enriches the network communication driven through contextual evaluation views.

2. Model-based Planning and Control of Sustainability in Global Value Creation Networks

It is desirable to have a formalized method to increase profitability while increasing sustainability in GVCNs. The model-based approach proposed in this section incorporates all development phases of company cooperation [9] (Fig 1).
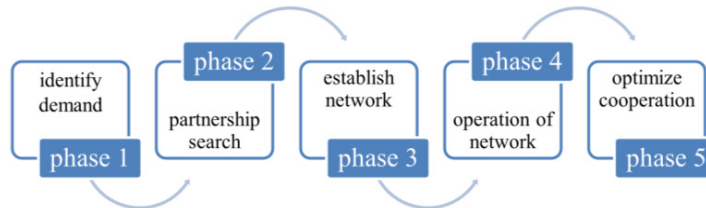

Fig 1. Development Phases of Company Cooperation

In the first phase of this approach every participating enterprise has to identify its individual demand for external cooperation. As a prerequisite, the information of internal and external competences and abilities has to be available. The phase of partnership search is used to compare the desired competences and abilities with the profiles of potential partners. As a result a common cooperation profile for the upcoming business of the partnership has to be derived. For the establishment of the network specifications, the integration of business and production processes as well as organizational aspects have to be taken into account. The operating phase is characterized by the monitoring of the performance. The experiences from the operations are finally used to derive possible optimization potentials [10].

2.1. Role of Enterprise Models for the Development of Cooperation

An integrated support of the described phases can be organized by using enterprise models as a common information backbone for the management disciplines on the individual as well as on network level with the objective of developing, establishing, operating and optimizing global value creation networks. With this approach a holistic, consistent and fast implementation of communication structures on all levels of a network is subsequently possible [11]. As an integration basis the Integrated Enterprise Modelling (IEM) method [12] is used in this approach.

To ensure a holistic transparency, these individual partner models have to be integrated into a consistent network model, which can be built up step by step during the establishment of the network. Such a model has to also contain the connected description of the network products, processes, systems and organization.

To use a business process modelling approach for planning and control in all stages of development of cooperation between companies, it is not enough to model the business processes and organizational structure. An integrated approach must be able to support all central factors and design parameters regarding planning and control tasks. The influencing factors are:

1. Network complexity
2. Network relationships
3. Network coordination

The structural complexity rises with increasing organizational differentiation and is represented by the variables vertical (depth), horizontal (width) and spatial complexity (geographic coverage). The depth of global value creation

network is determined by the number of levels of value creation. In GVCNs typically multistage relationships between suppliers and buyers can be observed. Substantial for the complexity in this case is the respective product. The width is represented by the number of partners within one stage of value creation. The spatial complexity represents the number of facilities and the operating range of value creation which has to be bridged [13].

Beside the aspect of complexity the relationship and coordination plays a substantial role within planning and control of GVCNs. Cooperation is mainly characterized by relationships, which are in need of intelligent information and communication technology (ICT). Due to the progressing development of ICT, especially regarding real time information, the provision of the required information for network partners is simplified, but at the same time it implicitly increases the degree of complexity. Decisions for outsourcing further value creation is facilitated and leads to an increase of sub-contracting and therefore an increased width of the network. Simultaneously, the outsourcing leads the loss of direct process knowledge, so the control and intervention into the service provision gets harder [14]. With an increasing degree of complexity the conformity of the main strategic objectives is gaining in importance to avoid additional behavioral oriented steering and control mechanisms.

2.2. Integrated Management System for Global Value Creation Networks

For covering the above mentioned central influencing factors during the whole phases of company cooperation the simple use of enterprise models does not suffice. Therefore, further methods and mechanisms especially for managing relationships and coordination have to be integrated. Here the IEM and its corresponding tools MO²GO and the Process Assistant are offering the required ICT-based support [15], [16]. The strategic sustainability vision of the individual partners as well as the whole GVCN can be created in MO²GO via appropriate advanced views. A specific strategy suite offers the possibility to map decision-chains from the strategic level to the execution of operational tasks and to connect the relating measures for control. This is achieved by integrating the ECOGRAI method [17], in order to elucidate the relationship between sustainability indicators and objectives. The elements of this view are connected with MO²GO classes, so that attribute and indicator values can be evaluated over the entire enterprise model. The approach allows mapping indicators to related objectives. By the connection of the objectives to model elements a consistent and integrated representation is ensured.
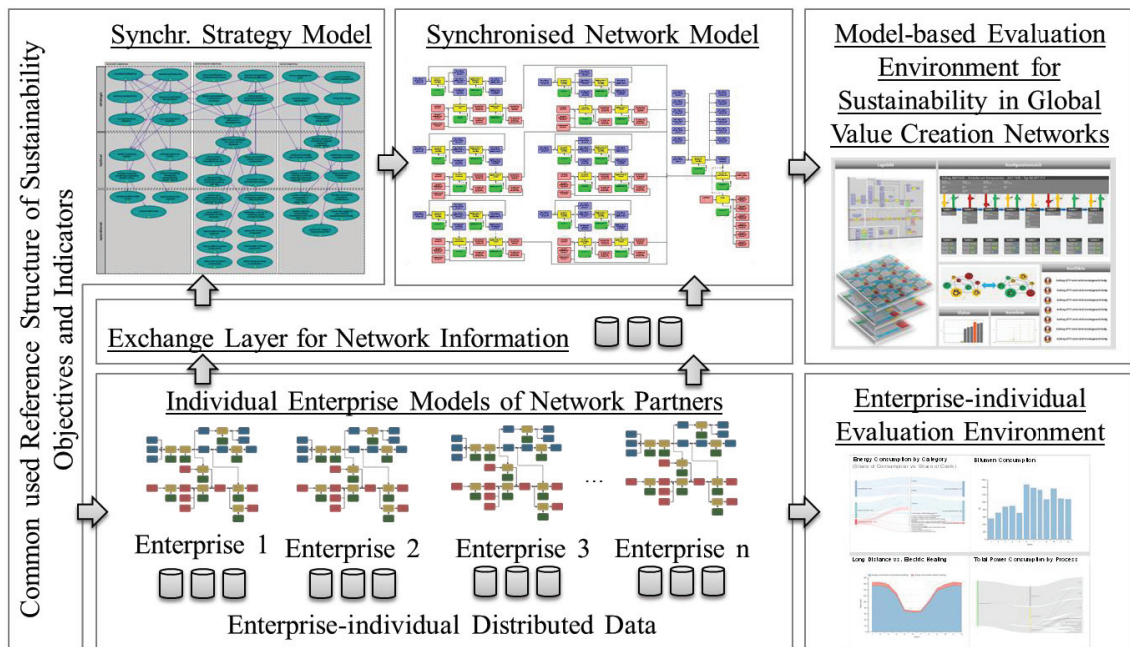

Fig. 2. Architecture of Model-based Planning and Control Environment

The needed information is not directly imported into the model but the source systems are connected so the use of real data within individual evaluation views is facilitated. In order to evaluate the performance against the enterprise and network goals, the partners have to collect and track performance data to fulfill the monitoring demands on both, network and enterprise level. An exchange layer, for network relevant information, ensures same data structure and format. With MO²GO multiple users can work simultaneously, distributed over different companies, on one collaborative network model. With the aid of a flexible client-server-system, MO²GO clients, adapted to the particular modelling task (e.g. for process redesign, target definition or requirements management) are used. The whole architecture of the model based planning and control environment allows a distributed modelling under multi-perspective views (Fig. 2.).

The rising complexity of such an integrated network model requires mechanisms to ensure consistency and an efficient model management. Therefore, a framework for contextual enterprise modelling is applied which provides configurable individual model application and evaluation views [18]. These views are reducing the range of objects to those which are needed by the user for his task. Elements are not only hidden from the view, but also rearranged or presented in completely different way [19]. Based on the enriched network model the Process Assistant acts as the information and communication platform. By using the integrated enterprise modelling and the network model, the Process Assistant creates its content automatically and makes information concerning the business process model available to all users in a HTML-based form via the company's intranet and on network level via internet. The presented components are used for the establishment of an Integrated Management System for Global Value Creation Networks.

3. Multi-perspective Modelling Method for Sustainable Industrial Value Creation – A Use Case

The use case, described in this chapter has been performed in the context of the Collaborative Research Centre SFB 1026 – "Shaping Global Manufacturing Sustainable Value Creation". A network of seven companies for producing a sustainable Smart Urban Wheeler [20] has been established to test the method. During the investigation a network model, containing the main components (seat, wheels, frame, fork, caliper brake, pedal set) and their assembly, has been created based on the existing method IEM (Fig. 3). The multi-perspective modelling method covers the whole process from strategy building, planning of measurements to the evaluation of a global value creation network configuration. Thus, the following section concentrates on the extensions of the IEM and is showing its functionalities.
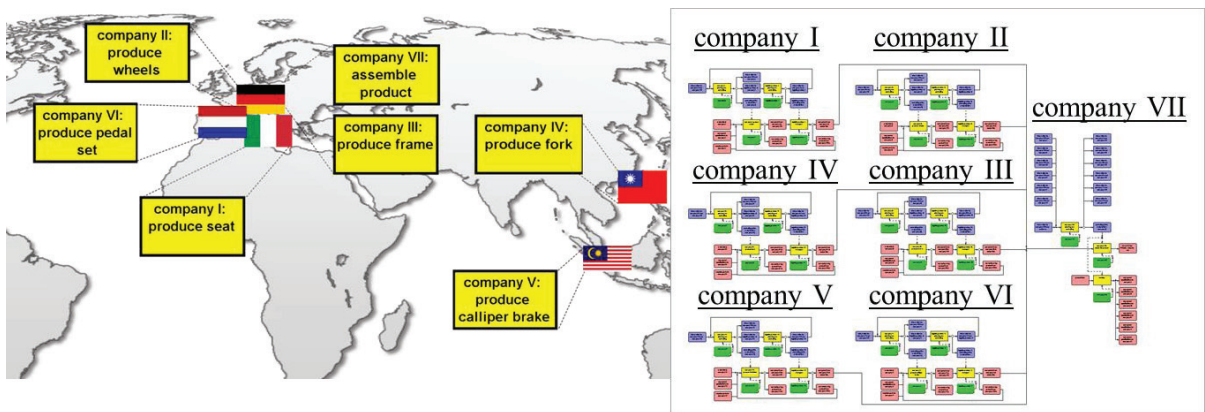

Fig. 3. Global Value Creation Network for Smart Urban Wheeler

3.1. Usage of Multi-perspective Modelling Approach

In a first step an objective map (Fig. 4. (a)) for the designed network, supported by the integrated strategy suite, was defined. The intuitive graphical user interface was used to describe sustainability objectives for the economic, environmental and social dimension as well as for strategic, tactical and operational realization level. In an interdisciplinary workshop an initial set of 44 objectives was built up in collaboration with several partners of the CRC. Based on the developed strategy, a set of indicators for the measurement of target achievements was derived and described for the set objectives. Several existing indicator systems regarding sustainability (e.g. VDI 4070 [21], ISO 14031 [22] or the Benchmark index [23]) and the ones developed within the CRC [24], [25], [26] were assessed for measuring the target achievement. The derived set of indicators was subsequently connected to the sustainability objectives for the alignment of their internal relation (Fig. 4. (b)).
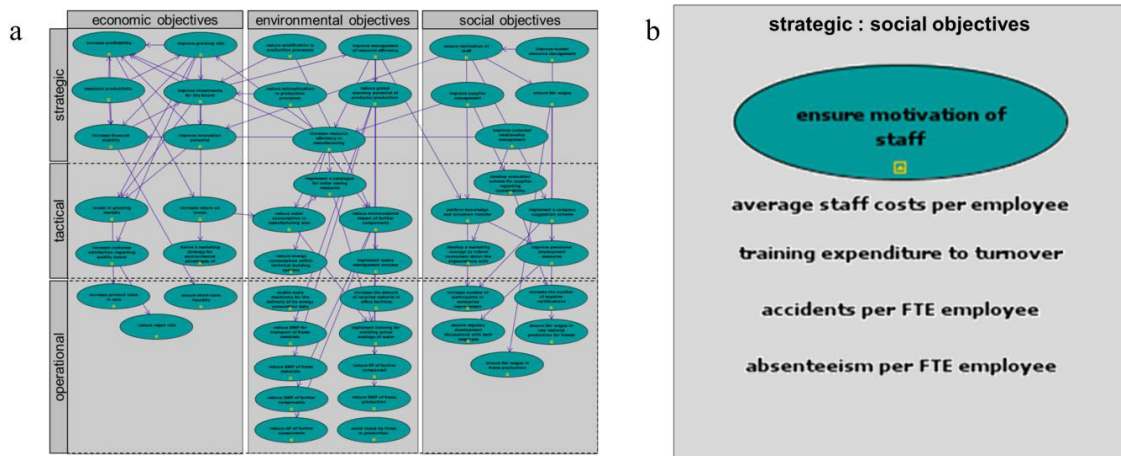

Fig. 4. (a) Structure of the Objective Map; (b) Exemplary Objective with attached Indicators

After the objectives and indicators are connected via the strategy suite, a further mapping of objectives to enterprise objects (e.g. process steps, machines, products or buildings) of the network model was performed. Here the relevant sustainability targets were set in relation to the individual model elements of every network actor. These relationships are then used to derive the evaluation views for the individual roles within the network structure. With a set of reference datasets, from the different disciplines within the Collaborative Research Center, an initial database for the evaluation was established. Thus, the enriched integrated network model could be used to represent the results in the model-based evaluation environment (Fig. 5.) [27].
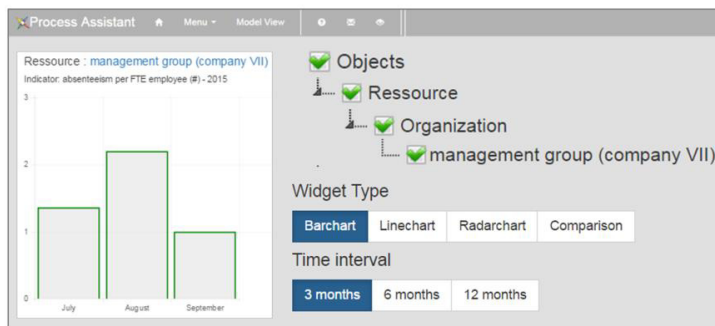

Fig. 5. Model-based Evaluation Environment (Cockpit Configurator)

This web-based network management tool called Process Assistant uses the information (objectives, indicators, model elements and data) of the enriched enterprise model and its relation for a contextual (e.g. role-based, objective-based or resource-based) derivation of several evaluations. In the example shown in Fig. 5 the user is part of the management group of company VII. By choosing this model element as part of the organization a list of elements related processes, objectives and indicators occurs. In that case the user chooses the indicator absenteeism per FTE (foul-time-equivalent) employee as a bar chart for a time interval of three month. The implemented management cockpit immediately delivers this evaluation based on the connected data. Along this path an individual dashboard with enterprise-related as well as network-related can be configured easily by every individual user as introduced in the architecture of the model-based planning and control environment (Fig. 2). A role-model is used to identify the model-elements for which a user is authorized.

3.2. Lessons Learned

As shown in the use case the description of environmental, social or economic relevant content with the relating processes or resources enables new evaluations and cause-impact analysis, e.g. which process impacts the environment most. The approach requires a higher effort especially in the beginning by synchronizing the strategies of the network partners into a common and measureable objective system. But, after this step the integrated model represents the common information backbone for further communication within the network by providing transparency and an integrated core of information. Nevertheless there is still a drawback for an intuitive collection of data especially in the operational phase of such network constructs. This could be compensated by smart instruments supporting the mapping and collection.

4. Conclusion and Outlook

The integrated modelling platform enables stakeholders in Global Value Creation Networks to collaborate. Especially the network engineers can benefit from getting transparency about cause-impact relations through task-oriented modelling clients. Moreover, the stakeholders get decision-relevant information through individual context-sensitive sustainability evaluation views. The arising network complexity gets manageable through the model-based contextual management system. Furthermore, the issue of sustainability has become a key factor of entrepreneurial activity. The operational steering and control mechanisms of the enterprise performance under sustainability aspects do not keep pace with this development [28]. A major obstacle to the realization of sustainability objectives like energy and resource efficiency or preventing child labor in GVCNs is the complexity of the integration of heterogeneous roles and organizations involved. There is for example no transparent consensus about what kind of information must be provided on a regular basis to the GVCN by the various stakeholders throughout the product life cycle and where this information can be generated [29]. Reference solutions for the integration of all roles acting from the strategic to the operational level are not yet available. However, this integration is the necessary prerequisite for the realization of innovative sustainable service offerings. This gap could be closed by the extension of the multi-perspective modelling approach for sustainable industrial value creation to an integrated steering and control instrument for assessing and increasing sustainability in GVCNs.

Acknowledgements

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