KPIs to Manage Innovation Processes in VEEs – Initial Thoughts and Results

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Abstract. While enterprise collaboration has become a significant factor to achieve business success, the distributed structure of virtual enterprise environments still carries new challenges towards successful operation of business processes within these networks. As one group of business process, innovation processes do challenge virtual enterprises to a much higher degree, because new products and services are target point. This paper discusses the utilization of key performance indicators to enable and to support the continuous flow of information between the collaborators. They are essential towards successful innovation processes and their usability in managing these processes. As the predicted impact and outcome are essential factors, the manageability of ongoing innovation processes decreases with its rising innovative potential and level of uncertainty. The performance indicators raised by each enterprise of the network are highly divertive. This presents another challenge to the management of these distributed innovation processes, which may be met by partial unification and ICT based communication platforms.

Keywords: Key performance indicators, virtual enterprise environments, systematic business innovation, uncertainty levels of innovation processes

1 Introduction

As one of the first researchers Josef Schumpeter described the innovation term by discussing the impacts of newly combined processes and products on the balance of the economic markets [1]. A second line of research was discussing the diffusion of innovation paradigm raised by Rogers and gained a lot of attention [2]. Since then, research on innovation constantly gained influence and became a concept of interest for both, business managers and economists. The competition within the global market forces enterprises to shorten and improve their development processes and innovation cycles [3-4]. Providing innovative products and services, which address current customer needs, is a key factor to business success for most enterprises (e.g. Apple, Google).

To meet current market needs, enterprises have to connect each other in networks. This may provide single enterprises with the ability to extend their products, include competencies of other enterprises or simply to expand their production volume. Be-

cause these collaborations are constantly gaining importance, new challenges raise by managing their distributed processes [5].

Combining these issues, the challenge of managing innovation processes within enterprise networks appears. Regarding this task, supporting communication flows and monitoring the performance of innovation processes gain significant value. A possible approach is the utilization of key performance indicators (KPIs) to measure the performance of systematic business innovation processes in virtual enterprise environments. Initial thoughts and results covering this approach are described within this paper. Section 2 introduces the concept of Virtual Enterprise Environments and the levels of uncertainty regarding innovation processes. Section 3 highlights the application of Key Performance Indicators on Innovation management. Finally a short discussion and conclusions summarizes the paper.

2 Approaching Systematic Business Innovation in Virtual Enterprise Environments

2.1 Terminology and Concept of Virtual Enterprise Environments

The idea of networking is based on the collaboration of independent enterprises aiming at taking different advantages, while maintaining their individual independency [6]. The rising challenges for collaborative networks to maintain their ability to compete have led towards a broad field of research concerning collaborations. Higher demands in product complexity and rising market intensity have led from hierarchical, single organisations over strategic alliances and modular organizations to virtual enterprise environments. This also led from mass-production, standardized services and fixed hierarchical structures to the implementation of task-oriented ad-hoc collaborations. This high level of dynamical behaviour is influencing the connections and behaviour within a VEE [7].

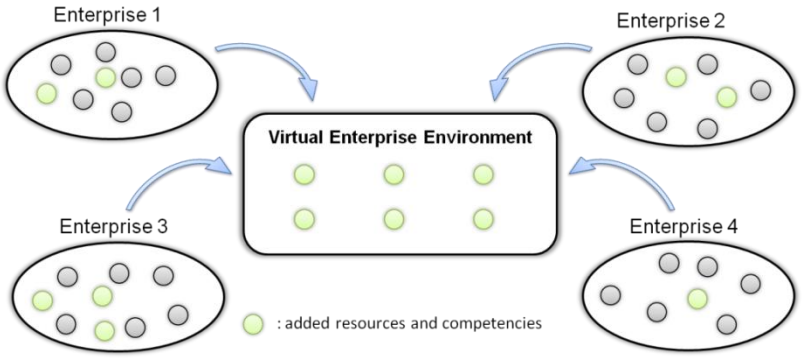

Fig. 1. Assembling a Virtual Enterprise Environment, similar in [8]

Regarding the fuzzy-terms of virtual organisations and virtual enterprise environments in particular, no clear typology can be identified [9], although some authors

have suggested quite a few definitions of different network types [10]. Various variants and manifestations of collaborative networks have appeared during the last years [11]. However, virtual organisations shall be perceived as the collaboration between organisations in general and virtual enterprise environments as the collaboration between enterprises, as sketched in **Fig. 1**. Here four enterprises bundle resources, competencies and relationships within a virtual enterprise environments.

2.2 Systematic Approach Towards Innovation

While business innovation itself is a widely used and fuzzy term [8], only few widely accepted models, approaches and tools have been developed [12]. Especially little research work is available concerning business innovation in enterprise collaboration, such as [8, 13-14]. A summary of the existing approaches is composed by Kotelnikov [15]. Service innovation has been added by the authors as an individual new area. As shown in **Fig. 2**, it is comprised of eight interwoven areas. This concept is called "systematic innovation", due to the inclusion of the most important approaches to the topic of business innovation. This integrated view will be developed within further research.

Fig. 2. Systemic approach to innovation - eight interwoven areas (adopted from [8, 15])

The focus will be put on product, service, process and technology innovation, as these areas have a more direct connection to the manufacturing within the VEE and their performance is therefore easier to monitor. On the other hand, the impact of marketing, strategy or organizational innovation is less tangible, long-ranging and difficult to quantify.

2.3 Business Innovation and Level of Uncertainties - Exemplary Concepts

One approach to categorize innovation activities is to apply different areas of uncertainty (inspired by [8]). **Fig. 3** shows the different levels of uncertainty for incremental, market, technical and radical innovation concerning market and technical uncertainty by positioning them within the displayed grid. The incremental innovation

can merely be perceived as the improvement of existing structures, since it implies rather small changes of existing structures and therefore contains a small amount of uncertainty. The market and the technical innovation include more significant innovation, which has a bigger impact on the market or the technical environment and therefore contains higher uncertainty. A radical innovation carries a high amount of uncertainty in both areas.

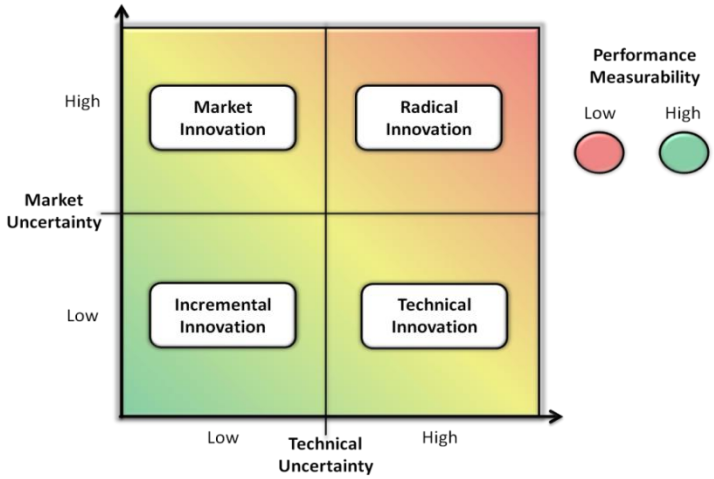

Fig. 3. Areas of uncertainty influencing the performance measurability of innovation processes, inspired by [8]

This grid can be applied to analyze the performance measurability of innovation processes. Measuring the performance of ongoing innovation processes demands the ability to predict its output and to monitor its impact. This performance measurability directly decreases with rising uncertainty. Therefore it is in principle possible to measure the performance of incremental innovation, since these changes apply on existing structures with existing measurement routines. Measuring the performance of radical innovation on the other hand, is a significantly more challenging task, since the outcome of these processes is usually unexpected and their impact is not to be predicted.

3 Applying Key Performance Indicators on Innovation management

3.1 Key Performance Indicators to Measure Process Performance

A broad range of approaches to evaluate process performances in general have been developed, following the raising importance of VEEs. An overview on the evolution of the main approaches is given in **Fig. 4**. It sorts them by their comprehensiveness and time of development. Key performance indicators (KPIs) as tool to measure process performance have gained massive attention during the last decade [16]. A collec-

tion of KPIs is integrated into the Value Reference Model (VRM) of the Value Chain Group. KPIs are also used to manage supply chains and existing approaches connect them with the SCOR model [16]. Another relation can be identified towards the balanced scorecard, as many enterprises apply KPI scorecards within practice [17].

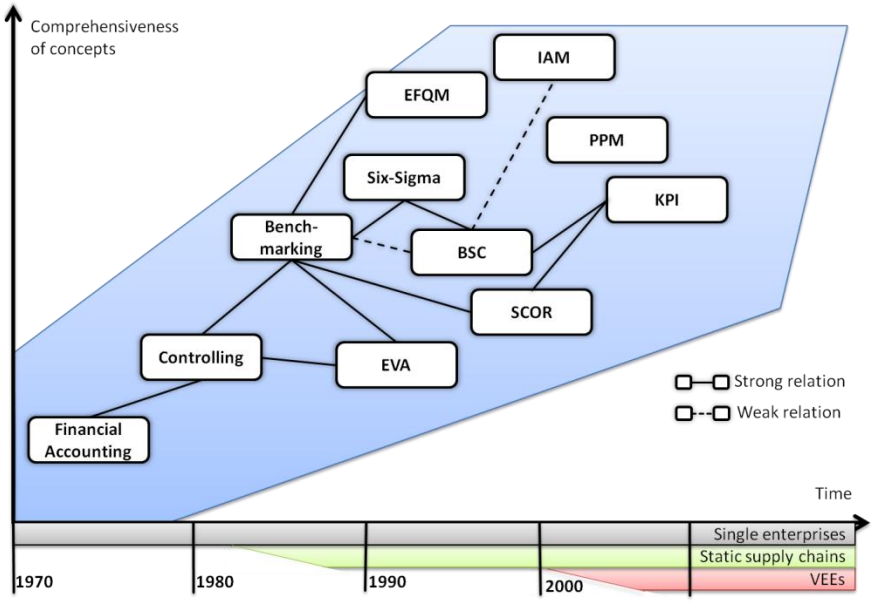

Fig. 4. Performance measurement approaches (similar in [18])

Key performance indicators are a type of performance measurement. They are usually used to evaluate the success of an organisation or an activity, which they are related to. Opposed to the stage-gate approach, which are oriented towards the achievement of milestones, key performance indicators can be used to measure the performance of repetitive tasks. For example, these KPIs can be the error rate within a production process or the rate of satisfied customers.

The selection of the right KPIs is an important issue regarding the comprehension of the needs and weak points of an organisation. The selection of which KPIs are important depends on the organisation and the branch or the market the organisation reaches for. Due to the importance of identifying the right KPIs, this selection process has to be supported. This happens usually by applying management tools, such as the balanced scorecard and is often related to business improvement processes. Following, we will discuss the concept of KPI and the applicability in the context of VEE.

3.2 Discussion on KPIs to Monitor and Manage Innovation and Improvement Processes in VEEs

The success of incremental innovations and business improvement processes can directly be measured by monitoring KPIs that represent the efficiency of the improved

processes and the business itself. These KPIs vary regarding the subject of the process and their selection is a challenging task. Nevertheless their general attention and the success of concepts like continuous improvement processes (CIP) and its approaches to evaluate process performance show that measuring business improvement can already considered state of the art.

Table 1. KPIs adapted from the Value Reference Model (VRM) for systematic business innovation

Number of new ideas.	**Number of new ideas.**	**UoM**
Idea Yield.	The percentage of ideas accepted into concept development.	%
R&D Investment Ratio.	Percent R&D resources/investment devoted to new products.	%
Expected Commercial Value.	This equals the net present value of product cash flows multiplied by the probability of commercial success minus the commercialization cost. This is multiplied by the probability of technical success minus the development costs	$
Number of Ideas in Pipeline	Number of ideas/proposed products in the pipeline or the investigation stage (prior to formal approval).	#
Product Innovation Index	Number of new, innovative, or upgraded product features distinguishable from the previous product.	#
Design Effort	Average number of engineering man-months for each design released to production. This ratio shows the resources required	time

Despite approaches to measure the quality or maturity level of ideas and knowledge (compare the MATURE1 project), no directly applicable tools to measure the performance of innovation processes could be identified. Regarding more uncertain types of innovation, the development of KPIs becomes significantly more difficult. This is caused by the huge impact of creativity and intuitive thinking, which can hardly be quantified by applying KPIs. Another barrier towards the application of KPIs is the previously described market or technical uncertainty influencing the ability to monitor innovation processes. Without an idea of the estimated outcome of the innovation process and its impact on the market, defining KPIs becomes rather difficult. However, some general KPIs provided by the value reference model (VRM) can be

[1] http://mature-ip.eu/

adapted as initial step forward. A selection of the most suitable KPIs towards systematic business innovation is listed in **Table 1**. This list may be extended by KPIs measuring the estimated risk of the innovation due to technical and market uncertainty.

Due to the distributed structure of a VEE, the innovation processes of a VEE also differ from those within single enterprises. The ideas and information usually circulate between geographically distributed units. Since the VRM provides a framework for the management of value chains, it can partly be used for innovation management in VEEs. However, this adaptation requires elaboration that will be addressed in further research.

Since VEEs are comprised of diverging enterprises that house different processes and follow individual strategies and paradigms, the relevant KPIs to each enterprise will vary as well. This makes the management of the collaborative innovation processes a very demanding challenge. To overcome this challenge, complying with a set of core KPIs within the VEE may be necessary. Moreover, an ICT based platform needs to be applied, which enables and supports the communication within the VEE and monitors the KPIs of the distributed innovation processes.

To utilize a KPI for managing an innovation process, information about its subject and position within the process has to be provided. The information related to each KPI should be: Name, description, unit of measurement, calculation formula, information about relations (related innovation process and process owner) and Range of values (green zone, yellow zone, red zone).

4 Discussion and Conclusion

The elaboration of KPIs for business innovation in VEEs is in its infancy. As already shown, the definition of KPIs is easier if the level of uncertainty is lower. Secondly the dynamic VEE makes it even more difficult to define KPIs. It is much easier if KPIs are defined for relatively stable business environments, as these environments allow a better understanding of the other enterprises. Nevertheless, complying with common core KPIs may be necessary. For proper management of the distributed innovation processes, an ICT based platform should be applied, which allows the monitoring of the relevant KPIs and supports the communication regarding the innovation process within the VEE.

Regarding the state of the art towards business innovation and business innovation it can be noticed, that key performance indicators (KPIs) are already utilized to manage and monitor business improvement processes. One important factor to consider is that different selections of KPIs may suit to each enterprise. It has to be pointed out that these KPIs can already differ significantly within enterprises of the same branch.

Nevertheless, the management of business innovation processes instead becomes a lot more difficult. Since key elements like creativity and innovative thinking can hardly be measured and quantified, alternative indicators have to be used. The value reference model (VRM) provides a broad basis to select possible KPIs regarding the systematic business innovation. A possible selection made out of these KPIs has been listed in **Table 1**.

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