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A Performance Measurement System For Global Manufacturing Networks

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Abstract

New developments coming along with globalisation increasingly force companies to realize efficient global manufacturing networks (GMN). Current research offers abundant methods aiming at the configuration of GMNs. However, less attention is paid to identifying the need for adapting existing networks and the comparison of enhanced network configurations. In other fields, like for example logistics, performance measurement systems (PMS) are applied to accomplish these tasks. This paper therefore seeks to support the improvement of network configurations by providing a PMS for GMNs.

In the course of this research existing PMS are reviewed and a multidimensional evaluation is carried out. The system with the best fit is chosen and transferred to the field of GMNs. Subsequently, performance attributes are deduced from a strategic and operational point of view based on a literature review as well as the application of concepts known from life-cycle-management and systems theory. The proposed PMS is validated by an industrial case study.

The results of the multidimensional evaluation show that the concept of selective key figures that is known from the field of logistics has the best fit to serve as a basis for a novel PMS for GMNs. The transferred PMS consists of metrics evaluating the strategic success factors of GMNs like flexibility and delivery reliability on the one hand and possible operational bottlenecks like complexity on the other hand. The validation of the PMS in a real life environment shows that it contributes to overcoming the identified gap in the literature and supports practitioners in the process of enhancing GMNs.

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Keywords: Global Manufacturing Network; Performance Measurement System; Strategic Success Factors

1. Introduction

1.1. Motivation

Manufacturing companies face increasingly competitive and volatile environments due to the inexorable progress of globalisation during the last decades [1,2]. New developments like the global mobility of people, decreasing communication and transportation costs and the reduction of customs as well as trade restrictions enable companies to realise efficient global manufacturing networks (GMNs) in order to be prepared for the upcoming challenges [3,4].

The network configuration development as a decision process follows the generic sequence of formulating the problem, specifying the target system, investigating the action alternatives, selecting one alternative and making decisions during the implementation phase [5]. While research focusses on the overall network configuration development as well as the single steps of the decision process less attention is paid to the starting point of the configuration of GMNs - the identification of the need for action or as it is formulated by the Institute of Manufacturing of the University of Cambridge: “Why is it necessary to evolve the manufacturing network?” [6]

The answer to this question necessitates a continuous monitoring of the forecast for the key performance indicators that are used to evaluate the existing manufacturing network. The aim of this research therefore is to support the identification of the need for evolving a manufacturing network by providing a Performance Measurement System (PMS) that is ”defined as the set of metrics used to quantify both the efficiency and effectiveness of actions“ [7]. As metrics have to be defined individually by each company in order to consider individual requirements [8,9] the PMS shall not be formulated by providing a list of predetermined metrics but by defining relevant evaluation dimensions that need to be covered by individually definable key figures.

1.2. Structure of the Paper

The paper is arranged as follows. The literature review provides an analysis of the state of the art concerning PMS for

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GMNs as well as the identified research gap. The third section is used for the description and comparison of existing concepts for PMS as well as the selection of the concept with the best fit for the evaluation of GMNs. Sections four and five contain the deduction of key figures from a strategic respectively operational point of view followed by the resulting PMS in section six. The description of the application of the PMS in an industrial case study and the conclusions close the paper.

2. Literature review

2.1. Structure of the state of the art

Existing literature dealing with performance measurement of GMNs and - in a larger context - of supply chains is vast. The relevant research can be classified in two categories. The first one contains methods to examine performance measurement aspects in the context of the configuration process of GMNs. Models that are belonging to the second category in contrast exclusively focus on performance measurement of GMNs.

2.2. Integrated Performance Measurement Approaches

Relevant integrated performance measurement approaches are provided by Liebeck [3], Varandani [10] and Herm [11]. Liebeck [3] presents a market- and resource-oriented network design model that emanates from the market service of a company with respect to the customers point of view. The cost-side of the company is considered by a process-oriented modelling and monetary evaluation of the necessary production steps. With this approach Liebeck [3] combines the external market view with the internal business-management view.
Varandani [10] proposes a multi-stage network configuration process model starting with a single objective mathematical model that optimizes the total landed costs. By varying the input parameters a set of possible network configuration alternatives is created. These solutions are evaluated with respect to the resulting management complexity of the network in a second step. By this means Varandani [10] expands the strategic point of view of the network configuration by an objective considering the operational practice.
Herm [11] uses so called business capabilities for the configuration of GMNs. The definition of capabilities results amongst others from the analysis of relevant value-adding processes for the manufacturing of a product. In this respect Herm [11] attributes more value to the product than comparable approaches. For the evaluation of network alternatives Herm [11] comes back to the four main dimensions of business objectives cost, time, quality and flexibility as suggested by De Toni & Tonchia [12].

2.3. Stand alone Performance Measurement Approaches

Besides the integrated consideration of performance measurement, literature provides models focussing the design of PMS relating to GMNs.
Ude [13] postulates that performance measurement approaches need to be independent of the method how a network configuration alternative is generated in contrast to the integrated evaluation models. He proposes a multi-stage procedure that combines the quantitative evaluation by means of a simulation model and qualitative aspects by the application of the multi-criteria decision analysis method PROMETHEE. The main considered qualitative objectives are costs and throughput time. Furthermore, the approach includes methods to analyse the robustness of possible network configuration alternatives. By applying PROMETHEE supplemented by Monte Carlo simulations and sensitivity analysis Ude [13] shows a clear focus on the preparation of a decision for one alternative by providing an in depth analysis and comparison of possible solutions.
Krebs [14] proposes an approach for the cross-linked site selection with respect to multidimensional uncertainties. The modelling of qualitative uncertainties is carried out by means of fuzzy set theory. The Market Value Added represents the main objective. With the clear focus on site selection Krebs [14] covers one aspect of the holistic evaluation of GMNs in depth.
Chan [15] presents both quantitative and qualitative performance measurements for supply chains. While quantitatively a classification is conducted in cost and resource utilisation the categories quality, flexibility, visibility, trust and innovativeness are distinguished qualitatively. In order to prioritize the performance measures the analytic hierarchy process (AHP) is applied. However, the metrics are a conglomeration that is not integrated in a framework that describes the performance of a supply chain out of multidimensional views. [15]
This shortcoming forms the starting point for the framework for supply chain performance measurement proposed by Gunasekaran et al. [8]. Their framework is spanned by the four major supply chain activities plan, source, make/assemble and deliver on the one hand and the management levels strategic, tactical and operational on the other hand. For each combination of supply chain activity and level of management performance measurement metrics are provided. The proposed framework is a mapping of responsibilities and company departments. Multidimensional perspectives like the financial aspects or the customers point of view that need to be covered by the performance measurement metrics are not considered. [8]
Bhagwat & Sharma [16], Richert [17] and Giese [18] try to overcome this deficit by developing a PMS for supply chains on the basis of the Balanced Scorecard (BSC) concept. Representative for these PMS a closer look is taken at the concept of Bhagwat & Sharma [16]. They assign the proposed metrics of Gunasekaran et al. [8] to the four perspectives of the BSC: financial, customer, internal business and learning & growth [21]. Hereby a comprehensive PMS has been created for the measurement of strategic supply chain performance. The authors recommend future research in order to examine whether the four perspectives of the BSC and the listed metrics are adequate to analyse the performance of a supply chain.
Beamon [19] took a similar approach and developed a PMS for supply chains with the focus on strategy. The performance measurement types resources, output and flexibility are considered. The first dimension contains cost metrics, the second customer service aspects and the third one the ability to change. It needs to be emphasized that this PMS formed the basis for a multi-objective optimisation model for supply chain planning [20]. Hence, a connection between the PMS and supply chain design has been established. However, the developed PMS on the basis of the BSC appear more balanced as they include the dimensions proposed by Beamon and beyond that consider additional aspects.