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Target system based design of quality control strategies in global production networks

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Abstract

Increasing globalization drives companies to produce in global networks, where each site acts autonomously according to its individual target system, influenced by specific location factors or its defined specialization. Despite distributed value creation processes, the overall production quality must be ensured. Hence, a simulation-based approach is presented, which allows for designing an optimal across-site quality control strategy by evaluating different quality measures depending on individual target systems of different sites. At first, a categorization of quality measures and an applicable target system model are presented. Secondly, a simulation approach is described to evaluate implemented measures according to defined performance indicators.
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1. Introduction

In order to gain competitive advantages in an environment of growing global competition and increasing globalization of sales and procurement markets, companies are distributing their manufacturing activities in global production networks [1]. They increasingly focus on their core competences and specialize for example concerning manufactured products, the supplying market or the processes carried out [2]. Hence, global production networks consist of own corporate sites as well as locations of external partners and suppliers exchanging a wide range of materials and services. Therefore, it can be concluded that competition is no longer fought between individual companies but between competing networks [3].

Additionally, depending on the specialization and the respective location factors (e.g. available process technology, factor costs, infrastructure), a strategic role in accordance with the respective company strategy is often assigned to the individual actors in the production network [4]. This role defines a specific target system, according to which each site acts autonomously and defines individual production related improvement actions. This leads to mutual interdependencies, target conflicts and asymmetric information distribution among the different actors [5]. Given this context, the management and control of production networks is a growing challenge for companies [6]. Especially the decentralized decision-making structures and processes, which follow the individual target systems, cause difficulties identifying realizable and expedient control and improvement measures.

The assurance of exceptional production quality along the whole product engineering process in the network leads to special challenges in this context [7]. Despite the involvement of many partners with divergent target systems, the required quality of the final product must be ensured with minimum cumulative quality and testing costs, as such activities are not perceived as value adding by customers [8]. Currently, quality control strategies completely focus on the considered process without adequately regarding the specific site role. Moreover, the impact on the individual target system of each actor in the production network is neglected. Thus, quality control measures may not be implemented after an intra-site analysis, even though they would have a positive effect in a holistic view of the production network. In addition, due to the asymmetric information distribution, redundant measures may be carried out at different sites, which leads to significant inefficiencies in the production network.

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Therefore, this article presents an approach, which enables globally operating companies to design an optimal across-site quality control strategy purposefully by evaluating different quality measures depending on individual target systems of different sites. Hereafter, the relevant state of the art in literature is discussed. The designed methodology is presented in chapter 3. Finally, chapter 4 concludes with a summary.

2. Foundations and state of the art

2.1. Target systems in global production networks

Targets are ideas about desired states of a company that should occur as outcome of implementing measures. In a target system, hierarchical in nature, sub-goals are aligned with overall company targets. The sub-goals may be neutral, complementary or adversarial and can be operationalized using Key Performance Indicators (KPI) as compressed metrics [9]. Target systems of individual actors in production networks are influenced by the strategic orientation of the company and activities for coordinating the supply network. Within a company's target system, different hierarchy levels are distinguished. At the highest level, corporate objectives are defined, then divisional or business unit objectives, followed by objectives of departments, and position or station targets [10]. In order to differentiate target systems on a business unit level especially regarding manufacturing or purchasing as link to other partners in the production network, different plant or site roles are described in literature.

From the internationalization motives of globally operating companies, Weber derives four types of sites: resource-oriented, market-oriented and innovation-oriented locations as well as lead plants [11]. Resource-oriented sites produce high lot sizes and a low number of variants. They focus on minimizing production costs while considering time and quality efficiency. Market-oriented sites aim at fulfilling regionally specific customer requirements. They are located in major sales regions, because a customer-oriented expertise is important. Innovation-oriented sites aim at developing innovative products, manufactured as prototypes or in small series. Research and development expertise as well as high capabilities of local suppliers are required. Lead plants have executive functions regarding products or core processes, so they are mostly located in industrialized countries.

Ferdows classifies site roles based on the site competence and the strategic goal of the site [12]. As site competence, he defines the scope of technical activities beyond production, such as procurement activities, supply network management, or process and product development. Related to the strategic goal, three main objectives are differentiated: low production costs, capabilities and knowledge as well as market proximity. Offshore and source factories focus on low-cost production with higher site competences at the source factory. The main objectives of lead and outpost factories are capabilities and knowledge. In lead factories, new products, processes and technologies for the entire company are continuously developed. The main task of outpost factories is to collect information about customers, suppliers and competitors. Finally, the strategic goal of server (low site competence) and contributor factories (high site competence) is market proximity in order to serve national or regional markets.

Vokurka and Davis classify factory types according to existing production facilities in standardizers, customizers and automators [13]. Standardizers produce high volumes with low product, material and customer diversity. Their facilities are set to standard output and markets. In contrast, customizers manufacture low volumes but in high diversity of variants for many different types of customers, which requires high process flexibility. Automators produce high volumes but with high product diversity at the same time.

Wiendahl, Reichardt and Nyhuis define six types of factories according to the perception of the market: high-tech, low-cost, variant flexible, customized, responsive, and volume flexible factory [14]. Innovative products and technologies at the highest process quality characterize the high-tech factory. Due to the high proportion of innovations delivery times, costs and variant diversity are not in focus. In the low-cost factory, mature products are produced in high lot sizes and few variants with the objective of continuous cost reduction. The variant flexible factory has the strategic objective to supply the market demand with customized products. Due to the high variety of products, the focus is on changeability and learning speed of the factory. Quality plays a subordinate role. The customized factory is an extended form of the variant flexible factory, but the focus is the manufacturing of customized products, with the aim to satisfy the customer in terms of cost, time and quality requiring a high degree of changeability. The responsive factory focuses on the dimension of time, in particular in minimizing the lead-time. By high-performance logistics, rapid availability of the products at the customer can be ensured. The volume flexible factory can serve the fluctuating demand by varying lot sizes. For this purpose, a high degree of flexibility and a low level of automation are necessary.

2.2. Quality control in global production networks

The topic of quality control in global production networks is a relatively young research field. Robinson and Malhotra note in their literature analysis that the work so far separate between intra-organizational quality management and inter-organizational coordination in production networks and state the necessity to integrate these parts [15]. Fish demonstrates in a case-based analysis the positive influences between quality management and coordination of production networks and identifies measures from product development to service. Improved lead times, flexibility and delivery reliability by reduced process variation as well as a reduction of stocks and unnecessary transport (transport of defective parts) by lower scrap rates are discussed as main positive influences [16].

Liu and Hipel present a decision model for selecting optimal quality control strategies for supply chains of complex products [17]. The approach consists of a framework model, the House of Supply Chain Quality (HSCQ), based on the concept of the Quality Function Deployment (QFD) methodology. Affected modules or components are combined with suitable but unspecified quality measures. The resulting quality control strategies are characterized using the described

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