A holistic model for international manufacturing network management

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Abstract

This paper presents a holistic model for the management of international manufacturing networks. It focuses on the relation among the decision dimensions strategy, configuration and coordination. Based on an extensive literature review, a conceptual model is presented. The model has been validated multiple times. Its applicability is demonstrated in this paper along of an illustrative case study. We contribute to the literature on manufacturing strategy and especially the new paradigm of manufacturing networks addressing the lack of management tools in this field. Findings are limited by the narrow body of knowledge about the diverse field of manufacturing network management.

Keywords: Manufacturing, network, holistic, fit

Introduction

Managers need "analytical views and contingent thinking […] in order to make relevant decisions about the transformation of the manufacturing network" (Cheng et al., 2011, p. 1328). A manufacturing network is defined as a group of geographically dispersed factories of one multinational corporation that holds responsibility and control over those factories and defines a certain style of organisational structure for them (Cheng et al., 2015; Colotla et al., 2003). Providing models and analytical tools for the management of such networks is especially relevant for practitioners and academics. This is due to the ever increasing importance of globally dispersed manufacturing activities (UNCTAD, 2014) and due to the shift towards a new paradigm of research focussing on such networks (Cheng et al., 2015; Ferdows, 2008; Ferdows et al., 2016).

Researchers have already contributed to some of the network-specific questions regarding the management of an international manufacturing network (IMN). Those either address network strategy (e.g. Miltenburg, 2009; Rudberg and Olhager, 2003; Shi and Gregory, 1998), network configuration (e.g. Meijboom and Vos, 1997; Pontrandolfo and Okogbaa, 1999; Shi et al., 1997), or network coordination (e.g. Pontrandolfo and

Okogbaa, 1999; Rudberg and West, 2008). Especially configuration and coordination are highly interdependent (Cheng et al., 2015; Hayes, 2005; Rudberg and Olhager, 2003). However, there is rare integrational research for IMN management, thus research has widely missed to integrate the two interdependent decision dimensions network configuration and coordination (Cheng et al., 2015; Hayes, 2005; Rudberg and Olhager, 2003). Furthermore, there is a lack of management tools regarding international manufacturing networks (Ferdows et al., 2016).

Accordingly, our guiding research question is: How does a holistic model for IMN management have to be designed? We especially focus on the relationship among the decision categories of the IMN.

The model we propose allows the integration of yet isolated and individual network decisions into an overall network model. This facilitates management of IMN and provides a framework for further research. Researchers can use the model to systematically investigate decision making in issues relevant for IMN. Further, our model is a starting point for evaluating the interdependencies of strategy, configuration, and coordination in different contexts (e.g. different industries). Motivated by system theory and a cybernetic perspective on management problems (Bleicher, 2004), we derived a conceptual model from literature. It links research on manufacturing strategy and IMN with contingency theory (Christiansen et al., 2003; Drazin and Van de Ven, 1985; Stobaugh and Telesio, 1983). We tested the model in two empirical quantitative studies and in 10 in-depth case studies over time, of which we use one case study to illustrate its applicability in this paper.

The paper is structured as follows: First, we provide a very brief review of the literature on the relevant topics business and manufacturing strategy, network advantages, network configuration and coordination, and the fit among those topics. Second, we present our conceptual model for IMNs, followed by an illustrative case. Eventually, we will close this paper with a discussion of our findings, followed by our conclusion.

Literature review

Business strategy

The business strategy is "the plan used to establish a market position, conduct operations, attract and satisfy customers, compete successfully, and achieve its goals" (Miltenburg, 2005, p. 215). According to Miltenburg, business strategy also gives information about the importance of manufacturing outputs on network and factory level. The content of business strategy comprises different goals for the company like financial, growth or social goals. Further, it gives information about the products produced and markets served by the company. This includes defining market segments and product lines. Eventually, the business strategy defines how the functional areas must cooperate to achieve desired competitive advantages (Miltenburg, 2005). This is especially important since other functions than manufacturing also have an impact on competitive capabilities (Koufteros et al., 2002). From business strategy, the functional strategies are derived subsequently and hierarchically with the goal to support the business goals (Fine and Hax, 1985; Mills et al., 1995; Miltenburg, 2005, 2009).

Manufacturing strategy

The extant body of literature on manufacturing strategy can be divided into content-related and process-related work; the prior addresses issues like competitive priorities, manufacturing capabilities, and strategic choices, whilst the latter covers patterns or procedures of developing and implementing manufacturing strategy (Dangayach and Deshmukh, 2001). We focus on the prior one to identify relevant factors for our model.

Manufacturing strategy is a key element of an organisation's strategy (Chatha et al., 2015). It makes a statement about the task of the manufacturing function (Skinner, 1978) and thus helps deriving a competitive advantage from manufacturing (Skinner, 1969). This formulated goal is directly linked to and derived from the business strategy (Koufteros et al., 2002; Rosenzweig and Easton, 2010; Wheelwright and Hayes, 1985) and provides information on how a company uses its assets and prioritises its activities to achieve its business goals (Miller and Roth, 1994). Today, there is general agreement about the following competitive priorities being the content of manufacturing strategy: cost, quality, delivery, and flexibility (Boyer and Lewis, 2002; Hayes and Wheelwright, 1984; Kim and Arnold, 1996; Rosenzweig and Easton, 2010; Spring and Boaden, 1997).

Supporting and being derived from business strategy, competitive priorities should guide the structural and infrastructural decisions for manufacturing. Those lead to the development of manufacturing capabilities, i.e., the "manufacturer's ability to compete on the dimensions of quality, delivery, flexibility, and cost relative to primary competitors in its target markets" (Rosenzweig and Easton, 2010, p. 129). Eventually, the manufacturing output (Miltenburg, 2009), which can be monitored as manufacturing function's performance, results.

Network capabilities

Shi and Gregory (1998) propose four capabilities on network level which are derived from the IMN's two main decision categories, namely its configuration and coordination. Those are: accessibility, thriftiness, mobility, and learning. They complement on a network level the traditional manufacturing capabilities cost, quality, delivery, and flexibility from the factory level. This also means that they can be used to define certain target conditions of the network like priorities on factory level (Rudberg, 2004). Similar to capabilities on factory level, there are trade-offs between the capabilities on network level (Shi and Gregory, 1998). Additionally, Colotla et al. (2003) suggest that there is interdependence between capabilities on network and factory level. Each decision on one level affects the other level as well, leading to changes in the overall IMN. Hence, network and factory level capabilities and performance must be considered integrated and cannot be managed apart from each other.

Configuration

The configuration determines the physical arrangement of structural elements in the international manufacturing network. As such configuration specifies the location of plants and the dispersion of physical resources among them (Meijboom and Vos, 1997). Additional the specialisation and technological equipment of plants, the strategic factory role and the design of the supply chain are associated fields of network configuration (Friedli et al., 2014). Basically, the configuration defines at which and in how many locations value chain activities are performed. This is generally a trade-off decision between concentrating activities in few locations and dispersing activities across the globe. Facility characteristics (size, focus, capabilities), geographic dispersion, degree of vertical integration and organizational structure are the main levers for configuration adjustments (Miltenburg, 2009). Different scholars proposed schemes for network classification in order to detect flaws and advantages of different configurational set-ups and to ensure focussed factory operations. In practice, the physical network set-up usually is a mix of two or more configuration alternatives (Friedli et al., 2014).

Coordination

The international manufacturing network coordination comprises the organisation and management of worldwide dispersed activities (Friedli et al., 2014). As such coordination defines how production and distribution facilities are interconnected and linked in order to realize the company's strategy (Cheng et al., 2015; Colotla et al., 2003). The interaction between all network players involves information sharing, resource and responsibility allocation and effort alignment. International enterprises can obtain competitive advantages through the efficient coordination of activities across multiple factories and regions, such as reacting quickly to fluctuating exchange rates, commodity prices or labour costs by shifting production volumes (Miltenburg, 2009; Rudberg and West, 2008). The network structure determines the degree of coordination to a large extent. For example, networks with a process focus tend to have a stronger interaction than networks with a product or market focus (Shi and Gregory, 1998).

Fit

In reference to international manufacturing networks the concept of fit can be subdivided into two distinct categories – an external and an internal perspective of fit (Arogyaswamy, 1987). Internal fit is achieved through the consistent alignment of the chosen strategy and structural as well as infrastructural elements of the network (Hill and Brown, 2007). The concept of internal fit has been addressed by numerous scholars (Rudberg, 2004; Safizadeh et al., 1996; Van Dierdonck and Miller, 1980) focussing on fit between different network attributes, e.g. the fit between production tasks and the corresponding manufacturing system (Kim, 1993). Contrary, external fit refers to the degree of consistency between a networks competitive environment and its organisational set-up including the three layers strategy, configuration and coordination (Friedli et al., 2014). In the 1980s the concept of a simplistic global formula for international manufacturing networks was replaced by the idea of "fit". Meaning a company, which is able to identify the key success criteria for its industry and develop the respective organisational capabilities will be successful in its competitive environment (Bartlett and Ghoshal, 1998). In the literature of system fit multiple equally effective and efficient organisational design alternatives are conceivable. Both philosophies of fit share this concept of equifinality (Drazin and Van de Ven, 1985). Hence, there is no single best way in achieving fit between internal network system elements or external environmental contingencies (Donaldson, 1996; Sousa and Voss, 2008).

Conceptual model

Following the literature, business strategy defines which markets have to be served and what products have to be produced by the manufacturing function. Naturally, a certain strategic vision and core of competitive advantage will be mirrored in these decisions. From a manufacturing perspective, this core can be operationalised along the differentiation factors price, quality, delivery, and flexibility (Hill, 1989). With a specific combination of these factors, e.g., being a highest quality, high cost but not very fast and flexible provider, a guiding self-conception of the company's competitive advantage results for the manufacturing function. Naturally, besides markets and products, the business strategy will further comprise strategic goals regarding the profitability and growth of the company, sometimes even several goals more are added, e.g., regarding sustainability.

Entering a foreign market and further internationalise the business is a strategic decision for a company. Hence, the markets in the business strategy can not only refer to

certain customer segments but do also specify the geographic markets the company wants to serve, e.g. the home market and certain markets in countries abroad.

Customers selected by the business strategy have certain needs and requirements that are translated in competitive priorities for the respective products offered (e.g. Miltenburg, 2005; Skinner, 1969). Usually each product in each market will have specific market requirements regarding price, quality, delivery etc. (cf. Miltenburg, 2009). Hence, with the geographic markets, the different customer segments with various requirements translating into different competitive priorities, and with the products being already defined by the business strategy, much of the target picture and contextual factors for manufacturing can be considered as pre-determined. From the multiple combinations of those three goals (market regions, products, customers) as well as of the financial and growth goals, results a diverse set of requirements the manufacturing function has to fulfil.

Similar to the deduction of competitive priorities, the IMN translates goals from the business strategy into network priorities. The IMN defines how important the physical proximity to markets, competitors, suppliers, resources, and other assets is (accessibility), how important the achievement of economies of scale and scope are and how important it is to reduce redundancies within the network (thriftiness), how important the exchange of information and knowledge among the factories is (learning), and how important the shifting of production volumes and processes is (mobility) for the success of the IMN. Since network priorities and competitive priorities are interdependent and affect each other either in a positive and reinforcing or in a negative way (cf. Colotla et al., 2003), the IMN must carefully choose how priorities are set in an iterative process. Different combinations of priorities are possible, which is in line with the idea of equifinality (Drazin and Van de Ven, 1985).

The desired capabilities necessary to achieve the goals set in the priorities are realised through altering the physical design of the IMN, the structure and infrastructure of the factories, and the way manufacturing is managed. It is widely accepted that the IMN has certain levers on factory and network level (Miltenburg, 2009). Using these levers, the IMN will first adapt the hardware of the IMN, i.e., its configuration including the number and location of factories, the specialisation of the factories, and the site roles assigned to the factories (Friedli et al., 2014). The configuration will be designed always first, since only when the question from where and how to serve customers is answered, can the specific requirements for the interplay of these factories be addressed. Often, configuration decisions are driven by the contextual factors of the market regions, customers and products selected. For example, local content requirements of chosen markets or product characteristics that impact logistics costs represent contextual factors that might require a local presence. Next, the IMN coordination, i.e., the organisation of the factories and the way these factories cooperate and compete with each other, is designed. This includes decisions regarding the degree of autonomy of each factory, the centre organisation, and the exchange of resources across factories are made (Friedli et al., 2014). Management frameworks can help making the decisions more transparent and facilitate discussions (Friedli et al., 2014). Coordination decisions can only be made depending on the configuration of the network, due to the interdependencies that exist among the two dimensions. Eventually, structural and infrastructural levers on factory level are used to build up the relevant manufacturing capabilities and competencies necessary to serve the respective customers. Network capabilities thus support and enforce the manufacturing capabilities. Eventually, the outcomes are expected to be better than without integrating the network perspective. The conceptual model is depicted in figure 1.

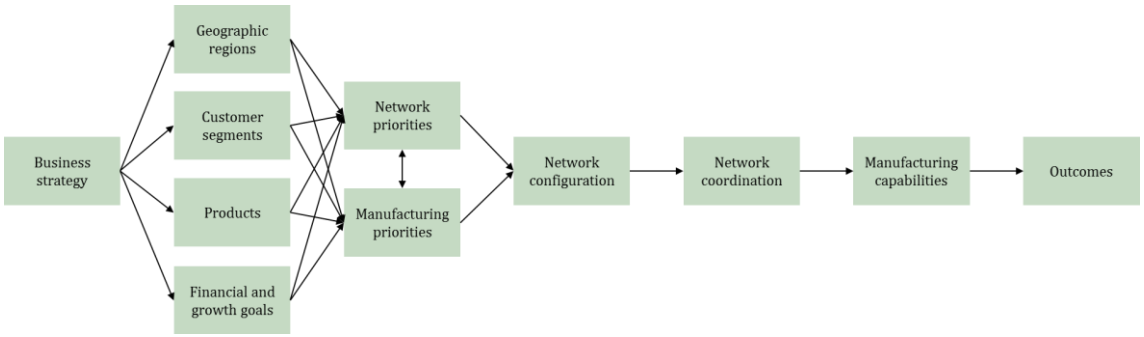


Figure 1 – Conceptual model for IMN management

Illustrative case

The purpose of the illustrative case is to show how the conceptual model has been applied in practice. The model was applied during a six month project at Electrical Component Company (ECC), a manufacturer of power equipment in the B2B market. Today, ECC operates in a global market that is characterized by overcapacities. Despite annual growth rates of 3% overcapacities will remain in the foreseeable future, resulting in a current capacity utilization of approximately 80%.

In reference to the business strategy the overall vision is to bring energy safely to the customer, implying high requirements in terms of quality. The idea of being a high-quality supplier of electrical equipment is consistent throughout all activities of the network. However, from the current market environment as illustrated above, an enormous price pressure results, which the network has to deal with. Quality and costs are thus the driving factors for the network. The business strategy defined European countries, Brazil, India, and China as the target markets due to their volume or growth potentials. Customers are differentiated in two groups. ECC distinguishes between utility companies, operating electrical grids, and so-called Engineer Procure Construct (EPC) companies, building electrical grids on behalf of utility companies. Utility companies focus on life-cycle costs and as such put an emphasis on product performance. Thus utility companies are less sensitive to costs, whereas EPCs try to stay within the negotiated project budget and accordingly exhibit a higher sensitivity in terms of costs. Both customer groups are scattered across the globe. All customers are served with similar products, so there is not a huge product range the network has to manage. The current focus of the business is placed on efficiency increases at existing capacities in order to realize higher utilisation rates, which is in line with the above mentioned cost focus. This supports the effort of becoming number 1 in the market in terms of sales volume and EBIT and surpassing the strongest competitor, who is currently the market leader.

There are certain contingency factors that affect the network structure. The products ECC manufactures are characterised by very high logistic costs due to their bulkiness. The manufacturing of few products is very demanding but in general, the complexity of production is on a relatively lower level. Furthermore, there are certain local content requirements in the countries selected by the business strategy as target markets.

Access to markets and customers is important for ECC due to the high logistics costs and the rather tough competition. Also, proximity to know-how and qualified suppliers and work force is important to achieve the strategic goals. Thriftiness is viewed as a priority for the network to keep up productivity and achieve financial goals. The reduction of redundancies is viewed as an issue to foster cost savings and increase profitability within the network while economies of scale improves profitability within the existing manufacturing capacities. Mobility is a major topic for the ECC network to better utilise

capacities of the network and increase productivity. To further improve quality and productivity, internal learning is of utmost importance for the network. However, the network wide access to suppliers and raw materials yields improvement potential. Stronger regionalisation of supply chains in China and India are key to become independent from European deliveries and a stronger leveraging of global sourcing enhances the cost structure of the Chinese, the Indian as well as the Western European factories. Granting access to best-cost labour is a crucial capability according to network management. So far the network has physical access to best-cost labour through factories in China, India und Southern Europe. But the access has not been leveraged for the Southern American and the Western European factories by means of extended workbenches. Mobility of production volumes and orders is significant for the network to guarantee an equal utilization of factories. This is also a precondition to outsource certain process steps to best-cost countries.

Two sets of manufacturing priorities are defined for the ECC network. First, purchasing-driven EPC customers related priorities with a focus on cost with quality rather less important but still not unimportant. Second, engineering-driven customers related priorities with a focus on quality, flexibility, and innovation. Due to the large overcapacities in the market, cost is becoming ever more important as a competitive priority for these factories as well.

From the priorities derives the following footprint to fulfil the requirements regarding access and cost: Two factories are located in Western Europe, one in Eastern Europe, one in South America, one in India and one in China. The factories are vertically integrated. In order to give each factory a clear focus and disentangle customer groups with different implications for competitive priorities, customers are assigned to factories according to their requirements profile. In consequence the European sites focus on the production of competitive high quality transformers, whereas the Non-European sites focus on serving price competitive markets with local products. To further facilitate thriftiness, reduce redundancies, and unlock local cost advantages, configuration is adapted towards a stronger process orientation. China and India are established as global hubs for mechanical design activities, which are associated with a high proportion of manual labour. As such they function as an extended workbench and provide mechanical drawings for all other sites in the network. Thus two strategic goals are addressed simultaneously. On the one hand this drives utilization at the Chinese and the Indian factory. On the other hand the cost base is improved at all other sites, which will trigger additional sales. Additionally, China and India take responsibility for localized research & development departments with the goal to provide customized products better fulfilling the needs of their price competitive market than products based on European designs have been able to. Utilizing access to resources and suppliers, the Southern European supplier for welded sheet metal components is certified for the Western European factories. Higher logistic costs are overcompensated by significantly lower product costs. In this way the Western European factories profit from best-cost suppliers in the network. In the course of the project further configurational adjustments in adherence to strategic goals have been made.

Coordination is adapted subsequently. The hub structure enforces a stronger collaboration in the network, stimulates learning across sites and ultimately decreases performance differences. The stronger process focus of the factories requires centrally coordinated rules for transfer prices as well as a global sales and operations planning process. The designs have to be exchanged over a design library accessible by all sites. Therefore a standardized bill of materials as well as a standardized engineering process have to be in place. Moreover, the local Chinese and Indian research & development team

have to be integrated in central R&D function commonly provided by all factories together. The central R&D department defines topics for fundamental research, coordinates joint research activates between factories and is responsible for the knowledge exchange among all network players. Referring to access to suppliers and raw materials, a better organisational separation of global and local sourcing as well as the establishment of global sourcing beyond commodities are key. Therefore the range of responsibilities for global sourcing has to be adjusted.

Through adjustments with regards to configuration and coordination each factory is provided with clear cut goals regarding their markets, customers, and products. With being focused on only one customer group each, the factories now are assigned with binding competitive priorities they have to follow. Hence, they are now able to develop the necessary manufacturing capabilities and become competitive in their respective markets. Furthermore, the factories can derive which competencies they have to build to best contribute to the overall network.

Discussion

Based on existing literature on the management of international manufacturing networks, we proposed a conceptual model in this paper. Whilst designing conceptual models is in line with other research in the field of manufacturing strategy, the explanatory power of this model is limited to the extant body of literature.

From a theoretical perspective, certain questions remain unanswered in the model proposed. First, the process how exactly the interdependent priorities on network and factory level are defined in an iterative process. Second, how configuration and coordination have to be managed to account for the interdependencies and what impact those interdependencies have on the network design. Third, how a network evaluates the different design alternatives available following the idea of equifinality.

Conclusion

This paper contributes to the literature on manufacturing strategy, especially the manufacturing network paradigm. Previous research has focused on the individual decision dimensions of network management. The paper at hand, in contrast, investigates the interrelationships among those dimensions. A conceptual model has been derived from those previous findings and illustrated with a real-life case study.

Further research needs to be conducted to better understand the interdependencies between strategy, configuration, coordination, and manufacturing capabilities. Also, the impact of contextual factors has not yet been sufficiently investigated. However, our findings are a first step towards a systematic management of international manufacturing networks.

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