Effectuation in manufacturing: how entrepreneurial decision-making techniques can be used to deal with uncertainty in manufacturing

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Abstract

Aspiring countries all over the world gain market share in manufacturing and rapidly close the productivity and quality gap that has until now protected some parts of the industry in Europe and the United States from dislocation. However, causal production planning and manufacturing, the basis for productivity and quality, is challenged by the ever-greater need for flexibility and customized products in an uncertain business environment. The result is an increasing manufacturing complexity driven by the high number of product variations. Production managers are thus faced with a high degree of uncertainty under which they have to make their decisions. In many ways, manufacturing managers face similar challenges as entrepreneurs do: they have to operate in an uncertain environment, cannot rely on forecasts and have to involve different stakeholders inside and outside the company in order to be successful. This article uses a case-study-based approach to assess how production managers can apply decision-making principals of successful entrepreneurs. “Effectuation” instead of causal decision-making can be applied to handle the uncertainty of mass customization, to seek the right partners in alliances and to advance towards virtual production. In order to deal with uncertainty in manufacturing, managers have to allow a more entrepreneurial handling of situations. To the best of our knowledge, this study is the first to connect effectual decision-making with the manufacturing context. The findings help managers to use their resources more efficiently and contribute to bridge the gap between production research and entrepreneurship.

Keywords: Case Studies; Decision-making behavior; Effectuation; Production Planning; Entrepreneurship

1. Introduction

The worldwide financial crisis only slowed down globalization for a little instant. The KOF Index of Globalization is pointing upward since 1980, showing a continuous growth of economic, political and social integration worldwide [1]. High-wage countries particularly feel the pressure of a globalized economy in the manufacturing sector. In Germany, for instance, the number of jobs in this sector has decreased from 1991 to 2012 by about 3.7 million [2]. In order to sustain a healthy industrial base and to equalize the trade balance, high-wage countries need to continuously improve their manufacturing techniques to defend their competitive advantage. Since 2006, the Cluster of Excellence “Integrative Production Technology for High-Wage Countries” of RWTH Aachen University addresses this challenge by researching methods of organization and use of technology to enable the mass-production of highly customized products in high-wage countries [3].

The main challenges for production managers in these surroundings are globalization itself, environmental complexity and uncertainty. Increasing globalization leads to a stronger competition between manufacturers from different countries, especially for non-specialist goods. With low labor costs and
growing home markets put emerging markets pressure on high-wage countries. This together with increasing customer requests for customized products complicates the environment in which manufacturers are making decisions. As a result production cycles get shorter and product variations increase. All of these factors lead to reduced certainty in production planning.

In the past, the competitive advantage of high-wage economies was based on productivity and quality. However, in a globalized economy recently shaken by a worldwide financial crisis and recession, linear-causal, analytical planning approaches are merely inapplicable [4]. Faced with the multiple challenges listed above, production managers need to turn to alternative ways of decision making. The situation of production managers becomes more and more comparable to the situation of entrepreneurs who cannot rely on any great experience from the past and who need to adapt their course continuously to address new challenges. In 2001, Sarasvathy introduced the concept of “Effectuation” to entrepreneurial research to compare the way how decision making of entrepreneurs significantly differs from the typical, causal-analytical way [5]. In this article, we assess three case studies of manufacturing companies to identify principles of effectual behavior. The article is part of an effort in the RWTH Aachen University Cluster of Excellence to combine new findings with regards to production management in a comprehensive theory of production.

2. Conceptual Background

2.1. The concept of effectuation

Rational decision-making models have been the foundation of neoclassical economics for a long time. In the context of entrepreneurship, scholars have claimed that most opportunities are discovered through a deliberate search process. Drucker calls it “the discipline of innovation” [6]. Individuals pursuing these opportunities are perceived as goal-driven, acting fully rationally [7]. Typical components of a business plan, such as a market assessment, financial planning or a competitor analysis are expressions of this notion. Sarasvathy [5] referred to this way of deliberate decision making as the causation model. In this model, targets are firmly defined and resources are explicitly acquired to achieve fixed targets. It follows the paradigm: “To the extent we can predict the future, we can control it” [5] p. 252. However, entrepreneurs often start only with a generalized aspiration, an idea, and then try to recombine the resources at their immediate disposal (e.g., who they are, what they know, what they own) to turn this idea into an opportunity [8]. The effectuation process is flexible and takes advantage of environmental opportunities as they arise. In other words, in their highly uncertain environment of creating new ventures, entrepreneurs learn as they go. Involving a network of stakeholders bound by effectual commitment, entrepreneurs can expand resources and converge constraints to create new markets [9]. The feedback cycle of effectuation is depicted in fig. 1. The entrepreneur increases the number of resources by acquiring new means (upper cycle) and reduces the decision space of various possibilities by acquiring new artifacts through the interaction with other stakeholders.

Fig. 1. Feedback cycles of effectuation. Source: [10]

Sarasvathy [5] p. 252 states four effectuation principles:

- Controlling an unpredictable future rather than predicting an uncertain one: faced with high uncertainty, entrepreneurs do not try to predict the future, they rather try to control aspects of it
- Affordable loss, rather than expected returns: entrepreneurs do not try to maximize returns, they try to do as much as possible with limited means
- Strategic alliances rather than competitive analyses: entrepreneurs seek stakeholders for strategic alliances instead of competition analyses
- Exploitation of contingencies, rather than exploitation of preexisting knowledge: causation models work well with preexisting knowledge on, e.g., a technology, but effectuation exploits unexpected changes and opportunities

Since its introduction in 2001, effectuation has attracted a lot of interest and researchers have presented several conceptual and empirical contributions. Articles have further shaped the concept of effectuation [11], evaluated the role of the entrepreneur in the firm [12], the relationship between effectuation and over-trust [13], [14], the creation of opportunities by entrepreneurs (“creative imagination”) [15] and the impact of effectual behavior on venture performance [16]. In order to test the theory, researchers have interviewed expert entrepreneurs [17], compared differences in decision making between entrepreneurs and students [18] and between entrepreneurs and managers with regards to marketing decisions [19]. More recent studies have focused on the performance of new ventures taking contextual factors into account [20] or conducted a survey-based validation of the theory with 196 participants [21].

However, effectuation is not limited to new venture creation. Corporations can also learn from successful entrepreneurs. Harting [22] conducted interviews with the founders of CarMax and Circuit City to test the existence of effectual behavior in a corporate setting. The author hypothesized that effectual reasoning is predominant in the early stage of a venture creation and less dominant in later stages. However, the results were mixed showing that causal reasoning is not necessarily the dominant decision-making behavior in later stages. Brettel et al. [23] analyzed the application of effectual behavior in the context of corporate R&D projects assessing the impact of entrepreneurial action on
R&D project performance. The authors find that project innovativeness is an important moderator for the impact of effectual behavior on project performance. While “means-driven” behavior has no influence on R&D performance for highly innovative projects, “preference for affordable loss”, “preference for partnerships” and “acknowledging the unexpected” have a significant relationship with R&D project performance when innovativeness is high. The findings show that the concept of effectual behavior is transferable to the corporate world particularly in the case, when the innovativeness of projects is high. The results encourage us to think that the concept is transferable to other environments with similar characteristics, such as manufacturing.

2.2. Reduced predictability in manufacturing

The interconnectedness of a globalized economy forces manufacturing companies to take a high number of decisions daily, incorporating a myriad of internal and external factors [24]. Many of these factors are beyond direct control of the companies: Changing exchange rates, raw material price volatility and regional market dynamics can have a significant impact on the company profitability. At the same time, product life cycles continue to shorten as the customers demand more personalized products at a higher rate. As a result, manufacturing companies need to produce a high number of heterogeneous products in smaller batch sizes [25].

Variable demand increases the competition and manufacturers seek to win customers with a high number of product variations. For example, the VW Polo was sold in 2004 with an incredible 52,612,300,800 variants in the UK [26]. Ultimately, the decreased demand predictability leads to higher production complexity and requires much more supply chain flexibility. Through this high level of uncertainty, linear-causal long-term planning becomes obsolete and production managers need to turn to a rather effectual decision-making behavior leveraging their resources at hand.

3. Case studies and methodology

We hypothesize that many production managers apply effectual decision-making techniques without being aware of it. In order to identify effectual behavior in manufacturing, we have analyzed recent publications in leading production management journals as well as book publications. After an extensive literature review, we decided to focus on case-study publications, because they describe real-life management situations and clearly demonstrate decision-making behavior. Furthermore we tried to find case studies that are based on different challenges. As outlined in the introduction, critical challenges for manufacturing companies are increasing competition through globalization (“high-wage countries vs. low-wage countries”), increasing production complexity and increasing demand uncertainty. These factors reduce the predictability of manufacturing cycles.

Case studies were selected based on the following criteria:
- Subject companies needed to be located in high-wage countries
- The described situation needed to be a management reaction to increased uncertainty caused by globalization, uncertainty about demand or complexity in the supply chain
- Decision-making behavior needed to be inferable

For the purpose of this article, we selected three case studies for further analysis, as they fulfill all criteria stated above. We have summarized the three case studies in table 1 [27], [28], [29]. In the next step, we adapted the framework proposed by Sarasvathy [5] to the manufacturing context. Table 2 summarizes the four dimensions of our framework.

The first dimension means in the manufacturing context can effectual behavior occur if the production is organized based on the available means and resources instead of trying to adhere to causally planned output targets. Effectual behavior on the second dimension, affordable loss, occurs

| Authors | Topic | Changeable manufacturing | Supply chain integration | Virtual production |
|---------|-------|----------------------------|-------------------------|-------------------|
| Schmidt, A. [27] | Supply chain integration | McCarthy, T., Golicic, S. [28] | Schuh, G., Friedli, T., & Kurr, M. [29] |
| 2010 | Euregio Bodensee (virtual) | Several companies in one region experienced increased competitive pressure and a saturation of their markets. | In order to manufacture individualized products more efficiently, 25 companies created a production network. Individual companies act as service provider within the network so that the companies can collectively bid for projects. |
when the production considers the potential risk or downside of an investment or inventory decision, instead of the expected returns. On the third dimension, effectuation involves the creation of partnerships, which implies the trust-based interaction with suppliers and customers in the manufacturing context. The fourth dimension considers the acknowledgement of the unexpected as effectual behavior when manufacturers can turn uncertainty in supply and demand into their own benefit instead of avoiding them.

4. Results

We have assessed the three case studies along the four dimensions of our framework. A summary of the results can be found in table 3.

Table 2. Delineation of effectuation and causation in the manufacturing context

| Dimension                        | Effectuation characteristics                      | Causation characteristics                      |
|----------------------------------|--------------------------------------------------|------------------------------------------------|
| Means vs. goals                  | Manufacturing approach is driven by available means and resources | Manufacturing approach is driven by targets (output, sales, utilization) |
| Affordable loss vs. expected returns | Manufacturing approach is guided by advance commitments to what one is willing to lose | Manufacturing approach is oriented towards the maximization of returns |
| Partnerships vs. competitive market analysis | Uncertainty is reduced through partnerships and pre-commitments of self-selected stakeholders | Uncertainty is identified and avoided through market and competitor analyses and other measures (e.g., higher inventories) |
| Acknowledge the unexpected vs. overcome the unexpected | Contingencies/surprises are seen as a source of opportunities | Contingencies/surprises are avoided or quickly overcome to reach given manufacturing targets |

Table 3. Results of case study assessment

| Topic                                  | Changeable manufacturing | Supply chain integration | Virtual production |
|----------------------------------------|--------------------------|--------------------------|--------------------|
| Authors                                | Schmidt, A.              | McCarthy, T., Golicic, S. | Schuh, G., Friedli, T., & Kurr, M. |
| Means vs. goals                        | Effectual: modular production and processes can be re-combined easily to produce many variants | Effectual: combination of means along supply chain to improve overall transparency | Effectual: every member in the partnership contributes its resources to a combined resource pool |
| Affordable loss vs. expected returns   | Effectual: modular manufacturing makes steady returns from economies of scale difficult | Causal: lower inventory levels and lead times improve expected returns | Effectual: control over revenues delegated to network. Difficult to optimize returns |
| Partnerships vs. competitive market analysis | n/a                      | Effectual: trust in partnerships improves forecasting | Effectual: partnership of 25 firms, knowledge sharing in the network |
| Acknowledge the unexpected vs. overcome the unexpected | Effectual: uncertainty as a chance to develop new markets | Causal: reduce uncertainty in demand through joint planning | Causal: goal of capacity management is higher utilization |
developments in the market. Even the employees are trained on multiple jobs to vary employment as needed [27] p. 122.

The approach of Sennheiser electronic clearly follows the effectual notion of embracing uncertainty as an opportunity for the company. By making the production as reactive as possible, Sennheiser can leverage uncertainty and turns it into a competitive advantage as the company can react more quickly to changing customer demands. The modular production gives the company a repertoire of means that can be re-combined in order to produce as many variants as required. The production is not driven by output goals, but rather by the optimal recombination of available resources. At the same time, the company sacrifices steady returns from monolithic production in favor of a more risky, customer-focused modular production.

4.2. Supply Chain Integration: Companies A (chemicals), B (consumer goods), C (textiles)

The supply chain integration study is based on interviews with executives from three companies, which are forced by increasing demand uncertainty to engage in collaborative forecasting with their supply chain partners. Company A is a chemical company that develops demand forecasts jointly with its customers and updates them on a daily basis. The collaboration increased the reactivity of the supply chain, increased product availability and decreased inventories and security buffers for all involved parties [28] p. 440. Consumer goods company B follows the same approach and significantly benefits from the knowledge about sales trends, thus allowing the company to service 800 retailers instead of only 100 retailers with traditional planning methods [28] p. 442. Textile company C also includes suppliers into the integrated supply chain planning. This approach significantly reduced the bullwhip effect to the benefit of all involved parties [28] p. 445.

The supply chain integration of companies A, B and C is a good example of how firms apply effectual decision logic to leverage dispersed knowledge in networks. The combination of knowledge across the supply chain allows all parties to increase the overall transparency, thus focusing on combined means instead of individual goals. Demand forecasts are not based on a competitive market analysis but instead are the result of a joint effort based on trust in the partnership. However, the effectual use of means and partnerships is targeted at fulfilling the rather causal goal of reducing demand uncertainty. In that way, members of the supply chain try to overcome the unexpected through joint planning with the result of improving expected returns.

4.3. Virtual production: Euregio Bodensee

The third case study outlines the virtual factory Euregio Bodensee based on executive interviews. It was established in 1995 as a collaboration of 25 small-and-medium-sized enterprises (SME) in south Germany and north-west Switzerland. The companies realized that they could react to production flexibility and product customization more efficiently in a network. Within the network, every company serves as a service provider and management roles are distributed throughout the network [29] p. 163. When an order comes in, it is dispatched centrally to the involved companies. The companies can prepare their proposals for sub-elements of orders, they would have never been able to handle on their own [29] p. 169. The network therefore allows an efficient capacity and competence management for all involved companies, which leads to improved capacity utilization.

The effectual intent of engaging in such a partnership is clear. Companies can combine their own means to co-create new artifacts in the network. The partnership stands above consideration of competitive market analysis. Instead, new opportunities are created for all participants that would not be accessible for the individual. However, the participants delegate control over revenues to the partnership thus forsaking their ability to optimize expected returns. They follow the effectual notion of committing to a certain affordable loss, instead of planning with expected returns. They use the (uncertain) upside potential of winning contracts beyond their individual expertise level. On the other hand, the partnership is also based on a causal logic of increasing individual utilization by combining resources in the network.

5. Discussion

To the best of our knowledge, this is the first study to identify effectual decision-making behavior in the manufacturing context. We contribute to the emerging field of research with regards to corporate entrepreneurship by enlarging its perspective towards manufacturing. On the other hand, we contribute to production research, especially production planning and process management, by analyzing decision-making behavior from a new perspective, challenging the dominating scheme of causal-linear planning. Effectual decision making is particularly important for production managers in high-wage countries since the mass production of highly customized products is accompanied by high uncertainty. Production planning in a global environment in contrast usually has the goal to reduce uncertainty. The case study of Sennheiser shows how companies can embrace uncertainty in the effectual sense in order to create new markets. On the other hand, we find that the notion of effectuation to combine distributed means along the supply chain and in virtual production can also be used to overcome the unexpected. As manufacturing depends on predictability of demand and high capacity utilization, we find that some principles of effectuation are used to fulfill causal goals of demand forecasting or capacity management. As predicted by management theory, effectuation and causation are not mutually exclusive, but complement each other depending on the decision-making context and the individual task at hand.

It would be very interesting for researchers to further investigate the link between partially effectual and causal behavior in the context of manufacturing. This study shows that our current understanding of effectuation is transferable to manufacturing companies and we can identify aspects of effectual behavior in specific production management decisions. We believe that a survey among production managers to test effectuation constructs would be a fruitful avenue for further research.
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