THE POTENTIALS OF "EFFECTUATION" FOR THE RESOLUTION OF THE "POLYLEMMA OF PRODUCTION"

Günther Schuh
WZL at RWTH Aachen University
Professor
E-mail: g.schuh@wzl.rwth-aachen.de

Malte Brettel
WIN at RWTH Aachen University
Professor
E-mail: brettel@win.rwth-aachen.de

Cathrin Wesch-Potente
WZL at RWTH Aachen University
COO Cluster of Excellence "Integrative Production Technology for High-Wage Countries"
E-mail: c.wesch@wzl.rwth-aachen.de

Till Potente
WZL at RWTH Aachen University
Head of Production Management
E-mail: t.potente@wzl.rwth-aachen.de

Marius Rosenberg
WIN at RWTH Aachen University
Research Assistant
E-mail: rosenberg@win.rwth-aachen.de

Michael Keller
WIN at RWTH Aachen University
Research Assistant
E-mail: keller@win.rwth-aachen.de

Torben Schmitz
WZL at RWTH Aachen University
Research Assistant
E-mail: t.schmitz@wzl.rwth-aachen.de

—Abstract —
High-wage countries deal with strong challenges for their manufacturing industry. Aspiring countries all over the world gain the knowledge to produce advanced goods and increase their market shares in manufacturing. This shift of manufacturing processes bears the risk of relocation of further activities such as research and development.
To prevent the described transformation and increase the market position of high-wage countries, the Cluster of Excellence "Integrative Production Technology for High-Wage Countries" of RWTH Aachen University focuses on the resolution of the "Polylemma of Production". It describes the field of tension between planning and value oriented production as well as scale and scope oriented production.
In this paper, we analyze the entrepreneurship approach "effectuation" in terms of its benefits for the resolution of the described polylemma. Due to its flexible design, effectuation allows situative adaptions to integrate new parameters into a planning process.

Key Words: *Production Management, Effectuation, Polylemma of Production*
JEL Classification: M11

1. INTRODUCTION

1.1. Production planning and "Polylemma of Production"

Production management in high-wage countries faces a variety of problems to deal with. Valuable and individual goods have to be produced with both low manufacturing costs and flexible manufacturing resources which leads to two dilemmas (Schmitt et al,2010:53). The first dilemma is the field of tension between scale and scope manufacturing (market oriented view). By specializing a production system on economies of scale, e.g. by standardizing processes, low manufacturing costs can be achieved while the production system looses its flexibility to react to changes of external impact factors. Economies of scope on the other hand describe the focus on individual products and therefore adaptive manufacturing technologies. The second dilemma deals with the difficulties to combine value orientation and planning orientation in the production planning process (resource oriented view). Planning oriented production management comes along with models, simulations as well as optimization algorithms and

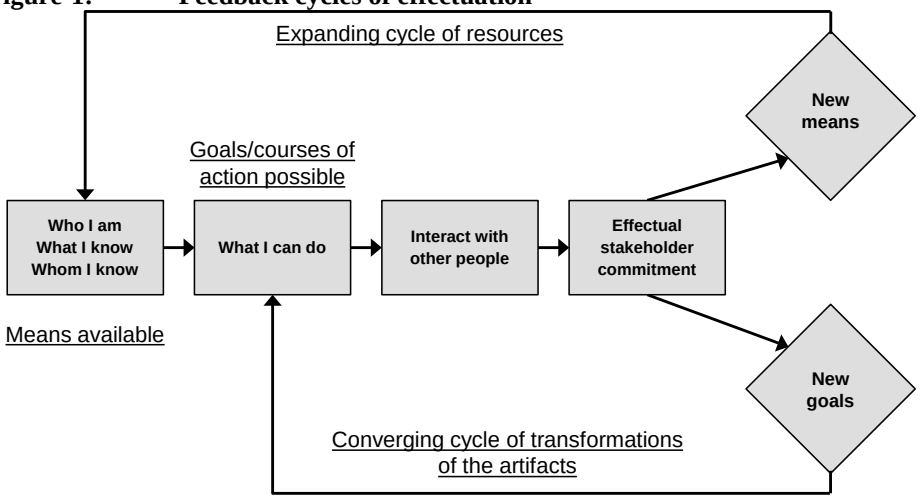
reaches for a high degree of accuracy in planning but also increases planning efforts and therefore costs. Value oriented planning on the other hand seeks for a maximization of the value added by using efficient planning processes. It opposes the planning orientation because the planning tasks are not considered beneficial for increasing the value of a good. Both dilemmas define the "Polylemma of Production". The Cluster of Excellence "Integrative Production Technologies for High-Wage Countries" at RWTH Aachen University aims to reduce this polylemma (Brecher et al.,2011b:52). In this paper, we analyze the potentials of a planning approach and therefore focus on the dilemma of planing vs. value orientation.

1.2. Entrepreneurial planning with "Effectuation"

A widely recognized definition of entrepreneurship has been developed by Shane and Venkataraman. According to them, entrepreneurship is "the scholarly examination of how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and exploited." (Shane and Venkataraman,2000:218).
Sarasvathy promotes a different approach in which opportunities are not discovered but created and the ability to plan a new enterprise is based on the possibility to predict the future (Grichnik et al,2010:56). The classical planning approach, called "causation" by Sarasvathy, assumes the future to be perfectly controllable by a prediction based on historical data. An effect (goal) is set and resources are chosen to cause this desired effect (Sarasvathy,2001:245p.). The focus is to find a strategy to maximize profits (Sarasvathy,2008:81).
The other option to plan a new enterprise is defined by Sarasvathy as "effectuation". It assumes the future to be adaptable within certain boundaries. An entrepreneur does not have to predict the future as long as it can be formed by himself. A set of resources is given and different effects (goals) are defined that can be created by the resources at hand. (Sarasvathy,2001:245p.) Based on different capabilities and networks, a decision space with various possibilities is set. The decisions for possible strategies are made according to the risks the individual entrepreneur is willing to take. The aim is to minimize the losses by choosing variants with a low level of risk (Sarasvathy,2008:81). Fig. 1 shows two resulting feedback cycles of effectuation. The upper one increases the number of resources by acquiring new means (resources), the lower one is reducing the

decision space because artifacts (boundaries) resulting from the interaction with stakeholders appear (Grichnik et al.,2010:60).

Figure-1: Feedback cycles of effectuation



Source: Grichnik et al.: 2010: 60

Five principles have been developed to characterize the effectuation concept: "bird-in-hand", "affordable loss", "crazy quilt", "lemonade" and "pilot-in-the-plane". The "bird-in-hand" principle expresses that the available resources are the ones that should be used to create something new. The decision space created by the "bird-in-hand" principle is reduced by the affordable loss principle that eliminates those options that lay above the individual level of risk. The "crazy quilt" principle is used to further reduce the decision space and to increase the controllability. Stakeholders, also competitors should be integrated to benefit from different resources or different risk adversities but also include a set of boundaries as a condition for their engagement. The "lemonade" principle tries to seize opportunities created by unplanned and unexpected events. Finally, the "pilot-in-the-plane" principle describes the influence of human action as an important part of the planning process. An actor who applies effectuation can be compared to a pilot in a plane who gains control over a situation (Sarasvathy,2008:80ff.).
In this paper, we analyze how and to what extend effectuation and its principles can be used to resolve the Polylemma of Production defined above.

2. COMPARING THE PLANNING PROCESS IN PRODUCTION AND ENTREPRENEURSHIP

To assess the planning approach "effectuation" in terms of its benefits for the resolution of the "Polylemma of Production", we develop an assessment tool based on a set of eight distinct dimensions that we describe in this chapter.

2.1 Developing comparison dimensions and corresponding attributes

In case of a decision under uncertainty like the launch of an enterprise, uncertainty can be overcome in different ways: one way is to improve the prognosis (planning school) to reduce uncertainty, another one is to adapt faster (learning school) to deal better with uncertainty. A third option is to influence the environment. (Wiltbank et al.,2006:983pp.). The latter two options enhance the ability to control a situation. Therefore, the first two dimensions are defined to be the "focus on prognosis" and the "focus on control".

Based on a typology matrix by Sarasvathy (Sarasvathy 2008:93p.), Küpper distinguishes different domains for the application of planning methods. On the one hand, the product and therefore the technology involved can be established or new. On the other hand, the market can be created due to a new product or already existing (Küpper,2010:64p.). This leads to two more dimensions: "technology focus" and "market focus".

In production planning, two main differences between the two orientations can be seen in the number of details and sub processes that are taken into account. For a value oriented method, the number of details and sub-processes is lower than for a planning oriented method (Brecher,2011a:22p.). Based on these differences, the dimensions "level of detail" and "volume of planning processes" are determined.

The Cluster of Excellence "Integrative Production Technology for High-Wage Countries" is structured in different fields of action. Two of these fields of action are related to the dilemma of planning vs. value orientation that we focus on in this paper. One is the field of "virtual production systems", the other one is the field of "self-optimizing production systems". Virtual production systems are characterized by the usage of simulation tools that make planning processes more efficient (Brecher,2011c:6pp.). Self-optimizing production systems consist of elements that adapt their behaviour and the persuasion of its goals according to external influences (Frank,2004:22). We track the ability of a planning approach

to promote virtual and self-optimizing production systems by comparing the virtualisation and self-optimization suitability.
For the purpose of an evaluation of all planning approaches discussed, the dimensions found have to be fitted with characteristic attributes. The first two dimensions “focus on prognosis” and “focus on control” receive the corresponding attributes “weak” and “strong”. The third and forth dimensions “technology focus” and “market focus” are equipped with the attributes “established” and “new”. For the fifth and sixth dimensions “level of detail” and “volume of planning processes” the attributes are defined as “low” and “high”. The attributes for the last two dimensions “suitability for virtualization” and “suitability for self-optimization” are defined to be “low” and “high” as well.

2.2. Analysing and interpreting commonalities and differences

For the analysis and the interpretation of the commonalities and differences between the planning approaches, we create a generic morphology consisting of the described dimensions and their attributes. All planning methods are assessed and categorized according to their attributes as shown in Fig. 2.
The morphology reveals a number of similarities and differences between the planning approaches. Both effectuation and value oriented production planning are not focussing on the prediction of possible future scenarios but rather try to seek for strategies to minimize wasting resources and by this form the future. Due to the application of heuristics and strategies, the framework of both approaches can be influenced and therefore partly controlled. Within the effectuation and the value orientation approaches, methods for continuous optimization exist and are applied emphasizing the suitability for self-optimization. Planning oriented approaches focus strongly on prediction. Considerable effort is put on the anticipation of the future and detailed planning. Therefore, the flexibility for adaption within the planning process is low.
Besides the similarities between effectuation and value orientation, also some differences exist. One difference is that effectuation is designed for new technologies in new markets whereas value orientation is only possible for established and known technologies. Due to the high degree of freedom within the effectuation approach, it is difficult to virtualize its planning processes other than it is possible for value orientation and planning orientation.

Figure-2: Generic morphologies of the analysed planning approaches

		Planning orientation		Value orientation		Effectuation	
	Dimension	Attributes		Attributes		Attributes	
Effectuation	Focus on prognosis	weak	strong	weak	strong	weak	strong
	Focus on control	weak	strong	weak	strong	weak	strong
	Focus on technology	established	new	established	new	established	new
	Focus on market	established	new	established	new	established	new
Planning / Value orientation	Level of details in production planning	low	high	low	high	low	high
	Volume of production planning	low	high	low	high	low	high
	Suitability for virtualization	low	high	low	high	low	high
	Suitability for self-optimization	low	high	low	high	low	high

The analysis of the generic morphology demonstrates that the effectuation approach is structured and designed in a similar way as value oriented approaches in production planning. Therefore, the potential of effectuation lies in the extension of value oriented methods. Furthermore, the self-optimization field of action, but not the virtualisation field of action is supported by effectuation. Possible potentials of effectuation can be seen in the integration of effectuation in today's research about self-optimizing production systems.

3. POTENTIALS OF EFFECTUATION TO RESOLVE THE POLYLEMMA OF PRODUCTION

In this chapter, we present two of research projects of the Cluster of Excellence "Integrative Production Technology for High-Wage Countries" of RWTH Aachen University for which integrations of the effectuation approach are possible.

3.1. Potentials for High Resolution Production Management

High Resolution Production Management (HRPM) is an approach where highly resolved data is provided to improve the acquisition of information in production. In an environment of external and internal dynamics, employees have to make decisions based on profound information. This information is provided by optimally aggregated and rehashed production data (Schuh et al.,2001:62pp.).

One central element of HRPM is the so called “viable controller”. The “viable controller” supports the controllability in production and offers a high potential to integrate the heuristics of effectuation. It is designed to aggregate feedback data from production and support the decisions of the employee in terms of production management by providing suitable decision rules. To achieve this, the viable controller consists of several components: an IT system that provides information and prepares decisions, a monitoring routine of feedback data in case of interventions in the production process, decision rules based on highly resolved data and a routine to deal with inconsistent information (Schuh et al.,2011:74pp.).
Regarding the elements and goals of the viable controller, some parallels to the logic of effectuation can be found. The effectuation feedback loop gathers information about stakeholders and taps new resources and goals. This new information is integrated in the decision making if and how the goal of the enterprise has to be adapted. Repeating communication with existing and new customers leads to further sharpening of the final products and goals. In the effectuation process, a serious of heuristics regarding the decision making process exist (five principles). These principles could be used as a template to design heuristics for the decision making process within the viable controller.

3.2 Potentials for Cognitive Systems in Production Technology

A further possible potential is the application of effectuation in research about cognitive systems in production technologies. Cognitive systems try to use the human ability to process information and to come to decisions for production control where conventional control systems would be too complex to handle and too inflexible. The application of cognitive systems is focused on production processes on shop floor level (Behnen et al.,2011:103pp.).
The cognitive architecture offers a field of application for effectuation due to the algorithms it contains to support the decision making process. The potentials of effectuation can be explained by the example of Soar, a cognitive architecture used in informatics and also production technology. Soar represents a mechanism for transparent decision making that imitates biological structures. It consists of a memory to store the knowledge about the abilities, the environment and the history. The process of decision making is based on the perception of information from the environment, the development and evaluation of alternatives, the selection of an alternative and its application. The criteria for decision making are

free to choose and can consist of heuristics, decision rules or sequences of steps. Soar contains also the ability to adapt existing plans and goals to new situations (Behnen et al.,2011:107pp.).
In a cognitive system like Soar, the principles of effectuation could be beneficial to create heuristics that deliver resilient decision alternatives.

4. CONCLUSION

In this paper, we contribute to the Cluster of Excellence "Integrative Production Technology for High-Wage Countries" by investigating a new approach for the resolution of the "Polylemma of Production" as described above. The comparison of different dimensions over all planning approaches unveiled that effectuation and value orientation show a similar pattern. Especially the capability of effectuation to be implemented in existing research projects such as HRPM and Cognitive Systems in Production Technology demonstrates the potentials of effectuation for the resolution of the Polylemma of Production.

ACKNOWLEDGEMENT

The presented work is being investigated within the publicly funded research project "Cluster of Excellence - Integrative production technology for high-wage countries" by the German Research Foundation (Deutsche Forschungs-gemeinschaft, DFG) at RWTH Aachen University.

BIBLIOGRAPHY

Behnen, Daniel, Brecher, Christian, Hammann, Georg, Herfs, Werner, Koeppe, Ralf, Pauly, Detlef, Possel-Dölken, Frank and Verl, Alexander (2011), "Potentiale kognitiver Systeme in der Produktionstechnik", ((in: Christian Brecher et al.-Eds., *Wettbewerbsfaktor Produktionstechnik: Aachener Perspektiven - Aachener Werkzeugmaschinenkolloquium*,), Berlin, Germany: Springer, pp.101-123.
Brecher, Christian, Jeschke, Sabina, Schuh, Günther and Aghassi, Susanne (2011a), "Integrative Produktionstechnik für Hochlohnländer", (in: Christian Brecher-Ed., *Integrative Produktionstechnik für Hochlohnländer*,), Berlin, Germany: Springer, pp.17-81.

Brecher, Christian, Kozielski, Stefan and Schapp, Lutz (2011b), „Integrative Produktiontechnik für Hochlohnländer“, (in: Gausemeier, Jürgen and Wiendahl, Hans.-Peter-Eds., *Wertschöpfung und Beschäftigung in Deutschland*,), Berlin, Germany: Springer, pp.47-70.
Brecher, Christian, Kozielski, Stefan and Karmann, Oliver (2011c), ”Integrative Produktionstechnik für Hochlohnländer“, (in: Christian Brecher et al.-Eds., *Wettbewerbsfaktor Produktionstechnik: Aachener Perspektiven - Aachener Werkzeugmaschinenkolloquium,),Herzogenrath, Germany: Shaker*, pp. 1-16.
Frank, Ursula (2004), Selbstoptimierende Systeme des Maschinenbaus – Definitionen und Konzepte, Paderborn, Germany: Heinz-Nixdorf-Institut.
Grichnik, Dietmar, Brettel, Malte, Koropp, Christian and Mauer, René (2010), Entrepreneurship - Unternehmerisches Denken, Entscheiden und Handeln in innovativen und technologieorientierten Unternehmungen, Stuttgart, Germany: Schäffer-Poeschel.
Küpper, Daniel (2010), Die Erfolgswirkung von Effectuation im Kontext von F & E-Projekten - Eine empirische Analyse, Wiesbaden, Germany: Gabler.
Sarasvathy, Saras D. (2001), ”Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency”, *Academy of Management Review*, Vol.26, No. 2, pp.243-263.
Sarasvathy, Saras D. (2008), Effectuation – Elements of entrepreneurial expertise, Cheltenham, UK: Elgar.
Schmitt, Robert, Vorspel-Rüter, Michael, Wienholdt, Henrik (2010), “Handhabung von Komplexität in flexiblen Produktionssystemen - Kundenindividuelle Produkte zu Kosten der Massenproduktion”, *Industrie-Management*, Vol. 26, No. 1, pp.53-56.
Schuh, Günther, Lödding, Hermann, Stich, Volker (2011), “High Resolution Production Management“, (in: Christian Brecher et al.-Eds., *Wettbewerbsfaktor Produktionstechnik: Aachener Perspektiven - Aachener Werkzeugmaschinen-kolloquium*,), Berlin, Germany: Springer, pp.61-80.
2011, 1. Aufl.; Shaker, Herzogenrath, 2011, S. 61 - 80.
Shane, Scott, Venkataraman, Sankaran (2000), “The promise of entrepreneurship as a field of research“, *Academy of Management Review*, Vol. 25, No. 1, pp.217-226.
Wiltbank, Robert, Dew, Nicholas, Read, Stuart, Sarasvathy, Saras D. (2006), “What to do next? The case for non-predictive strategy”, *Strategic Management Journal*, Vol. 27, No. 10, pp. 981 - 998.