CHANGEABILITY IN OPERATIONS: A CRITICAL STRATEGIC RESOURCE FOR EUROPEAN MANUFACTURING?

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Abstract:

Changeability has become a buzzword for operations management, especially in German literature. Therefore, we analyze the concept in comparison with existing concepts for variability, such as flexibility and agility. Agility is an enterprise-wide concept incorporating product design as well as manufacturing systems design and aiming at lean and often dislocated manufacturing processes. Flexibility means that an operation system is variably within a specific combination of in-, out and throughput. Changeability, in contrast, means the ability of an operation system to alter autonomously the configuration to meet new, previously unknown demands e. g. from the market. Changeability is then the ability to realize new states of the in-, out- and throughput. Additionally, the reconfiguration of the system has to be realized as quickly as the environmental changes. Therefore, to be changeable, the speed of adaptation is important.

Introduction:

In order to implement changeability successfully, it has to be included in strategic considerations, with the objective to generate competitive advantages from an inside out perspective. Changeability has the potential to become a strategic resource for manufacturing companies, because it fulfils the necessary conditions of strategic resources. In this context, we define changeability as a strategic resource in an operation system, which allows changing quickly from efficient state in time t_0 to another efficient state in time t_1. Thereby, t_0 and t_1 have different input or output levels meeting the market requirements on the demand side or market opportunities on the supply side.

The realization of changeability requires the integration of considerations about organizational structures and processes, information systems and manufacturing technology. The linking of these fields allows the consideration of new organizational principles like decentralized and autonomous structures operations. The strong emphasizes on decentralization of decision processes allows a partial self-organization of changes in the operation system. An important condition is an extensive variability of information systems and the mobility of system elements.

In this paper we focus on the operation system, which is a subsystem of the production system. The other subsystem is the management system. We exclude considerations on the system elements itself (machinery, workers) and also the variability concepts for whole enterprises. The subsystems are interconnected through the information system that enables the feedback and information flow (Dyckhoff 2003). Up to now tasks, that have been carried out typically in the management systems are more often relocated to the operation system.

Terms of Variability

Short Literature Review

The research on the variability (e.g. Tan 1998, p. 376) of enterprises is widespread and has generated a wide range of terms and concepts. Therefore, we classify several terms of variability. We concentrate on variability classes that concern the operation system as a whole. The narrow focus allows a more exact specification and distinction of the concepts and gives the necessary basis for the effects of changeability. Especially strategic considerations in overall business management and operations management have to take into account the whole operation system and its potentials, not the single variability potentials of the system elements. Indeed, the variability of a system is at least partially determined by the variability of the elements or subsystems. Thus we consider the effects of their variability on the operation system variability. The most discussed terms in current literature for the variability of operation systems are the flexibility, the agility, reconfigurability, as well as adaptability. We will now analyze those terms, and present on basis of this analysis why we suggest another approach for variability in operation systems.

Reconfiguration and adaptation as well as the corresponding verbs and nouns are not used purposeful for a whole paradigm or concept, but as more value-free synonyms for variability (e.g. reconfiguration for organizational variability (Teng/Grover/Fiedler 2003, p. 289.). Reconfiguration means the redesign and change of the relationships and the change of the existing structure of an operation system, thus focuses especially on the change of the throughput of an manufacturing company. Adaptability (Katayama/Benett 1999, p. 43-51) means the feature of a company's operation system to modify its cost performance according to the demand from the market, which means that the variable costs are higher and the fixed costs are lower than with traditional operation systems. As a result the company is able to generate profits also with lower sales in a changing market.

Flexible manufacturing is heavily discussed in literature. Thereby we have to consider that there are different forms of flexibility. It is to be separated form manufacturing flexibility, which is actually a super ordinate term for various flexibility measures and concepts in manufacturing (D'Souza/Williams 2000, p. 578). All forms of flexibility result in specific abilities to alter the capability of a specific system (a machine, an operation system) in a current state of in-, out- and throughput. Flexible manufacturing means an operation system, which is able to change it's in- or output, based on the constraints of the manufacturing system. The potentials for altering the output are in specific flexibility potentials of the system elements. An example is production cells that are able to produce a certain amount of output.

A broader approach represents agile manufacturing. An agile manufacturing system aims at supporting the company to reach the following objectives of Agility. (Golmann/Nagel/Preiss 1995, pp. 73-120):

- Enriching the customer - The customer gets involved into the whole product-lifecycle, which means the customer participates in design, manufacturing as well as marketing processes
- Organizing to manage change and uncertainty – an agile company is organized in such a way as to allow it to thrive on change and uncertainty, its structure is flexible enough to allow rapid configuration of human and physical resources
- Cooperating to enhance competitiveness - The internal and external cooperation is an essential part of the operational strategy of an agile manufacturing enterprise
- Leveraging the impact of people and information.

Agile manufacturing research suggests an enormous set of tools for reaching those goals. There are several research institutes trying to provide the necessary technologies, processes and practices for the implementation of agility based on agile manufacturing systems (DeVor/Graves/Mills 1997, pp. 815f.) Agile manufacturing therefore is an approach focussed on supporting the enterprise to reach agility. The suggested measures comprehend many instruments and concepts that have been already developed and are combined to reach agility. Therefore, agile manufacturing is often called a toolbox, that engages existing concepts for reaching more effective and variable production processes. Due to the strong accent on variable and flexible processes, agile and flexible production sometimes is used equally (Dugnay/Landry/Pasin 1997, p. 1183).

Deficits in current Variability Concepts

We consider agility and flexibility as the two most important concepts in the discussion of operation system variability. Many flexibility approaches suffer in our consideration from the focus on technological benefits for physical manufacturing. Apart from organizational and management literature in general, the variability of the relationships of system elements is not considered enough for an economically oriented consideration of variability in operation systems. Besides the fact that there are different variability concepts in literature, the effective variability is important for the operative and strategic performance of the company. There are the following issues to be considered:

- The execution of change processes has to be performed more often by the operational units of the operation system. This means, the necessary reconfigurations are not planned by the managing system of the production system but are made (partially) autonomous by the workers in the operation system.
- The change processes have to be attached faster and with lesser forerun. This means that the time between the occurrence of the change necessity and the point, where the new state of the operation system is needed gets shorter. This phenomenon is known as turbulence in the literature.
- The companies has to attach the necessary changes at a low costs.

Therefore, the strategic consequence is, that the operation system has to be designed according those needs.

Agility acts too loosely with concerns of the manufacturing systems. The suggested method to combine various concepts is not generally being expected to work in practice (Gunasekaran/Tirtiroglu/Wolstencroft 2002). The claimed ability for operations, to adapt

quickly on changes also focuses only on the change in customers needs. Contrariwise, operations have also have to (re-)act to changes in the technological and competitive environment. Nonetheless, the objectives of agile manufacturing are valid. But they are too widespread on different functions within the enterprise. Agility is much concerned with effectiveness, but in practice a combination of TQM, MRPII, CIM, and Business Process Reengineering would be costly and surely not efficient. Therefore, a concept for the implementation of rapid changes is necessary, that also respects efficiency concerns in the operation system. Additionally, agile manufacturing is covering a wide range of abilities in manufacturing, which are not necessary in all kinds of operations. According to Gunasekaran et al. (2002, p. 414), it is not necessary to become agile, if it is necessary to change. We agree to that argument, and point out, that agile manufacturing is a toolbox, that may be realized, but not all tools at the same time are necessary to stay competitive in a certain environment.

The presented concepts are not contributing those requirements at the same time. Flexible manufacturing is providing the necessary variability for a current production state very fast, but is not able to handle the turbulence, because the forerun for changing the state are too long. Agile manufacturing is providing the necessary abilities for changing the operation system for structurally altered outputs because of the change of market demands and technology advancements, but is not bearing in mind the cost aspect.

To sum up, flexible manufacturing as well as agile manufacturing are lacking dedicated measures for the implementation of fast and widespread changes in operation in structural measures as well as in operational concerns in the operation system. Therefore, we suggest an additional ability in operation systems, the ability to change or changeability. Changeability is intended to handle the problem of the complexity occurring when to alter the operation system due to the changing needs in the environment. The approach recognizes the impossibility of reaction on the changes in the environment with the agile or flexible manufacturing concepts alone. Additionally, a reaction that comes too early in the operation system on turbulence in the environment would either require accepting high parallelized cost for a second plant or the relatively long production stop in the reconfigured plant. Therefore, changeability aims at a fast reaction on mostly already known changes in the environments. These changes are manageable of the system, because of the already built change potentials in the operation system. The management delays the change, to extend the operative time of the manufacturing system. This reaction is anyway faster than that of the competition, because of the changeability in the system. Additionally, the old system state is longer “on-line” and generates revenues for the enterprise.

Changeability in Operation Systems

Definition of Changeability

Changeability is the ability to deal with modifications in the social, technological and competitive environment in a reactive as well a proactive way. We define an operation system as a subsystem of the enterprise for the transformation of input factors, e.g. goods and services, into output factors, e.g. tangible goods and services for satisfying customer needs. Additionally, we define a change as the transition of a system from a status *A* to the status *B* within a perceptible t_w period of time. Every state has particular flexibility potentials *a* and *b*. In this context, changeability of operations systems describes the competence for goal-oriented changes between two system states A and B by modifying the in-, out-, and/or throughput of the system. Figure 1 visualizes the this thesis and indicates the management systems, which is actually managing the changeability in the operation system as well as observing the input and the output of the operation system to anticipate eventually necessary changes.

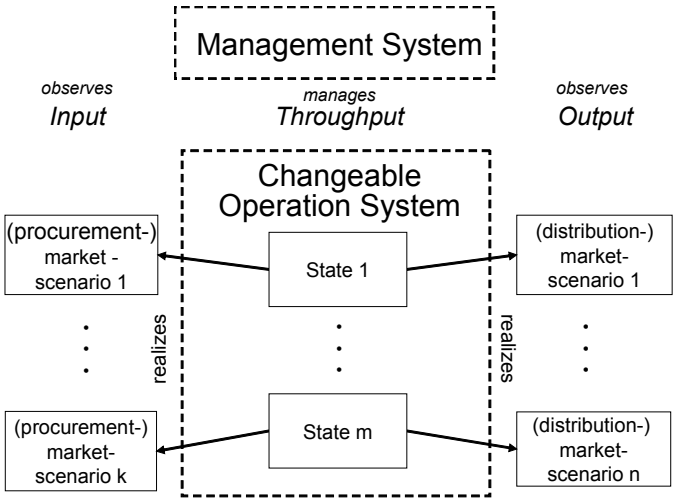

Figure 1: Thesis on Changeability

Framework for the Analysis Changeability

Unlike many system-theoretical approaches of operation systems, we take autonomous actions of the system's elements as a basis of our approach. The qualities of a system are not determined exclusively through the attributes of its elements and their relationships, but in particular through the individual abilities and the actions of the system elements that are possible through that. Therefore, we also consider the individual abilities and the actions of the system elements. In this point of view, a modification of the abilities of the active system elements and/or a modification of the relationships between these system elements results in a change of the whole system. We assume that the research of changeability of operation systems and/or the development of a management of the changeability consequently must concentrate on the active system elements'.

According to Blecker (2003) we distinguish actors in three groups. The first type consists of *human actors*, e.g. planners and workers. Because of the increasing integration of modern information and communication technologies into automation systems and their growing local "intelligence", *artificial actors* build up the second type of actors in production systems. For example, facilities with embedded computational intelligence may act autonomously in a production process. As in human actors, they perform different tasks and interact with other actors in the production system under physical and cognitive limitations. Baldwin and Clark have shown that an analysis of an operation system also has to include the interactions between machines and humans apart from physical aspects:"Like humans, machines perform many tasks and transfers in the system of production. Like humans, machines make decisions; indeed, they are making increasingly complex and sophisticated decisions. And like humans, machines have physical and cognitive (i.e., information processing) limitations, which must be taken into account in designing a system of production." (Baldwin/Clark 2003, p.5) The third type of actors consists of composed units. We call this type, *organizational actors*, because they consist of a varying number of human and/or artificial actors following organizational principles, e.g. autonomous or virtual teams on the shop floor, and act as a whole. Examples of organizational actors are part-autonomous teams, virtual teams and manufacturing rungs as well as so-called socio-technical operation units.

The amount of the change potentials of the actors as well as the relationships between the actors build up the changeability of the operation system. Change potentials are the abilities of *actors* and their *relationships* as the two sources of the change potentials as well as the

infrastructure, as an essential restriction of change processes. We present some exemplary examples for the development of changeability in the following

A design field for building changeability is the transformation and transaction abilities of the *actors*. The transformation abilities concern the possibilities for the modification of the characteristics of materials, semi-finished and finished products as well as of the information. Especially the enlargement of the mobility of actors supports the building of changeability. Through that, reconfigurations can be carried out for example, which facilitates new, special changed transformation processes. Beneath the transformation of goods and materials, the exchange of them in the operation system between actors is another alternative to build changability. Transactions represent an pass on of the property rights on the various objects in the production system. Transactions necessitate a coordination of the replacement process and the ability for the cooperation. A smooth and goal-oriented realization of transactions requires a fast and complete availability of information concerning the transaction objects. Furthermore, the relationships to the transaction partners must be available.

Thus, the *relationships,* necessary for the realization of transactions, represent the second design field to build changeability. The objective is a fast, low-cost construction of relationships. A prevention of communication problems during the relationship construction between actors requires the continuous use of technical and social standards and norms. This occurs for example through an improvement of human-machine-interfaces and the application of highly standardized network protocols. These measures allow a friction free reconfiguration of relationships. Necessary condition for the construction of relationships between actors is the knowledge of an actor about important parameters of another actor. The high number of relationships necessary for high change potentials requires extended capabilities at the information processing and data memory capacity of the actors. Many of those relationships are in a current state unused; therefore we call the latent relationships. A high number of relationships per actor show, however, furthermore a high complexity of the relationships. This makes furthermore high requirements on the harmonization and/or standardization of up to now heterogeneous interfaces. Both material and data processing interfaces are to be considered. Figure 2 illustrates the activities of the Management as well as the necessary measures during the change process in the operation system.

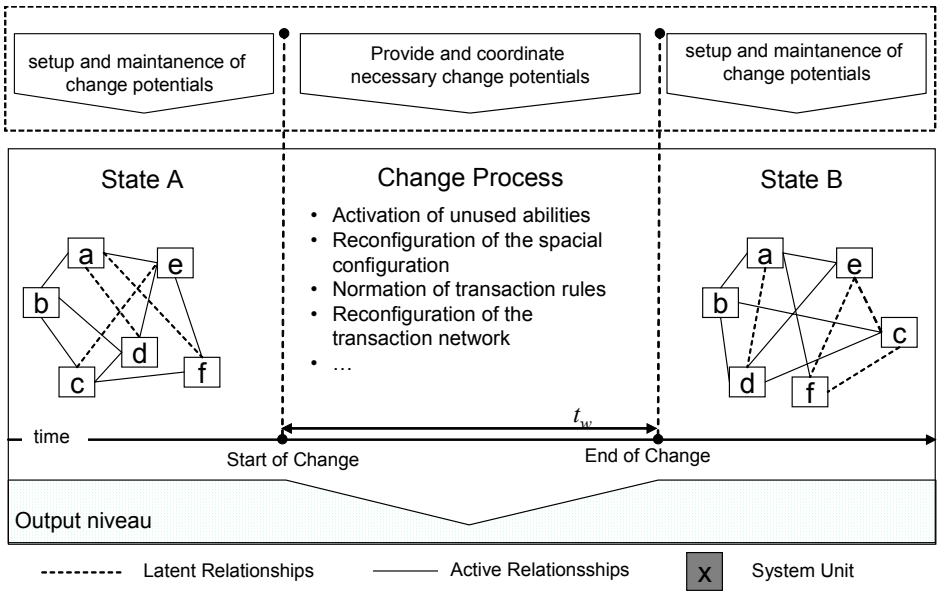

Figure 2: Change Process in the Operation System

However, for the construction of relationships an appropriate *infrastructure* is necessary, which means the expansion of the courses of action of the actors as well as for the spacial reconfiguration. In particular, the supply systems, e.g. for electricity, water, gases, as well as the networking infrastructure, have to be adjusted to potential change processes. Ubiquitous or at least easy to alter supply and disposal systems support the spacial reconfiguration of transformation processes. Additionally, the structural assumptions for a replacement of artificial actors must be provided. Yet, corresponding concepts for plant constructions did not exist. However, an actual research project, for example ProMotion (http://www.mobile-produktion.de), concentrates on this lack.

Analysis of Changeability

We presume that the variation of the environment implies a variation of the in-, out and/or throughput. This variation has to equal each other (Ashby, 1957). This means, that a slight variation of the customer demand or the basic-technologies of the production induce also only a slight variation of the product itself. If the variation of the environment is extensive, then also a extensive variation of the enterprise is necessary. The changes in the environment thus induce changes in the enterprise. We stated that those changes in the enterprise may be executed through changing the system state by altering structurally in-, out- and/or throughput. We can state that the in or output may change structurally even if the throughput is not changing structurally, because of the flexibility potentials in the operation system. Also, we claim that there is a change in the state of the throughput, if the in- or output remains the same. This would lead e.g. to much lower costs because of structural reconfigurations in the throughput, e.g. by radically changing the relationships of system elements and/or changing the production technologies.

The changeability approach presented concentrates on isolating the change processes to reach the goal of short, but efficient changes in the operation system. Through the separation of in- or output changes by the use of current potentials in the operation system on the one hand or the changes of the throughput by holding the in- and output the same change processes can be attached during the operation of the system because the complexity of the changes is lowered. This reduces complexity and allows a speeding up of the change process itself. The costs of the change are determined by the change potentials of the actors and their relationships and

the time needed for the change. This time is additionally determined by the complexity of the change process. To reduce the overall costs of change overtime, the following fields have to be optimized:

- Splitting up change processes in more controllable chunks
- Speeding up change processes
- Building the right change potentials in the operation system

In this view, a higher changeability is reached, if the sum of the change processes in a period of time is realized at a lower total cost for change at a higher level of change. The up to now presented change potentials in the operation systems are nothing but slack in the operation system. From a strategic point of view, this slack should bring the company competitive advantages and a solid, sustainable competitive position. The slack in the system is costly, so the management has to care for a minimizing the cost for the slack. This means that the change potentials of actors as well as the change potentials of relationships have to be extended und cost considerations. Therefore, we argue that change potentials have to be abolished as soon as possible, if they are outdated.

Requirements for the Rapid Change in Operation Systems

Changeability is not an end in itself. It is an important factor for industrial firms in order to handle with varying environmental conditions successfully at the market. Changeability is to be planned from that precisely, to be constructed and to be used. Previous research mainly focuses, however, on the technical aspects and/or the leadership in transformation-capable enterprises. On the other hand for the successful realization of change processes a coordinated course actions within the *management of changeability* (Blecker/Graf 2004). The setup and realization of a management the changeability must focus the actors in the production system. The amount of the change potentials of the actors as well as the relationships between the actors build up the changeability of the operation system. The management of changeability as a task of the production management covers the planning, organizing and controlling of the change potentials. The setup of these change potentials concerns the entire spectrum of production-technological and -economical decisions. A comprehensive enumeration and contents-related description of the measures to the construction of changeability is hardly possible from that. We outline here the management of changeability on basis of the essential design fields from actor-oriented point of view.

Technological prerequisites. The presented approach bases strongly on the application and goal-oriented use of modern technological advancements. Beneath the highly flexible machines and facilities, especially information technologies are important. In the last few years Internet Technologies became the leading innovation drive for manufacturing technologies. for the interconnection of The interconnection of assembly lines as well as sharing detailed data with corporate Ethernet networks leads to a direct communication between Enterprise Resource Planning (ERP) respectively Production Planning and Control (PPC), Manufacturing Execution Systems (MES) and Automation Technologies in the sense of Enterprise Application Integration (EAI) (Blecker/Graf 2003). Because of the resulting high availability of real-time data from shop floor equipment new (production) planning and control mechanisms as well as continuous information and communication structures between administrative and production systems arise. Furthermore, due to the evolution of the direct, IP supported networking on machinery level, we expect an increase of distributed services in production processes.

Strategic Implications of Changeability

Changeability from a Market-based Perspective

To show strategic implications of changeability, we have test it from the market based view, as well as from the resource based view. From a market-based view, success factors are an important concept for strategic management. Critical success factors are defined as factors that enable companies to gain a competitive edge over their competitors. Thus, critical success factors largely determine a company's long-term prosperity and growth. The kind of factors that are critical for strategic success have not been clearly defined as of yet. This is mainly due to conceptual deficiencies of research in this area. Still, there is a large degree of consent regarding costs, quality, flexibility, time, product variety, and service of being critical success factors (Diller/Luecking 1993). We examine some success factors and the effects of Changeability on them.

Although some other major critical success factors have been discovered, costs are still of major importance to strategic management. *Costs* are supported through the lowering of change costs, which is actually not directly affecting the unit costs, therefore its not directly influencing the success factor costs. Beneath costs, quality is the most mentioned success factor. Changeability especially influences conceptual quality, because the fast changes allow a better matching of the attributes of the product to the customer demand. Production quality is defined as the transfer of conceptual quality into product quality. This part of quality is not supported by changeability. Management has in turn to care for the quality of the products after the finishing of the change processes. In the last decade, from a strategic point of view flexibility is mentioned to be an highly important success factor. The flexibility of a current state in the operation system is not altered by changeability. If strategic flexibility is considered of a longer period of time, it is enhanced if there are change processes that actually affecting the customer. This is not necessarily the case if the changes are necessary do to new demands from the market.

There are several effects of changeability on success factors, but they are "only" derived, which means changeability is not directly enlarging some success factors. Changeability is not directly attracting the customer; therefore, changeability is neither a success factor nor a strategy in the market-based view. Changeability therefore is a classical success potentials, that may be realized on market or not. The realization of a competitive advantage with only one critical success factor is not enough to assure profits. Thus, companies have to realize several success factors simultaneously. The market-based view suggests the implementation of hybrid strategies such as mass customization or outpacing strategies. However, these strategies concentrate on the overcoming of porter's cost/differentiation distinction (Porter 1986). There are several other critical success factors that are supported by Changeability. Thus, companies have to clearly verify whether they will try to implement one of the suggested strategies or if they will try to realize a completive advantage by realizing and defending a set of success factors (Kaluza 1996).

Latest approaches for realizing hybrid strategies emphasize the importance of a highly changeable manufacturing at moderate costs. Examples are here Mass Customization founded by Pine (1993) and the Dynamic Product Differentiation developed by Kaluza. Changeability supports these Strategies, because they are strongly suggesting a high capability for changing production processes for meeting customer needs at a relatively low cost. Kaluza is already suggesting a high product-changing potential, which means the operation system is able to alter quickly the production program and produce (sequentially) a high number of variants. This covers partially with the changeability in our approach. Mass customization also aims at low costs through with a high number of variants, especially enabled through modularization

of the products and processes. The set up of changeability in operation system matches with that aim, because the altering of outputs is realized through a change in the processes with different actors.

Changeability from a Resource-based Perspective

There is evidence among many authors that a unilateral view on competitive advantage neglects the internal perspective. Competitive advantage is created not only by realizing success factors, but also by internal capabilities and processes (Penrose 1953). The so-called resource based view (Wernerfeld 1984), attaches more importance to that issue. Grant (1998 p. 107) summarizes the resource based perspective as „A definition of the firm in terms of what it is capable of doing“. Capabilities, competencies and resources are resources in the sense of the resource-based view if they are not transferable, resisting wear, inimitable and not substitutable. These criteria may be valid for organizational, tangible, intangible, and financial resources.

Changeability foots on the presented potentials for change in the actors and relationships. These potentials may itself be strategic resources, but they do not have to be. We hold the distinction of tangible, intangible and organizational resources but we use further on potentials or resources. Essential for changeability is the availability of potentials as well as the necessary combination, which is in the resource based view actually the acquiring ability. In changeability, the acquiring ability is stronger pronounced than with other resources. As stated above, a dedicated management of changeability can assure the realization of potential rents deriving from the change potential by the implementation of the necessary combination. First of all, to reach changeability, organizational potentials have to be set up and used. These are the quality and the variability of relationships as well as the ability to fulfil transactions between the actors. Strategic management can enhance them by consequently enlarging the abilities of individual actors, e.g. with sustained training of human actors or the ubiquitous use of Internet technologies for a better connectivity between the actors in the operation system. Second, Tangible potentials or resources in the operation system for changeability may be the infrastructure or the mechanical actors. The infrastructure supports changeability if there are few barriers like walls or fixed supply system (network, water etc.). Mechanical actors may be tangible potentials resources if they are highly flexible in work load as well as if they are mobile. Third, intangible potentials or resources are the necessary know how of the actors to fulfil the change process by using their abilities and their built in flexibility. Especially the know how regarding the possible changes in all attributes (“self-referring know how”) is important for the suggested autonomous change processes.

To realize the competitive advantages from the resource based perspective, another ability of the firm is necessary, according to Grant (1991). If an enterprise fulfils all criteria for a sustainable competitive advantage, it is not ensured that it is able to realize that advantage. The necessary ability to do so is the acquiring ability. The Problem of the acquiring ability targets mainly on not clearly defined resources (Bamberger/Wrona 1996), like changeability. In opposite to financial resources, which can be realized more easily, changeability depends on the successful coordination (negotiation) between the actors, that actually provide the resource, and the management, that wants to realize the resources. This problem originates from the ambiguity if the resource derives mainly from the used technologies (like internet, flexible machines) or from the know how of the (human) actors and the relationships in the operation system. The complex processes necessary in the operation system cannot be overseen by the management, therefore the employees have to be poised to realize the change process. To use changeability as a strategic resource, management has to care for the motivation of the actors and the will to change; otherwise the competitive advantage is not realizable. Changeability creates competitive advantages by combining organizational,

tangible, and intangible abilities which results in a strategic resource. Figure 3 summarizes the requirements for strategic resources.

Requirements for resources	Characteristics of Changeability
Non-imitability	Costs for other firms are very high to obtain changeability
Uniqueness	Origins in the combination of the unique Change potentials
Non-substitutability	Costs for substitution of changeability are very high
Value (ability for utility-endowment on the market)	Time on market with new products is reduced
Ability to acquire the (potential) rents	A dedicated Management of Changeability ensures the realization of Rents

Figure 3: Changeability and the necessary conditions for strategic resources

The building of strategic resources implies the set up of the competence over a period of time. This means, a strategic resource of today is almost partially the result of the efforts of the past. Changeability especially foots on the learnings and decisions from the past, because the combination of existing change potentials requires experience, and the set up of latent relationships between actors needs time. Additionally, change potentials have to be reduced or set up to hold costs down. As a result, the actual changeability depends on the path, which was chosen in the past. This "path-dependency" is strongly discussed in a derivative of the resource-based-view, the dynamic-capabilities-approach, which origins mainly from Teece et al. (1994, 1997). He subsumes such resources as „Dynamic Capabilities"and adds through that more dynamic considerations to the resource based view. Additionally, the Dynamic-Capabilities-Approach adds through the mentioned path dependency evolutionary principles to strategic management. The strategy forming and implementing process is then to be considered as never ending process, which is always varying and changing the currently implemented strategy. Changeability in this sense is a vehicle to a successful evolution of the strategic position of (production) enterprises for staying competitive in turbulent environments. The dynamic-capabilities approach additionally refocuses the view on resources and concentrates on the processes and positions that an operation system has. Processes are the actual and potential arrangement of transactions between the actors that are relevant for change processes. Processes are either transforming or integration processes in the dynamic capabilities approach and enable the company to change the business strategy based on the capabilities in the system. Positions are a variation of the types of resources refocused for dynamic considerations for changing business Strategies. Accordingly, changeability as a dynamic capability enables one to change business strategies based on the capabilities for changing in- out- or throughput in the operation system. This is through the path that has been made in a operation system, e.g. the up to now accomplished changes; the processes, that are much more variable in changeable operation systems as well as the positions of the system elements, the actors, that allow an rapid reconfiguration.

We have shown that changeability has several strategic implications, which especially are valid from a resource based perspective. Finally, Strategic management has to decide how to

implement changeability and especially at which hierarchy level the management should be responsible for the changeability. The management of changeability is located at the managerial (sub-) system of the production system. The management in the production system has to act on the basis of a strategy. Changeability is focused on the operation system. This means that it concentrates on the functional unit of manufacturing in the enterprise. Therefore, Changeability should be integrated into the manufacturing strategy. If the change necessities are very demanding, changeability may also be a manufacturing strategy itself. The advantage of this strategy would be seamless concept from the strategic operations management down to the actors in the operation system.

Conclusion

The paper presents the difficulties with the current variability approaches for operation systems. We have shown that variability concepts lacking the cost perspective. Furthermore, the environment forces the operation systems to change even more frequently. Therefore, approaches for changeable structures at moderate costs are necessary. Our approach on changeability can meet these environments.

In European locations the relatively high costs for employees necessitate a high productivity and effectively of them. Changeability is an approach that uses the well trained workforce within the complex change processes through the (partially) autonomous application of change processes in the operation system. Through the unified view on artificial and human acting elements in the operation system the advancements of Information and Production technology can be used for the fast end efficient execution of changes. Therefore, the building of changeability in operation system is an investment in competitive advantages for manufacturing industries in Europe.

Further research areas in the presented context are developing instruments and methods for the management of changeability and the execution of change processes in business management. Another task is the alignment of the potentials in information and production technology with the organizational and managerial processes in the operation system to support changeability. Interdisciplinary research is necessary to overcome the barriers that may occur in this field and hinder changeable structures.

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