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Assuring the Competitiveness of European Manufacturer through Changeability in Manufacturing

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Abstract: Changeability has become a buzzword for operations management, especially in German literature. Therefore, we analyse this 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 autonomously alter the configuration to meet new, prior unknown demands e. g. from the market. Changeability is then the ability to realise new states of the in-, out- and throughput. Additionally, the reconfiguration of the system has to be realised as quickly as the environmental changes. Therefore, to be changeable, the speed of adaptation is important.

JEL Classification: M11, L21, L23

Key words: changeability, operations system, competitive advantage, strategic resource

Introduction

An actual Europe-wide survey conducted by KPMG Int. of 172 senior executives says, that European manufacturers that operate in Europe have a future, but only if they provide innovative, technically advanced products of the 'next generation' (KPMG 2005, p. 3f.). This requires constant change in the production program and to establish new processes for the production of innovative goods. Changeability in operations may be a concept to deal with the turbulence from supply and distribution markets, as well as technological advancements in IT and manufacturing technology.

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This allows staying competitive in the global context in existing European manufacturing sites. We analyse operation systems to find measures for the implementation and maintenance of changeability. To effectively implement and use the concept, management needs measures or guidelines for finding an optimal level of changeability.

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. This allows adapting e.g. technological investment and human resources to meet this objective. Then 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 enables the ability to change quickly from an 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 realisation of changeability requires the integration of considerations about organisational structures and processes, information systems and manufacturing technology. The linking of these fields allows the consideration of new organisational principles such as decentralised and autonomous structures operations. The strong emphasis on the decentralisation of decision processes allows a partial self-organisation of changes in the operation system. An important condition is an extensive variability of information systems and the mobility of system elements.

We exclude considerations on the system elements themselves (machinery, workers) and also the variability concepts for whole enterprises. In this paper we focus on the operation system, which is a subsystem of the production system. The other subsystem is the management system. The subsystems are interconnected through the information system that enables the feedback and information flow (Dyckhoff 2003). An important aspect is the increasing decentralisation, which means a distribution of decision rights to the operation system, that have (traditionally) been located in the management system.

Terms of Variability

Literature Review

The research on the variability (Tan 1998, p. 376) of enterprises is widespread and has generated a wide range of terms and concepts. Therefore, we have to classify several terms of variability. To analyse terms of variability, it is necessary to focus on a specific research object. This allows a clearer distinction of different terms. We

concentrate on variability classes that concern the operation system as a whole. 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 flexibility, agility, reconfigurability and adaptability. We will now analyse those terms, and present on the basis of this analysis why we suggest another approach for variability in operation systems. There are many differing definitions due to the heterogeneity of the opinions in the literature.

Reconfiguration and adaptation as well as the corresponding verbs and nouns are not used purposefully for a whole paradigm or concept, but rather as value-free synonyms for variability (e.g. reconfiguration for organisational 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 a manufacturing company. The management attaches in this case the alternations to the operation system, without using at least partial self-organisation from the employees in the operation system. 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 should also be able to generate profits with lower sales in a changing market. Reconfiguration and adaptation focus on specific aspects of variation. Reconfiguration mainly deals with the technical change of order in the operation system. Adaptation focuses on the cost side of variation.

Flexibility in manufacturing is heavily discussed in literature. Thereby we have to consider that there are different forms of flexibility. It is to be separated from 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 its in- or output, based on the constraints of the manufacturing system. The potentials for altering the output reside in specific flexibility potentials of the system elements. An example is production cells that are able to produce a certain amount of different outputs.

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

- Enriching the customer – The customer gets involved in the whole product-lifecycle, which means the customer participates in design, manufacturing as well as marketing processes
- Organising to manage change and uncertainty – an agile company is organised 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
- Co-operating to enhance competitiveness – The internal and external co-operation 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 focused 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). This is an inexpedient generalisation. Flexibility in operation is a general concept for the description and also measurement in operations, whereas agility respectively agile manufacturing is dedicated to the support of a specific, technology-oriented enterprise-wide value-creation concept.

Deficits in Current Variability Concepts

We consider agility and flexibility as the two most important concepts in the discussion of operation system variability. As stated above, the other ones are specific or the terms are only seldom used in the literature. The flexibility approaches suffer in our consideration from the focus on technological benefits for physical manufacturing. Apart from organisational 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. These 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 have to attach the necessary changes at low costs.

Agility acts too sketchily with concerns of the manufacturing systems. The suggested method to combine various concepts is generally not expected to work in practice (Gunasekaran/Tirtiroglu/Wolstencroft, 2002). The claimed ability for operations, to adapt quickly to changes also focuses only on the change in customers' needs. Contrariwise, operations also have to (re-)act on 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 often 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 covers 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 realised, but not all tools at the same time are necessary to stay competitive in a certain environment.

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. 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. Additionally, an excessively early reaction in the operation system to turbulence in the environment would either require accepting high-parallelised 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. To handle the changes in the operation system, management has to establish potentials and competencies to convert the external changes into internal changes. Finally, the aim is to delay the change as long as possible, and to extend the operative time of the manufacturing system. During the operation the management gathers the possible change potentials and competencies. In the case of change, selected change potentials are bundled and during a short change introduced into the operative processes.

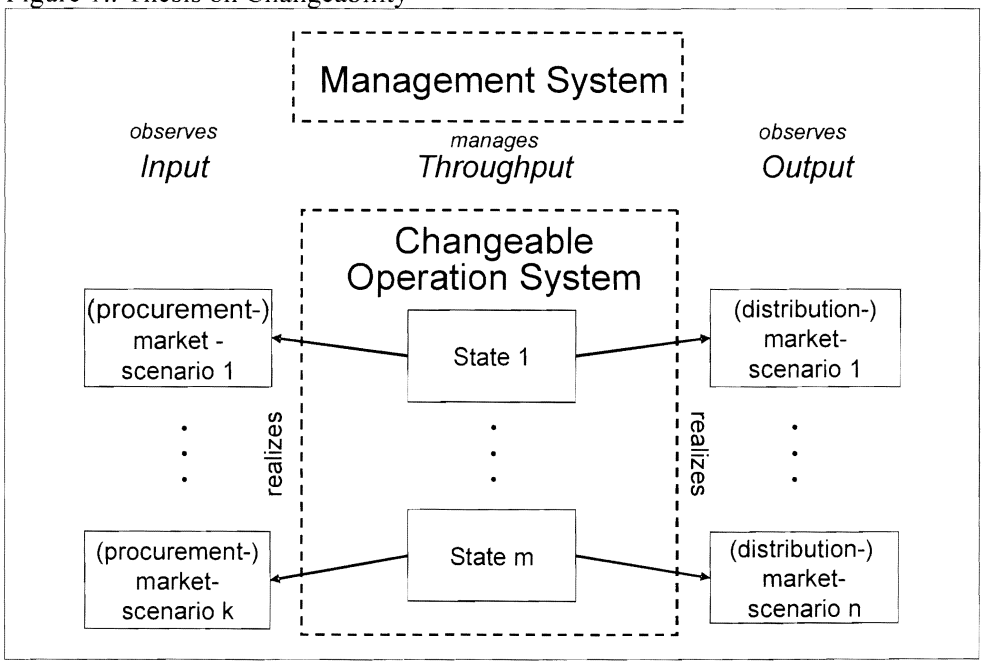
To realise this approach, we suggest an additional ability in operation systems, the ability to change or changeability. Changeability is intended to handle the problem of the complexity occurring of when to alter the operation system due to the changing needs in the environment. In the next section changeability is developed further.

Changeability in Operation Systems

Definition of Changeability

Changeability is the ability to deal with modifications in the social, technological and competitive environment. 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 tw period of time. Every state has particular flexibility potentials a and b. In this context, changeability of operation 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 visualises 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 eventual necessary changes (Graf 2005).

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 the management of the changeability consequently must concentrate on the active system elements.

According to Blecker (2003, 2005) 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, organisational actors, because they consist of a varying number of human and/or artificial actors following organisational principles, e.g. autonomous or virtual teams on the shop floor, and act as a whole. Examples of organisational 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 builds 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 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 changeability. Transactions represent a pass on of the property rights on the various objects in the production system. Transactions necessitate a co-ordination of the replacement process and the ability for the Cupertino. A smooth and goal-oriented realisation 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 realisation 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 standardised network

protocols. These measures allow a friction free reconfiguration of relationships. A 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 harmonisation and/or standardisation of up to now heterogeneous interfaces. Both material and data processing interfaces are to be considered. Figure 2 illustrates exemplarily the alternation of processes by the activation of unused relationships.

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 spatial 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 spatial reconfiguration of transformation processes. Additionally, the structural assumptions for a replacement of artificial actors must be provided. Yet, corresponding concepts for plant constructions didn't exist. However, actual research project, for example ProMotion (http://www.mobile-produktion.de), concentrates on this lack.

Analysis of Changeability

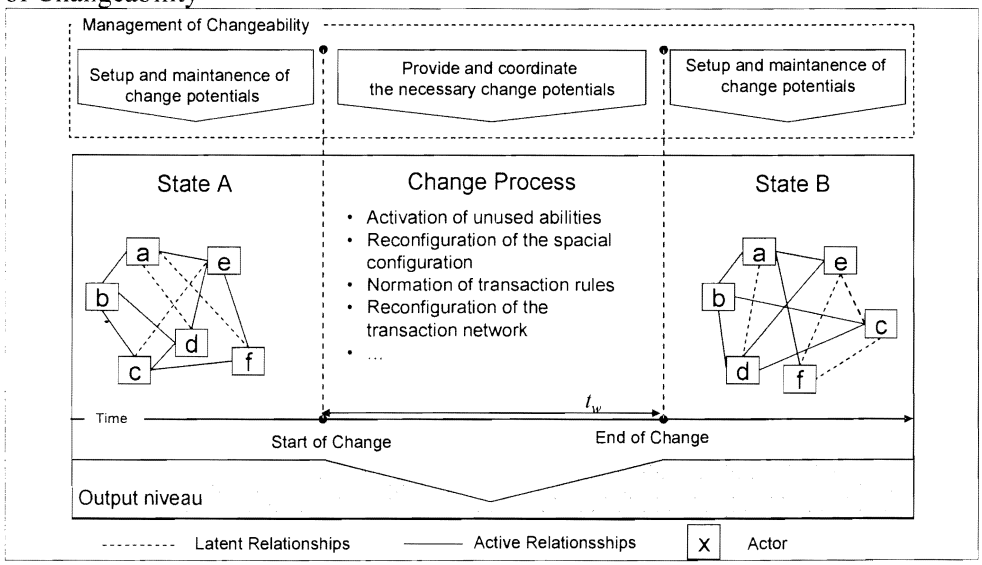
We presume that the variation of the environment implies a variation of the in-, out and/or throughput. This variation has to equal each other. This means, that a slight variation of the customer demand or the basic-technologies of the production also induce only a slight variation of the product itself. If the variation of the environment is extensive, then an extensive variation of the enterprise is also necessary. The changes in the environment thus induce changes in the enterprise. We stated that those changes in the enterprise might 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 up to now concentrates on isolating the change processes to reach the goal of short, but efficient changes in the operation system. Figure 2 illustrates exemplary the change process as well as the states before and after the change process where changeability is developed. 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. The reduced complexity enables the 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 over time, the following scopes have to be optimised:

- The range of the change process. We suggest splitting up change processes in more controllable chunks to reduce complexity. Additionally, it is easier to evaluate the success of the resulting system state.
- The speed of the change process. An acceleration of change processes can be reached through proper preparation and especially the extensive use of Internet technologies (Blecker 2005)
- The selection of change potentials. Building the right change potentials in the operation system is the critical task. Therefore instruments e.g. for the measurement of competencies have to be established.

In this view, a higher changeability is reached, if the sum of the change processes in a period of time is realised at a lower total cost for change at a higher level of change. The up to now presented change potentials in the operation systems is 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 the minimising of 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 and have cost considerations. Therefore, we argue that change potentials have to be abolished as soon as possible, if they are outdated.

Figure 2.: Overview: Change Process in the Operation System and the Management of Changeability



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 varying environmental conditions successfully at the market. Changeability is from that to be planned, to be built up and to be used precisely. Previous research mainly focuses, however, on the technical aspects and/or the leadership in transformation-capable enterprises. The amount of the change potentials of the actors as well as the relationships between the actors builds up the changeability of the operation system.

The successful realisation of changeability has to be implemented within a management of changeability. The subject of the management of the changeability is the actor in the production system. The management of changeability as a task of the production management covers the planning, organising and controlling of the change potentials. The set-up of these change potentials concerns the entire spectrum of production-technological and economic decisions. A comprehensive enumeration and contents-related description of the measures to the construction of changeability is hardly possible from that. Additionally, the management of changeability has to plan and co-ordinate the change process. Figure 2 illustrates the activities of the management as well as the necessary measures during the change process in the operation system.

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. 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 test it from the market based view, as well as from the resource based view. The market-based view is an environment-oriented strategy approach that was developed initially by Porter (1980). Principally, the market-based view argues the Structure – Conduct – Performance approach, which is a central part of the industrial economics. It assumes that the industry structure (Structure) determines the behaviour of an enterprise (Conduct) and with that the success (Performance). 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. They have to be critical and recognised by the customer. As a consequence, the firms have to focus on specific success factors. Thus, critical success factors largely determine a company's long-term prosperity and growth. The kinds 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 (Blecker 1998). Still, there is a large degree of consent regarding costs, quality, flexibility, time, product variety, and service of being critical success factors. Exploiting these critical success factors creates strategic advantages for the respective company for a certain period. Thus, a company needs to have at least in one of these critical success factors a competitive advantage in order to survive in today's competition.

Changeability supports companies to exploit several success factors by the preposition of several success potentials. Therefore, we examine some success factors and the effects of Changeability on them (Diller/Luecking 1993).

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 it is not directly influencing the success factor costs.

Quality as a success factor is also important. Quality is defined as the degree of customer satisfaction provided by a product or service. Quality consists of two major sources: conceptual quality and production quality. Conceptual quality describes to what extent a customer needs are taken into consideration in the conceptual and designing phase of a product or service. 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.

Flexibility as a success factor is an important characteristic of companies enabling them to quickly adapt to changes in their environment. Flexibility is not directly enhanced. 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 affect the customer. This is not necessarily the case if the changes are necessary to implement new demands from the market.

Product variety forces the production, apart from the technical requirements, to engage different production processes. This causes operations to handle a higher amount of information in production planning and control. Changeability enables the management to shift the product variety so that it is matching the customers' needs, but it is not enlarging product variety.

To sum up, 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 realised on the market or not.

The realisation of a competitive advantage with only one critical success factor is today often not enough to assure profits (Kaluza 1996, p. 193f.). Thus, companies have to realise several success factors simultaneously. Some authors of the market-based view suggest the implementation of hybrid strategies such as outpacing strategies. However, these strategies concentrate on the overcoming of porter's cost/differentiation distinction (Porter 1980). 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 realise a completive advantage by realising and defending a set of success factors (Kaluza 1996, p. 194).

Latest approaches for realising hybrid strategies emphasise the importance of highly changeable manufacturing at moderate costs. Examples here are Mass Customisation 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 quickly alter the production program and produce (sequentially) a high number of variants. This covers partially with the changeability in our approach. Mass customisation also aims at low costs through a high number of variants, especially enabled through modularization of the products and processes. The set up of changeability in an operation system matches with that aim, because the altering of outputs is realised 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 realising success factors, but also by internal capabilities and processes (Penrose 1953). The so-called resource based view attaches more importance to that issue. Grant (1998, p. 107) summarises 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 organisational, tangible, intangible, and financial resources.

Changeability foots on the presented potentials for change in the actors and relationships. These potentials may be strategic resources by themselves, but they do not have to be. We hold the distinction of tangible, intangible and organisational resources but we use further potentials or resources. First of all, to reach changeability, organisational 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 betters 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 such as walls or a fixed supply system (network, water etc.). Mechanical actors may be tangible potential resources if they are highly flexible in workload 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 realise 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 realise that advantage. The necessary ability to do so is the acquiring ability. With changeability, the acquiring ability is stronger pronounced than with other resources. As stated above, a dedicated management of changeability can assure the realisation of potential rents deriving from the change potential by the implementation of the necessary combination. The problem of acquiring ability targets mainly on not clearly defined resources, (Bamberger/Wrona 1996) such as changeability. In opposite to financial resources, which can be realised more easily, changeability depends on the successful co-ordination (negotiation) between the actors, that actually provide the resources, and the management that wants to realise the resources. This problem originates from the ambiguity if the resource derives mainly from the used technologies (such as the Internet, flexible machines) or from the know how of the (human) actors and the relationships in the operation system. The management cannot oversee the complex processes necessary in the operation system; therefore the employees have to be poised to realise 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 realisable. Changeability creates competitive advantages by combining organisational, tangible, and intangible abilities, which results in a strategic resource. Figure 3 summarises the requirements 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 keep costs down.

Figure 3.: Changeability and the Necessary Conditions for Strategic Resources

Requirement		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 to market
Ability to acquire the (potential) rents	✓	A dedicated Management of Changeability ensures the realization of Rents

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). They subsume 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 a never ending process, which is always varying and changing the currently implemented strategy. The presented approach on 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 of an operation system. Processes are the actual and potential arrangement of transactions between the actors that are relevant for change processes. Processes are either transforming or integrating processes in the dynamic capability approach and enable the company to change the business strategy based on the capabilities in the system. The central hypothesis is to reach 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. As a consequence, it concentrates on the functional unit of manufacturing in the enterprise. Therefore, Changeability should be integrated as a main objective into the manufacturing strategy to reach a proper realisation. If the change necessities are very demanding, changeability may also be a manufacturing strategy itself.

Conclusion

The paper presents the difficulties with the current variability approaches for operation systems. We have shown those 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 requirements in turbulent environments.

Especially in European locations the relatively high costs for employees necessitate a high productivity 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 development of changeability in operation systems is an investment in competitive advantages for manufacturing industries in Europe.

Further research has to be done to develop 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 organisational 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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