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Standardization and Adaption Requirements in Production System Transplants

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***Abstract*—**As German companies roll out their standardized production systems to offshore manufacturing plants, they face the challenge of implementing them in different cultural environments. Studies show that the local adaptation is one of the key factors for a successful implementation. Thus the question arises of where the line between standardization and adaptation can be drawn. To answer this question the influence of culture on production systems is analysed in this paper. The culturally contingent components of production systems are identified. Also the contingency factors are classified according to their impact on the necessary adaptation changes and implementation effort. Culturally specific decision making, coordination, communication and motivation patterns require one-time changes in organizational and process design. The attitude towards rules requires more intense coaching and controlling. Lastly a framework is developed to depict standardization and adaption needs when transplanting production systems into different cultural environments.

***Keywords*—**Culture, influence of national culture on production systems, lean production, production systems.

I. Introduction

SINCE the publication of MIT's study "The machine that changed the world" [1] Lean Production has emerged as the leading paradigm of organizing production processes [2]. The results of the study spurred a wave of implementation of lean production methods in companies across industrial nations [3], [4]. As initial attempts failed to deliver long term results it became clear that the key to a successful long term adoption of lean production practices lies not in copying the individual methods but in adapting them to the company's own needs and implementing them as an integrated production system [5], [6], [7],[8]. This requires taking into account technical, organizational and social factors [9], [10], [11]. In the last decade an increasing number of German companies developed standardized production systems based on their own socio-technical environment [12]. As they roll out their production systems to offshore manufacturing plants, German companies face the challenge of transplanting these into different cultural environments. A study revealed that top performing companies manage to achieve a higher degree of standardization across plants whilst still reaching a better degree of local adaptation of their production systems when transplanting them to plants outside Germany [13]. Thus the question arises of which components can be standardized and which components have to be adapted, when transplanting a production system to offshore manufacturing plants and especially into different cultural environment. To answer this question the components of production system have to be analysed on their dependence on cultural factors.

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II. Literature Review

The transfer of production systems is not a new topic. Transferring management systems and especially Japanese management systems has been in the focus of research in the past decades, with different schools of thought emerging in the literature [14]. In [15] Koontz differentiates between so called "science" and "artistic" components within a management system, with "artistic" components being rooted in culture. He asserts that only the "science" components of a management system are applicable across all nations. In support of this view White & Trevor examine Japanese companies in the UK [16]. The authors state that an establishment of the Japanese management systems in the UK, containing practices like lifetime employment or constant job rotation, would not be possible without great structural changes of those firms in the UK. Moreover Fukuda [17], conducting a survey among Japanese subsidiaries in Hong Kong and Singapore, finds that the degree of acceptance and implementation of Japanese Management Systems to be at a very low level.

Based on his analysis of Japanese companies in the US, UK and also in Asian countries Kono concludes in [18] that the "artistic" components of Japanese Management Systems can also be transferred, since they are based on rational thinking and developed through logical judgment. By comparing American and Japanese automotive plants both in the US and Japan Womack, Jones &Roos attribute the higher productivity in the Japanese plants to their superior "Lean Production" methods [1]. Their analysis focuses on technical principles of production control, like value stream design, flow and pull, deeming them universally transferrable.

The "Hybridization Theory" asserts that management systems are neither rejected nor accepted but hybridized with locally used management systems after the transplant [19], [20]. For the evaluation of the grade of adaption the so-called "application-adaption evaluation model" and a five-point grading system is developed [20]. In [21] Lillrank found that management system transfers are often not successful because

mental distances are not regarded. By stating that management principles firstly have to be abstracted before the actual transfer and then adapted to the local environmental and cultural conditions he supports the view of the Hybridization Theory. In [22] Kennly& Florida examine the transfer of Japanese management systems to the US in the sectors of automobile and electronic industry. They find that Japanese management systems had been transferred to the automobile industry to a much higher degree and conclude that this higher degree of transfer is simply due to a higher effort taken in the automobile industry. In [23] Pil&Mac Duffie study Japanese auto plants and come to the same conclusion of successful transfers in this sector as Kennly& Florida. However, they state that some adaption to better fit the local culture is needed. In their analyse of Toyota's culture in its US plants [24] Liker &Hoseus also point out that although most of its methods have been transferred from Japan, the Toyota Production System has been adapted to better fit the local cultural environment in the US.

In [25] Werner develops a framework for transferring partially autonomous team work to offshore manufacturing plants, which takes national culture into account. Requirements for development are obtained by comparing the ideal culture for partially autonomous team work with the national cultural profiles. However, this approach is limited to the principle of partially autonomous team work.

Overall, culture has been accepted as an essential factor of influence on the transferability of production systems. Especially supporters of the culturalist point of view [16], [17] and of the Hybridization Theory [19],[21] come to the result that production systems have to be adapted and cannot be simply transferred to foreign facilities. Recent research focuses on the impact of national and organizational culture on manufacturing performance. The findings suggest that manufacturing performance depends more on organisational than on national culture with production systems supporting a performance oriented organisational culture [26]. Nevertheless national culture is found to be a factor upsetting the development of a performance oriented organizational culture thus becoming a factor to be overcome when transplanting a production system [27].However, literature does not provide approaches on how an adaption of productions system regarding these cultural factors has to be performed in detail.

We conclude that although culture has been recognized as a contingency factor when transplanting production systems, there currently is a lack of research regarding the influence of culture on the different subsystems and components of a production system and on how to take this factor into account when transplanting production systems into different cultural environments.

To analyse the dependency of the various components of a production system on culture a three-step approach is used in this paper. First the influence of culture on work behaviour is analysed. In a second step production systems are broken down into their components. Each component is analysed on its dependence on work behaviour, thus establishing a link to their cultural dependency. In a third step a framework is developed, depicting the standardization and adaption needs of the various components of a production system when transplanting it into different cultural environments.

III. Influence of Culture on Work Behaviour

Culture can be seen as "the collective programming of the mind that distinguishes the members of one group or category of people from another" [28], consisting of shared values, beliefs and attitudes that shape the behaviour of the group members [29].

To analyse the influence of culture on work behaviour Hofstede's cultural model was used. The model is empirical and was developed following a comprehensive survey in subsidiaries of IBM in over 70 countries. It explains not only differences in value patterns between countries but also gives insight on how culture affects work behaviour [28]. Further empirical researches have fully used the Hofstede dimensions to investigate the influence of culture on work behaviour, organization and management [30], [31], [32].

Hofstede's model is based on five cultural dimensions: power distance, uncertainty avoidance, individualism vs. collectivism, masculinity vs. femininity and long-term vs. short-term orientation. Power distance (PDI) refers to the extent in which an unequal distribution of power within groups or organizations is accepted by the members. Uncertainty avoidance (UAI) refers to the tolerance for uncertainty and ambiguity and the tendency to accept and rely on rules and formalization. The dimension individualism vs. collectivism (IDV) refers to the integration of individuals in primary groups and the tendency of a society or group to focus on the needs of the individual or the needs of the group. The dimension masculinity vs. femininity (MAS) refers to the societal preference for modesty and cooperation (low masculinity) or assertiveness and achievement (high masculinity). The dimension long-term vs. short-term (LTO) orientation reflects the fostering of virtues oriented towards future rewards (long-term orientation) or present rewards (short-term orientation) and mostly reflects a deeper difference in values between Western and Asian cultures. [28]

Consistent with the aim of this paper, the influence of culture on work behaviour for all dimensions was analysed using Hofstede's work, as well as the work of authors using Hofstede's framework, as presented in [32]. The influence of culture on work behaviour is summarized in Table I.

TABLE I
Influence of Culture on Work Behaviour

Element of work behaviour	Influencing cultural dimension
Leadership style, expressed in - decision making - coordination	PDI, IDV, MAS
Communication patterns	IDV
Motivation, determined by - work goals - reward allocation - secondary factors	PDI, IDV, MAS
Attitude towards rules	UAI, IDV

Leadership styles can vary between autocratic (high PDI) and delegative (low PDI). Autocratic leadership is reflected in centralized decision making and a more direct control oriented style of coordination. Delegative leadership allows for a decentralized decision making and self-coordination. Furthermore decision making can be based on seeking assertiveness (high MAS, high IDV) or consensus (low MAS, low IDV). Communication patterns can be high context (low IDV) or low context (high IDV). High-context cultures distinguish themselves by the fact that the gross of information is transmitted implicit, which means that the majority of the information is understood by context. Because of this it is highly dependent on direct, personal communication. Low context cultures have a great share of explicit messages; therefore, the scope for interpretation by the receiver is limited. The influence of culture on motivation is expressed in different expectations regarding work goals, appraisal and reward allocation. Achievement and challenging work might act as motivators in more performance oriented countries (high MAS), whilst harmonic work place relations are preferred in countries more oriented on quality of life (low MAS). There is also a different view on what a just allocation of rewards is (e.g. individual reward (high IDV) vs. group reward (low IDV), equity oriented (high MAS) vs. equality oriented (low MAS) rewards etc.). Secondary factors such as the employed leadership style or the assignment of individual (high IDV) or group tasks (low IDV) also affect motivation. The attitude towards rules reflects the degree of acceptance and adherence to defined rules and standards. They are both higher in countries with high UAI and high IDV. [28], [32]

IV. Structure of Production Systems

A production system can be defined as an integrated framework of defined aims, principles and methods that guide the design and operation of manufacturing processes, taking into account economic, strategic, organisational and social aspects of the company's environment [5], [33], [11].

Based on the analysis of several production systems used by manufacturing companies today, the principles and methods of production systems can be classified into six subsystems: standardization, visual management, quality of products and processes, production control, employee-orientation, continuous improvement [9], [34]. The structure of production systems with an overview of the most common principles and methods is summarized in TABLE II.

TABLE II
Common Principles and Methods of Production Systems

Subsystem	Common principles & methods
Standardization	Components
	Processes
Visual management	5S
	Andon boards
Quality of products and processes	Quality assurance
	Poka yoke
	Jidoka
	TPM (total productive maintenance)
Production control	JIT (just in time)
	One piece flow
	Pull
	Heijunka
	Value stream design
	Takt time
	Kanban
	SMED (single minute exchange of die)
Employee-orientation	Leadership
	Motivation
	Team work
	Individual accountability
	Qualification
Continuous improvement	Problem solving
	PDCA (plan-do-check-act)
	Quality circles
	Suggestion systems
	Root cause analysis
	A3 reporting

"Standardization" is main element of each production system. The aim of this principle is to reduce cost and support continuous improvement efforts by standardizing components across product lines, and processes. Elements of the "visual management" subsystem are aimed at increasing work place cleanliness, process transparency and process stability. The subsystem contains methods such as 5S for organizing the work place and the use of andon boards for tracking progress. The subsystem "quality of products and processes" contains principles such as quality assurance, poka yoke and jidoka (autonomation) as well as methods like TPM (total productive maintenance). The subsystem "production control" contains principles like JIT (just in time), one piece flow, pull and heijunka (production levelling). The methods to support these principles include value stream design, the use of takt time, kanban and SMED (single minute exchange of die). The subsystem "employee-orientation" contains principles such as leadership, task assignment, individual accountability, motivation, qualification, and team work. The subsystem "continuous improvement" is central to all production systems. Its aim is the elimination of waste. It consists of principles such as problem solving and the PDCA (plan-do-check-act) cycle and methods like quality circles, suggestion systems, root cause analysis and A3 reports. [35], [6], [2], [9]

V. Analysis of the Dependence of the Most Common Principles and Methods of Production Systems on Work Behaviour

In order to assess the influence of culture on the various components of a production system their dependency on work behaviour has to be analysed first.

A. Standardization

The standardization of components across product lines is done due to economic reasons [9]. It is a purely technical measure and thus not dependent on work behaviour.

Standardizing processes requires deciding on how the standardized processes look like. Furthermore employees need to adopt the defined standards and work according to them [6]. This makes standardized processes dependent on the employees' motivation as well as their attitude towards rules.

B. Visual Management

The 5S method first requires defining how the work place should be structured and for the employees to respect the defined standards for cleaning and organizing the workplace [6]. This makes this method dependent on decision making and the workers attitude towards rules.

Using andon boards for tracking production progress is a technical measure [35] and thus not dependent on work behaviour.

C. Quality of Products and Processes

The quality assurance principle refers to achieving product quality by stable processes, error prevention and continuous improvement [9]. This makes quality assurance dependent on the employees' motivation to maintain or improve quality. Quality assurance implies assigning specific activities to fulfil the required product and process quality [35]. Stable processes and quality assurance related activities also require adhering to standardized processes [2]. This makes quality assurance dependent on the attitude towards rules.

Poka yoke refers to the principle of integrating sensors or passive devices into machines and manual operations in order to avoid accidental mistakes due to worker error [35]. Since these are technical measures, poka yoke is not dependent on work behaviour.

Jidoka, also known as "autonomation", refers to sensors and mechanisms incorporated in automated processes that detect abnormalities and stop the process in order to avoid the production of defective parts [35]. Since these are technical measures, jidoka is not dependent on work behaviour.

The aim of TPM is to reduce the downtime of machines and equipment by performing scheduled maintenance work [9]. This requires coordinated work by individual or teams of maintenance workers [36]. This makes TPM dependent on decision making, coordination and communication. Furthermore performing thorough machine check-ups and maintenance is contingent with the employees' motivation.

D. Production Control

JIT is a main element of lean production [9]. It refers to producing only the necessary products in the necessary quantities at the necessary time, thus avoiding overproduction and inventory pileups. Running a JIT production requires the implementation of all the other principles and methods of production control [3].

The principle of one piece flow relies on setting up and running flow production lines. Setting up is a technical measure [3] and thus not dependent on work behaviour. Running a flow production line requires adhering to standard processes [2], making it thus dependent on workers attitude towards rules. Line balancing when cycle times vary across work stations requires coordinating the workers. Dealing with problems on the line also involves decision making.

Pull and heijunka are both production scheduling principles. They are implemented and supported by the methods of value stream design, takt time and kanban [35]. As such none of these principles and methods is directly dependent on worker behaviour.

SMED is a method to reduce machine down time by reducing setup time [35]. This involves standardizing equipment like tools and jigs. Furthermore it requires keeping tools and jigs always ready to use by cleaning them after use, bringing the new tools and jigs to the machines and preparing them parallel to the running process [35]. This requires coordination and adherence to defined standard processes, making SMED dependent on the workers attitude towards coordination and towards rules.

E. Employee-orientation

The principles of the sub-system employee orientation are directly influenced by culture as described earlier in this paper.

Team work and individual accountability are directly moderated by the cultural dimension IDV.

Qualification refers to improving both technical and leadership skills of the employees by regular trainings on and off the job [24]. Training requires both communication and learning, thus being dependent on communication patterns, the employees' motivation to learn and on culture specific learning patterns.

F. Continuous Improvement

Problem solving is the main principle of continuous improvement. It requires identifying, analysing and prioritizing problems as well as finding and implementing solutions [2]. This requires deciding on activities and coordinating the implementation. Furthermore detecting and reporting problems and devising solutions are also dependent on the workers motivation.

The PDCA cycle is a principle to aid the implementation of solutions. It requires employees to plan their actions and also to follow up, check the results and make necessary changes [2]. This implies decision making and coordination. A thorough follow-up is also dependent on the employees' motivation.

Quality circles are groups of employees coming together to discuss and find solutions to current problems with the aim of improving quality and productivity [35]. For this the employees' motivation is crucial. The work within groups also requires decision making and coordination, thus making this method dependent on work behaviour.

Suggestion systems aim at collecting improvement ideas from all employees [35]. Employee motivation is the main prerequisite for this. Suggestion systems also involve the

communication of ideas [35], thus making it dependent on communication patterns.

Root cause analysis is a method for finding and analysing problems. It requires systematic work and an in-depth analysis of data [2]. This makes this method dependent on the workers motivation to do a thorough work and on their attitude towards rules.

A3 reporting is a method used to support problem solving and visual management by summarizing relevant information on a specific issue on one A3 sheet [2]. Thus this method is not dependent on work behaviour.

The dependence of the individual components of production systems on work behaviour is summarized inTABLE III.

TABLE III
DEPENDENCE OF THE MOST COMMON PRINCIPLES AND METHODS OF PRODUCTION SYSTEMS ON WORK BEHAVIOUR

Subsystem	Common principles & methods	Decision making	Coor-dination	Comm-unication patterns	Moti-vation	Attitude towards rules	Technical method
Standardization	Components						x
	Processes	x			x	x	
Visual management	5S	x				x	
	Andon						x
Quality of products	Quality assurance				x	x	
& processes	Poka yoke						x
	Jidoka						x
	TPM	x	x	x	x		
Production control	JIT						
	One piece flow	x	x			x	
	Pull						x
	Heijunka						x
	Value stream design						x
	Takt time						x
	Kanban						x
	SMED		x			x	
Employee	Leadership						
orientation	Motivation		directly influenced by culture				
	Team work						
	Individual accountability						
	Qualification			x	x		
Continuous	Problem solving	x	x		x		
improvement	PDCA	x	x		x		
	Quality circles	x	x		x		
	Suggestion systems			x	x		
	Root cause analysis				x	x	
	A3 reporting						x

VI. STANDARDIZATION AND ADAPTION REQUIREMENTS OF PRODUCTION SYSTEMS

Based on the analysis of the dependence of the components of production systems on work behaviour we propose a descriptive framework to answer the question of which components of production systems can be standardized and which require a local adaption when transplanting them into a different cultural environment. Thus we suggest the division of the components of production systems into three categories: components allowing a high degree of standardization, components requiring a lower degree of adaption and components requiring a higher degree of adaption.

The degree of adaption is defined according to the required adaption measures. We identify two types of adaption measures: one-time measures and on-going measures.

One-time measures consist of adaptations of organisational structures and systems to fit the culturally contingent patterns of decision making, coordination, communication and motivation. For example the preference for an autocratic leadership style in high PDI countries requires team leaders to make decisions and act as coordinators. The emphasis on delegative leadership in low PDI countries allows for autonomous work groups with team leaders taking a more supportive and administrative role. This leads to a one-time adaption of the organigram regarding the distribution of roles and responsibilities.

On-going measures consist of systems and activities designed to overcome cultural barriers and support the sustainable implementation of the production system. The focus is on the attitude towards rules which requires expanding or intensifying training, coaching and controlling activities in countries with low UAI or IDV in order to support adherence to defined standards. The on-going activities lead to a higher implementation effort, also involving the extensive use of expatriates.

Subsystems and technical methods can be standardized. Subsystems are broadly formulated and set the path for achieving the company's formulated aims. Technical methods do not rely on work behaviour or conflict with cultural specific values and can thus be standardized. The sustainable transplant of all principles of the employee-orientation subsystem as well as of TPM, JIT, problem solving, PDCA, quality circles and suggestion systems require a lower degree of adaption, consisting of one-time changes in organisational structures and systems. The sustainable transplant of standardized processes, 5S, quality assurance, one piece flow, SMED and root cause analysis require a higher degree of adaption, consisting of both one-time measures as well as on-going measures to support the adherence to standardized processes and to assure the achievement of set quality and productivity targets. The framework is summarized in Fig. 1.

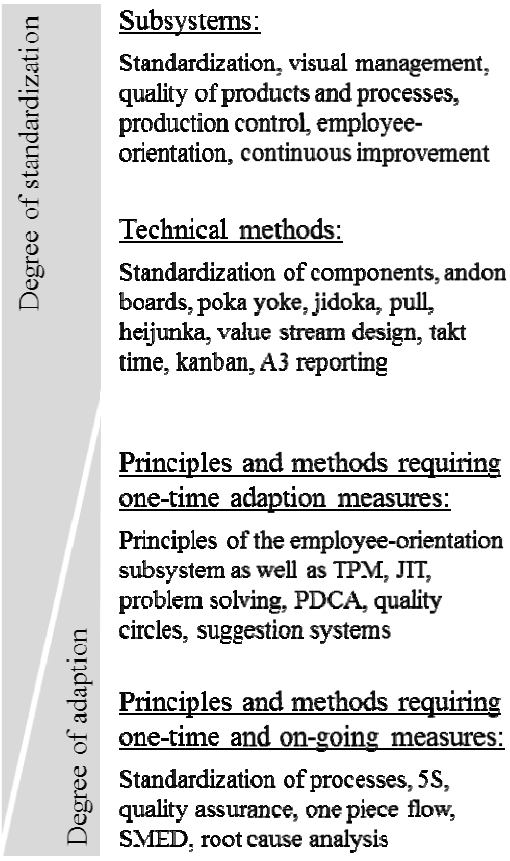

Fig. 1 Standardization and adaption requirements of production systems

VII. Conclusion

The analysis reveals that all subsystems of production systems are to some degree dependent on work behaviour and are thus influenced by culture. As studies show, the successful implementation of production systems in different cultural environments is dependent not on the host country's cultural traits but rather on the company's ability to adapt to the local conditions, thus overcoming the cultural barriers. This requires both one-time and on-going adaption measures.

The challenge for companies transplanting their production system to offshore manufacturing plants lies in identifying the risks and opportunities posed by the cultural traits of the host country and devising adequate one-time and on-going adaption measures to support a sustainable implementation of their production system.

Further research should focus on developing cultural specific measures for supporting the sustainable transplant of production systems.

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