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The Use of Organizational Innovation Concepts in Manufacturing Companies

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Abstract. The main purpose of this paper is to map the adoption of selected innovative organizational concepts in manufacturing companies. A further objective of our research is to find out how different organizational concepts are represented in different manufacturing company's types and how they are related to the use of advanced manufacturing technologies. Based on a sample of 118 Slovenian manufacturing companies collected through the 2018-19 European Manufacturing Survey edition, results give information about the most used organizational concepts, their utilization degree, planned use and average year of implementation. In addition, results give evidence that the use of selected organizational concepts is very positively related to the use of specific advanced manufacturing technologies.

Keywords: Organizational Innovation Concept, Manufacturing Company, Advanced Manufacturing Technology, European Manufacturing Survey, Slovenia.

1 Introduction

The importance of innovation to competitiveness has been acknowledged for many years now. Unfortunately, the term innovation is still sometimes more synonymous with product innovation or technical innovation than process or organizational or managerial innovation. Organizational innovations are often neglected in innovation theory [1]. Keupp et al. [2] made an extensive literature review on innovation management, where analysing more than 342 articles, they found out that there is a low number of articles dealing with the field of non-technical innovation, while the number of articles in the field of technical innovation is much higher.

Although organizational innovation is considered an important contributor and trigger to the product innovation, and ultimately to company success, organizational or non-technical innovation needs further and deeper understanding [3]. Many studies analyse specific organizational innovations. On the other hand, there is a lack of papers that try to identify and measure the organizational innovation in companies [4, 5].

Therefore, our paper contributes to analysis of specific organizational concepts in manufacturing companies from different perspectives.

Organizational innovation does have an impact on company output, first directly and second, through its interrelationship with technical innovation [1]. Accordingly, several studies exist that emphasize the interdependence of technological and management innovations and their joint, complementary influence on organizational outcomes [5]. These studies usually focus on organizational (and technical) innovation and its impact on innovation and financial performance. On the other hand, there are not many studies that look for relationship between specific organizational concepts implementation and the use of specific advanced manufacturing technologies (AMT).

The main purpose of this paper is to map the adoption of selected innovative organizational concepts in Slovenian manufacturing companies and the relationship with selected AMT. The structure of the remainder of the paper is as follows. Section 2 gives a brief description of organizational innovation. Section 3 describes used research methodology. Section 4 comprises the results of the analysis and discussion, while the conclusions are presented in section 5.

2 Organizational innovation concepts

Management innovations, also called organizational, administrative, and managerial innovations, are non-technological innovations that have been conceptualized in contrast to technology-based product and process innovations and pertain to new organizational structures, administrative systems, and management practices [5]. Birkinshaw et al. [6] defined management innovation as ‘the generation and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals’. OECD Oslo Manual from 2005 [7] defines an organizational innovation as the implementation of a new organizational method in the company’s business practices, workplace organization or external relations.

There are several ways to differentiate organizational innovation. The first possibility is into structural organizational innovations and procedural organizational innovations. Structural organizational innovations influence, change and improve responsibilities, accountability, command lines and information flows as well as the number of hierarchical levels, the divisional structure of functions (R&D, production, human resources, financing, etc.), or the separation between line and support functions. Procedural organizational innovations affect the routines, processes and operations of a company. Thus, these innovations change or implement new procedures and processes within the company, such as simultaneous engineering or zero buffer rules. Organizational innovation can be further differentiated along an intra-organizational and inter-organizational dimension. While intra-organizational innovations occur within an organization or company, inter-organizational innovations include new organizational structures or procedures beyond a company’s boundaries. These comprise new organizational structures in an organization’s environment, such as just-in-time processes

with suppliers or customers, supply chain management practices with suppliers or customer quality audits. Intra-organizational innovations may concern particular departments or functions or may affect the overall structure and strategy of the company as a whole. Examples for intra-organizational innovations include the implementation of teamwork, quality circles, continuous improvement processes, certification of a company under ISO 9000, zero-buffer principles, environmental audits etc [4].

Scholars have started emphasizing that, in order to capture the full benefits of innovation, technological innovation needs to be combined with management innovation [8-10]. Historically research on innovation types has followed a technological imperative. It assumes that companies mainly organize their innovation efforts through R&D activities and has thus focused on a narrow definition of product and process innovations associated with the R&D function in manufacturing organizations [10]. The socio-technical system theory challenged the technological imperative and argued that changes in the technical (operating) system of the organization should be coupled with changes in the social (administrative) system in order to optimize organizational outcome [11-13]. Therefore, our research looks for relationship between technical and organizational innovation concepts.

3 About European Manufacturing Survey

The research data was collected using the EMS, a Consortium of Research Institutions coordinated by the Fraunhofer Institute for Systems and Innovation Research – ISI, the largest European survey of manufacturing activities. The survey's questions deal with manufacturing strategies, application of innovative organizational and technological concepts in production, cooperation issues, production offshoring and backshoring, servitisation, and questions of personnel deployment and qualification. In addition, data on performance indicators such as productivity, flexibility, quality and returns is collected. The survey takes place every three years.

The responding companies present a cross-section of the main manufacturing industries. Included are producers of rubber and plastics, metal works, mechanical engineering, electrical engineering. The survey is conducted among manufacturing companies (NACE Revision 2 codes from 22 to 32) having at least 20 employees. Our research is based on EMS data from a Slovenian subsample from the year 2018/19 round. We sent 778 questionnaires and received 118 responses – a 15% response rate. In our 2018/19 subsample, manufacturing companies from NACE divisions 22, 25 and 28 are represented most widely with around 25% of companies from NACE 25, around 20% from NACE 28, and around 16% from the NACE 22 division. We classified manufacturing companies in three size classes based on the number of employees. The largest share of respondents is from medium sized companies (around 43%), followed by small companies (32%) and large companies (25%).

We present the results of our research with the use of descriptive statistics and linear regression model to analyse the dependency between organizational concepts and AMT.

4 Results and discussion

4.1 Organizational concepts in EMS

In EMS 2018, we have divided 11 organizational concepts used in manufacturing companies into 3 groups: Organization of production (OP – 4 concepts); Management/controlling (MC – 5 concepts) and Human resources (HR – 2 concepts).

For each organizational concept, we have asked for the following information:

- Use of organizational concept (yes/no).
- Use planned in the upcoming period of three years.
- Year in which organizational concept has been used for the first time in factory.
- Extent (level) of actual utilization compared to the most reasonable potential utilization in the factory: Extent of utilized potential “low” for an initial attempt to utilize, “medium” for partly utilized and “high” for extensive utilization. High utilization of an organizational concept means, for example, that it involves at least 70% of employees in the company.

Table 1. Characteristics of used organizational concepts.

Organizational concept	Group	Share [%]	Year of introduction	Planned use [%]	Level of use
ISO 900x	MC	83,9	2003	15,8	2,80
Training of employees	HR	83,9	2005	26,3	2,08
Standardised instructions for work	OP	79,7	2002	20,8	2,55
Instruments for promoting staff loyalty	HR	67,8	2005	18,4	2,10
CIP, TPM, TQM, Six Sigma	MC	59,3	2009	29,2	2,25
Display boards in production (Visual Manag.)	MC	52,5	2012	41,1	2,44
EN ISO 14001	MC	43,2	2007	34,3	2,78
Value Stream Mapping	OP	37,3	2010	16,2	1,98
SMED	OP	36,4	2011	34,7	1,98
Production controlling following pull principle	OP	33,9	2011	20,5	2,03
Energy management system (EN ISO 50001)	MC	15,3	2014	17,0	2,37

As we can see from Table 1 both concepts from “Human resources” group have very high adoption rate in manufacturing companies. The age of Industry 4.0 and fast technological pace require that all employees acquire new knowledge and skills in different areas. They are also becoming more and more priceless and scarce, therefore companies must introduce specific instruments to promote staff loyalty (e.g. attractively designed responsibilities, offering learning opportunities, flexible working hours, child-care etc.). Quality standards, such as ISO 9001, have always had a high adoption rate, as they are prerequisite to conduct business in global economy. The pressure of environmental challenges in front of us requires also introduction of specific certified environmental management systems (e.g. EN ISO 14001). As many companies introduced specific organizational concepts in the last few years, the average year of first introduction of organizational concepts differs from previous EMS rounds. Except for Stand-

ardized instructions for work, all other three organizational concepts from “Organization of production” group are among the youngest, as well as Visual management from the “Management/controlling” group.

The column “Planned use” presents share of companies that do not possess a specific organizational concept, but are planning to introduce it in the period from 2019 to 2021. We can see that the share of companies that are planning to invest in organizational concepts in the next 3 years is quite high. More than 40% of companies that do not use display boards in production is planning to introduce them by the year 2021. That environmental issues are important is clearly presented also by the fact that one third of companies without environmental systems will introduce them by the end of 2021. CIP and SMED methods are also planned in one third of companies that at the moment do not use them.

Next, we looked at the extent of potential use or actual utilization (low – 1, medium – 2, high – 3). Both quality and environmental standards have a very high share of companies who claim a high use of the standard (around 80% claim to use them to full potential and with average grade of 2,8 for all analysed companies that use them). As expected from the previous research standardized instructions for work are also used at a high level. There is an increase in share of companies that use visual management at the high level comparing to previous EMS rounds. This means that different display equipment in production is becoming widely used and at the same, it delivers required results. Comparing to previous EMS rounds there is also an increase in the share of companies that use continuous improvement methods to more full potential. It can be seen that both concepts from “Human resources” are often used to a very low potential (grade around 2,1). Pull principle, SMED and value stream mapping methods have the lowest average potential use grade of around “2”.

The concept “Certified energy management system (e.g. EN ISO 50001)” has a very low adoption rate (around 15%). Therefore, we have excluded this organizational concept in further analysis.

4.2 Organizational concepts and advanced manufacturing technologies

In our last EMS 2018/19 research round, we have analysed the use of 16 AMT and ICT. Technologies were divided into four groups Digital factory (9 technologies); Automation and robotics (2 technologies); Additive Manufacturing Technologies (2 technologies) and Energy efficiency technologies (3 technologies).

In this paper, we are focusing on Industry 4.0 specific AMT from the digital/smart factory area, industrial robots and additive technologies (we are skipping energy efficient technologies). Table 2 presents the share of AMT and ICT use. When we looked at the use of both types of discussed robots together, we found that at least one type of robots is present in 64% of companies, making industrial robots the most widely used technology from our list. If we combine both types of additive manufacturing technologies, we can observe that at least one of them is used in around one third of the companies. In this paper we are skipping the more in-detail discussion of AMT and ICT use as the focus is on organisational concepts.

Table 2. AMT adoption in Slovenian manufacturing companies

AMT	Share [%]
Digital factory	
Mobile/wireless devices for programming and controlling facilities (e.g. tablets)	32,2
Digital solutions to provide drawings, work schedules or instructions on the shop floor	54,2
Software for production planning and scheduling (e.g. the ERP system)	62,7
Digital exchange of product/process data with suppliers / customers (EDI)	51,7
Near real-time production control system (MES)	39,8
Systems for automation and management of internal logistics (WMS, RFID)	20,3
Product-Lifecycle-Management-Systems (PLM) or Product Data Management (PDM)	19,5
Virtual reality, or simulation for product design, or product development	38,1
Artificial Intelligence (Deep Learning, Machine Learning or Neural Networks)	5,1
Automation and robotics	
Industrial robots for manufacturing processes (e.g. welding, painting, cutting)	50,0
Industrial robots for handling processes (e.g. assembling, sorting, packing processes, AGV)	35,6
Additive manufacturing technologies	
3D printing technologies for prototyping (prototypes, demonstration models, 0 series)	32,2
3D printing technologies for manufacturing of products, components and forms, tools, etc.	23,7

Our goal was to look for relationship between selected organizational concepts and the use of described AMT. We analysed the following six organizational concepts: Standardized and detailed work instructions (SWI); Measures to improve internal logistics (WMS); Setup time or change-over reductions methods (SMED); Pull principle (KANBAN); Visual management (VM) and Methods of assuring quality in production (Q).

We have used linear regression method to look for relationship between a dependent variable (each organizational concept) and independent variables (each AMT). Table 3 presents (Pearson) correlation coefficients for selected organizational concepts and AMT from the group “Digital factory” and Table 4 presents results for the groups “Automation and robotics” and “Additive manufacturing technologies”. Our regression procedure aggregates the empirical results based on the percentage of statistically significant regression coefficients ($p < 0.05$).

Table 3. Organizational concepts and digital factory technologies

Org. con.	Mobi. device	Digital solut.	ERP	EDI	Con-trol	Inter. logist.	PLM, PDM	Virt. real.	AI
SWI	+0,078	+0,170	+0,220	+0,186	+0,067	+0,203	+0,142	+0,137	+0,021
VSM	+0,294	+0,251	+0,232	+0,395	+0,303	+0,438	+0,373	+0,224	+0,141
SMED	+0,270	+0,236	+0,293	+0,344	+0,463	+0,317	+0,472	+0,348	+0,226
Kan-ban	+0,273	+0,155	+0,182	+0,262	+0,185	+0,305	+0,280	+0,138	+0,160
VM	+0,255	+0,217	+0,320	+0,270	+0,461	+0,227	+0,382	+0,152	+0,220
Q	+0,165	+0,209	+0,289	+0,304	+0,357	+0,247	+0,364	+0,259	+0,192

Table 4. Organizational concepts and, robots and additive manufacturing technologies

Organizational concept	Manufac. robots	Assembly robots	3D pro-totyping	3D manu-facturing
Standardised work instructions	+0,042	+0,112	+0,168	+0,133
Warehouse Management Systems	+0,210	+0,305	+0,369	+0,353
SMED	+0,123	+0,357	+0,307	+0,406
Kanban	+0,251	+0,328	+0,388	+0,316
Visual Management	+0,170	+0,246	+0,219	+0,251
Quality in Production	+0,104	+0,291	+0,275	+0,219

Table 3 and 4 show that in general all six analysed organizational concepts are positively and significantly correlated with majority of AMT. The organizational concept that illustrates work processes and work status (Visual Management) is positively and significantly correlated with all AMT. Digital solutions on the shop floor, ERP, EDI and systems for automation and management of internal logistics are positively correlated with all analysed organizational concepts.

Table 5 presents additional results of linear regression analysis, where we present results for the whole model for each selected organization concept. The model is not significant only for the first organizational concept Standardized instructions for work (Sig. F change is 0,522). For all other organizational concepts, the model is significant, meaning that AMT are relevant predictors for organizational concept use.

Table 5. Results of the regression analysis

Organizational concept	<i>R</i>	<i>R</i> Square	Adjusted <i>R</i> Square	Std. Error of the Estimate	<i>R</i> Square Change	Sig. <i>F</i> change
Standardised work instruc.	,323	,105	-,007	,40573	,015	0,522
Warehouse Man. Systems	,575	,331	,247	,42144	,331	0,000
SMED	,632	,399	,324	,39731	,399	0,000
Kanban	,499	,249	,155	,43701	,249	0,003
Visual Management	,547	,299	,211	,44537	,299	0,000
Quality in Production	,486	,237	,141	,45716	,237	0,006

Predictors: (Constant), Manufac_3D, Internal_log, Virtual_reality, Robots_manuf, AI, ERP, Robots_assem, EDI, Control_system, Mobile_dev, PLM_PDM, Digital_sol, Prototype_3D

5 Conclusion

Since there is not much less research in the area of non-technical innovation than in the area of technical innovation, this paper gives emphasis on this type of innovation. We have analysed how widely selected organisational concepts are used, what is the extent of their potential use, what differences exist in the use and extent of use of these concepts and which are the characteristics of the adopters (company size, technological intensity, OEM/supplier etc.). There is a big difference in the exploitation of organizational concept potential use between analysed concepts. The ones with earlier average year of introduction have higher level of exploiting the potential use. On average, the dispersion of organizational concepts is higher in larger companies, suppliers and within companies from medium or high technological sectors.

The last finding is proved by the analysis of the relationship between organizational concepts and AMT. Our research showed that the use of several organizational concepts, that deal with organization or/and management and controlling of production, are strongly and positively correlated with AMT from “Digital factory” area, robots and additive manufacturing technologies. We can argue that the use of these AMT is not possible without carefully planned and implemented organizational concepts.

Our research has, therefore, practical and managerial implications. Our results show that the use of specific AMT clearly positively affects the need to implement organizational innovation concepts and vice versa. This is a clear message to managers that technical innovation and the use of AMT requires also organizational concepts to support the potential of AMT.

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