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THE CROATIAN MODEL OF INNOVATIVE SMART ENTERPRISE FOR DIFFERENT SIZES OF ENTERPRISE

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ABSTRACT

This paper deals with the issue about models that will help Croatian companies to bridge the gap between their current situation and that of the developed companies. The paper presents research within the project Innovative Smart Enterprise.

The aim of project Innovative Smart Enterprise is to understand current state of manufacturing enterprises in Croatia and to help them find a new path for improvement. The focus is on new manufacturing technologies, integration of ICT (Information and communication technologies) within processes and new organizational concepts in production related to Industry 4.0.

Previous research was done to describe the current state of Croatian manufacturing companies and an analysis was made to find out which basic lean methods Croatian companies should acquire and use. A selection of six basic lean methods was made and the foundation of generic HR-ISE (Croatian model of innovative smart enterprise) model was defined. This paper presents models based on the generic HR-ISE model. The data for research were collected from small, medium and large companies through surveys. This research shows that surveyed companies in Croatia are aware that they need new model for production system in order to stay competitive. Through this research Croatian manufacturing companies have picture of the current state and guidelines for improvement.

KEY WORDS

Industry 4.0, Innovative Smart Enterprise, lean

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INTRODUCTION

Manufacturing is a cornerstone of the economy of developed nations. An important characteristic of manufacturing is that it requires the new skills of everyone included in production system. New skills can be gained through external or internal knowledge. Employees should share their knowledge between other colleagues but also acquire knowledge from different sources. Those new skills are related to basic digital skills, leadership skills for creation of flexible organization of production, analytical and critical thinking, monitoring to make improvements, complex problem solving and teaching others. The biggest challenge for manufacturing companies is to work successfully in a turbulent business market where is necessary to fulfill all customer's needs and wishes. The first three industrial revolutions came as a result of mechanization, electricity and development of Information Technology (IT). Today, the introduction of the Internet of Things and Services into the manufacturing environment is ushering in a fourth industrial revolution: Industry 4.0 [1].

Countries are developing their own unique strategy for industrial improvement, which is connected with their vision, values and culture. A very popular new topic is the level of readiness for the industrial countries. The Roland Berger study shows Croatia as country that hesitates to move toward Industry 4.0 [2] (Fig. 1). Previous research shows that most of the enterprises of Croatian manufacturing industry are closer to 2nd industrial generation than to 3rd industrial generation [3]. All mentioned was the motivation to start the INSENT (Innovative Smart Enterprise) project. The main objective of this project is to develop the Croatian model of Innovative Smart Enterprise (HR-ISE model). The profound research was done to describe the current state of Croatian manufacturing enterprises. A synthesis of an analysis of Croatian manufacturing enterprises was done through development of Croatian model of Innovative Smart Enterprise. The research for the detailed definition of the HR-ISE model was based on questionnaires that were sent to manufacturing enterprises within Croatia. A different number of employees were in the surveyed enterprises so the HR-ISE model is adapted to small, medium and large company. The HR-ISE model for each size of company is based on the generic HR-ISE model [3]. The main feature of Industry 4.0 is a Smart enterprise. There are smart personalized products, smart services and smart procedures with high level of collaboration. Everything within Smart enterprise is connected so information is shared at the right time with people who need it. Such manufacturing system needs flexibility, high level of ICT, ability to offer extended products (product and service integrated into single product), vertical integration called Production Networks [4] and horizontal integration called Manufacturing Networks [5].

The research methodology for this paper started with literature review and analyses of previous research, second step was related to creation of questionnaires based on literature review and previous research, the third step was related to analyses of questionnaires and connection with surveyed companies and their managers to find the model that could help them to improve their work. This paper shows objectives and priorities of Croatian manufacturing companies but also gives guidelines for enterprises to create their own way for improvement of organization.

PHASES OF THE RESEARCH

Several phases were necessary to realize project INSENT. The three main aspects of the project are:

- The profound research in order to describe current state of Croatian manufacturing enterprises. It was necessary to gather the data from as much as possible enterprises. After that, it was possible to answer on the question: “Where are we now?”
- Through development of Croatian model of Innovative Smart Enterprise, the answer on the question “Where do we want to be?” is more closely formed, (Fig. 2).
- At this point of the project appears term “Learning factory”, which represents a special learning environment established in one laboratory at the University of Split. With new specialized environment it is possible to simulate processes of a real factory through specialized equipment. There are virtual reality gadgets, specialized assembly tables, automatic assembly stations, automated vehicles and whole system is supported with HR-ISE model. It is place where is possible to transfer developed HR-ISE model to Croatian enterprises.

These three main aspects are realized through four work packages in the period of four year. The first work package is related to analysis of current state of Croatian manufacturing companies, the second is development of the HR-ISE model, the third is establishment of the Learning Factory and the fourth is project dissemination. Project is completely aligned with EU strategy for growth of competencies of enterprises. Especially, manufacturing small and medium enterprises, which are seen as backbone of EU economy.

Analysis of Current State of Croatian Manufacturing Enterprise

Work package 1 was oriented to the current state of Croatian manufacturing enterprises. To define the current state, the questionnaires were designed with special care. The attention was on important factors that affect competitiveness of Croatian manufacturing enterprises. Those important factors are development of product, technology that is currently used, management of work orders, traceability of the product and the monitoring of production conditions, inventory management, quality assurance, product lifecycle management and usage of lean methods. For each question, related to mentioned areas, companies chose the answer that best describes their condition. The questionnaires brought a picture of each company that participated in the research. Also, it was important to find out how Croatian manufacturing enterprises understand lean methodology and new ways of work that brings Industry 4.0. The usage of Lean methodology is important to prepare system for Industry 4.0. A framework for Industry 4.0 presents supplementation to Lean methodology [8]. Example for this is smart product which belongs to Industry 4.0, and it contains information of Kanban (Lean method) to realize an order-oriented production.

Development of Croatian Model of Innovative Smart Enterprise – HR-ISE Model

Through Work package 2 the HR-ISE model was defined in order to help Croatian manufacturing companies. Companies that operate in different situations on the market need sophisticated organization models, which are characterized by modular production networks where flexibility is at high level. Regarding to the global

competition, the only way that Croatian company survives is to provide high quality, customized products with customized services at reasonable prices and with short delivery times. It is hard to predict the behavior, trends and demands, but to withstand all trends the changes are inevitable. The main aim of the generic HR-ISE model is to make unique steps for process and structural reorganization of Croatian enterprise based on lean principles. There were six basic lean methods that is necessary to implement, that part of the house is unreplaceable, (Fig. 3). There were missing parts so it was necessary to completely define the HR-ISE model. The model is shown in the form of the house.

The six basic lean methods and the generic HR-ISE were discussed with managers in Croatian manufacturing companies. The surveys were completed and profound analysis was done to completely define the HR-ISE model, (Fig. 4). The entrepreneurial structure in Croatian enterprises is very stiff and capacity increase is time-consuming and expensive process, flexibility has to be generated by an improved organizational model. A new organizational model will enable production on demand. The development of the Internet and its availability makes possible to develop your own sale network. It is not necessary to have an intermediary in sale. Today, buyer buys from his home and he knows exactly what he wants. The buyer searches for manufacturers that can produce a product according to his wishes and needs, that kind of product expresses his individuality and creativity.

The new HR-ISE model is oriented to objectives, people and priorities. The lean methods in the model are support to clearly defined objectives and priorities. Objectives and priorities can be defined through steps for implementation of lean methodology. The implementation of lean methods will lead to the improvement of existing technologies or products. The HR-ISE model represents steps for implementation, where base lean methods are standardized work and 5S, and those methods are first activity for implementation. That way will help companies to define their priorities for improvement. Previous research shows that the role of employees is crucial for the HR-ISE model, especially their motivation to move forward. The education is necessary to employees in Croatian enterprises, especially in the area of lean principles and new business models. The implementation of the model like HR-ISE house can significantly reduce costs. There are several priority areas for action in production process, if work is observed as one of them, first it will be necessary to standardize work. The standardized work is preparation for new technologies, what will bring increase of productivity [9]. Many other companies develop their own production system, they are usually inspired by Toyota production system (TPS). Companies are spending enormous amounts of resources developing, implementing and managing a company-specific production system (XPS) [6]. The "X" factor represents the adaptation of the improvement program to the specific needs of a company. The XPS is a strategic improvement program and there is no end date of that program. The research about XPS included 30 multinational companies and results showed that lot of companies use similar lean methods. It is possible to create some model that includes lean methods, objectives and priorities like HR-ISE model and each company has that model as a base model and then companies do little modifications according their needs. If there is some method in the HR-ISE model which is not appropriate for specific production, then companies will find other method and replace it in the model.

Establishment of HR-ISE Learning Factory

A Learning Factory is a learning environment where processes and technologies are based on the real industrial site which allows a direct approach to product creation process. The Learning Factory's mission is to integrate design, manufacturing and business realities into the engineering curriculum. This is accomplished by providing balance between engineering science and engineering practice. Learning Factories are based on a didactical concept emphasizing experimental and problem-based learning. The continuous improvement philosophy is facilitated by own actions and interactive involvement of the participants. It is a "living lab" for demonstration and implementation of the HR-ISE model. In the Learning Factory procedures for improvement of production system layout and for implementation are defined according to the HR-ISE model. It is possible to do an analysis of some existing production system layout (with methods like Spaghetti diagram, process mapping). There is specialized equipment for design of future-state layout (by using visTABLE touch software). This environment enables knowledge transfer to enterprises from Croatian economy. Beside purchased and donated equipment, development of the custom made laboratory equipment is mostly done by students as a part of practice-based learning path, under supervision of mentors.

The laboratory shown in Fig. 5 represents a Lean Learning Factory (LLF). That factory is a member of the International Association of Learning Factories (IALF) and it participated in the European project Network Innovative Learning Factories. This environment serves students, industry partners and scientists.

ADAPTATION OF THE HR-ISE MODEL TO THE COMPANY SIZE

For the realization of the research, the survey was sent to the companies in Croatia and Bosnia and Herzegovina, 37 companies answered. The surveyed companies that were included into research for development of the HR-ISE model have different sizes of enterprise (small enterprises with 10 to 49 persons employed, medium-sized enterprises with 50 to 250 persons employed and large enterprises with over 250 persons employed). Surveyed companies are located in different regions in Croatia, (Fig. 6). The aim was to cover with this research main regions in Croatia and manufacturing enterprises that have a lot of experience in industry.

The HR-ISE model has several changes according to the size. There were 46% of the surveyed companies that have over 250 employees, 41% of them have between 50 and 250 employees and 13% have between 10 and 49 employees. The surveyed companies belong to different industries, (Fig. 7).

The survey that was sent to the companies has 22 questions about lean principles, objectives, priorities and employees. It also contains generic HR-ISE model shown in Fig. 3. The motivation for this adaptation is fact that small and medium-sized enterprises are mentioned as the backbone of the European economy.

Small companies in Croatia rarely introduce Lean methods on their own initiative and the biggest problem is lack of knowledge about Lean methods. That is reason why there are competencies, education, qualification and innovation most important for employees. The development of new products is objective which closely follows

customer satisfaction at the top of the house, (Fig. 8). The order of lean methods is slightly different from HR-ISE model because team work is replaced by flexibility which is important to small companies. The SMED method is also crucial, its application enables small lot sizes, reduces production times and time when machine does not operate.

Medium sized companies emphasize that their objective is continuous improvement that closely follows customer satisfaction. The education is very important in medium-sized companies but new markets and the introduction of new technologies are above the education. There were 73% of medium-sized companies that mentioned new markets as first priority and 60% of them mentioned introduction of new technologies as second priority. The last two methods for application are different for this model, because medium sized companies need flexibility and PDCA cycle in their model, (Fig. 8). The HR-ISE model for a large company does not differ significantly from the previously obtained HR-ISE model, (Fig. 10). The main objective that closely follows customer satisfaction is costs reduction.

The responsibility is one of the main requirements for employees, this system is big and it tends to go towards decentralization. The digitalization process brings development of visual management so visualization is important method for large companies.

The objectives have not changed much by changing the size of a company. Customer satisfaction is most important to everyone. However, large companies point out cost reduction immediately after customer satisfaction, medium sized companies put continuous improvement and small sized companies put development of new products after customer satisfaction. The requirements for employees and priorities also have some corrections. There are several different things between models but the aim is to define model that is adjusted to the size of the enterprise. The HR-ISE model for each size should be observed as a set of lean methods and principles supported by an enterprise information system. It is desirable that information system is unique and offers possibility to connect with other applications for different purposes. Applications could be developed as universal web applications or adjusted to different devices as tablet, personal computer or smart phone. An example of web application for Kaizen is shown in Fig. 11. The advantage of this Web application is that every worker through his smartphone can enter a description of the problem (rather than print it on a Kaizen board). That is stored in the database and automatically becomes visible to everyone in the enterprise, it helps to solve problem quickly.

INTEGRATION OF THE HR-ISE MODEL INTO THE COMPLETE MODEL OF THE INNOVATIVE SMART ENTERPRISE

Models adjusted to different sizes of enterprise are integrated into the complete model of the Innovative smart enterprise. The companies use Enterprise resource planning (ERP) or Manufacturing Execution System (MES) that has central planning and managing of production system [7]. A new model of Innovative smart enterprise has completely new approach for production planning and managing. That approach is related to each work station. The ERP or MES system is connected with developed model of Innovative smart enterprise that uses defined lean methods and respects

priorities to achieve objectives. Introduction of model that is shown in Fig. 12 is a big challenge. The main features of this model are:

- adaptation of business processes to customers through support of Customer relationship management (CRM), reduce of all types of wastes and continuous improvement,
- it ensures the existing and increasing competitiveness on the domestic and global markets,
- it changes way of thinking at all organizational levels, it includes all employees.

The model also needs support of Total quality management and Cyber physical production systems. In Croatian companies the current situation mentioned before is related to second industrial generation, what means that there are no possibilities to transform the whole production process into fourth generation right now. But, there is a possibility to create a new way of work through the reapplication and transformation of old capabilities. New product configurator helps customers to express their needs and at the same time it provides inputs for production because it is connected with ERP system as shown in Fig. 12. The buyer of 21st century buys from his own home and wants a product made only for him. The previous research in Croatia, that was done to show the usage of Internet configurator, showed that only 4 companies of 2300 surveyed have product configurator. When system has inputs it shares information through whole system because everything is connected. The HR-ISE model operates in the background and supports system so when product is done, the most important objective is realized – customer satisfaction. The customer relationship management is also involved all the time in order to have a feedback.

CONCLUSION

The model presented in this paper is original Croatian model, adapted to the current situation in Croatian industry. It represents a way to achieve advanced solutions for production. The process for develop this model has been described briefly. According to the results of previous researches, it is clear where Croatian industry is and why it is called “hesitator” according to readiness for Industry 4.0. However, a strong motivation is there to change the current situation. The knowledge and new skills gained through application of new ways of work can significantly help Croatian manufacturing companies. Their employees have a place – Lean Learning Factory (LFF) where they can experience how to implement new methods step by step, discuss about their challenges with implementation, ask for advice or help during the process. It is known that with new technologies and old organization there is no progress. The industry processes require new organizational concepts, the introduction of new technologies but also the biggest focus on employees, their development, especially life long learning. All mentioned represents the components that have to be balanced in order to achieve the highest performance, otherwise a good effect will be achieved but in a very small extent.

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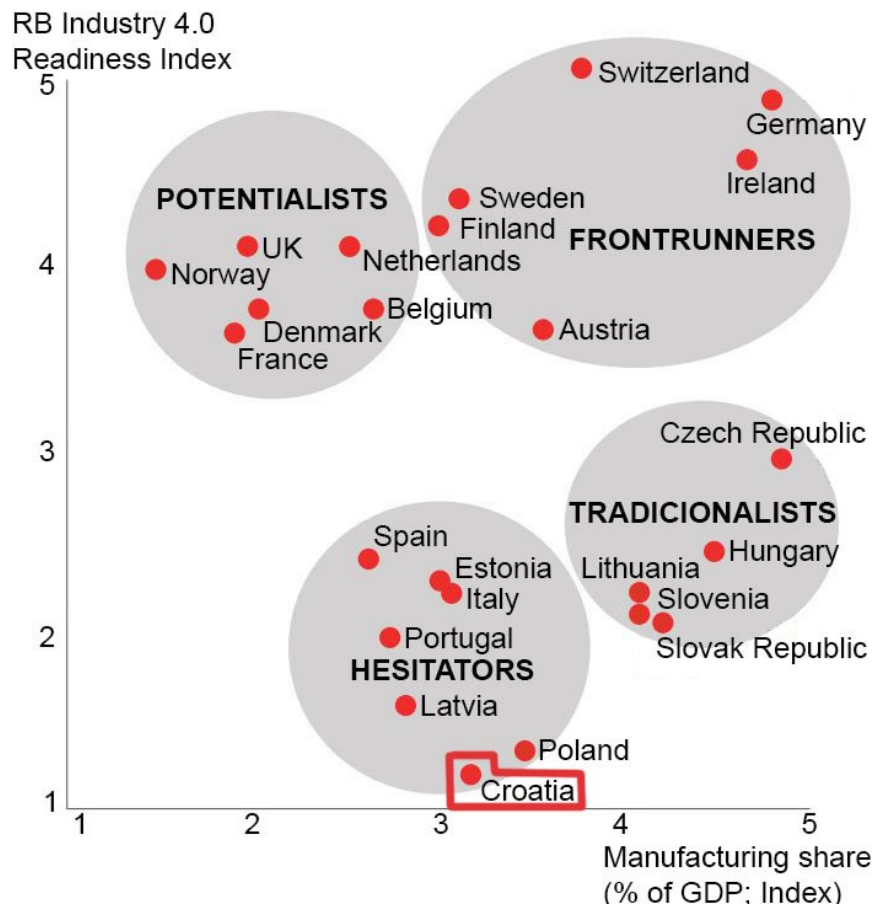


Fig. 1. An analysis of European countries that reveals four different clusters according to readiness for Industry 4.0 [2].

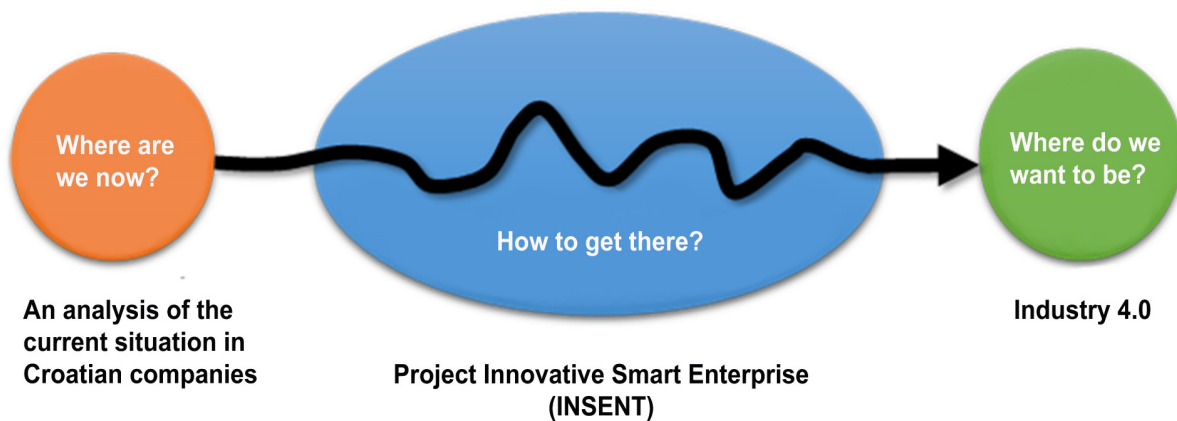


Fig. 2. The main questions for the INSENT project.

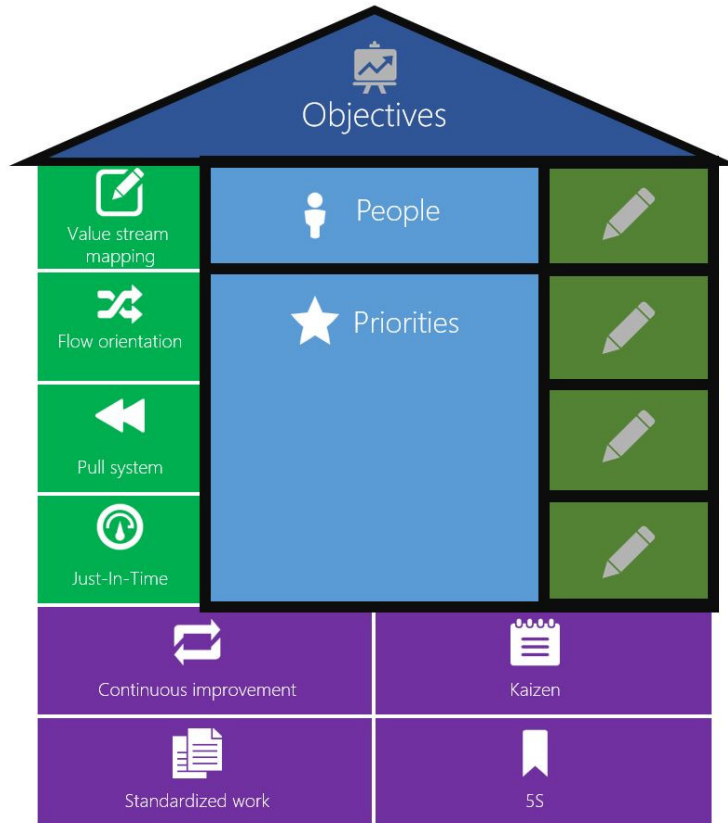


Fig. 3. The generic HR-ISE house with basic lean methods and without objectives, priorities and requirements for employees [3].



Fig. 4. The HR-ISE model [4].

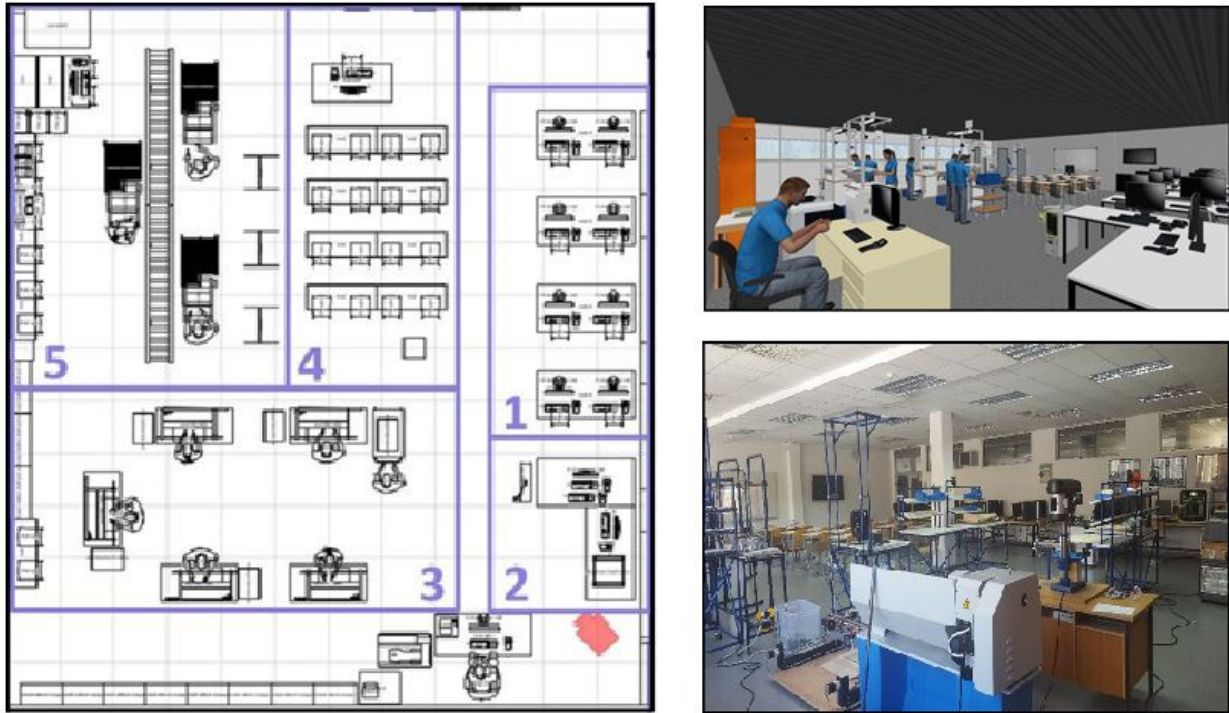


Fig. 5. The laboratory as Lean Learning Factory.



Fig. 6. Location of 37 Croatian manufacturing companies included in the research.

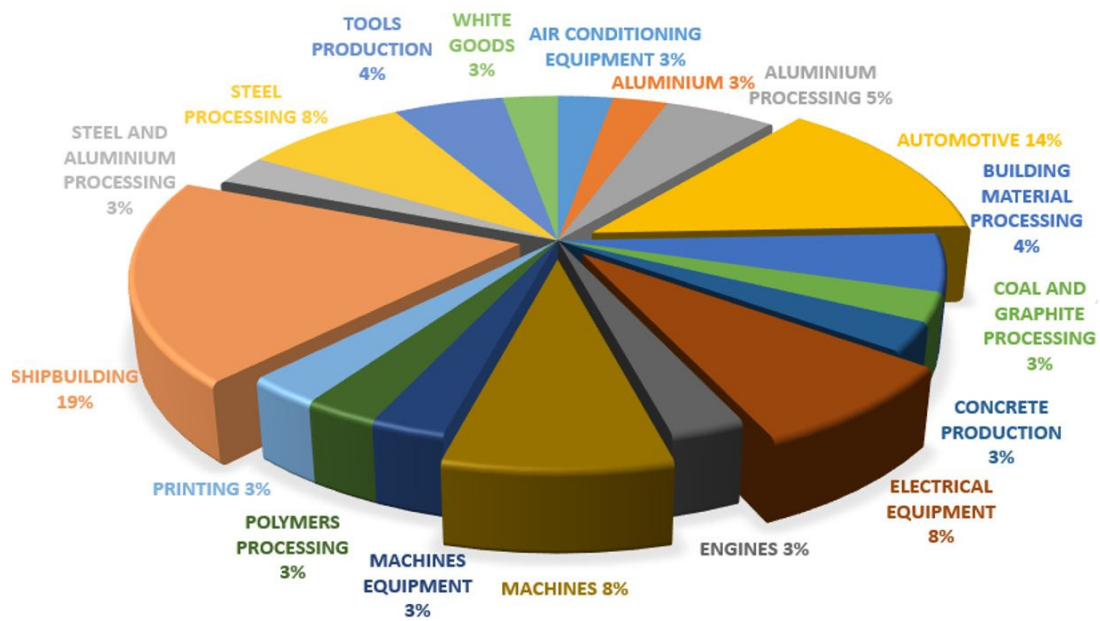


Fig. 7. The surveyed enterprises belong to different industries.

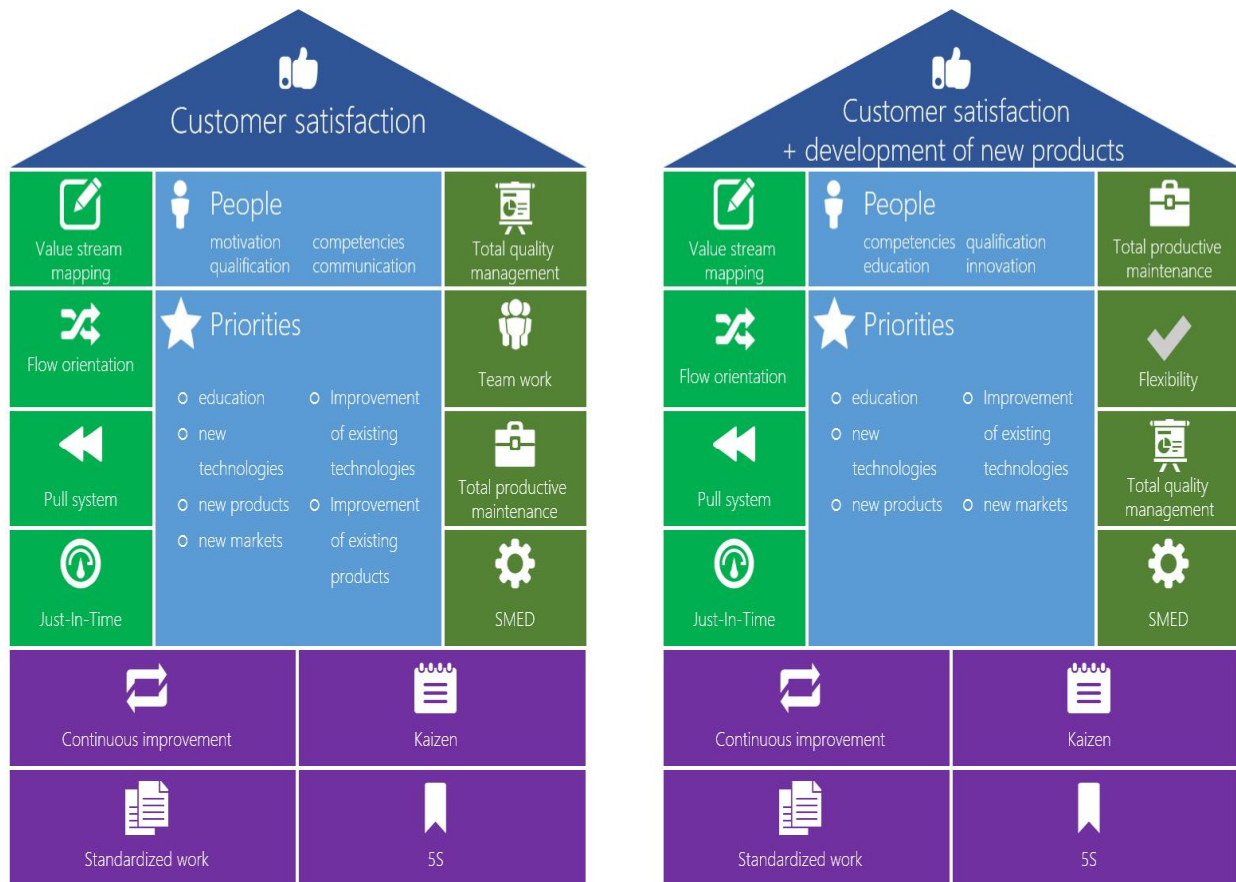


Fig. 8. Comparison of the HR-ISE model and HR-ISE model for small enterprises.

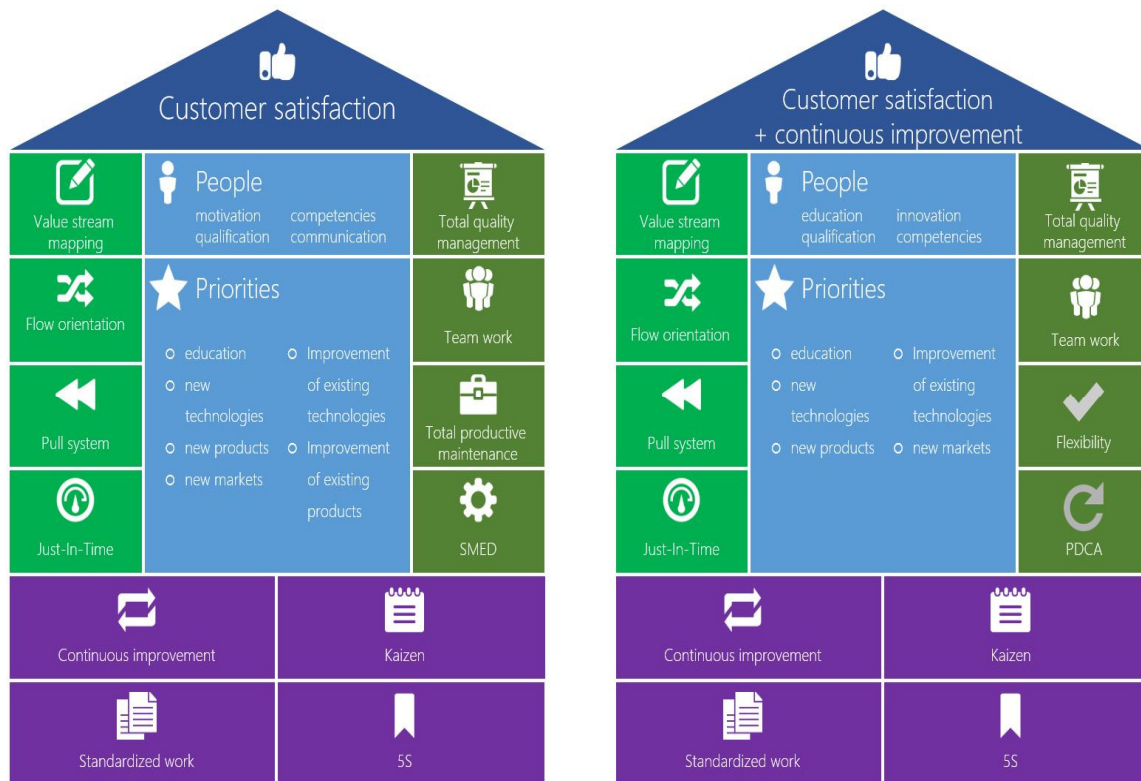


Fig. 9. Comparison of the HR-ISE model and HR-ISE model for medium enterprises.

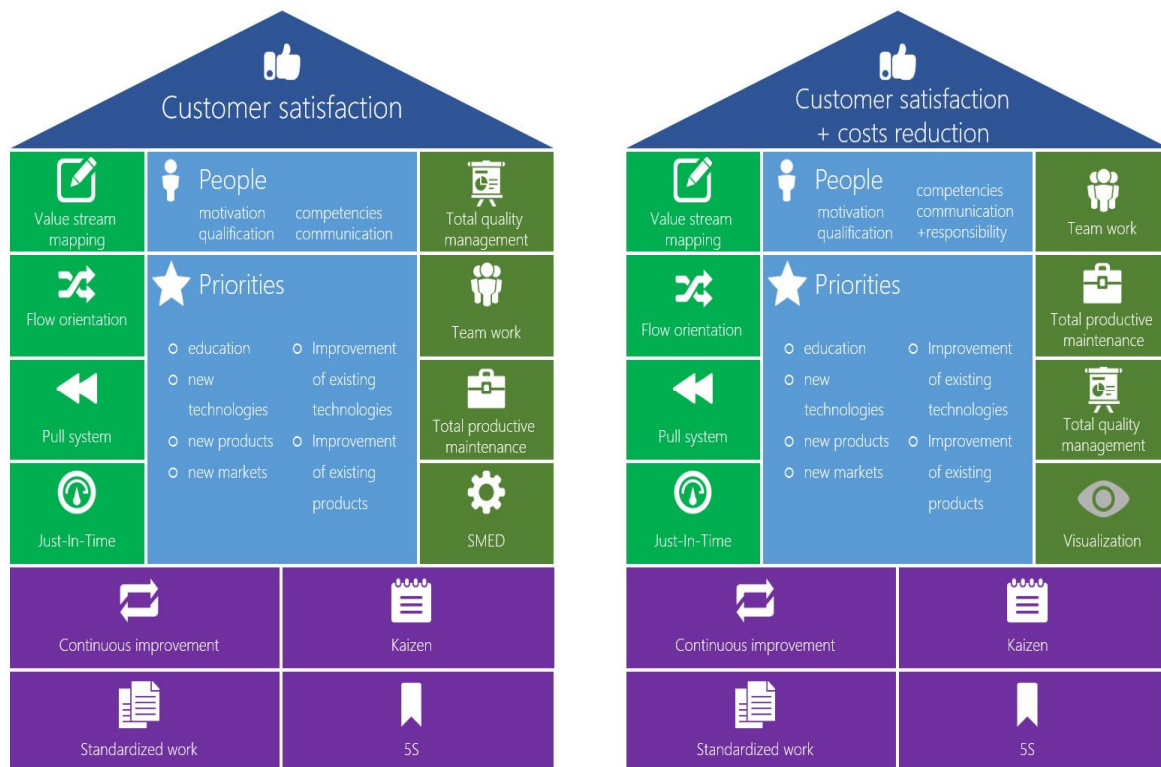


Fig. 10. Comparison of the HR-ISE model and HR-ISE model for large enterprises.

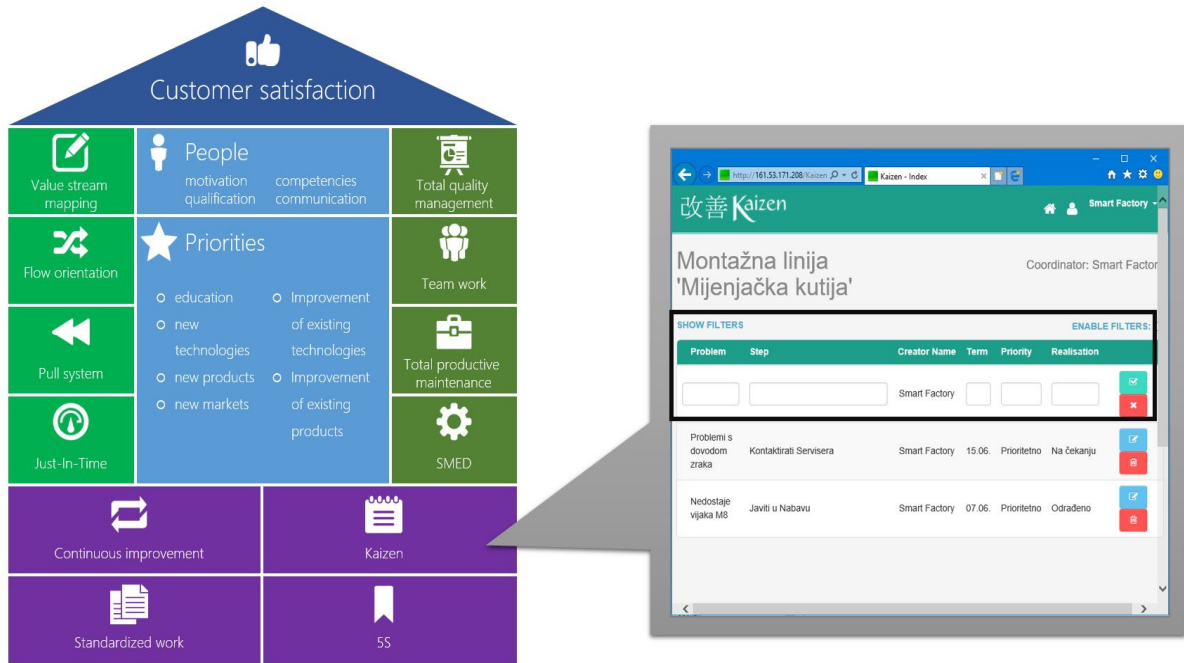


Fig. 11. An example for Web application for Kaizen.

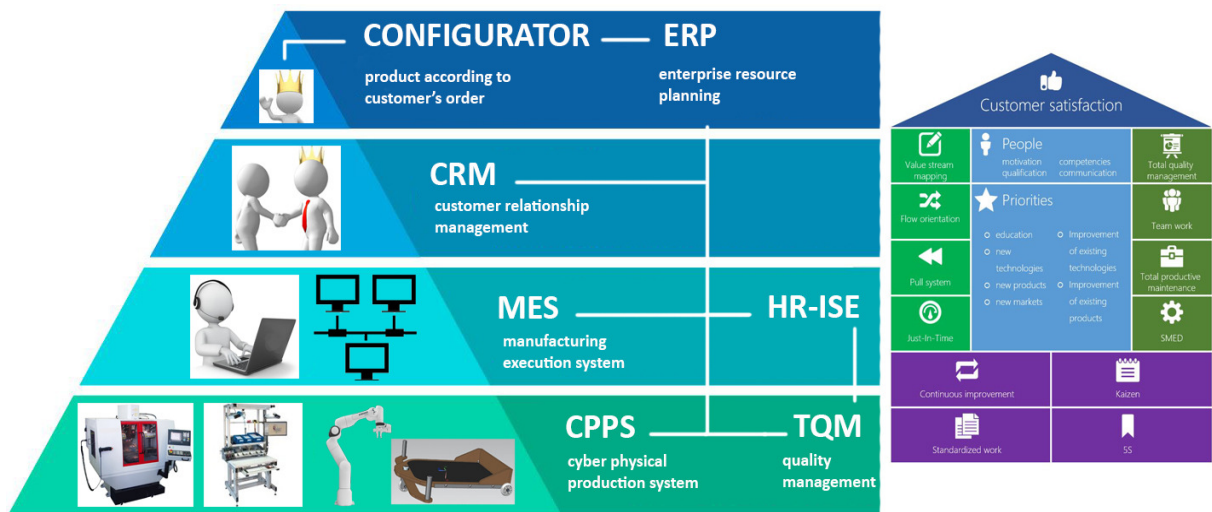


Fig. 12. A review of developed model for Innovative Smart Enterprise.