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OPTIMIZATION OF PRE-PRODUCTION AND PRODUCTION OPERATIONS IN THE FORESTRY INDUSTRY USING RFID TECHNOLOGY

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Keywords: RFID technology, pre-production operations, production operations, forestry industry
Abstract:line The main objective of this paper is to improve logistics and design to improve the register timber in stock and timber in the sale itself to optimalization of pre-production and production operations in the forestry industry. The proposal could improve the registration using RFID technology. The proposal based on RFID technology will ensures smooth and easy flow of information. Technology will be introduced in stocks, which will result in better record keeping and transfer of timber storage and at the same time will be introduce RFID technology in the timber sale.

1 Introduction

RFID technology is defined as radio frequency identification, and it is a form of automatic identification and data capture. The technology utilizes the transmission of information via the electromagnetic field by radio - frequency signals. It consists of four basic parts: a label reader and antenna and computer unit with software. RFID technology is a system which, uses its elements, captures and transmits data stored in the labels and displays them on a computer through the reader. It can be used in all areas related to manufacturing, logistics, transportation, registration, then in automotive and electronics industries as well as in other areas. Interest for this type of technology is increasingly growing.

The functioning process of RFID technology:

1. The label contains a chip and a helical antenna. Chip is inserted into the data. The antenna communicates with the reader.

2. The reader is also part of the antenna. The reader is a device that captures via an antenna and provides data transfer, which reader identify.

3. Computer Unit: includes software that displays data from the reader [3].

2 Pre-production operations in the forestry industry

Pre-production operations include:

1. Planning

Planning in the forest enterprises includes the following plans: NHP - National economic plan and PSL - The care program of the forest. NHP is drawn by national economic center. PSL is implemented for all forest lands, which are located in the Slovak Republic [7].

2. Preparation of the workplaces

During the preparation of workplaces is taken into account rational and economic character of the training in order to achieve the most effective outcome depending on the production and technical conditions in the implementation of forestry work [1].

3. Marking trees for felling

Trees selected for felling are marked individually with color indelible mark with a minimum diameter of five centimetres or clearly legible tion of 130 cm from the ground on the trunk and the root swelling. Finally, it provides a measure by meter. It measures the length and thickness of the wood [4].

3 Production operations in the forestry industry

Production operations include:

1. Wood extraction

Wood extraction is understood as the felling trees, its limbing and debarking. Work is dependent on the used technology in felling operations [1].

There are three types of felling:
- Restoration felling,
- Educational felling,
- Calamity felling.

The aim of regeneration felling is forest regeneration. It is often used in practice narrower term rotation felling. Educational felling focuses on the education of these stands in premature stands. Educational felling can be termed premature and term extraction, namely extraction in premature stands. Another type of felling is calamity felling. It is a random large-scale felling and imission felling in forests dying as a result of industrial emissions. [1]. The next figure (Figure 1) describes work organisation of production operations in the forestry industry.

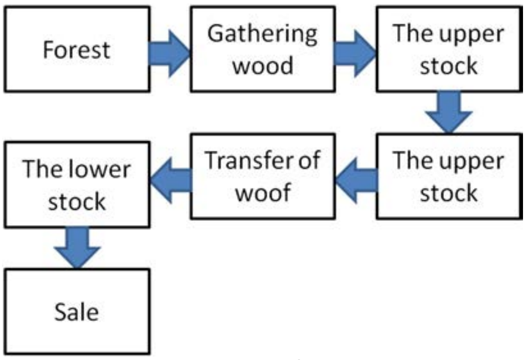

Figure 1 Work organisation of production operations

Forest – place of extraction. Gathering wood – felling wood transferred from forest to the upper stock. The upper stock - in practice it is place, where truck can get in. Transfer of wood - is linked with wood transport from the upper stock to lower stock by trucks. The lower stock - in other words, it is the manipulation - shipping stock - stock, whose function is to take over wood, registration, storage, wood handling and sale. Sale - is carried out either in stock or in the form of auctions.

2. Reforestation

Forest regeneration is the process by which there is a replacing of the adult forest with the new forest. It is one of the basic activities of cultivation. There are three kinds of forest regeneration, namely: restoration of natural, artificial or combined.Natural regeneration is carried out under the assistance of the parent stand. The process is linked to the possible impacts of the arrived seeds on bare surface or directly under the parent stand. In order to correct natural regeneration is necessary in order to achieve favorable conditions. Artificial regeneration is carried out by means of sowing seeds or planting seedlings. Therefore, it is more expensive than natural regeneration. It raises the cost of planting and planting seedlings. Combined recovery is a combination of natural and artificial regeneration. If you can not ensure natural regeneration of the whole area, then it is necessary for filling the artificial surface to ensure recovery [2].

3.Extracting – production technologies

In the production process there is a change of raw product to final product. Extracting production processes change the trees in the forest to wood assortments. Extracting – production technology uses three main felling methods which are classified according to the degree of processing skidding:
- Method of product lines,
- Trunk method,
- Tree method

Product lines method performed in the stand clinker, limbing , if necessary debarking, cut up into individual tribes range. In the trunk method, the trees are cut down, debarking. When the tree method leads to the execution of woodlice in other working operations are performed at selected place (OM) [1].

4. Felling and limbing

First phase for wood extraction is felling (separation of above-ground tree from the ground). In terms of terrain in Slovakia, felling is carried out only by saw. Working felling operation consists of the following operations:
- Determine the direction the tree will fall,
- Modification of workplace,
- Modification of the bottom of the felling of the tree.
- Creating a notch
- The execution of the main cut,
- Rake in the direction of tree fall,
- Adaptation of the butt end and stump [1].

5. Wood sortimentation

Felled trees from forests are not regulated, so they are not suitable for sale. Therefore wood sortimentation must be made; it specifies the conditions of customers in terms of tree species, shape and quality.

6. Gathering of wood

Gathering wood is an activity related to movement of the timber stand at OM. Activity is carried out either wholly in the whole area of the timber from the forest stock, or it is divided into sections.

7. Wood handling

The essence is to regulate branched trunk to selections according to customer requirements. Wood manipulation according to individual tree species includes the assessment allowable size and thickness of pruning, sorting to selections, labelling and storing in heaps by product range. [3] Wood sortimentation is governed by the standard STN 48 0055 for coniferous trees and STN 48 0056 for deciduous trees [5], [6].
Wood assortments:
1st class - logs and veneer production, musical instruments and special technical needs .
2nd Class - cutouts for the production of plywood, matches , sports, technical and other special needs.
3rd Class- cutting logs, derricks, mining, construction, and the sleepers for various purposes without further processing
4th Class - mining logs, poles and pole stage, coniferous wood for trees.
5th Class - wood intended for the mechanical and chemical processing,
6th Class - wood for fuel [5], [6].

8. Transfer of wood

Wood transportation is provided in two ways:
1. The transport of wood from the forest to the upper stock. These are stocks for temporary storage wood. For a long tree, i. j. of 12.5 m in the upper stock, wood is shortened, so as to be able to transport over public roads,
2. Transfer of wood from upper forest stock or from lower forest stock. There is a further manipulation of the timber [7].
Last wood transport is carried out at the sale, so that the logs are transported to the customer by trailers or articulated vehicle. Hydraulic hand is used to loading the timber on the vehicle [1].

4 Application of RFID technology in the forestry industry

RFID technology will be used in the stocks, in the wood auctions, in the sales of wood and it improves the stock registration. Currently, registration of timber from the forest to the stock works by pedigree timber transport and processing, where are recorded information about timber . This card contains several lines, and per line must be written of tree species, diameter, length, quality, wood volume in m3 etc. After the application of RFID technology should be all the necessary information entered into the tag. The stock would have the appropriate technology that would simply have registered incoming and outcoming timber.

Labels and catalogues are used at the auction of wood in company. Labels are placed on the timber and showed the number. Relevant information - of tree species, diameter and length are assigned to the numbers in the catalogue, which will receive each auction participant. The application of this technology could replace the labels by RFID tags, where the information will be saved. The worker has a manual RFID reader, would have only scans the tag and all the information as of tree species, diameter and length of the date and place of workload would be immediately viewed. It would be more transparent and easier for consumers and would not have to look for information in the catalogue.

This proposal would be also useful in the sales of wood. If customers want certain tree species of a given diameter and length and quality; the employee, attendant computer with the appropriate software, knows that in a stock is what the customer requires. It would be therefore a quick and easy download and storage timber into and from the stock, and it improves processing time. After the application of this technology would be significantly improved the flow of information storage, and an improvement in the sale of wood. It is important to choose each element appropriately to achieve efficient transfer of information.

The following picture (Figure 2) describes process of RFID technology.

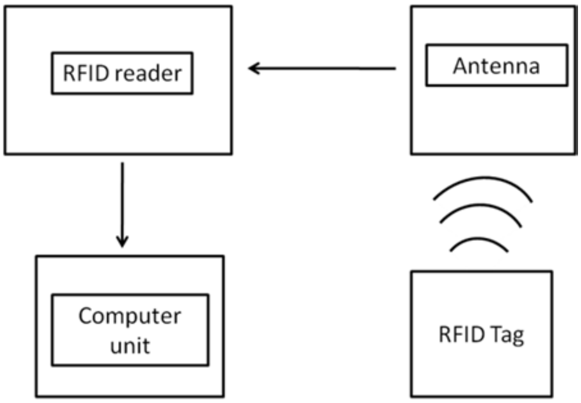

Figure 2 Process of RFID technology

Function and location of the tag:

Tag is placed on the forehead of wood that will be further shortened and edited, it will be removed in unloading. It is advisable to select the type of the tag memory R / O (read only), it contains only the data entered during marking the timber, and it cannot be simply changed. Removed tags are rejected, as when removing tags from the front of timber, removing can causes their deformation and malfunction. The frequency range and distance range are important. The flat antenna is placed at the entrance gate, trucks with wood will pass through the entrance gate, it would be sufficient to used low-frequency tags, which have a short range, but on the other hand, this type of tag has high value and low frame rate. Therefore, it is preferable to choose tags from very high frequencies (from 300 MHz to 3 GHz) and a greater range (up to 3 meters), and to have a much lower price and better readability and you can read about 200 tags simultaneously. In terms of power tag, it is advisable to opt for passive tags, because they work without its own power. They are driven by a signal sand by antenna from reader and thus recharges the capacitor in the tag, it allows communication [3]. Subsequently, the tag is deactivated after an interruption of signal from the antenna.

Function and antenna location:

It is advisable to select the antenna with circular polarization. These antennas are distributed on two levels creating a circular effect. Constantly emitting rotating wave field ensures reliable load any tags that are in it. It is necessary to take into account the working temperature of the tags, working temperature should be in the range of - 20 ° C to + 60 ° C. In view of the fact that the gate is placed far away from the building, where the system will be installed, the antenna will be placed every 5 m.

Function and location of the reader:

The reader can reads information from the tag and transfers them to a computer unit. Antenna would be connected to the reader with cables. The reader would be located in the building.

Function and location of the computer unit :

It is needed to buy software that can reads the information. Computer unit would be connected through the card via Wi –Fi. Computer unit will be operated by trained storekeeper.

The process of RFID technology application:

1. The construction of the project (planning, graphic documentation).
2. The purchase of individual elements: software, tags, antennas, readers and computer unit.
3. Installation of purchased elements.
4. Training of employees.

Application of RFID technology in felling activity:

1. RFID tags contain a chip with memory and a helical antenna. Information on tree species, diameter, length, date of wood felling and place of wood felling will be stored in the chip.
2. Tag will have a metal casing and it will be charged with the plastic pins on each of the logs for the collection from OM to the stock. In particular, tag will be placed on the front of the log.
3. Information will be inserted into the chip and immediately sent to the foresters in stock. There would be no problem in accepting the identification in stocks or any theft of wood.
4. Wood loaded on a truck goes to the stock.
5. The antenna stored on the gateway captures the tag information after a truck entrance to the stock area.
6. The tag is located in the electromagnetic field of antenna, and thus tags are capable of transmitting a radio signal.
7. The reader placed in the stock reads information.
8. Read information will be displayed on a computer unit.

Timber can be easily and quickly identify, and count using tags. Thanks to tag attached to the timber and device stored in the stock, it can be possible to monitor the timber from felling in the forest to the final customer.

Next figure (Figure 3) shows application of RFID technology in the stock.

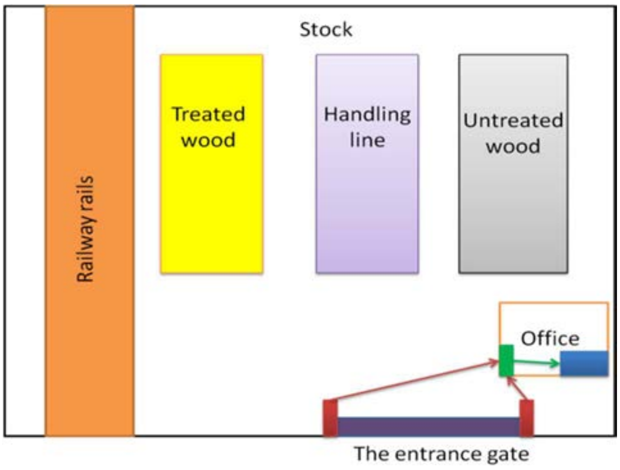

Figure 3 Application of RFID technology in the stock

The legend: Red color - antenna, it transfers information using an antenna to the office. Green color - reader, reader obtains the information and subsequently transferees them to the computer unit. Blue color - computer unit displays the information on the monitor. Yellow color - a place designed for the localisation of tags in case of wood sales.

Conclusions

Computer unit would be connected through the card via WiFi. Computer unit will be operated by trained This proposal would improves the flow of information and the sale of wood and also reduce the theft and loss of wood. Another advantage of the proposal is that the wood could not be lost. It is predicted that the losses from timber felling to its transport to the stock consist of about 20%. After the application of the RFID technology should to reduce the loss by 10%. Moreover, by recording the wood using RFID technology will not downshift the timber from a higher category to a lower category. It would also save time of workers, improving organization of work and running of the process of registration of logs in stock. The investment in this technology would be great benefit for business. This proposal would make simpler a sale of logs.

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PRODUCT VARIETY INDUCED COMPLEXITY AND ITS MEASUREMENT

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Keywords: complexity, combinatorics, configuration, product, scale
Abstract: Mass customization has become a novel trend in the manufacturing of products as it offers high product flexibility to customers. As a result, producers of such products have to cope with incresing demands on manufacturing and related complexity management. This paper aims to develop so called configuration complexity measure to determine the extent of mass-customized production variety. Product configuration complexity scale has been also developed in order to assess concurrent product architecturs based on the offered variety extent for their product. The method presented in this paper is a useful method with minimum input data required and with important output information for product decision-makers.

1 Introduction

High frequency of topics on complexity-related problems within mass customized (MC) production, including technology of production, in research publications clearly evokes their significance. Especially product variety induced complexity is often a matter of interest for theorists and practitioners. Our focus in this paper goes towards an exploration of product variety induced complexity (VIC) based on combinatorial principles to measures and to enumerate the VIC. Finally, in Section 3 we analyze mutual relations between numbers of possible product configurations and establish so called VIC scace to capture the effect of growing number of product components with impact on overall production complexity.

2 Related work

So far, several approaches have been taken in order to assess complexity of the manufacturing system. Different authors focused on partial problems – sources of complexity and covered only a partial manufacturing environment. Complexity of any system is affected by three variables, namely state of the system elements, their number and relationships among them [1]. Different definitions of manufacturing complexity have been provided so far but the very first metric is associated with the Shannon`s information theory [2] related to the amount of information (in bits) in uncertainty of information system. From this approach, it is evident, that the fewer processes, machines and/or product configurations – the lower is the overall complexity of the system. Zhu et al. [3] and Desmukh et al. [4] applied and proposed entropy based measures in terms of assembly in conjunction with part types and derived their own measures to capture the process complexity in manufacturing. Suh [5] defined complexity in relation to product design through achievement of functional and design requirements. Kim et al. [6] introduced number of metrics for complexity on the basis of system components, elements and their relations. These measures cover majority of system elements but cannot be extended to other manufacturing domains except for cell production. Frizelle and Woodcock [7] defined two original types of complexity, static and dynamic currently corresponding with structural and operational complexity. Their metrics have been further applied and even developed in the works of other authors [8-11]. Other

Other authors [e.g. 12-15] discussed complexity sources in terms of manufacturing, supply chain management, machining.

3 Methodological framework

In the context with this objective, let us start by introduction of product configurations for the three component types, when assuming the following number of input components: number of stable components i=2, number of voluntary optional components j=3 and the number of compulsory optional components k=2, while only one of them must be selected (l=1). This customizable assembly operation follows the Class and Sub-class of product configuration $CL_i\ SCL^k_j \rightarrow CL_2\ SCL^2_3$. Then, exactly six product configurations may occur (see Fig. 1) under the assumption that the case represents single assembly node.

In a case when the same assembly node composition is a part of assembly chain (with up-stream assmebly), then the number of product configurations is a multiplication of all upstream product configurations within this assembly line.

Theoretically, for all cases of the Class CL_1, single stable component is not be counted as a product configuration. If the number of stable components $i \geq 2$,

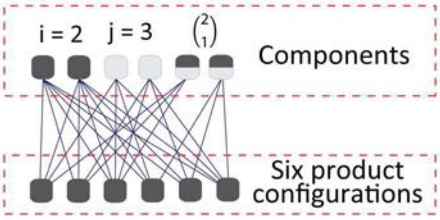

Figure 1 Single assembly model in terms of MC resulting with six product configurations

and if zero voluntary optional components are selected, we identify one product configuration for assembly of only stable components.

3.1 Product configuration ontology

In this section, wider description for quantification of all possible design alternatives understood as the product design space, will be treated.

This description refers to hierarchy of product ontology, as shown in Fig. 2.

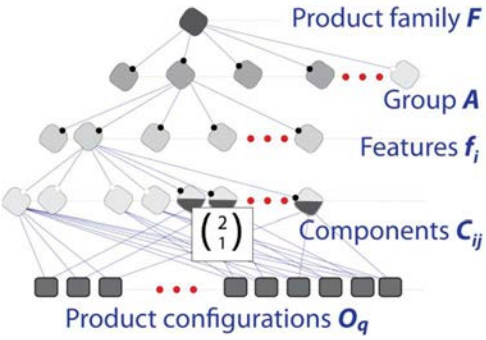

Figure 2 Product configuration ontology

To explain the hierarchy, the following working definitions can be useful. Any product activity is here considered as a compact package of products divided into features $\{f_1,\ldots f_m\}$. Feature consists of a set of components $f_i=\{C_{i1},C_{i2},\ldots,C_{ij}\}$. Components represent characteristics of individual feature and will be denoted as C_{ij}, where $j=(1,\ldots n)$ and $i=(1,\ldots m)$. Each component is linked by options (product configurations) $O_q=\{O_1,O_2,\ldots,O_r\}$, but the number of configurations depends on structure of components which can be of different nature.

3.2 Combinatorial models for individual assembly nodes

The purpose of determining configurations during the product development phase is to assess relative degree of service customization, since this measure expresses external perception of variety induced complexity. As it was already proved by Krus [16], value of vVIC should be reduced to minimum. In order to proceed in accordance with this statement, this sub-section aims to propose a framework for determination of all possible product configurations.

Product variety models in our approach will be represented by directed bipartite graphs. Initial nodes in such graphs are represented by components of product features and end-nodes are represented by the number of all possible product configurations (see Fig. 2).

Configuration definition process captures the requirements of both, customer and producer of the future product. For such purpose and to satisfy the MC principles, this paper proposes to adopt so called Scenarios assuming combining the three component types. We distinguish between the following situations: Scenario#1 is the one in which only stable and voluntary component permutations play a role for consumers. Within this scenario, only combinations of available stable C^S_{ij} and voluntary optional C^V_{ij} components belonging to feature f_i are counted among possible product configurations. In Scenario#2, additional component type may appear in the definition of product composition, namely compulsory optional component C^C_{ij}. This component type provides higher flexibility in specifying the future product composition. Summary scenario merging three attributes types together offers high flexibility of product composition in line with MC strategy. Final number of all available options – configurations demonstrates the extent of product variability as consumers are only focused on the extent of customization offered.

The two individual Scenarios#1-2 present a unique methodology to combine the three mostly used component types that the product, design and production engineers have to be aware of when designing new product design architecture. Appearance of the two scenarios is very frequent in the production architecture engineering. In our previous works (e.g. ([17-20]), a calculation method to obtain all possible product alternatives $\sum Conf$ within the Scenarios#1-2 has been provided as follows:

$$\sum \boldsymbol{Conf} = \prod_{\substack{i=1 \\ j=1}}^{\substack{m \\ n}} \left(\sum_{q=1}^{r} \boldsymbol{O_q}\right)_{ij}. \tag{1}$$

Practical importance of such measure, especially in the case of high numbers of available components, can be explained by the following example. Let us say that a structure of feature components consists of all three component types. If we had three components C^V_{ij} and three compulsory components, where selection of at most two of them is allowed. Then, one would obtain in total 42 product configurations.

Enumeration of the final value of product options is based on the previously developed combinatorial metric of product variability (Equation 1):

$$\sum \boldsymbol{Conf} = (\mathbf{2}^{j}) \times \left(\sum_{j=1}^{n} \boldsymbol{C}_{ij}^{C} \left(\frac{\boldsymbol{k}!}{\boldsymbol{l}!(\boldsymbol{k}-\boldsymbol{l})!} \right) \right) = \mathbf{2}^{3} \times \left(\left(\frac{3!}{\mathbf{1}!(\mathbf{3}-\mathbf{1})!} \right) + \left(\frac{3!}{\mathbf{2}!(\mathbf{3}-\mathbf{2})!} \right) \right) = \mathbf{8} \times (\mathbf{3}+\mathbf{3}) = \mathbf{42}, \quad (2)$$

where l is the number of components to be chosen from a set of all components k belonging to feature f_i; component C^{C}_{ij} adopts the condition that $1 \leq l < k$.

Current product variety in terms of MC may involve high number of features and attributes. Then, each feature can be represented by the different types of components. Products have either fixed features with voluntary attributes or they are completely customizable. The problem of such product is in the quantification of all possible design alternatives that are understood as the design space. Then, designers have to cope with future the extent of variety already in the design stage of product development. In the case of complex products, there is a lack of consistent methodological frameworks allowing to model representations of a large number of components.

4 Combinatorial-based configuration complexity scale

On the basis of the above-explained methodology, it is possible to create a graph showing the number of component configurations for class CL_2 based on the dependence of component configurations and the number of voluntary optional components C^{V}_{ij}. It is evident that the number of component configurations varies only depending on the number of voluntary optional components.

As can be seen in Fig. 3(a), component class CL_2 is substantial for the creation of Configuration complexity (CC) scale. The class reaches the highest values of component configurations among all classes for the given number of initial nodes (stable and voluntary optional components). The values of component configurations from CL_2 are then considered to be the upper bound values of the scale concept. In order to define a degree of complexity, a concept of configuration complexity scale is defined, as can be seen in Fig. 3(b).

Procedure for creation of configuration scale concept consisted of the following steps:

- Generation of all possible component (product) assembly configurations;
- Defining the number of component configurations of each component class CL and sub-class SCL;
- Analysis of the results and obtaining the upper bound values of configuration complexity scale.

Complexity degrees/levels based on total number of component configurations in case when CL_2 can be defined, as seen in Table 1.

Table 1 Complexity degrees based on summary values of product configurations

1.	The first level CC with 2-4 config.; in notation SCL_{1-2}
2.	The second level CC with 5-8 config.; in notation; to SCL_3
3.	The third level CC with 9-16 config.; in notation; to SCL_4
4.	The fourth level CC with 17-32 config.; in notation; to SCL_5
5.	The fifth level CC with 33-64 config.; in notation; to SCL_6
6.	The sixth level CC with 65-128 config.; in notation; to SCL_7
7.	The seventh level CC with 129-256 config.; in notation; to SCL_8
8.	The eighth level CC with 257-512 config.; in notation; to SCL_9
9.	Etc.

Numbers in brackets are the values of component configurations for a certain number of stable and optional components.

Conclusions

This pape aimed to contribute to the theory of complexity management as it concernes with number of disciplines, such as operations research, supply chains, product portfolio, prodocution and technological complexity, variety, with aim to optimize. Moreover, Theoretical background of the problem area provides linking of the mentioned disciplines and additionally, provides solution for the management of product complexity.

Various researches, so far, dealt with generally known and derived appraoches leading to manufacturing complexity optimization, to general process optimization, such as platforming, modularization or MC in general.

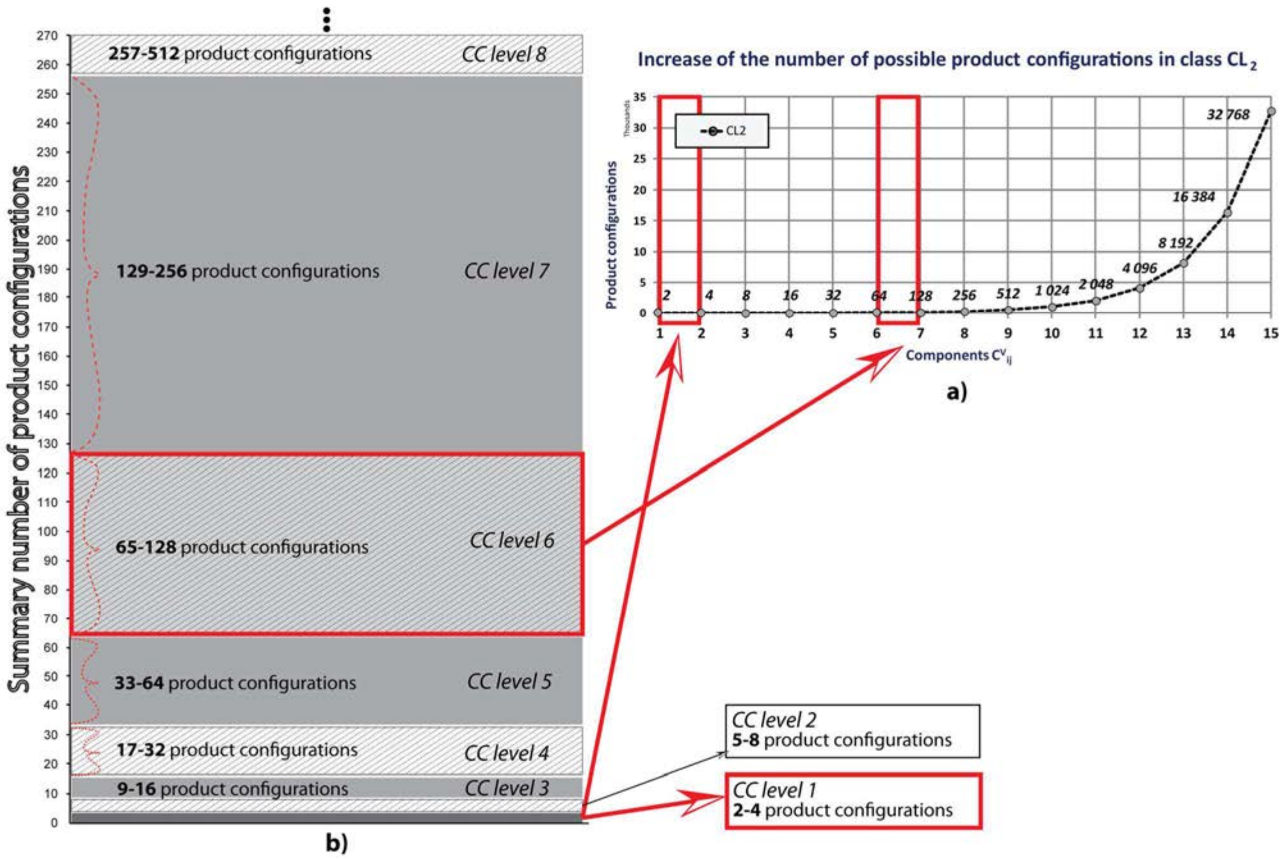

Figure 3 (a) Increase of the number of configurations in CL_2 ; (b) Graphical representation of CC scale with defined upper bounds

None of the appraoches, so far, provided a valid or comprehensive measure of product-based complexity in terms of MC.

There is still room for future research in this area, e.g. product complexity along the product life cycle, including product design stage, production/assembly, delivery,...). Framework Scenarios #1-2 developed under the theoretical analysis, have determined minimum pre-conditions for the development of conceptual framework of mass customized manufacturing (MCM). Individual building elements of the MCM have been organized into a system with roles, conditions and mutual relations among them allowing product managers to make clear easily-obtained decision for the suitable product platform variety. This way, it is possible to apply the quantification method to enumerate number of product configuratinos of any MCM model and to determine the value of the system's CC. Subsequently, it is possible to benchmark concurrent systems' CCs using the CC slace, where one of the alternative varieties may have lower level of CC than other. Such model may have lower number of product alternatives for customers but with enough demand for their products.

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IMPACT OF CONTROLLING SYSTEMS ON DIRECT COSTS OF CONSTRUCTION PROJECTS

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Keywords: exploitation of economic controlling systems, direct costs, construction projects
Abstract: Cost planning and cost management is one of the condition for successfully manage to construction project. Efforts to reduce direct costs is a priority for reaching and realization of the objectives. Implementation of controlling is one way to achieve these goals. Currently, there are several ways to automate and systematized these activities. One of them are Controlling systems. Several studies indicate that their use have a lot of benefits. Article discusses the issue of exploitation level of Controlling systems for cost management and reduce direct costs of construction projects. The main objective of this article is to confirm the hypothesis that verify to the following statement: Enterprise size has an impact on the use of Controlling systems for direct cost planning in construction projects and exploitation of Controlling systems have a significant impact on reducing the direct costs of construction projects in difference to the size of construction enterprises.

1 Introduction and problem statement

Recent years are characterized by dynamic progresses exploitation and implementation of information and communication technologies [1]. The need for data and information in the knowledge society is growing very quickly [2]. The competitive environment is forcing companies to make quick and effective decisions on a daily basis [3]. With increasing amounts of data and information, there is an even more important selection and the need to use relevant data to support decision making in the management and coordination of companies and projects in each area [4]. The use of advanced technologies to support management in many companies is a priority and one of the main steps and procedures to successfully manage companies and projects [5]. Interconnectivity the various technologies and systems and their multifunctionality avoid talking about this group of technologies only at intervals of information systems [6]. These in many cases are separated.

Information and communication technologies (ICTs) (Communiaction-Information Technologies - ICTs) represent a complex hardware and software. This includes communication technologies that enable data processing [7]. ICT is a broad term and includes a number of technologies [8]. The economic system is relatively broad term. But the opposite of ICT is only focused on the economic agenda. The economic system is a type of system, whose main functionality is the economic agenda of the business or project [9]. In many cases it includes accounting software. Building business success depends on many factors [10]. Level managing all operations and effects are ultimately reflected in the amount of costs and prices realized performance [11], [12]. That is the upshot - profit. One of the goals of any entrepreneur is to make a profit. Strategic controlling identify future opportunities and risks of routing each company or business [13]. This is a basic function of strategic controlling. It follows another important task - to manage and control all implemented measures to move towards implementation of the goals of the corporate strategy [14]. Involvement at this stage The operational controlling. It is timely to recognize deviations from the basic direction by properly elected executive - operational tools [15]. Strategic and operational controlling jointly created two functional units that are connected and influence each other [16].

According to E. Mayer [17] controlling is a management process focuses on operating result, which is realized by means of planning, monitoring and verification. Controlling is based on the harmonization of the objectives set out by managers and staff and objectives set out by company. Controlling has a major role to ensure long-term company's survival and stable employment. These tasks require coordination management system that can be achieved by establishing an appropriate organizational structure and integration objectives with planning and information systems.

Controlling systems are information systems that perform the functions exercised by the controlling in company. They are supporting tools that make automation of planning, management and control activities in the company. In the context of controlling it is important to

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plan costs for the selected activity. The cost of the construction project can be divided according to the different phases. The very process of construction cost management project includes the following [18]:

- cost planning and economic feasibility of the project at the planning stage,
- monitoring and forecast of efficiency and utilization of financial sources,
- proposal for measures to deal with deviating development (cost and time) at the realization stage of construction project,
- assessment of the real effectiveness of the construction project at realization stage of construction project.

Control of costs and estimated costs of the construction project is to specify the cost of the necessary procedures, which are implemented throughout the lifecycle of a construction project. Costs of construction projects can be classified according to several different criteria. In terms of cost calculation formula is broken down [12]:

- **direct costs -** this includes:
  - direct material,
  - direct wages,
  - costs for machinery and equipment,
  - subcontracting,
- manufacturing overhead,
- administrative expenses.

This breakdown is also important in terms of research, the results of which are also interpreted in this paper.

2 Methodology

2.1 Research objectives and methods

In the article they were used empirical methods of investigation and research. Within the empirical methods were used on a larger scale observation, questionnaire survey and interviews with business. From theoretical methods they were most used method of abstraction, analysis and synthesis, and methods of induction and deduction. The methodological framework during the research:

1. Determine the subject and scope of research.
2. Selection of the research group and content.
3. Processing questionnaires for data collection.
4. Data collection.
5. Evaluating data based on the detection levels of importance factors examined.
6. Verify the statistical significance of the results based on the Kruskal-Wallis test.

2.2 Data collection methods

The questionnaire survey appeared to be the fastest and most effective way of obtaining the necessary information for research purposes. The questionnaire was designed and distributed in electronic form. For preparation of the questionnaire was used online platform forms which permit the questionnaire in electronic form, accessible to him of the selected target group respondents based on the destination address where the questionnaire is placed. This form ensures that the questionnaire can only see us respondent and no adverse unprofessional person.

The survey sample was approached by e-mail with the request to participate in the research. Total were interviewed 1276 of respondents (participants of construction projects). It participated in the questionnaire survey 125 respondents, but only 55 companies completed the entire questionnaire to use in our research. It represents a return of 4.31%. Given the scale of the areas examined in the questionnaire survey, it is possible to return to the level of 4.31% which is considered as good. Complete the questionnaire contained approximately 2,500 research questions, broken down into research areas of the same nature and its actual completion took approximately 50 minutes.

2.3 Research sample

The questionnaire survey featured data collection using the online questionnaire. Link to the online questionnaire was sended to respondends in electronic form with an explanatory covering letter.

Main characteristics of research subjects in terms of the size of the company we can see thereunder. Participated in the survey and a questionnaire completed by 34,55% of micro-companies, 30,91% of small companies, 21,82% of medium-sized companies, what constitutes 35.71% of the research sample and 12,73% of large enterprises (Figure 1).

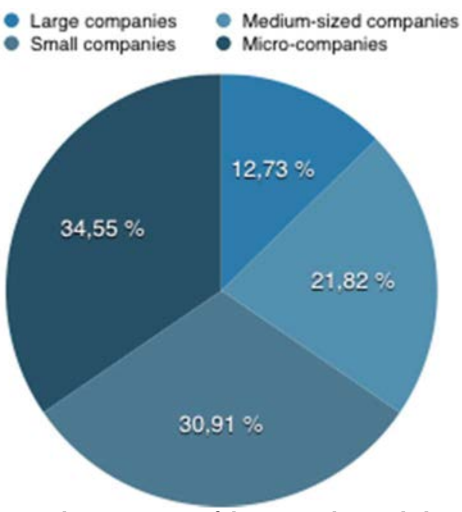

Figure 1 Characteristics of the research sample by size of construction company

Important insights into the research sample represents the breakdown of respondents by participants in construction projects (Figure 2).

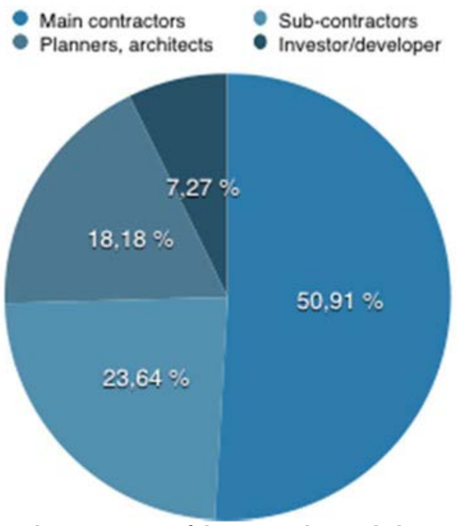

Figure 2 Characteristics of the research sample by participant of construction project

2.4 Data processing method

The obtained data were evaluated based on several statistical methods through software MS Excel and statistics. Results of the research were based on a descriptive and inductive statistics.

Evaluation of data was based on the use of so-called exploitation rate, respectively impact rate. Arithmetic average of the selected area was determined by the average value. The range was fixed by Likert scale (1 to 5). Using the measures have been made arithmetic mean of the values for the selected area under consideration.

Statistical significance was tested by Kruskal - Wallis test at the significance level $\alpha = 0.05$. Kruskal - Wallis test (Kruskal - Wallis ANOVA) is a direct generalization of the Wilcoxon two-sample test case for independent samples. Kruskal - Wallisow test is similar to the non-parametric one-way analysis of variance [19].

Kruskal - Wallisow assay is based on the ranks. This is a non-parametric method for testing. Research samples were tested, whether they were of equal distribution. It is used to compare two or more samples dependent on the same or different size [20], [21].

2.5 Hypotheses

Basic scientific hypotheses in these areas have been set as follows:

$H1_0$: Enterprise size has an impact on the use of Controlling systems for direct cost planning in construction projects.

$H1_1$: Enterprise size has not an impact on the use of Controlling systems for direct cost planning in construction projects.

$H2_0$: Exploitation of Controlling systems has a significant impact on reducing the direct costs of construction projects in difference to the size of construction enterprises.

$H2_1$: Exploitation of Controlling systems has not a significant impact on reducing the direct costs of construction projects in difference to the size of construction enterprises.

2.6 Objectives of research

The main objective of the research was to verify that the exploitation of controlling systems has a significant impact on reducing the direct costs of construction projects in difference to the size of construction companies. It comes with the knowledge that the enterprise size has an impact on the exploitation of Controlling systems for direct cost planning and construction projects.

3 Results

The aim of this survey was to understand and verify the effect of size on the use of Controlling systems. Endpoints are compared between companies. It is expected that large companies behave differently in ICT investment as small and medium sized companies (SMEs). The same is true for investing in a specific instrument for the do a controlling (includes direct cost planning). The results of the use can be seen in figure 3.

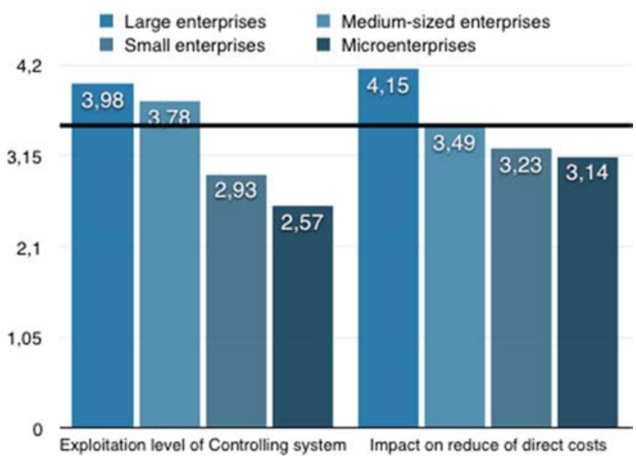

Figure 3 Exploitation level of Controlling systems for cost management and impact to reduce of direct costs

Large construction enterprises use Controlling systems for the purpose of direct costs planning in construction projects in the rate 3,98. This is a very high impact. Medium-sized construction enterprises achieved utilization rate 3,78. It is equally high.

Conversely, small enterprises achieved utilization rate of only 2,57 and micro-enterprises only 2,93. This is a very low value. This means that small enterprises have been a minor use tool a Controlling System. This probably reflects a lot of things. The survey reveals that small businesses really do not have enough funds to invest in progressive systems. On the other hand, many companies that either do not see the advantage of a lot of things out manually.

Table 1 Kruskal-Wallis test for examing of the statistical significance

	Kruskal-Wallis ANOVA based on ranking, Variable – size of construction enterprise p=0,0347		
	Code	Number of valid responses	Exploitation level
Large enterprises	1	7	3,98
Medium-sized enterprises	2	12	3,78
Small enterprises	3	17	2,93
Microenterprises	4	19	2,57

Source: own processing - the output of STATISTICA 12

Table 1 describes the Kruskal - Wallis test for examining the statistical significance of construction enterprises size impact on the exploitation of Controlling systems. Controlling systems amounted p = 0.0347. From that it follows that statistical significance was confirmed a confidence level of $\alpha = 0.05$ and we accept the hypothesis $H1_0$, thus: Enterprise size has an impact on the use of Controlling systems for direct cost planning in construction projects.

Table 2 Kruskal-Wallis test for examing of the statistical significance

	Kruskal-Wallis ANOVA based on ranking, Variable – impact on reducing the direct costs of construction projects in difference to the size of construction enterprises. p=0,0216		
	Code	Number of valid responses	Exploitation level
Large enterprises	1	7	4,15
Medium-sized enterprises	2	12	3,49
Small enterprises	3	17	3,13
Microenterprises	4	19	3,14

Source: own processing - the output of STATISTICA 12

A similar situation occurs also when examining the exploitation of Controlling system impact on reducing direct costs of construction projects. The degree of Controlling system exploitation impact to reduce direct costs of construction projects is 4,15 for large construction enterprises. The degree of Controlling system exploitation impact to reduce direct costs of construction projects is 3,49 for the medium-sized construction enterprises. The degree of Controlling system exploitation impact to reduce direct costs of construction projects is only 3,13 for small enterprises. Influence is clearly demonstrated for large construction companies (Figure 3).

Table 2 describes the Kruskal - Wallis test for examining the statistical significance of exploitation of Controlling system impact on reducing direct costs of construction projects. It amounted p = 0.0216. From that it follows that statistical significance was confirmed a confidence level of $\alpha = 0.05$ and we accept the hypothesis $H2_0$, thus: Exploitation of Controlling systems has a significant impact on reducing the direct costs of construction projects in difference to the size of construction enterprises.

Conclusions

Several surveys have shown that the use of ICT is a very effective tool to reduce costs in the chosen area. Our survey was more specific. Subject of research was the impact of exploitation of controlling systems to reduce the direct costs of construction projects. It was also researched the rate of exploitation of Controlling system tools. Within the framework of the research are expected positive impact of exploitation of Controlling Systems. These expectations have been included in the determination of basic research hypotheses. Both hypotheses were confirmed. That means, enterprise size has an impact on the use of Controlling systems for direct cost planning in construction projects and exploitation of Controlling systems has a significant impact on reducing the direct costs of construction projects in difference to the size of construction enterprises.

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